Course Code: CSE 3107
Course Title: Communication Engineering

Dr. Foez Ahmed, SMIEEE

Associate Professor | Dept. of ICE

University of Rajshahi, Rajshahi-6205

Email: foez28@ru.ac.bd

Lecture # 06

Frequency and Phase Modulation

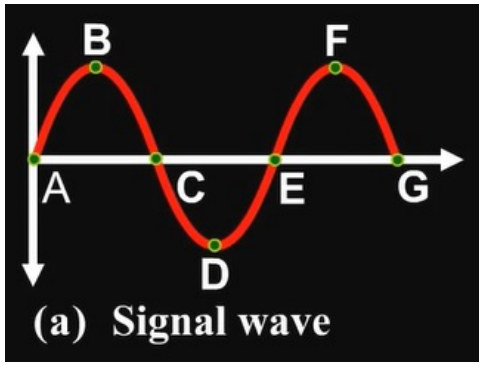
Outline

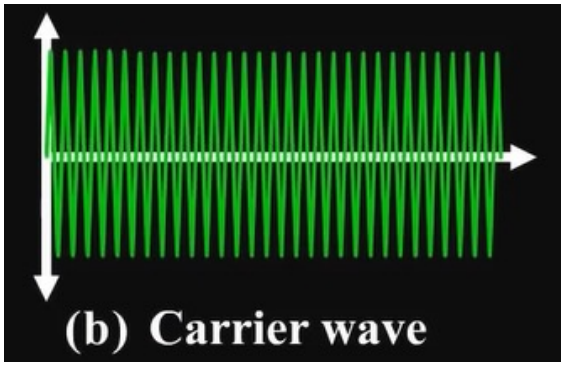
- **Frequency Modulation**
- **Phase Modulation**
- **Comparison between FM and PM**

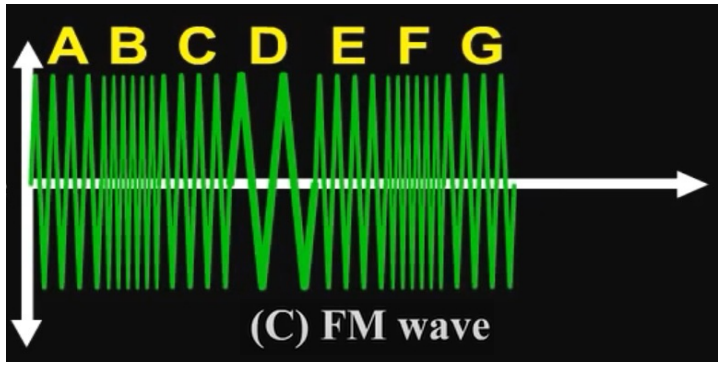
Frequency Modulation

❑ Frequency Modulation ?

✓ It is a process in which the Frequency of the carrier signal is changed/altered, in accordance with the amplitude of the original/modulating signal is called Frequency modulation, while the phase and Amplitude of the carrier signal remain constant.

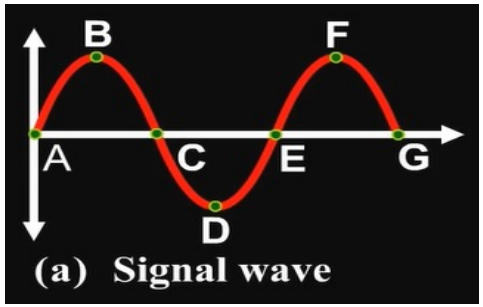


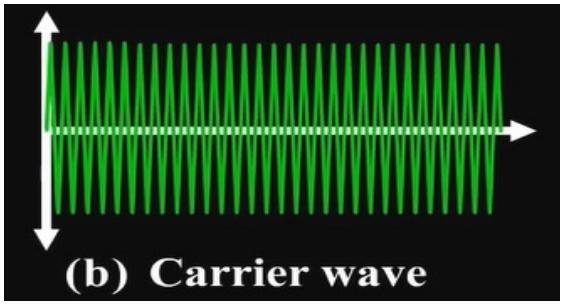


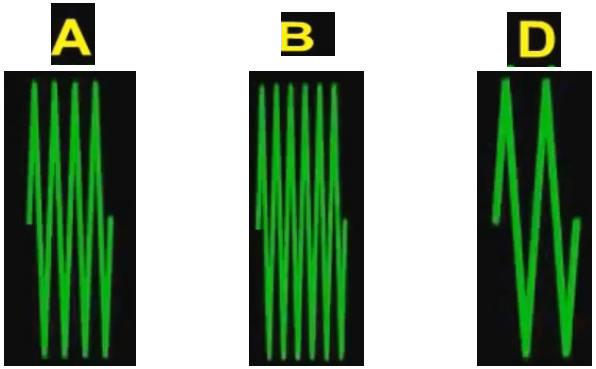


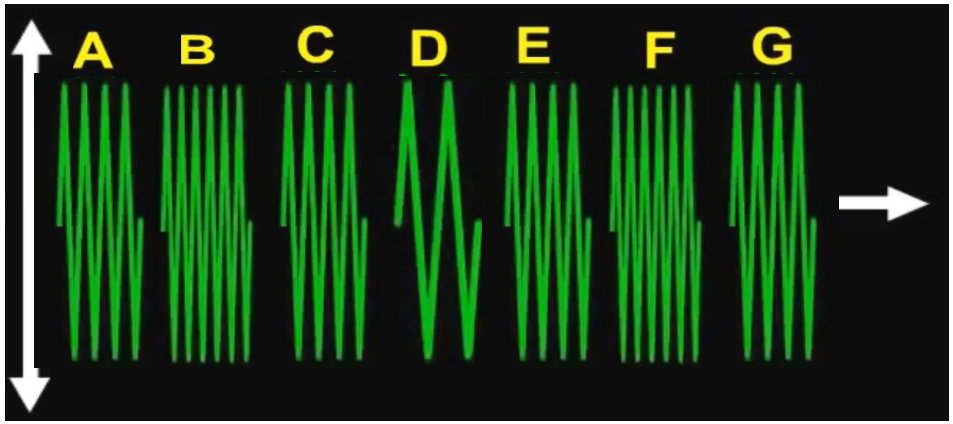
Frequency Modulation

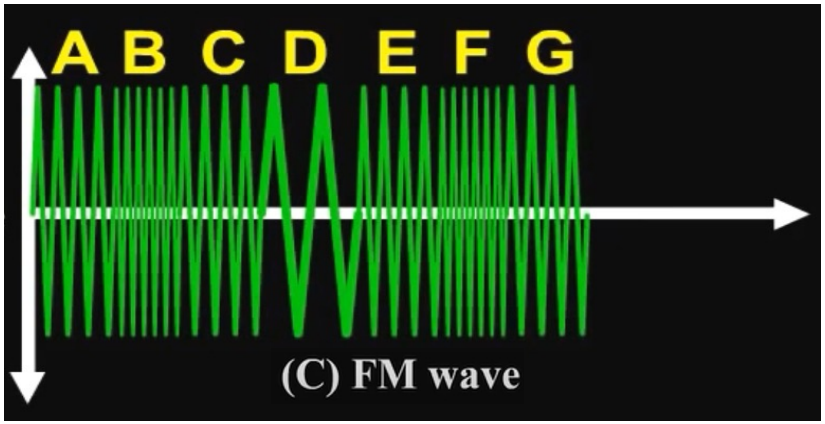
❑ **Frequency Modulation Phenomena:**









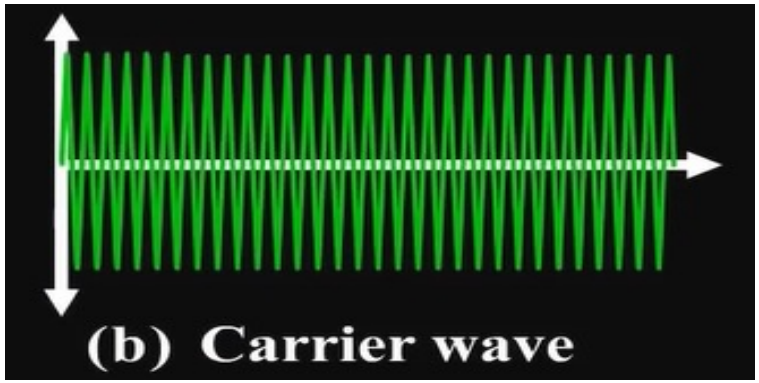


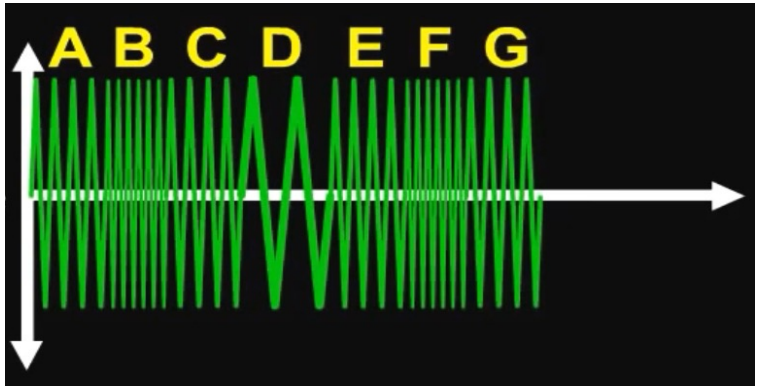
Frequency Modulation

❑ **Frequency Modulation Phenomena:**

✓ **Center (Carrier) Frequency:** The center (carrier) frequency is the **frequency of the unmodulated carrier signal** and represents the nominal frequency about which the instantaneous frequency of the FM signal varies in response to the modulating signal.

✓ **Resting Frequency:** The resting frequency is the instantaneous frequency of an FM signal in the **absence of modulation.**



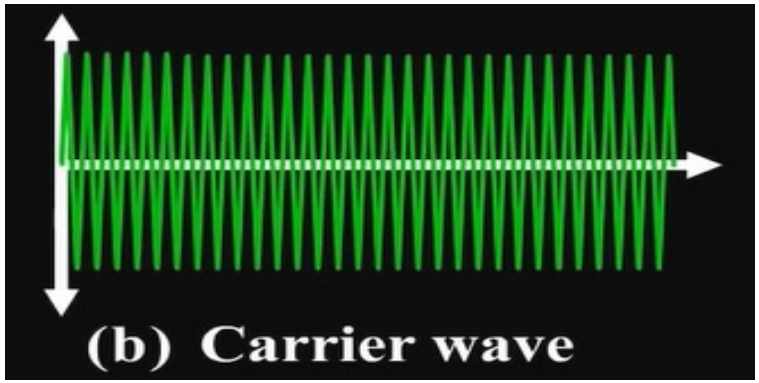


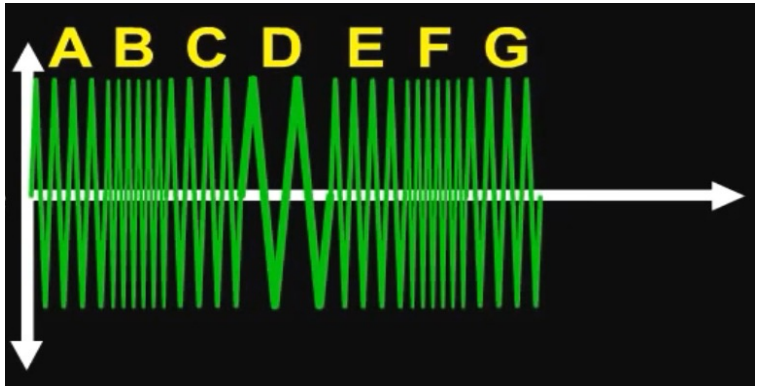
Frequency Modulation

❑ Frequency Modulation Phenomena:

- ✓ **Frequency Deviation:** The amount by which the carrier frequency is varied from its unmodulated value, called the deviation, is made proportional to the instantaneous amplitude of the modulating voltage.
- ✓ It is typically denoted by Δf and measured in hertz (Hz).
- ✓ The instantaneous frequency therefore varies between fc−Δf and fc+Δf
- ✓ **Deviation Ratio:** The shift in carrier frequency from its resting point compared to the amplitude of the modulating voltage.

Deviation Ratio = f_{dev}/f_{AF}





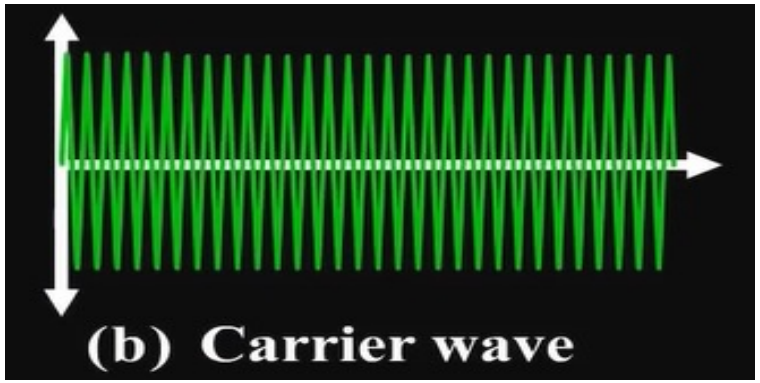
Frequency Modulation

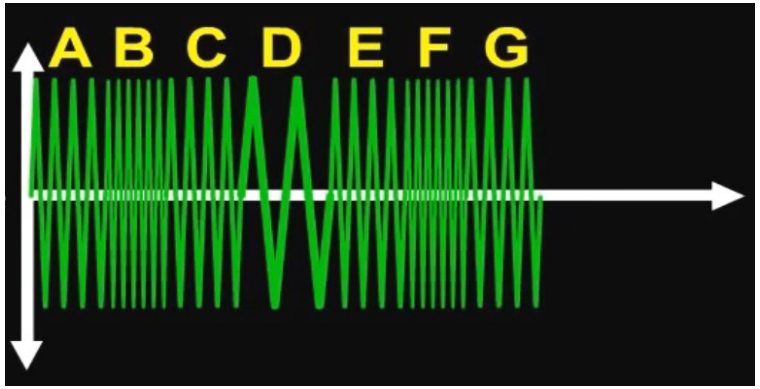
❑ Frequency Modulation Phenomena:

- ✓ Frequency deviation quantifies the extent of frequency variation produced by modulation and directly determines the **bandwidth** and **modulation index** of an FM signal.

- ✓ If the frequency deviation of the carrer is known and the frequency of the modulating voltage (AF) is known, we can estabilish the modulation index (MI), as follwos:

Modulation Index (MI) = f_{dev}/f_{AF}





Frequency Modulation

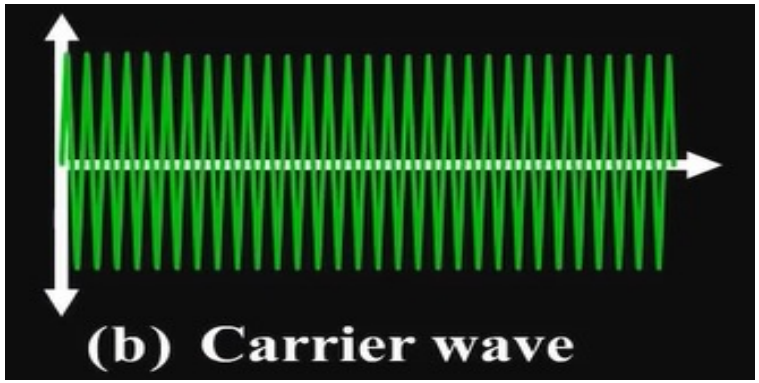
❑ **Frequency Modulation Phenomena:**

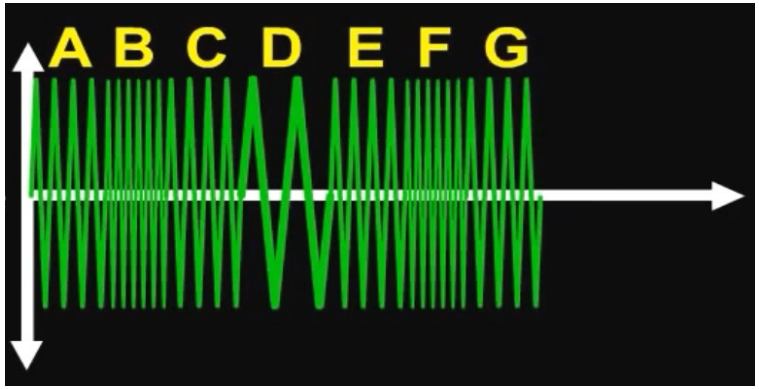
✓ **Frequency swing: It** is the **peak-to-peak variation of the instantaneous frequency** of an FM signal about its center (carrier) frequency.

✓ Mathematically,

Frequency swing=2Δf

Δf: frequency deviation





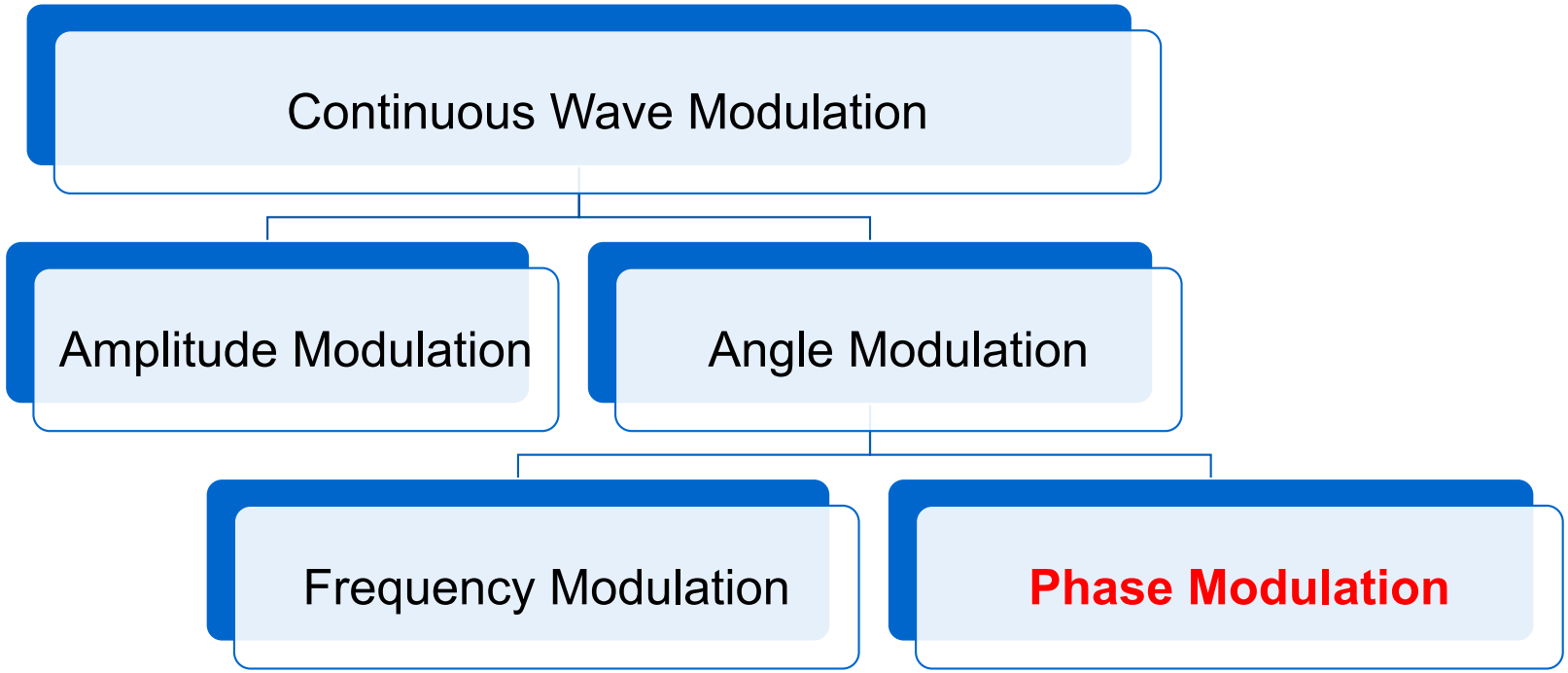
Frequency Modulation

❑ **Properties of Frequency Modulation:**

1. FM has infinite number of sidebands.
2. Because the amplitude of the FM wave does not change, FM is much **less affected by noise and s**uitable for **efficient power amplification**
3. FM requires **much more bandwidth; even w**ith increasing depth of modulation, requirement of bandwidth increases in FM.
4. Power efficient because transmitted power in FM is independent of modulation index.
5. At certain values of modulation indexes, carrier components may vanish. These values are known as *eigen values*.

Phase Modulation

❑ **Phase Modulation:**



Phase Modulation

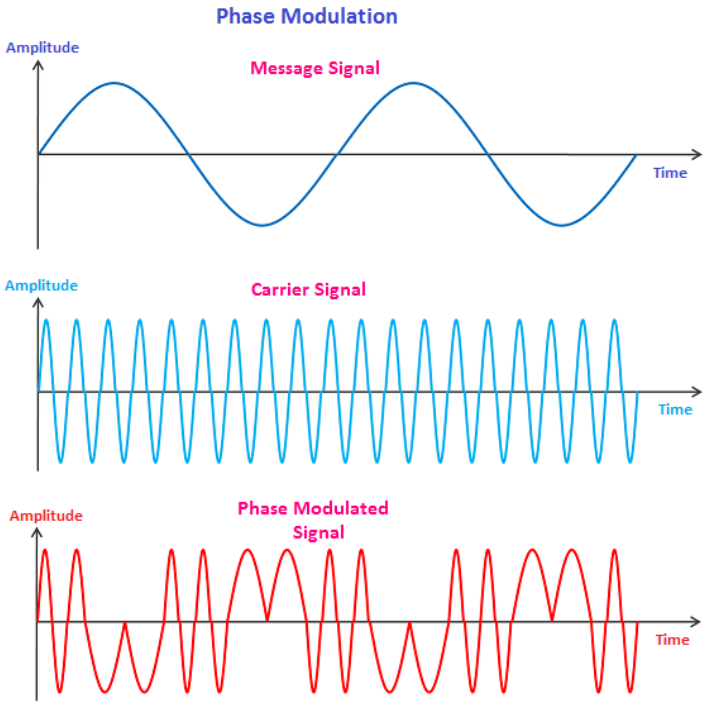
❑ Phase Modulation:

✓ It is a type of angle modulation in which the phase of the carrier wave is varied **in direct proportion to the instantaneous amplitude of the modulating (message) signal**, while the carrier amplitude and frequency remain constant.

✓ Mathematically,

$$v = A\sin(\omega_c t + m_p sin\omega_m t)$$

Where, m_p = modulation index for phase modulation



Phase Modulation

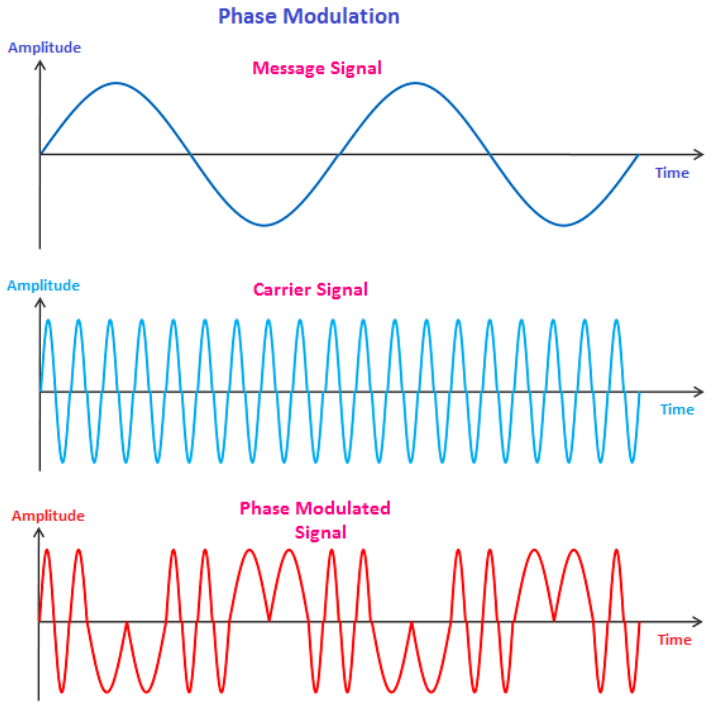
❑ Phase Modulation:

Let,
Message signal, $v_m = V_m \sin(\omega_m t)$
Carrier signal, $v_c = V_c \sin(\omega_c t)$

So, the PM signal will be,

$$v_{pm} = V_c \sin(\omega_c t + v_m)$$
$$\therefore v_{pm} = V_c \sin(\omega_c t + V_m \sin(\omega_m t))$$

N.B. PM is very much similar to FM and another important type of angular modulation along with FM.



Comparison between FM and AM

Parameters	AM	FM
Constant parameters	Frequency and phase	Amplitude and phase
Quality	Poorer sound quality	Better sound quality
Frequency range	535 to 1700 kHz or up to 1200 bits per second.	88.1 to 108.1 MHz. Or up to 1200 to 2400 bits per second.
Bandwidth BW	BW is much less than FM. $Bw = 2 . f_m$	BW is large. $Bw = 2 \times (\delta + f_m)$
No of sidebands	2	Depends upon the modulation index
Complexity	Less complex	More complex
Noise	AM receivers are highly susceptible to noise	FM receivers are better immune to noise
Efficiency	Low	High
Application	MW (medium wave), SW (short wave) band broadcasting, video transmission in TV.	Broadcasting FM, audio transmission in TV.

Thank You All