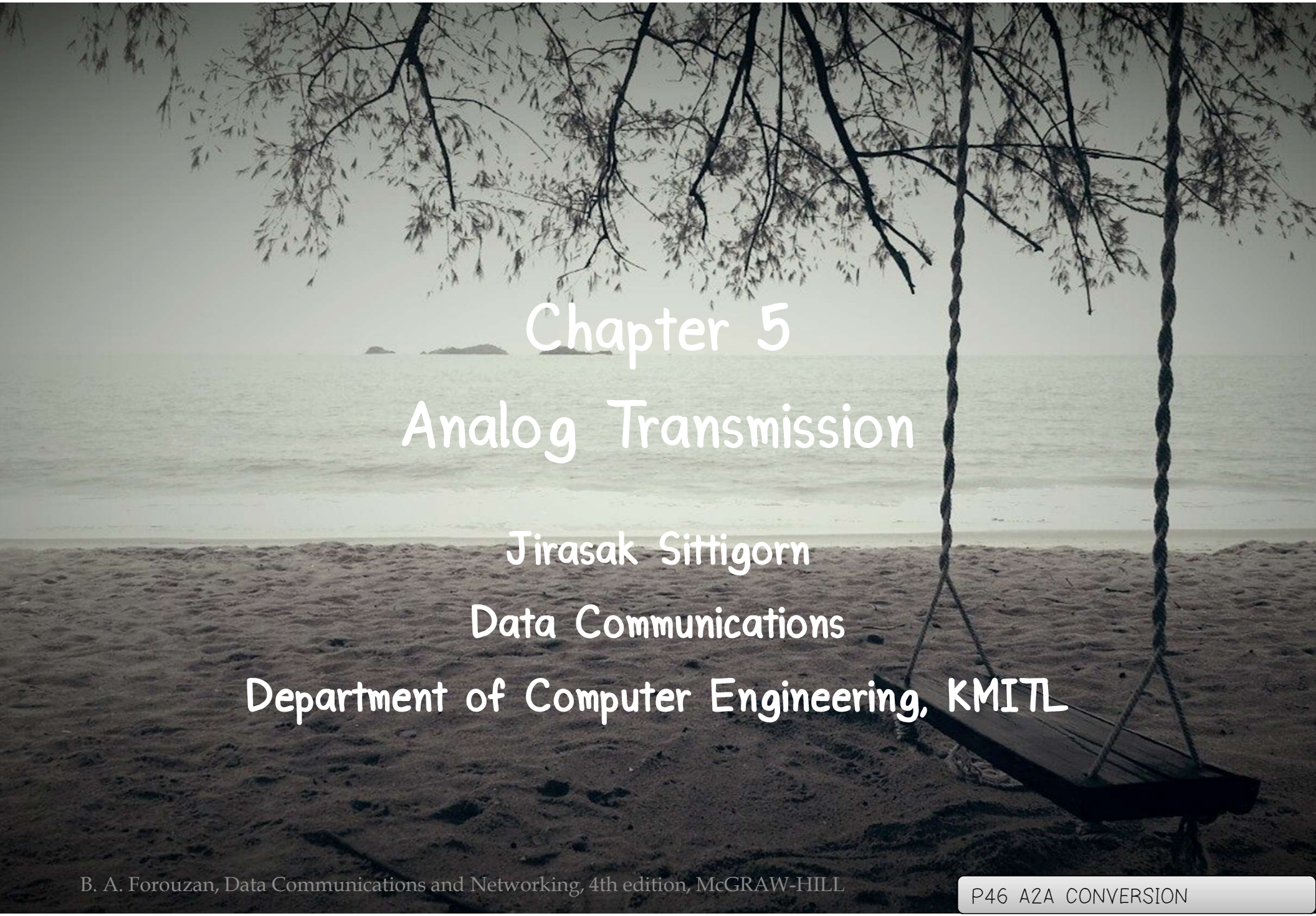

Chapter 5
Analog Transmission

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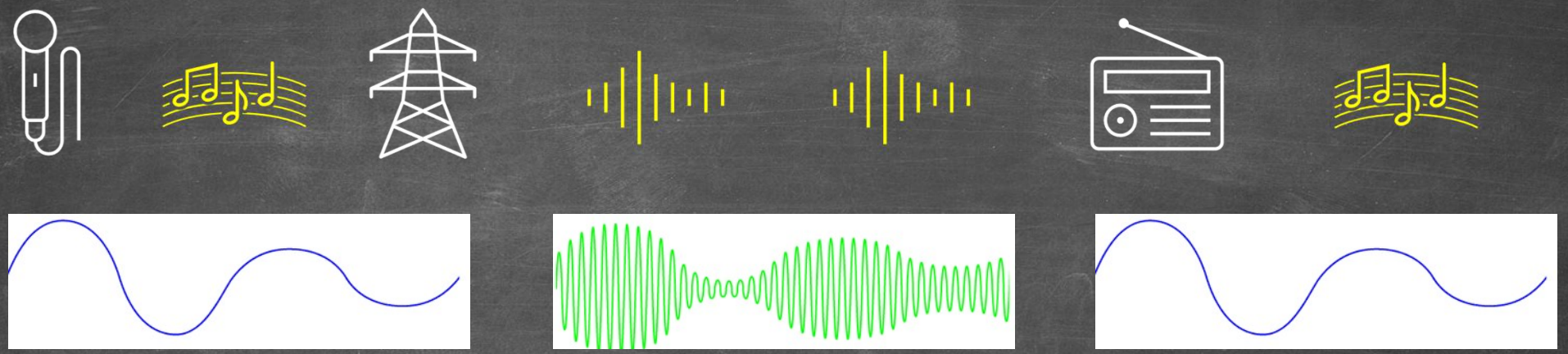
Data Communications
Department of Computer Engineering, KMITL

P46 A2A CONVERSION

ANALOG-TO-ANALOG CONVERSION

- AMPLITUDE MODULATION
- FREQUENCY MODULATION
- PHASE MODULATION

ANALOG-TO-ANALOG CONVERSION



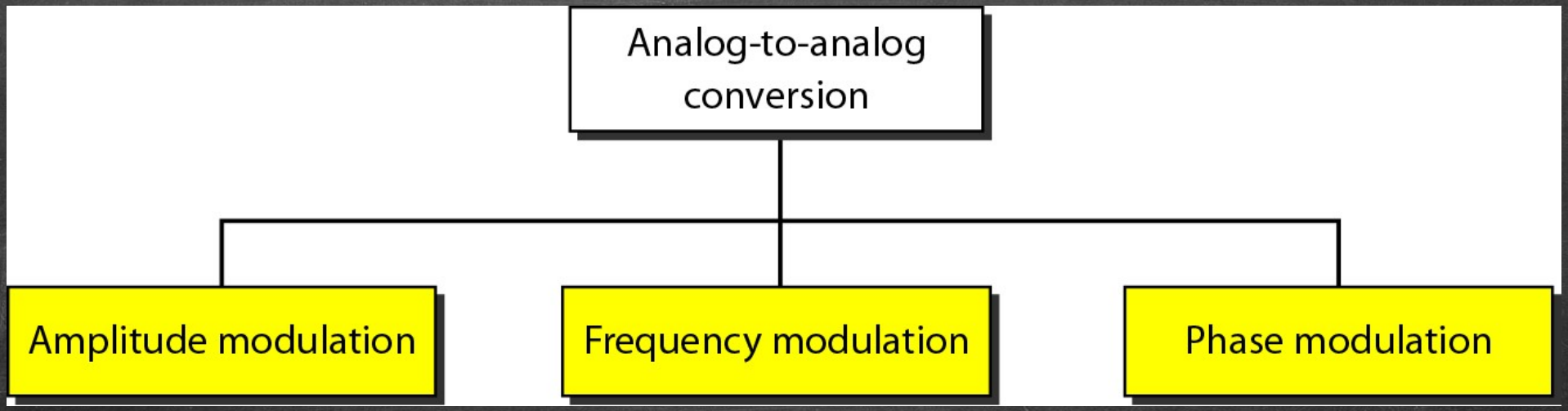
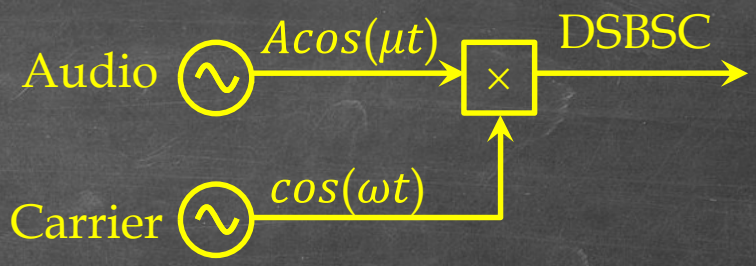


Figure 5.15 Types of analog-to-analog modulation

Double Sideband Suppressed Carrier

- Audio Signal : $A\cos(2\pi f t) \Rightarrow A\cos(\mu t)$ rad/sec
- Carrier Signal : $\cos(2\pi f_c t) \Rightarrow \cos(\omega t)$

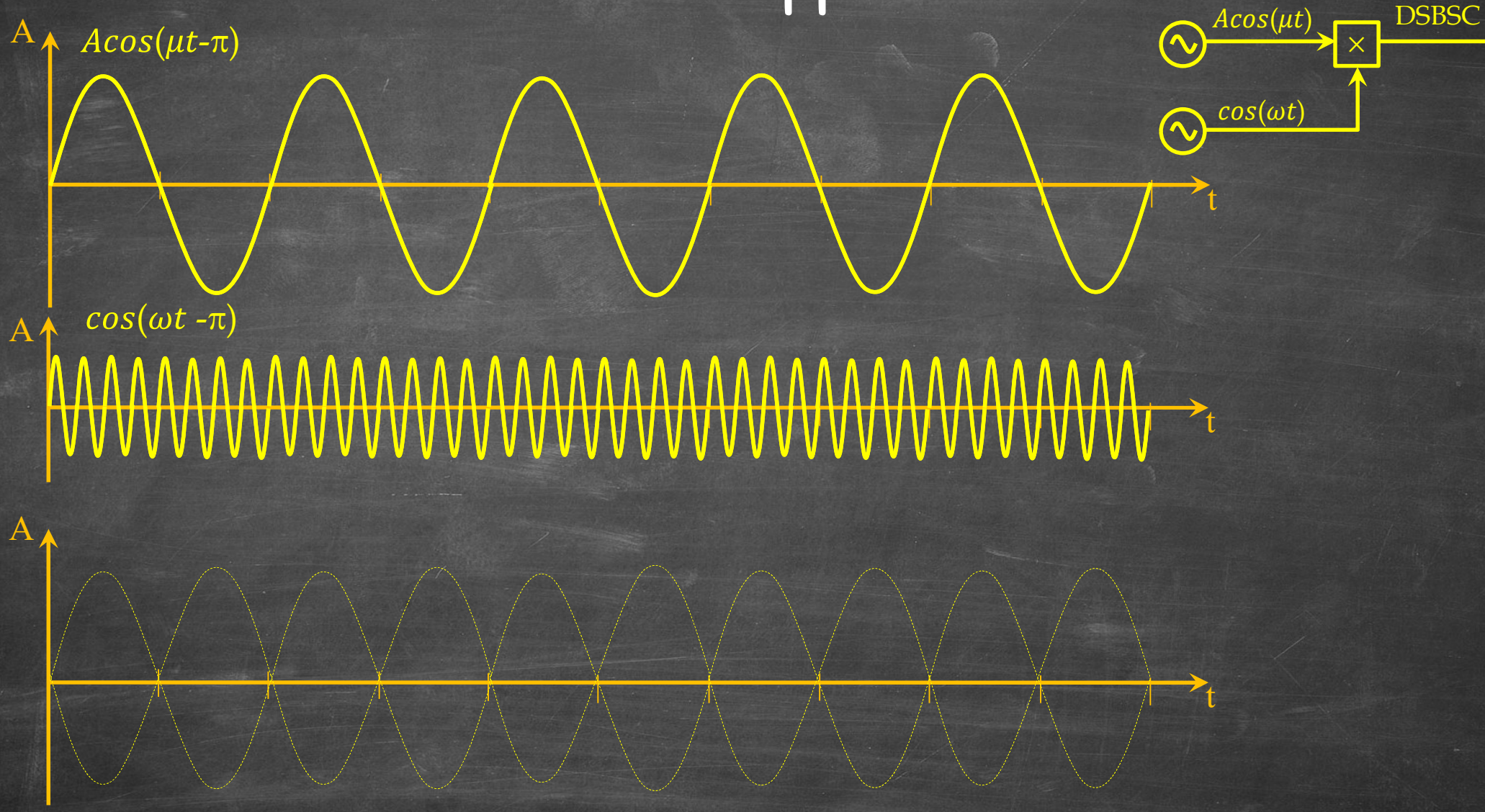
$$f_c \gg f \rightarrow \omega \gg \mu$$



- DSBSC : $A\cos(\mu t)\cos(\omega t)$

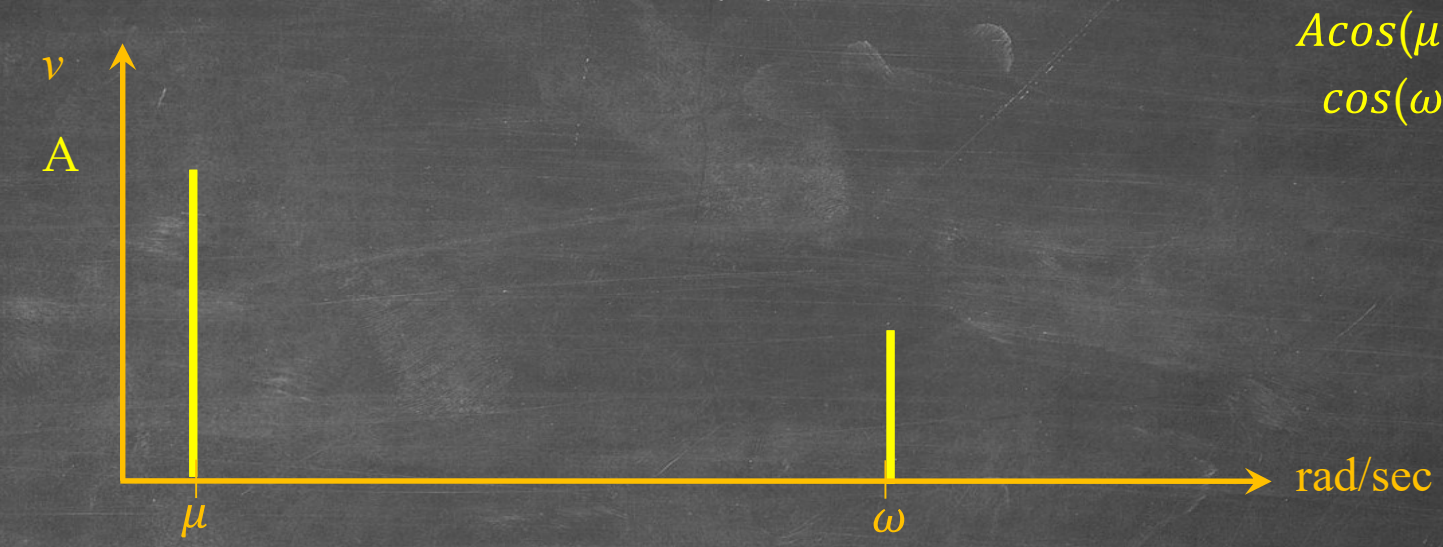
$$A\cos(\omega t)\cos(\mu t) = \frac{A}{2}\cos(\omega - \mu)t + \frac{A}{2}\cos(\omega + \mu)t$$

Double Sideband Suppressed Carrier

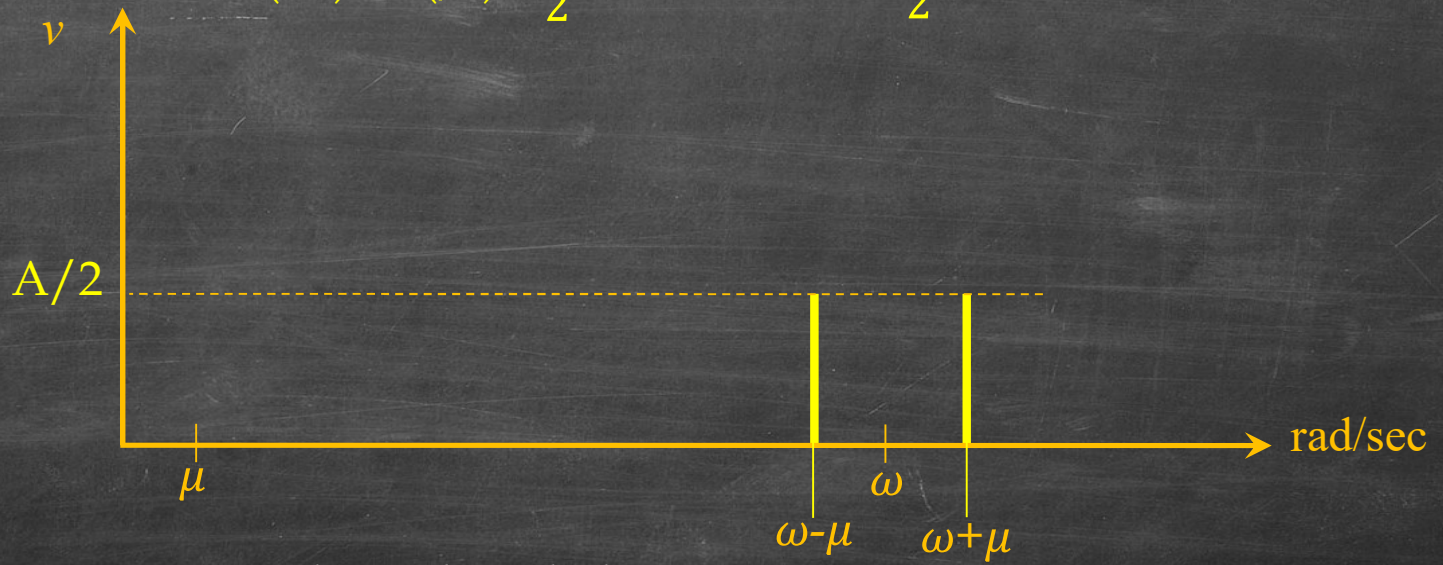


Double Sideband Suppressed Carrier

$\omega \gg \mu$



$$A\cos(\omega t)\cos(\mu t) = \frac{A}{2}\cos(\omega - \mu)t + \frac{A}{2}\cos(\omega + \mu)t$$



Amplitude Modulation

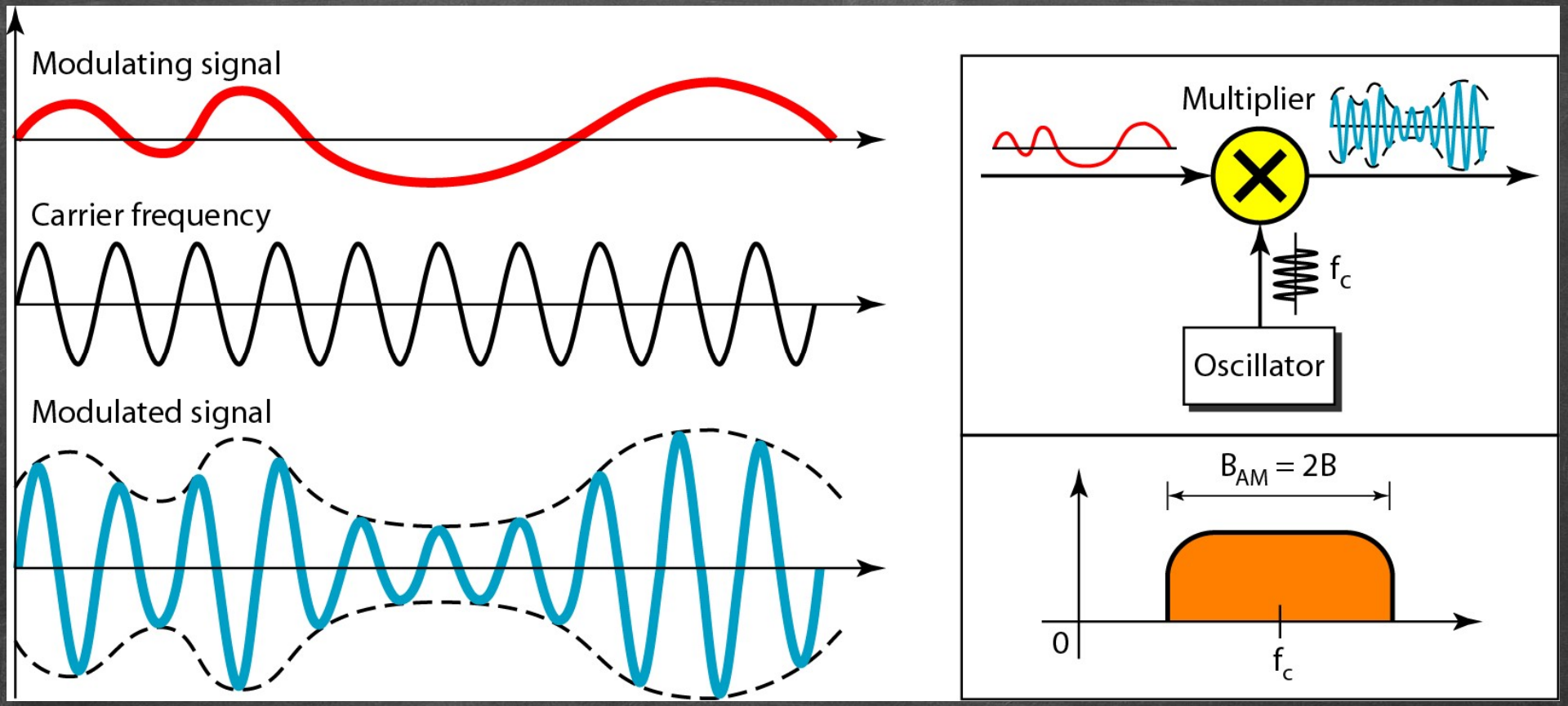


Figure 5.16 Amplitude modulation

Amplitude Modulation

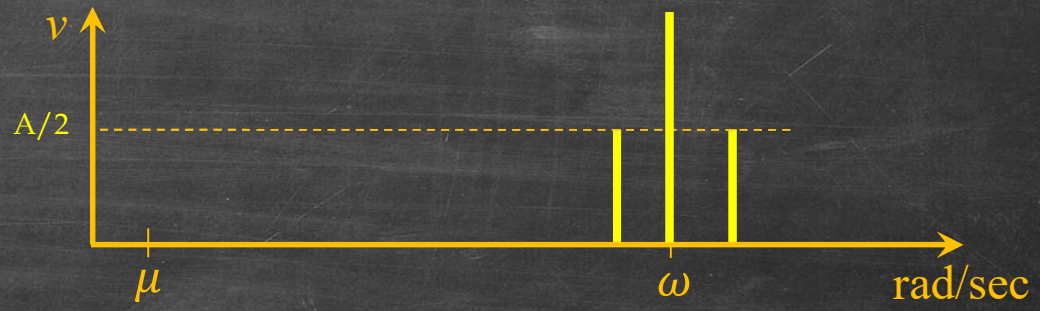
- Audio Signal : $m(t) \Rightarrow A\cos(\mu t)$
- Carrier Signal : $\cos(\omega t)$
- $\mathbf{AM} = E[1 + m(t)] \cdot \cos(\omega t)$

$$= [A + A\cos(\mu t)] \cdot \cos(\omega t)$$

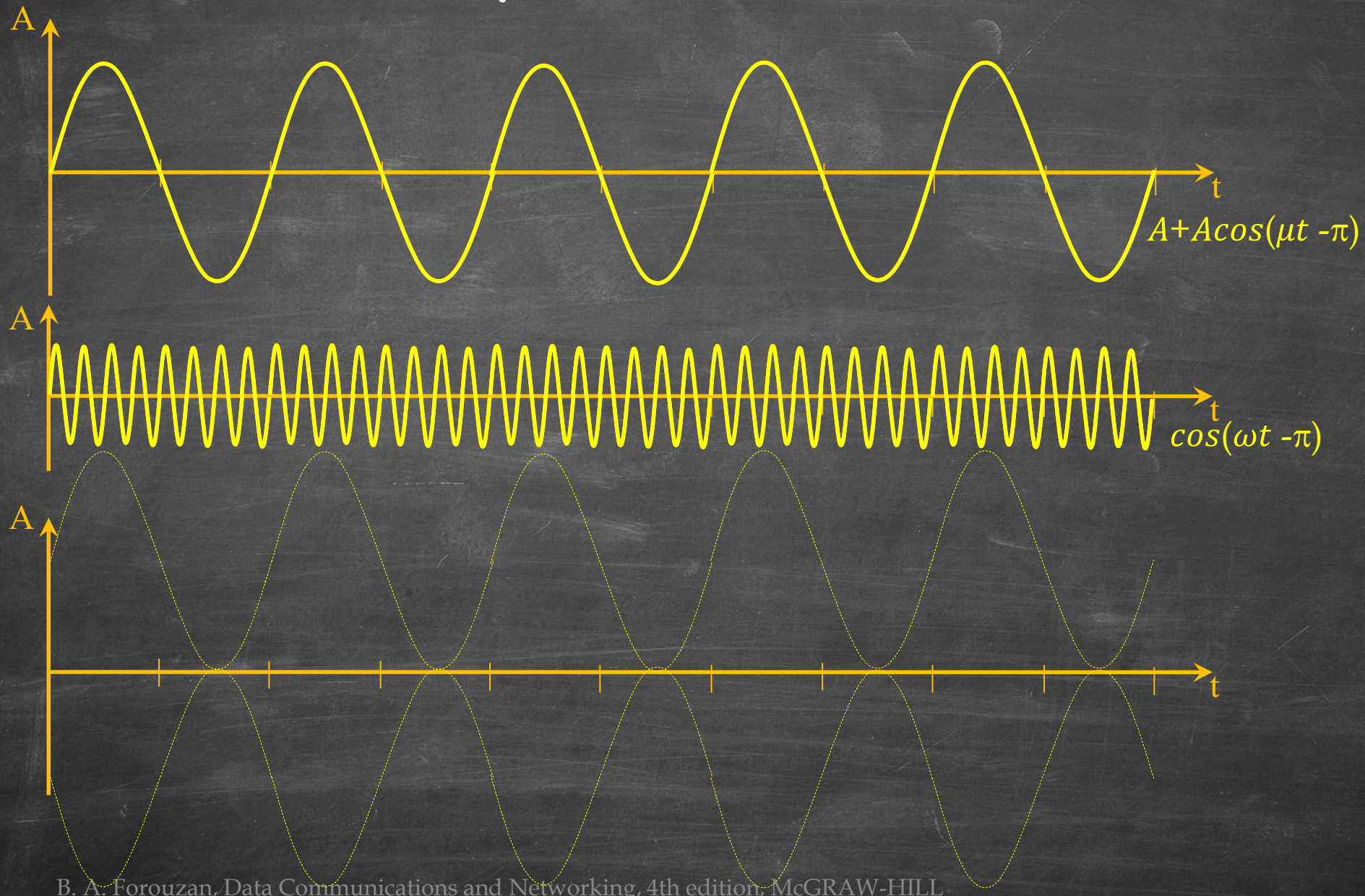
$$= A \cdot \cos(\omega t) + A \cdot \cos(\omega t) \cdot \cos(\mu t)$$

DSBSC

$$= A \cdot \cos(\omega t) + \frac{A}{2}\cos(\omega - \mu)t + \frac{A}{2}\cos(\omega + \mu)t$$



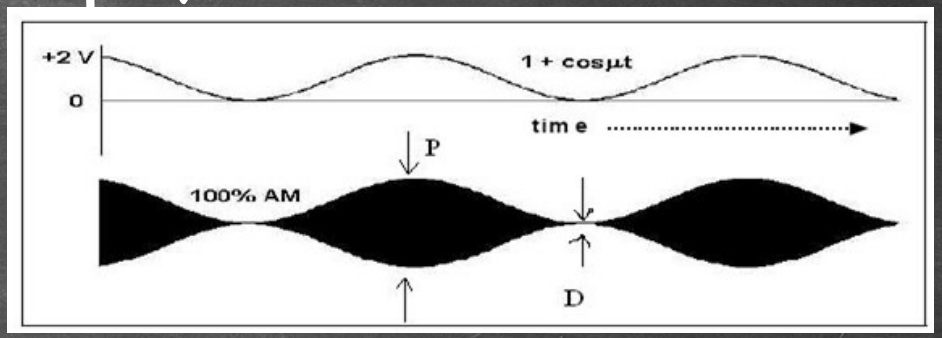
Amplitude Modulation

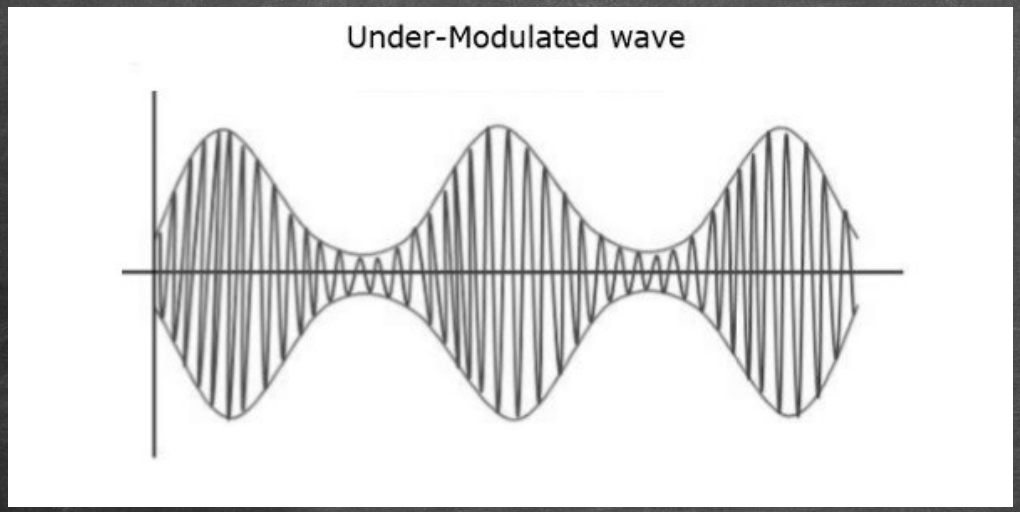


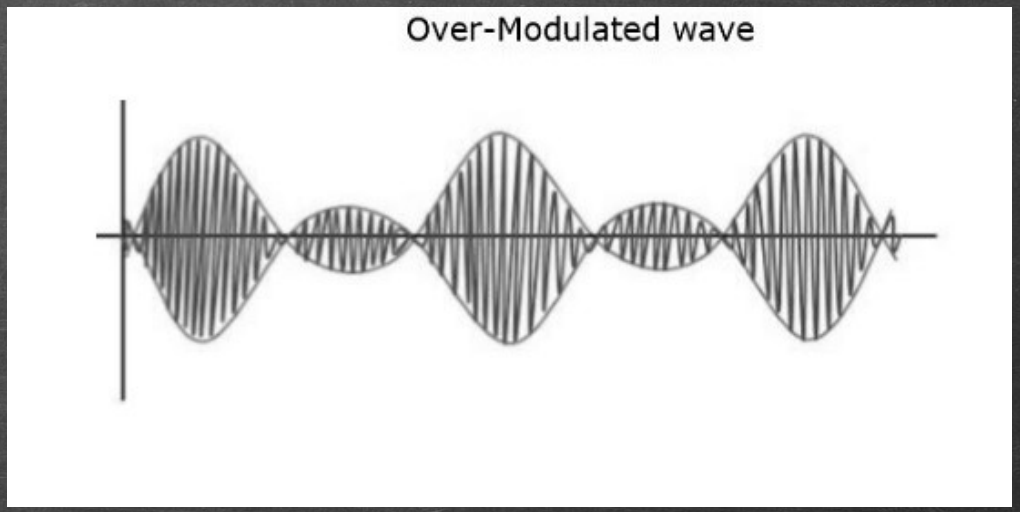
Amplitude Modulation

- Modulation index (Modulation Depth)

$$m = \frac{P-D}{P+D}$$

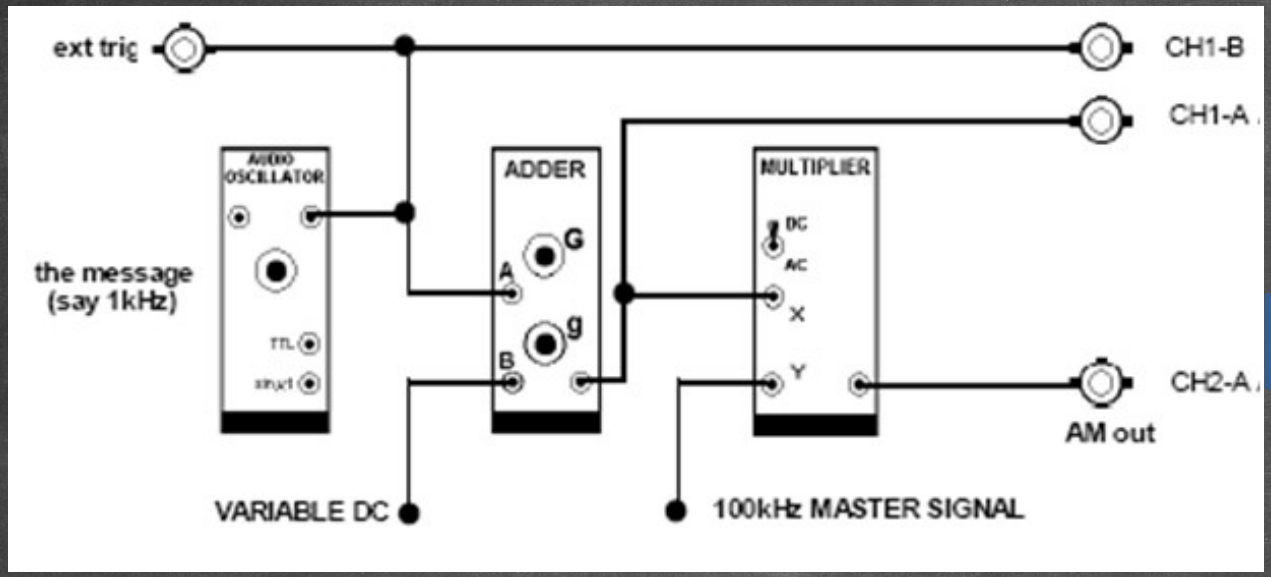


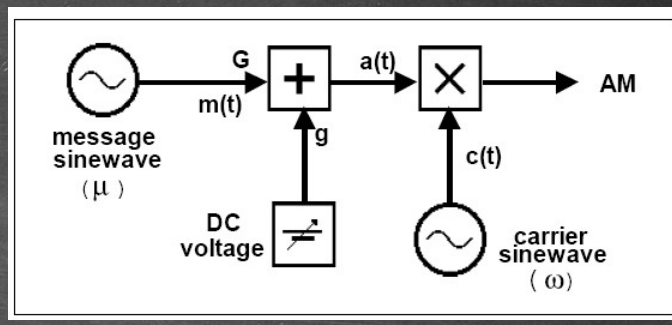


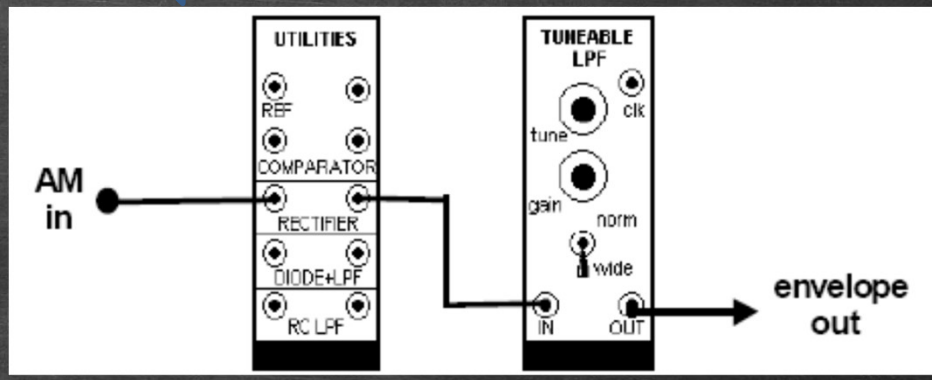


https://www.tutorialspoint.com/analog_communication/analog_communication_amplitude_modulation.htm

Implementation of AM







Standard Bandwidth Allocation for AM

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

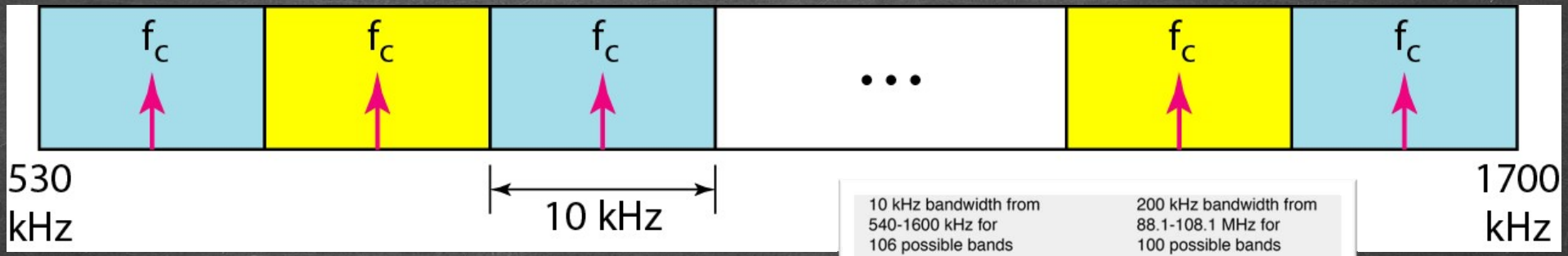
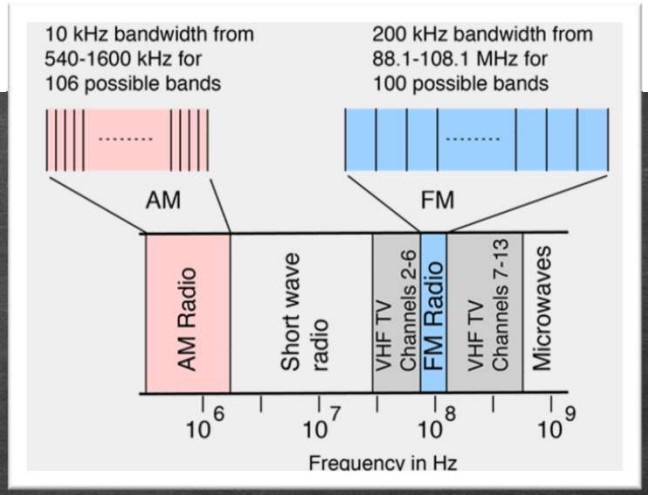


Figure 5.17 AM band allocation



http://hyperphysics.phy-astr.gsu.edu/hbase/Audio/radio.html

Frequency Modulation

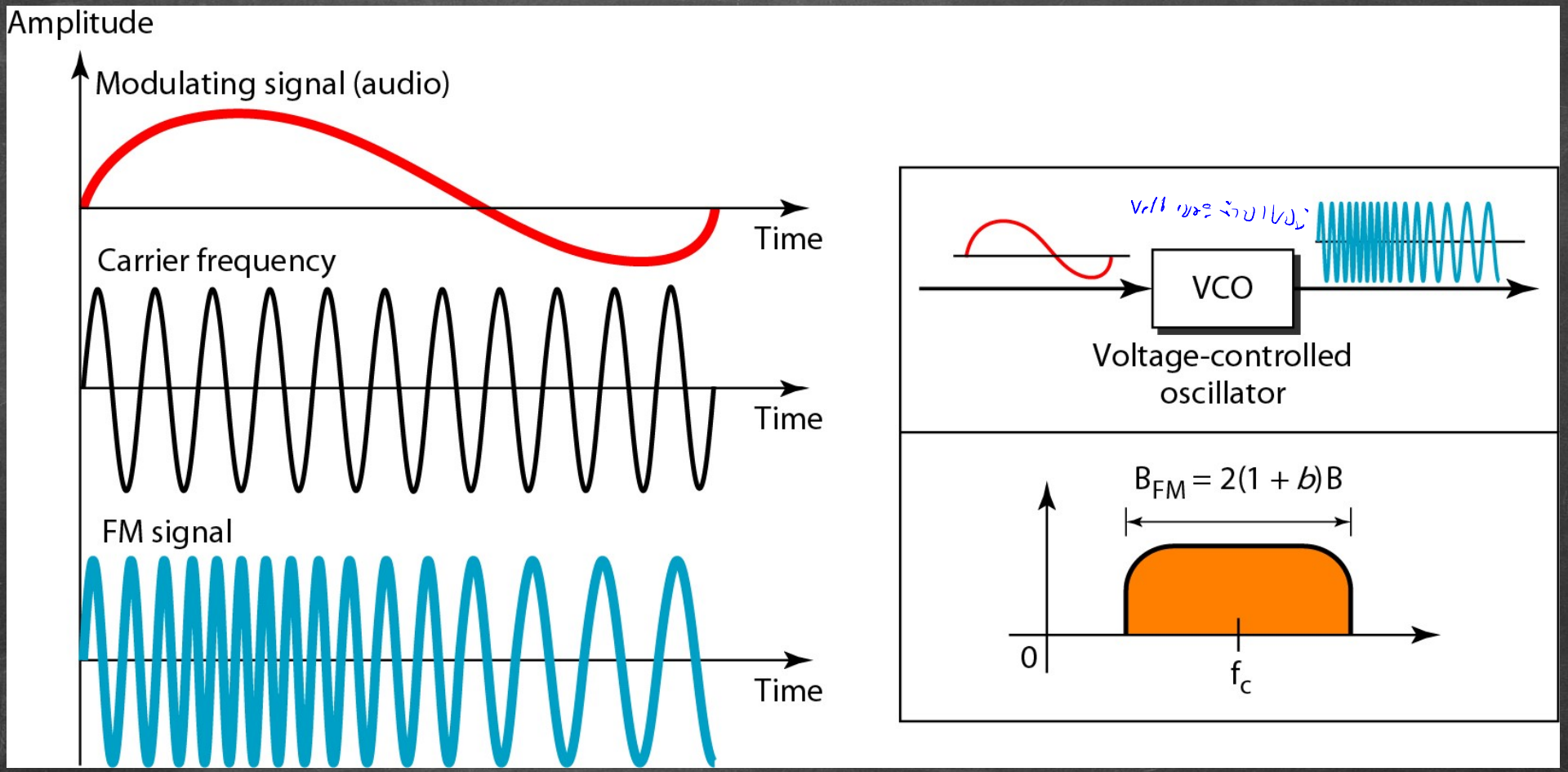
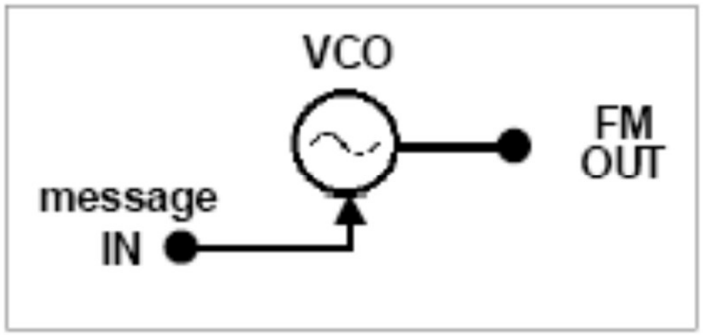
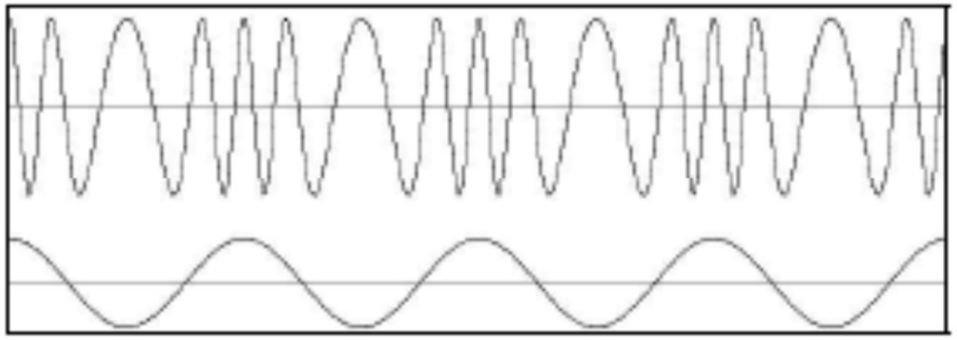


Figure 5.18 Frequency modulation

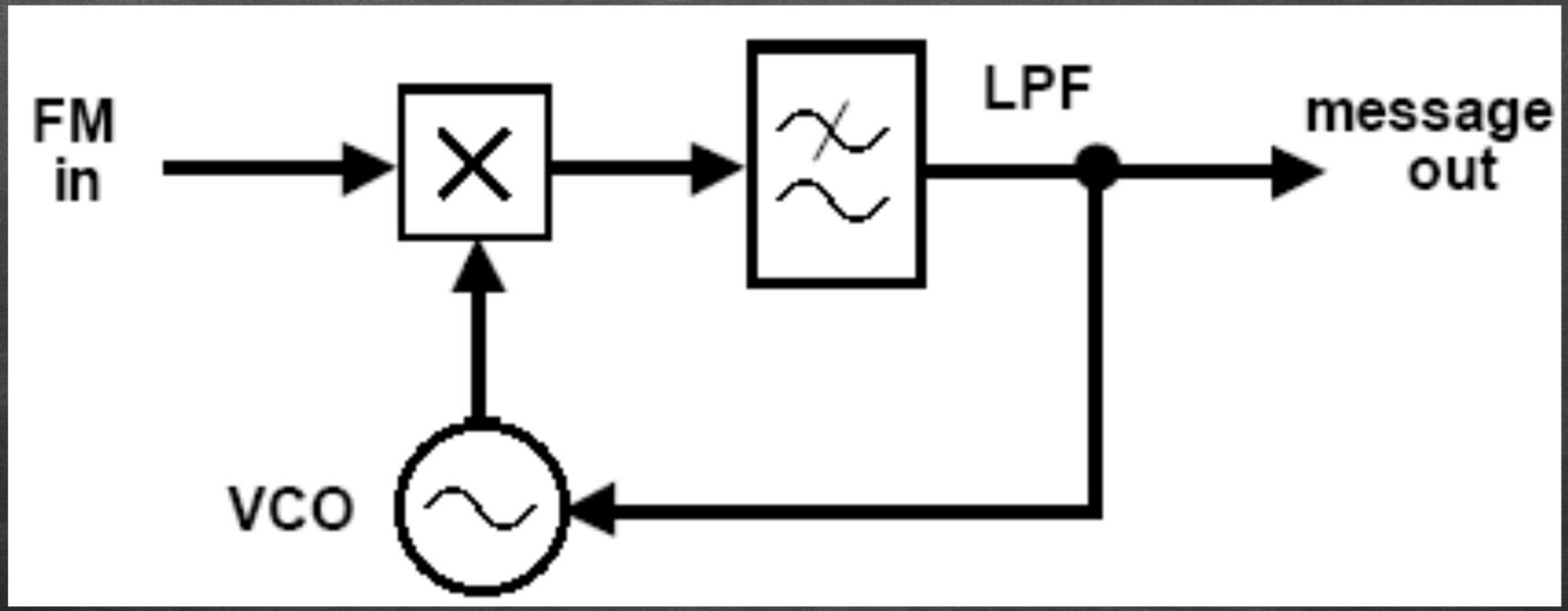
Implementation of FM



(a)



(b)



Standard Bandwidth Allocation for

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

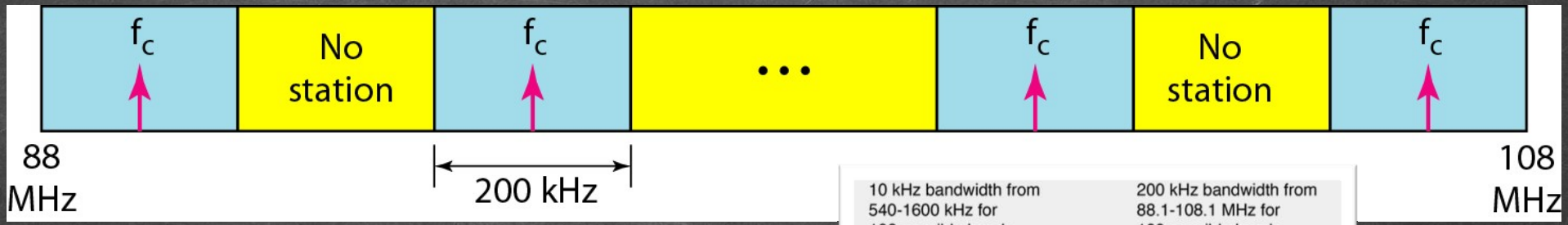
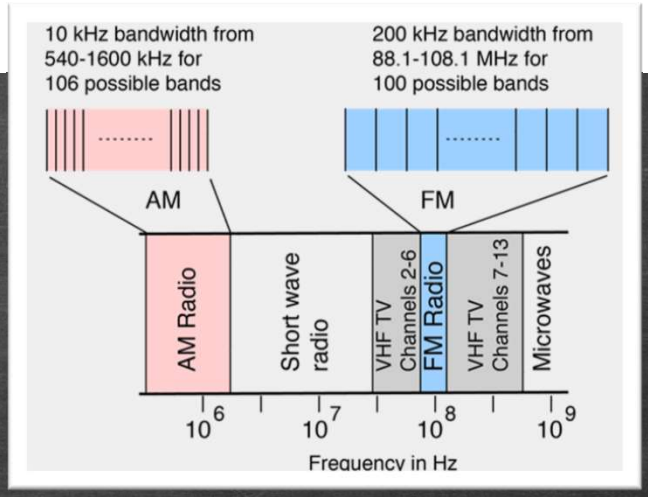
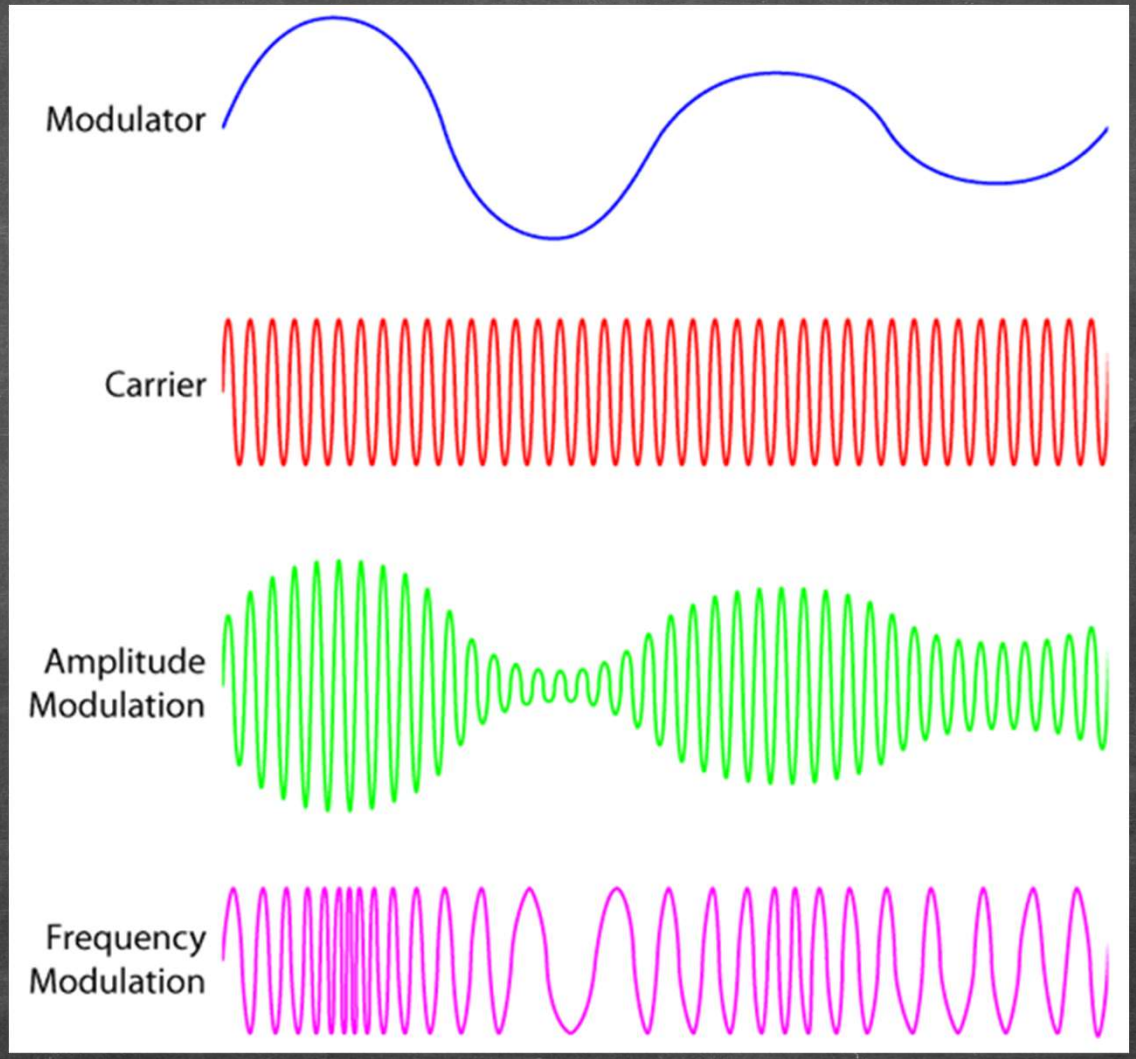


Figure 5.19 FM band allocation



http://hyperphysics.phy-astr.gsu.edu/hbase/Audio/radio.html

AM vs FM



https://mriquestions.com/signal-squiggles.html

Phase Modulation

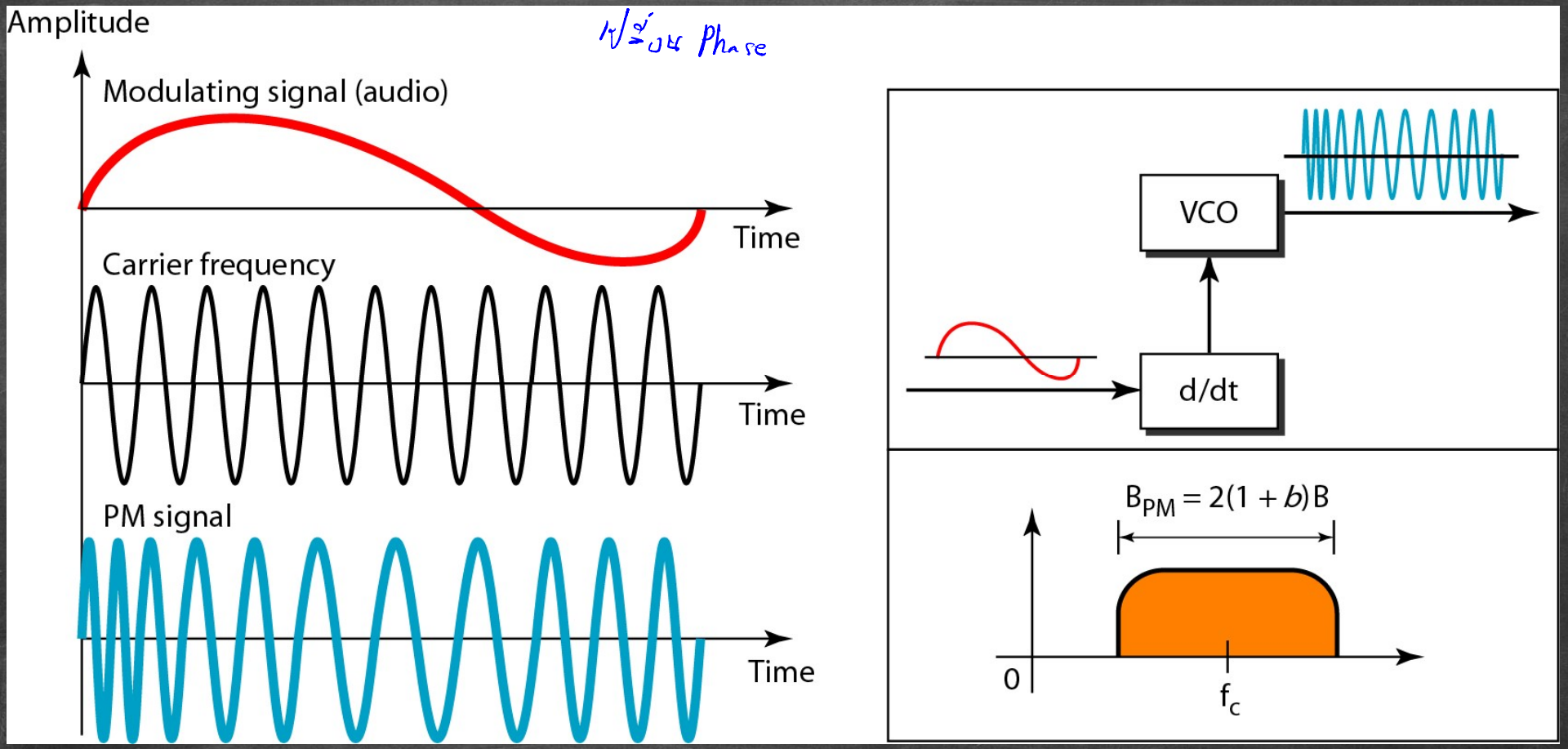


Figure 5.20 Phase modulation

Note

- The total bandwidth required for PM can be determined from the bandwidth and maximum amplitude of the modulating signal: $B_{PM} = 2(1 + \beta)B$.

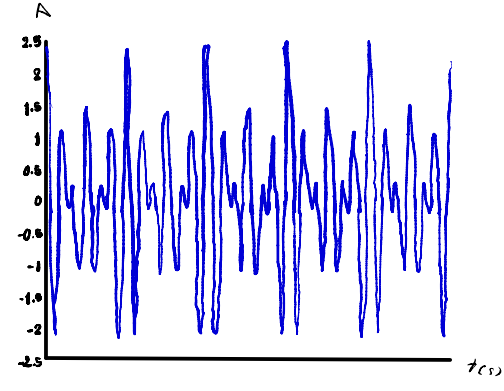
$AM = [g + 6 \cdot m(t)] \cos(\omega t) \Big/ 6 \cdot m(t) = 2 \cdot \cos(\mu t)$

ค.ถี่ของตัวพาห์ = 20 Hz

ค.ถี่ของสัญญาณข่าวสาร = 100 Hz

$g = 0.5$

สัญญาณ AM ใน Time Domain



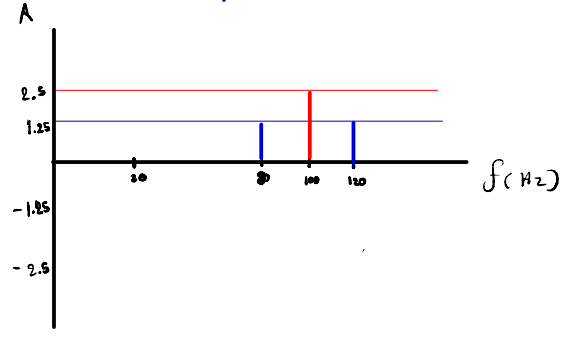
$AM = [g + 2\cos(\mu t)] \cos(\omega t)$

$\omega = 2\pi f_c t = 200\pi t$

$\mu = 2\pi f_m t = 40\pi t$

$AM = [g + 2\cos(40\pi t)] \cdot \cos(200\pi t)$

สัญญาณ AM ใน Frequency Domain



ค่าดรรชนีการ Modulation index (Modulation Depth)

$m = \frac{P - D}{P + D}$

$P = 2.5 - (-2.5) = 5$

$D = -1.5 - 1.5 = -3$

$= \frac{5 - (-3)}{5 - 3}$

$= 8/2 = 4$ Over-Modulated

$AM = [g + 6 \cdot m(t)] \cdot \cos(\omega t)$ / $6 \cdot m(t) = 2 \cdot \cos(\mu t)$

6301010921 ศุภกร หงษ์ทอง sec 3

ก. ถี่ของสัญญาณข่าวสาร = 20 Hz

ข. ถี่ของสัญญาณพาหะ = 100 Hz

$g = 2$

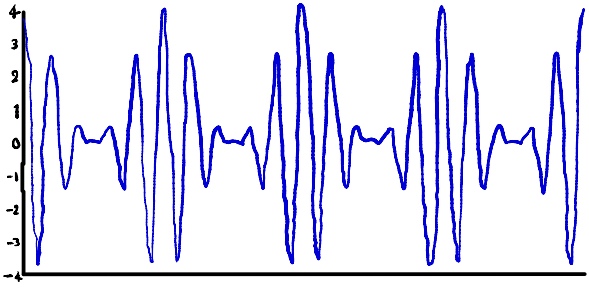
$AM = [g + 2\cos(\mu t)]\cos(\omega t)$

$\omega = 2\pi f_c t = 200\pi t$

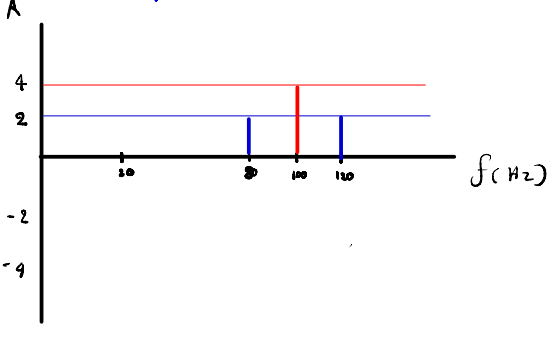
$\mu = 2\pi f_m t = 40\pi t$

$AM = [g + 2\cos(40\pi t)] \cdot \cos(200\pi t)$

สัญญาณ AM ใน Time Domain



สัญญาณ AM ใน Frequency Domain



ค่าความลึกการ Modulation index (Modulation Depth)

$P = 4 - (-4) = 8$

$D = 0 - 0$

$m = \frac{P - D}{P + D}$

$= \frac{8 - 0}{8 + 0}$

$= 1$ Modulate

6301092l ศุภกร หอยข่อ sec 3

$AM = [g + 6 \cdot m(t)] \cdot \cos(\omega t) \;/\; 6 \cdot m(t) = 2 \cdot \cos(\mu t)$

ก. ถี่ของตัวพา = 20 Hz

ข. ถี่ของสัญญาณ = 100 Hz

$g = 3$

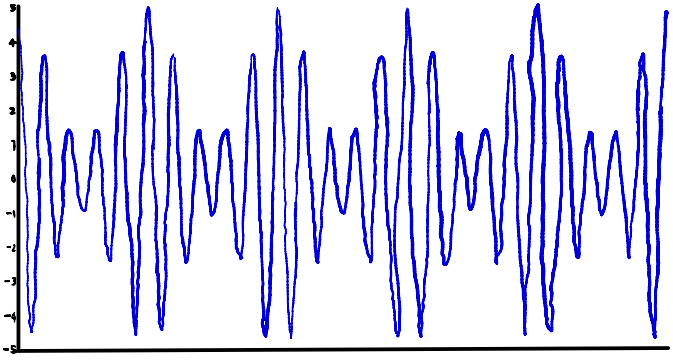
$AM = [g + 2\cos(\mu t)]\cos(\omega t)$

$\omega = 2\pi f_c t = 200\pi t$

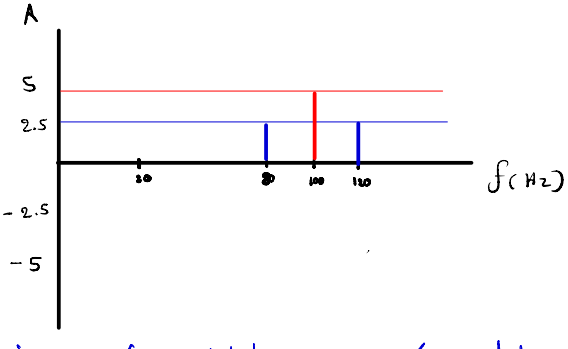
$\mu = 2\pi f_m t = 40\pi t$

$AM = [g + 2\cos(40\pi t)] \cdot \cos(200\pi t)$

สัญญาณ AM ใน Time Domain



สัญญาณ AM ใน Frequency Domain



ค่าดรรชนีการ Modulation index (Modulation Depth)

$m = \dfrac{P - D}{P + D}$

$P = 5 - (-5) = 10$

$D = 1 - (-1) = 2$

$= \dfrac{10 - 2}{10 + 2}$

$= \dfrac{8}{12} = \dfrac{4}{6} = 0.67$ Under - Modulate