hrs	/ /20		Exams Office Use Only

University of the Witwatersrand, Johannesburg

Course or topic No(s)	ELEN3024
Course or topic name(s) Paper Number & title	Communication Fundamentals
Examination/Test* to be held during month(s) of (*delete as applicable)	November 2011
Year of Study (Art & Sciences leave blank)	Third
Degrees/Diplomas for which this course is prescribed (BSc (Eng) should indicate which branch)	B.Sc (Eng) Elec.
Faculty/ies presenting candidates	Engineering
Internal examiners and telephone number(s)	Dr. DJJ Versfeld x7212
External examiner(s)	Dr. K Ouahada
Special materials required (graph/music/drawing paper) maps, diagrams, tables, computer cards, etc)	None
Time allowance	Course Nos: ELEN3024 — Hours: Three
Instructions to candidates (Examiners may wish to use this space to indicate, inter alia, the contribution made by this examination or test towards the year mark, if appropriate)	Answer *ALL* questions. Type '2' Examination - Written A4 permitted. Show all working. Total marks: 115 - Full marks 100

Internal Examiners or Heads of Department are requested to sign the declaration overleaf

1. As the Internal Examiner/Head of Department, I certify that this question paper is in final form, as approved by the External Examiner, and is ready for reproduction.

2. As the Internal Examiner/Head of Department, I certify that this question paper is in final form and is ready for reproduction.

(1. is applicable to formal examinations as approved by an external examiner, while 2. is applicable to formal tests not requiring approval by an external examiner—Delete whichever is not applicable)

Name:____________________________ Signature:____________________________

(THIS PAGE NOT FOR REPRODUCTION)

Note: Show all workings, complete with the necessary comments. Marks will be allocated for all working and logical reasoning and not just for the correct answer.

Question 1

Refer to the modulator depicted in Fig. 1.

(a) Sketch the output v_{out} in the time domain when a square wave with frequency f_c is used to modulate a sinusoidal signal $m(t) = a\cos 2\pi f_m t$, under the condition that $f_m \ll f_c$.

(2 marks)

(b) Sketch what happens in the frequency domain, assuming that all appropriate filtering has been done to ensure that the circuit operates as a proper modulator.

(2 marks)

(c) Assuming that the message signal, $m(t) = a\cos 2\pi f_m t$, determine the power-spectral density of the modulated signal, the power in the modulated signal, and the power in each of the sidebands. (Base your calculations on the fact that the effective carrier is given as $A_c \cos 2\pi f_c t$)

(6 marks)

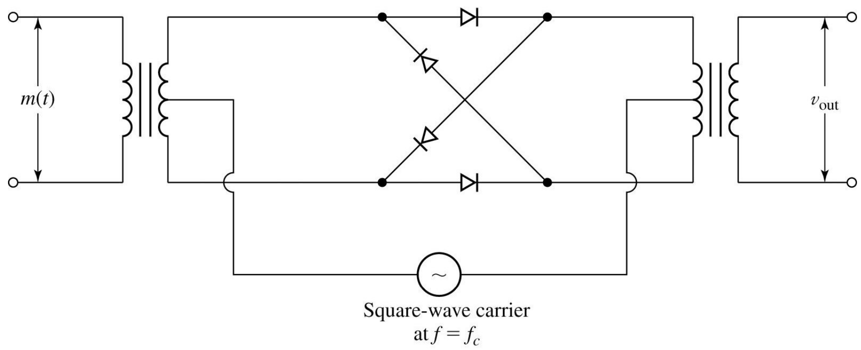

Figure 1: Modulator

(Total 10 marks)

Question 2

The message signal $m(t) = 10$ sinc $(400t)$ frequency modulates the carrier $c(t) = 100 \cos 2\pi f_c t$ to give $u(t)$. The modulation index is 6.

(a) Write an expression for the modulated signal $u(t)$.

(b) What is the maximum frequency deviation of the modulated signal?

(c) What is the power content of the modulated signal?

(d) Find the bandwidth of the modulated signal.

(Total 10 marks)

Question 3

Determine under which conditions the following two signals can be used as basis functions for FSK transmission.

$$u_1(t) = \sqrt{\tfrac{2\mathcal{E}_b}{T_b}} \cos 2\pi f_1 t,\ 0 \le t \le T_b$$
$$u_2(t) = \sqrt{\tfrac{2\mathcal{E}_b}{T_b}} \cos 2\pi f_2 t,\ 0 \le t \le T_b$$

(Total 10 marks)

Question 4

For a receiver based on the minimum-distance criterion:

(a) Show that the cost function

$$J = \int_{-\infty}^{\infty} |r(t) - ah(t)|^2 dt$$

can be reduced to

$$J = E_h \left| \frac{y}{E_h} - a \right|^2 - \frac{|y|^2}{E_h} + E_r.$$

(5 marks)

(b) Explain the general principle of operation.

(5 marks)

(Total 10 marks)

Question 5

Consider a baseband PAM system with output as depicted in Fig. 2.

(a) Show that when the sampled pulse shape $g(kT) = \delta_k$, no intersymbol interference is present.

(5 marks)

(b) Assuming that the symbol period $T = 1$, demodulate the pulse train depicted in Fig. 2, and show the individual pulses used for transmission.

(10 marks)

(c) For this particular PAM system, how many bits are represented per symbol?

(2 marks)

(d) What is the effect of the roll-off factor α on the system?

(3 marks)

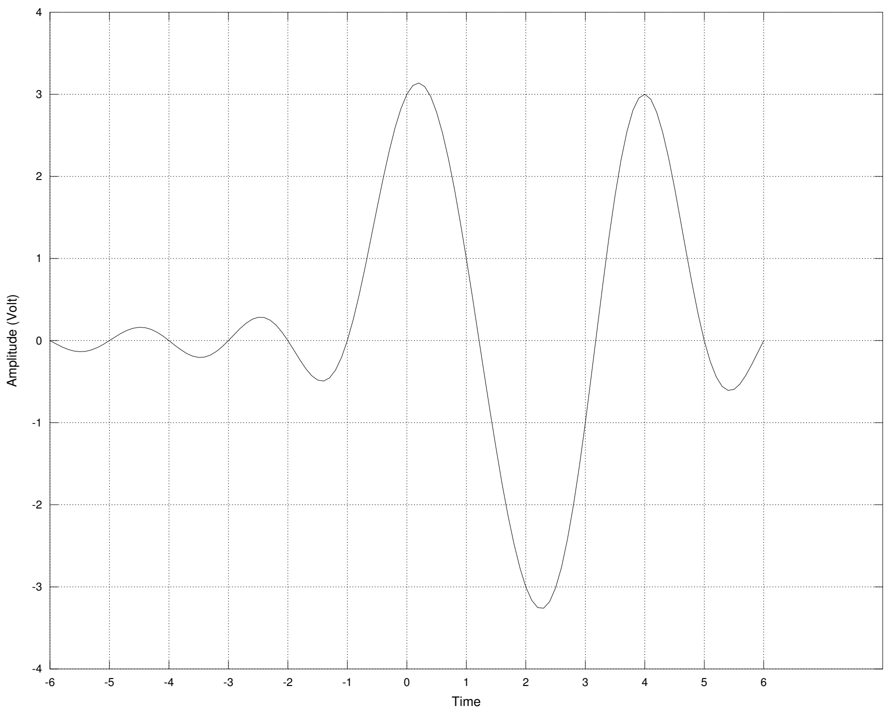

Figure 2: Pulse train

(Total 20 marks)

Question 6

(a) Consider the two octal signal point constellations depicted in Fig. 3. Compare the maximum allowable peak error for the two constellations, as well as the average power for each constellation, assuming that for both systems the maximum amplitude is A. For the constellation of Fig. 3a, all the nearest-neighbour signal points are separated in distance by d_1 units, whilst in Fig. 3b the minimum distance between constellation points is d_2.

(25 marks)

(b) Show the optimal decision boundaries for the constellation of Fig. 3a.

(5 marks)

(c) Show the optimal decision boundaries for the constellation of Fig. 3b.

(5 marks)

(d) Determine the minimum symbol rate necessary if the desired data rate is 90 Mbits/s.

(2 marks)

(e) Is it possible to assign 3 data bits to each point of the signal constellation such that the nearest (adjacent) points differ in only one position for Fig. 3a? If so, sketch the solution; if not, explain why not.

(3 marks)

(f) Is it possible to assign 3 data bits to each point of the signal constellation such that the nearest (adjacent) points differ in only one position for Fig. 3b? If so, sketch the solution; if not, explain why not.

(3 marks)

(g) Which system would you propose to be used? Motivate your answer.

(2 marks)

(a) 8-QAM System A

(b) 8-QAM System B

Figure 3: Two alternative octal signal point constellations

(Total 45 marks)

Question 7

Consider the 16-QAM constellation with alphabet $\mathcal{A} = \{\pm c \pm jc, \pm c \pm j3c, \pm 3c \pm jc, \pm 3c \pm j3c\}$. Sketch the corresponding constellation and determine an approximate expression for the symbol error rate.

(Total 10 marks)

(Exam Total 115 marks)

(100%=100 marks)

Table 1: Bessel functions of the first kind, $J_n(m)$

β	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}
0.00	1.00														
0.25	0.98	0.12													
0.5	0.94	0.24	0.03												
1.0	0.77	0.44	0.11	0.02											
1.5	0.51	0.56	0.23	0.06	0.01										
2.0	0.22	0.58	0.35	0.13	0.03										
2.4	0	0.52	0.43	0.20	0.06	0.02									
2.5	-0.05	0.50	0.45	0.22	0.07	0.02	0.01								
3.0	-0.26	0.34	0.49	0.31	0.13	0.04	0.01								
4.0	-0.40	-0.07	0.36	0.43	0.28	0.13	0.05	0.02							
5.0	-0.18	-0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02						
5.45	0	-0.34	-0.12	0.26	0.40	0.32	0.19	0.09	0.03	0.01					
6.0	0.15	-0.28	-0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02					
7.0	0.30	0.00	-0.30	-0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02				
8.0	0.17	0.23	-0.11	-0.29	-0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03			
8.65	0	0.27	0.06	-0.24	-0.23	0.03	0.26	0.34	0.28	0.18	0.10	0.05	0.02		
9.0	-0.09	0.25	0.14	-0.18	-0.27	-0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01	
10.0	-0.25	0.05	0.25	0.06	-0.22	-0.23	-0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01