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

Main Examination - 2021

Title of paper: **Digital Communication Systems**

Course Number: **EEE543**

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
4. Useful information is attached at the end of the paper.

This paper contains 5 pages including this one.

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

Question 1

a) Describe the succession of processes in the transmission of information from one point to another [8]

b) With an aid of a diagram describe frequency division multiple access (FDMA) [6]

c) Describe the following terms

i) Point-to-point communication [2]

ii) Point-to-multipoint communication [2]

d) One advantage of a MIMO system is *spatial diversity*. This technique is shown in **Figure 1** below.

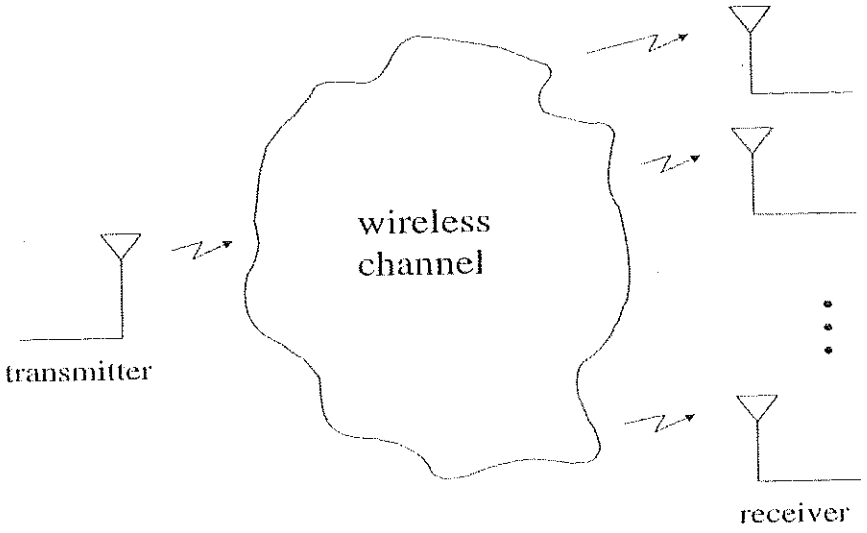

Figure 1

One technique to combine the signals at the receiver is *Selection Combining* (SC), find the effective SNR for this technique [7]

Question 2

a) Given the figure below Figure 2, a correlator receiver for M-ary signals

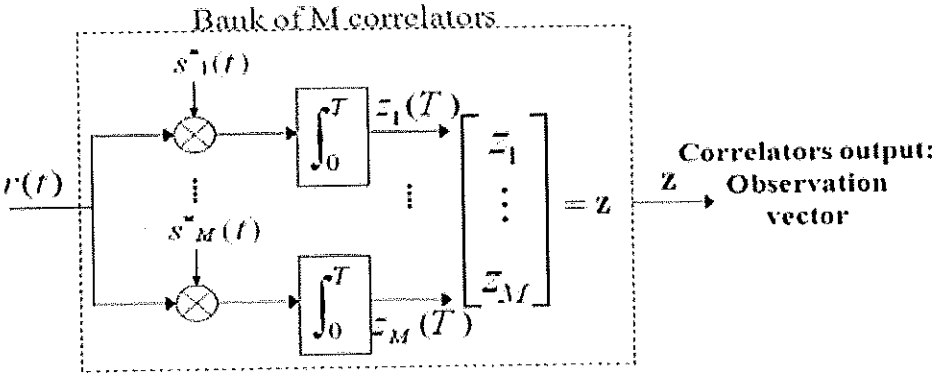

Figure 2

i) Write the general equation of the output signal $z_i(T)$ [3]

ii) State the *rule* of selecting the most possible signal or estimated $s_i(t)$ that was sent from the observation vector **z**. [4]

b) Consider a single input multiple output (SIMO) communication system

i) With an aid of a diagram describe the SIMO system [4]

ii) Give the equation of the received signal and the channel capacity. [4]

c) An OFDM modulator can be implemented using an IDFT on a block of N information symbols

i) Write the IDFT formula for the modulated symbols [3]

ii) Given the symbol set $\boldsymbol{s} = \{1 + 1i, 1 + 3i, 3 + 1i, 3 + 3i\}$, write the modulated OFDM symbols using the equation in i) above. (Leave your answer in expanded form) [7]

Question 3

a) Given the probability set $P(x_i)_{i=1,2,\dots,6} = \{0.25, 0.05, 0.12, 0.08, 0.20, 0.30\}$, construct a Huffman code [10]

b) An MPSK receiver can be reduced and be implemented by $N = 2$ correlators. With an aid of a diagram describe how this simplification be can achieved and how the estimate angle is obtained [6]

c) Consider a cooperative system where two users share information via a relay

i) Describe the *basic* decode and forward (DF) scheme, use a diagram to support your answer [5]

ii) Write the equation of the received signals at the **relay** and the **destination** during phase I [4]

Question 4

a) One method to counter the practical difficulties of the Nyquist condition for zero ISI is the using the *Raised Cosine* filter', write the equation of the raise cosine filter [4]

b) Describe three timing features of the eye pattern. [6]

c) Describe the minimum distance decision rule in detection of signals in Gaussian noise. Use diagrams and associated equations to support your answer. [6]

d) Consider a MIMO communication system,
   i) Give four benefits of a MIMO system [4]
   ii) Given the channel matrix $\boldsymbol{H}$ and the covariance matrix $\boldsymbol{R}$ determine the channel capacity [5]

Question 5

a) Digital receivers include Zero Forcing (ZF) receiver and a Linear Minimum Mean Square Error (LMMSE) receiver. Given the channel matrix $\boldsymbol{H}$, in both cases, show how the estimate of the transmitted vector can be obtained from the received signal $\mathbf{y}$. [12]

b) Show that the channel capacity of an ideal AWGN channel with infinite bandwidth is given by

$$C_{\infty} = \frac{1}{\ln 2}\frac{S}{\eta} \approx 1.44\frac{S}{\eta}\ \text{b/s} \qquad [6]$$

c) Given the convolutional encoder below

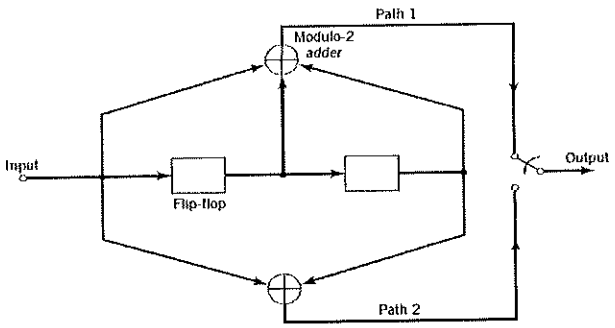

Figure 5

i) Find the generator polynomials for *Path 1* and *Path 2* [2]
ii) Given the input sequence $m = 11011$, find the encoder output sequence [5]

Table 1

z	$Q(z)$	z	$Q(z)$	z	$Q(z)$	z	$Q(z)$
0.00	0.5000	1.00	0.1587	2.00	0.0228	3.00	0.00135
0.05	0.4801	1.05	0.1469	2.05	0.0202	3.05	0.00114
0.10	0.4602	1.10	0.1357	2.10	0.0179	3.10	0.00097
0.15	0.4404	1.15	0.1251	2.15	0.0158	3.15	0.00082
0.20	0.4207	1.20	0.1151	2.20	0.0139	3.20	0.00069
0.25	0.4013	1.25	0.1056	2.25	0.0122	3.25	0.00058
0.30	0.3821	1.30	0.0968	2.30	0.0107	3.30	0.00048
0.35	0.3632	1.35	0.0885	2.35	0.0094	3.35	0.00040
0.40	0.3446	1.40	0.0808	2.40	0.0082	3.40	0.00034
0.45	0.3264	1.45	0.0735	2.45	0.0071	3.45	0.00028
0.50	0.3085	1.50	0.0668	2.50	0.0062	3.50	0.00023
0.55	0.2912	1.55	0.0606	2.55	0.0054	3.55	0.00019
0.60	0.2743	1.60	0.0548	2.60	0.0047	3.60	0.00016
0.65	0.2578	1.65	0.0495	2.65	0.0040	3.65	0.00013
0.70	0.2420	1.70	0.0446	2.70	0.0035	3.70	0.00011
0.75	0.2266	1.75	0.0401	2.75	0.0030	3.75	0.00009
0.80	0.2169	1.80	0.0359	2.80	0.0026	3.80	0.00007
0.85	0.1977	1.85	0.0322	2.85	0.0022	3.85	0.00006
0.90	0.1841	1.90	0.0287	2.90	0.0019	3.90	0.00005
0.95	0.1711	1.95	0.0256	2.95	0.0016	3.95	0.00004
4.00	0.00003						
4.25	10^{-5}						
4.75	10^{-6}						
5.20	10^{-7}						
5.60	10^{-8}						