Roll No. 4014

M.Sc.(Informatics)/I-Sem.-2014

Paper:IT-13

Introduction to Communication and Systems

Time:3 hours *Maximum Marks:75*

Write your Roll No. on the top immediately on receipt of this question paper.

Attempt **five** *questions in all.* **Q.1** *is compulsary*

Q.1 (a) Find the Fourier coefficient corresponding to the function (5)

$$f(x) = \begin{cases} 0 & , -5 < x < 0 \\ 3 & , 0 < x < 5 \end{cases} \qquad Period = 10$$

(b)Write the corresponding Fourier series. (5)

(c) How should $f(x)$ be defined at $x = -5, x = 0$ and $x = 5$ in order that the Fourier series will converge to $f(x)$ for $-5 \leq x \leq 5$? (5)

Q.2 (a) Find the Fourier transform of $f(x) = \begin{cases} 1 & |x| < a \\ 0 & |x| > a \end{cases}$ (5)

(b) Graph $f(x)$ and its Fourier transform for $a = 3$. (3)

(c) Show that (4)

$$sgn(t) \rightleftharpoons \frac{1}{i\pi f}$$

$$\frac{1}{\pi t} \rightleftharpoons isgn(f)$$

where the signum function $sgn(f)$ is defined by:

$$sgn(f) = \begin{cases} 1, & f > 0 \\ 0, & f = 0 \\ -1, & f < 0 \end{cases}$$

(d) Using the frequency - shifting property, determine the Fourier transform of the signal $g(t) = u(t)\cos(2\pi f_c t)$ where $u(t)$ is the unit step function. (3)

Q.3(a) Draw the AM waveforms for less than 100%, with 100%, more than 100% and with 0% modulation. Assume that the modulation signal is a pure sine wave. (3)

(b)A sinusoidal carrier has amplitude of $10V$ and frequency $30kHz$. It is amplitude modulated by a sinusoidal voltage of amplitude $3V$ and frequency $1kHz$. Modulated voltage is developed across 50Ω resistance. (3)

(*i*) Write the equation of modulated wave.

(*ii*)Determine the modulation index.

(*iii*) Draw the spectrum of the modulated wave.

(c)If $x(t)$ is modulating signal and $c(t) = A\cos\omega_c t$, the carrier signal, then the equation for AM wave will be (3)

$$s(t) = x(t)\cos\omega_c t + A\cos\omega_c t.$$

(*i*) Show that the total power of the AM signal is $P_t = \frac{1}{2}\left[A^2 + \overline{x^2(t)}\right]$.

(*ii*)Show that if $x(t) = V_m\cos\omega_c t$, then $P_t = P_c\left(1 + \frac{m_a^2}{2}\right)$ where P_c is the unmodulated power and m_a the modulation index for AM.

(d) The antenna current of an AM transmitter is $8A$ if only the carrier is sent, but it increases to $8.93A$ if the carrier is modulated by a single sinusoidal wave. determine the percentage modulation. Also find the antenna current if the percent of modulation changes to 0.8. (3)

(e) Explain the generation of AM waves using Switching modulator. (3)

Q.4(a) Explain the generation of $DSBSC$ waves using Balanced modulator. (3)

(b) In single tone $DSBSC$ modulation, the modulated wave is given by

$$s(t) = \frac{1}{2}V_m V_c\left[\cos 2\pi(f_c + f_m)t + \cos 2\pi(f_c - f_m)t\right]$$

where V_m and V_c refers to the amplitude of the modulating signal and the carrier signal respectively and other symbols have their usual meaning. Obtain the spectrum of the $DSBSC$ modulated wave. Also sketch the schematic diagram of the spectrum. (4)

(c) Describe briefly the process of coherent detection of $DSBSC$ modulated wave. (4)

(d) The SSB signal containing the upper side band (USB) is given by

$$s_u(t) = \frac{A_c}{2}\left[m(t)\cos(2\pi f_c t) - \hat{m}(t)\sin(2\pi f_c t)\right]$$

where $m(t)$ is the message signal and $\hat{m}(t)$ is its Hilbert transform. Find $s_u(t)$ if $m(t) = A_m \cos(2\pi f_m t)$. Hence describe the phase discrimination method for generating an SSB modulated wave. (4)

Q.5(a) Explain the process of vestigial sideband modulation (VSB). Describe the generation of VSB modulated wave. (5)

(b) Explain the terms (*i*) Frequency modulation (FM) , (*ii*) phase modulation (PM). Describe their generation. How do you distinguish between the two? (4)

(c) The Fourier series representation of a single tone FM wave may be written as:

$$s(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos\left[2\pi(f_c + nf_m)t\right]$$

β represent the modulation index. Using the foregoing distinguish between the (*i*) narrow band FM and (*ii*) the wide band FM. Also sketch the discrete amplitude spectrum (+-ve frequency only) of an FM signal, normalized with respect to carrier amplitude , for the case of sinusoidal modulation of fixed frequency and varying amplitude , when $\beta = 1$ and 2. (6)

Q.6(a) An analog signal is expressed as:

$$x(t) = 3\cos(50\pi t) + 10\sin(300\pi t) - \cos(100\pi t).$$

Calculate the Nyquist rate for this signal. (3)

(b) Write short note on any two of the following: (7)

(*i*) Pulse amplitude modulation (PAM).

(*ii*) Pulse position modulation (PPM),

(*iii*) Pulse width modulation (PWM).

(c) What do you understand by a uniform random variable? Let Z be a uniformly distributed random variable, defined by

$$f_Z(z) = \begin{cases} \frac{1}{2}, & -1 \le z \le +1 \\ 0, & \text{otherwise} \end{cases}$$

Let the random variable $X = Z$ and the random variable $Y = Z^2$. Find $E(X)$, $E(Y)$, σ_X, σ_Y and $Cov(XY)$. (5)