JAYPEEINSTITUTEOFINFORMATIONTECHNOLOGY

ElectronicsandCommunicationEngineering

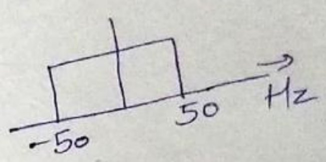
Digital Systems (18B11EC213)

TutorialSheet:7 Solution

Q.1.

- $\text{sinc}(100t)$

$$\text{sinc}(100t) \xrightleftharpoons{F.T.} \frac{1}{100}\text{rect}\left(\frac{f}{100}\right)$$



$f_m = 50\text{Hz}$

Nyquist Rate$(f_s) = 2f_m = 100\text{ Hz}$

- $\text{sinc}^2(100t)$

$$\text{sinc}(100t)\cdot\text{sinc}(100t) \xrightleftharpoons{F.T.} \frac{1}{100}\text{rect}\left(\frac{f}{100}\right) \underset{\text{convolution}}{\otimes} \frac{1}{100}\text{rect}\left(\frac{f}{100}\right)$$

$f_m = 50 + 50 = 100\text{Hz}$

$f_s = 2f_m = 200\text{Hz}$

- $2\cos(200\pi t) + \sin(400\pi t)$

$f_m = 200\text{ Hz}$

$f_s = 2f_m = 400\text{Hz}$

- $\sin(100\pi t)\sin(200\pi t)$

$= \frac{1}{2}\cos(100\pi t) - \frac{1}{2}\cos(300\pi t)$

$f_m = 150\text{Hz}$

$f_s = 2f_m = 300\text{Hz}$

Q.2. $f_m = 3.4\text{ kHz}$

Nyquist Rate $= 2f_m = 6.8\text{ kHz}$

Bandwidth of guard band = Sampling rate − Nyquist Rate

$= 8 - 6.8 = 1.2\text{ kHz}$

Q.3.

- $x_1(t) + x_2(t)$

$f_m = 20\,Hz$

$f_s = 40\,Hz$

- $x_1(2t)$

compression in time domain, There will be expansion in frequency domain.

$$x_1(2t) \overset{F.T.}{\rightleftharpoons} \frac{1}{2} X_1\left(\frac{f}{2}\right)$$

$f_m = 2 \times 10 = 20\,Hz$

$f_s = 40\,Hz$

- $x_2(t+3)$

$$x_2(t+3) \overset{F.T.}{\rightleftharpoons} e^{j6\pi f} X_2(f)$$

No change in frequency

$f_m = 20\,Hz$

$f_s = 40\,Hz$

- $x_1(t) \cdot x_2(t)$.

$$x_1(t) \cdot x_2(t) \overset{F.T.}{\rightleftharpoons} X_1(f) \otimes X_2(f)$$

thus

$f_m = 10 + 20 = 30\,Hz$

$f_s = 60\,Hz$

- $x_1(t) \otimes x_2(t)$

$$x_1(t) \otimes x_2(t) \overset{F.T.}{\rightleftharpoons} X_1(f) \cdot X_2(f)$$

thus $f_m = 10\,Hz$

$f_s = 20\,Hz$

Q.4

Ans: (a) power of carrier $= \frac{V^2}{R_L} = \left(\frac{V_{rms}^2}{\sqrt{2}}\right)^2 \frac{1}{R_L}$

$= \frac{V_m^2}{2R_L} = \frac{8\times8}{2\times8} = 4W$

(b) $P_T = P_c + P_{SB}$ ——— (1)

P_T can be calculated in (c) part

(c) $P_T = P_c\left(1+\frac{\mu^2}{2}\right) = 4\left(1+\frac{(1)^2}{2}\right) = 6W$

Put in (1)

(b) $P_T = P_c + P_{SB}$

$P_{SB} = (6-4)W$

$\boxed{P_{SB} = 2W}$

(d) Efficiency $= \frac{P_{SB}}{P_T}\times100 = \frac{2}{6}\times100 = 33.33\%$

Q.5

Ans: (a) $\mu_T = \sqrt{(0.3)^2+(0.4)^2+(0.5)^2+(0.6)^2}$

$\boxed{\mu_T = 0.927}$

(b) $P_T = P_c + P_{SB}$

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

$P_{SB} = \frac{P_c\mu^2}{2} = \frac{80\times(0.927)^2}{2} = 34.37W$

(c) $P_T = P_c + P_{SB}$

$= 80+34.37 = 114.37W$

(d) $\eta\% = \frac{34.37}{114.37}\times100$

$= 30\%$

Q. 6.

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

$=100\cos(2000\pi t) + \cos(2000\pi t)[2\cos(200\pi t)+\cos(600\pi t)]$

$=100\cos(2000\pi t) + 2[\cos(2000\pi t)\cos(200\pi t)]+[\cos(2000\pi t)\cos(600\pi t)]$

$=100\cos(2000\pi t) + [\cos(2200\pi t)+\cos(1800\pi t)]+0.5[\cos(2600\pi t)+\cos(1400\pi t)]$

The sideband of 1300 Hz will be,
$s_1(t)=0.5\cos(2600\pi t)$

The average power carried by this 1300 Hz sideband will be,
$P_1=(0.5)^2=0.25$ W

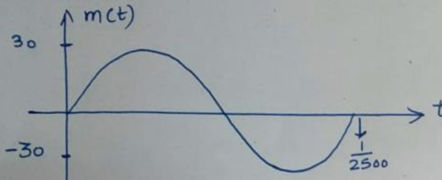
Q.7.

Q1

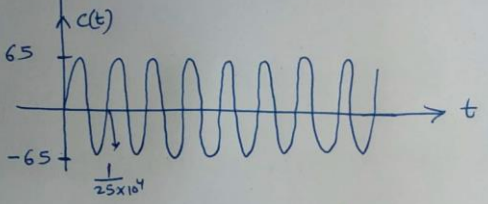
$m(t) = 30 \sin(2\pi \times 2500t)$

$c(t) = 65 \sin(2\pi \times 25\times10^4 t)$

a)

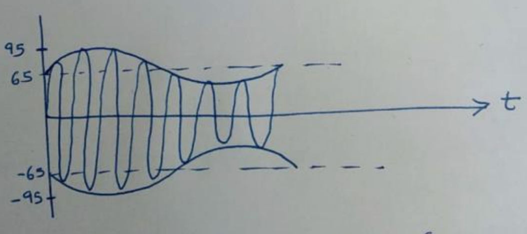


b)



c) $V_{AM}(t) = [A_c + m(t)] \sin(2\pi \times 25\times10^4 t)$ $\quad K_a \simeq 1$

$V_{AM}(t) = [65 + 30\sin(2\pi \times 2500t)] \sin(2\pi \times 25\times10^4 t)$



d) $m_a = \frac{A_m}{A_c} = \frac{30}{65} = \frac{6}{13} = 0.4615$

$\% m_a = 46.15$

e) $f_m = 2.5$ kHz , $f_c = 250$ kHz

f) f_c, f_c+f_m, f_c-f_m.

Q. 8

Ques2
Soln

1) Since an angle modulated signal is essentially a sinusoidal signal with constant amplitude, we have

$$P = \frac{A_c^2}{2} = P = \frac{100^2}{2} = 5000$$

2) The maximum phase deviation is

$$\Delta\phi_{max} = max\,|4\sin(2000\pi t)| = 4$$

3) The instantaneous frequency is

$$f_i = f_c + \frac{1}{2\pi}\frac{d}{dt}\phi(t)$$

$$= f_c + \frac{1}{2\pi}\cos(2000\pi t)\,2000\pi$$

$$= f_c + 1000\cos(2000\pi t)$$

Hence the maximum frequency deviation is

$$\Delta f_{max} = max\,|f_i - f_c| = 4000$$

4) The angle modulated signal can be Interpreted both as a PM and an FM signal.

It is a PM signal with phase deviation constant $k_p = 4$ and message signal $m(t) = \sin(2000\pi t)$ and it is an FM signal with frequency deviation constant $K_f = 4000$ and the message signal $m(t) = \cos(2000\pi t)$