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Communication Assignment 4

Q#1 (5.1-2)

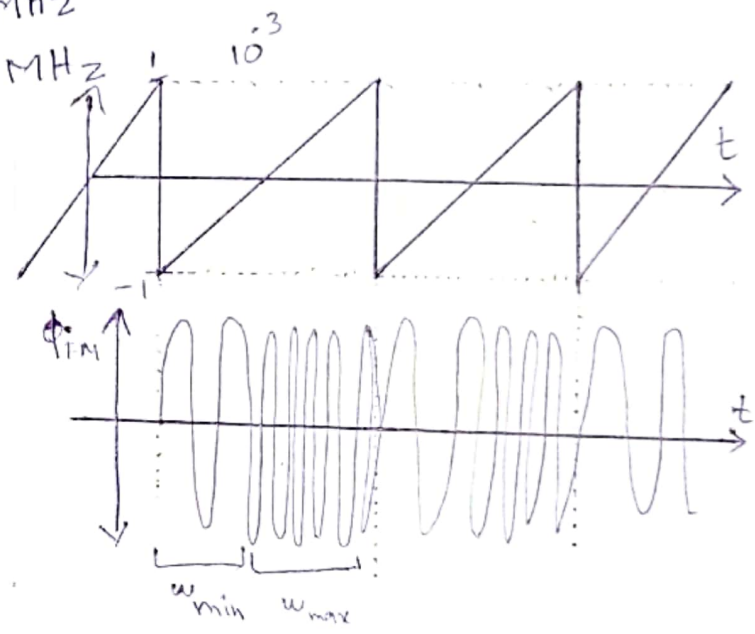
(a) $\omega_c = 2\pi \times 10^6$, $K_f = 2000\pi$, $K_p = \pi/2$

for FM :- $\Delta F = \frac{K_f m_p}{2\pi} = \frac{(2000\pi)(1)}{2\pi} = 1\,KHz$

$f_c = \frac{\omega_c}{2\pi} = 1\,MHz$

and $f_{max} = f_c + \Delta f = 1.001\,MHz$

$f_{min} = f_c - \Delta f = 0.999\,MHz$



for PM :-

$\Delta F = \frac{K_p m_p'}{2\pi} = ?$

let $m(t) = 2000t$

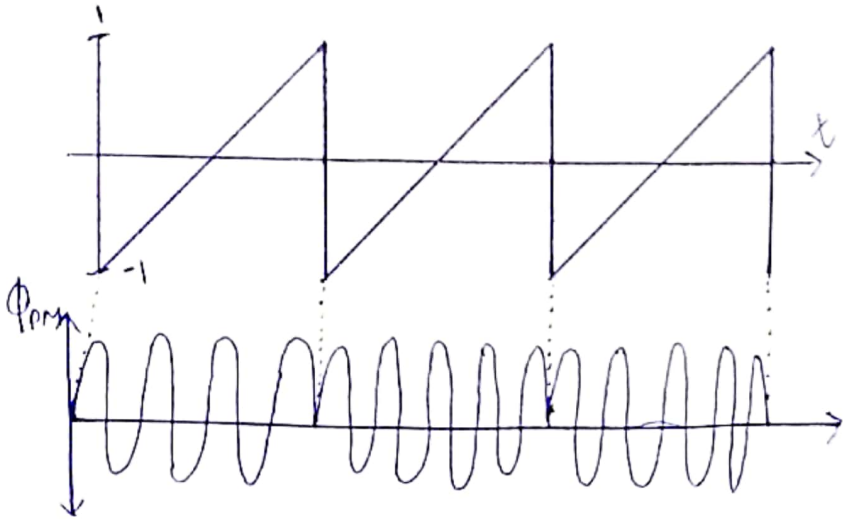
$\phi_{PM} = \cos\left(2\pi(10^6)t + \frac{\pi}{2} m(t)\right)$

$= \cos(2\pi \times 10^6 t + 1000\pi t)$

$= \cos(2\pi(10^6 + 500)t)$

$f = 10^6 + 500 = 1000500\,Hz$

and there will be a phase shift of (π-radians)



Q2 (5.2-2)

$K_f = 500\pi$, $m_p = 4$, $B = 5/T$, $K_p = 0.25\pi$

$$B = \frac{5}{0.03+0.01} = 125\ Hz$$

$$B_{FM} = 2(\Delta F + B) = 2\left[\frac{1}{2\pi} K_f m_p + B\right] = 2\left[\frac{(500\pi)(4)}{2\pi} + 125\right]$$

$$B_{FM} = 2250\ Hz$$

$$B_{PM} = 2(\Delta F + B) = 2\left[\frac{K_p m_p'}{2\pi} + B\right]$$

$$m_p' = \frac{4-(-4)}{0.01-0}t = \frac{8}{0.01} = 800 \quad \text{for } t = 1$$

$$B_{PM} = 2\left[\frac{(0.25\pi)(800)}{2\pi} + 125\right]$$

$$B_{PM} = 450\ Hz$$

Q3 (5.2-5)

$$\phi_{EM}(t) = 5\cos\left(\omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t\right)$$

(a) $A = 5$ $\quad \theta = \omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t$

$$P = A^2/2 = \frac{25}{2} = 12.5\ W$$

(b) $$\omega_i = \frac{d(\theta)}{dt} = \frac{d}{dt}\left(\omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t\right)$$

$$\omega_i = \omega_c + 20000\pi\cos 1000\pi t + 20000\pi\cos 2000\pi t$$

$$\omega_i - \omega_c = \Delta\omega = 20000\pi\left(\cos 1000\pi t + \cos 2000\pi t\right)$$

$$\Delta\omega_{max} = 40000\pi$$

$$\Delta f = \frac{\Delta\omega_{max}}{2\pi}, \quad \Delta f = 20\ KHz$$

(c) $\theta = \omega_c t + 20 \sin 1000\pi t + 10 \sin 2000\pi t$

$\theta - \omega_c t = \Delta\theta = 20 \sin 1000\pi t + 10 \sin 2000\pi t$

$\Delta\theta_{max} = 30 \text{ rad}$

(d) $B = \frac{2000\pi}{2\pi} = 1\text{KHz}$

$B_{FM} = 2(\Delta f + B) = 2(20000+1000) = 42\text{KHz}$

Q8-4 (5.3-2)

$\omega_c = 98.1\text{MHz}$

$\Delta f = 75\text{KHz}$

$f_{c_1}(\text{NB-FM}) = 100\text{KHz}$, $\Delta f = 10\text{Hz}$

$x = 125, 60 \Rightarrow n_1 = 125, n_2 = 60$

$f_{c_2} = n_1 \times f_{c_1} = (125)(100\text{K}) = 12.5\text{MHz}$

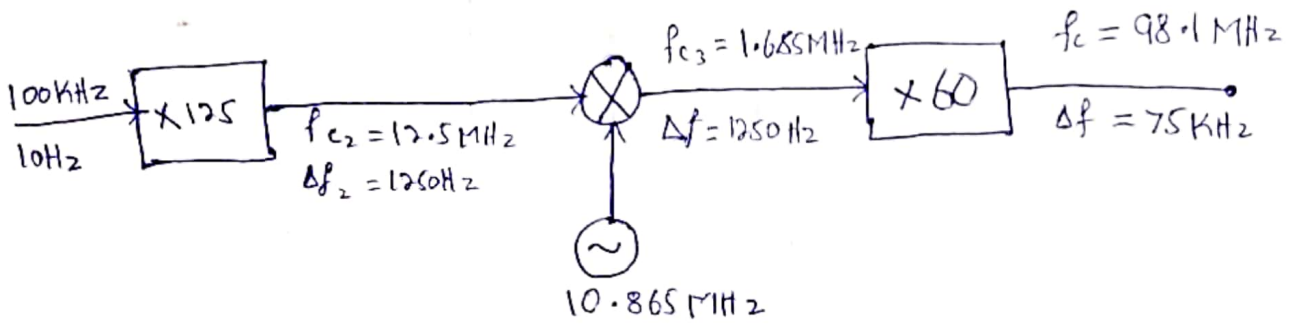
$f_{c_3} = \frac{\omega_c}{n_2} = \frac{98.1\text{M}}{60} = 1.635\text{MHz}$

$f_{c_3} = f_{c_2} \pm f_{LO}$

$f_{c_3} = f_{c_2} - f_{LO}$

$1.635\text{M} = 12.5\text{M} - f_{LO}$

$f_{LO} = 10.865\text{MHz}$



Q:-5 (5.4-2)

$f_c = 10KHz$, $\Delta f = 1KHz$

$f_{inst} = 1 \pm 10\ KHz = 9KHz - 11KHz$

$\Phi_{FM} = A \cos(20000\pi t \pm 2000\pi t)$

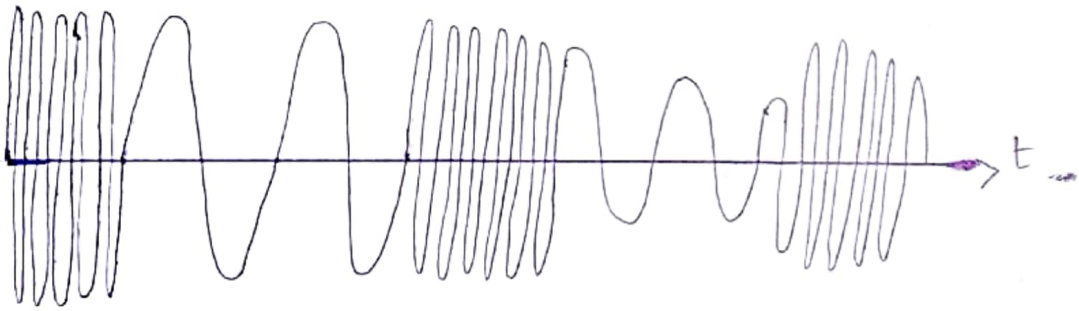
$\dot{\Phi}_{FM} = -A(20000\pi \pm 2000\pi) \sin(20000\pi t \pm 2000\pi t)$

E = Envalope $= A(20000\pi \pm 2000\pi)$

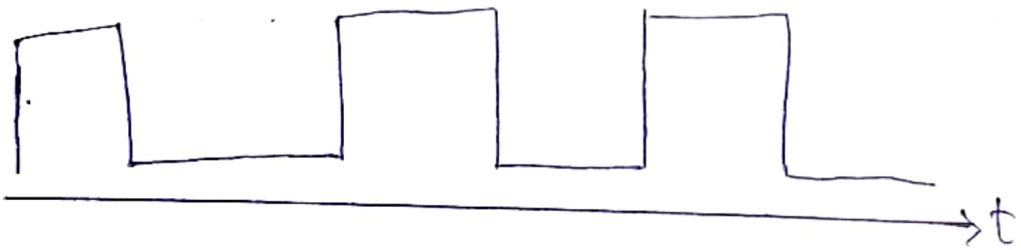
(a) same as given

(b)

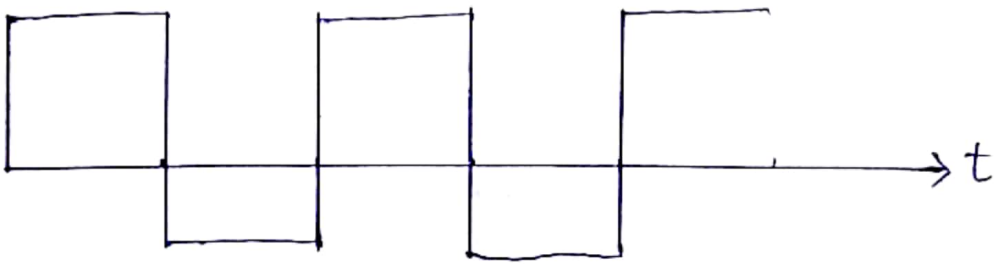
(b)(c)



(d)



(e)



Assignment: 5

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Q:-6 (5.6-1)

$f_c = 1530\,KHz$, $f = 455\,KHz$

$f_{LO} = f_c + f = 1985\,KHz$

$f_c' = 1985\,K + 455\,K = 2440\,KHz$

so the signal of frequency 1530KHz is also available or can be heard at the station of frequency 2440 KHz

Q:-7 (5.6-2)

88 to 108 MHz

$f = 10.7\,MHz$

$f_{LO} = 88 + 10.7$ to $108 + 10.7$ MHz

$f_{LO} = (98.7 \text{ —— } 118.7\ MHz)$

for image station

$f = (2)(10.7)MHz = 21.4\,MHz$

$f_{image} = 88 + 21.4$ to $108 + 21.4$ MHz

$f_{image} = (109.4 \text{ —— } 129.4)\ MHz$

Q8-8 (4.10) from Agbo

$A_m \cos(2\pi \times 10^4 t)$

(a) $K_f = 5\pi \times 10^4$

(i) $A_m = 2, 4$

$$\beta = \frac{K_f A_m}{\omega_m} = \frac{(5\pi \times 10^4)(2)}{2\pi \times 10^4} = 5$$

as $\beta > 1$, so the signal is of type Wide Band FM.

$$B_{FM} = 2(\beta+1) f_m = 2(5+1)\left(\frac{2\pi \times 10^4}{2\pi}\right) = 120\,KHz$$

(ii) $A_m = 4$

$$\beta = \frac{(5\pi \times 10^4)(4)}{2\pi \times 10^4} = 10$$

$\beta > 1$, WBFM signal

$$B_{FM} = 2(\beta+1) f_m = 2(10+1)(10^4) = 220\,KHz$$

(b) (i) $A_m = 2$

$K_p = 2.25$,

$\beta = (2.25)(2) = 4.5$

$\beta > 1$, WBPM signal

$$B_{PM} = 2(\beta+1) f_m = 2(5.5)(10^4) = 110\,KHz$$

(ii) $A_m = 4$

$K_p = 2.25$

$\beta = (2.25)(4) = 9$

$\beta > 1$, WBPM signal

$B = \cancel{(2.25)}(\; 2(9+1)(10^4) =$

$B = 200\,KHz$

Q:-9 (4.13) – agbo

$K_f = 10^5\pi$

$T = 0.1ms$, $f = 10KHz$

Third harmonic is $B = 3f = 30KHz$

(a) $\Delta f_{FM} = \frac{K_f m_p}{2\pi} = \frac{(2)(10^5\pi)}{2\pi} = 100KHz$

(b) $\Delta f_{AM} = \frac{K_p m_p'}{2\pi}$ * $m_p' = \frac{2-(-2)}{(0.15-0.05)} \times 10^3 = 40KHz$

$K_p = \frac{\Delta f_{AM} \times 2\pi}{m_p'} = \frac{(100K)(2\pi)}{40K} = 5\pi$

(c) $\beta = \frac{\Delta f_{FM}}{B} = \frac{100k}{30k} = 3.333Hz$

$\beta > 1$, so the signal is WBFM

$B_{FM} = 2(\beta+1)B = 2(\frac{10}{3}+1)30k = 260KHz$

(d) $B_{FM} = 2(\beta+2)B = 2(\frac{10}{3}+2)30K = 320KHz$

Q:-10 (4.18) – agbo

(a) $f_{c1} = 125KHz$, $\Delta f_1 = 30Hz$

$f_c = 80MHz$, $\Delta f = 48KHz$

$n = \frac{48000}{30} = 1600$

$n_1 - n_2 = \sqrt{1600} = 40$

$n_1 - n_2 = 2^3 \times 5 = 40$

$n_1 = \frac{f_{c2}}{f_{c1}}$, $f_{c2} = n_1 f_{c1} = (40)(125000) = 4.5\,MHz$

$n_2 = \frac{f_c}{f'_{c_2}} = f'_{c_2} = \frac{80M}{40} = 207\ 2MHz$

$f_{LO} = f_{c2} \pm f'_{c_2} = 5\,MHz \pm 2MHz$

$f_{LO} = 7\,MHz\ ,\ 3MHz$

(b)

(c) $\frac{\Delta f}{\Delta f_1} = n_1 n_2$

(b) $2^6 \times 5^2 = 2^6 \times 25$

As only doubles and tripplers are allowed so,

2	1600
2	800
2	400
2	200
2	100
2	50
5	25
5	5
	1

$2^9 \times 3 \approx 1600 = 1536$

$n_1 = 2^4 \times 3 = 48$, $n_2 = 2^5 = 32$

$n_1 = \frac{f_{c2}}{f_{c1}}$, $48 = \frac{f_{c2}}{125K}$, $f_{c2} = 6MHz$

$n_2 = \frac{f_c}{f_{c2}}$, $f'_{c_2} = \frac{80M}{32} = 2.5MHz$

$f_{LO} = 6MH \pm 2.5MHz = 3.5\,MHz$ and $8.5MHz$

(c) $n_1 n_2 = \frac{\Delta f}{\Delta f_1}$, $\Delta f_1 = \frac{\Delta f}{n_1 n_2} = \frac{48K}{1536} = 31.25\,Hz$

$\boxed{\Delta f_1 = 31.25\,Hz}$