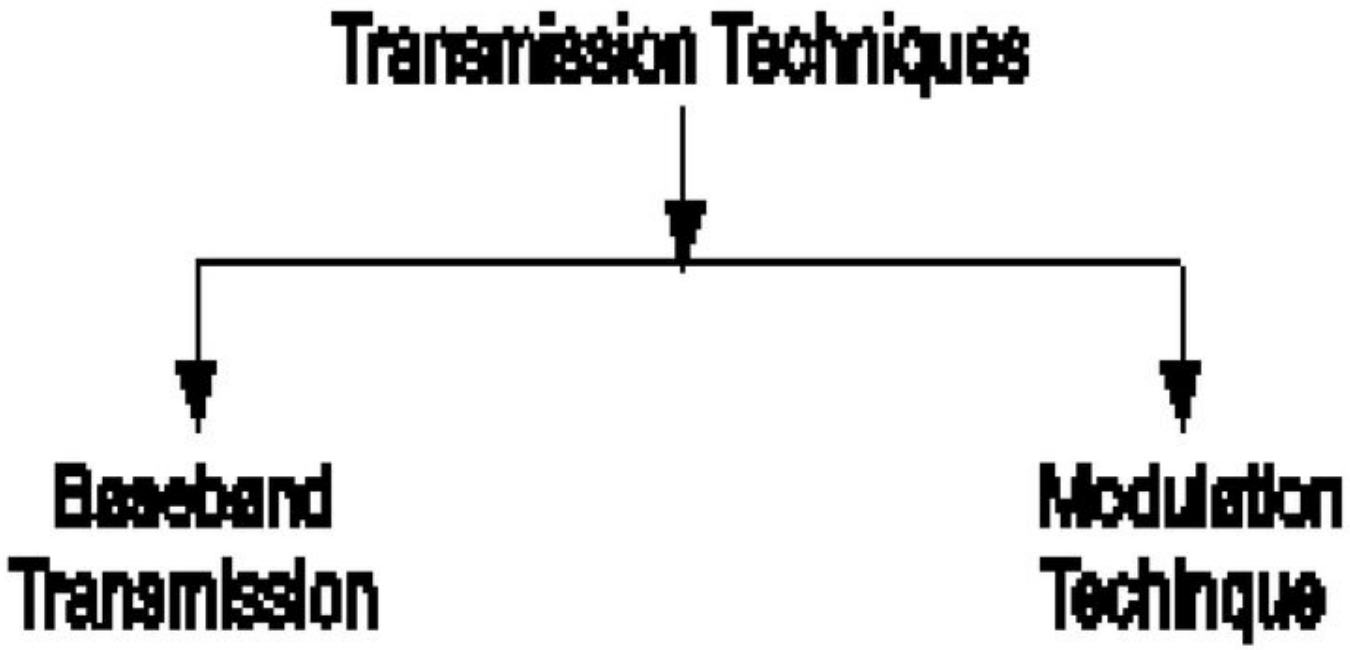
Transmission Techniques



Baseband Transmission

The electrical equivalent of original information is known as the baseband signal.

The communication system in which the baseband signals are transmitted directly is known as **baseband transmission**.

Baseband transmission is effective only for wire communication.

Example, Telephone network, data communication in computer networks through coaxial cable.

But it is inefficient for wireless or radio communication.

Limitations of Baseband Transmission

1)Baseband signal having small frequency range from 20 Hz to 20 KHz only
(so no large channel accommodation, mixing of signals).

2)Due to small frequency range, baseband signal cannot travel long distance in free space or air.

3)After a travel of short distance signal gets suppressed. So not used for radio communication. i.e. wireless communication.

To make the baseband signal efficient for radio communication modulation technique is used.

Modulation Technique

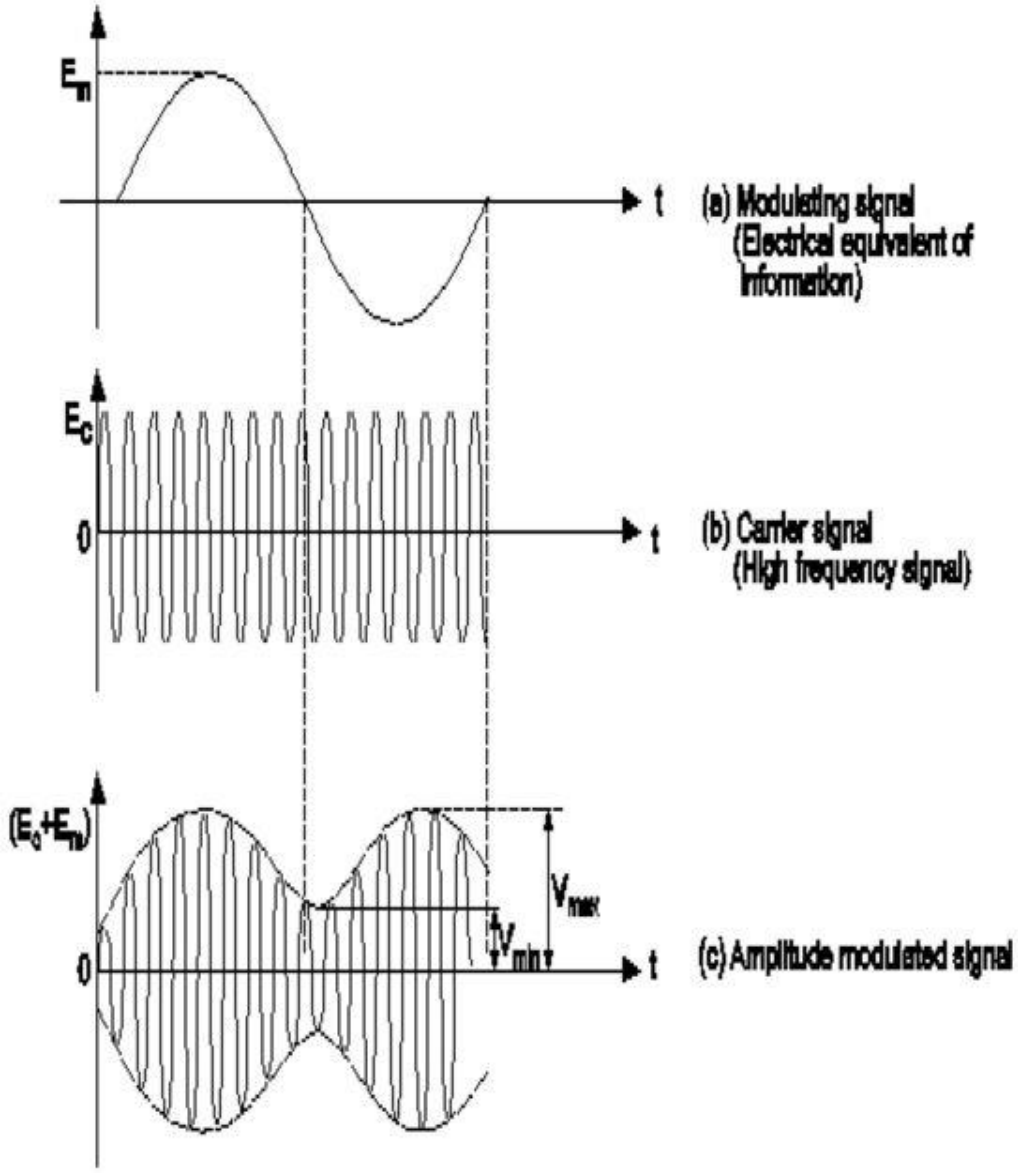
To overcome the drawbacks of baseband transmission and to transmit baseband signals by radio, modulation techniques must be used.

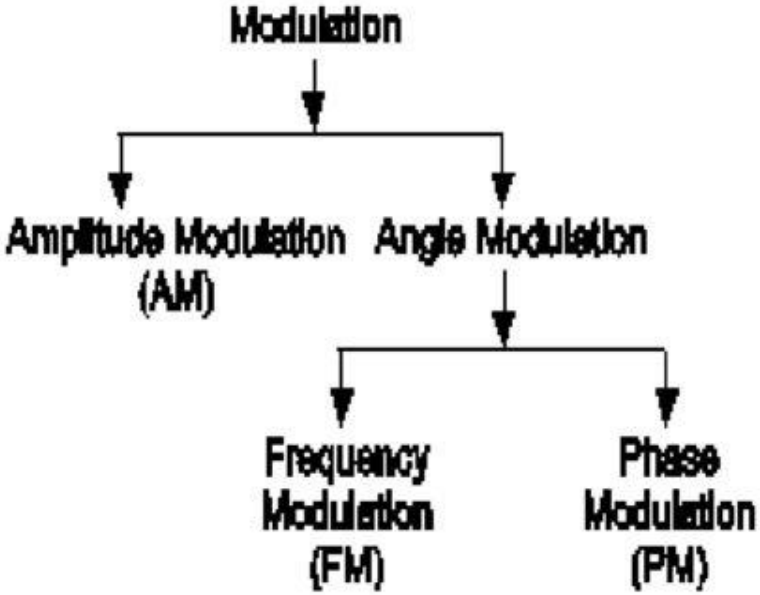
Baseband signal (Information signal) is a low-frequency signal and cannot travel longer distance. Just like we cannot walk at longer distance.

Definition:

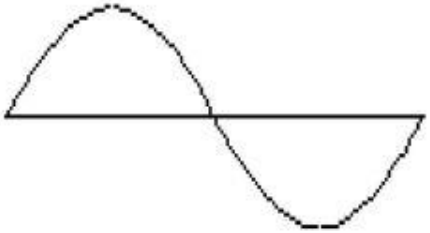
Modulation is the process of superimposing low-frequency information signal on a high-frequency carrier signal

Modulation Technique


E_m
t
(a) Modulating signal
(Electrical equivalent of
Information)
E_c
0
t
(b) Carrier signal
(High frequency signal)
(E_c+E_m)
V_{max}
V_{min}
0
t
(c) Amplitude modulated signal

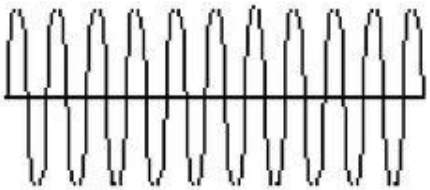

Modulation
Amplitude Modulation
(AM)
Angle Modulation
Frequency
Modulation
(FM)
Phase
Modulation
(PM)

Modulation Technique



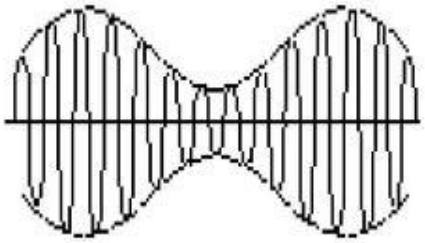
Modulating signal (Information)

Modulating signal (Information)



Carrier (High-Frequency signal)

Carrier



Modulated signal

Modulated signal

When man sits in car becomes modulated signal

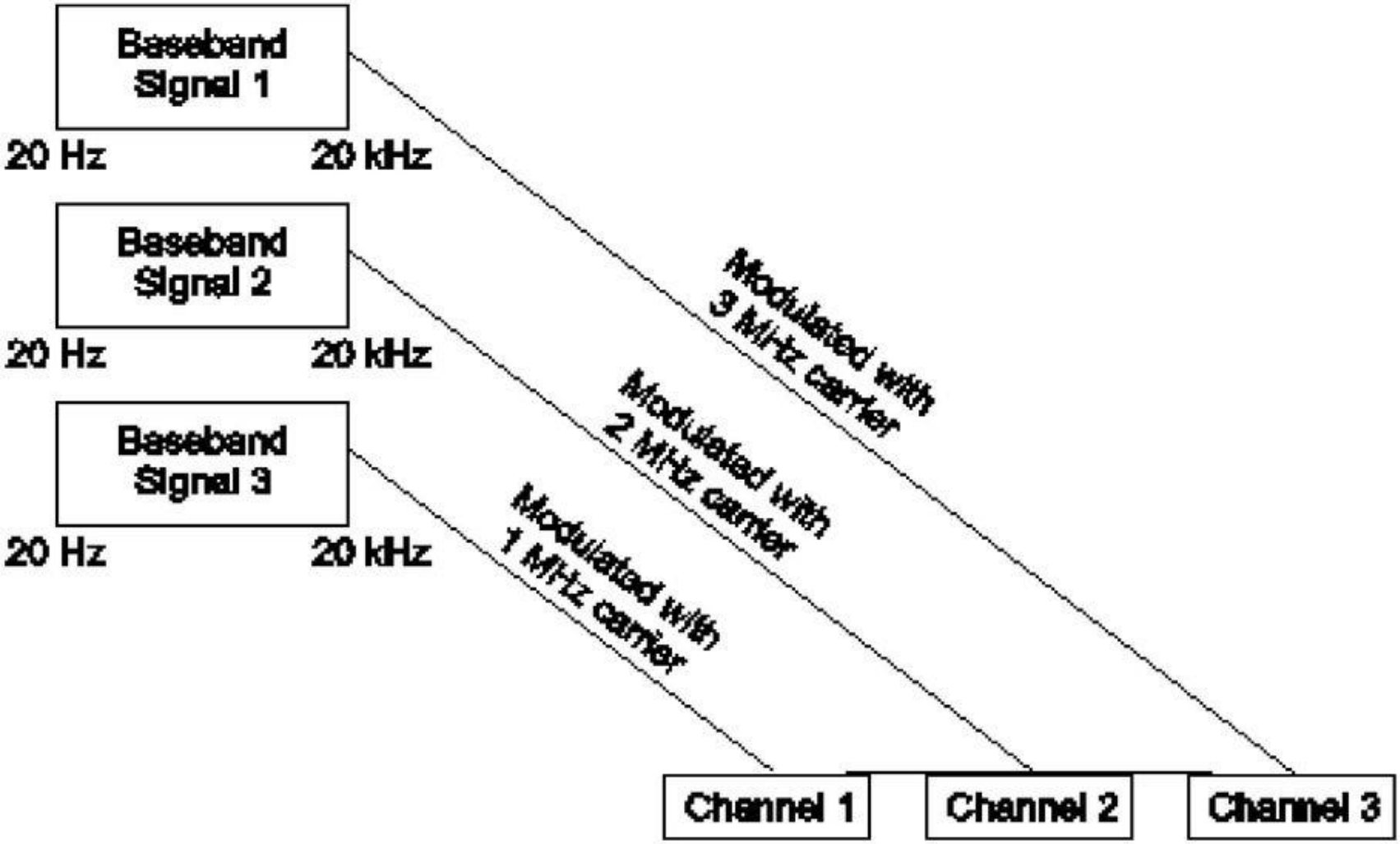
Need of Modulation

Baseband signal transmission cannot be used for radio communication. To transmit the baseband signal for radio communication, modulation must be used.

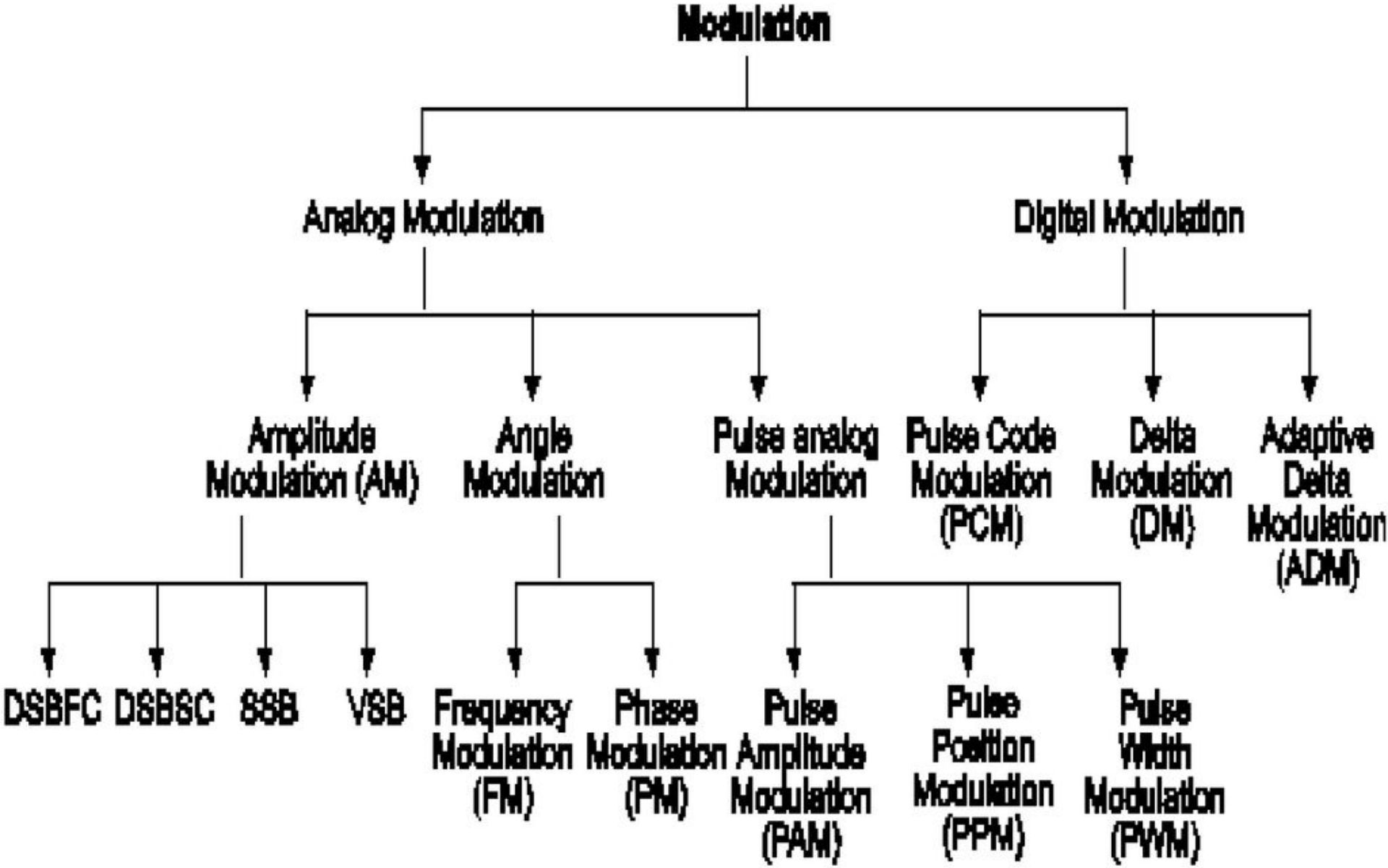
Modulation is necessary because of following advantages:

1. Reduction in height of antenna.
2. Avoids mixing of signals.
3. Increase the range of communication.
4. Multiplexing is possible.
5. Improves quality of reception

Avoids Mixing of Signal



Classification of Modulation



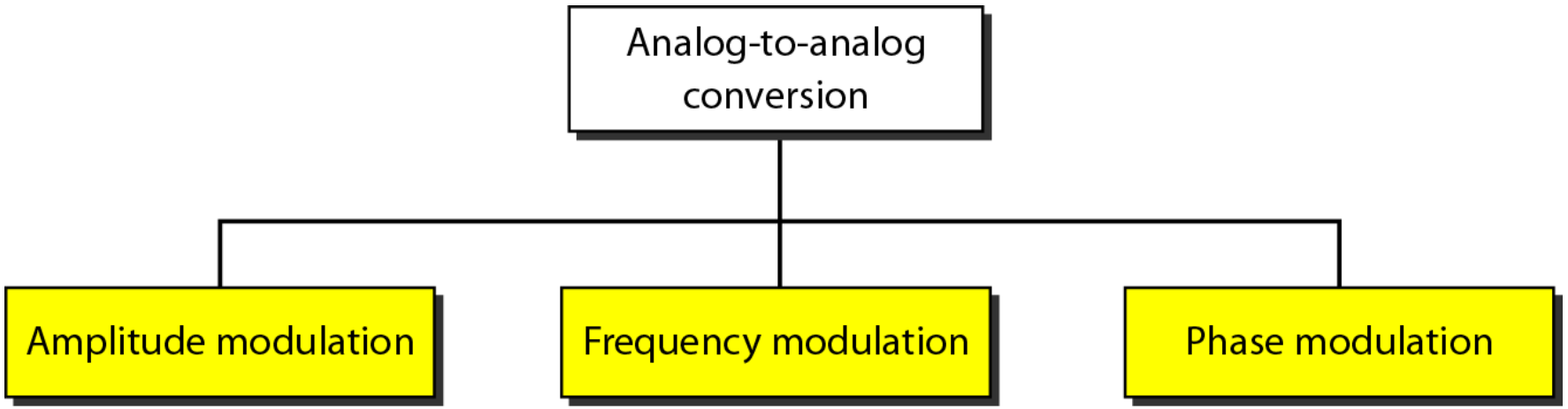
5-2 ANALOG AND DIGITAL

Analog-to-analog conversion is the representation of analog information by an analog signal. One may ask why we need to modulate an analog signal; it is already analog. Modulation is needed if the medium is bandpass in nature or if only a bandpass channel is available to us.

Topics discussed in this section:

- **Amplitude Modulation**
- **Frequency Modulation**
- **Phase Modulation**

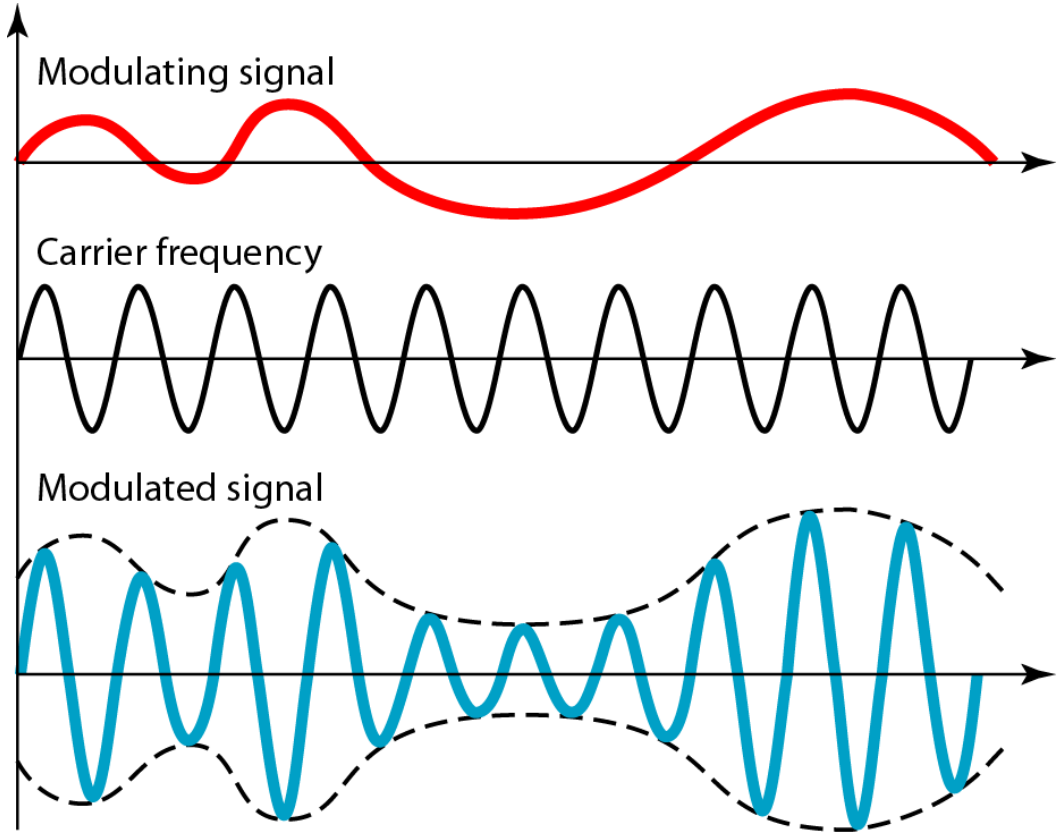
Figure 5.15 *Types of analog-to-analog modulation*

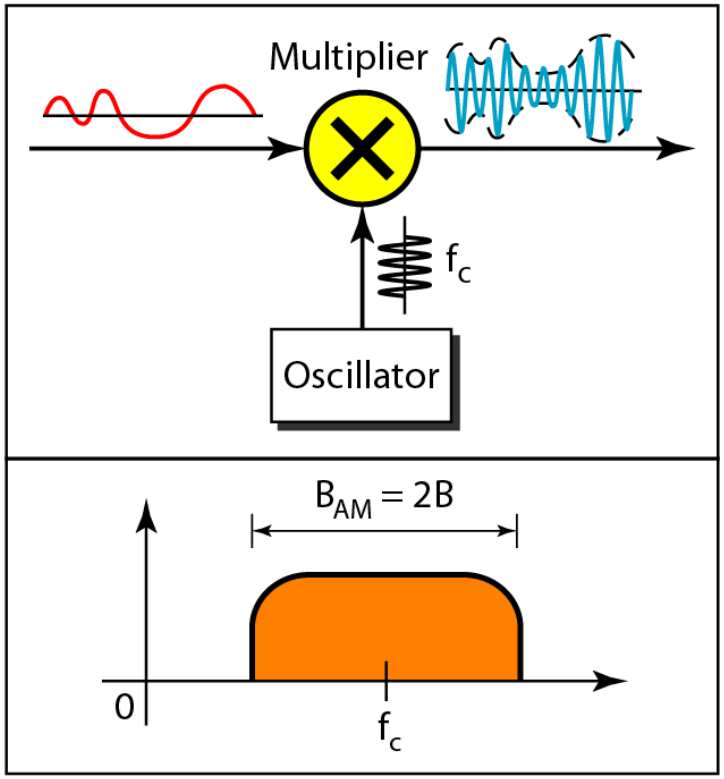


Amplitude Modulation

- A carrier signal is modulated only in amplitude value
- The modulating signal is the envelope of the carrier
- The required bandwidth is 2B, where B is the bandwidth of the modulating signal
- Since on both sides of the carrier freq. f_c, the spectrum is identical, we can discard one half, thus requiring a smaller bandwidth for transmission.

Figure 5.16 *Amplitude modulation*





Modulation Index

Definition:

In AM, the modulation index (m) is defined as the ratio of amplitudes of modulating signal to the carrier signal.

$$\text{M.I.} = \frac{\text{Modulating Signal Amplitude}}{\text{Carrier Signal Amplitude}}$$

$$\boxed{m = \frac{E_m}{E_c}} \qquad \ldots (2.4)$$

If modulation index is expressed in percentage, it is called **'percentage modulation'.**

i.e. $$\boxed{\%m = \frac{E_m}{E_c} \times 100} \qquad \ldots (2.5)$$

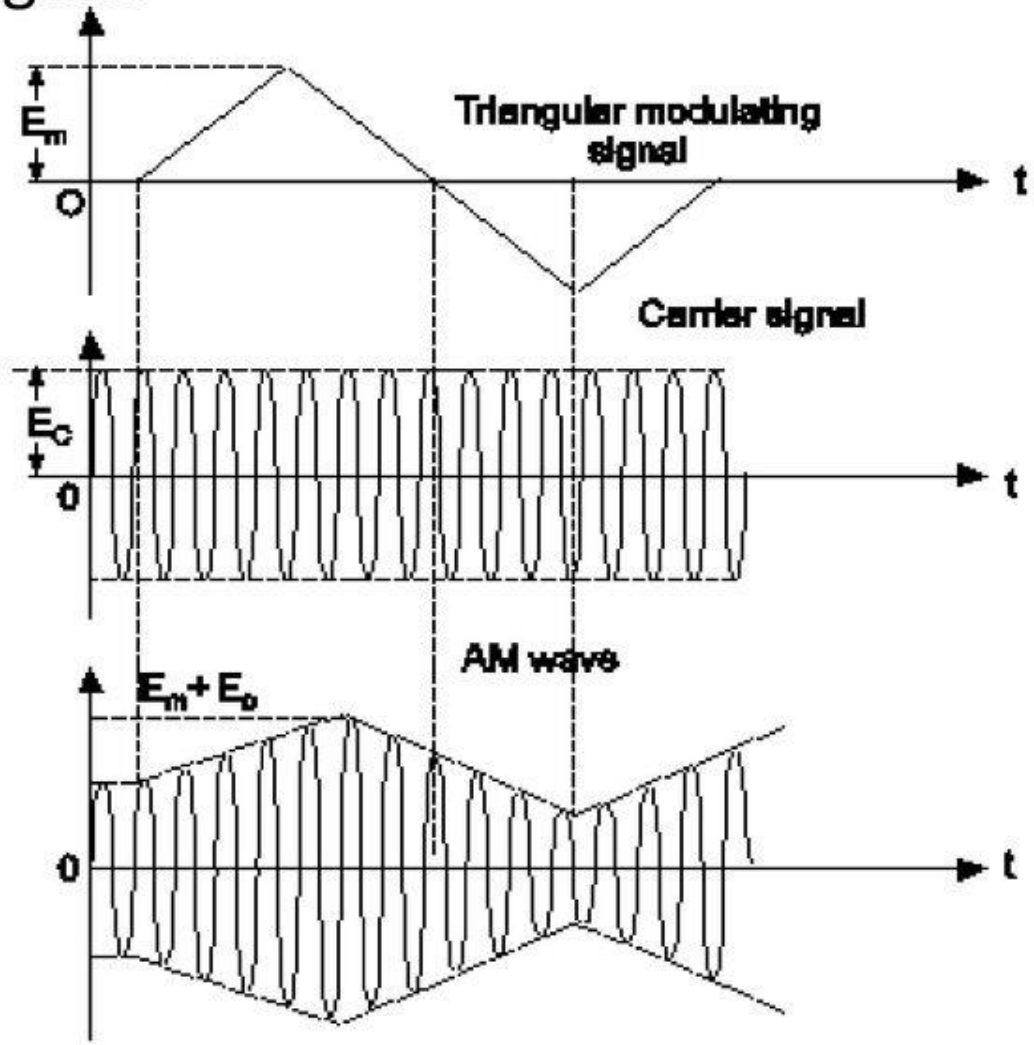
Referring to Fig. 2.6, the modulation index is

$$\boxed{m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}}$$

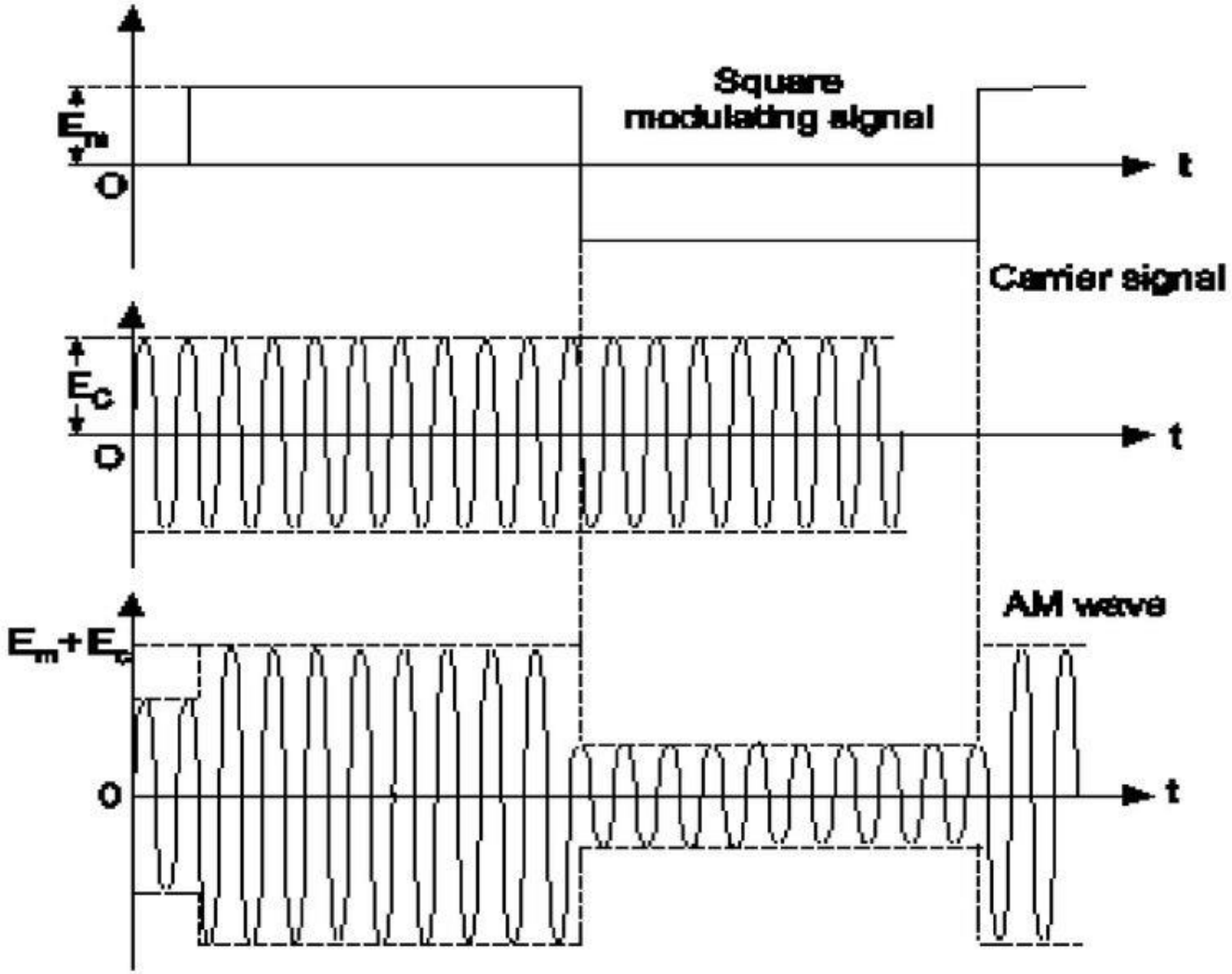
Example

Draw the AM wave for triangular and square wave modulating signal.

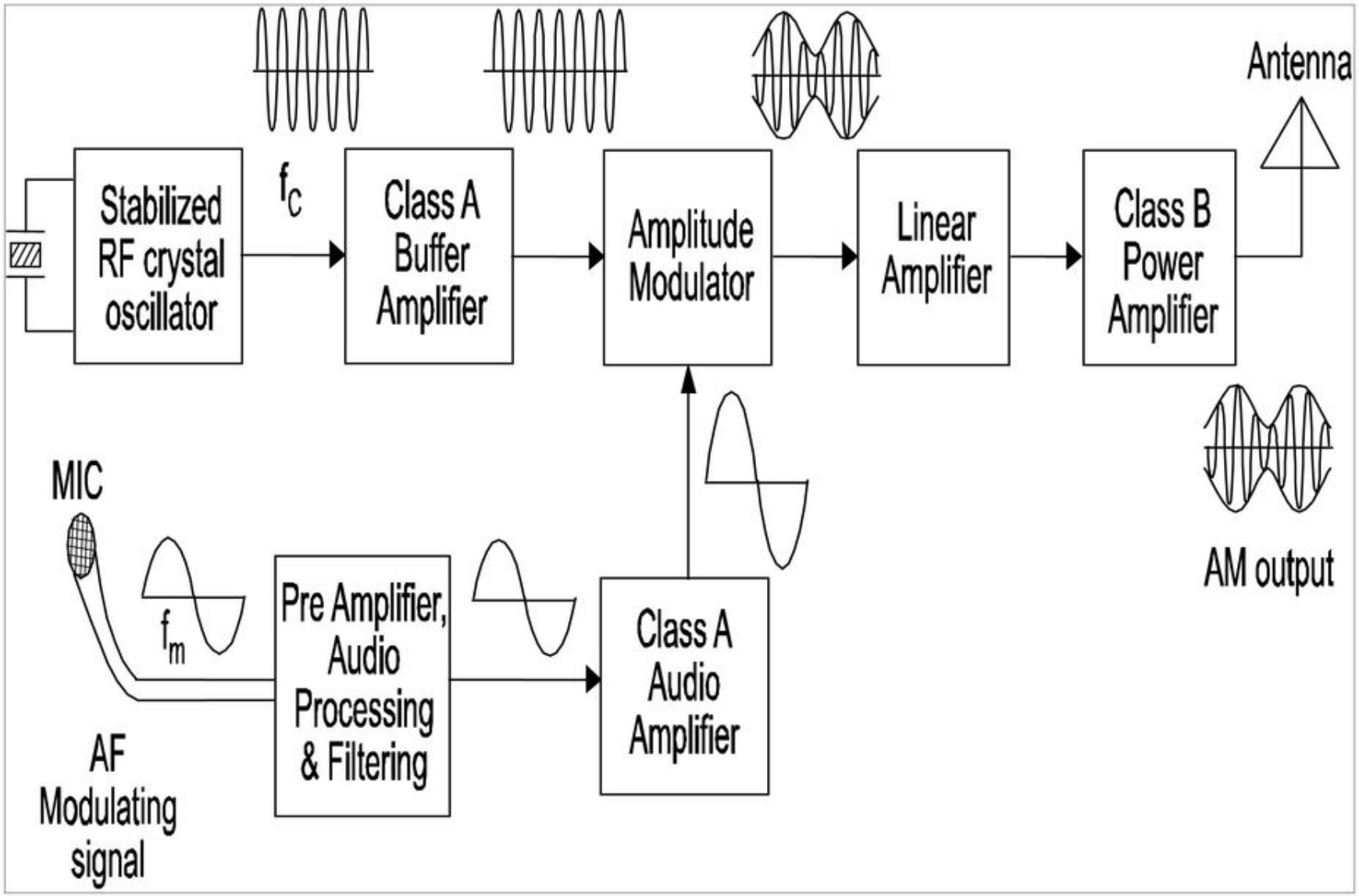
Solution:



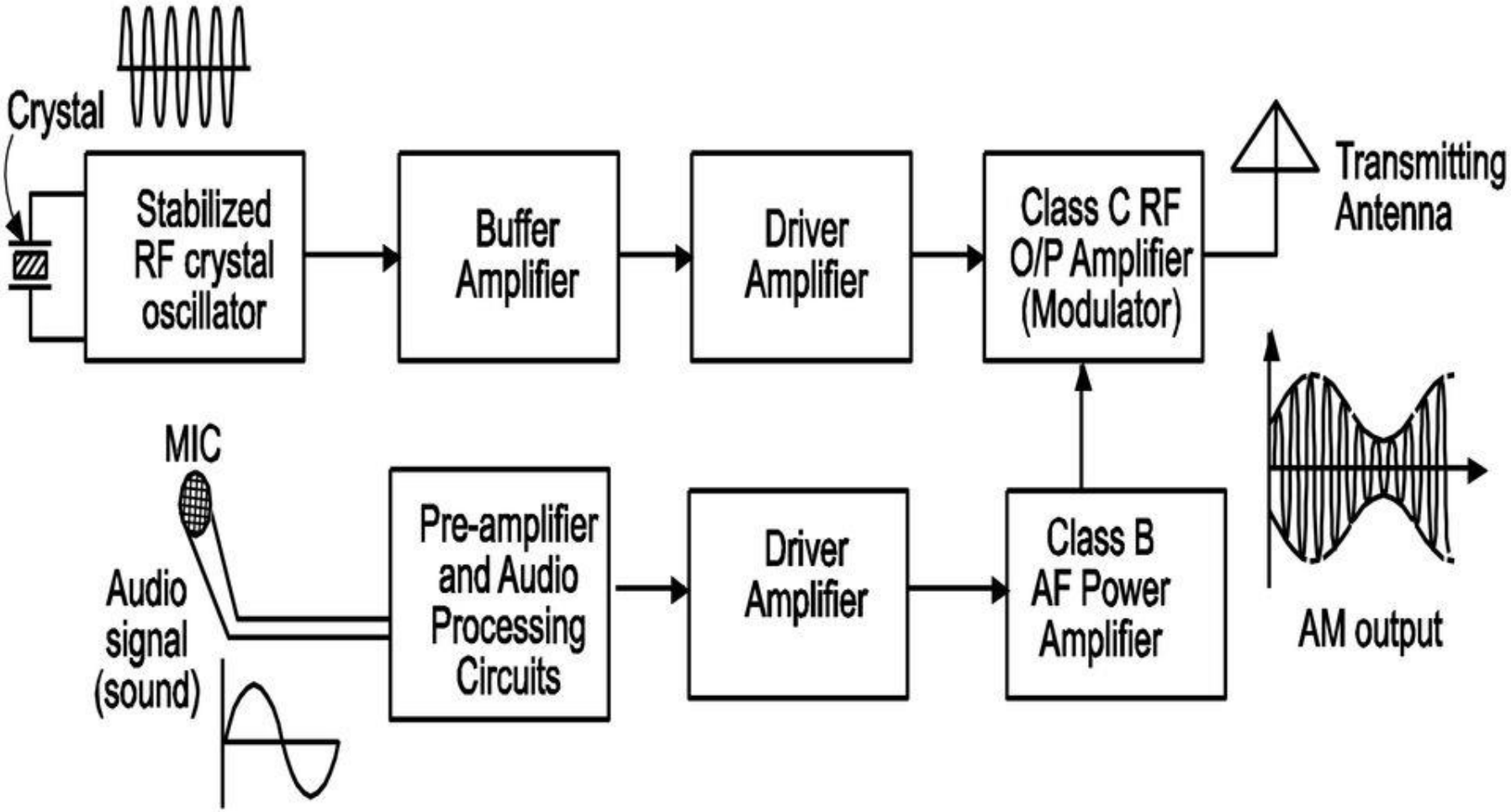
For square wave input.



Low Level Modulated AM Transmitter



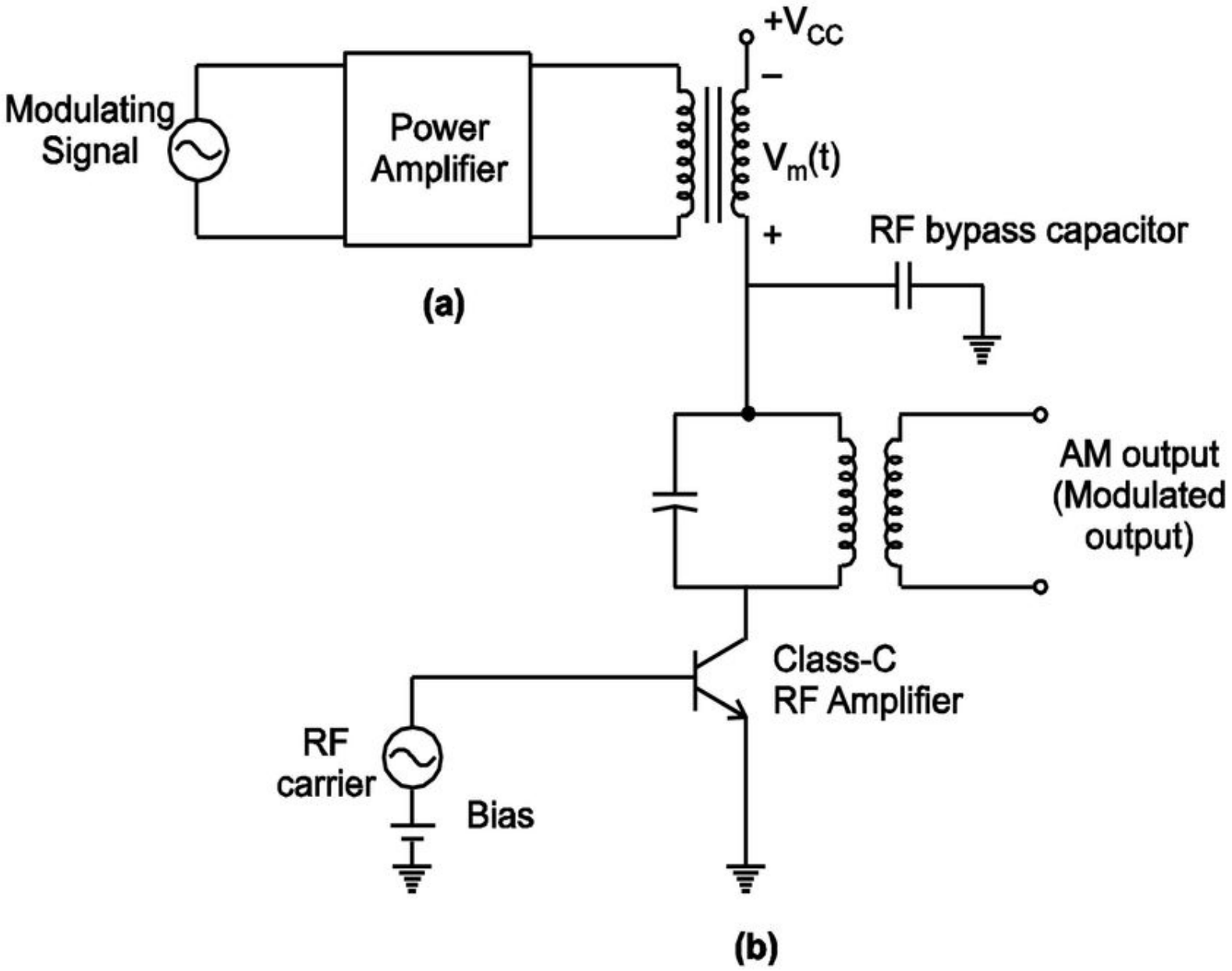
High Level Modulated AM Transmitter



Comparison between High Level and Low Level Modulation

Sr. No.	High Level Modulation	Low Level Modulation
1.	Modulation takes place at high power level.	Modulation takes place at low power level.
2.	Class-C amplifier are used which are highly efficient.	After modulation linear amplifiers (Class A, AB or B) are used.
3.	Very high efficiency.	Low efficiency than high level modulation.
4.	Complex because of very high power.	Easy because of low power.
5.	Used in high power broadcast transmitters.	Used in TV transmitters (IF modulation method). In laboratory equipments, walkie-talkies etc.

AM Modulator Circuit using BJT



Advantages of AM

1. AM transmitters are not complex.
2. AM receivers are simple and easy to detect.
3. Less expensive.
4. Covers large distance.

Disadvantages of AM

1. Requires large bandwidth.
2. Requires large power.
3. Gets affected due to noise.

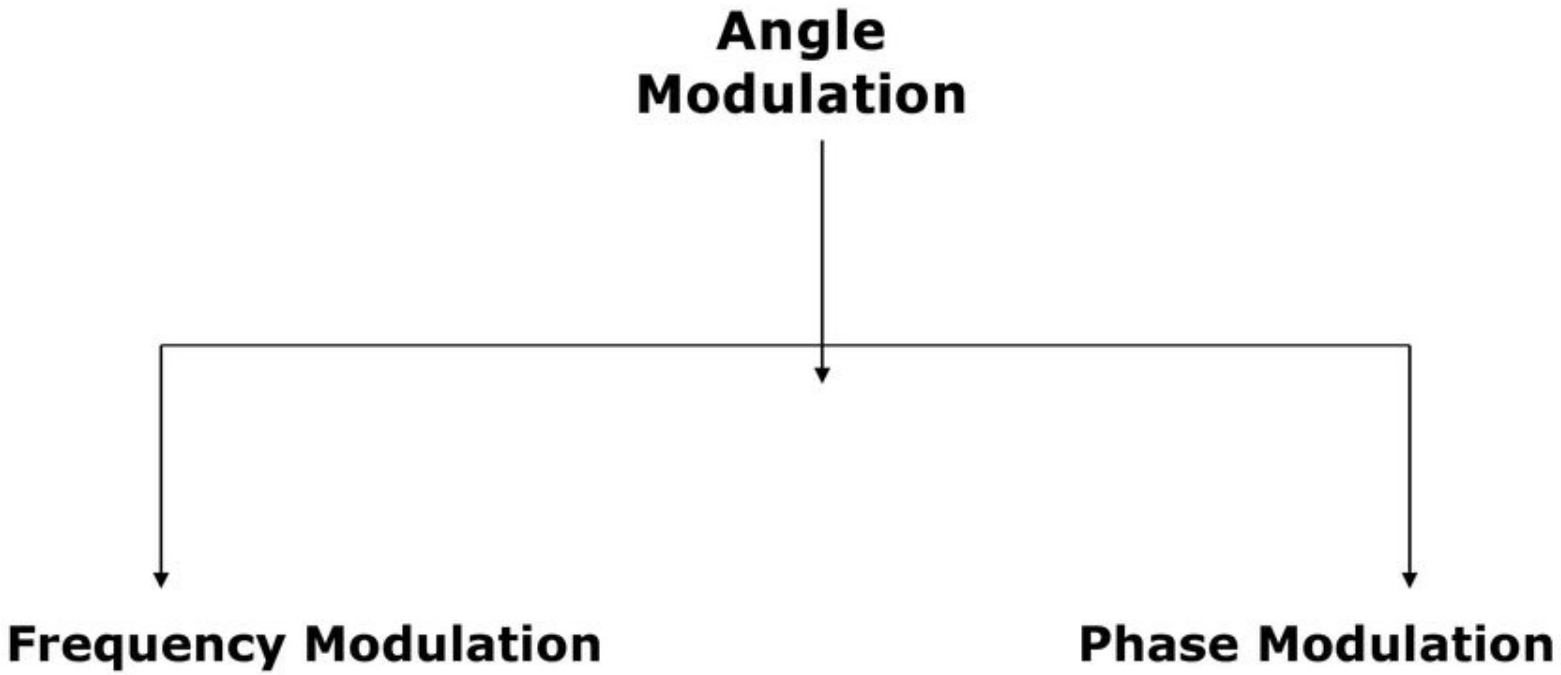
Applications of AM

1. Radio broadcasting.
2. Picture transmission in TV (VSB is used).

Note

The total bandwidth required for AM can be determined from the bandwidth of the audio signal: $B_{AM} = 2B$.

Angle Modulation



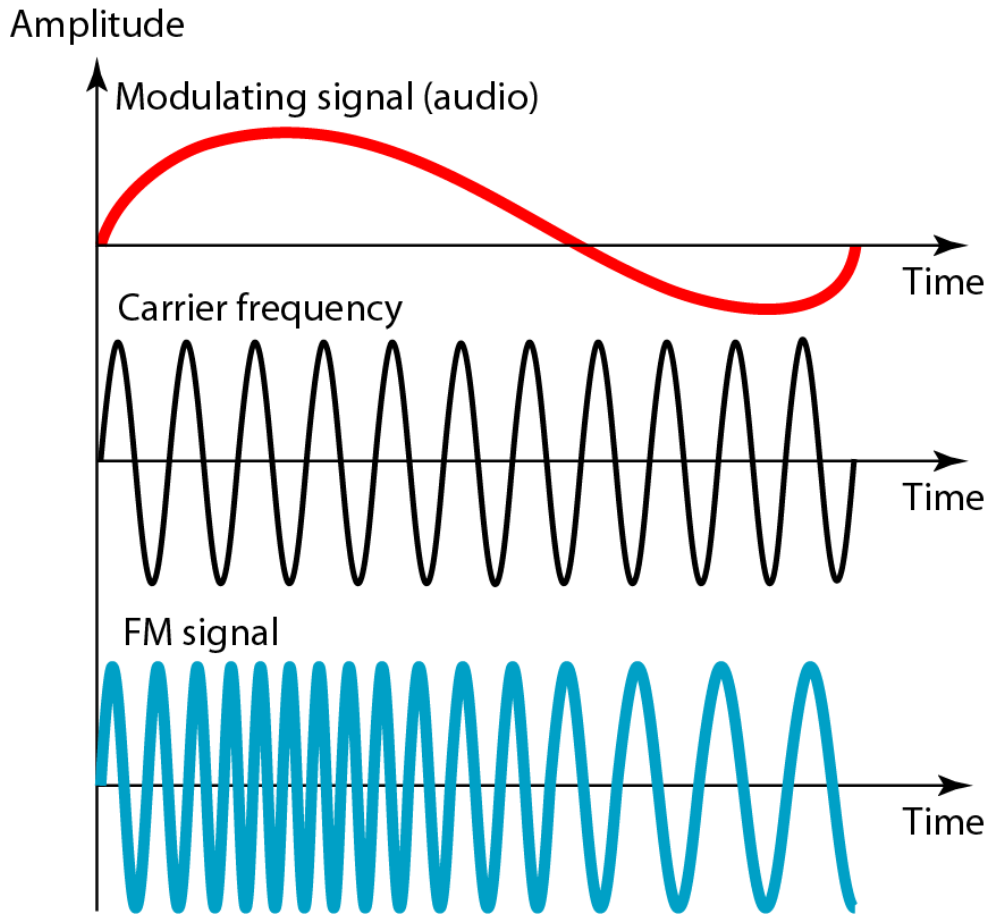
Frequency Modulation

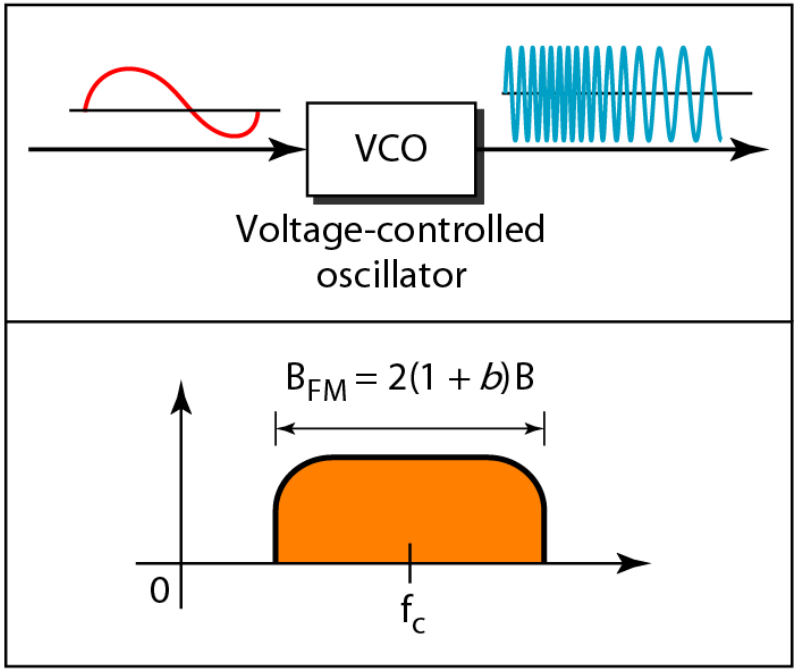
- The modulating signal changes the freq. f_c of the carrier signal
- The bandwidth for FM is high
- It is approx. 10x the signal frequency

Note

The total bandwidth required for FM can be determined from the bandwidth of the audio signal: $B_{FM} = 2(1 + \beta)B$. Where β is usually 4.

Figure 5.18 *Frequency modulation*





Modulation Index

Definition:

Modulation Index is defined as the ratio of frequency deviation (δ) to the modulating frequency (f_m).

$$\text{M.I.} = \frac{\text{Frequency Deviation}}{\text{Modulating Frequency}}$$

$$mf = \frac{\delta}{fm}$$

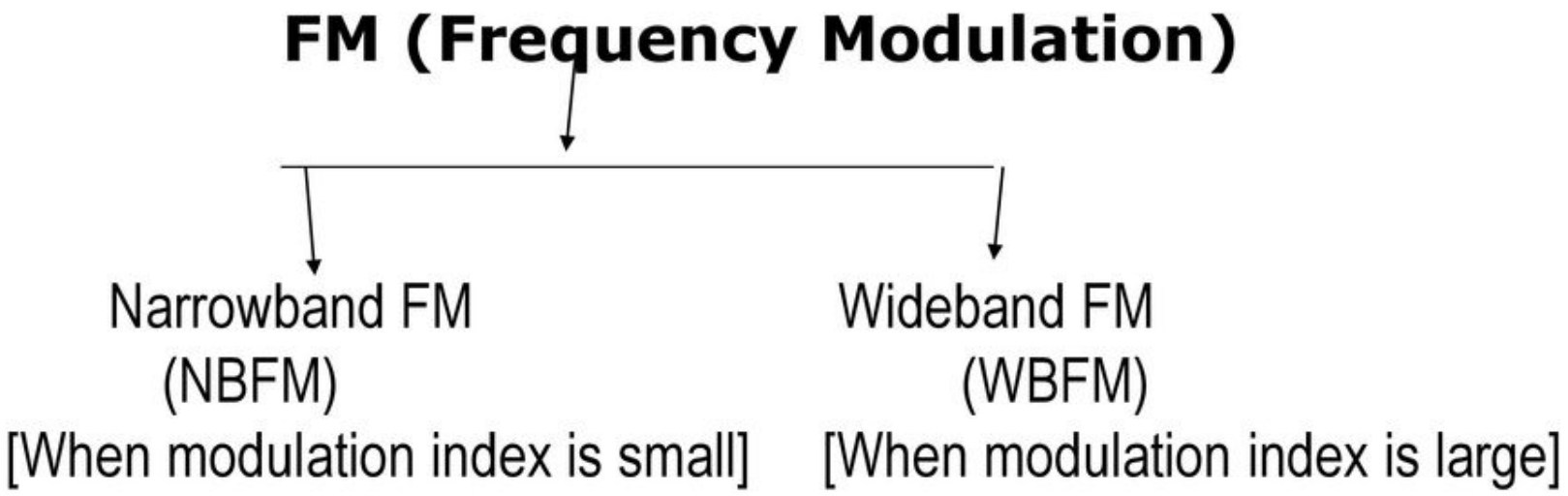
In FM M.I.>1

Modulation Index of FM decides –

(i)Bandwidth of the FM wave.

(ii)Number of sidebands in FM wave.

Types of Frequency Modulation



Comparison between Narrowband and Wideband FM

Sr. No.	Parameter	NBFM	WBFM
1.	Modulation index	Less than or slightly greater than 1	Greater than 1
2.	Maximum deviation	5 kHz	75 kHz
3.	Range of modulating frequency	20 Hz to 3 kHz	20 Hz to 15 kHz
4.	Maximum modulation index	Slightly greater than 1	5 to 2500
5.	Bandwidth	Small approximately same as that of AM BW = $2f_m$	Large about 15 times greater than that of NBFM. BW = $2(\delta+fmmax)$
6.	Applications	FM mobile communication like police wireless, ambulance, short range ship to shore communication etc.	Entertainment broadcasting (can be used for high quality music transmission)

Representation of FM

FM can be represented by two ways:

1. Time domain.
2. Frequency domain.

1. FM in Time Domain

Time domain representation means continuous variation of voltage with respect to time as shown in Fig.

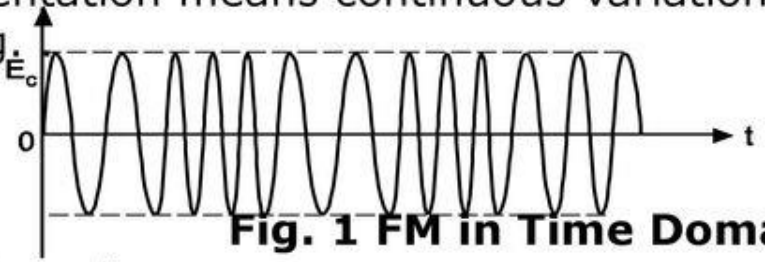


Fig. 1 FM in Time Domain

2. FM in Frequency Domain

- Frequency domain is also known as **frequency spectrum.**
- FM in frequency domain means graph or plot of amplitude versus frequency as shown in Fig. 2.29.

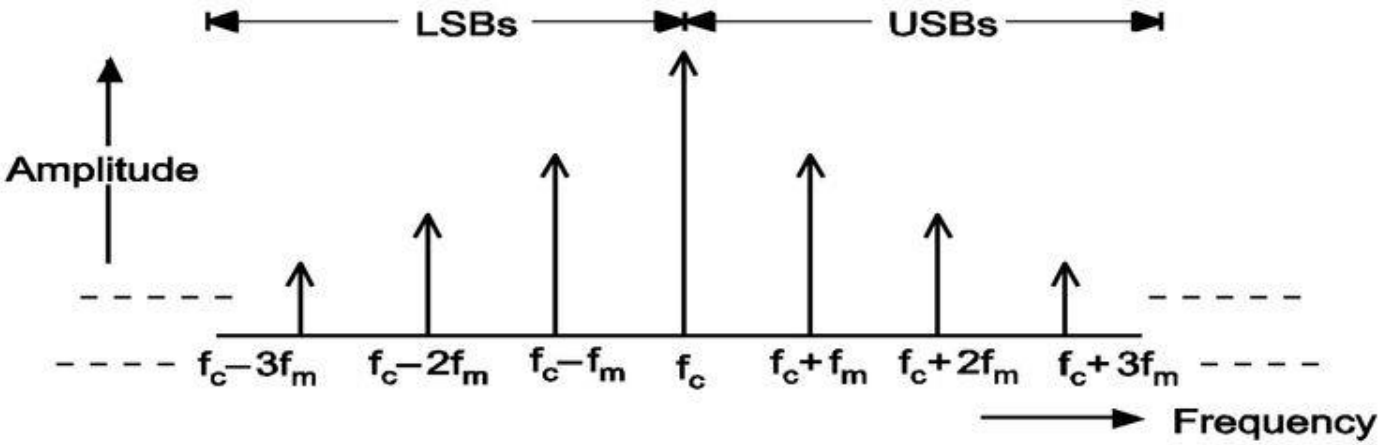


Fig. 2: FM in Frequency Domain

•

The time constant of pre-emphasis is at 50 μs in all CCIR standards.

- In systems employing American FM and TV standards, networks having time constant of 75 μsec are used.
- **The pre-emphasis is used at FM transmitter** as shown in Fig. 3.

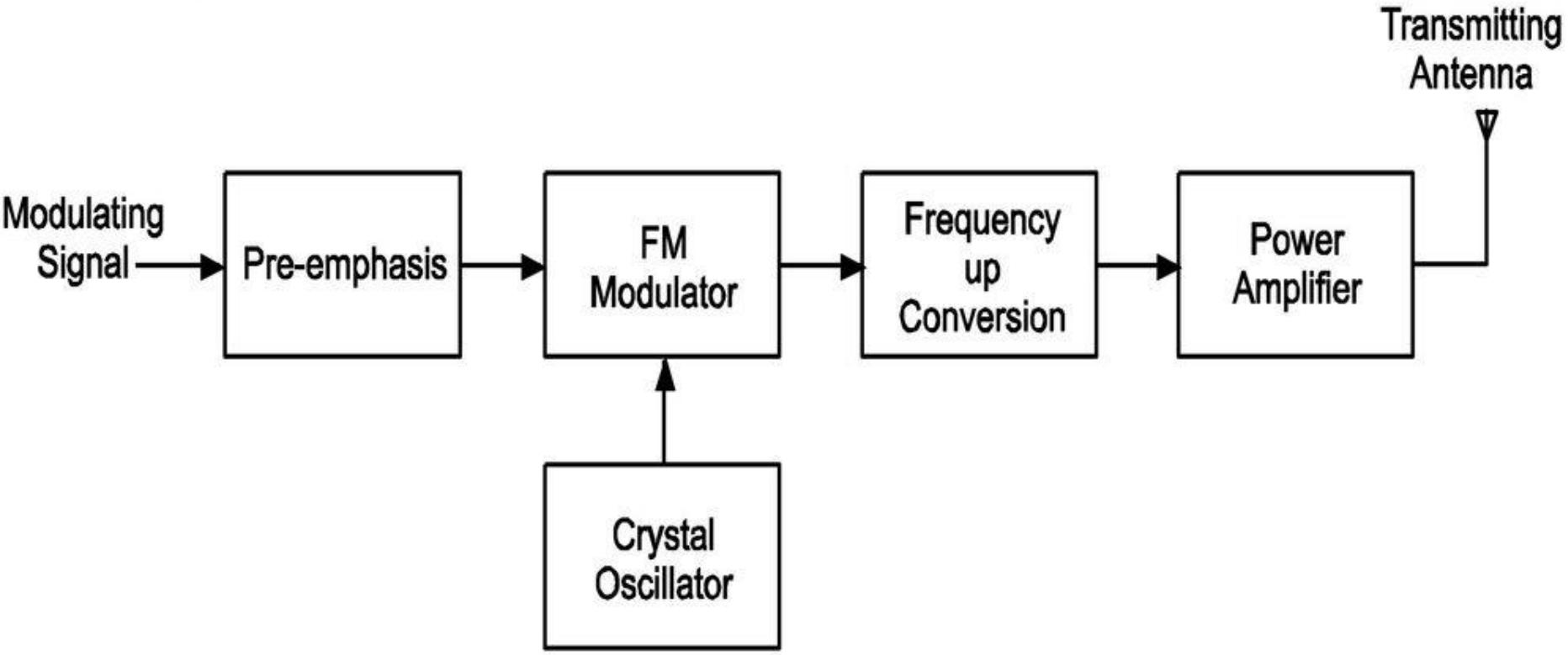


Fig. 3: FM Transmitter with Pre-emphasis

De-emphasis

- De-emphasis circuit is **used at FM receiver**.

Definition:

The artificial boosting of higher modulating frequencies in the process of pre-emphasis is nullified at receiver by process called de-emphasis.

- De-emphasis circuit is a low pass filter shown in Fig. 4.

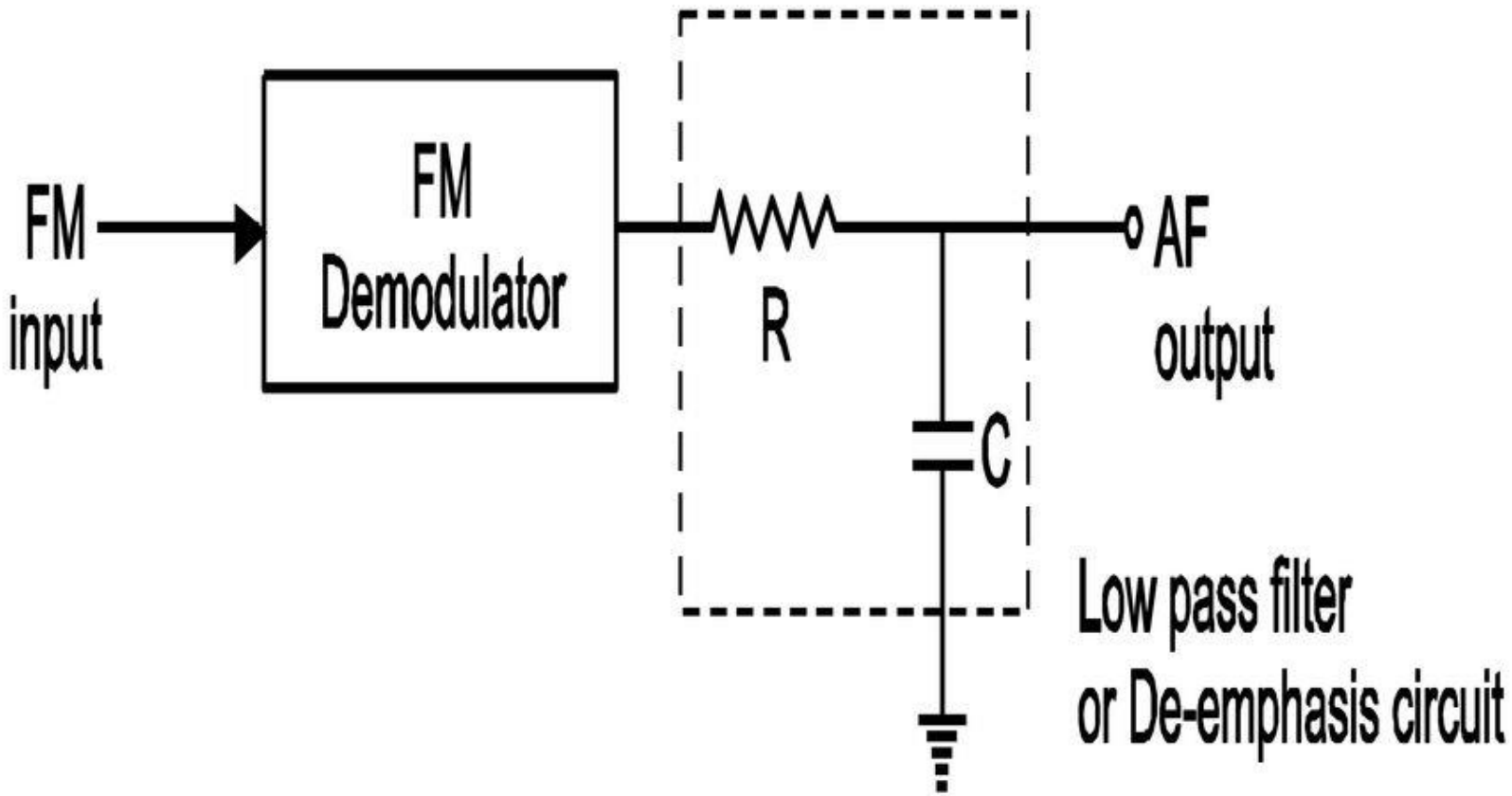


Fig. 4: De-emphasis Circuit

Comparison between Pre-emphasis and De-emphasis

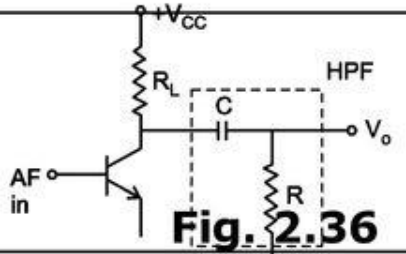
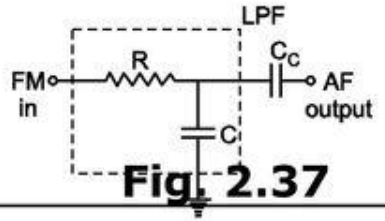
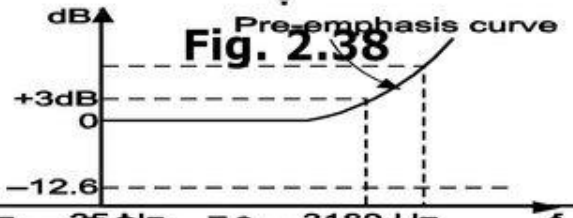
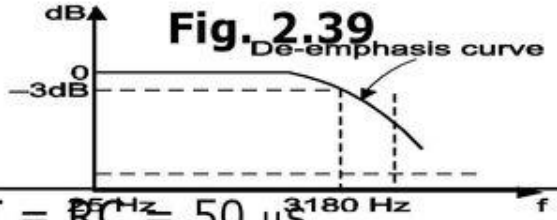
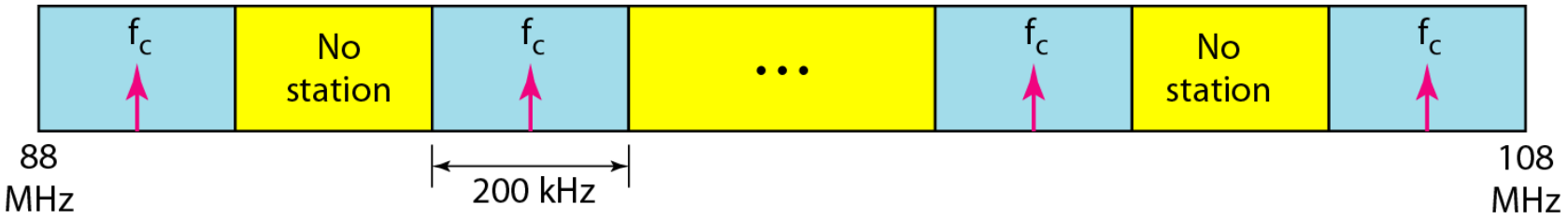
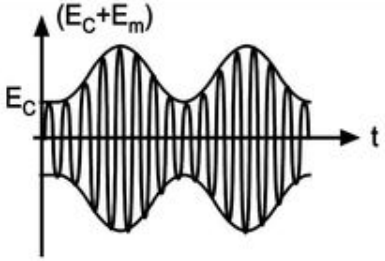
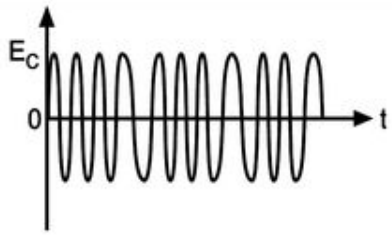
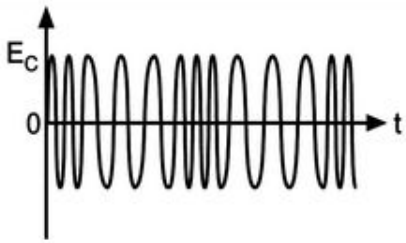
Parameter	Pre-emphasis	De-emphasis
1. Circuit used	High pass filter.	Low pass filter.
2. Circuit diagram	 Fig. 2.36	 Fig. 2.37
3. Response curve	 Fig. 2.38	 Fig. 2.39
4. Time constant	T = RC = 50 μs	T = RC = 50 μs
5. Definition	Boosting of higher frequencies	Removal of higher frequencies
6. Used at	FM transmitter	FM receiver.

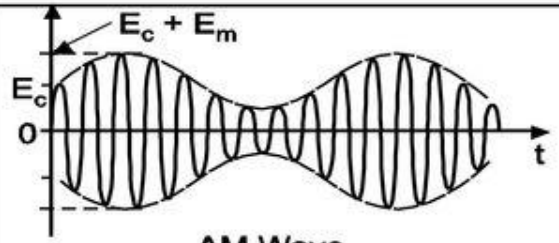
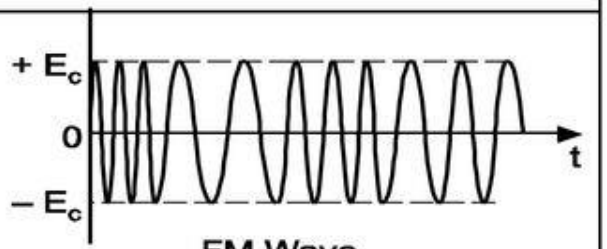
Figure 5.19 *FM band allocation*



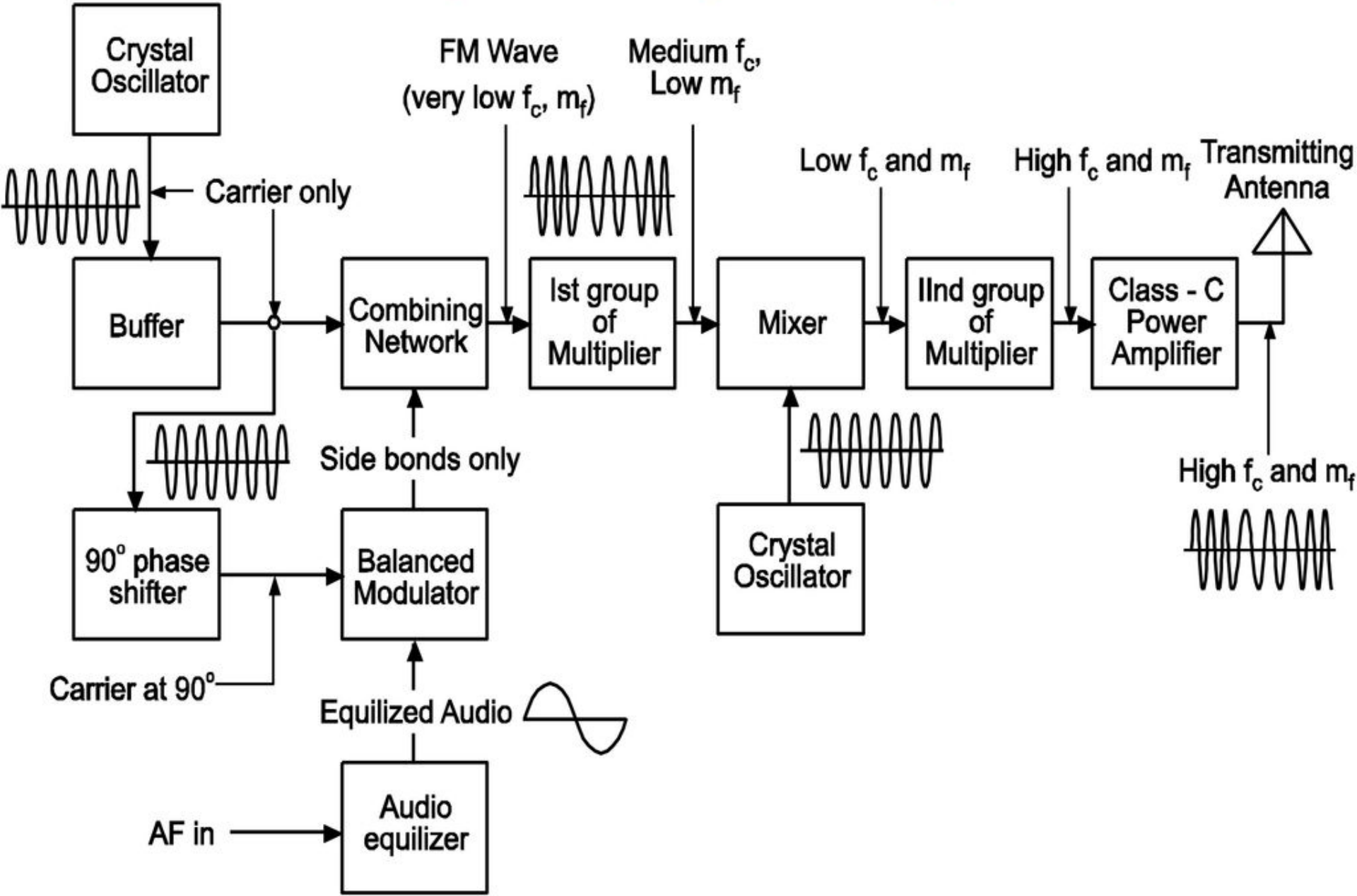
Types AM, FM, PM Definition, Waveforms

Sr. No.	Parameter	AM	FM	PM
1.	Definition	Amplitude modulation is a technique of modulation, in which amplitude of carrier varies in accordance with amplitude of modulating signal. Keeping frequency and phase constant.	Frequency modulation is a technique of modulation, in which frequency of carrier varies in accordance with amplitude of modulating signal. Keeping amplitude and phase constant.	Phase modulation is a technique of modulation in which phase of carrier varies in accordance with amplitude of modulating signal. Keeping amplitude and frequency constant.
1.	Definition	Amplitude modulation is a technique of modulation, in which amplitude of carrier varies in accordance with amplitude of modulating signal. Keeping frequency and phase constant.	Frequency modulation is a technique of modulation, in which frequency of carrier varies in accordance with amplitude of modulating signal. Keeping amplitude and phase constant.	Phase modulation is a technique of modulation in which phase of carrier varies in accordance with amplitude of modulating signal. Keeping amplitude and frequency constant.
2.	Waveforms	 Fig. 2.3	 Fig. 2.4	 Fig. 2.5

Comparison between AM and FM

Parameter	AM	FM
1. Definition	Amplitude of carrier is varied in accordance with amplitude of modulating signal keeping frequency and phase constant.	Frequency of carrier is varied in accordance with the amplitude of modulating signal keeping amplitude and phase constant.
2. Constant parameters	Frequency and phase.	Amplitude and phase.
3. Modulated signal	 AM Wave	 FM Wave
4. Modulation Index	$m = Em/Ec$	$m = \delta / fm$
5. Number of sidebands	Only two	Infinite and depends on m_f.
6. Bandwidth	$BW = 2f_m$	$BW = 2 (\delta + f_{m\ (max)})$
7. Application	MW, SW band broadcasting, video transmission in TV.	Broadcasting FM, audio transmission in TV.

FM Transmitter (Armstrong Method)



Advantages / Disadvantages / Applications of FM

Advantages of FM

1. Transmitted power remains constant.
2. FM receivers are immune to noise.
3. Good capture effect.
4. No mixing of signals.

Disadvantages of FM

The greatest disadvantages of FM are:

1. It uses too much spectrum space.
2. The bandwidth is wider.
3. The modulation index can be kept low to minimize the bandwidth used.
4. But reduction in M.I. reduces the noise immunity.
5. Used only at very high frequencies.

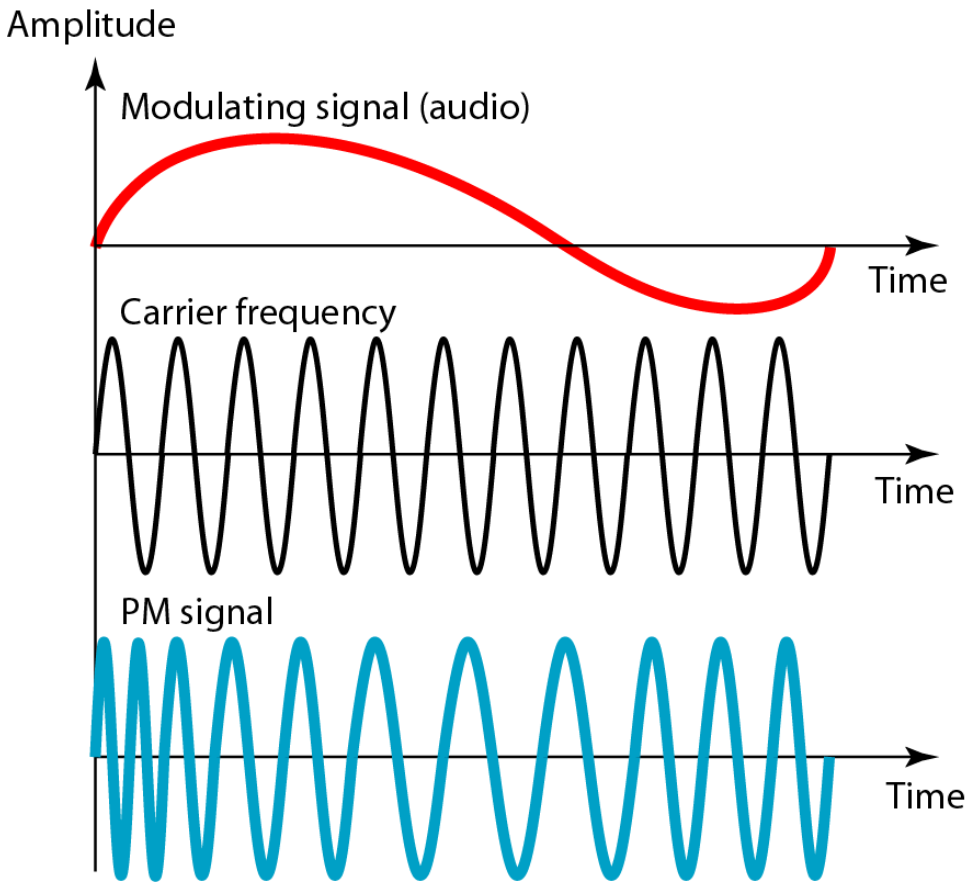
Applications of FM

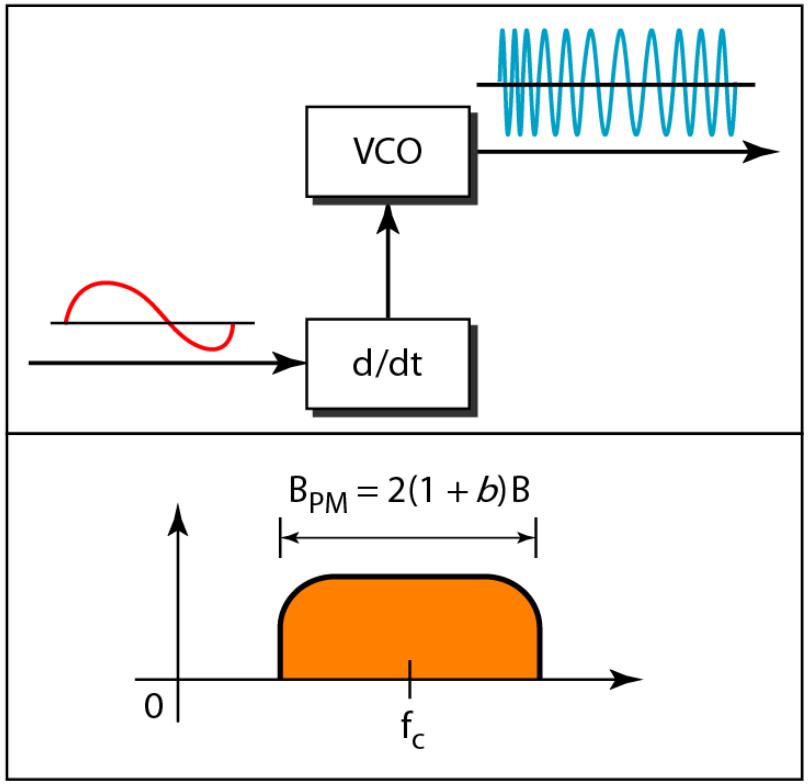
1. FM radio broadcasting.
2. Sound transmission in TV.
3. Police wireless.

Phase Modulation (PM)

- The modulating signal only changes the phase of the carrier signal.
- The phase change manifests itself as a frequency change but the instantaneous frequency change is proportional to the derivative of the amplitude.
- The bandwidth is higher than for AM.

Figure 5.20 *Phase modulation*





Note

The total bandwidth required for PM can be determined from the bandwidth and maximum amplitude of the modulating signal:

$$B_{PM} = 2(1 + \beta)B.$$

Where $\beta = 2$ most often.