CHAPTER 6

Frequency Modulation

(Part 4 of 4)

6.5 Multi-tone FM signal

Bandwidth of multi-tone FM signal

- The highest frequency of multi-tone modulating signal: f_H
- If Δf is constant for all the frequency components of modulating signal, the bandwidth of multi-tone FM signal is estimated by

$$B_{FM} \approx 2(m_{f_H} + 1)f_H \quad \text{where} \quad m_{f_H} = \frac{\Delta f}{f_H}$$

The modulation index of the highest frequency component

For example, if $m_{f_H} = 3.2$, round it to 4.

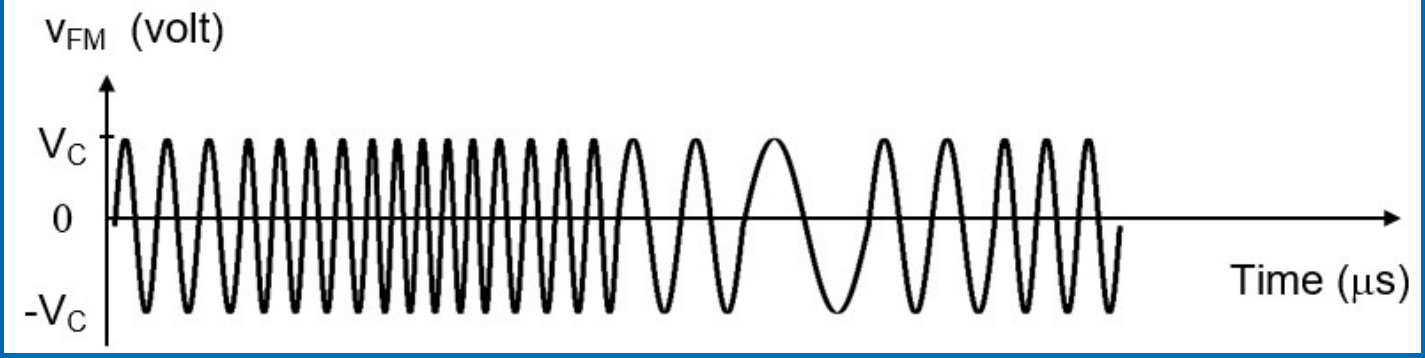
If not integer, rounded to the next highest integer

6.6 Transmitted Power in FM

- FM waveform is a sine or cosine signal whose frequency is changing.
- Frequency does not affect the power of a sine or cosine signal.
- Hence, Power of FM signal, P_{FM} = Power of a sine or cosine signal.

$$\text{Power} = \frac{V_{rms}^2}{R_L} \quad \text{where } V_{rms} = \frac{V_c}{\sqrt{2}} \quad \text{for sinewave}$$

$$\text{Hence, } P_{FM} = \frac{V_c^2}{2R_L}$$

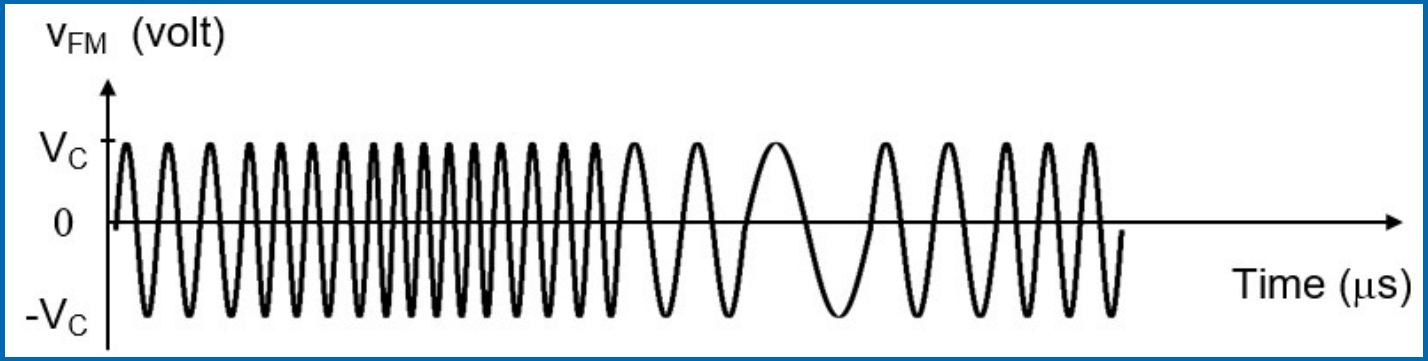


6.6 Transmitted Power in FM

- The power of an FM signal is constant.

$$P_{FM} = \frac{V_c^2}{2R_L}$$

- 10 kW is sufficient to cover the whole of Singapore.



6.7 Advantages & Applications of FM

1. Demodulated o/p level is independent of FM level (NBFM and WBFM)

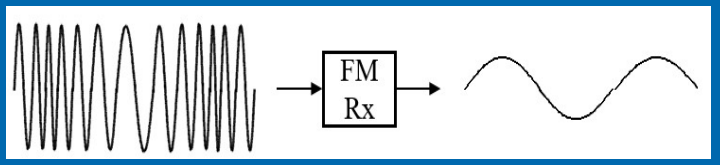
Tx

TX = Transmitter

RX = Receiver

Rx near Tx

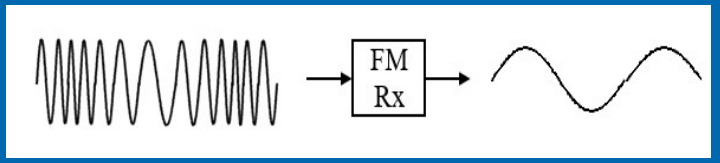
Received signal strong



Same o/p level

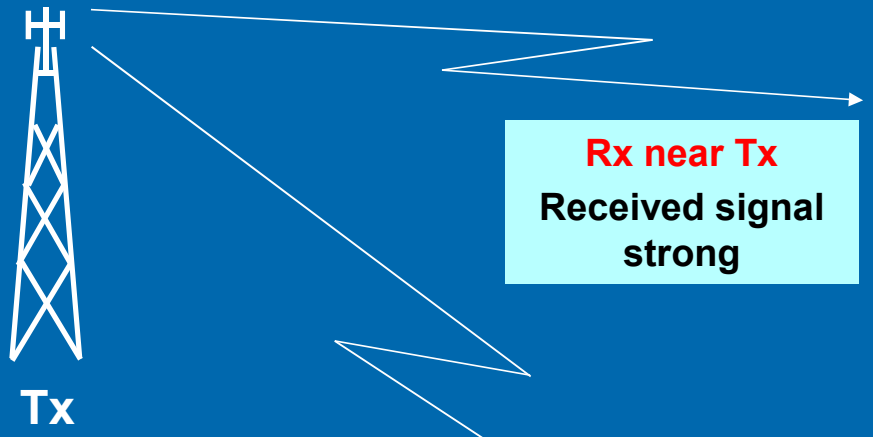
Rx far way from Tx

Received signal weak

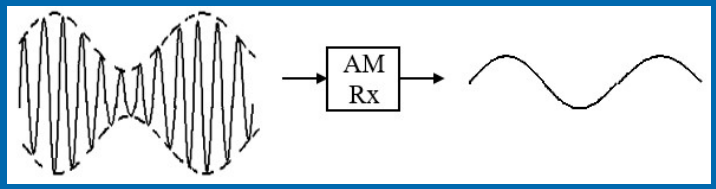


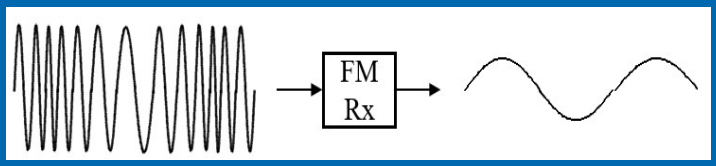
6.7 Advantages & Applications of FM

1. Demodulated o/p level is independent of FM level (NBFM and WBFM)



Rx near Tx
Received signal strong



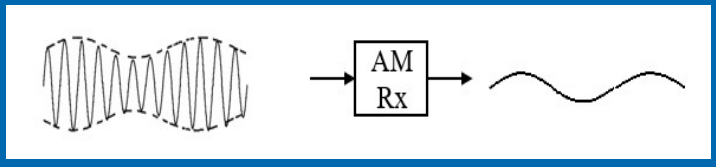


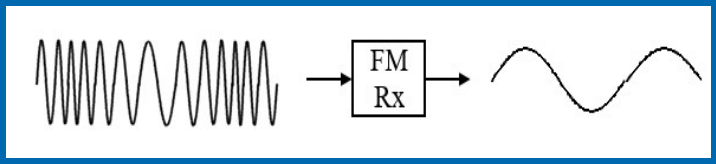
Strong o/p

TX = Transmitter

RX = Receiver

Rx far way from Tx
Received signal weak





weak o/p

Same o/p as Rx near Tx

6.7 Advantages & Applications of FM

2. No need to transmit at high power

- Demodulated o/p level is **NOT** dependent on received FM level. Therefore, no need to ensure a big FM signal at receiver

- Hence, transmission power in FM can be lower than AM to cover the same area.

6.7 Advantages & Applications of FM

3. Good noise immunity (WBFM only)

- Transmitting an FM signal with a large Δ_f will produce a large demodulated output.

$$V_{o(max)} = k_d \Delta_f$$

- Increasing Δ_f does not increase V_C.

- A higher SNR can be achieved at the receiver output without increasing transmission power.

  In AM, DSBSC and SSB, higher SNR at the receiver output can only be achieved by increasing transmission power.

6.7 Advantages & Applications of FM

Applications of FM

Advantages of FM	Suited for
1. Demodulated o/p level is not dependent on received FM level.	Mobile receivers and/or transmitters.

6.7 Advantages & Applications of FM

Applications of FM

Advantages of FM	Suited for
2. No need to transmit at high power.	Battery operated transmitters

6.7 Advantages & Applications of FM

Applications of FM

Advantages of FM	Suited for
3. Good noise immunity	Receivers installed in noisy environment

6.7 Advantages & Applications of FM

Applications of FM

Advantages of FM	Suited for
1. Demodulated o/p level is not dependent on received FM level.	Mobile receivers and/or transmitters
2. No need to transmit at high power	Battery operated transmitters
3. Good noise immunity	Receivers installed in noisy environment

wireless mic
cordless phones

6.7 Advantages & Applications of FM

Applications of FM

Advantages of FM	Suited for
1. Demodulated o/p level is not dependent on received FM level.	Mobile receivers and/or transmitters
2. No need to transmit at high power	Battery operated transmitters
3. Good noise immunity	Receivers installed in noisy environment

Radio-taxi
Police car radio
FM Broadcasting

6.8 Disadvantage of FM (WBFM only)

1. **Bandwidth is large.**

   FM has the largest bandwidth compared with all the other modulation system.

2. **More expensive to transmit.**

End

CHAPTER 6

(Part 4 of 4)