USN | | | | | | | | | |

Internal Assessment Test 1 – March 2018

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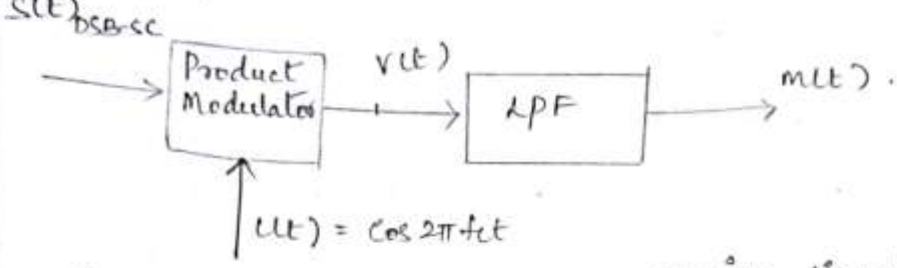
|---|---|---|---|---|---|
| Sub: | Principles of communication systems | Sub Code: | 15EC45 | Branch: | TCE/ECE |
| Date: | 14/03/2018 Duration: 90 mins Max Marks: 50 | Sem / Sec: | 4/A,4/A | | |

Answer any FIVE FULL Questions

| | | MARKS | OBE CO | OBE RBT |
|---|---|---|---|---|
| 1 (a) | A modulating signal given by $m(t) = 2\sin(1000\pi\ t)$ amplitude modulates a carrier given by c $(t) = 10\sin(2\pi\ \ 106^6\ t)$ with a modulation index of 0.5. Find:<br>a) Frequencies present in the modulated signal,<br>b) Amplitude of each side band.<br>c) Bandwidth required.<br>d) Total transmitted power before and after modulation<br>e) Sketch the spectrum | [10] | co1 | L3 |
| 2 (a) | What is FDM? With a neat block diagram, explain FDM. | [5] | co1 | L4 |
| (b) | Explain the operation of a mixer with a neat block diagram | [5] | co1 | L4 |
| 3 (a) | Explain the operation of coherent detection of DSBSC modulating wave along with costas loop circuit. | [10] | co2 | L4 |
| 4 (a) | What is VSB modulation? Explain the characteristics of a VSB filter. | [10] | co1 | L4 |
| 5(a) | Explain the operation of the switching modulator with circuit diagram, and waveform. | [6] | Co2 | L4 |
| (b) | Describe the operation of envelope detector with neat diagrams and waveforms. Bring out the significance of RC time constant of the circuit in detection of message signal without distortion | [4] | Co2 | L1 |
| 6(a) | Discuss briefly the operation of the ring modulator with circuit diagram and relevant waveforms. | [5] | Co2 | L2 |
| (b) | A carrier signal c $(t) = 10\cos(2\pi 10^6\ t)$ is modulated by a message signal $m(t) = 2\cos(8\pi\ 10^3\ t)$ to generate a DSB SC signal. Sketch the spectrum and calculate the bandwidth, power and modulation efficiency. | [5] | Co1 | L3 |

3a) Coherent Detection of DSB-SC

Block Diagram:




→ Here its assumed that the carrier signal used is similar to that of $c(t)$ used at Transmitter

→ The Modulated DSBSC signal is applied to the Coherent Detector & the carrier signal is supplied by the Local oscillator.

→ The obtained signal is then passed through of Low pass filter which removes the higher frequency components other than $f_c$.

$$V(t) = S(t)_{DSBSC} \cdot c(t)$$

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

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

$$V(t) = \frac{A_c m(t)}{2} + \frac{A_c}{2} m(t) \cos 2\pi (2f_c) t.$$

After passing through a low pass filter

$$v(t) = \frac{A_c m(t)}{2}.$$

If we consider the carrier signal with phase.

$$c(t) = \cos(2\pi f_c t + \phi)$$

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

$$= \frac{A_c m(t)}{2} \left[ \cos(4\pi f_c t + \phi) + \cos\phi \right]$$

$$v(t) = \frac{A_c m(t)}{2} \cos(4\pi f_c t + \phi) + \frac{A_c m(t)}{2} \cos\phi$$

After passing through a low pass filter

$$v(t) = \frac{A_c m(t)}{2} \cos\phi .$$

case i: if $\phi = 0$

$$v(t) = \frac{A_c m(t)}{2}$$

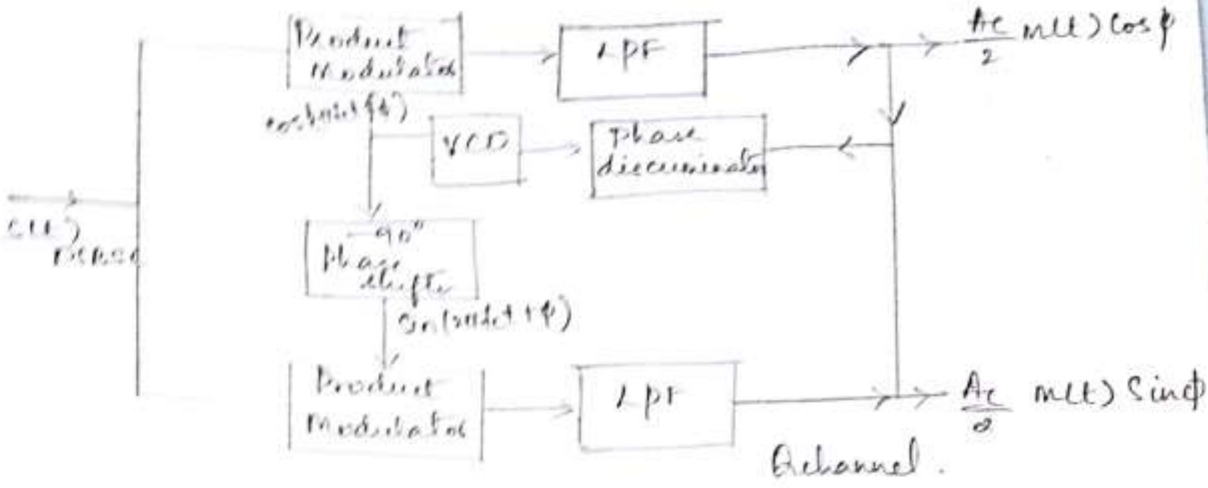
message signal can be retained.

case (ii) if $\phi = 90^\circ$

$$v(t) = 0.$$

message signal cannot be retained

Costas Detector :-




→ This consists of two coherent detectors with same input (s(t) DSBSC) signal.

→ This consists of a phase discriminator which takes difference between the phase as input & provides the corresponding voltage as output

→ This output works as input for Voltage Controlled oscillator (VCO) which intern produces oscillations

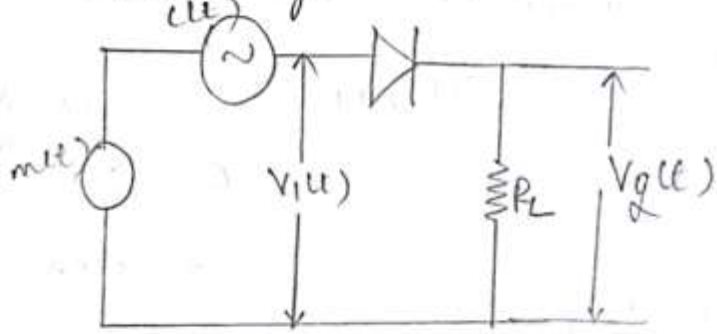
→ Now, the output of I channel will be $\frac{A_c}{2} m(t)\cos\phi$ and output of Q channel will be $\frac{A_c}{2} m(t)\sin\phi$.

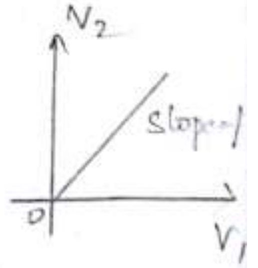
→ ∴ if $\phi = 0^\circ$ or $\frac{\pi}{2}$ then we are in the position to retain the message signal.

5a) Switching Modulator:: This is the modulator used to generate AM wave by capturing the effect of ON & OFF (switch).

→ An ideal diode can be best candidate to serve as a switch

→ circuit Diagram.




→ $V_1(t)$ can be given as

$$V_1(t) = m(t) + c(t).$$

and $V_2(t) = \begin{cases} V_1(t), & c(t) > 0 \\ 0, & c(t) < 0. \end{cases}$

$\therefore\ V_2(t) = V_1(t) \cdot g_p(t).$

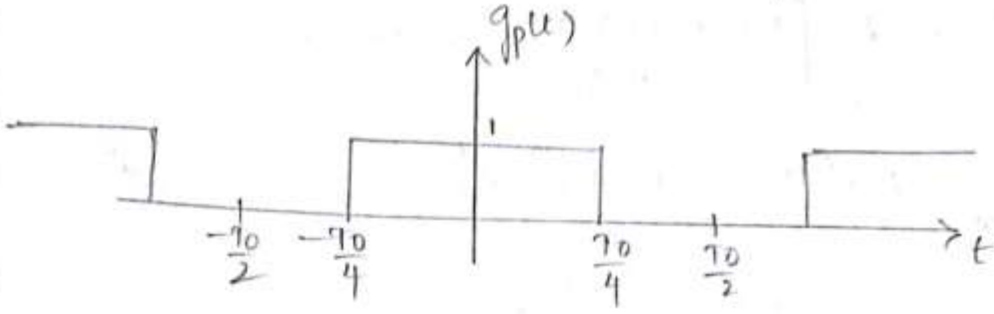
where $g_p t$ is a periodic signal with Period $(T_0) = \frac{1}{f}$ and 50% duty cycle.

Ideal diode is replaced by $g_p(t)$ because of its non linear behaviour

∵ $g_p(t)$ is a periodic signal it can be given in terms of fourier series

$$g_p(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega t)$$

$b_n = 0$ even signal.




$$a_0 = \frac{\text{area under the curve}}{\text{time period}} = \frac{T_0/2}{T_0} = \frac{1}{2}$$

$$a_n = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos 2\pi(2n-1)f_c t$$

$$\therefore \quad V_2(t) = \left[m(t) + c(t)\right]\left[\frac{1}{2} + \frac{2}{\pi}\sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos 2\pi(2n-1)f_c t\right]$$

$$V_2(t) = \left[m(t) + A_c \cos 2\pi f_c t\right]\left[\frac{1}{2} + \frac{2}{\pi}\sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos 2\pi(2n-1) f_c t\right]$$

if $n = 1$

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

$$= \frac{m(t)}{2} + \frac{2\,m(t)}{\pi} \cos 2\pi f_c t + \frac{A_c}{2} \cos 2\pi f_c t + \frac{A_c 2}{\pi} \cos^2 2\pi f_c$$

After passing through a LPF.

$$V_2(t) = \frac{A_c}{2}\cos 2\pi f_c t + \frac{m(t)\cdot 2}{\pi}\cos 2\pi f_c t.$$

$$= \frac{A_c}{2}\left[1 + \frac{m(t)\,4}{\pi A_c}\right]\cos 2\pi f_c t$$

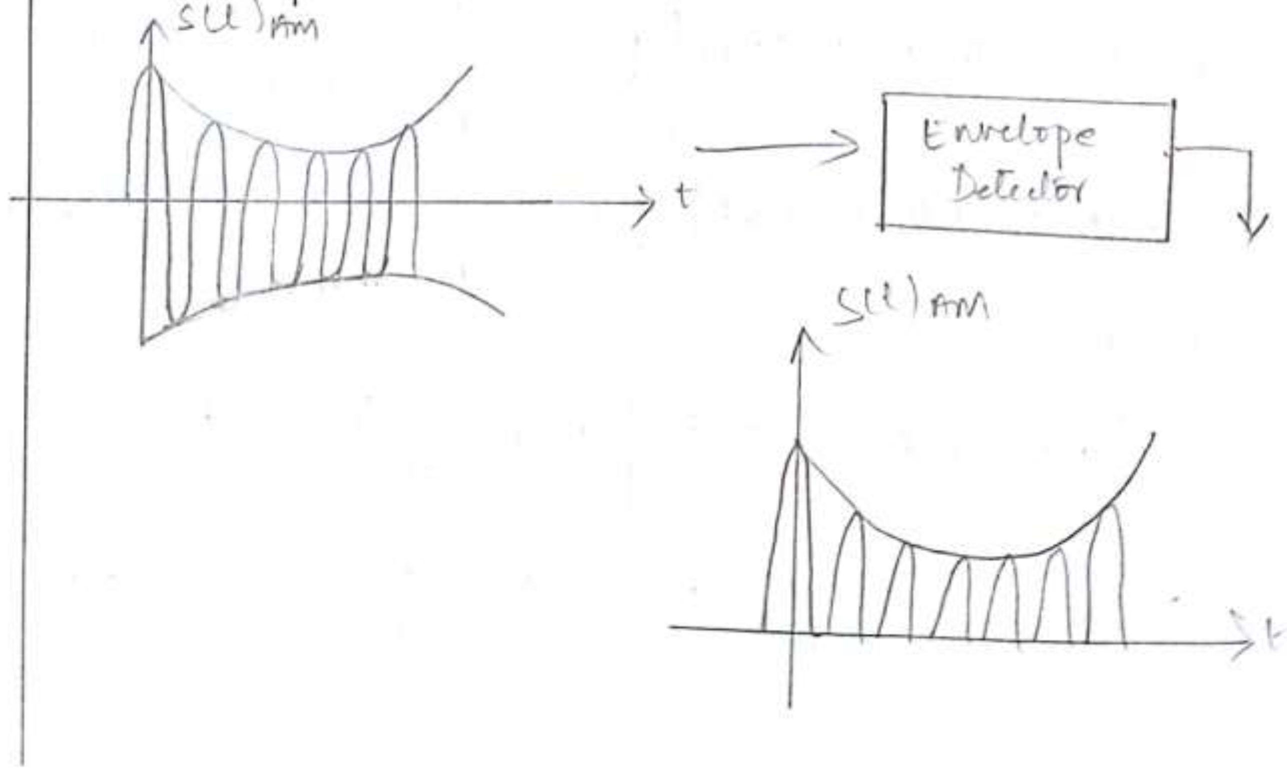
$$2V_2(t) = A_c\left[1 + \frac{m(t)\,4}{\pi A_c}\right]\cos 2\pi f_c t \quad \text{— (1)}$$

$$s(t)_{AM} = A_c\left[1 + m(t)\cdot K_a\right]\cos 2\pi f_c t \quad \text{— (2)}$$

Comparing (1) and (2)

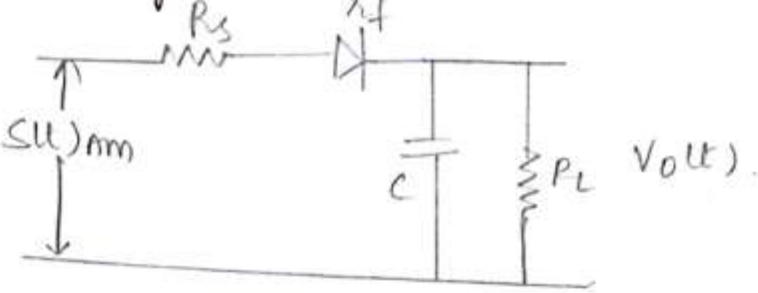
$$K_a = \frac{4}{\pi A_c} \quad \& \quad s(t)_{AM} = 2V_2(t).$$

5b) Envelope Detector :



Envelope is the trace drawn by touching the peak amplitudes of the signal.

circuit Diagram.




→ During the positive half cycle of the input signal diode is forward biased and capacitor charges to it maximum value i.e., peak of input signal

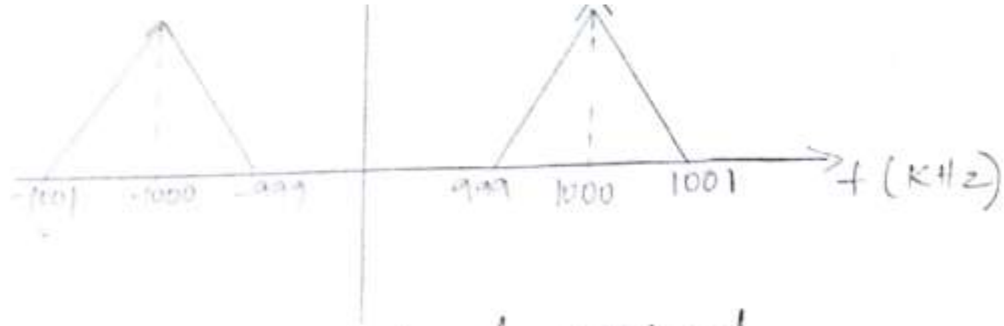
→ when the input signal becomes lower the Max value the capacitor starts discharing through capacitor till the next positive ~~half~~ cycle.

→ when the input signal becomes greater than the voltage across the capacitor then the capacitor charges and cycle repeats.

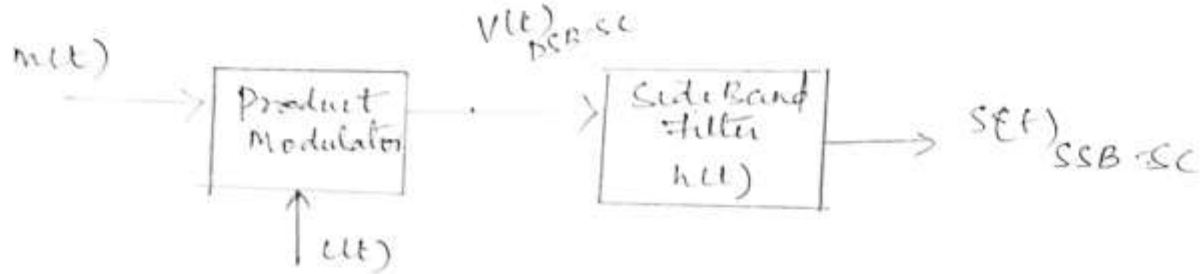
→ The charging time constant should be as small as possible compared to carrier period for the rapid charging of capacitor

$$\text{i.e.,}\ (R_s + r_f)C \ll \frac{1}{f_c}.$$

→ The Discharging time constant should be as large as possible for the slow discharging compared with the message period




(7) SSB → lower side band retained.




~~hetter~~ here

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

$$V(f) = \frac{A_c}{2}\left[M(f-f_c) + M(f+f_c)\right]$$

$$\rightarrow S(t)_{SSB-SC} = V(t)_{DSB-SC} * h(t)$$

$$S(f) = V(f) \cdot H(f).$$

where $H(f) = \frac{1}{2}\,\mathrm{sgn}(f+f_c) - \frac{1}{2}\,\mathrm{sgn}(f-f_c)$

$$\therefore \; S(f) = \frac{A_c}{2}\left[M(f-f_c)+M(f+f_c)\right]\left[\frac{1}{2}\left(\operatorname{sgn}(f+f_c) - \operatorname{sgn}(f-f_c)\right)\right]$$

$$S(f) = \frac{A_c}{4}\Big[M(f-f_c)\operatorname{sgn}(f+f_c) - M(f-f_c)\operatorname{sgn}(f-f_c)$$

$$+ M(f+f_c)\operatorname{sgn}(f+f_c) - M(f+f_c)\operatorname{sgn}(f-f_c)\Big]$$

$$= \frac{A_c}{4}\left[M(f-f_c)\operatorname{sgn}(f+f_c) - M(f+f_c)\operatorname{sgn}(f-f_c)\right] +$$

$$\frac{A_c}{4}\left[M(f+f_c)\operatorname{sgn}(f+f_c) - M(f-f_c)\operatorname{sgn}(f-f_c)\right]$$

on taking IFT

$$= \cancel{\frac{A_c}{4}\left[M(f-f_c) - (-M(f+f_c))\right]} + \frac{A_c}{2}\, m(t)\cos 2\pi f_c t$$

$$+ \frac{A_c}{4}\left[j e^{-j2\pi f_c t}\,\hat{m}(t) - j e^{j2\pi f_c t}\,\hat{m}(t)\right]$$

$$= \cancel{\frac{A_c}{4}\left[M(f-f_c) + M(f+f_c)\right]} + \frac{A_c}{2}\, m(t)\cos 2\pi f_c t$$

$$+ \frac{A_c}{4}\left[\frac{e^{j2\pi f_c t}\,\hat{m}(t) - e^{-j2\pi f_c t}\,\hat{m}(t)}{j}\right]$$

$$= \cancel{\frac{A_c}{2}\left[M(f-f_c) + M(f+f_c)\right]} + \frac{A_c}{2}\hat{m}(t)$$

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

$$S(t)_{LSSB\text{-}SC} = \underline{\frac{A_c}{2}}\left[m(t)\cos 2\pi f_c t + \hat{m}(t)\sin 2\pi f_c t\right]$$

(8) Amplitude Modulation :- It is the process of varying peak amplitude of the carrier wave according to the message signal by keeping frequency and phase constant.

Single tone :-

$$S(t)_{Am} = A_c\left[1 + K_a m(t)\right]\cos 2\pi f_c t.$$

$$m(t) = A_m \cos 2\pi f_m t$$

$$c(t) = A_c \cos 2\pi f_c t.$$

$$S(t)_{Am} = A_c\left[1 + K_a A_m \cos 2\pi f_m t\right]\cos 2\pi f_c t$$

$$S(t)_{Am} = A_c \cos 2\pi f_c t + A_c \mu \cos 2\pi f_m t \cos 2\pi f_c t$$

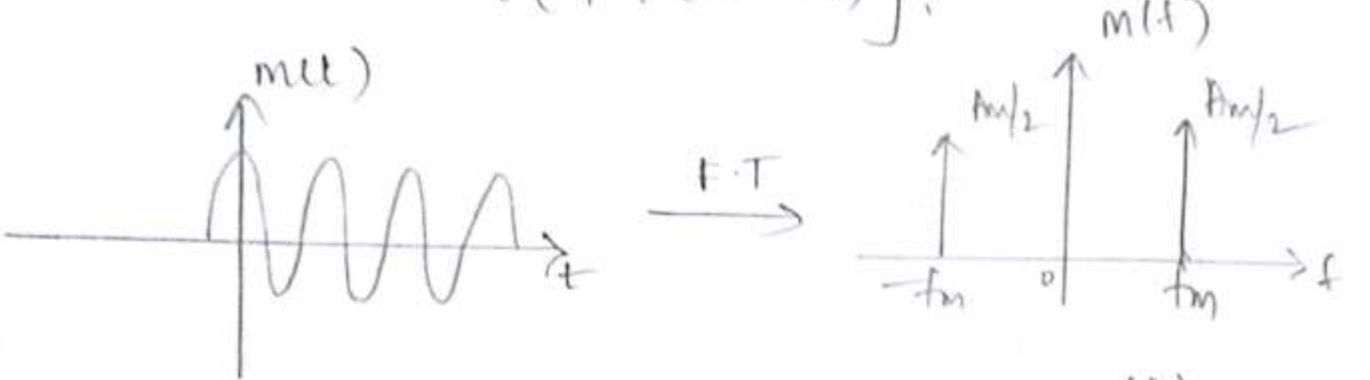
$\mu = K_a A_m$ modulation index

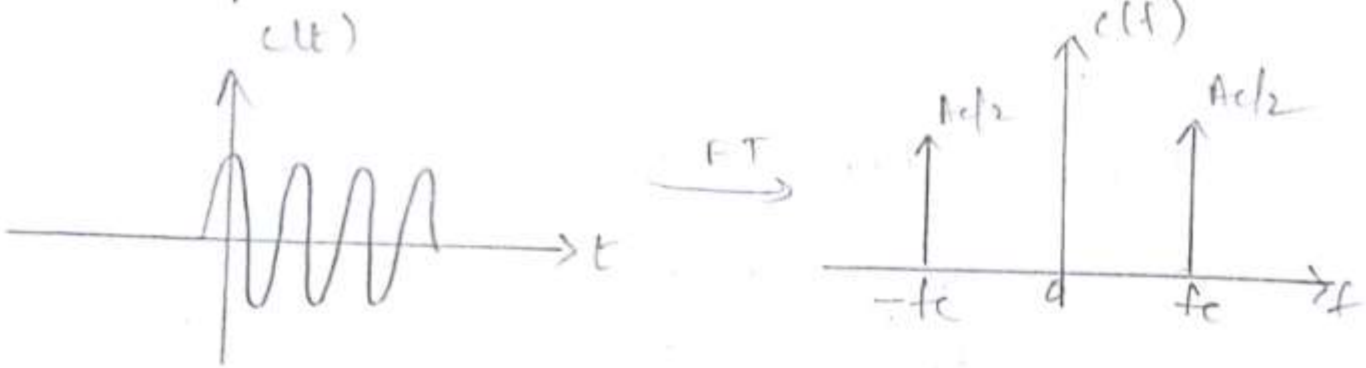
$$S(t)_{Am} = A_c \cos 2\pi f_c t + \frac{A_c \mu}{2}\left[\cos 2\pi (f_c + f_m)t + \cos (2\pi (f_c - f_m)\right.$$

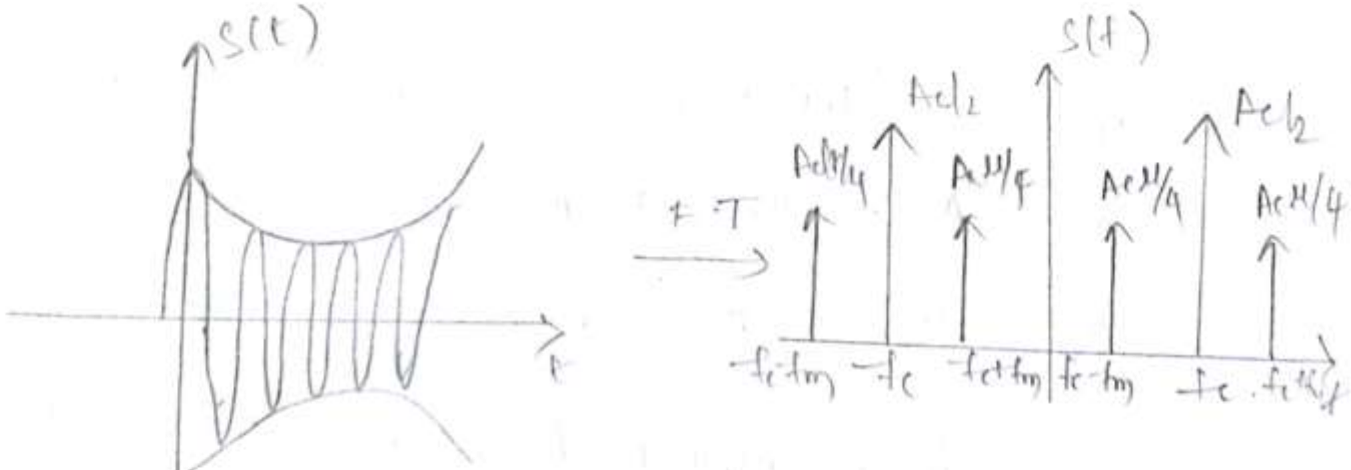
By taking Fourier Transform:

$$S(f)_{AM} = \frac{A_c}{2}\Big[\delta(f - f_c) + \delta(f + f_c)\Big] + \frac{A_c \mu}{4}$$

$$\Big[\Big(\delta(f - (f_c + f_m)\Big) + \delta(f + f_c + f_m)\Big] + \delta\big(f - (f_c - f_m)\big) + \delta\big(f + (f_c - f_m)\big)\Big].$$



Multitone signal

$m(t) = A_{m_1} \cos 2\pi f_{m_1} t + A_{m_2} \cos 2\pi f_{m_2} t + - - - -$

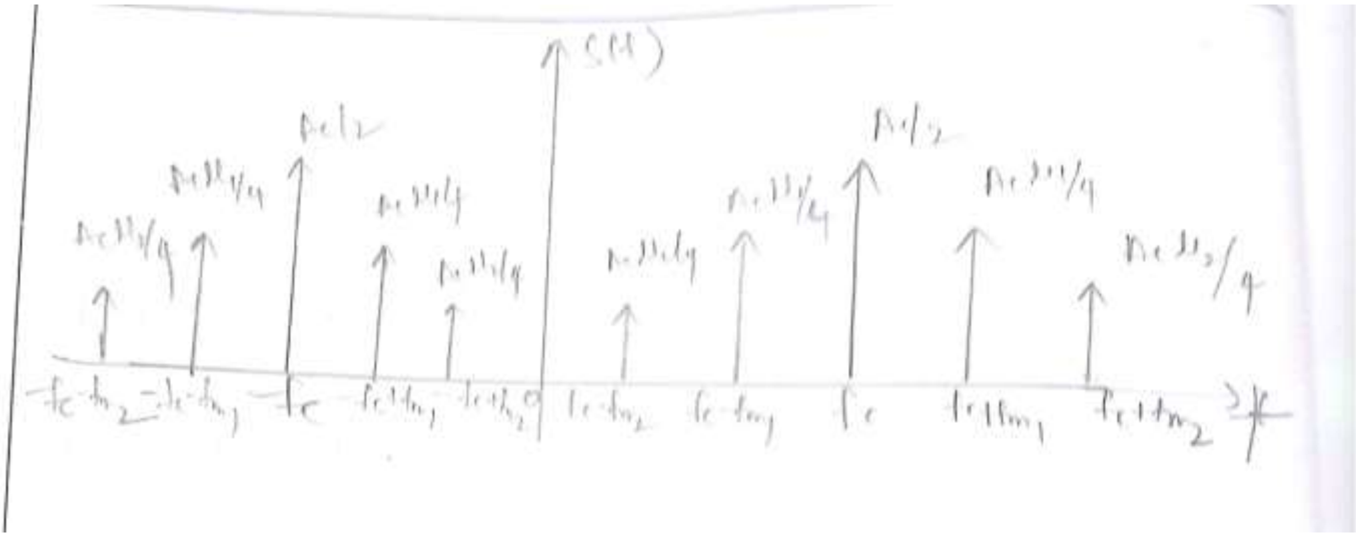
$c(t) = \cos 2\pi f_c t$

$$S(t)_{Am} = A_c \left[ 1 + k_a \left( A_{m_1} \cos 2\pi f_{m_1} t + A_{m_2} \cos 2\pi f_{m_2} t \right) \right] \cos 2\pi f_c t$$

$$S(t)_{Am} = A_c \cos 2\pi f_c t + \frac{A_c \mu_1}{2} \left[ \cos(2\pi(f_c + f_{m_1})t) + \cos 2\pi (f_c - f_{m_1})t \right]$$
$$+ \frac{A_c \mu_2}{2} \left[ \cos 2\pi (f_c + f_{m_2})t + \cos 2\pi (f_c - f_{m_2}) t \right]$$

By taking fourier transform

$$S(f) = \frac{A_c}{2} \left[ \delta(f - f_c) + \delta(f + f_c) \right] +$$
$$\frac{A_c \mu_1}{4} \Big[ \delta(f - (f_c + f_{m_1})) + \delta(f + (f_c + f_{m_1})) + \delta(f - (f_c - f_{m_1})) + \delta(f + (f_c - f_{m_1})) \Big] +$$
$$\frac{A_c \mu_2}{4} \Big[ \delta(f - (f_c + f_{m_2})) + \delta(f + (f_c + f_{m_2})) + \delta(f - (f_c - f_{m_2})) + \delta(f + (f_c - f_{m_2})) \Big]$$


S(f)
Ac/2
Ac/2
-fc
fc
fc+fm2
f

1(a):- Given
$m(t) = 2\sin(1000\pi t)$ = Message signal —— (i)
$c(t) = 10\sin(2\pi 10^6 t)$ = carrier signal —— (ii)
$\mu = 0.5$ = Modulation index.

from eqn(i)

$f_m = 500$ Hz
$f_c = 10^6$ Hz = 1000 kHz

The time domain AM eqn is given by.

$s(t)_{AM} = A_c(1 + K_a m(t))\sin 2\pi f_c t$
$= 10(1 + K_a A_m \sin 2\pi f_m t)\sin 2\pi f_c t$
$= 10(1 + 0.5 \sin 2\pi f_m t)\sin 2\pi f_c t$
$= 10(1 + 0.5\sin 2\pi 500 t)\sin 2\pi 10^6 t.$
$= 10\sin 2\pi 10^6 t + 5\sin 2\pi(500)t \sin 2\pi 10^6 t$
$= 10\sin 2\pi \underline{10^6} t + \frac{5}{2}[\cos 2\pi(\underline{10^6 - 500})t$
$- \cos 2\pi(\underline{10^6 + 500})t]$

a) frequencies presented in modulated signal.

i) $f_c = 10^6$ Hz.

ii) $f_c + f_m = 10^6 + 500 = 1000500$ Hz.
iii) $f_c - f_m = 10^6 - 500 = 999500$ Hz

b) Amplitude of each side band.

| Time domain | Freq. domain |
|---|---|
| $(Amp)_{USB} = 5/2 = 2.5V$. | $(Amp)_{USB} = \frac{A_c\mu}{4} = 1.25\ V$ |
| $(Amp)_{LSB} = 5/2 = 2.5V$. | $(Amp)_{LSB} = \frac{A_c\mu}{4} = 1.25V$ |

c) B.W of $f_m = (f_c + f_m) - (f_c - f_m)$

$= 2f_m = 2(\text{Message signal BW})\ Hz$

$= 2 \times 500 = 1000\,Hz.$

d) Power transmitted before modulation

$$P_t = P_c = \frac{A_c^2}{2R} = \frac{10^2}{2} = 50\text{ watts}$$

After modulation

$$P_t = P_c(1 + \mu^2/2)$$

$= 50(1 + 0.5^2/2)$

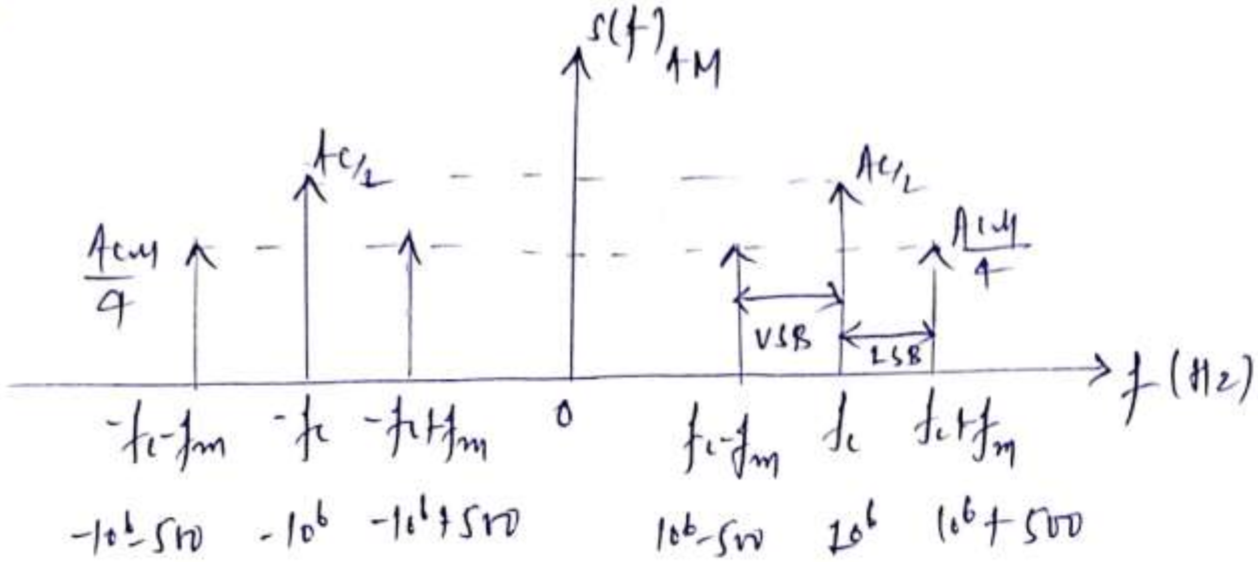
$= 50\left(1 + \frac{0.25}{2}\right)$

$= 50(1 + 0.125)$

$= 50(1.125)$

$= 50 \times 1.125 = 56.25\text{ watts}$

(e)




6(b) Given

$c(t) = 10\cos(2\pi 10^6 t)$ —— (i)

$m(t) = 2\cos(8\pi 10^3 t)$ —— (ii)

The modulated DSB-SC in time domain is given by

$$s(t)_{DSB\text{-}SC} = m(t)\,c(t)$$

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

$$= 10(2\cos 2\pi 4\times10^3 t)\cos 2\pi 10^6 t$$

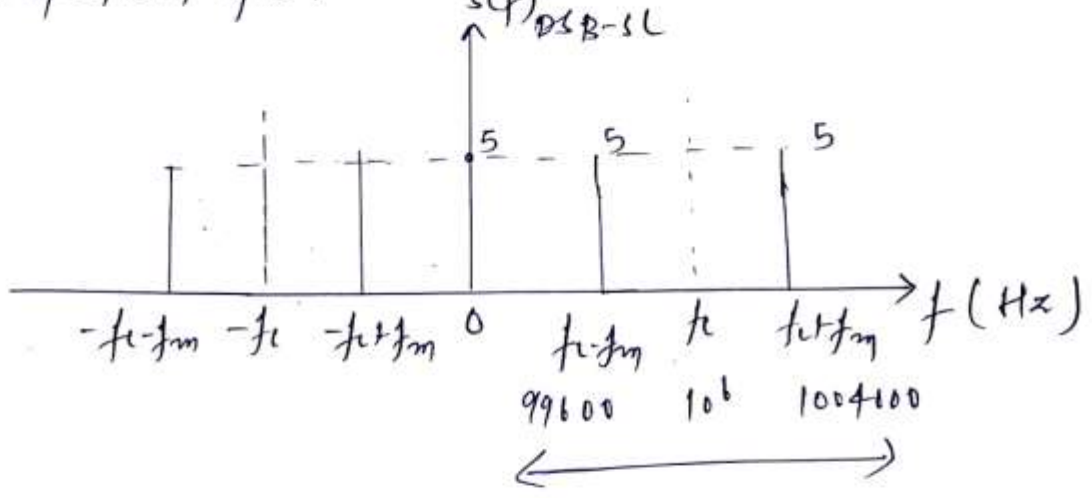
$$= \frac{20}{2}\left[\cos 2\pi(4\times10^3 + 10^6)t + \cos 2\pi(10^6 - 4\times10^3)t\right]$$

$$s(t)_{DSB\text{-}SC} = 10\left[\cos 2\pi(1004000)t + \cos 2\pi(996000)t\right] \quad \text{—— (iii)}$$

Taking FT of eqn (iii) given.

$$s(f)_{DSB} = \cancel{5\cos}\ 5[\delta(f-1004000)+\delta(f+1004000)] + 5[\delta(f-996000)+\delta(f+996000)]$$

(a) spectrum of DSB-SC




$$BW = \cancel{100}(f_c+f_m) - (f_c-f_m)$$
$$= 2f_m = 2\times 4000 = 8000 = 8KHz.$$

Power,

$$P_t = \frac{A_c^2 A_m^2}{4R}$$
$$= \frac{10^2 \cdot 2^2}{4} \quad (R = 1\Omega)$$
$$= 100W$$