The Open University of Sri Lanka
Department of Electrical and Computer Engineering
ECX5233– Communication Theory and Systems
Final Examination 2014/2015

Time : 0930 - 1230 hrs. Date: 2015- 09 - 11

Answer any FIVE *questions*

1.

(a) (i) What is understood by Fourier analysis of a non-sinusoidal repetitive waveform?
If the period of the above waveform is T, explain with necessary expressions how the waveform is Fourier analyzed. [3 *marks*]

(ii) What information can be retrieved from a signal when Fourier analyzed? [2 *marks*]

(b)

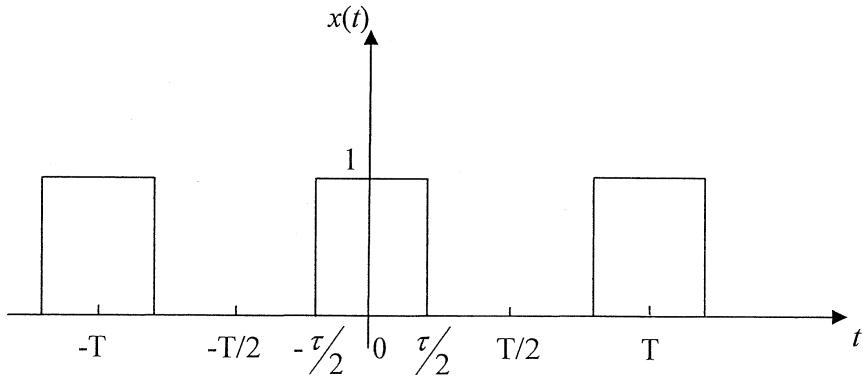


Fig.1

(i) Express the waveform given in Fig.1 as a trigonometric series. [4 *marks*]

(ii) Plot the amplitude spectrum of $x(t)$. [2 *marks*]

(iii) Redraw the amplitude spectrum of $x(t)$ for
1. larger value of T [3 *marks*]
2. smaller value of τ [3 *marks*]
and compare with your answer to (ii).

(iv) $x(t)$ is transmitted through a channel which shows *low-pass* characteristics. If the received signal is $x'(t)$, draw $x'(t)$ and compare with $x(t)$. Give reasons any differences. [3 *marks*]

2.

(a)

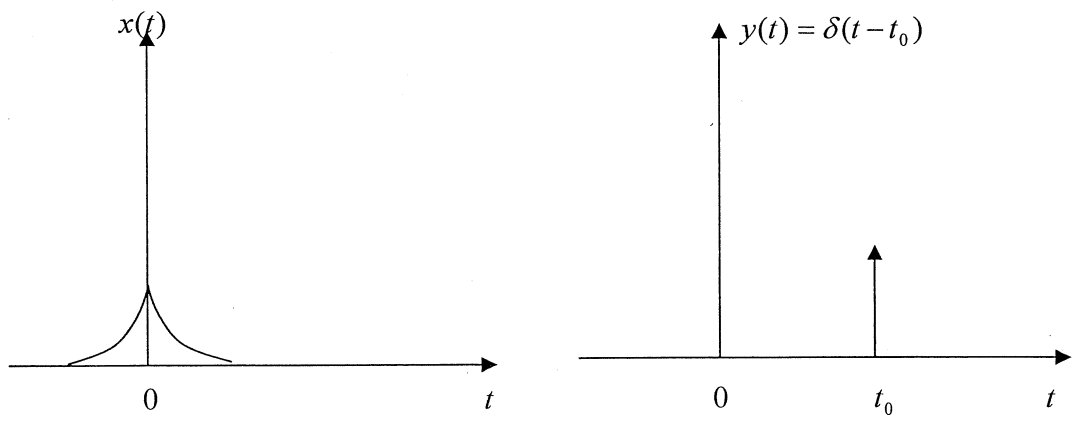


Fig.2.1

(i) Sketch $z(t) = x(t) * y(t)$. [2 *marks*]

(ii) Find $Z(\omega)$ in terms of $X(\omega)$ where $Z(\omega)$ and $X(\omega)$ are the Fourier Transforms of $z(t)$ and $x(t)$ respectively. [2 *marks*]

(b) Band limited signal $s(t)$ and its Fourier Transform $S(\omega)$ are shown in Fig.2.2.

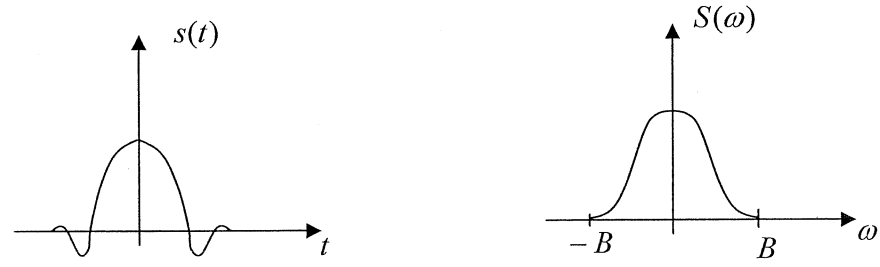


Fig.2.2

$s(t)$ is sampled using the impulse train $p(t)$ [Refer Fig.2.3 and 2.4].

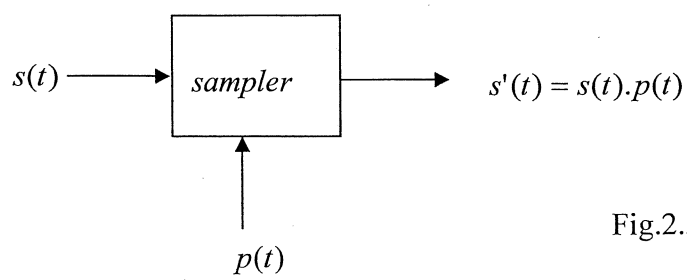


Fig.2.3

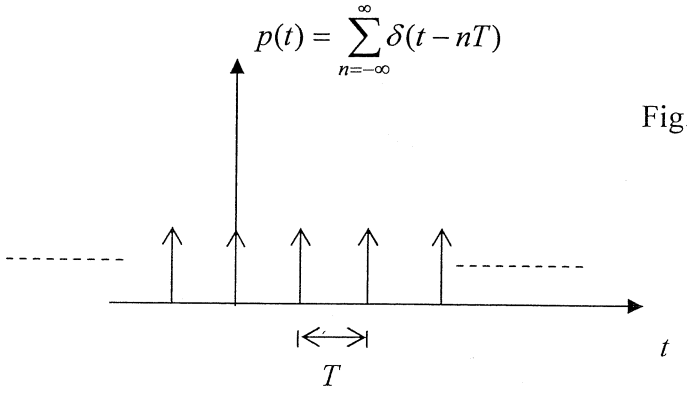


Fig.2.4

(i) Express $p(t)$ as a Fourier series and hence find $P(\omega)$. Show that $P(\omega)$ is an impulse train. [4 *marks*]

(ii) Using $P(\omega)$ and $S(\omega)$ find the frequency spectrum $S'(\omega)$ of the sampled signal $s'(t)$. [4 *marks*]

(iii) Sketch $S'(\omega)$. [2 *marks*]

(iv) Using the above sketch decide the maximum possible value for T, if $s(t)$ is to be recovered from $s'(t)$ without any distortions. [6 *marks*]

3.

(a) A voice signal $m(t)$ has the Fourier Transform $M(\omega)$ shown in Fig.3.1

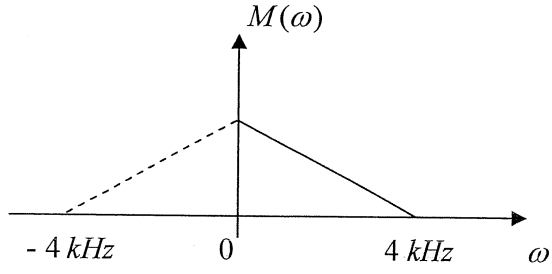


Fig.3.1

A sinusoidal carrier having the carrier frequency ω_c is modulated using $m(t)$. The resulting signal $x(t)$ is given by

$$x(t) = \cos(\omega_c t).m(t)$$

(i) State the type of modulation technique used here. [3 *marks*]

(ii) Find the frequency spectrum of $x(t)$ and sketch it. [5 *marks*]

(iii) Three voice signals $m_1(t)$, $m_2(t)$, $m_3(t)$ have the same spectral distribution given by $M(\omega)$. It is necessary to transmit these 3 signals using the above carrier. Suggest a suitable method and sketch the spectral distribution of the modulated carrier signal. [4 *marks*]

(b) The equation of a modulated carrier is given below:

$$x_c(t) = \cos(\omega_c t + \beta \sin \omega_m t)$$

(i) State the type of modulation used here. [2 *marks*]

(ii) When $\beta << 1$ simplify the above expression and find the bandwidth of $x_c(t)$. [6 *marks*]

4.

(a) Briefly explain with the help of a diagram how n channels are multiplexed using *Time Division Multiplexing* (*TDM*). [4 *marks*]

(b) Three messages $m_1(t)$, $m_2(t)$ and $m_3(t)$ are time division multiplexed by a sampler which sequentially samples three signals at a frequency f_T. The bandwidths of $m_1(t)$, $m_2(t)$ and $m_3(t)$ are 5 kHz, 7 kHz and 10 kHz respectively. Find the minimum possible value for f_T. Justify your answer. [5 *marks*]

(c) A sinusoidal signal is pulse code modulated. The amplitude of the signal is A and it is divided into n levels.

(i) Explain how an error is introduced due to quantization. [3 *marks*]

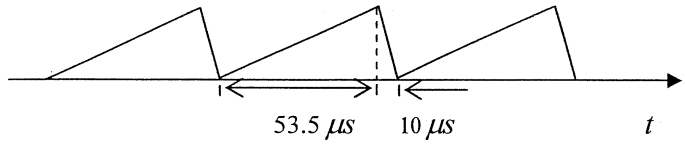
(ii) If the quantization error $e(t)$ is uniformly distributed between two adjacent amplitude levels, find the average quantization error $\overline{e^2(t)}$. [5 *marks*]

(iii) Find signal to noise ratio S/N. [3 *marks*]

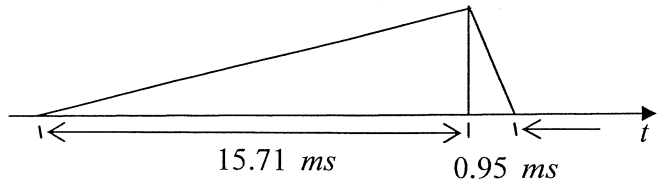
5.

(a) An analogue television image (a frame) consists of two fields. Each field consists of N lines. The horizontal- and vertical deflection signals are given below:

Horizontal deflection signal



Vertical deflection signal



(i) Why is horizontal deflection signal necessary? [3 *marks*]

(ii) What is the function of the vertical deflection signal? [3 *marks*]

(iii) Find the value of N. [4 *marks*]

(iv) Find the equivalent number of lines for the vertical deflection fly-back signal. [3 *marks*]

(v) Find the total number of pixels present in an image. [Note that the thickness of each line is one pixel] [4 *marks*]

(b) When an outdoor TV antenna is installed (in Sri Lanka), all antenna elements are kept horizontal. What is the reason for this? [3 *marks*]

6.

(a) How does channel noise affect an amplitude modulated signal? [3 *marks*]

(b) A binary transmitter transmits rectangular pulses. Pulse amplitude can be either +5 V or -5 V. Both the pulses are transmitted with equal probabilities. Due to channel noise $n(t)$, pulse amplitude is modified. The probability density function of $n(t)$ during the data transmission is given below:

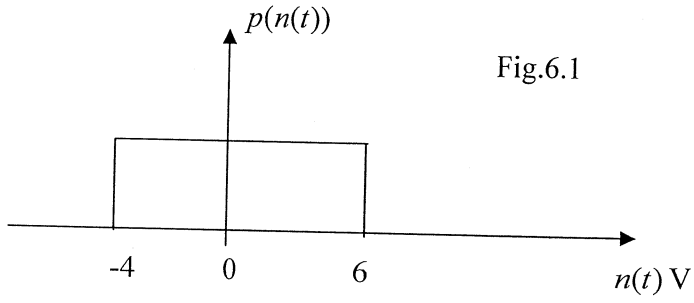


Fig.6.1

At the receiver the amplitude of the received pulse is detected. If the measured value is greater than 2 V the detector decides that +5 V pulse has been transmitted. Otherwise the detector decides that the transmitted pulse was a -5 V pulse.

(i) What is the average noise level in the medium? [4 *marks*]

(ii) What is the probability that +5 V pulse is detected as a -5V pulse? [6 *marks*]

(iii) Find the total power of the noisy received signal. Assume that the data signal and $n(t)$ are independent and uncorrelated. [7 *marks*]

7.

(a) (i) What is an *eye diagram*? [2 *marks*]

(ii) You are given a repetitive pulse train with pulse width T and pulse repetition time 2T. How are going to set up an oscilloscope to observe the eye diagram of this signal? [3 *marks*]

(iii) Eye diagrams of a transmitted signal and its received signal are available. What conclusions can be drawn from these diagrams regarding the transmission medium? Briefly explain. [3 *marks*]

(b) (i) When you watch TV news you listen to 2 news items N_1 and N_2. N_2 is less probable compared to N_1. Which news item brings you more information, N_1 or N_2? [2 *marks*]

(ii) A source emits 5 messages with probabilities0.40, 0.35, 0.15, 0.07 and 0.03.

1. Find the entropy of the source. [3 *marks*]

2. Find the Huffman code for the messages and find the average code length. [5 *marks*]

3. Calculate the code efficiency. [2 *marks*]

8.

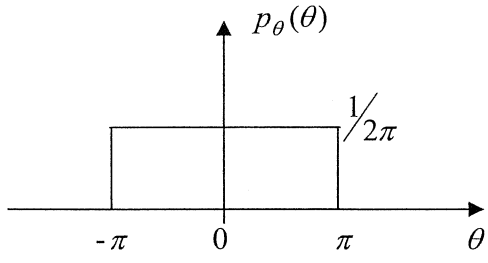
(a) What are the parameters that characterize a random variable? [3 *marks*]

(b) What is a random process? Can the parameters given in (a) be used to characterize a random process? Briefly explain. [4 *marks*]

(c) (i) What is a stationary process? [3 *marks*]

(ii) What is a wide sense stationary process? [3 *marks*]

(iii) A random process is given by $Y(t) = 2\cos(\omega t + \theta)$, where ω is a constant and θ is a random variable. The probability density function of θ is given below:



Find whether $Y(t)$ is wide sense stationary. [7 *marks*]