Durham University

EXAMINATION PAPER

Examination Session: May/June	**Year:** 2019	**Exam Code:** ENGI4121-WE01

Title: **MEng Engineering (Part III)**

Communications Systems Paper 1

Time Allowed:	2 hours	
Additional Material provided:	None.	
Materials Permitted:	None	
Calculators Permitted:	Models Permitted :	You are permitted to use only two models of calculator (Casio fx-83 GTPLUS or a Casio fx-85 GTPLUS).
Visiting Students may use dictionaries:	Yes	

Instructions to Candidates:	Answer ALL questions. All relevant workings must be shown.

Revision:

Question 1

(a) Explain why a Pulse Position Modulation (PPM) system requires the transmission of a synchronization signal, whereas a single channel Pulse Amplitude Modulation (PAM) or Pulse Width Modulation (PWM) system does not.

[10%]

(b) Binary data are transmitted by using a pulse *s*(t) for 0 and a pulse 3*s*(t) for 1. Show that the optimum receiver for this case is a filter matched to *s*(t) with a detection threshold $2E_s$ as shown in Figure Q.1. Assume that 0 and 1 are equi-probable, determine the probability of error of this receiver as a function of E_s/N where N is the noise power of additive white Gaussian noise with zero mean as expressed in equation (1.1).

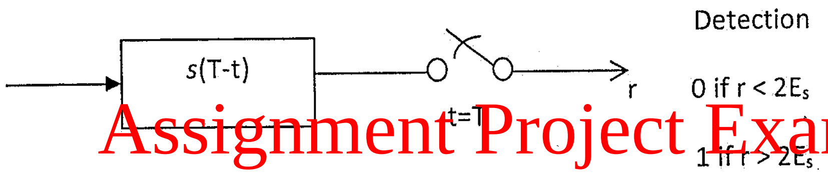

Figure Q.1

[45%]

$$p(v) = \frac{1}{\sqrt{2\pi\sigma_v^2}} exp\left(-\frac{v^2}{2\sigma_v^2}\right) \qquad (1.1)$$

and the noise power $N=\sigma^2{}_v$

(c) Five messages bandlimited to W, W, 2W, 4W, and 4W Hz, respectively are to be time-division multiplexed. Devise a commutator configuration such that each signal is periodically sampled at its own minimum transmission rate and the samples are properly interlaced. What is the minimum transmission bandwidth required for this Time Division Multiplexing (TDM) signal?

[20%]

(d) A baseband transmission system transmits the Manchester code where binary 1 is represented by +V for the first half of the bit duration and -V for the second half. Determine the correlation coefficient between the two baseband signals representing the one and the zero.

[10%]

(e) Give the output of a Phase Shift Keying (PSK) correlation detector if the stored replica has identical frequency as the incoming signal but has a phase offset equal to $\Delta\phi$. Comment on the result.

[15%]

continued

Question 2

(a) A transmitter produces 10 W of power which are applied to unity gain antenna at 2 GHz carrier frequency.

(i) Express the transmitter power in dBm and dBW.

(ii) Rewrite the free space equation given in equation (2.1)
(1) to express the free space path loss in dB
(2) to give the ratio of received powers at two distances, d_1 and d_2.

(iii) Find the received power in dBm at a free space distance of 10 m and 1 km from the transmit antenna. Assume unity gain for the receive antenna.

Free space propagation equation is given by

$$\frac{P_R}{P_T} = G_T G_R \left(\frac{c}{4\pi f d}\right)^2 \tag{2.1}$$

where P_T and P_R are the transmit and receive powers, respectively, c is the speed of light, G_T and G_R are the gains of the transmit and receive antennas, respectively, f is frequency and d is distance.

[45%]

(b) Discuss the different modes of radiowave propagation for the waves with frequency ranges in Table 1.

Frequency bands	frequency range
Extremely Low Frequency (ELF)	< 3 kHz
Very Low Frequency (VLF)	3-30 kHz
Low Frequency	30-300 kHz
Medium Frequency	300 kHz-3 MHz
High Frequency	3-30 MHz
Very High Frequency (VHF)	30-300 MHz
Ultra High Frequency (UHF)	300 MHz-3 GHz
Super High Frequency (SHF)	3-30 GHz
Extra High Frequency (EHF)	30-300 GHz

Table 1

[25%]

(c) Explain what is meant by handoff and discuss soft and hard handover used in cellular systems.

[15%]

(d) Discuss the causes of co-channel interference in cellular networks. [15%]

continued

Table of values of the error function and the complementary error function:

$$\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-u^2}\, du \qquad \operatorname{erf c}(x) = \frac{2}{\sqrt{\pi}} \int_x^\infty e^{-u^2}\, du$$

x	erf(x)	erfc(x)	x	erf(x)	erfc(x)
0.00	0.0000000	1.0000000	1.30	0.9340079	0.0659921
0.05	0.0563720	0.9436280	1.40	0.9522851	0.0477149
0.10	0.1124629	0.8875371	1.50	0.9661051	0.0338949
0.15	0.1679960	0.8320040	1.60	0.9763484	0.0236516
0.20	0.2227026	0.7772974	1.70	0.9837905	0.0162095
0.25	0.2763264	0.7236736	1.80	0.9890905	0.0109095
0.30	0.3286268	0.6713732	1.90	0.9927904	0.0072096
0.35	0.3793821	0.6206179	2.00	0.9953223	0.0046777
0.40	0.4283924	0.5716076	2.10	0.9970205	0.0029795
0.45	0.4754817	0.5245183	2.20	0.9981372	0.0018628
0.50	0.5204999	0.4795001	2.30	0.9988568	0.0011432
0.55	0.5633234	0.4366766	2.40	0.9993115	0.0006885
0.60	0.6038561	0.3961439	2.50	0.9995930	0.0004070
0.65	0.6420293	0.3579707	2.60	0.9997640	0.0002360
0.70	0.6778012	0.3221988	2.70	0.9998657	0.0001343
0.75	0.7111556	0.2888444	2.80	0.9999250	0.0000750
0.80	0.7421010	0.2578990	2.90	0.9999589	0.0000411
0.85	0.7706681	0.2293319	3.00	0.9999779	0.0000221
0.90	0.7969082	0.2030918	3.10	0.9999884	0.0000116
0.95	0.8208908	0.1791092	3.20	0.9999940	0.0000060
1.00	0.8427008	0.1572992	3.30	0.9999969	0.0000031
1.10	0.8802051	0.1197949	3.40	0.9999985	0.0000015
1.20	0.9103140	0.0896860	3.50	0.9999993	0.0000007

END