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TO Adda247

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

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GATE 2024
GATE
प्रचण्ड Batch
Communication System
PROBLEMS FROM AM &
DSB-SC, SSB-SC MODULATION
ECE

Chapter-1

Analog Communications

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

1. *Double Side Band (DSB-SC) Modulation and Demodulation*
2. *Single Side Band (SSB-SC) Modulation and Demodulation*
3. *Percentage Power Saving in All Amplitude Modulations*
4. *Problems from All Amplitude Modulations (AM/DSB/SSB)*

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Double Side Band (DSB-SC) Modulation → Overmodulated signal, $K_a = 1$

$\mu = A_m \rightarrow$ single tone

$$s(t)\Big|_{Am} = \underbrace{A_c \cos 2\pi f_c t}_{\text{Carrier}} + \underbrace{A_c K_a m(t) \cos 2\pi f_c t}_{\text{SB}}$$

Carrier

X

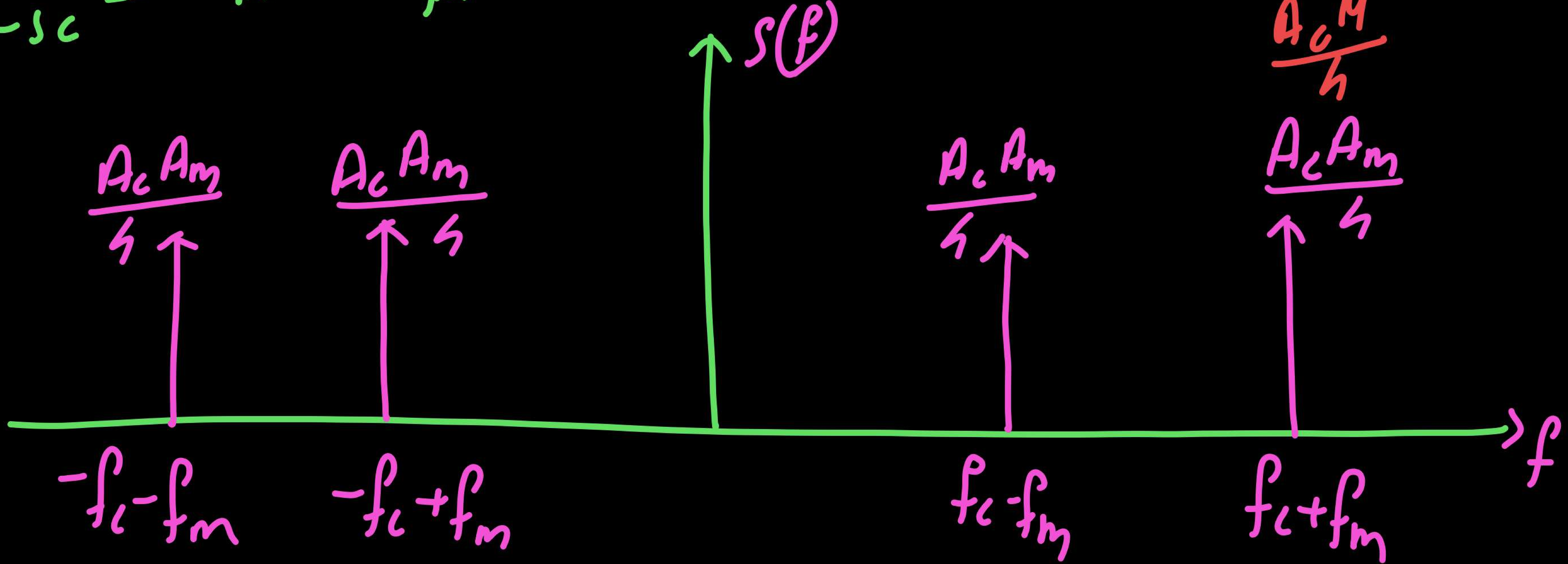
$$s(t)\Big|_{DSB-SC} = A_c m(t) \cos 2\pi f_c t = m(t) \cdot c(t) = m(t) A_c \cos 2\pi f_c t$$

$K_a = 1$, $\mu_a = K_a |m(t)|_{max} = K_a A_m$

$$\mu_a\Big|_{DSB-SC} = A_m$$

Single tone modulation:

$$s(t)\Big|_{DSB-SC} = A_m \cos 2\pi f_m t \cdot A_c \cos 2\pi f_c t$$

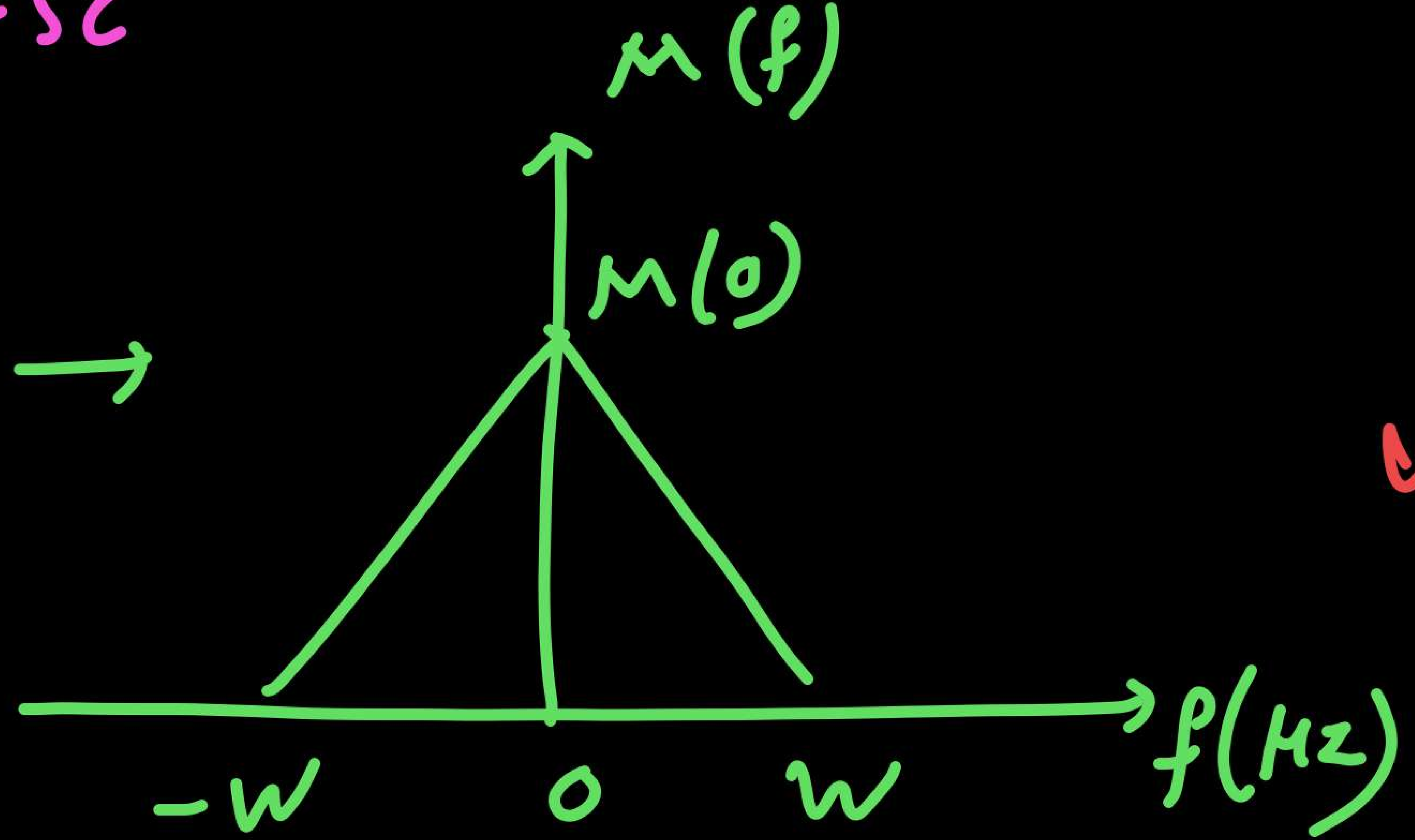


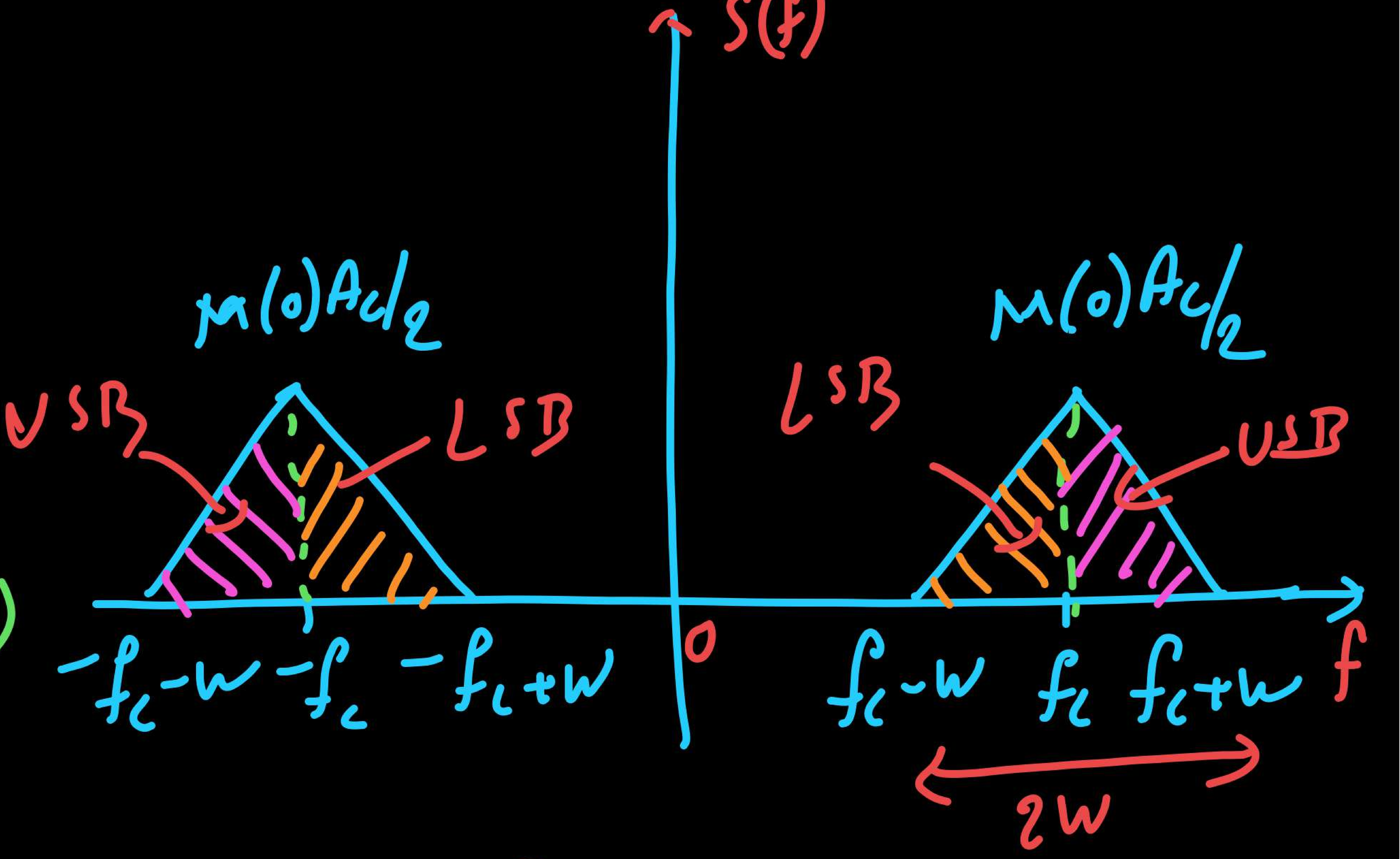
$$P_{avg} = P_t = P_c M^2/2 = P_c A_m^2/2 \Leftarrow \text{single tone} = \frac{A_c^2 A_m^2}{4} = P_{SB} = P_{total} = P_{avg}$$

$$P_{USB} = P_{LSB} = \frac{A_c^2 A_m^2}{8}$$

$$s(t)\Big|_{DSB-SC} = m(t)\cdot A_c \cos 2\pi f_c t$$

$m(t) \longrightarrow$





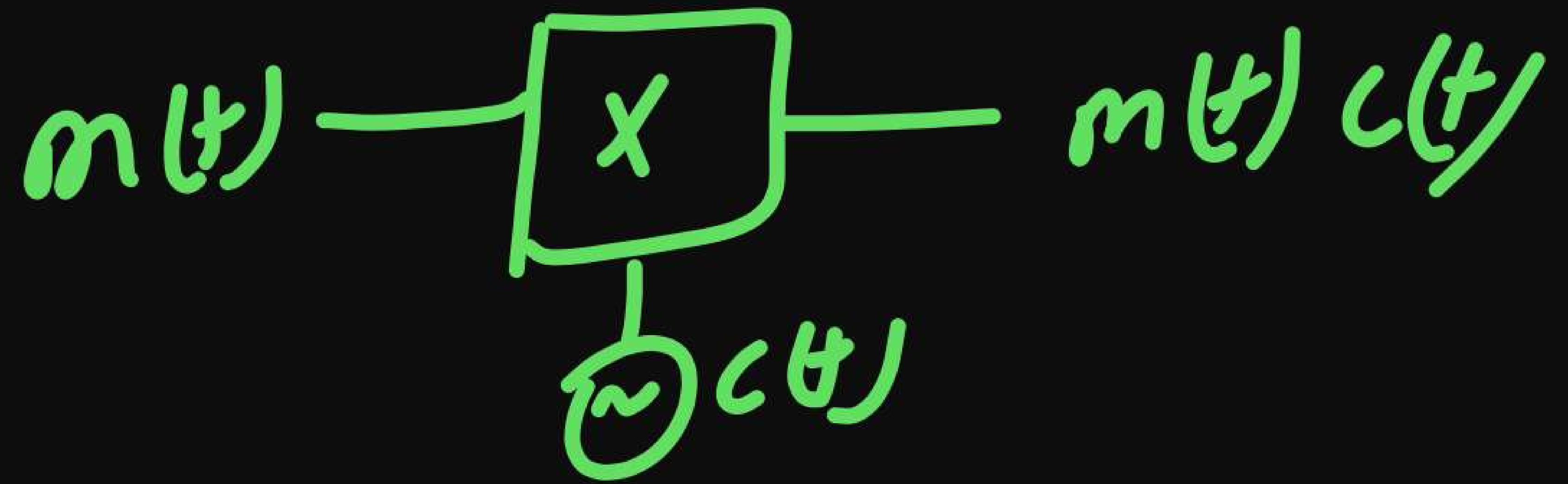
$$BW\Big|_{DSB-SC} = 2W$$

$$P_t = P_{avg} = P_{SB} = P_c A_m^2/2 = P_c\,\overline{m^2(t)} = \frac{A_c^2}{2}\,\overline{m^2(t)}$$

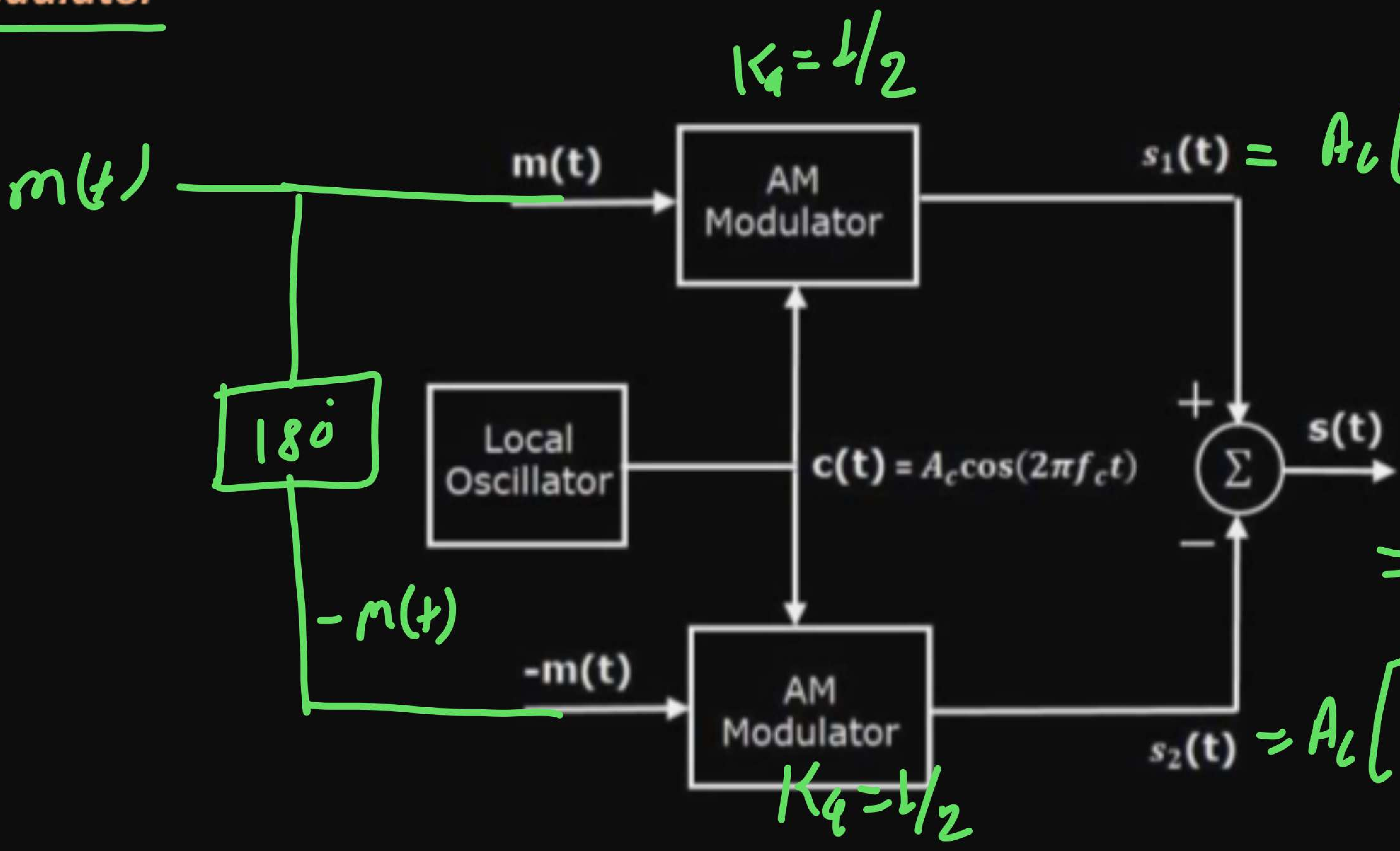
$$\%\eta = \frac{P_{useful}}{P_{total}} \times 100\%$$

$$= \frac{P_{SB}}{P_{total}} \times 100\% = 100\%$$

Generation of Double Side Band (DSB-SC)



Balanced Modulator

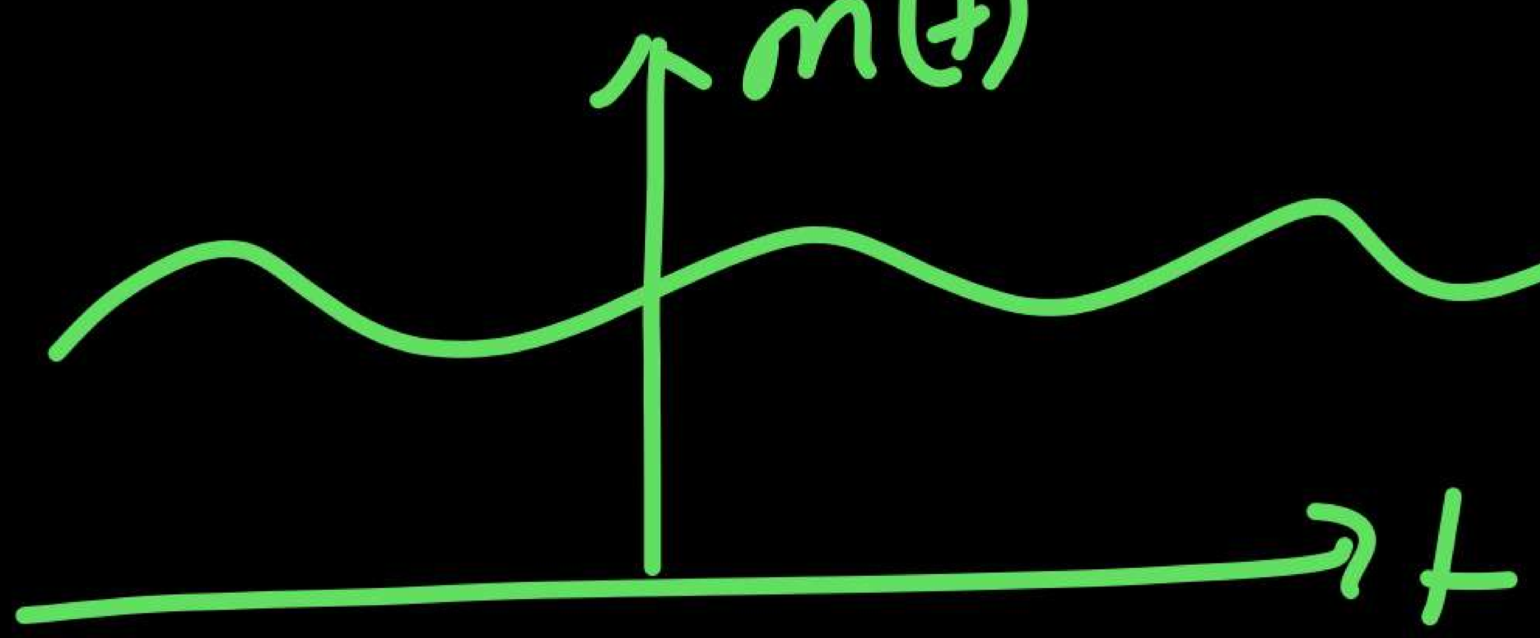


$$s_1(t) = A_c[1 + K_a m(t)]\cos 2\pi f_c t$$

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

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

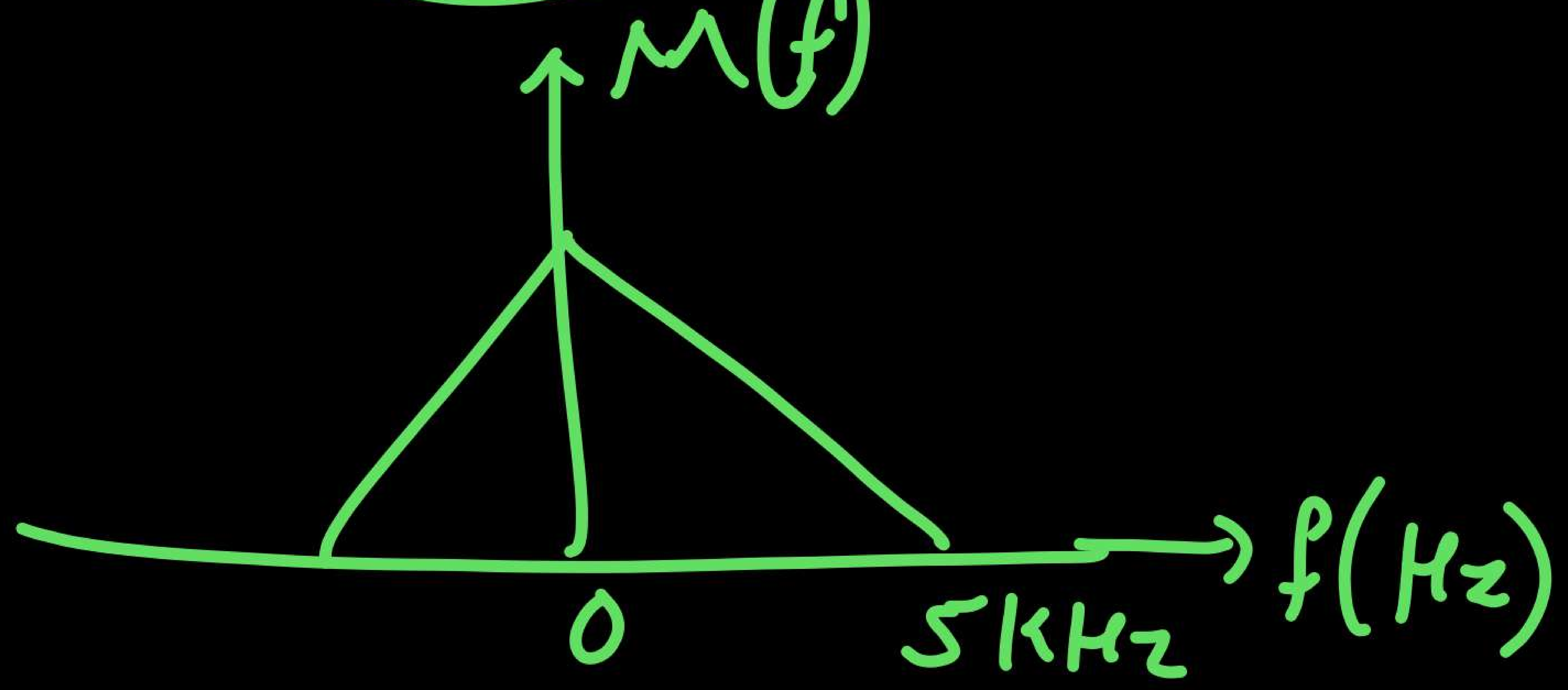
$$s_2(t) = A_c[1 - K_a m(t)]\cos 2\pi f_c t$$

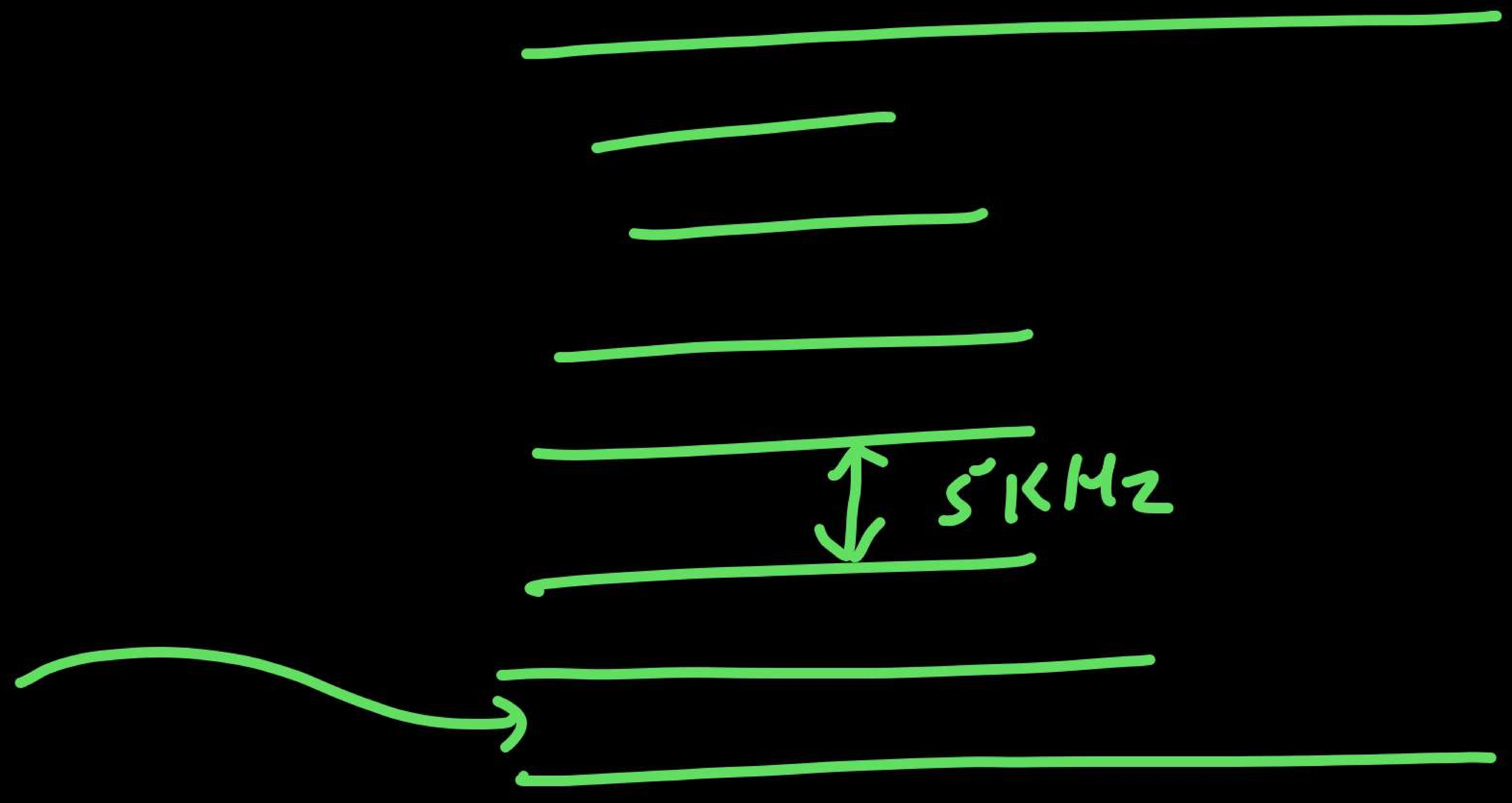


→ M(f)

300 - 3.5KHz

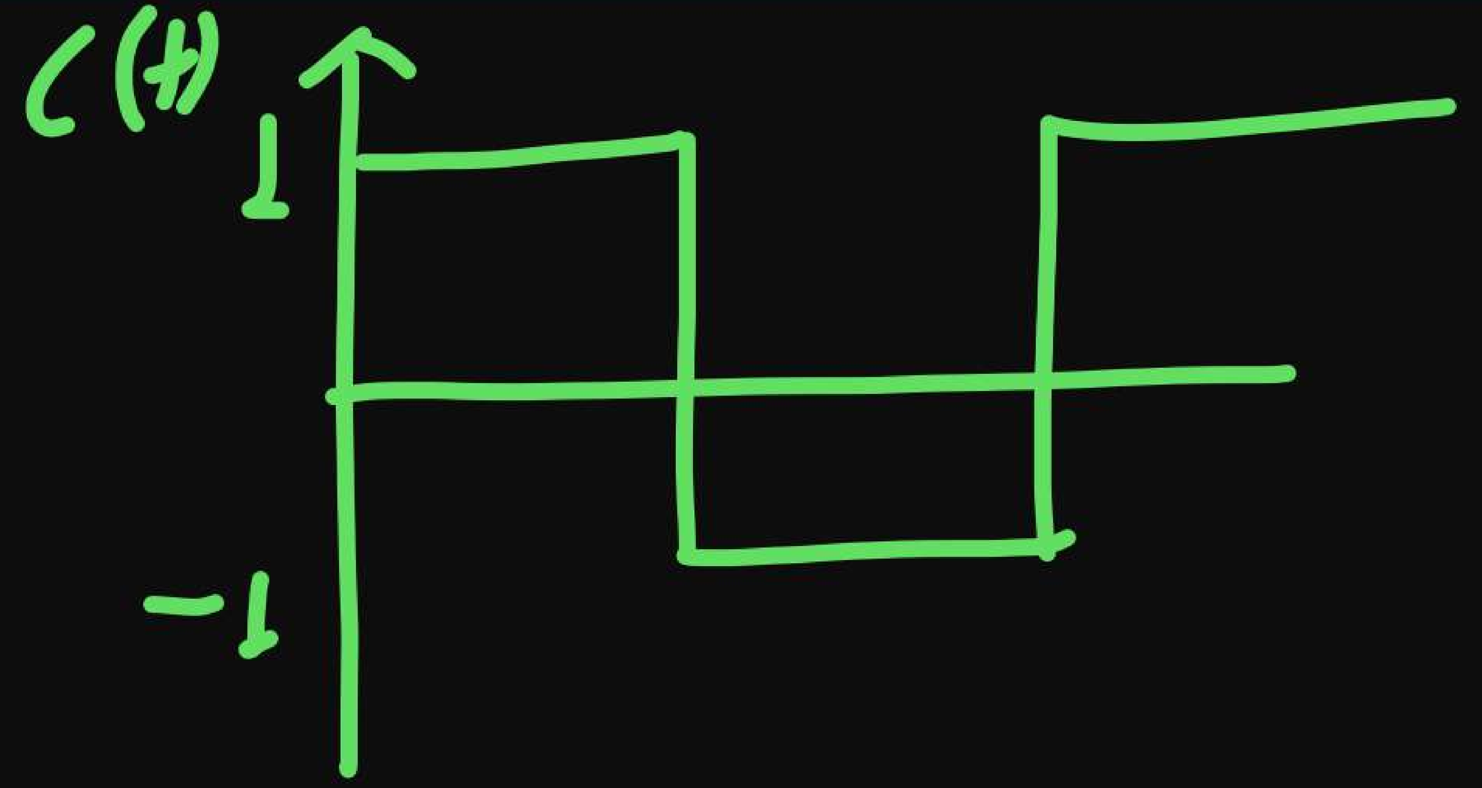
5KHz





Generation of Double Side Band (DSB-SC)

Ring Modulator



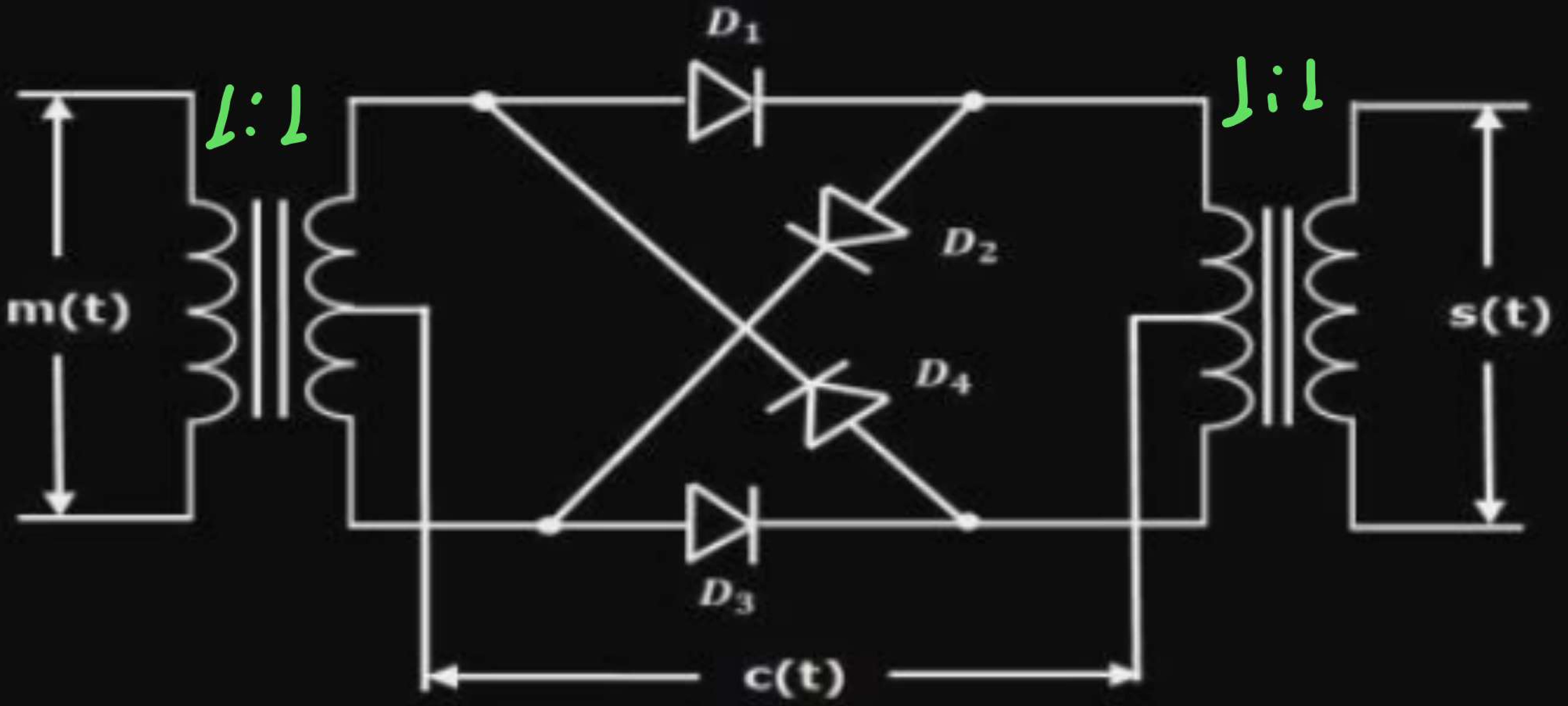
$c(t) = +ve$

D_1 & D_3 = FB, D_2 & D_4 = RB

$c(t) = -ve$

= D_2 & D_4 = FB

= D_1 & D_3 = RB



$$\left.\begin{aligned} s(t) &= m(t)\cdot 1 \\ &= -m(t) \\ &= m(t) \times -1 \end{aligned}\right\} m(t)c(t)$$

No use in general modulation

Demodulation of Double Side Band (DSB-SC)

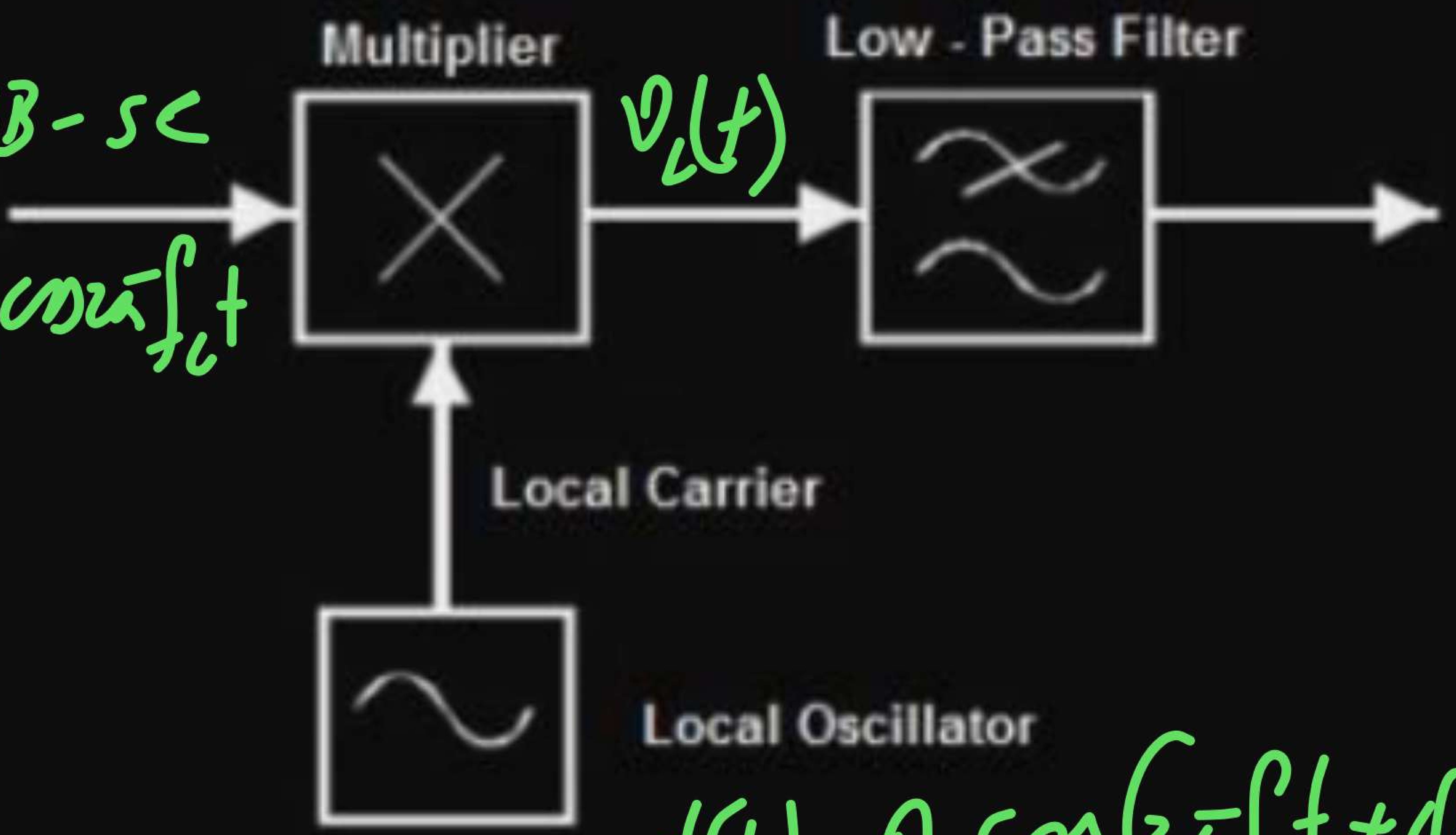
Synchronous Detector

overmodulated

DSB - SC

$m(t) A_c \cos 2\pi f_c t$

$v_1(t)$



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

$v_0(t) \propto m(t)$

$v_0(t) = \frac{A_c^2}{2} m(t) \cos\phi$

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

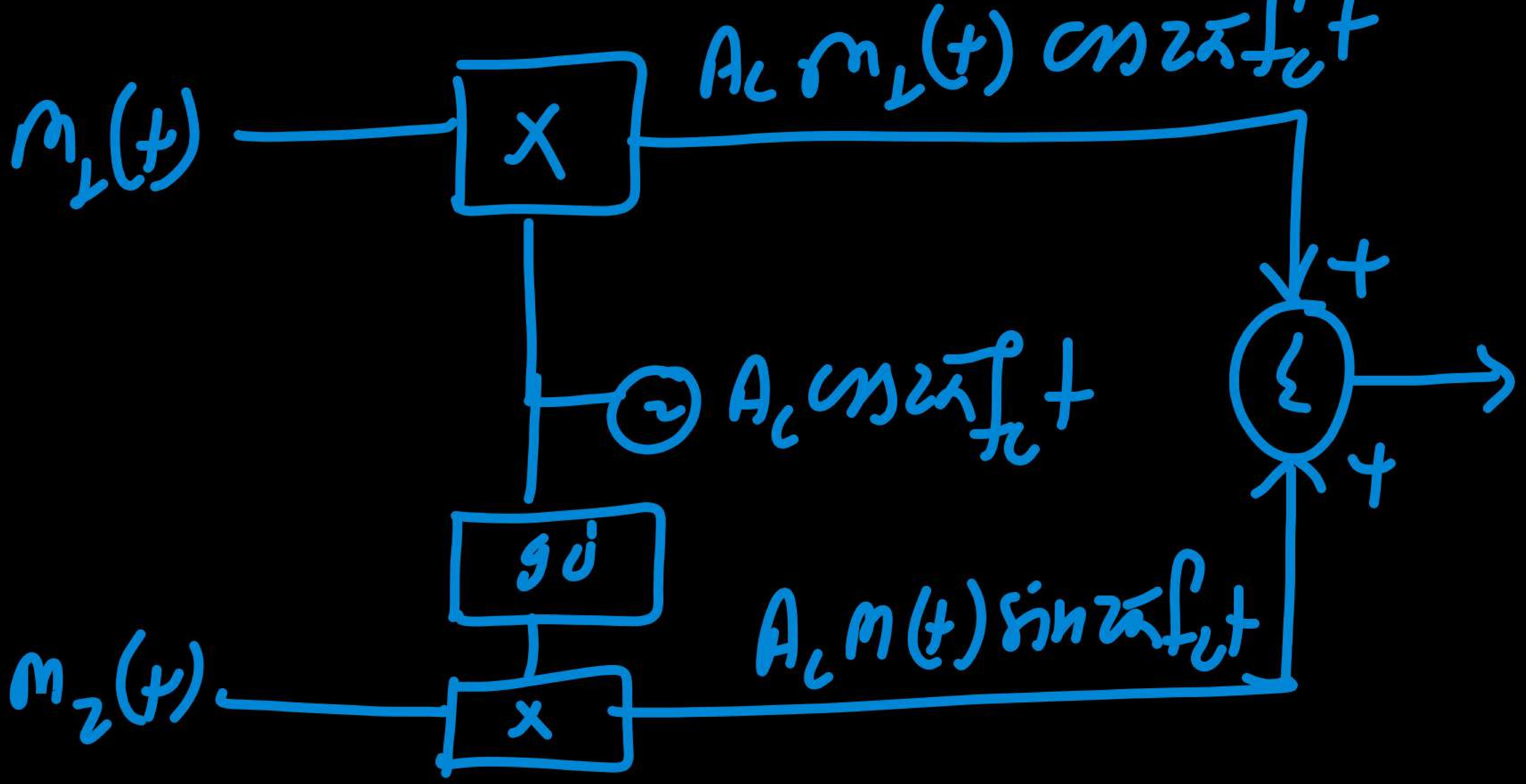
if $\phi = 90°$

$v_0(t) = 0$ (QNE)

Application of DSB-SC

⇒ Quadrature Amplitude Modulation [QAM]
⇒ Quadrature Carrier Multiplexing [QCM]
} Same

$$\left.\begin{aligned} s_1(t) &= m_1(t)\, A_c \cos 2\pi f_c t \\ s_2(t) &= m_2(t)\, A_c \sin 2\pi f_c t \end{aligned}\right] +$$



$$QAM = m_1(t) A_c \cos 2\pi f_c t + m_2(t) A_c \sin 2\pi f_c t$$

Single Side Band (SSB-SC) Modulation → Overmodulated

$K_a = 1$, $\mu = A_m$

Spectrum of SSB-SC

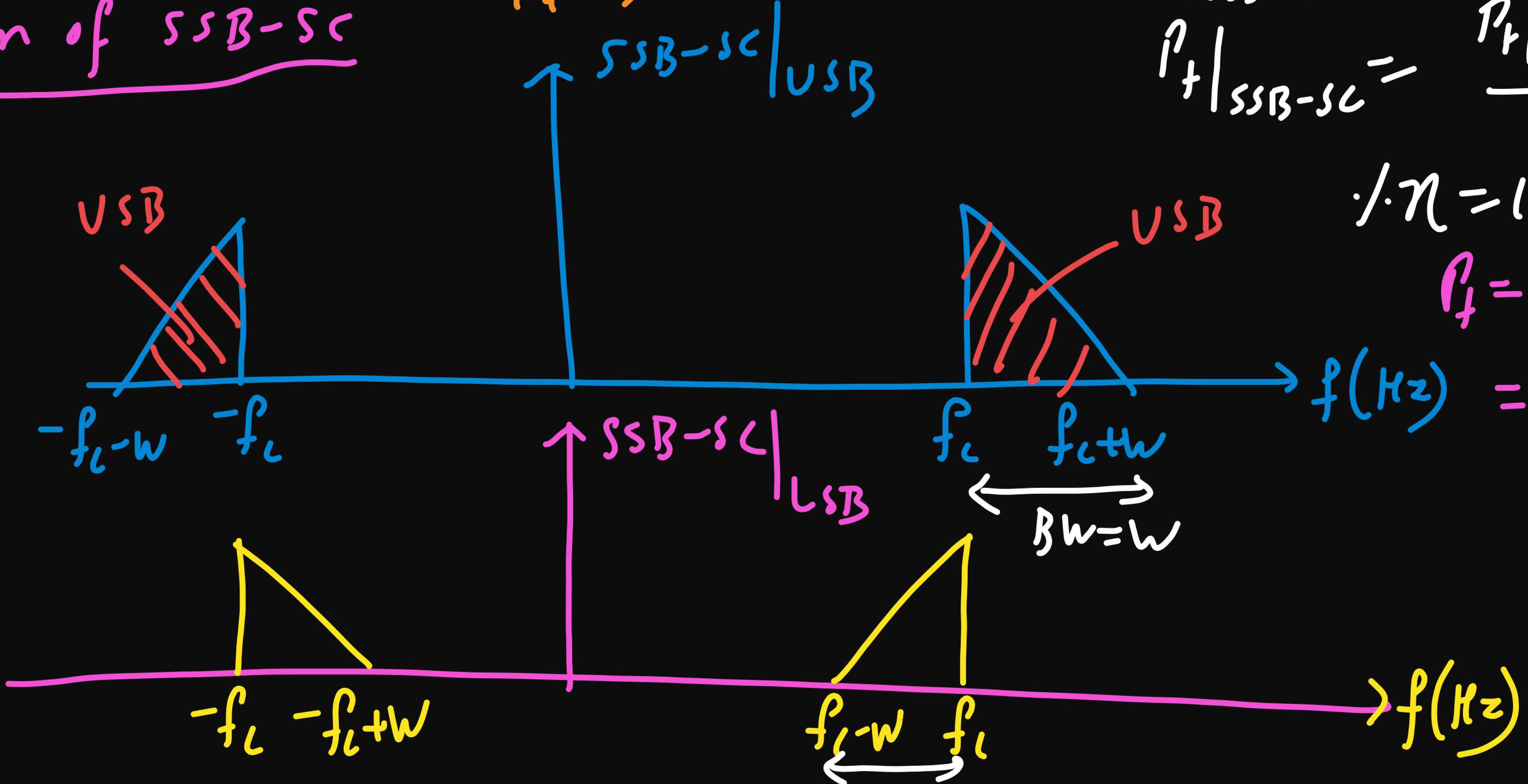
$BW|_{SSB-SC} = W$

$P_t|_{SSB-SC} = \frac{P_t|_{DSB-SC}}{2}$

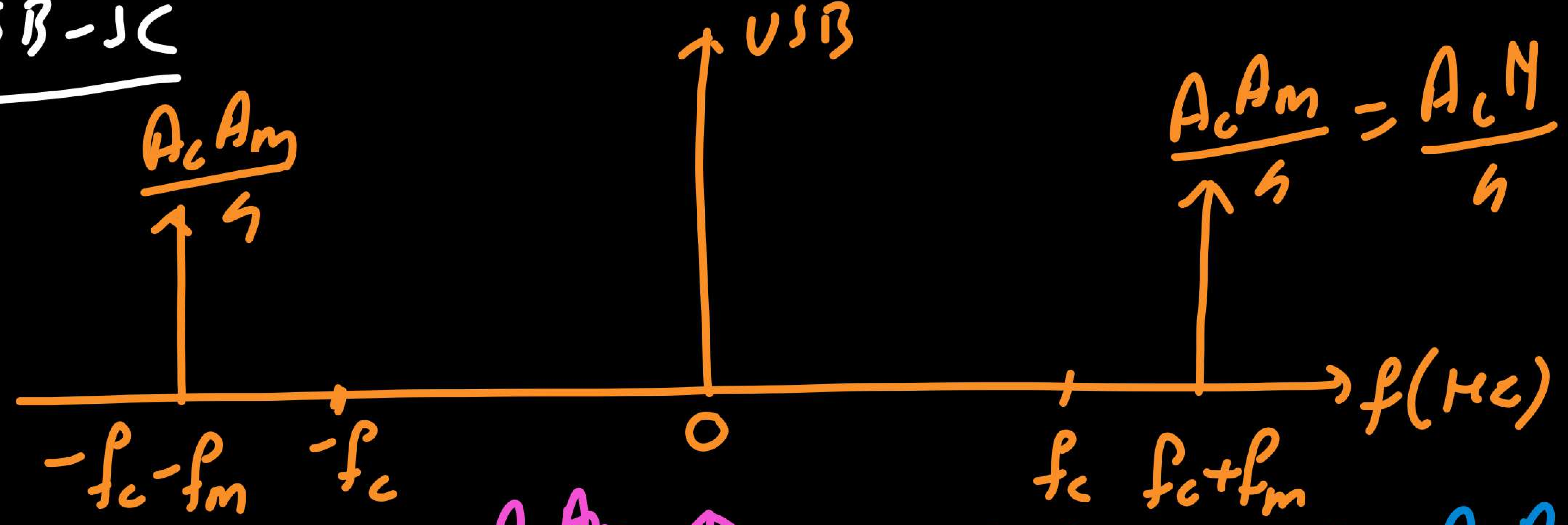
$\%\eta = 100\%$

$P_t = \frac{P_c}{2}\overline{m^2(t)}$

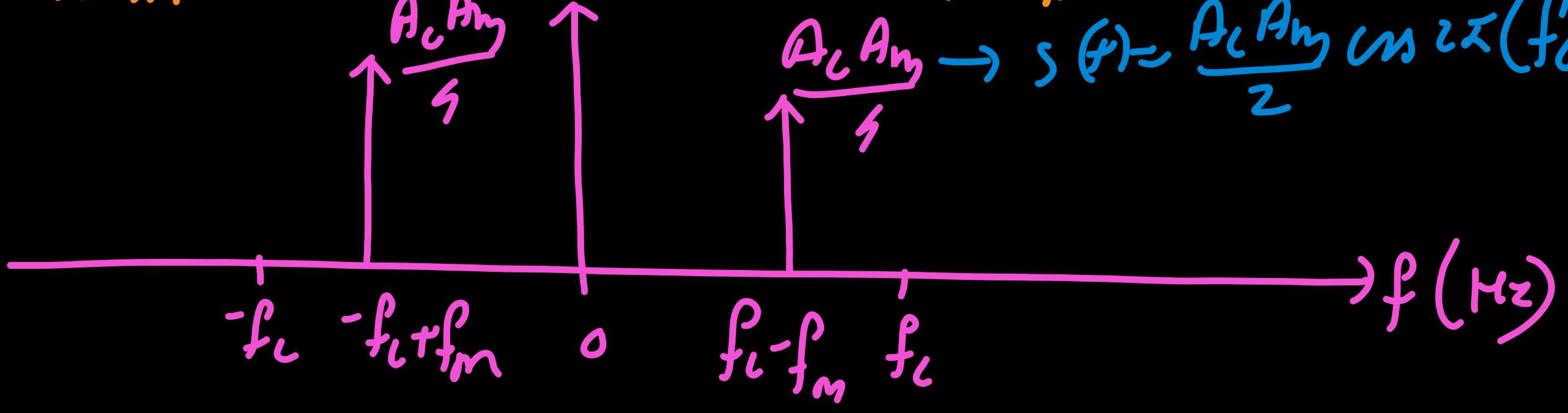
$= \frac{A_c^2}{4}\overline{m^2(t)}$



Single tone SSB-SC



$s(t) = \frac{A_c A_m}{2} \cos 2\pi (f_c+f_m) t$



$\rightarrow s(t) = \frac{A_c A_m}{2} \cos 2\pi (f_c - f_m) t$

$$P_t = P_{avg} = P_{SSB-SC} = P_{USB} = P_{LSB} = \frac{P_{SB}}{2} = \frac{P_{DSB-SC}}{2} = P_c \frac{\mu^2}{4} = P_c \frac{A_m^2}{4} = \frac{A_c^2 A_m^2}{8}$$

$BW = W = f_m$, $\% \eta = 100\%$

Time domain Eq. of SSB-SC

Single tone $\Rightarrow$ $S(t)\Big|_{SSB-SC} = \frac{A_c A_m}{2} \cos 2\pi (f_c \pm f_m) t$

'+' = USB
'−' = LSB

$\left.\begin{array}{l} BW = f_m \\ P_t = \frac{A_c^2 A_m^2}{8} \end{array}\right.$

$\% \eta = 100\%$

$S(t)\Big|_{DSB-SC} = \underbrace{\frac{A_c A_m}{2} \cos 2\pi (f_c + f_m) t}_{USB} + \underbrace{\frac{A_c A_m}{2} \cos 2\pi (f_c - f_m) t}_{LSB}$

$BW = 2 f_m$

$P_t = P_c \frac{A_m^2}{2} = \frac{A_c^2 A_m^2}{4}$

$\% \eta = 100\%$

$S(t)\Big|_{AM} = \underbrace{A_c \cos 2\pi f_c t}_{Carrier} + \underbrace{\frac{A_c M}{2} \cos 2\pi (f_c + f_m) t}_{USB} + \underbrace{\frac{A_c M}{2} \cos 2\pi (f_c - f_m) t}_{LSB}$

$BW = 2 f_m$

$\% \eta = \frac{M^2}{2 + M^2} \times 100\%$

$P_t = P_c + P_c \frac{M^2}{4} + P_c \frac{M^2}{4}$

* $s(t)\big|_{Am} = A_c \cos 2\pi f_c t + A_c K_a m(t) \cos 2\pi f_c t$

* $s(t)\big|_{DSB-SC} = A_c m(t) \cos 2\pi f_c t$

* $s(t)\big|_{SSB-SC} \rightarrow$ single tone $= \frac{A_c A_m}{2} \cos 2\pi (f_c \pm f_m) t$ '+' = USB
'−' = LSB

$$= \frac{A_c A_m}{2} \left[\cos 2\pi f_c t \cos 2\pi f_m t \mp \sin 2\pi f_c t \sin 2\pi f_m t \right]$$

$$= \frac{1}{2} m(t) \cdot A_c \cos 2\pi f_c t \mp \frac{1}{2} \hat{m}(t) A_c \sin 2\pi f_c t$$

$$\boxed{s(t)\big|_{SSB-SC} = \frac{A_c}{2} m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t}$$

'−' = USB
'+' = LSB

$$(BW)_{AM} = (BW)_{DSB-SC} > (BW)_{SSB-SC}$$
$$= 2W \qquad = 2W \qquad = W$$

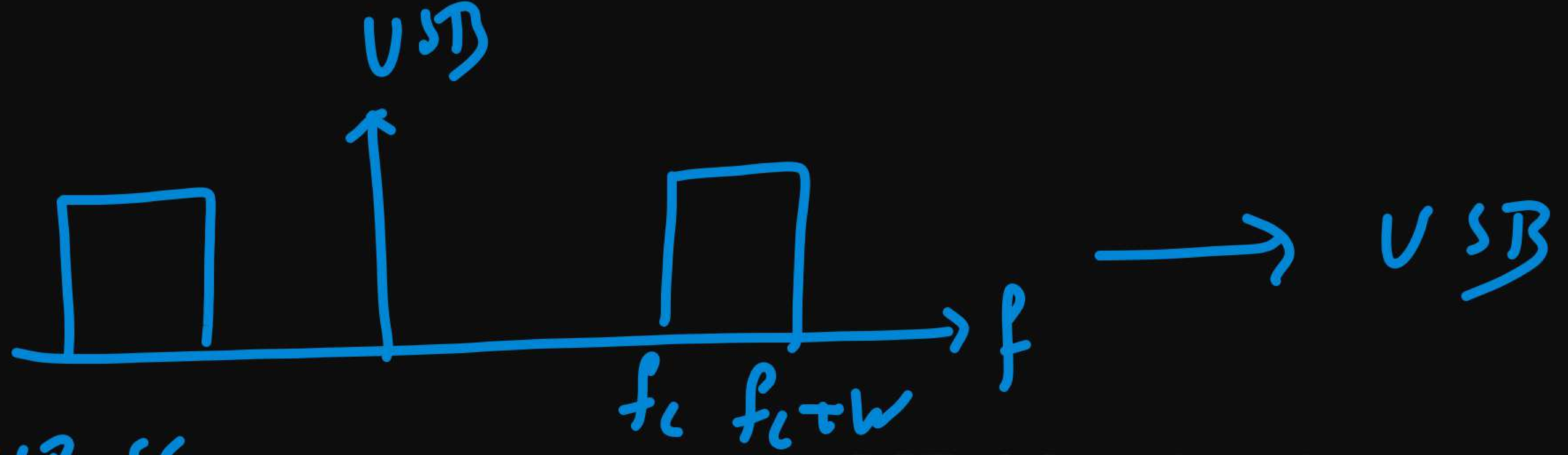
$$(P_t)_{AM} > (P_t)_{DSB-SC} > (P_t)_{SSB-SC}$$

$$(\%\eta)_{AM} < (\%\eta)_{DSB} = (\%\eta)_{SSB-SC}$$
$$100\% \qquad 100\%$$

Generation of Single Side Band (SSB-SC)

Frequency Discrimination Method (Filter Method)

This method is only applicable for voice signal.

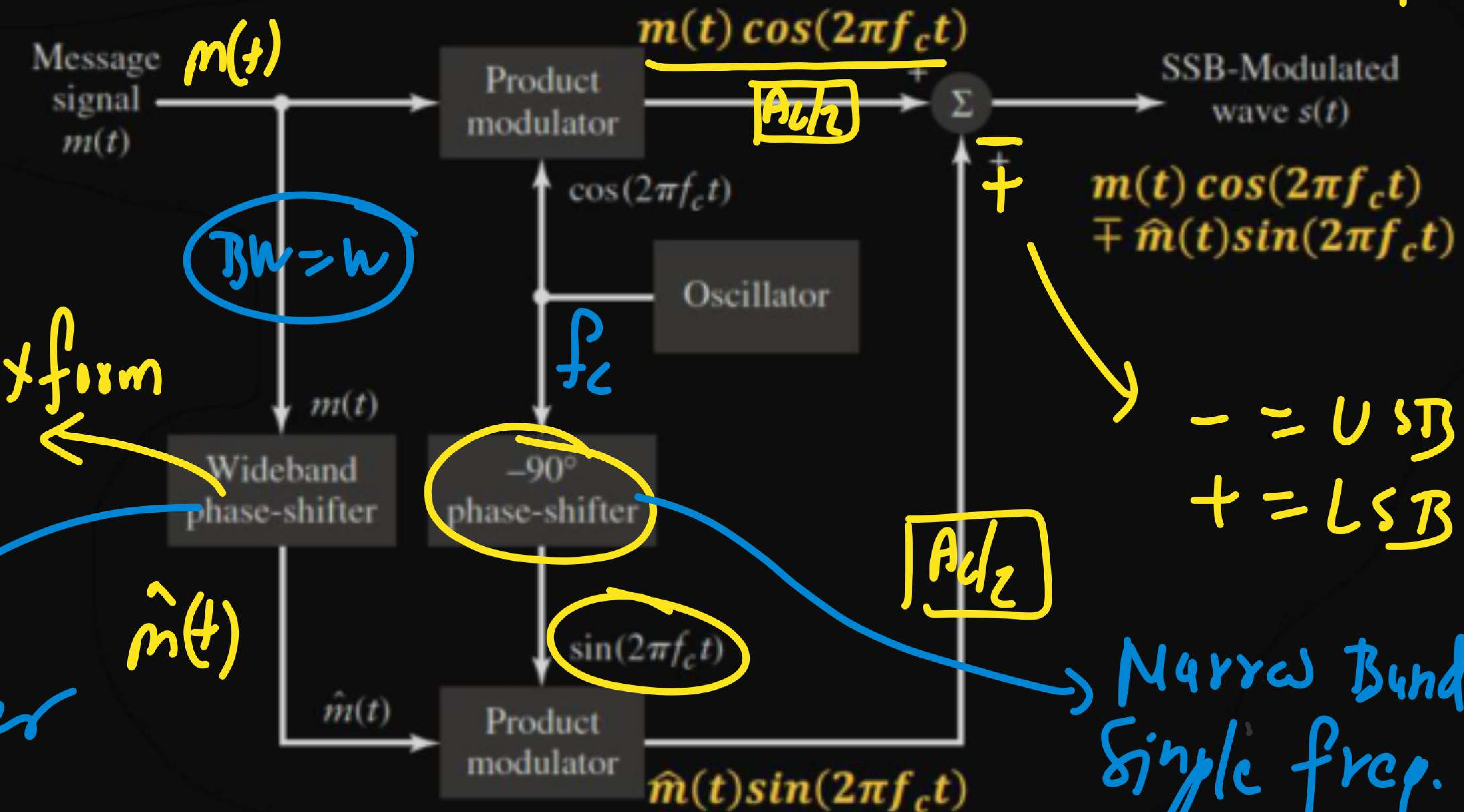


M(f)|Voice
-3500 -300 300 3500
DSB.SC
600
f_c-300 f_c f_c+300
M(f)|Audio
-20000 -20 20 20000
DSB-SC
40
f_c
M(f)|Video
-4.5M 4.5M
f_c

Generation of Single Side Band (SSB-SC)

Phase Discrimination Method

$= \frac{A_c}{2} m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$



$m(t)$

$\boxed{A_c/2}$

$\mp$

$BW = W$

f_c

$\hat{m}(t)$

$\boxed{A_c/2}$

LTI system → Non Causal ← Hilbert xform

Wideband 90° phase shifter

$- =$ USB

$+ =$ LSB

Narrow Band 90° phase shifter

Single freq. — ″ —

Demodulation of Single Side Band (SSB-SC) → over modulated signal

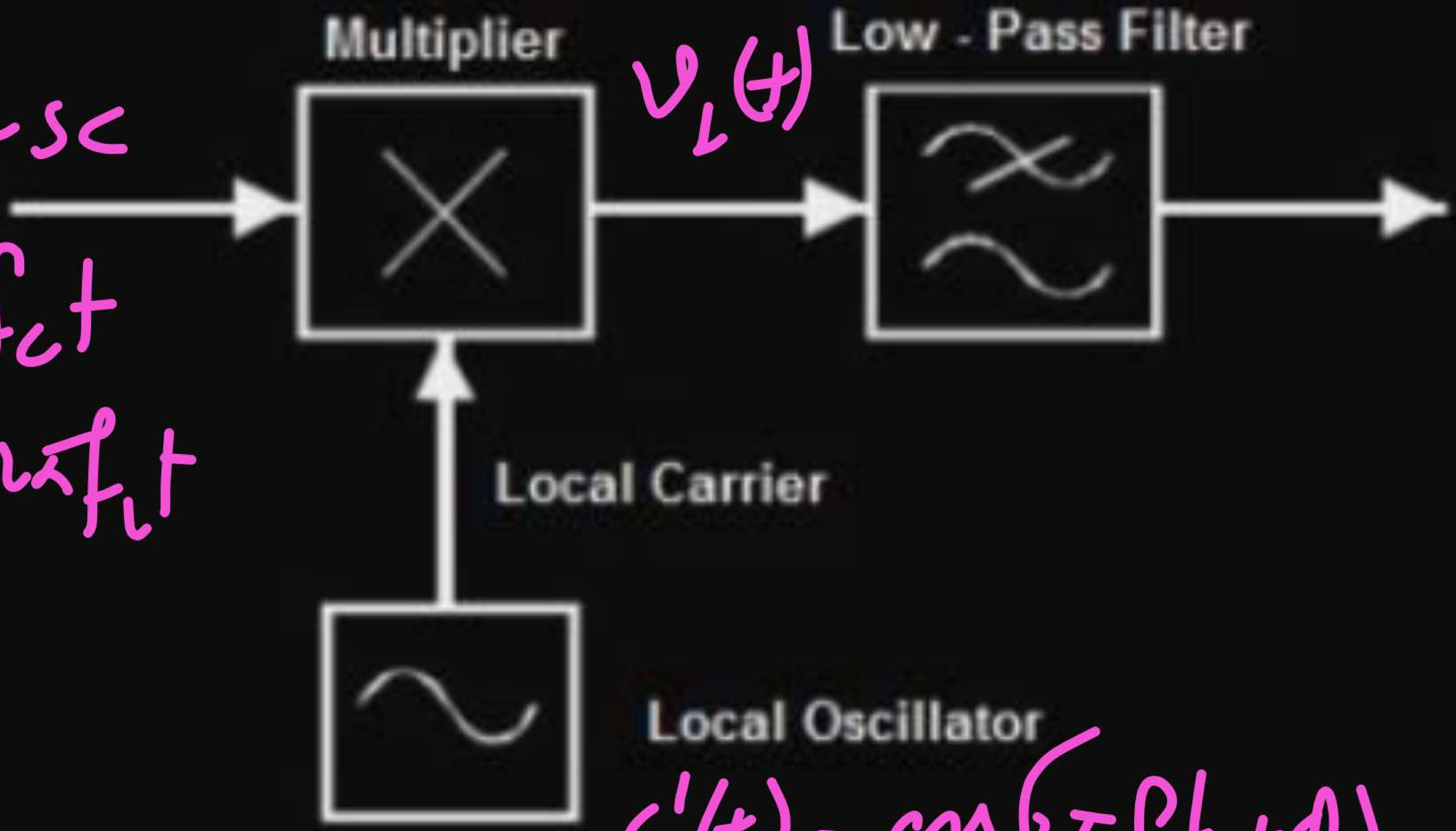
Synchronous Detector

$v_o(t) \propto m(t) \mp \hat{m}(t)$

SSB-SC

$= m(t)\cos 2\pi f_c t \mp \hat{m}(t)\sin 2\pi f_c t$

$v_1(t)$



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

$v_o(t) \propto m(t)$

$v_o(t) \propto \hat{m}(t)$

$v_o(t) \propto m(t) \mp \hat{m}(t)$

$v_1(t) = \left(m(t)\cos 2\pi f_c t \mp \hat{m}(t)\sin 2\pi f_c t\right)\cos(2\pi f_c t + \phi)$

$= m(t)\cos 2\pi f_c t \cdot \cos(2\pi f_c t + \phi) \mp \hat{m}(t)\sin 2\pi f_c t \cdot \cos(2\pi f_c t + \phi)$

$\downarrow$ LPF

$v_0(t) = \frac{m(t)}{2}\cos\phi \mp \frac{\hat{m}(t)}{2}\sin\phi$

for any value of ϕ

$v_0(t) \neq 0$ $\rightarrow$ No quadrature null effect.

for $\phi = 90^\circ$

$v_0(t) \propto \hat{m}(t)$

for $\phi = 0^\circ$

$v_0(t) \propto m(t)$

for $\phi = 45^\circ$

$v_0(t) \propto m(t) \pm \hat{m}(t)$

SSB-SC

Adv: BW is less

Power is less

Demodulation is always possible by Synchronous detector.

No Quadrature Null Effect.

limitations: By using Freq. disc. method (Filter method)

SSB-SC generation of only voice signals possible.

% Power Savings :

$$\% \text{ Power Saving} = \frac{P_{saved}}{P_{ref}} \times 100\%$$

$$\% \text{ Power saving from AM to DSB-SC} = \frac{\text{Power Saved}}{P_{AM}} \times 100\% = \frac{P_c}{P_{AM}} \times 100\% = \frac{P_{Am} - P_{SB}}{P_{Am}} \times 100\%$$

$$= \frac{P_c}{P_c\left[1 + \mu^2/2\right]} \times 100\%$$

$$= \frac{2}{2+\mu^2} \times 100\%$$

$$\text{for } \mu = 1 \quad = \frac{2}{3} \times 100\% = 66.66\%$$

% Power Saving from DSB-SC to SSB-SC :

$$\%\ P.S._{DSB-SSB} = \frac{P_{saved}}{P_{DSB-SC}} \times 100\% = \frac{P_{USB}}{P_{USB}+P_{LSB}} \times 100\% = 50\%$$

$$= \frac{P_c M^2/4}{P_c M^2/2} \times 100\% = 50\%$$

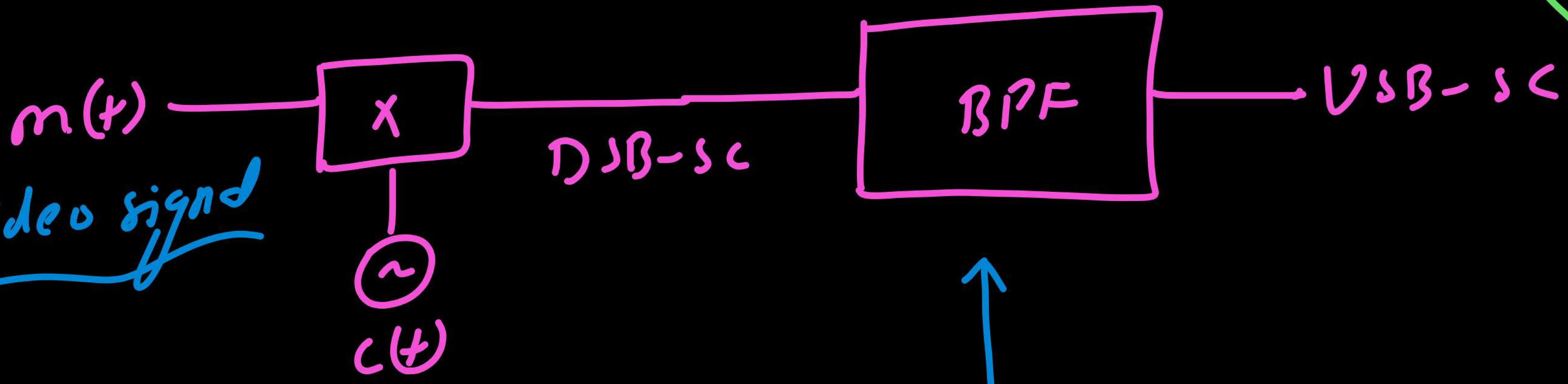
* % Power saving from AM to SSB-SC :

$$\%\ P.S.\Big|_{AM \to SSB} = \frac{P_{saved}}{P_{AM}} = \frac{P_{USB}}{P_{AM}} \times 100\% = \frac{P_c M^2/4}{P_c\left[1+M^2/2\right]} \times 100\%$$

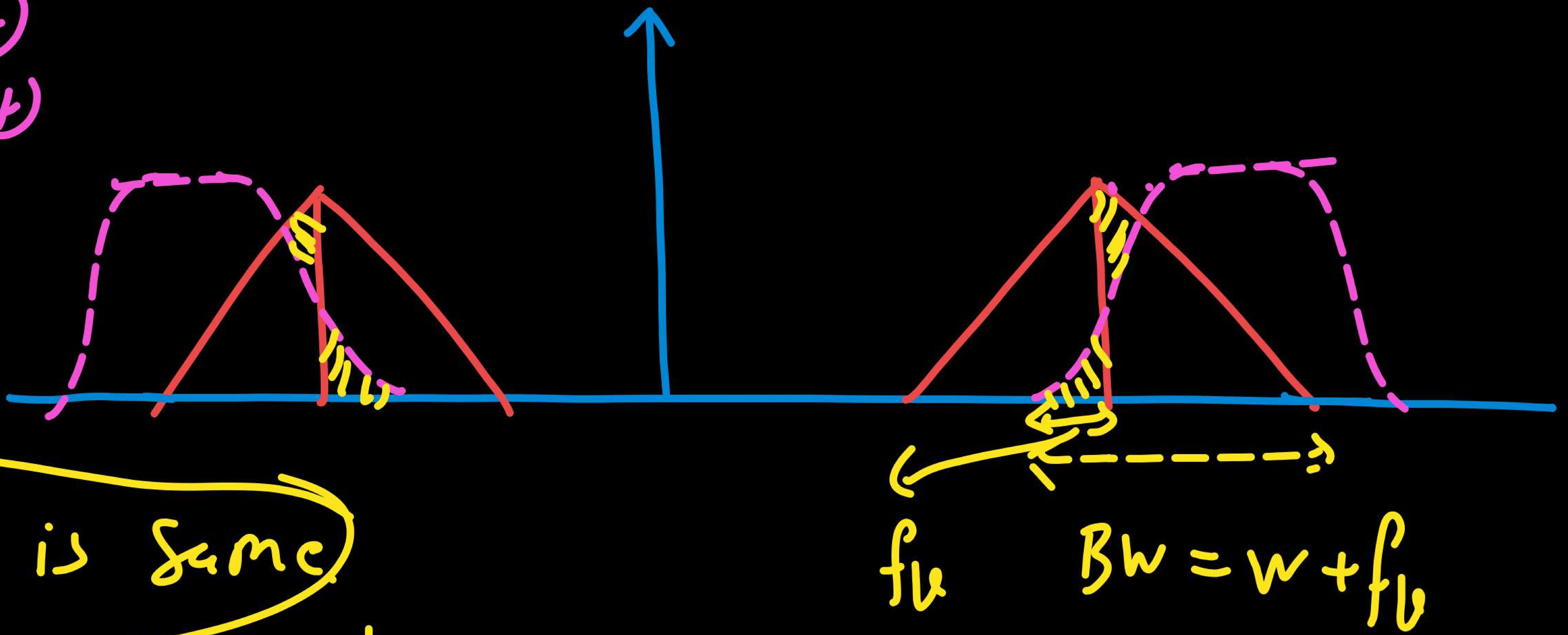
$$= \frac{M^2/4}{1+M^2/2} \times 100\%$$

VSB-SC → modified form of SSB-SC

Voice → SSB-SC
Video → VSB-SC
Audio → AM → FM



Video signal



VSB & SSB is Same

Only diff is BW ⇒ $BW|_{SSB} = W$

$BW|_{VSB} = W + f_v$

Problems Discussion :

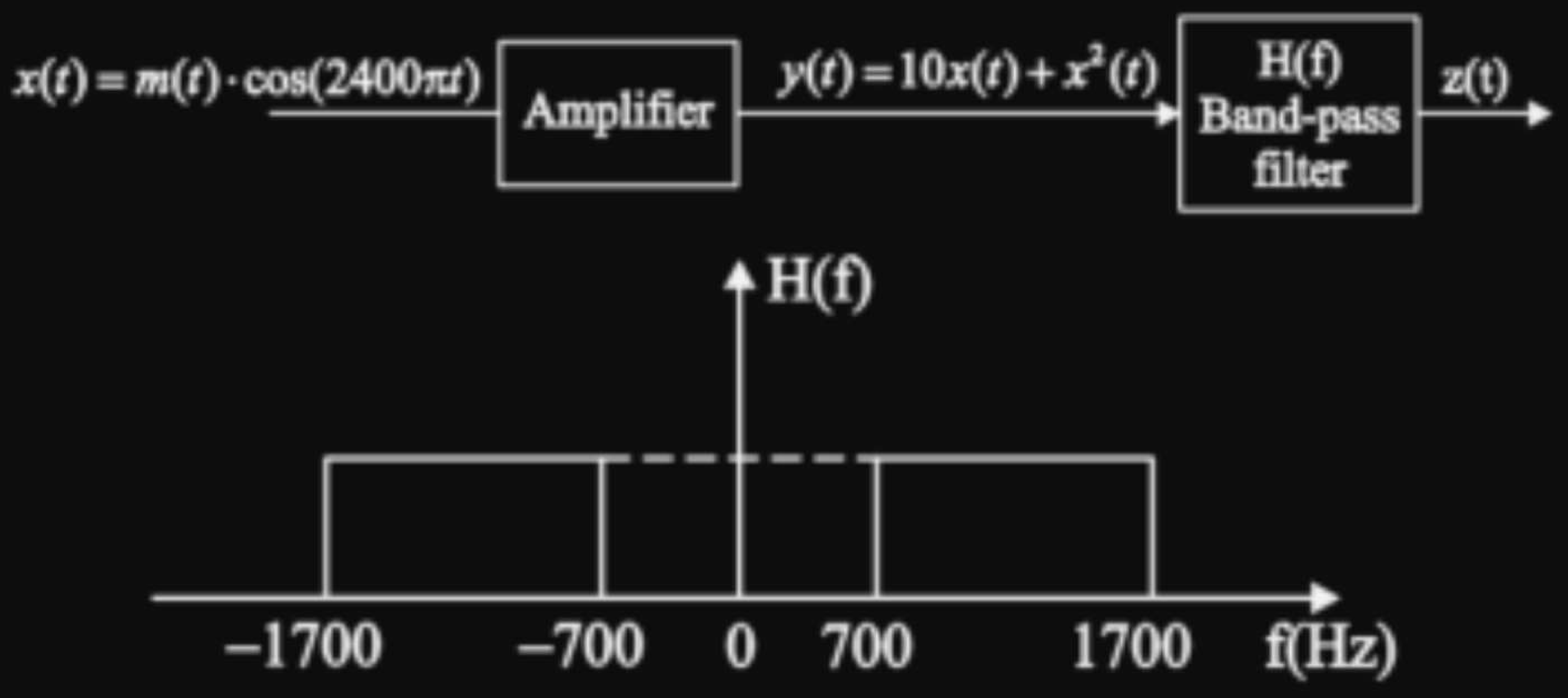
[GATE – EC – 2014]

1. Consider sinusoidal modulation in an AM system. Assuming no over modulation, the modulation index (μ) when the maximum and minimum values of the envelope, respectively, are 3 V and 1 V, is ---------.

Problems Discussion :

[GATE – EC1 – 2015]

8. In the system shown in Figure **(A)**, m(t) is a low-pass signal with bandwidth W Hz. The frequency response of the band-pass filter H(f) is shown in Figure (B).If it is desired that the output signal z(t) = 10x(t), the maximum value of W (in Hz) should be strictly less than ________



Problems Discussion :

[GATE - IN - 2004]

13. Due to an amplitude modulation by a sine wave, if the total current in the antenna increase from 4A to 4.8 A the depth of modulation in percentage is

(A) 93.8 **(B)** 80.1

(C) 90.1 **(D)** 20.2

Problems Discussion :

[GATE - EC - 2008]

14. Consider the amplitude modulated (AM) signal $A_c \cos \omega_c t + 2 \cos \omega_m t \cos \omega_c t$. For demodulating the signal using envelope detector, he minimum value of A_c should be

(A) 2 **(B)** 1

(C) 0.5 **(D)** 0

Problems Discussion :

[GATE - EC - 2010]

16. Suppose that the modulating signal is m(t) = $2\cos(2\pi f_m t)$ and the carrier signal is $x_c(t) = A_c \cos(2\pi f_c t)$. Which one of the following is a conventional AM signal without over – modulation?

(A) $x(t) = A_c m(t) \cos(2\pi f_c t)$

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

(C) $x(t) = A_c \cos(2\pi f_c t) + \dfrac{A_c}{4} m(t) \cos(2\pi f_c t)$

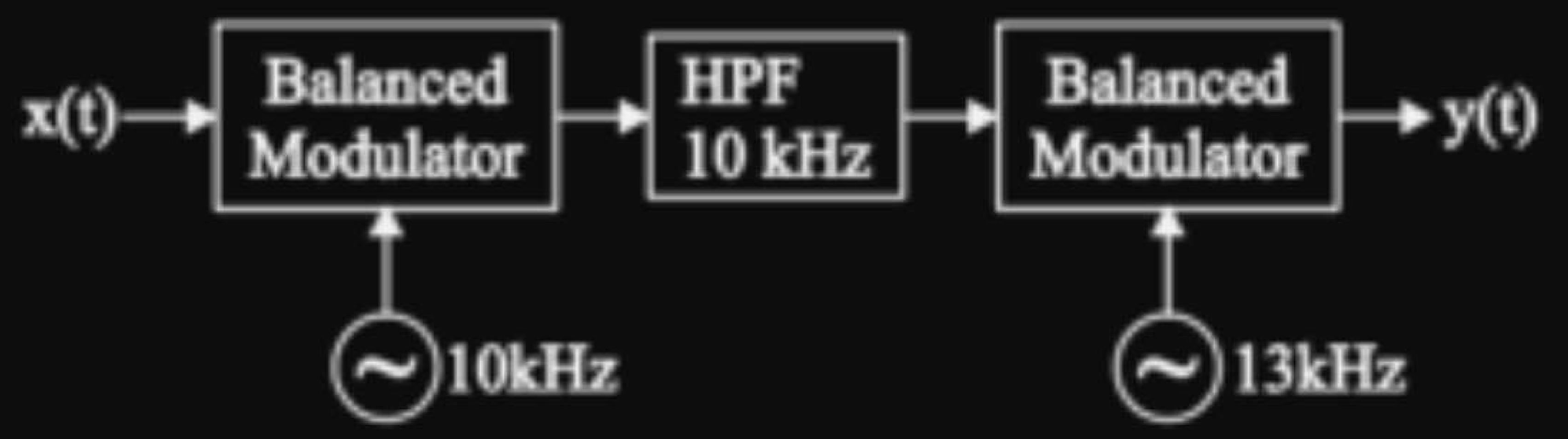
(D) $x(t) = A_c \cos(2\pi f_m t) \cos(2\pi f_c t)$

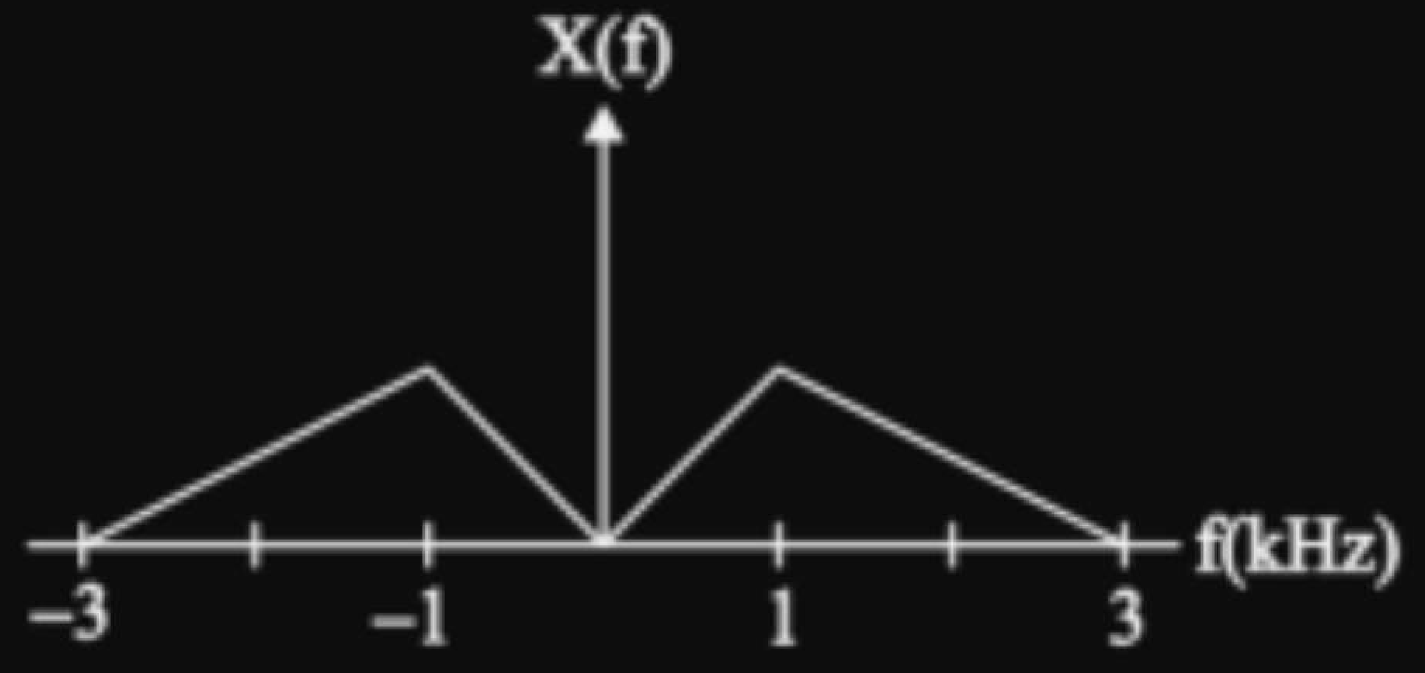
$+ A_c \sin(2\pi f_m t) \cos(2\pi f_c t)$

Problems Discussion :

[GATE - EC - 2004]

33. Consider a system shown in fig. Let X(f) and Y(f) denote the Fourier transforms of x(t) and y(t) respectively. The ideal HPF has the cut-off frequency 10 KHZ.





The positive frequencies where Y(f) has spectral peaks are

(A) 1 KHZ and 24 KHZ

(B) 2KHZ and 24KHZ

(C) 1 KHZ and 14 KHZ

(D) 2 KHZ and 14 KHZ

Problems Discussion :

[GATE - EC - 2000]

56. The amplitude modulated wave form s(t) = $A_c[1+K_a m(t)]\cos\omega_c t$ is fed to an ideal envelope detector. The maximum magnitude of $K_a m(t)$ is greater than 1. Which of the following could be the detector output?

(A) $A_c m(t)$

(B) $A_c^2[1+K_a m(t)]^2$

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

(D) $A_c\left|1+K_a m(t)\right|^2$

Problems Discussion :

[GATE - EC - 2004]

63. An AM signal is detected using an envelope detector. The carrier frequency and modulating signal frequency are 1 MHz and 2 KHz respectively. An appropriate value for the time constant of the envelope detector is

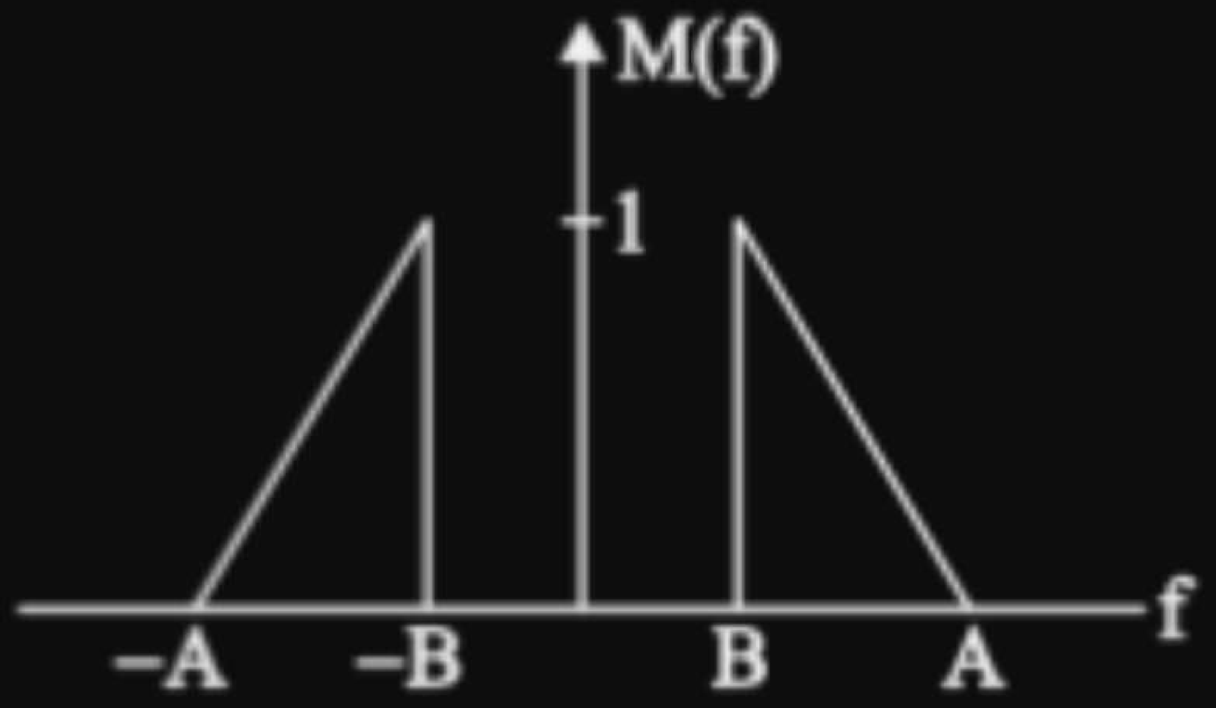
(A) 500μ sec **(B)** 20μ sec

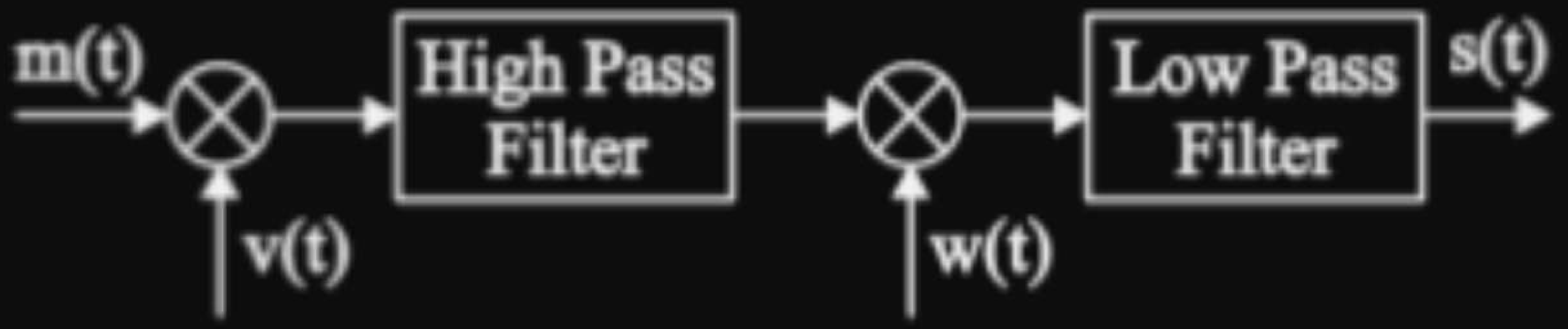
(C) 0.2μ sec **(D)** 1μ sec

Problems Discussion :

[GATE – EC – 2014]

80. In the figure, M (f) is the Fourier transform of the message signal m (t) where A = 100 Hz and B = 40 Hz. Given v (t) = cos $(2\pi f_c t)$ and w (t) = cos $(2\pi (f_c + A)t)$, where $f_c > A$. The cutoff frequencies of both the filters are f_c.





The bandwidth of the signal at the output of the modulator (in Hz) is -------.

Problems Discussion :

[GATE - EC - 2009]

111. For a message signal m(t) = $\cos(2\pi f_m t)$ and carrier of frequency f_c, which of the following represents a single side-band (SSB) signal?

(A) $\cos(2\pi f_m t)\cos(2\pi f_c t)$

(B) $\cos(2\pi f_c t)$

(C) $\cos[2\pi(f_c + f_m)t]$

(D) $[1+\cos(2\pi f_m t)]\cos(2\pi f_c t)$

THANKS FOR

Watching

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