DEPARTMENT OF ELECTRICAL ENGINEERING, IITD

ELL311, COMM. ENGG. MINOR-II Dur. 1 Hr. M.M. 25

MAKE ASSUMPTIONS, IF REQUIRED. 9 GRP. 01

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Prob.1: Let $x(t)$ be USB-SSB signal (message $m(t)$ & carrier w_c). Further let $\tilde{x}(t) = A_c \cos w_c t + x(t)$. Prove/disprove that $m(t)$ can be recovered from $\tilde{x}(t)$ using envelope detector. (3)

$$x(t) = m(t)\cos w_c t + m_h(t)\sin w_c t$$

$$\tilde{x}(t) = A_c \cos w_c t + m(t)\cos w_c t + m_h(t)\sin w_c t$$

$$= [A_c + m(t)]\cos w_c t + m_h(t)\sin w_c t$$

$$= E(t)\cos(w_c t + \theta)$$

2½

$$E(t) = \sqrt{[A_c + m(t)]^2 + (m_h(t))^2}$$

$$= |A_c + m(t)| \sqrt{1 + \left(\frac{m_h(t)}{A_c + m(t)}\right)^2} \ll 1$$

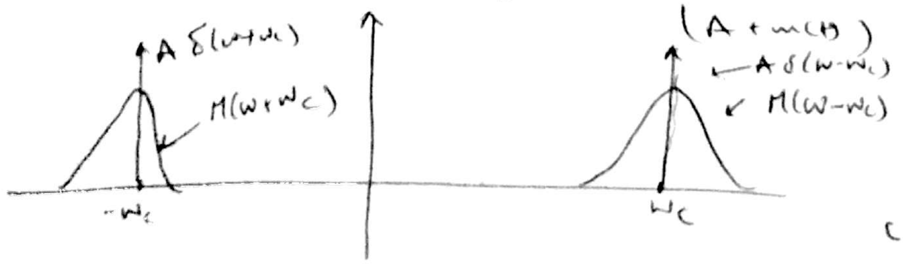
so

$$|E(t)| = |A_c + m(t)|$$

Passing $E(t)$ through a DC removal circuit will give $m(t)$.

Prob.2 Draw the phasor diagram for (i) AM signal; (ii) NBFM signal. (3)

(i)

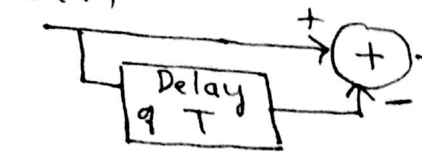


(ii)

$A\cos((\omega_c + m(t))t)$

(if $m(t) = m_p \cos \omega_m t$ for Narrow BFM is same as AM

Prob. 3 An FM signal $x(t) = A\cos(\omega_c t + k_f \int_{-\infty}^{t} m(\lambda)d\lambda)$ is passed through the following system



, where $T << \frac{1}{\omega}$ for all ω of interest.

Can one recover $m(t)$ from $y(t)$? How?

4

$y(t) = m(t) - m(t-T)$

$= A\cos(\omega_c t + k_f \int^{t} m(\lambda)d\lambda) - A\cos(\omega_c(t-T) + k_f \int_0^{t-T} m(s)ds)$ 1/2

Multiplying $y(t)$ with $\cos\omega_c t$

$A\cos(\ )\cos\omega_c t \quad - A\cos(\omega_c(t-T) + k_f\int\ )\cos\omega_c t$

$\cos(2\omega_c t + k_f\int) + \cos(\int) \quad - [\cos(2\omega_c t - \omega_c T + k_f\int) + \cos(\omega_c T + \int)]$

$= \cos(\int) + \cos(\int + \omega_c T)$

$\cos(2\int + \omega_c T) + \cos(\omega_c T)$

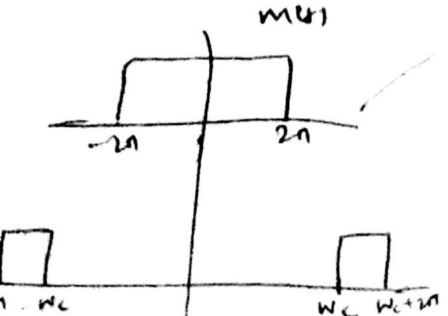
[No focus on Amplitude of signals see frequencies]

$= \cos(2\int)$

Yes ~~[illegible]~~ we can recover the $m(t)$ from $y(t)$, by multiplying it by $\cos\omega_c t$ and then a low pass filter and then $\cos^{-1}$ circuit.

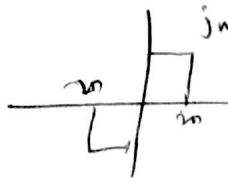
3

Prob. 4 Let $m(t) = \dfrac{\sin 2\pi t}{\pi t}$. Determine ($\omega_m = 2\pi$) the time domain expression for corresponding USB-SSB signal with carrier freq $\omega_c = 40\pi$ rad/s



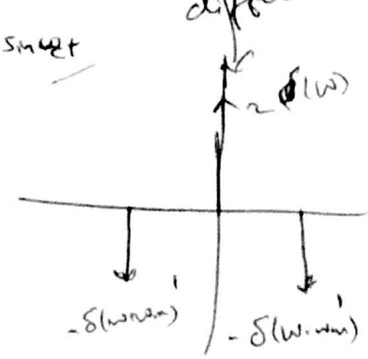
$m_+(t) = \frac{1}{2}(m(t) + j m_h(t))$

$m_-(t) = \frac{1}{2}(m(t) - j m_h(t))$



USB-SSB: $m(t)\cos\omega_c t + j m_H(t)\sin\omega_c t$

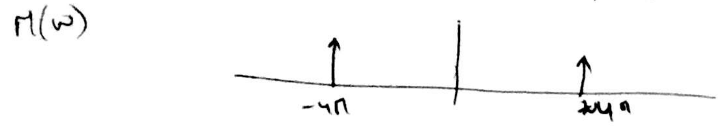
$jm_H(t) \rightarrow j\delta(\omega+\omega_m) + j\delta(\omega-\omega_m) + 2j\delta(\omega)$



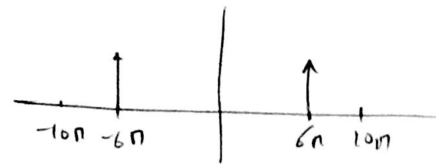
$\cancel{\frac{\sin 2\pi t}{\pi t}}$

1 1/2

Prob. 5 Let $m(t) = 2\cos \omega_m t$. This signal is LSB-SSB modulated with carrier frequency ω_c. Take $\omega_m = 4\pi$ & $\omega_c = 10\pi$. Find & plot the time-domain SSB signal. (3)

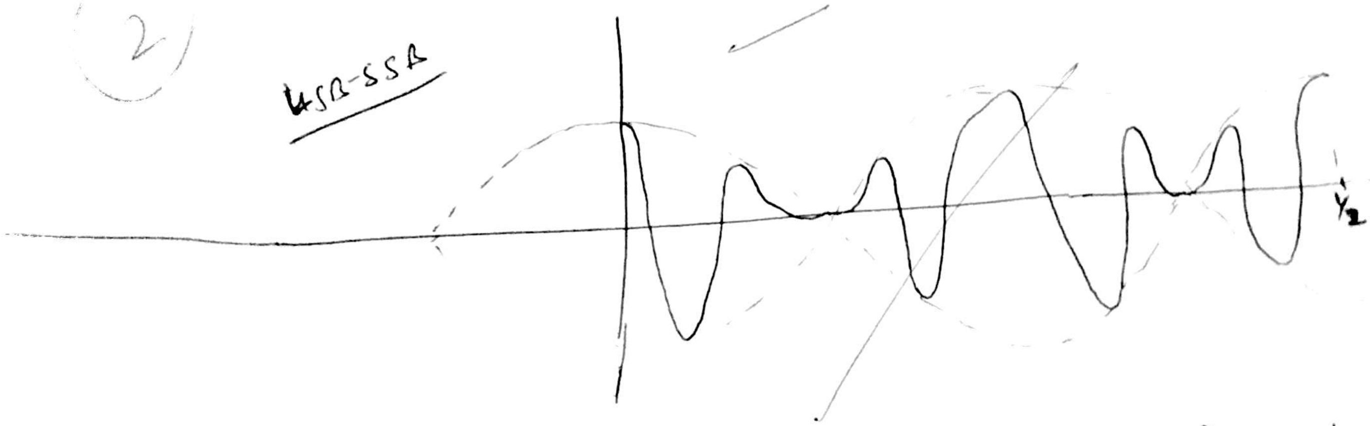


LSB-SSB-SC

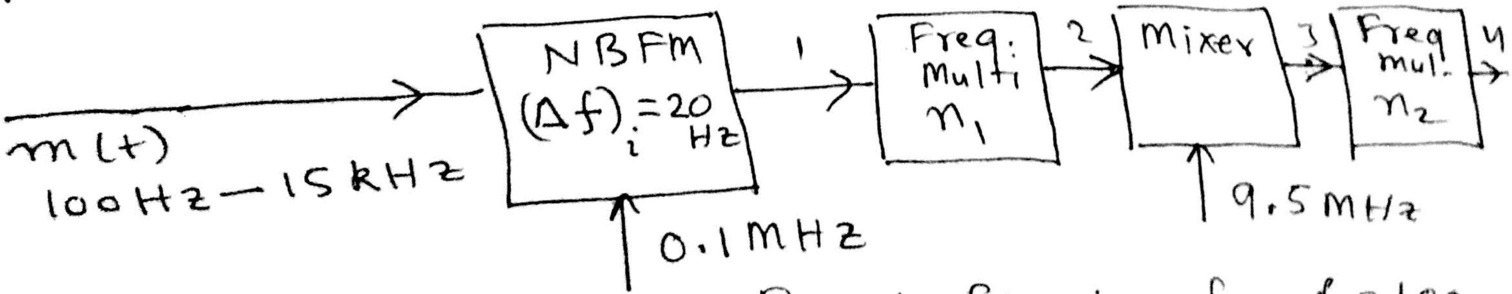


$\to$ $\boxed{2\cos(\omega_c - \omega_m)t}$

2



Prob. 6 Consider the block diagram for Armstrong method for FM generation. Determine n_1 & n_2 such that they could be realized by multiplication of 2, 3 & 5 only. (4)



Final $\Delta f = 75$ kHz & Final Carrier freq $f_c = 100$ MHz

	f_c	Δf
(4)	100 MHz	75 kHz
(3)	10 MHz	7.5 kHz
(2)	0.5 MHz	7.5 kHz
(1)	0.1 MHz	1.5 kHz

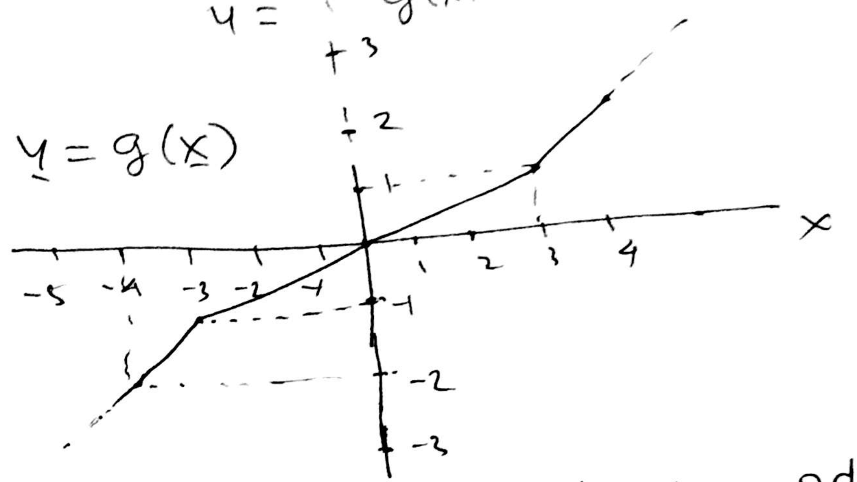
$\boxed{n_2 = 10 \quad n_1 = 5}$

0

$) = f_X(g^{-1})$

$y = g(x)$

Prob. 7 (5)



Let a random variable X, having pdf $f_X(x) = ke^{-2|x|}$ is transformed as given in fig. Find (i) k ; (ii) $f_Y(y)$, i.e. pdf of Y.

$y = g(x) = \begin{cases} x-2 & x > 3 \\ x/3 & -3 < x < 3 \\ x+3 & x < -3 \end{cases}$

$x = h^{-1}(y)$

(i) $\int_{-\infty}^{\infty} f(x)dx = 1 \quad = 2\int_0^{\infty} ke^{-2x} dx = 1 \qquad k = 1$

(ii) $\left| \frac{d}{dy}(x^{-1}(y)) \right| = 1$

$f_Y(y) = \begin{cases} e^{-2(y+2)} & y+2 > 3 \\ e^{-2(y+2)} & -3 < y+2 < 3 \\ e^{-2(y+2)} & y+2 < 3 \end{cases}$

$2\frac{1}{2}$

$2 \quad e^{-2(y+2)} \quad y > 1$

no steps