CMR INSTITUTE OF TECHNOLOGY

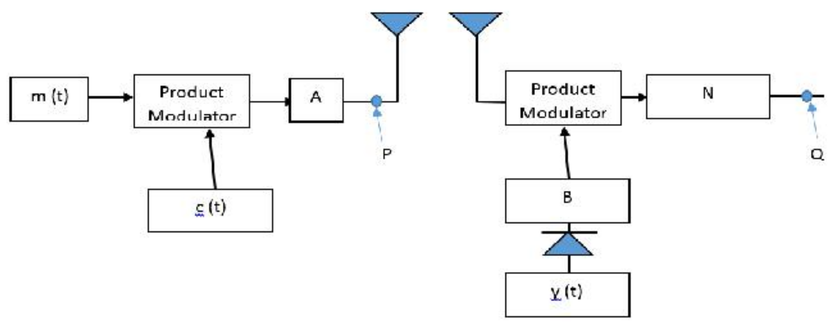
USN

Internal Assessment Test 1– March 2017

Sub:	Principle of Communication Systems						Code:	15EC45
Date:	30 / 03 /17	Duration:	90 mins	Max Marks:	50	Sem: 4	Branch:	ECE, A & D

Note: Question 1 is compulsory and Answer any four from Q2 to Q6.

Q		Question	Marks	CO	RBT
1		The transceiver modules are given separately in the figure below. The carrier signal $c(t) = 9cos(2\pi 3000t)$ is modulated using the message signal $m(t) = 1cos(2\pi 100t)$ using DSB-SC modulation techniqueat the transmitter. Similarly, the message signal is recovered at the receiver using demodulation techniques shown in the figure. Justify your analogy for the following sections. Given y (t) is periodic pulse of duty cycle 50 percentage and peak to peak voltage of 10 volts and fundamental period of the signal is 0.001 second			
	a.	Specify the type of the filter that can be used at A and the required bandwidth with plot.	02	CO1	L2
	b.	Draw the spectrum of the signal received at P.	02	CO1	L2
	c.	Find the type of the filter that can be used at B to minimize frequency spreading.	02	CO1	L2
	d.	Find the type of the filter that can be used at N to get back the information and also calculate its bandwidth and show its spectrum.	02	CO1	L2
	e.	Draw the spectrum of the signal recovered at position Q.	02	CO1	L2



Q		Question	Marks	CO	RBT
2		Describe about switch modulator with the circuit diagram and finally plot the spectrum of the modulated signal. (Assume the message signal as a single tone).	10	CO1	L1
3		Describe the mathematical formulation to generate SSB-SC using frequency discrimination method.	10	CO1	L3
4		Find the solution of the followings with brief mathematical flow. Assume the required integral operator so as to apply the function in the field of communications.			
	a.	$\int_{-n\pi}^{n\pi} sin^2(\theta).sin(\theta)d\theta$, for n ≥1, n is an integer.	02	CO1	L1
	b.	$\int_{-n\pi}^{n\pi} sin^2(\theta).cos(2\theta)d\theta$, for n ≥1, n is an integer.	02	CO1	L1
	c.	Draw the block diagram of Costas receiver.	04	CO1	L2
	d.	Under what condition there will be phase reversal in DSB-SC signal and Why?	02	CO1	L2
5	a.	An antenna current of an AM broadcast transmitter is 11 amps when it is modulated to a depth of 40% by an audio sine wave. It increases to 12 amp as a result of simultaneous modulation by another audio sine wave. What is the modulation index of the second wave.	05	CO1	L1
	b.	An AM signal is given by $s(t) = [10 + 4sin(1000\pi t)]cos(2\pi 10^6 t)$ volts. Calculate Ac, Am, modulation index, f_m, f_c and total power, power in side band, power in upper side band and power in lower side band respectively.	05	CO1	L1
6		The message signal $m(t) = A_1cos(w_1t) + A_2cos(w_2t)$ with $f_2 > f_1$ is used to modulate the carrier $c(t) = cos(w^ct)$ using VSB modulation techniques. Design the modulation and demodulation stage of the VSB technique with its filter response.	10	CO1	L3

Q1a. The filter that can be used at A should be BPF.

The required $BW = 2f_m$
$= 2\times100 = 200HZ$

(2)

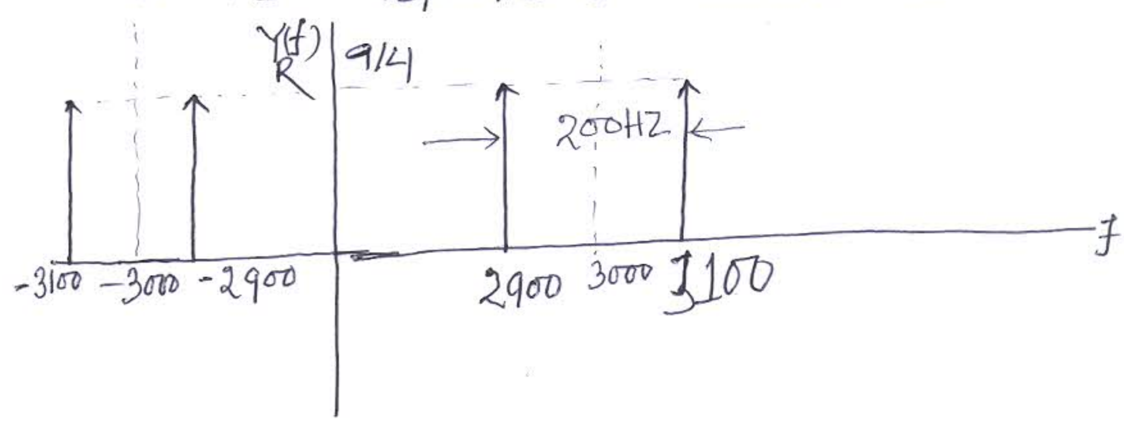
$y_R(t)$ at $P = m(t)\cdot c(t)$
$= 9\cos(2\pi\times100t)\cdot 9\cos(2\pi\times3000t)$
$= \frac{9}{2}\left[\cos(2\pi\,3100t) + \cos(2\pi\times2900t)\right]$ — (1)

b) Fourier transform of eq^n (1)

$Y_R(f) = \frac{9}{4}\left[\delta(f+3100)+\delta(f-3100)\right] + \frac{9}{4}\left[\delta(f+2900)+\delta(f-2900)\right]$ — (2)

So the spectrum will be

(2)



c) If $z(t)$ is a periodic pulse of duty cycle 50% & fundamental frequency can be calculated from the time period m; $T = \frac{1}{f_{ms}}$ or $f_{ms} = 1/T$
so; $f_{ms} = 1/0.001 = 1KHZ$.

If it is passed through the diode the signal will be appeared at the o/p for positive cycle & zero for negative cycle;

So; the Fourier ~~transform~~ ~~of~~ Series of the Signal can be written as

$$z_x(t) = \frac{A}{2} + \frac{2A}{\pi}\left[\cos\omega_c t - \tfrac{1}{3}\cos 3\omega_c t + \tfrac{1}{5}\cos 5\omega_c t - \cdots\right]$$

where $A = 5$ (Given) — (3)

To avoid frequency spreading & to demodulate the signal at the receiver, the higher order harmonics can be eliminated using Low-pass filter

$$z_x'(t) = \frac{A}{2} + \frac{2A}{\pi}\left[\cos\omega_c t - \tfrac{1}{3}\cos 3\omega_c t\right]$$

As per the calculation $f_{ms} = f_c$

$$\text{So } z_x'(t) = \frac{A}{2} + \frac{2A}{\pi}\left[\cos(2\pi \times 1000t) - \tfrac{1}{3}\cos(2\pi \times 3000t)\right] \quad (4)$$

d) To get back the information at 'N' LPF should be used

i.e. $z_N(t) = z_x'(t) \cdot z_R(t)$

$$= \frac{A}{2} + \frac{2A}{\pi}\left[\cos(2\pi \times 1000t) - \tfrac{1}{3}\cos(2\pi\, 3000t)\right] \times m(t)\cdot\cos(2\pi \times 3000t) \quad -(5)$$

$$= \frac{A}{2}\cdot m(t)\cdot\cos(2\pi \times 3000t) + \frac{2A}{\pi}\Big[m(t)\cdot\cos(2\pi \times 1000t)\cdot\cos(2\pi \cdot 3000t) - \frac{2A}{3\pi} m(t)\cos^2(2\pi \times 3000t)\Big]$$

(2)

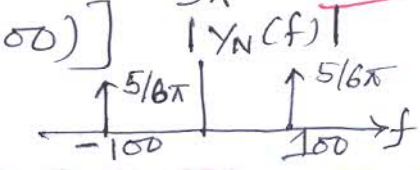
After passing through LPF

$$z_N'(t) = -\frac{2A}{3\pi} m(t) \times \tfrac{1}{2} = -\frac{A}{3\pi} m(t) = \frac{-5}{3\pi} m(t)$$

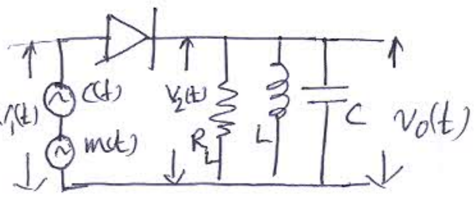
$$= \frac{-5}{3\pi}\cos(2\pi 100t)$$

(e) (2) So; $Y_N(f) = -\frac{5}{6\pi}\left[\delta(f+100) + \delta(f-100)\right]$

$$|Y_N(f)| = \frac{5}{6\pi}\left[\delta(f+100) + \delta(f-100)\right]$$



Q2.



For theory {3}

Assumption $|c(t)| >> |m(t)|$

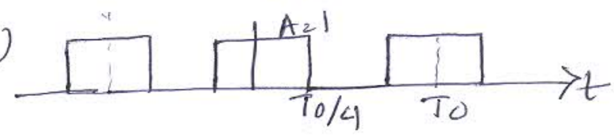
(or) $c(t) >> m(t)$

5

$v_2(t) \propto v_1(t)$ --- (1)

so; $v_2(t) \cong S_1(t) \cdot v_1(t)$ — (2)

where $S(t) = g_{T_0}(t)$



$g_{T_0}(t) = \frac{1}{2} + \frac{2}{\pi}\left[\cos \omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5}\cos 5\omega_c t - \cdots\right]$ —(3)

Substituting (3) in (2)

$v_2(t) \simeq \left[A_c \cos 2\pi f_c t + m(t)\right] \cdot \left\{\frac{1}{2} + \frac{2}{\pi}\left[\cos \omega_c t - \frac{1}{3}\cos 3\omega_c t + \cdots\right]\right\}$ —(4)

↳ After passing through the BPF of centered around f_c and BW spreading between $f_c + f_m$ & $f_c - f_m$ then, the resulting modified signal is;

$v_2'(t) \simeq \left[\frac{1}{2} A_c \cos 2\pi f_c t + \frac{2}{\pi} m(t) \cos(2\pi f_c t)\right]$

(or) $= \frac{A_c}{2}\left[1 + \frac{4}{\pi A_c} m(t)\right] \cos \omega_c t$ —(5)

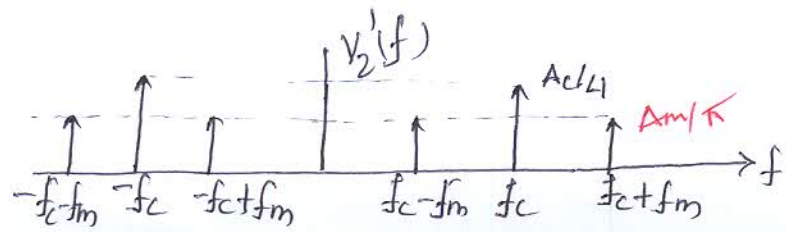
5 → 3+2

3

$= \frac{A_c}{2} \cos \omega_c t + \frac{4 A_c}{2\pi A_c} m(t) \cdot \cos \omega_c t$

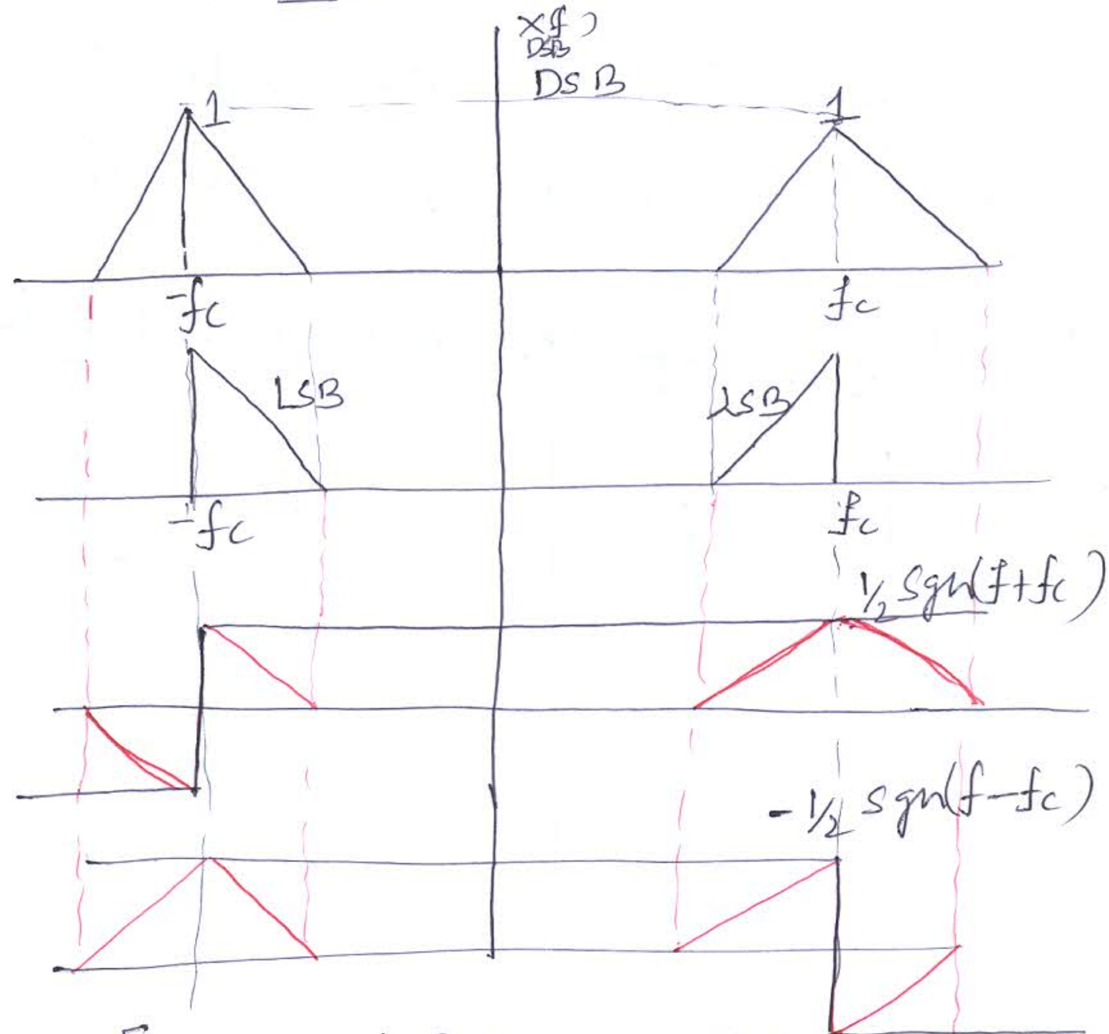
$= \frac{A_c}{2} \cos \omega_c t + \frac{2}{\pi} m(t) \cos \omega_c t$ [Assume $m(t) = A_m \cos \omega_m t$]

$V_2'(f) = \frac{A_c}{4}\left[\delta(f+f_c) + \delta(f+f_c)\right] + \frac{A_m}{\pi}\left[\delta(f+f_c+f_m) + \delta(f-f_c-f_m)\right]$
$+ \frac{A_m}{\pi}\left[\delta(f+f_c-f_m) + \delta(f-f_c+f_m)\right]$



2

$\underline{Q_3}$ SSB-SC $\underline{\text{Filtering method}}$



$$H_e(f) = \left[\frac{1}{2}\,sgn(f+f_c) - \frac{1}{2}\,sgn(f-f_c)\right] \quad -(1)$$

$$X_{DSB}(f) = \frac{1}{2}\left[A_c M(f+f_c) + M(f-f_c)\right] \quad -(2)$$

$$X_{SSB}(f) = \frac{1}{4} A_c \left[M(f+f_c)\,sgn(f+f_c) + M(f-f_c)\,sgn(f+f_c)\right] - \frac{1}{4} A_c \left[M(f+f_c)\,sgn(f-f_c) + M(f-f_c)\,sgn(f-f_c)\right] \quad (3)$$

$$= \frac{1}{4} A_c \left[M(f+f_c) * sgn(f-f_c)\right] + \frac{1}{4} A_c \left[M(f-f_c) * sgn(f+f_c)\right]$$

$$+ \frac{1}{4} A_c \left[M(f+f_c)\cdot sgn(f+f_c) - M(f-f_c)\,sgn(f-f_c)\right] \quad (4)$$

5

$$\hat{m}(t) \xleftrightarrow{\mathcal{F}} -j\,\mathrm{sgn}(f)\cdot M(f)$$

$$m(t)\cdot e^{\pm j2\pi f_c t} \xleftrightarrow{\mathcal{F}} M(f \mp f_c)$$

$$\hat{m}(t)\cdot e^{\pm j2\pi f_c t} \xleftrightarrow{\mathcal{F}} -j\,\mathrm{sgn}(f \mp f_c)\, M(f \mp f_c)$$

Applying above principle to eq^n (4)

5

$$x_{SSB}(t)\Big|_{LSB} = \frac{1}{2} A_c\, m(t)\cdot \cos\omega_c t + \frac{1}{2} A_c\, \hat{m}(t)\cdot \sin(2\pi f_c t) \quad \text{--- (5)}$$

$$x_{SSB}(t)\Big|_{USB} = \frac{1}{2} A_c\, m(t)\cdot \cos\omega_c t - \frac{1}{2} A_c\, \hat{m}(t)\cdot \sin(2\pi f_c t) \quad \text{--- (6)}$$

4(a) $\int_{-n\pi}^{n\pi} \sin^2\theta \cdot \sin\theta \cdot d\theta$ $\quad \forall n \geq 1$, where n is an integer

$= \int_{-n\pi}^{n\pi} \left(\frac{1-\cos 2\theta}{2}\right) \sin\theta \, d\theta$

$= \underbrace{\cancel{\int_{-n\pi}^{n\pi} \frac{1}{2} \sin\theta \, d\theta}}_{0} - \frac{1}{2} \underbrace{\cancel{\int_{-n\pi}^{n\pi} \cos 2\theta \cdot \sin\theta \, d\theta}}_{0}$

frequency mismatch

Periodic integral of a Sine or Cosine is zero

$= 0$ }

2

(b) $\int_{-n\pi}^{n\pi} \sin^2\theta \cdot \cos 2\theta \cdot d\theta$

$\int_{-n\pi}^{n\pi} \left(\frac{1-\cos 2\theta}{2}\right) \cos 2\theta \cdot d\theta$

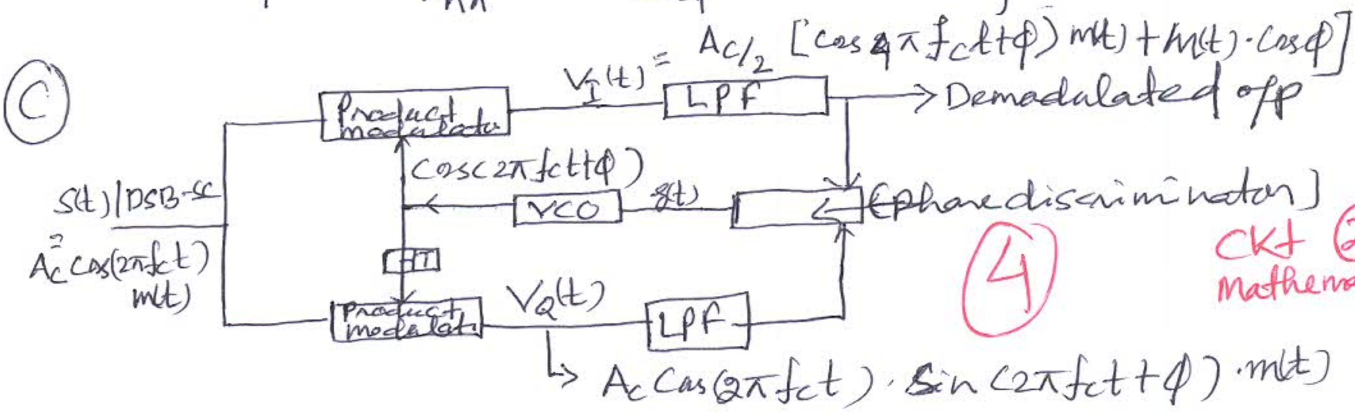
$= \underbrace{\cancel{\int_{-n\pi}^{n\pi} \frac{\cos 2\theta \, d\theta}{2}}}_{0} - \int_{-n\pi}^{n\pi} \frac{\cos^2 2\theta}{2} \, d\theta$

2

$= -\frac{1}{2}\left[\int_{-n\pi}^{n\pi} \frac{\cos(0) \, d\theta}{2} + \int_{-n\pi}^{n\pi} \cos 4\theta \, d\theta\right]$

$= -\frac{1}{4}\left[\theta\right]_{-n\pi}^{n\pi} = \frac{2n\pi}{-4} = -n\pi/2$ }

(c)



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Ckt 2
Mathematics 2

d) The phase reversal in DSB-SC occurs at the zero-crossing point of the message signal & it is due to the consideration that $f_c >> f_m$. 2

Thereby it has to change its magnitude (alters) during zero crossing

5a) Given $I_t = 11 amp$

$$11 = I_c\sqrt{\left(1+\frac{(0.4)^2}{2}\right)}$$

[Give 40% modalation index ~~achieved~~ for a single sine wave]

so $I_c = \frac{11}{\sqrt{1+\frac{(0.4)^2}{2}}} = 10.58 Amp$ 2

If the value of total current changed to 12 Amp by ~~two~~ different modulating signal. ~~[illegible]~~

Therefore,

$$I_{t2} = I_c\sqrt{\left(1+\frac{\mu_t^2}{2}\right)}$$

$$12 = 10.58\sqrt{1+\frac{\mu_t^2}{2}}$$ 2 5

$$\mu_t = 0.7569$$

$$\mu_t^2 = \mu_1^2 + \mu_2^2$$

$$(0.7569)^2 = (0.4)^2 + \mu_2^2$$

$$\mu_2 = 0.6426$$

or $\mu_2 = 64.26\%$ 1

(b) Given $[10 + 4\sin(1000\pi t)]\cos(2\pi\times10^6 t)$

so; $10\left[1+\frac{4}{10}\sin(2\times500\times\pi\times t)\right]\cos(2\pi\times10^6 t)$

The calculated values are

2 $\begin{cases} A_m = 4,\ A_c = 10,\ \mu = \text{modulation index} = 0.4 \\ f_m = 500\,Hz\ f_c = 10^6\,Hz \end{cases}$

1 $P_T = P_c\left(1+\frac{\mu^2}{2}\right) = \frac{10^2}{2}\left(1+\frac{(0.4)^2}{2}\right)$

$= 50\left(1+\frac{0.16}{2}\right) = 54W$

1 $P_{TSB} = \frac{A_c^2\mu^2}{4} = \frac{10^2\times(0.4)^2}{4} = 4W$

1 $P_{USB} = P_{LSB} = \frac{A_c^2\mu^2}{8} = \frac{(10)^2\times(0.4)^2}{8} = 2W$

(6) Given $m(t) = A_1 \cos(\omega_1 t) + A_2 \cos(\omega_2 t)$ & given $f_2 > f_1$

$c(t) = \cos(\omega_c t)$

DSB-SC

$$s(t) = (A_1 \cos\omega_1 t + A_2 \cos\omega_2 t)\cos(\omega_c t)$$

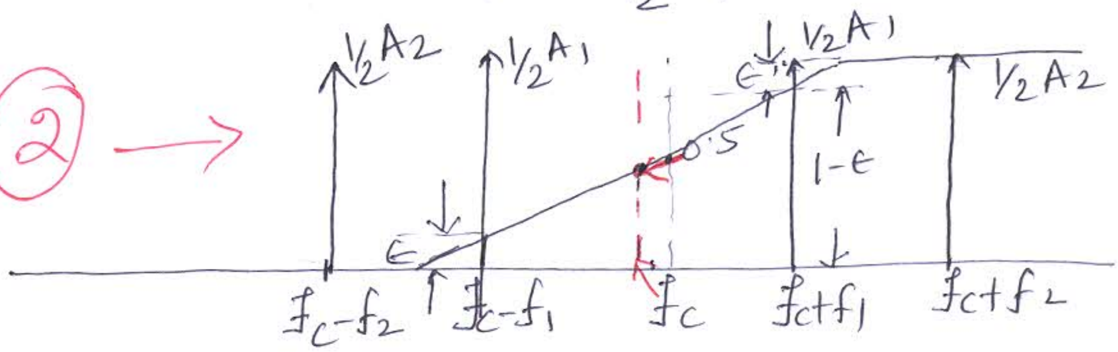
$$= \tfrac{1}{2} A_1 \cos(\omega_c - \omega_1)t + \tfrac{1}{2} A_2 \cos(\omega_c - \omega_2)t$$

(2)

$$+ \tfrac{1}{2} A_2 \cos(\omega_c - \omega_2)t$$

$$+ \tfrac{1}{2} A_1 \cos(\omega_c + \omega_1)t$$

(2) →



VSB spectrum $= |S(f)||H(f)|$

Modulation $V_{VSB}(t) = \frac{1}{2} A_1 \in \cos(\omega_c - \omega_1)t$

(2)

$$+ \frac{1}{2} A_1 (1-\in) \cos(\omega_c + \omega_1)t$$

$$+ \tfrac{1}{2} A_2 \cos(\omega_c + \omega_2)t$$

Demodulation

$V_{VSB}(t) \rightarrow (\times) \xrightarrow{v(t)}$ [LPF] $\rightarrow m(t)$, with $4\cos(\omega_c t)$ into the multiplier

(4)

$$v(t) = V_{VSB}(t)\, 4\cos\omega_c t$$

$$= 2A_1 \in \cos(\omega_c - \omega_1)t \cdot \cos(\omega_c t)$$

$$+ 2A_1(1-\in)\cos(\omega_c + \omega_1)t \cdot \cos\omega_c t$$

$$+ 2A_2 \cos(\omega_c + \omega_2)t \cos(\omega_c t)$$

$$= A_1 \in [\cos(2\omega_c - \omega_1)t + \cos\omega_1 t]$$

$$+ A_1(1-\in)[\cos(2\omega_c + \omega_1)t + \cos\omega_1 t]$$

$$+ A_2 [\cos(2\omega_c + \omega_2)t + \cos(\omega_2 t)]$$

After LPF

$$m(t) = A_1 \epsilon \cos(\omega_1 t) + A_1 (1-\epsilon) \cos \omega_1 t + A_2 \cos \omega_2 t$$

$$\boxed{m(t) = A_1 \cos \omega_1 t + A_2 \cos \omega_2 t}$$

Predicted message