GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering

Department of Electrical, Electronic and Telecommunication Engineering

BSc Engineering Degree

Semester 6 Examination – November 2020

(Intake 35 - ET)

ET 3223 – COMMUNICATION THEORY II

Time allowed: 3 hours 13 November 2020

ADDITIONAL MATERIAL PROVIDED

Page 6	USEFUL FORMULAE

INSTRUCTIONS TO CANDIDATES

This paper contains five questions and answer all the questions on answer booklets.

This paper contains 6 pages with the cover page.

This is a closed book examination

This examination accounts for 70% of the module assessment. A total maximum mark obtainable is 100. The marks assigned for each question and parts thereof are indicated in square brackets

If you have any doubt as to the interpretation of the wordings of a question, make your own decision, but clearly state it on the script

Assume reasonable values for any data not given in or provided with the question paper, clearly make such assumptions made in the script

All examinations are conducted under the rules and regulations of the KDU

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Question 1

A (6, 3) linear block code $\boldsymbol{C}$ over GF(2) is defined by the following parity check matrix $\boldsymbol{H}$,

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

(a) Find the generator matrix $\boldsymbol{G}$ of $\boldsymbol{C}$. [05]

(b) If $\mathbf{u}$ = (1 0 0) is the message to be encoded, find its corresponding code word $\boldsymbol{C}$. [05]

(c) Let's assume the derived codeword in part (b) is sent over a noisy channel, and received word is $\mathbf{r}$ = (0 1 0 1 0 0) that has a single error. Determine the syndrome. [05]

(d) Find the true error vector $\boldsymbol{e}$ [05]

Question 2

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(a) Draw the Huffman tree corresponding to the encoding table below in Table Q2.1. [14]

Table Q2.1

6/16

2/16

Symbol	Probabilities of Occurrence	Encoding
A	1/4	10
B	3/8	00
C	1/8	01
D	1/16	1100
E	1/16	1101
F	1/16	1110
G	1/16	1111

Based on the derived Huffman tree answer the following questions.
(i) Find the average code word length.
(ii) Find the entropy of the source.
(iii) Calculate the efficiency of the code.

(b) Consider the two codes listed below in Table Q2.2: [06]

nct

Table Q2.2

nct

Symbol	Code I	Code II
S_0	00	1
S_1	10	01
S_2	11	011
S_3	001	101
S_4	101	111

Proof that the Code I is a prefix code and Code II is not by constructing their individual decision trees)

Question 3

In an Amplitude Shift Keying (ASK) System symbol '1' is represented by $s(t) = A_c \cos(2\pi f_c t)$ and symbol '0' is represented by switching off the carrier.

(a) Show the sinusoidal carrier of amplitude of s(t) is $A_c = \sqrt{\frac{2E_b}{T_b}}$. Where E_b is the energy per bit and T_b is the bit duration. [04]

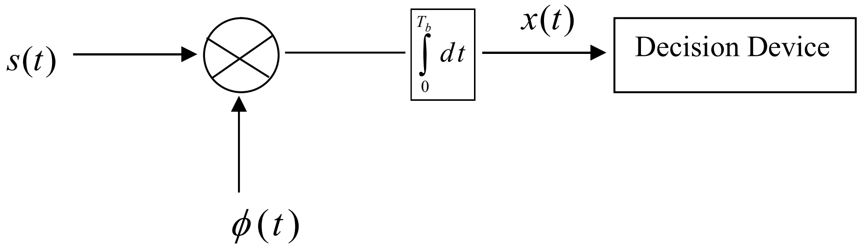

Figure Q3.1

Figure Q3.1 shows a coherent reception scenario for an AWGN channel with zero mean and variance of $N_0/2$. Where $\theta(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t)$ and, in the decision device if $x(t) > \frac{E_b}{2}$ the receiver decide in favor of symbol 1 and if $x(t) < \frac{E_b}{2}$ the receiver decide in favor of symbol 0.

(b) Compute the value of $x(t)$ [05]

(c) Find the conditional probability of the receiver deciding in favor of symbol x given that '1' was transmitted [03]

(d) Find the conditional probability of the receiver deciding in favor of symbol x given that '0' was transmitted [03]

(e) Show that the average probability of error for this ASK system is $\frac{1}{2} erfc\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)$. [05]

Question 4 [20]

The sample function of a Gaussian process of zero mean and unit variance is uniformly sampled and then applied to a uniform quantizer having the input-output amplitude characteristic shown in Figure Q4.1. Calculate the entropy of the quantizer output.

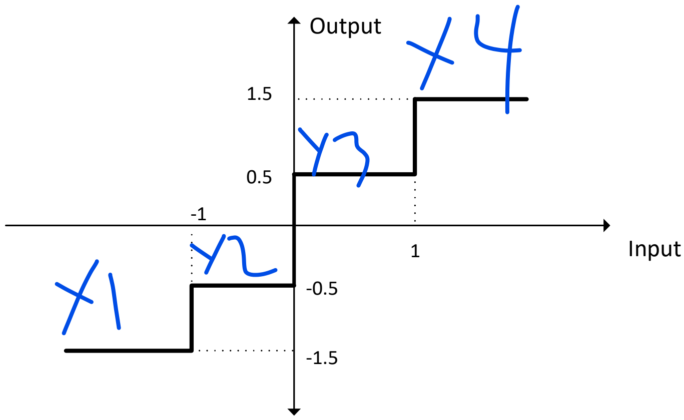

Figure Q4.1

Question 5

Consider the signal $s(t)$ shown in Figure Q5.1.

(a) Determine the impulse response $h(t)$ of an optimum filter matched to this signal. [02]

(b) Sketch the stated $h(t)$ as a function of time. [06]

(b) Write the relationship between the matched filter out put $y(t)$, $h(t)$ and $s(t)$ [02]

(b) Plot the matched filter output as a function of time. [08]

(c) What is the peak value of the output? [02]

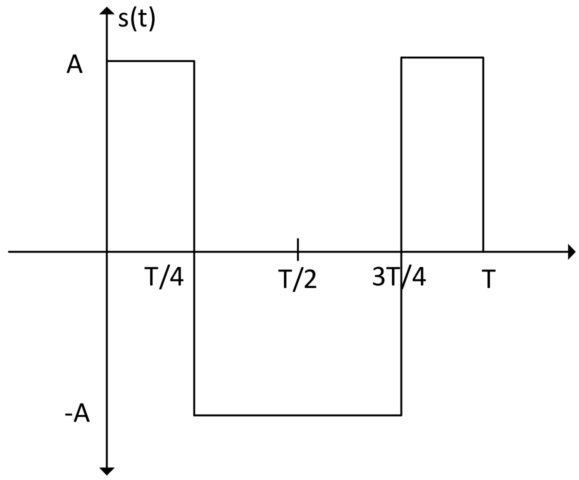

Figure Q5.1

End of question paper

USEFUL FORMULAE

Complementary Error Function

$$erfc(z) = 1 - erf(z)$$
$$= \frac{2}{\pi}\int_z^{\infty} e^{-t^2}$$

Trigonometric formulae

$\sin(A \pm B) = \sin(A)\cos(B) \pm \cos(A)\sin(B)$
$\cos(A \pm B) = \cos(A)\cos(B) \mp \sin(A)\sin(B)$
$\tan(A \pm B) = (\tan(A) \pm \tan(B)) / (1 \mp \tan(A)\tan(B))$

$\sin(2A) = 2\sin(A)\cos(A)$
$\cos(2A) = 2\cos^2(A) - 1 = 1 - 2\sin^2(A)$
$\tan(2A) = 2\tan(A) / (1 - \tan^2(A))$

$2\cos(A)\cos(B) = \cos(A + B) + \cos(A - B)$
$2\sin(A)\cos(B) = \sin(A + B) + \sin(A - B)$
$2\sin(A)\sin(B) = \cos(A - B) - \cos(A + B)$

The probability density function of a Gaussian distribution with expected value μ and variance σ^2 is

$$g(x) = \frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{1}{2}\frac{(x-\mu)^2}{\sigma^2}\right)$$