WELCOME

TO Adda247

"If you can think, you can Achieve"
So start thinking..

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GATE 2024

GATE

प्रचण्ड Batch

Communication System

DSB-SC & SSB-SC MODULATION

LEC–01

ECE

Chapter-1

Analog Communications

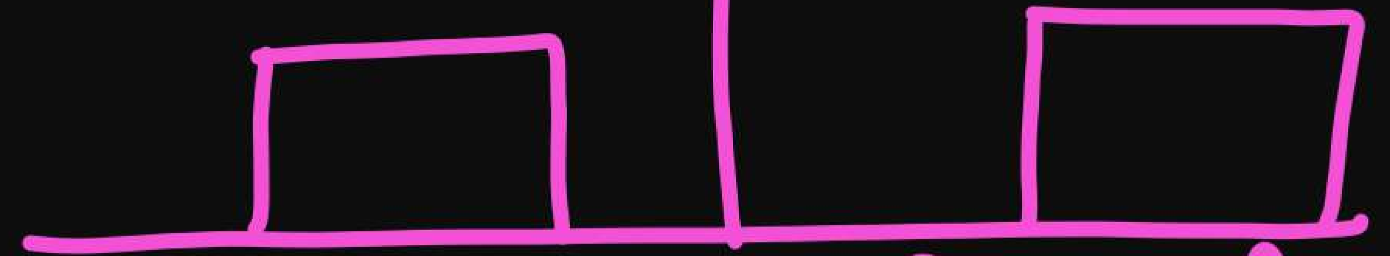
In today's lecture we will cover the following Topis :

1. *Generation of AM Signal : Square Law Modulator*
2. *Demodulation of AM Signal : Square Law Demodulator*
3. *Demodulation of AM Signal : Envelope Detector*
4. *Demodulation of AM Signal : Synchronous Detector*
5. *Double Side Band (DSB-SC) Modulation and Demodulation*
6. *Single Side Band (SSB-SC) Modulation and Demodulation*

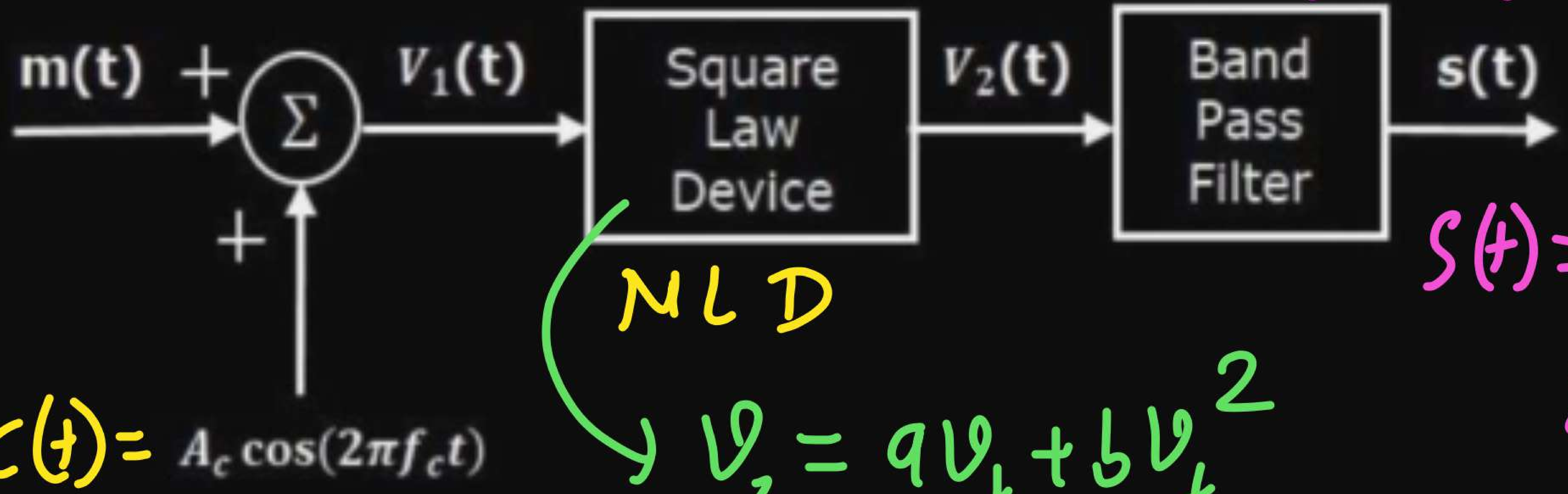
Generation of AM Signal

Square Law Modulator :

$v_1(t) = [m(t) + c(t)]$



(f_c-W) to (f_c+W)



NLD

$v_2 = a v_1 + b v_1^2$

AM Signal

$s(t) = aA_c\cos 2\pi f_c t + 2bA_c m(t)\cos 2\pi f_c t$

$= aA_c\left[1 + \frac{2b}{a}\right]\cos 2\pi f_c t$

$v_1 = m(t) + A_c\cos 2\pi f_c t$

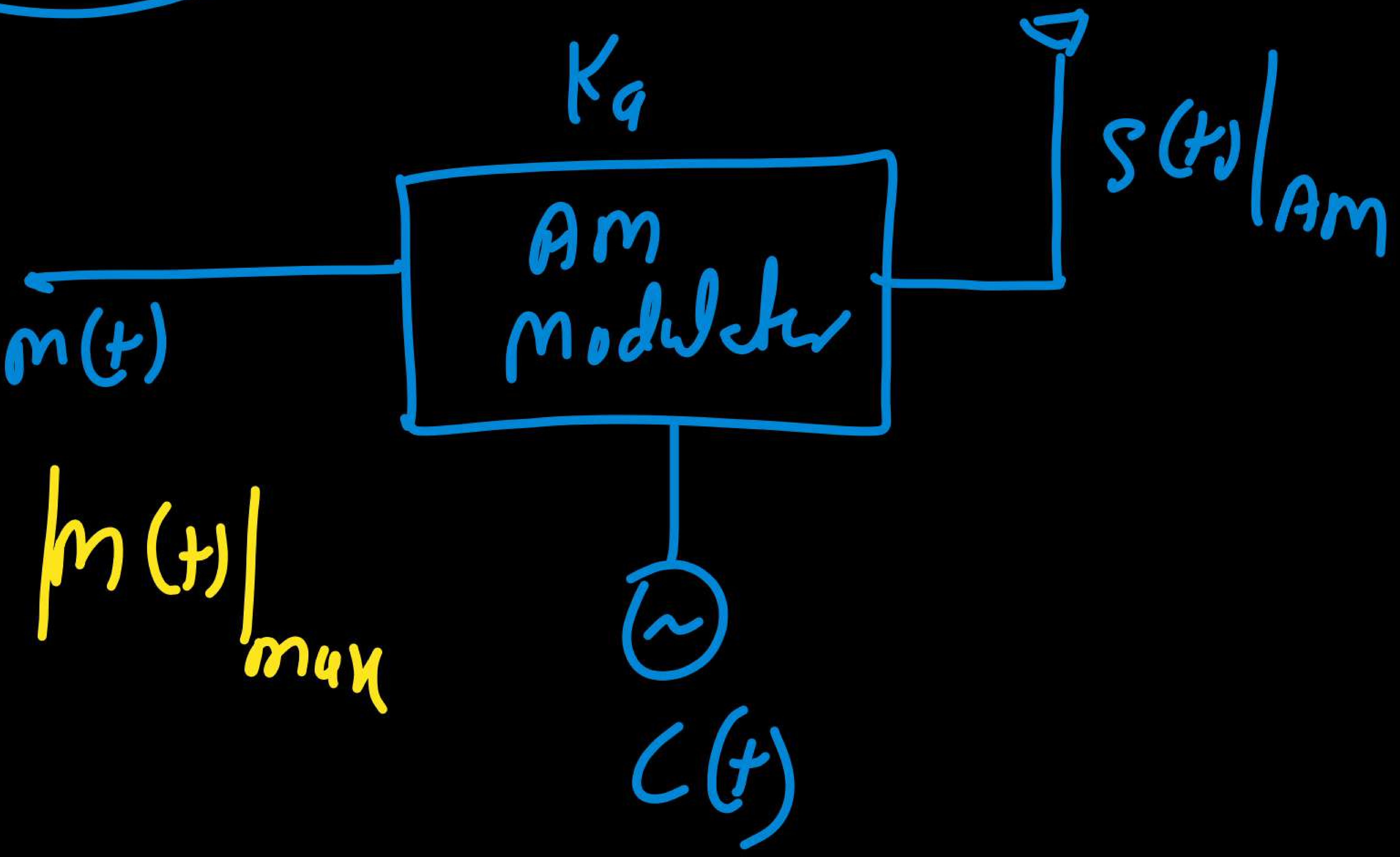
$v_2 = a m(t) + aA_c\cos 2\pi f_c t + b m^2(t) + bA_c^2\cos^2 2\pi f_c t + b\,2A_c m(t)\cos 2\pi f_c t$

X ✓ X (2W) X

$$s(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t$$

$$s(t) = aA_c\left[1 + \frac{2b}{a} m(t)\right] \cos 2\pi f_c t$$

$$K_a = \frac{2b}{a}$$



$$\mu = K_a |m(t)|_{max}$$

NLD / SLD ⇒

$$v_2 = a v_1 + b v_1^2$$

$$K_a = \frac{2b}{a}$$

$$SLD \Rightarrow v_2 = 5 v_1 + 1 \cdot v_2^2$$

$$K_a = \frac{2b}{a} = \frac{2 \times 1}{5}$$

$$K_a = \frac{2}{5} \text{ (per volt)}$$

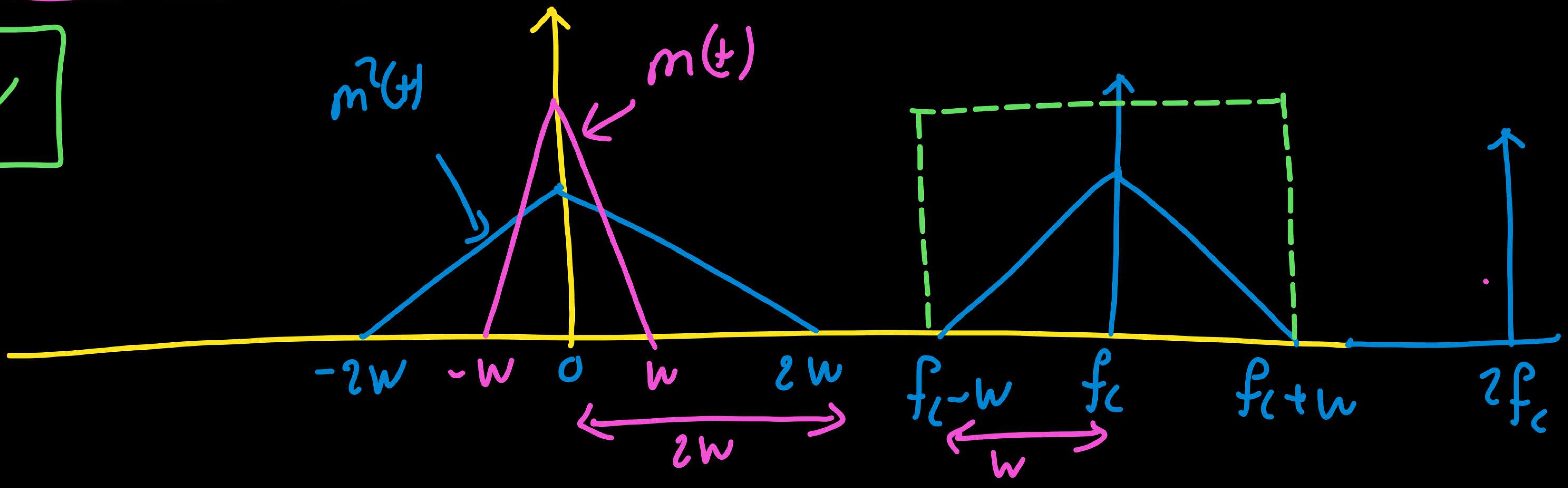
If MLD/SLD $\Rightarrow v_2 = 5 + 5v_1 + 2v_1^2$

($a = 5$, $b = 2$)

$$K_a = \frac{2b}{a} = \frac{2 \times 2}{5} = \frac{4}{5}$$

Limitation of Square Law Modulator:

$$f_c \geq 3W$$



Demodulation of AM Signal

Non Coherent (Asynchronous)

Square Law Demodulator

(i)

$$v_2 = aA_c\cos 2\pi f_c t + aA_c K_a m(t)\cos 2\pi f_c t + bA_c^2\cos^2 2\pi f_c t + bA_c^2K_a^2m^2(t)\cos^2 2\pi f_c t + 2bA_c^2K_a m(t)\cos^2 2\pi f_c t$$

$$v_o \propto K_1 m^2(t) + K_2 m(t)$$

$A_c[1 + K_a m(t)]\cos 2\pi f_c t$

$v_2 = av_1 + bv_1^2$

$$v_1 = A_c\cos 2\pi f_c t + A_c K_a m(t)\cos 2\pi f_c t$$

Noise part ← $V_o = \frac{bA_c^2 K_a^2 m^2(t)}{2} + \frac{2bA_c^2 K_a m(t)}{2}$ → Signal part

$V_o \propto K_1 m^2(t) + K_2 m(t) \Rightarrow K_1 = \frac{bA_c^2 K_a^2}{2}$

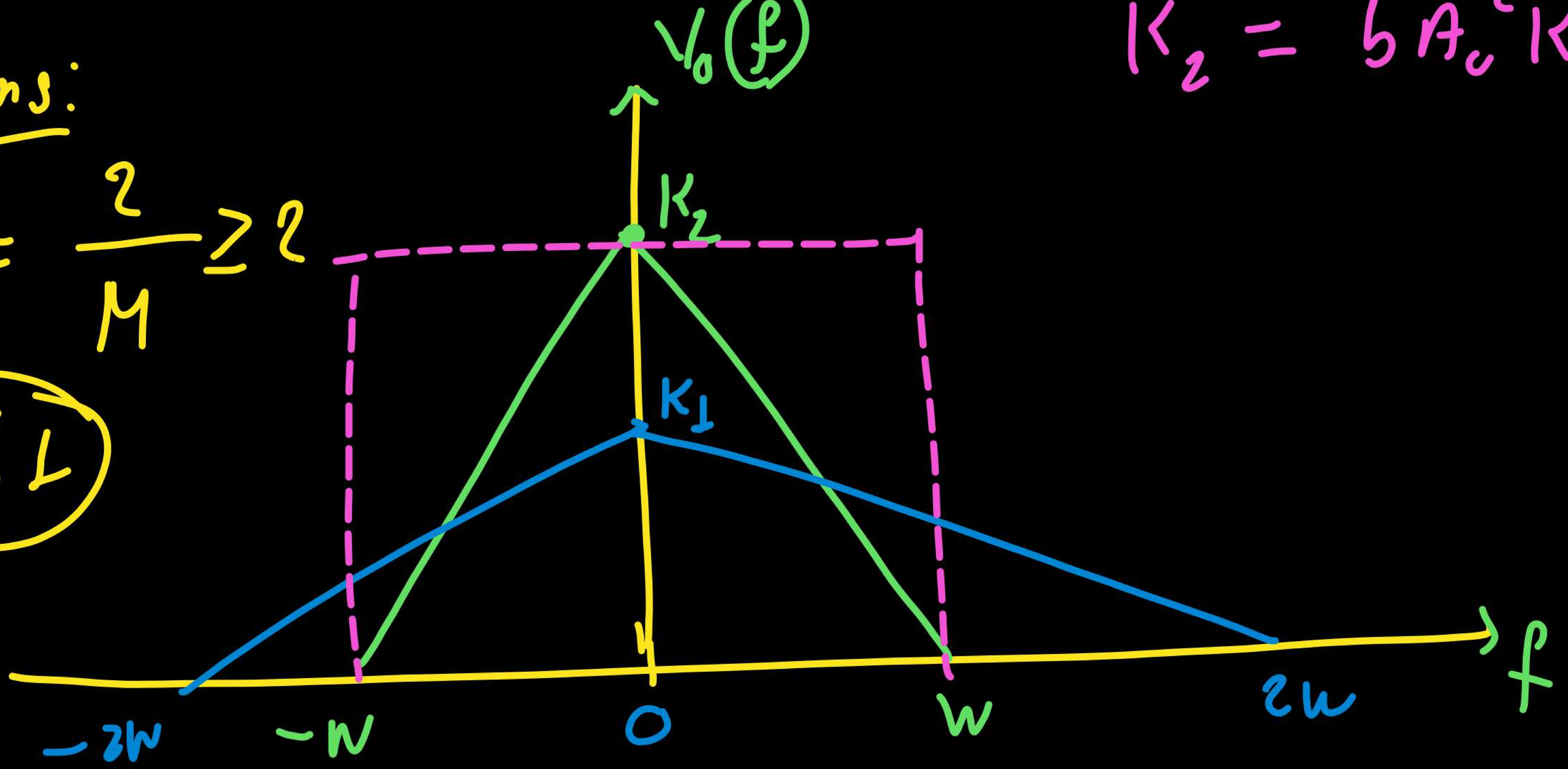
$K_2 = bA_c^2 K_a$

$\frac{K_2}{K_1} >> 1$

limitations:

$\left(\frac{S}{N}\right)_{min} = \frac{2}{\mu} \geq 2$

$\mu \leq 1$



$\frac{S}{N} = \frac{bA_c^2 K_a m(t)}{\frac{bA_c^2 K_a^2 m^2(t)}{2}}$

$\frac{S}{N} = \frac{2}{K_a m(t)} >> 1$

$\frac{S}{N}\Big|_{min} = \frac{2}{K_a |m(t)|_{max}} \geq 2$

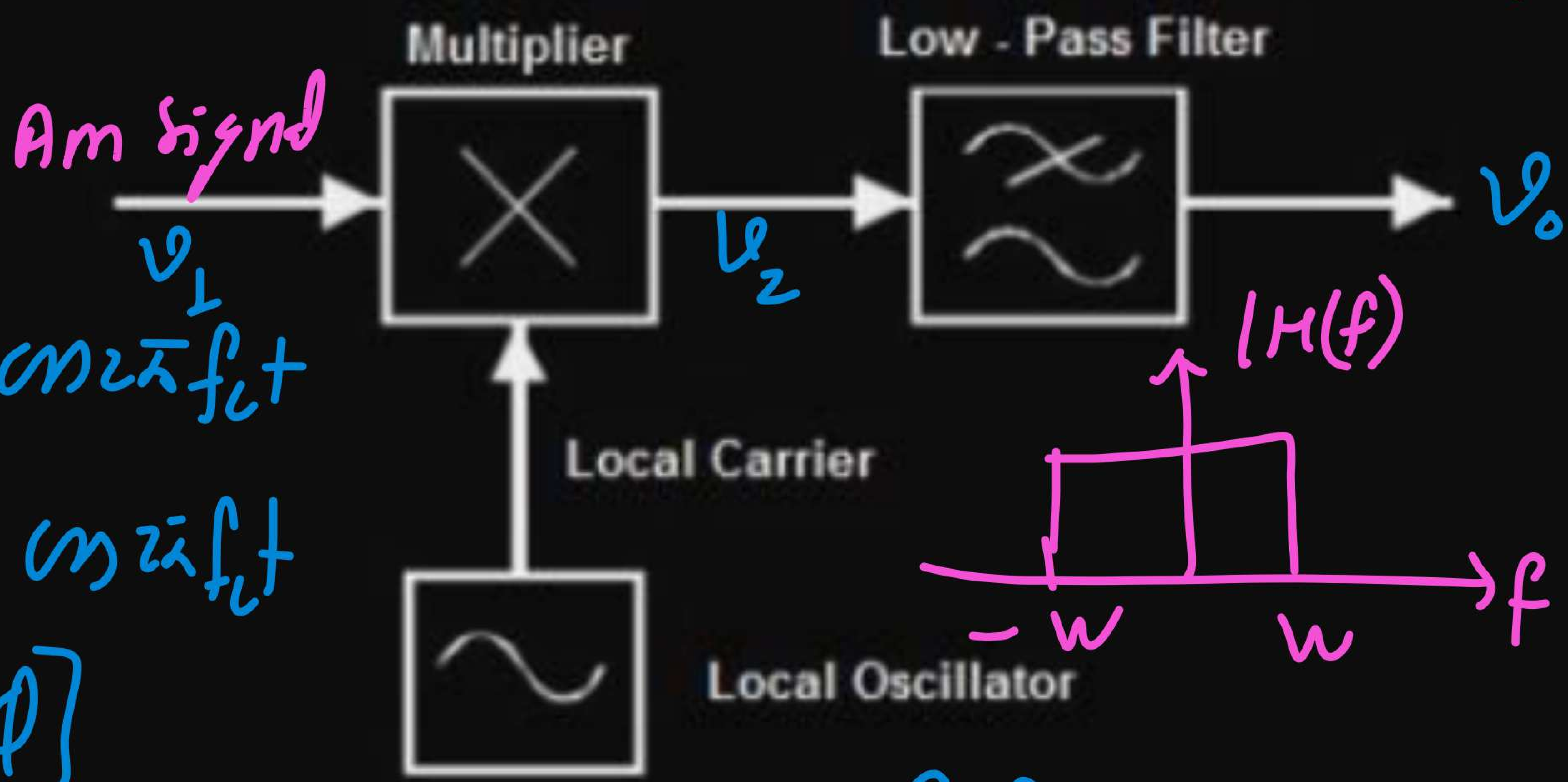
Demodulation of AM Signal

(Coherent)

Synchronous Detector

②

$v_0 \propto m(t)\cdot\cos\phi$



$v_1 = A_c[1+k_a m(t)]\cos 2\pi f_c t$

$v_2 = A_c^2[1+k_a m(t)]\cos 2\pi f_c t \cdot \cos[2\pi f_c t+\phi]$

$c'(t) = A_c\cos(2\pi f_c t+\phi)$

$$V_2 = \frac{A_c^2}{2}[1 + K_a m(t)]\left[\cos[2\pi(2f_c t) + \phi] + \cos\phi\right]$$

$\downarrow$ LPF

$$V_0 = \frac{A_c^2}{2} K_a m(t) \cos\phi$$

$$V_0 \propto m(t)\cos\phi$$

if $\phi = 90^\circ$

$V_0 = 0 \Rightarrow$ quadrature null Effect

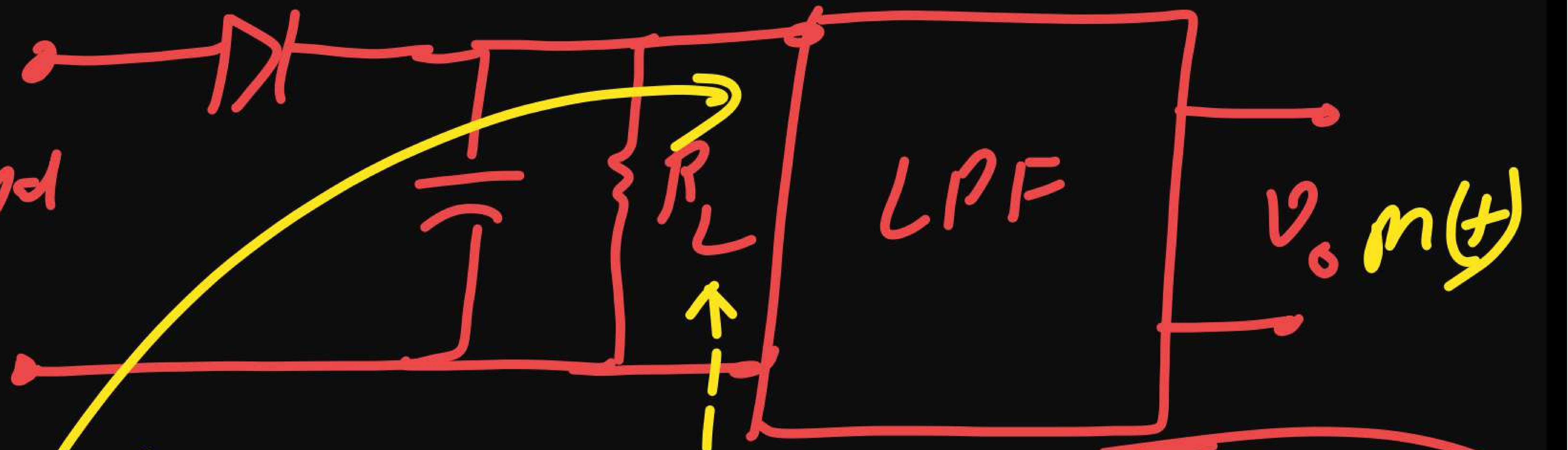
Adv: No limitation of μ.

Disadv: Same time Demodulation is not possible. (Quadrature Null Effect)

Demodulation of AM Signal

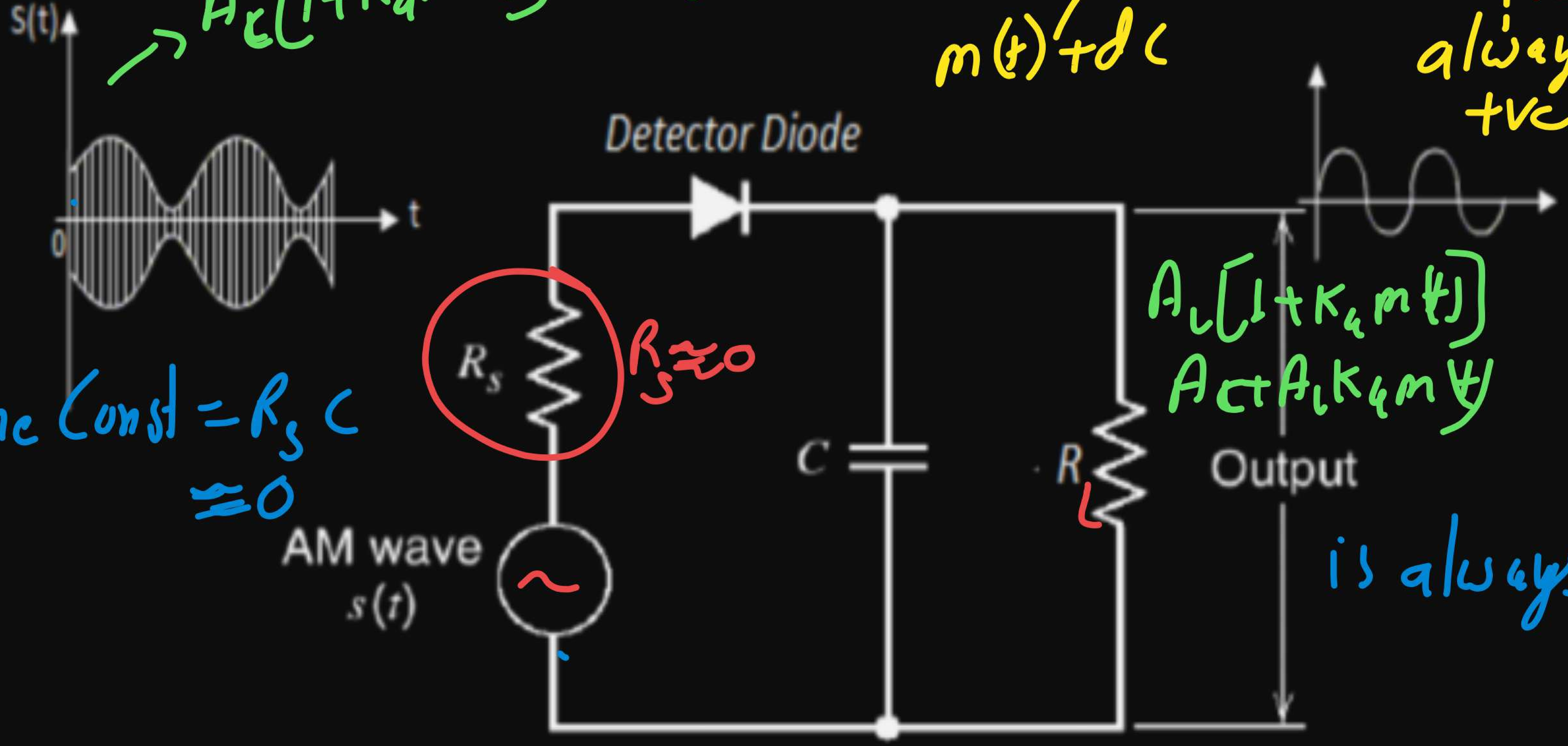
Non Coherent (Asynchronous)

Envelope Detector



$V_0 \propto m(t)$

$A_c[1+K_a m(t)]\cos 2\pi f_c t$



$R_s \approx 0$

Charging Time Const $= R_s C \approx 0$

$A_c[1+K_a m(t)]$

$A_c + A_c K_a m(t)$

is always +ve

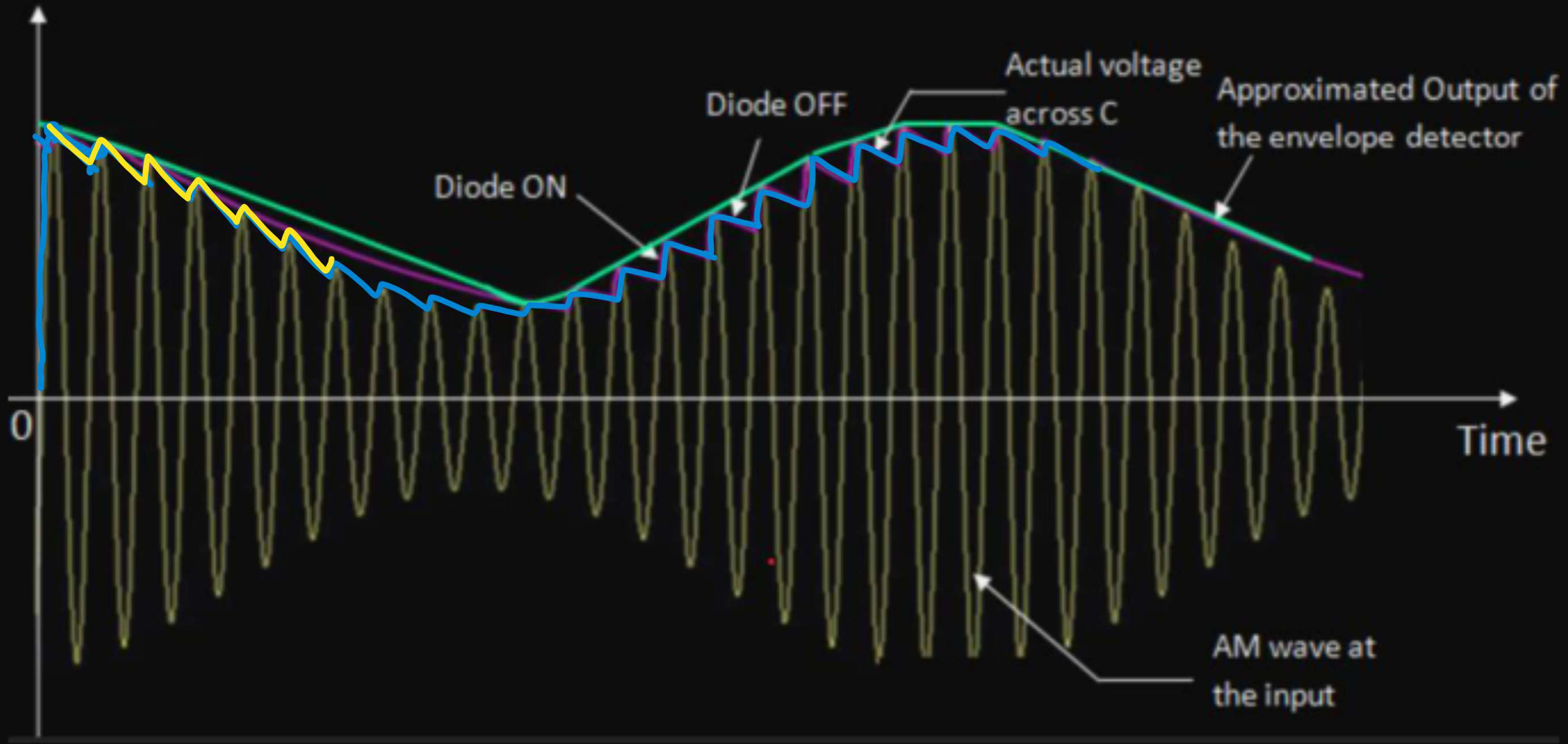
$R_s << L$

$R_L >> L$

Demodulation of AM Signal

Envelope Detector (Cont..)

Discharging Time Const. $= R_L C >> 1$



μ>1
ED
|A_c[1+K_a m(t)]|
μ<1
ED
A_c[1+K_a m(t)]
A_c
0
A_c K_a m(t)

Demodulation of AM Signal

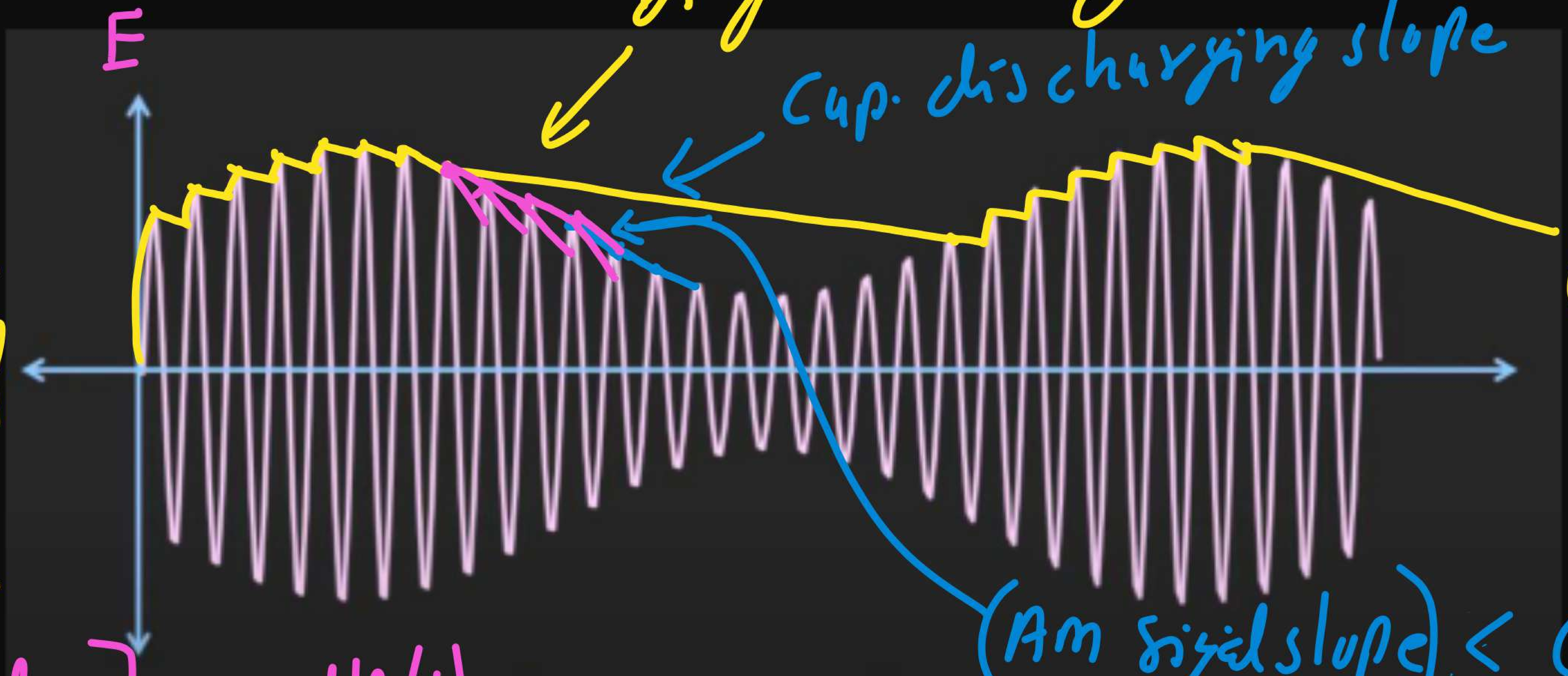
(ii) Diagonal clipping arises:

$R_s C << \frac{1}{f_c}$

Envelope Detector (Cont..)

limitation:

Demodulation is only possible for AM signal having $M \le 1$



$$\frac{1}{f_c} << R_L C << \frac{1}{f_m}$$

$$R_L C \le \frac{1}{2\pi f_m}\left(\frac{\sqrt{1-M^2}}{M}\right)$$

$(\text{AM signal slope})_{max} \le$ Cap. discharging slope

$$\left[\frac{dE}{dt}\right]_{min} \le \frac{dv_c(t)}{dt}$$

$$\frac{1}{f_c} << RC << \frac{1}{f_m}.$$

To avoide diagonal clipping:

$\mu \leq 1$

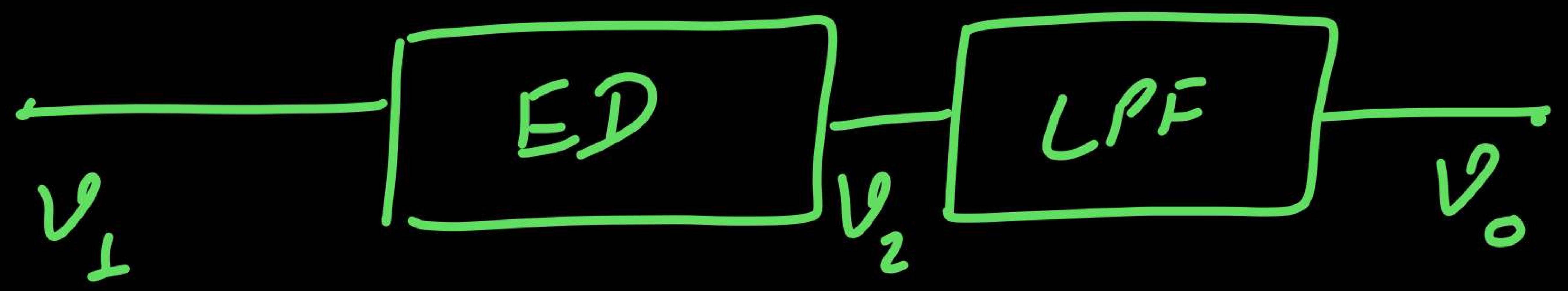
$$\frac{1}{f_c} << R_L C << \frac{1}{f_m}$$

$$R_L C \leq \frac{1}{\omega_m} \cdot \frac{\sqrt{1-\mu^2}}{\mu}$$

$$R_L C \leq \frac{1}{2\pi f_m} \sqrt{\frac{1-\mu^2}{\mu^2}}$$

$$R_s C << \frac{1}{f_c}$$

X



(i) $v_1 = A_c[1 + k_a m(t)]\cos 2\pi f_c t \longrightarrow v_2 = \left|A_c(1 + k_a m(t))\right| \longrightarrow v_0 = A_c\left|1 + k_a m(t)\right|$

$(\mu > 1)$

$= A_c\left|[1 + k_a m(t)]\right|$

(ii) $v_1 = A_c[1 + k_a m(t)]\cos 2\pi f_c t \longrightarrow v_2 = A_c[1 + k_a m(t)] \longrightarrow v_0 = A_c k_a m(t)$

$(\mu \le 1)$

$v_2 = A_c + A_c k_a m(t)$

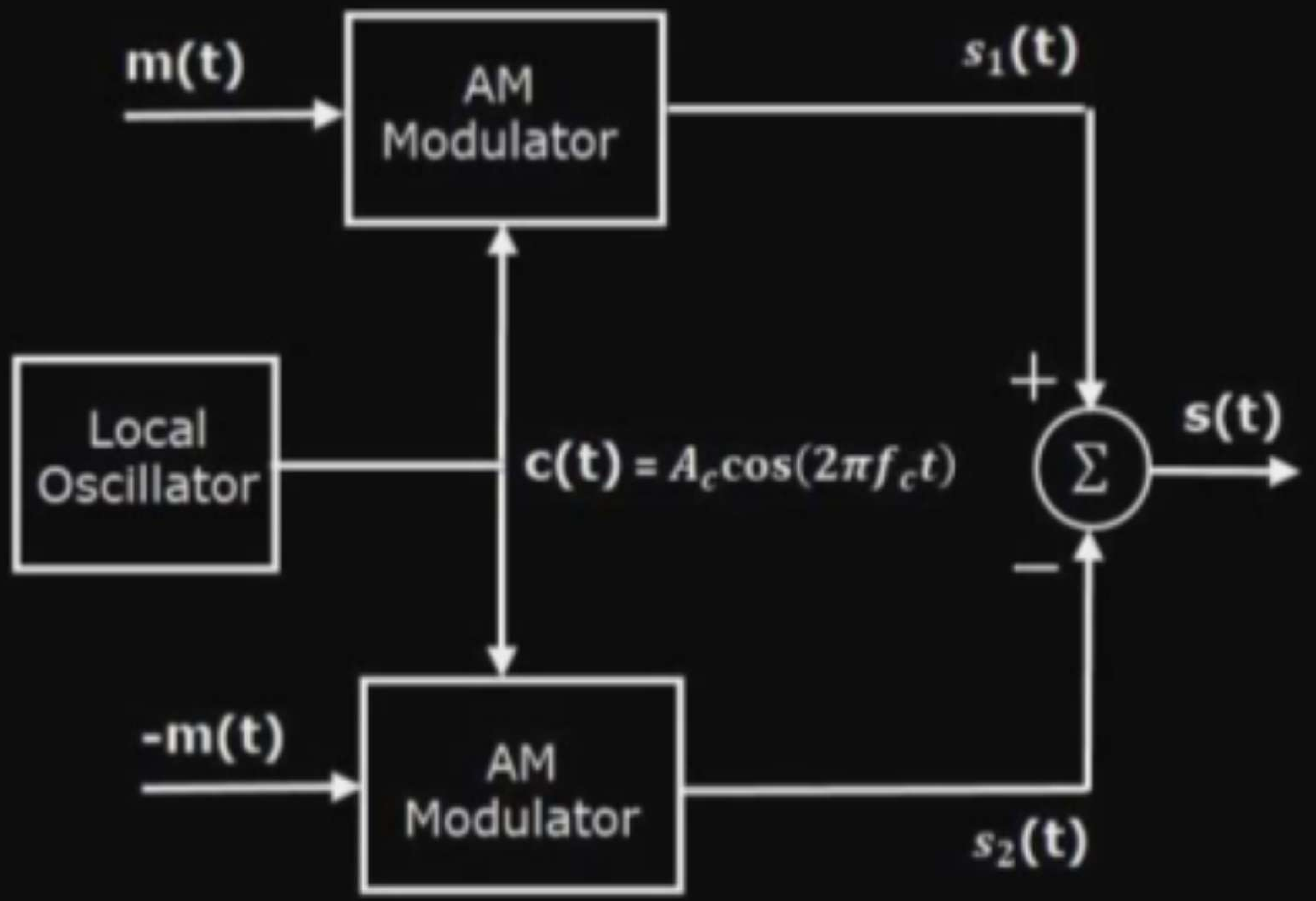
$v_0 \propto m(t)$

(iii) $v_1 = m(t) A_c \cos 2\pi f_c t \longrightarrow v_2 = \left|A_c m(t)\right| = A_c\left|m(t)\right| \longrightarrow v_0 = A_c\left|m(t)\right|$

Double Side Band (DSB-SC) Modulation

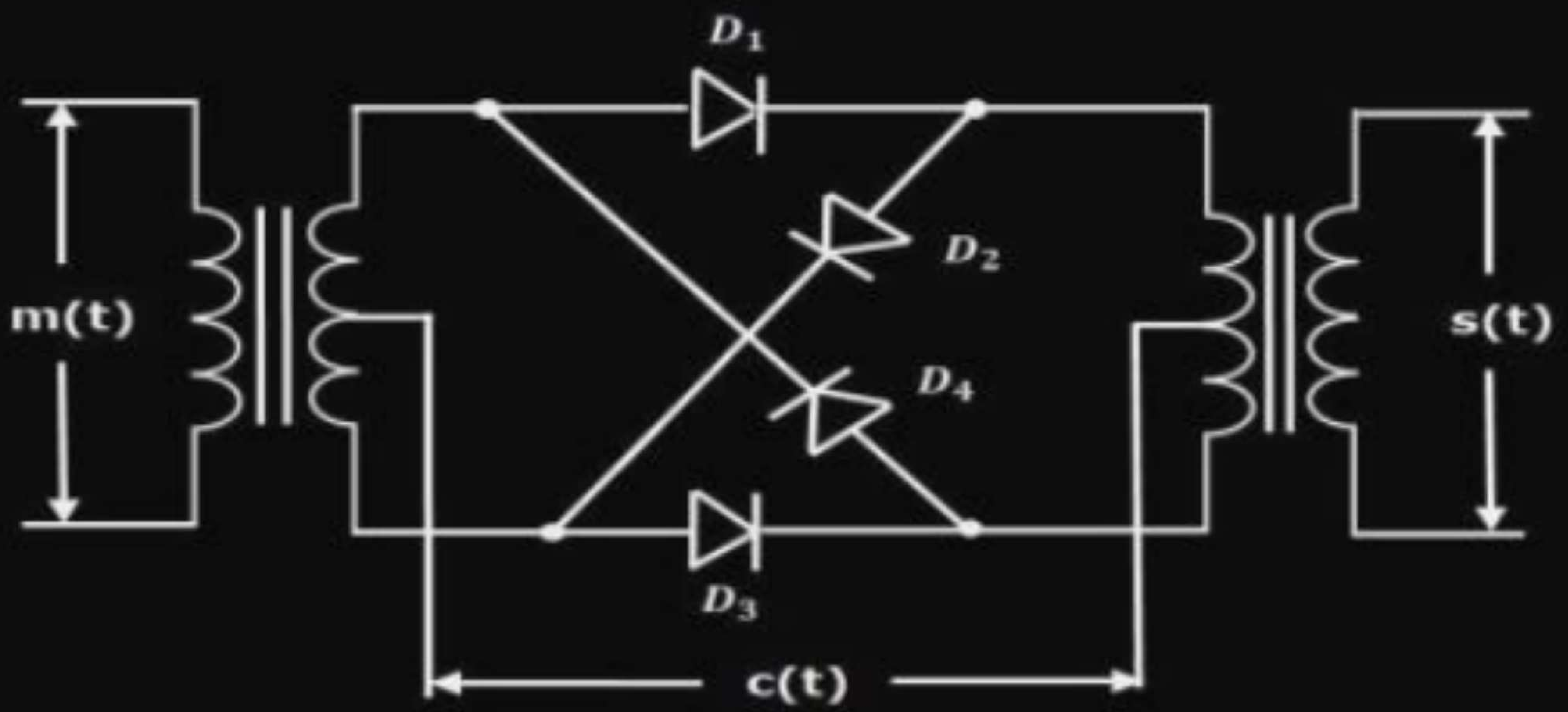
Generation of Double Side Band (DSB-SC)

Balanced Modulator



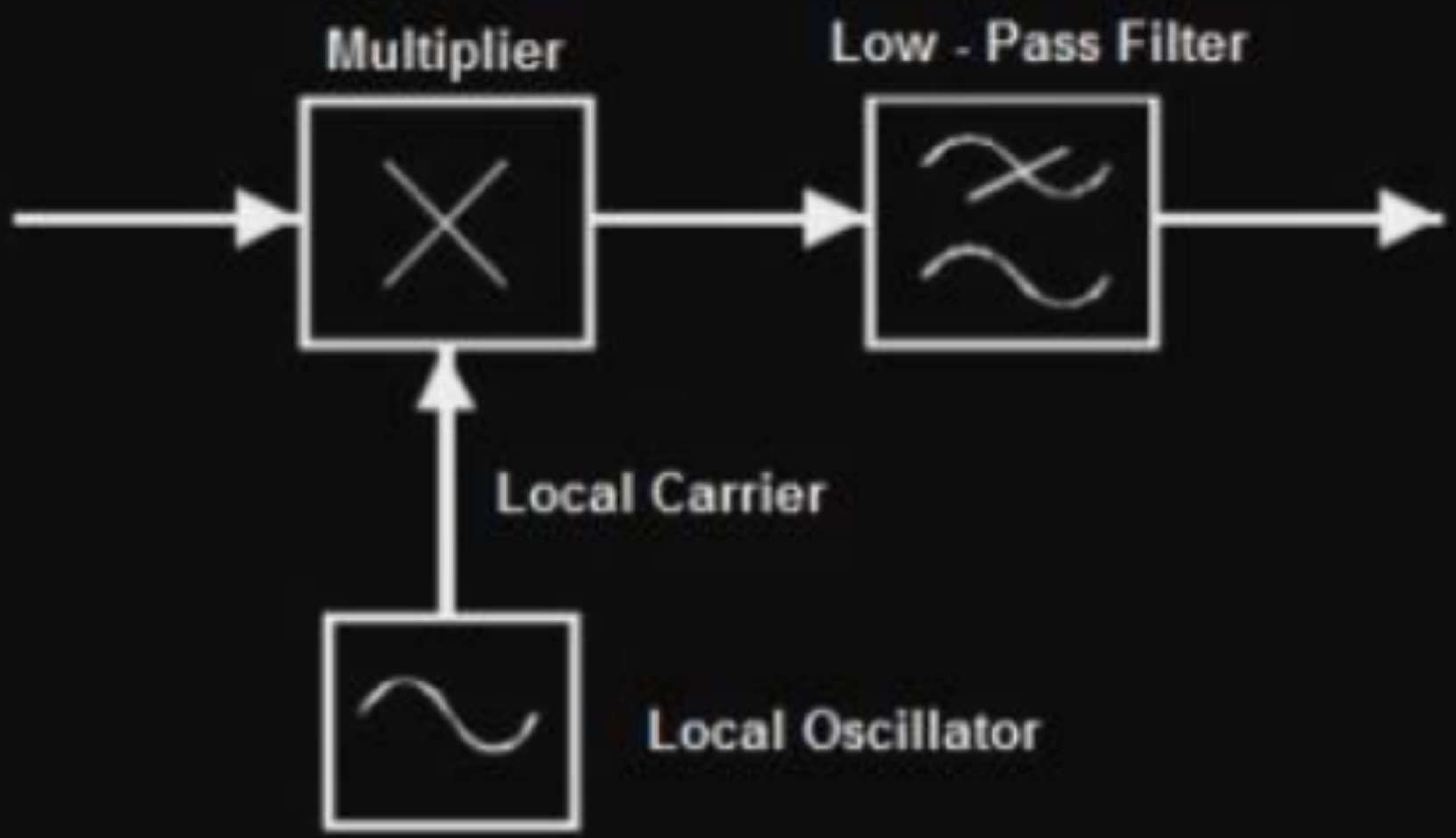
Generation of Double Side Band (DSB-SC)

Ring Modulator



Demodulation of Double Side Band (DSB-SC)

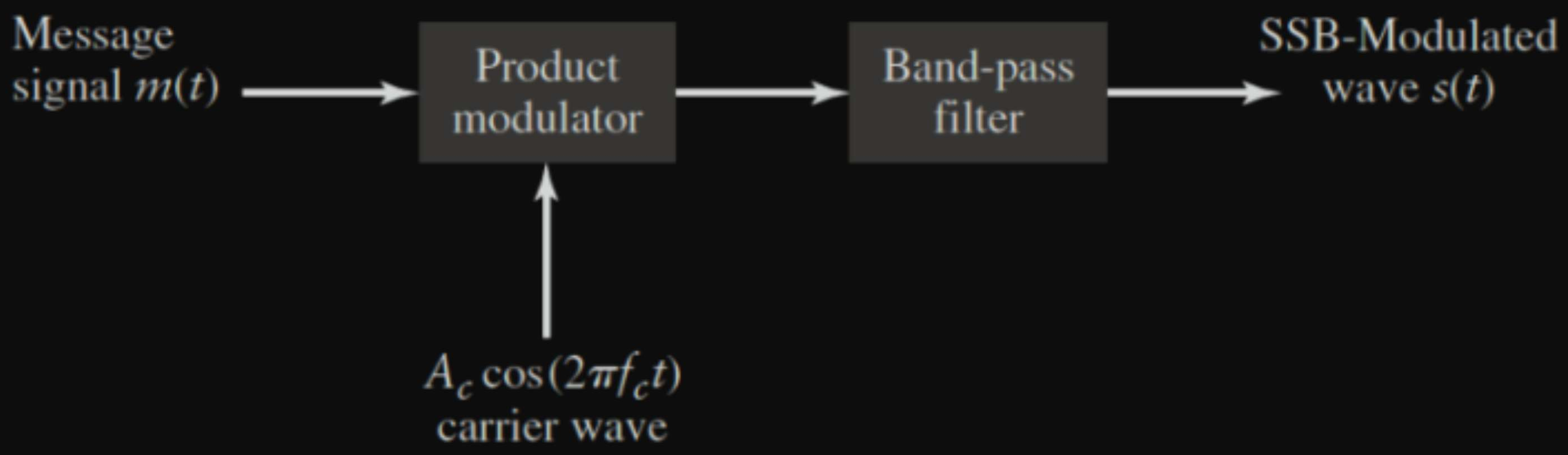
Synchronous Detector



Single Side Band (SSB-SC) Modulation

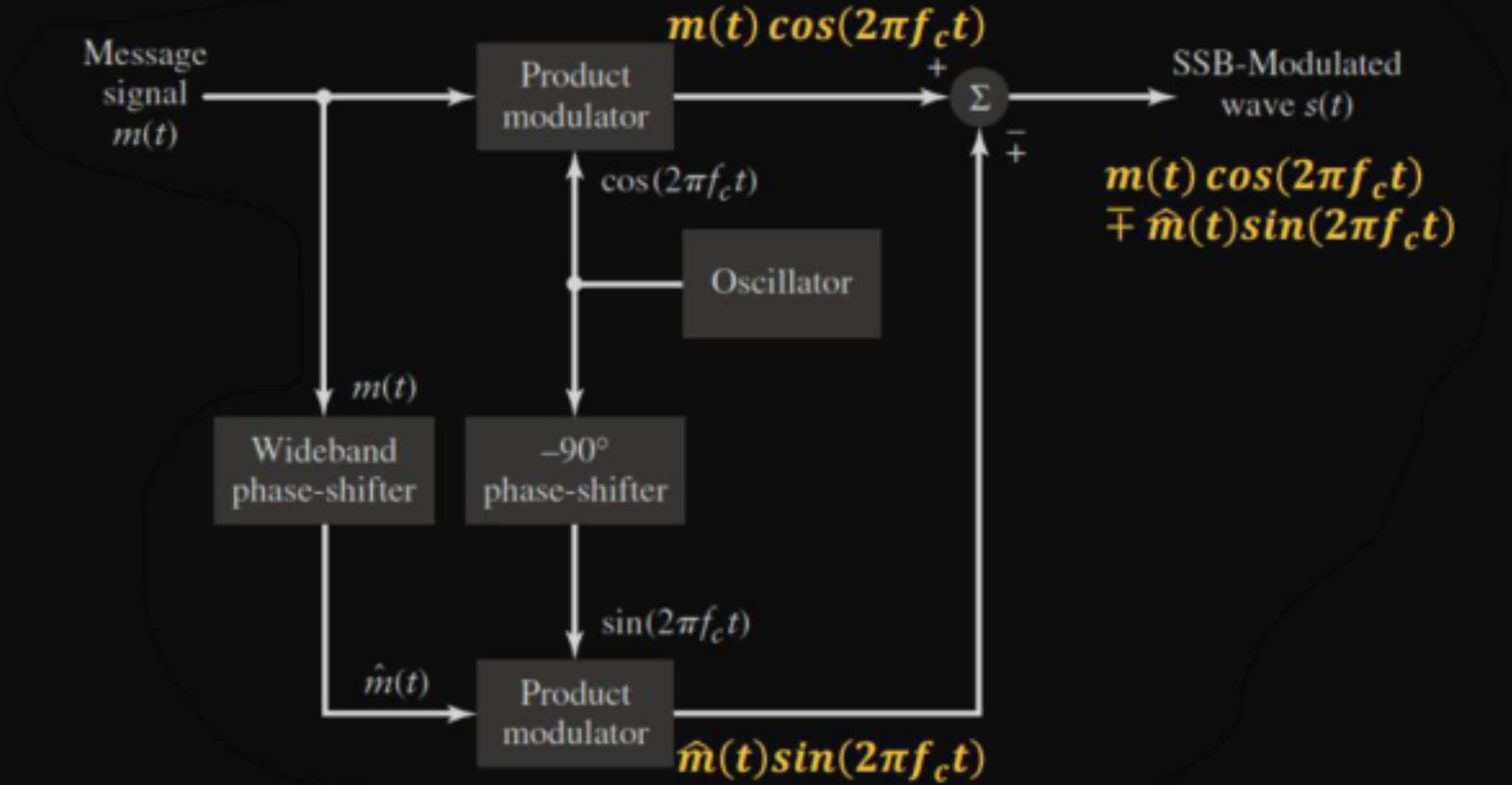
Generation of Single Side Band (SSB-SC)

Frequency Discrimination Method (Filter Method)



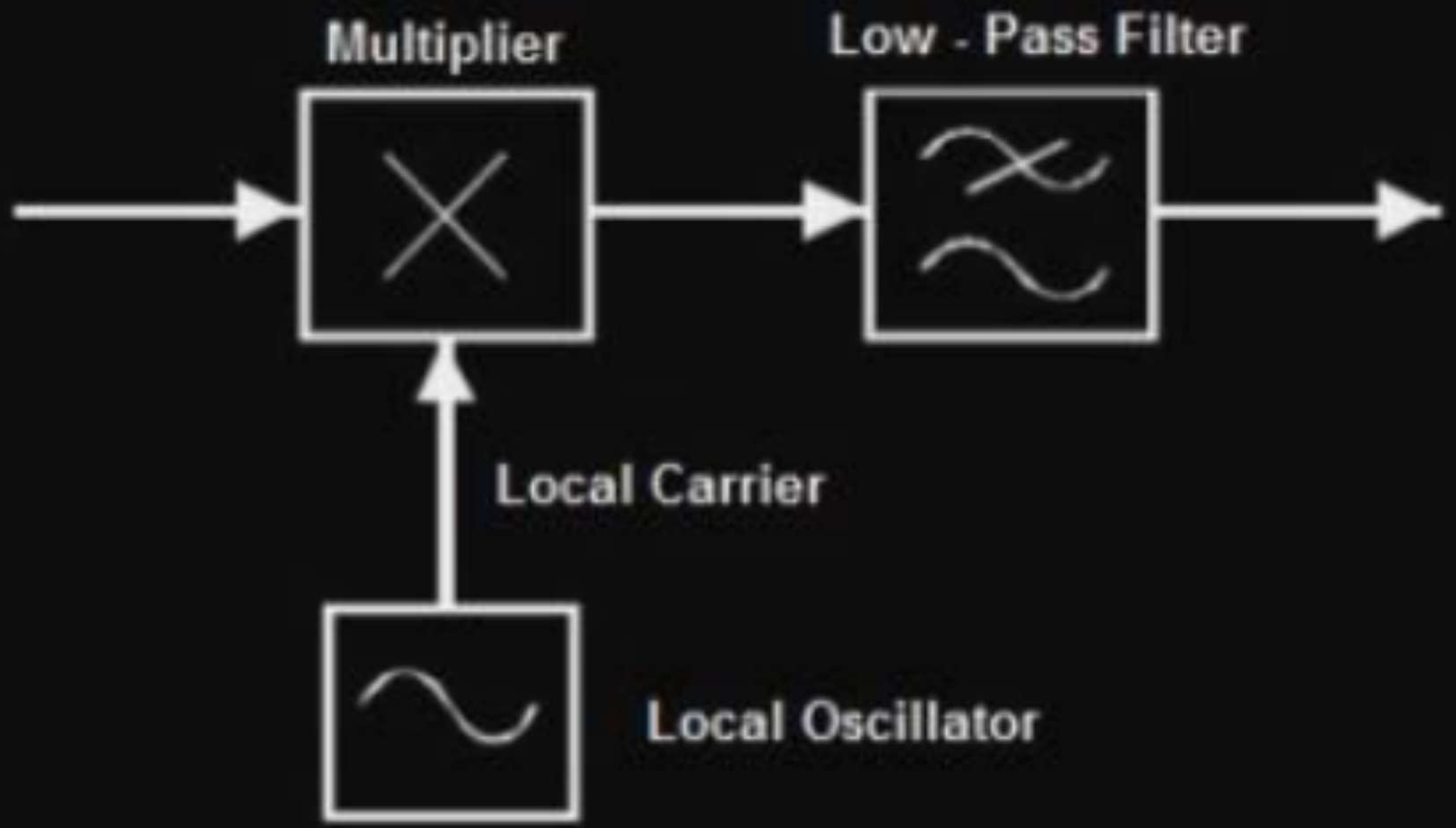
Generation of Single Side Band (SSB-SC)

Phase Discrimination Method



Demodulation of Single Side Band (SSB-SC)

Synchronous Detector



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