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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**:EEX5333 /ECX5533 Communication Theory and Systems**
Academic Year	: 2020/21
Date	: 2022 – 02 - 02
Time	: 1400-1700 hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Five (5)** pages.
3. Answer **Five (5)** questions. All questions carry equal marks.
4. Answer for each question should commence on a new page.
5. Important formulas are provided.
6. This is a Close Book Test **(CBT).**
7. Answers should be in clear handwriting.
8. Do not use red color pen.

1.

(a) Any periodic signal $x(t)$ can be generally represented by a trigonometric Fourier series as follows:

$$x(t) = a_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t) + B_n \sin(n\omega_0 t)$$

Give an example for $x(t)$ and sketch the waveform for the following situations:

(i) $a_0 = 0, A_n = 0, B_n \neq 0$ [4 *marks*]

(ii) $a_0 \neq 0, A_n \neq 0, B_n = 0$ [4 *marks*]

(b)

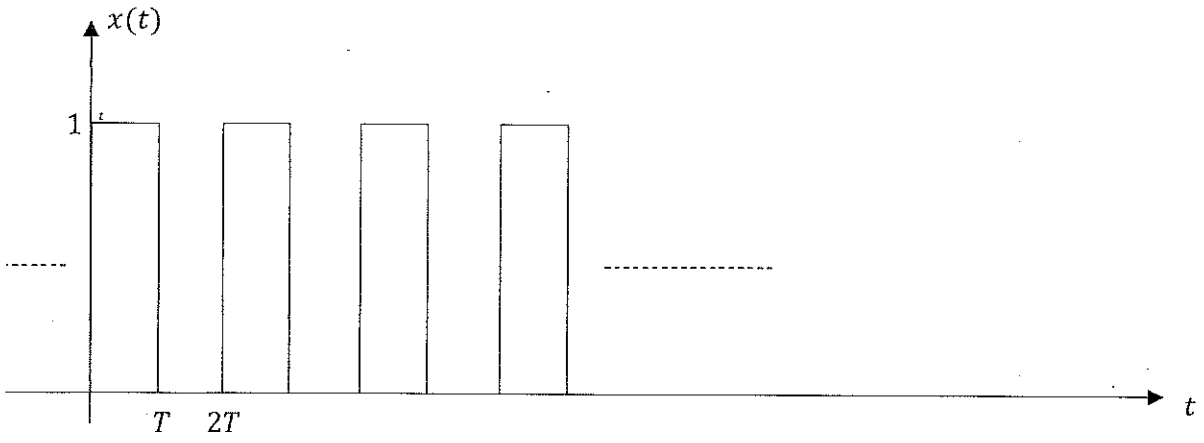

Fig.1

A rectangular pulse train is shown in Fig.1.

(i) Find a_0, A_n and B_n for $x(t)$. [4 *marks*]

(ii) Sketch the magnitude spectrum of the signal. [4 *marks*]

(iii) Give the amplitudes of the first four harmonics with the corresponding frequency values. [4 *marks*]

2.

(a) Find the Fourier Transforms of

(i) $h(t) = e^{-at}u(t)$, where $u(t)$ is the unit step function. [4 *marks*]

(ii) $g(t) = e^{-a|t|}$ [4 *marks*]

a is a positive real constant.

(iii) Show that both $h(t)$ and $g(t)$ show lowpass characteristics [4 *marks*]

(iv) Compare the 3-dB bandwidths of $h(t)$ and $g(t)$. [4 *marks*]

(b) The impulse response of an ideal lowpass filter is $h_L(t)$. The cutoff frequency of the filter is ω_C. Show that $h_L(t)e^{j\omega_0 t}$ represents a bandpass filter. Also find the bandwidth of the filter if $\omega_0 > \omega_c$. [4 *marks*]

3.

(a) Impulse train is given by $p(t) = \sum_{-\infty}^{\infty} \delta(t - nT_0)$

(i) What is T_0 ? [2 *marks*]

(ii) $p(t)$ can be expressed as a complex Fourier series as follows:

$p(t) = \frac{1}{T_0}\sum_{-\infty}^{\infty} e^{jn\omega_0 t}$. What is the relationship between T_0 and ω_0? [2 *marks*]

(iii) The continuous signal $x(t)$ is sampled by multiplying with $p(t)$.

If the sampled signal is $x_s(t)$, derive an expression for the Fourier transform $X_s(\omega)$. [5 *marks*]

(b) The signal $x(t)$ given in 3 (a) is bandlimited to $50\ kHz$. If $T_0 = 10\mu s$ sketch $|X_s(\omega)|$. [3 *marks*]

(c) A sinusoidal signal is given by $x(t) = 2\sin(2\pi \times 10^6)t$

(i) Write expressions for the third- and the fifth harmonics of $x(t)$. Assume that the amplitudes of both harmonics are 1. [4 *marks*]

(ii) The signal $y(t)$ is formed by adding the above two harmonics to $x(t)$. Find the minimum sampling frequency that can be used to sample $y(t)$, for the distortionless recovery of $y(t)$ from the sampled signal. [4 *marks*]

4.

(a) (i) What is binary phase shift keying (BPSK)? [3 *marks*]

(ii) A carrier signal $x_c(t) = \sin(\omega_c t + \alpha)$ is used for BPSK. If '1' is represented by $\sin(\omega_c t + \alpha)$, write an expression for the modified carrier signal for '0'. Also draw the constellation map. [4 *marks*]

(b) Two BPSK streams s_1 and s_2 are added as shown in Fig. 4.

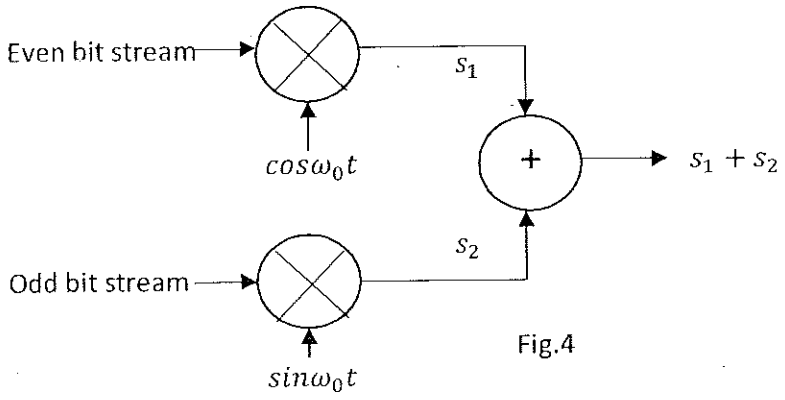

Fig.4

The data stream 1 -1 1 1 -1 -1 is split into 2 bit streams – the odd bit stream (data bits at odd positions) and the even bit stream (data bits at even positions). Here '1' is represented by 1 and '0' is represented by -1.

(i) Sketch the waveform s_1 [3 *marks*]

(ii) Sketch the waveform s_2 [3 *marks*]

(iii) Sketch the waveform $s_1 + s_2$ [4 *marks*]

(iv) The modulated version of the original bit stream 101100 is found in $s_1 + s_2$.

What is the type of modulation used here? Also sketch the constellation map. [3 *marks*]

5.

(a) A binary source transmits a binary signal S with following probabilities:

$S = +2\ Volts$ is transmitted with a probability 0.6.

$S = -2\ Volts$ is transmitted with a probability 0.4.

During the transmission noise $n(t)$ is added to S. The probability density function of $n(t)$ is given in Fig.5.

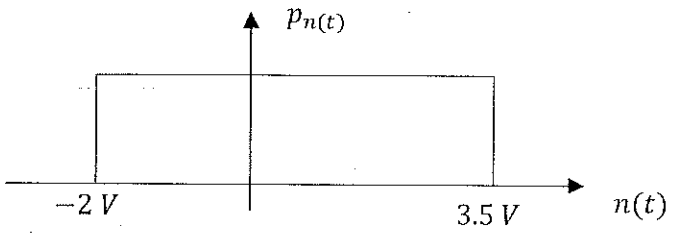

Fig. 5

The received signal $R = S + n(t)$ is compared with a threshold value $0.7\ V$.

If $R \geq 0.7\ V$ the transmitted signal is assumed to be $+2\ V$

If $R < 0.7\ V$ the transmitted signal is assumed to be $-2\ V$

(i) Find the total error probability at the receiver. [10 *marks*]

(ii) How would you find the optimum value for the threshold value? [5 *marks*]

(b) If a rectangular pulse stream is transmitted over a practical channel, explain how inter-symbol interference can occur. [5 *marks*]

6.

(a) When does a random variable become a random process? Give a practical example for a random process. [4 *marks*]

(b) What is a wide sense stationary process? [4 *marks*]

(c) The autocorrelation function of a wide sense stationary process $x(t)$ is given by

$$R_{xx}(\tau) = A + B\cos(\omega_0\tau)$$

(i) Find the power of $x(t)$. [6 *marks*]

(ii) Find the power spectral density function of the process. [6 *marks*]

7.

For a transmitted signal, by using a filter at the receiver to remove noise in signal, additional noise component can be introduced to the signal.

(a) What is the cause for this additional noise component N_D (distortion noise)? [4 *marks*]

We can use an optimum filter to reduce the total noise.

(b) If the power spectral density (PSD) of channel noise at the filter input is $S_N(\omega)$ and the transfer function of the optimum filter is $H_{op}(\omega)$, write an expression for

(i) the PSD of the channel noise at the filter output [4 *marks*]

(ii) the channel noise power N_C at the filter output. [4 *marks*]

(c) If the total noise power at the filter output is given by

$$N_O = N_C + N_D = \frac{1}{2\pi}\int_{-\infty}^{\infty}\left[\left|H_{op}(\omega) - \frac{S_m(\omega)}{S_r(\omega)}\right|^2 S_r(\omega) + \frac{S_m(\omega)S_n(\omega)}{S_r(\omega)}\right]d\omega \;;\quad S_r(\omega) = S_m(\omega)+S_n(\omega)$$

(i) select a suitable value for $H_{op}(\omega)$. [4 *marks*]

(ii) Justify your answer in (c) (i). [4 *marks*]

8.

(a) A basic group of a FDM signal has 12 channels. If 4kHz voice channels are used for this purpose

(i) sketch the base band signal if the channels occupy the frequency band 60 kHz – 108 kHz. [3 *marks*]

(ii) explain how the above base band signal is generated using amplitude modulation. [5 *marks*]

(b)

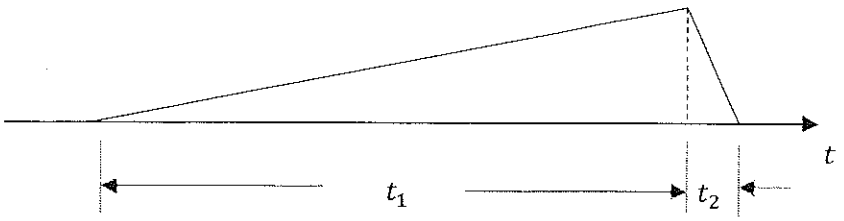

Fig 8

Vertical deflection signal of a TV receiver is shown in Fig. 8

(i) What are the factors that will affect the value of t_1? [4 *marks*]

(ii) What is t_2? [3 *marks*]

(c) A 7-bit data frame is transmitted in air. Due to the noise present in the medium bits can be received with errors. If the bit error probability is 0.001, find the probability that the frame is received without any error. [5 *marks*]