University of Swaziland
Faculty of Science and Engineering
Department of Electrical and Electronic Engineering

Main Examination 2017

Title of paper: **Communication System Principles**

Course Number: **EE442**

Time allowed: **3 hours**

Instructions:

1. Answer any FOUR (4) questions
2. Each question carries 25 marks
3. Marks for each question are shown at the right hand margin

This paper contains 4 pages including this one.

This paper should not be opened until permission has been granted by the invigilator.

Question 1

a) Draw the structure of an envelope detector and describe its operation. State the possible effects of the time constant RC (i.e. if RC is too small and RC is too large) on the output. [10 marks]

b) Calculate the **energy** and the **power** of each of the following signals

i) $x(t) = \frac{A}{2}\cos(2\pi ft)$ [4 marks]

ii) $x(t) = Ae^{j2\pi ft}$ [4 marks]

c) Show that the SNR for a DSB-SC is given by the equation below

$$\left(\frac{S}{N}\right)_{0DSB} = \frac{P_R}{N_0 W}, \text{ where } P_R = \frac{A_c^2 P_M}{2}$$ [7 marks]

Question 2

a) An angle modulation (AM) system uses a carrier signal $c(t) = 10\cos(2\pi 10^8 t)$ and a message signal $m(t) = 6\cos(2\pi 10^4 t)$. Given that $k_f = 50$, and $k_p = 30$

i) Write the signal expression of the phase of the output for the phase modulated signal [3 marks]

ii) Write the signal expression of the phase of the output for the frequency modulated signal [3 marks]

iii) Write the signal expression of the phase modulated signal [2 marks]

iv) Write the signal expression of the frequency modulated signal. [2 marks]

b) Let the message signal be $m(t)$ and the carrier signal $c(t) = A\cos(2\pi(600)t)$

i) For the conventional DSB AM modulated signal $u(t)$, find the Fourier transform $U(f)$ and express it in terms of $M(f)$ [5 marks]

ii) Sketch the spectrum of the signal $M(f)$ and $U(f)$ assuming $M(f)$ has a bandwidth $W = 200$ [5 marks]

iii) Find the power of the modulated signal $u(t)$ [5marks]

Question 3

a) Perform the **Gram-Schmidt orthogonalization** procedure in the signals given in **Figure 3** below:

[10 marks]

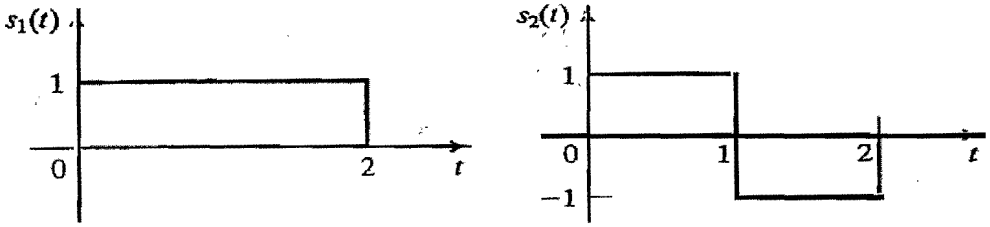

Figure 3

b) Draw the geometric representation of the following digital modulation schemes

i) Binary Antipodal signals [4 marks]

ii) Binary Orthogonal signals [4 marks]

c) Show that the code below is a linear block code [7 marks]

$$\mathcal{C} = \{00000, 10100, 01111, 11011\}$$

Question 4

a) Given the Tanner graph **Figure 4(a)** below,

i) Derive the parity check matrix **H** [10 marks]

ii) Find the density *r* of the code [2 marks]

iii) State whether the code is regular or irregular and justify your answer. [2 marks]

iv) Write the definition of the code i.e. *(n, k)* [2 marks]

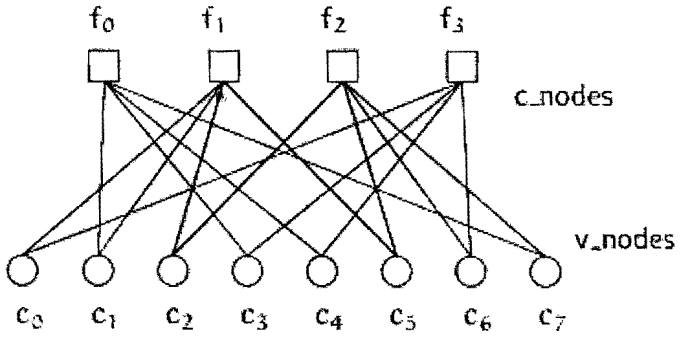

Figure 4(a)

b) The figure below, **Figure 4(b),** shows a convolutional encoder,

i) Find the generator sequences [6 marks]

ii) Find the rate of the code for $k = 1$ and the number of states [3 marks]

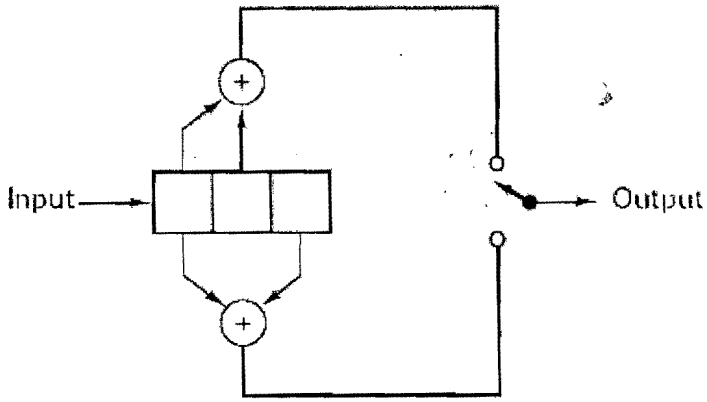

Figure 4(b)

Question 5

a) Describe the quantization process. [4 marks]

b) A 100 kHz signal is sampled at the Nyquist rate and an 8-level quantizer is used to quantize a signal.

i) Calculate the number of bits to encode one sample [2 marks]

ii) Calculate the number of bits per second transmitted [3 marks]

c) Differentiate between uniform and non-uniform quantization [4 marks]

d) In a binary communication system, the input bits transmitted over the channel are either 0 or 1 with probabilities 0.3 and 0.7, respectively. When a bit is transmitted over the channel, it can be either received correctly or incorrectly (due to channel noise). Let us assume that if a 0 is transmitted, the probability of it being received in error (i.e., being received as 1) is 0.01, and if a 1 is transmitted, the probability of it being received in error (i.e., being received as 0) is 0. 1.

i) What is the probability that the output of the channel is 1? [6 marks]

ii) Assuming we observe a one at the output of the channel, what is the probability that the input to the channel was a 1? [6 marks]