The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Final Examination 2013/2014
ECX5233 –Communication Theory and Systems

Time: 0930 – 1230 hrs. Date: 2014-08 -29

Answer any Five Questions

1.

(a) The signal $f(t)$ can be expressed in the form $f(t)= \sum_{n=-\infty}^{\infty} A_n \cos n\omega_0 t$.

What kind of signal is $f(t)$? Give *two* important characteristics of $f(t)$.

(b) The signal $g(t)$ can be approximated by the equation

$$g(t)= (2.\cos\omega_0 t)(1+\cos\omega_0 t)$$

- (i) What kind of function is $g(t)$?
- (ii) Express $g(t)$ as a Fourier series.
- (iii) Sketch the amplitude spectrum of $g(t)$.

(c) If $x(t) = g(t) + j\sin 2\omega_0 t$

- (i) Express $x(t)$ as a Fourier series.
- (ii) Sketch the amplitude spectrum of $x(t)$.
- (iii) Sketch the phase spectrum of $x(t)$.

2.

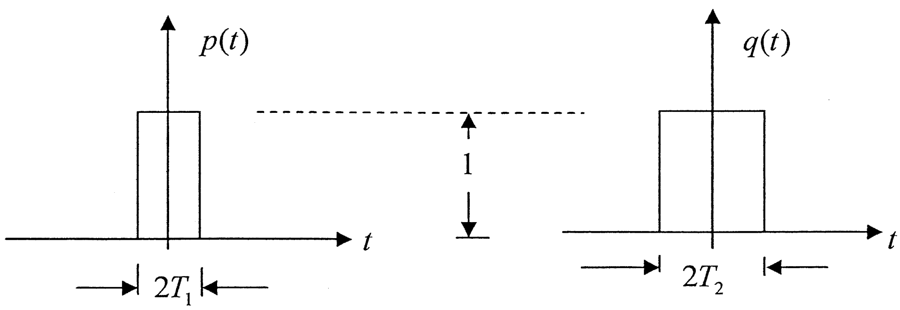


Fig.1

21

$p(t)$ and $q(t)$ are rectangular pulses having pulse widths of $2T_1$ and $2T_2$ where $T_2 > T_1$, as shown in Fig.1.

(a) Find the value of $z(x) = \int_{-\infty}^{\infty} p(t-x).q(t)\,dt$ for

(i) $-\infty < t < -(T_1 + T_2)$
(ii) $-(T_1 + T_2) < t < -(T_2 - T_1)$
(iii) $-(T_2 - T_1) < t < T_2 - T_1$
(iv) $(T_2 - T_1) < t < T_2 + T_1$
(v) $(T_2 + T_1) < t < \infty$
(vi) Sketch $z(t)$ for the range $-\infty < t < \infty$
(vii) Is $z(t) = p(t) * q(t)$? Justify your answer.

(b) (i) Find $P(\omega)$, the Fourier transform of $p(t)$.
(ii) Deduce $Q(\omega)$, the Fourier transform of $q(t)$.
(iii) Using the results of (i) and (ii) find $Z(\omega)$, the Fourier transform of $z(t)$.
(iv) Sketch $Z(\omega)$.

(c) A triangular pulse $s(t)$ has a height of 1.

$s(t) \neq 0$ for $-T < t < T$
$= 0$ otherwise

Use the results of (a) and (b) to find $S(\omega)$ the Fourier Transform of $s(t)$.

3.

(a) The Fourier Transforms of $x(t), y(t)$ and $z(t)$ are $X(\omega), Y(\omega)$ and $Z(\omega)$ respectively.

(i) If $z(t) = x(t - t_0)$, write an expression for $Z(\omega)$ in terms of $X(\omega)$.
(ii) If $z(t) = x(t).e^{j\omega_0 t}$, write an expression for $Z(\omega)$ in terms of $X(\omega)$.
(iii) Write an expression for the Fourier transform of $X(t)$ in terms of $x(\omega)$

(b) A carrier signal $y(t) = \cos\omega_0 t$ is amplitude modulated using the signal $m(t)$. The resulting amplitude modulated carrier $z(t)$ can be represented by

$$z(t) = m(t).y(t)$$

(i) State the type of A.M. technique used here. (DSB, SSB, DSB/SC or SSB/SC)
(ii) Derive an expression for $Z(\omega)$ [Hint: You may use the results in (a)]
(iii) Sketch $Z(\omega)$ if $m(t)$ is a *sinc* function.

(iv) During the generation of the carrier $y(t) = \cos\omega_0 t$, it is deformed due to harmonic distortion.

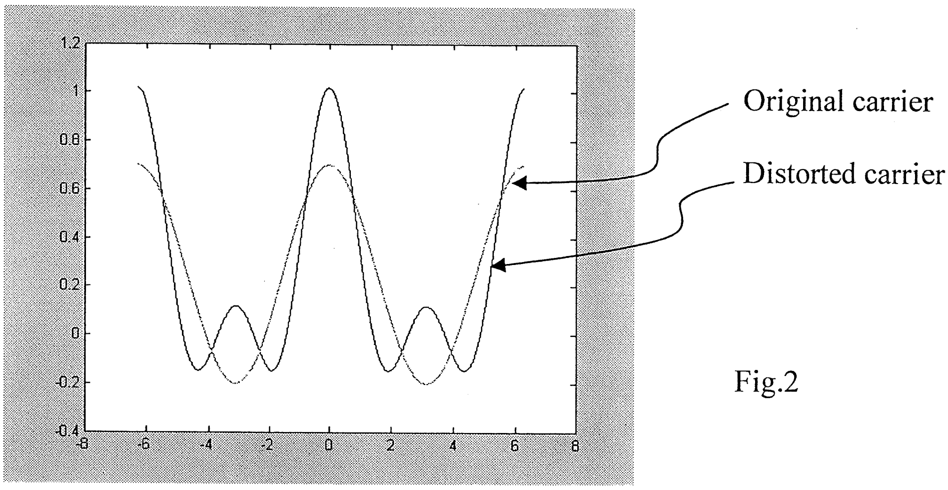


Fig.2

1. State the type of harmonic distortion found in the carrier.
2. Write an equation for the distorted (unmodulated) carrier. Assume that the d.c value of the carrier is zero.
3. Now the distorted carrier is amplitude modulated as given in (b). Write an equation for the modulated carrier $z_d(t)$ and sketch $Z_d(\omega)$ the Fourier Transform of $z_d(t)$. Assume $m(t)$ to be a *sinc* function

4.

A transmitter sends a binary signal $s(t)$. It can take the value -2 or +2 with equal probability. During the transmission noise $n(t)$ is added to $s(t)$. The probability density function of noise is given below:

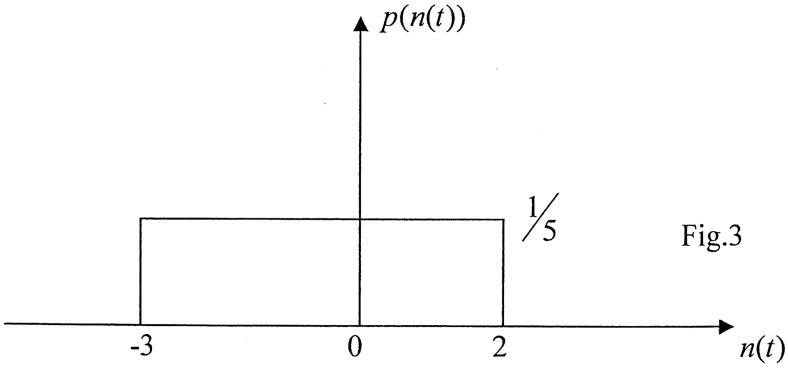


Fig.3

The noisy signal $s'(t) = s(t) + n(t)$ is received at the receiver. If the received signal level has a negative value the receiver assumes that -2 was transmitted by the transmitter. If the received level is positive then the receiver assumes that +2 was transmitted.

(i) Find the probability that -2 is received as +2.
(ii) What is the total error probability?
(iii) Find the signal to noise ratio at the receiver.

5.
(a) The Autocorrelation function of a random process $x(t)$ is defined as

$$\Re_x(t_1,t_2) = \overline{x(t_1).x(t_2)} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x_1 x_2 p(x_1,x_2)dx_1 dx_2$$

(i) What are x_1 and x_2?
(ii) What is $p(x_1,x_2)$?
(iii) When does $\Re_x(t_1,t_2)$ become a stationary process?

(b) A student is planning to do a study on electromagnetic noise ($n_{em}(t)$) present inside a laboratory.
Is $n_{em}(t)$ a random process? Justify your answer.

(c) A random process is given by $x(t) = A\sin(\omega t + \theta)$, where A and ω are constants. θ is a random variable uniformly distributed over $-\pi$ to π.

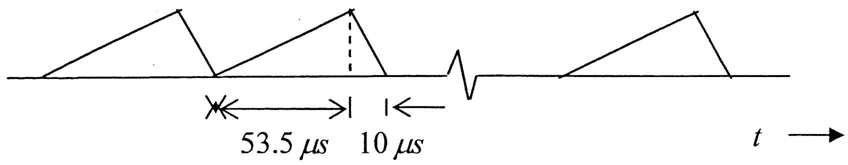
(i) Find the Autocorrelation function $\Re_x(t_1,t_2)$ of the random process $x(t)$.
(ii) Find $\overline{x(t)}$, the mean value of $x(t)$.
(iii) Is the process wide sense stationary? Justify your answer.

6.
(a) Explain following terms related to TV technology:

(i) Luminance and chrominance information of a TV signal.
(ii) Video and audio bandwidth.
(iii) Synchronization separator.

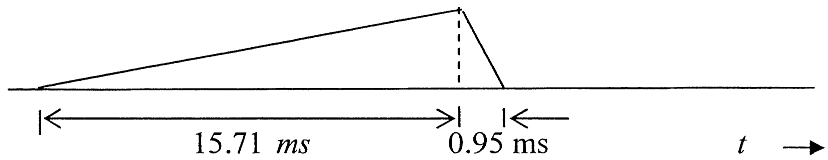
(b) On a TV picture thin horizontal lines were observed.
Give one possible reason for this phenomenon.

(c) The horizontal and the vertical deflection signals for a certain TV system are given below:



Horizontal deflection signal

Fig. 4



Vertical deflection signal

Calculate the number of active lines per frame.

7.

(a) Two binary channels are cascaded as shown in the figure 5..

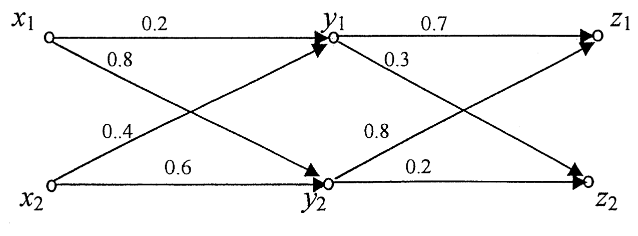


Fig.5

Transition probabilities for each channel are given in the diagram.

(i) What information about a channel can be extracted from transition probabilities?

(ii) Find the overall channel matrix.

(iii) If $p(x_1) = 0.4$ and $p(x_2) = 0.6$, find $p(z_1)$ and $p(z_2)$.
$p(x)$ is the probability for the value x.

(b) Messages m_1, m_2, m_3, m_4, m_5 and m_6 are transmitted with the probabilities 0.28, 0.26, 0.16, 0.13, 0.09, and 0.08 respectively.

Find

(i) the average information per message.
(ii) the Huffman code for the messages.
(iii) the average code length.

8.
(a) (i) Briefly explain the principle of Orthogonal Frequency Division Multiplexing (*OFDM*).
(ii) What are the advantages of using *OFDM* for picture transmission in digital TV systems?

(b) Briefly explain the following:

(i) Eye diagram of a signal.
(ii) Threshold detection