UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
MAIN EXAMINATION, MAY 2007

TITLE OF PAPER : COMMUNICATION SYSTEMS

COURSE NUMBER : E410

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : READ EACH QUESTION CAREFULLY
ANSWER ANY **FOUR** OUT OF **FIVE** QUESTIONS.
EACH QUESTION CARRIES **25 MARKS**.
MARKS FOR EACH SECTION ARE SHOWN ON THE RIGHT- HAND MARGIN.

THIS PAPER HAS 6 PAGES INCLUDING THIS PAGE.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

USEFUL INFORMATION

Cos (A ± B) = Cos A Cos B ∓ Sin A Sin B
Sin A Sin B = ½ [Cos (A - B) - Cos (A + B)]
Sin A Cos B = ½ [Sin (A + B) + Sin (A - B)]

Sin (A ± B) = Sin A Cos B ± Cos A Sin B.
Cos A Cos B = ½ [Cos (A + B) + Cos (A - B)]

Boltzmann constant k = 1.38 x 10^{-23} J/K

$$m(t) = V_m Sin\omega_m t$$

PM signal, $V_{PM}(t) = V_c Sin[\omega_c t + \beta p\ Sin\omega_m t]$

FM signal, $V_{FM}(t) = V_c\ Sin[\omega_c t - M_f\ Cos\omega_m t]$

$$\int Sinax\ dx = -\frac{1}{a} Cosax \qquad \int Cosax\ dx = \frac{1}{a} Sinax$$

TABLE A
Bessel functions of the first kind

m	$J_0(m)$	$J_1(m)$	$J_2(m)$	$J_3(m)$	$J_4(m)$	$J_5(m)$	$J_6(m)$	$J_7(m)$	$J_8(m)$	$J_9(m)$	$J_{10}(m)$
0.0	1.000	—	—	—	—	—	—	—	—	—	—
0.2	0.990	0.099	0.005	—	—	—	—	—	—	—	—
0.4	0.960	0.196	0.019	0.001	—	—	—	—	—	—	—
0.6	0.912	0.286	0.043	0.004	—	—	—	—	—	—	—
0.8	0.846	0.368	0.075	0.010	0.001	—	—	—	—	—	—
1.0	0.765	0.440	0.114	0.019	0.002	—	—	—	—	—	—
2.0	0.223	0.576	0.352	0.128	0.034	0.007	0.001	—	—	—	—
3.0	-0.260	0.339	0.486	0.309	0.132	0.043	0.011	0.002	—	—	—
4.0	-0.397	-0.066	0.364	0.430	0.281	0.132	0.049	0.015	0.004	—	—
5.0	-0.177	-0.327	0.046	0.364	0.391	0.261	0.131	0.053	0.018	0.005	0.001
6.0	0.150	-0.276	-0.242	0.114	0.357	0.362	0.245	0.129	0.056	0.021	0.006
7.0	0.300	-0.004	-0.301	-0.167	0.157	0.347	0.339	0.233	0.128	0.058	0.023
8.0	0.171	0.234	-0.113	-0.291	-0.105	0.185	0.337	0.320	0.223	0.126	0.060
9.0	-0.090	0.245	0.144	-0.180	-0.265	-0.055	0.204	0.327	0.305	0.214	0.124
10.0	-0.245	0.045	0.254	0.058	-0.219	-0.234	-0.014	0.216	0.317	0.291	0.207

QUESTION 1

(a) The letter **V** in grey, and **W** in black, are stuck side by side on a white wall.

(i) Present a single analogue TV scan of the letters. (3 marks)

(ii) Translate the information of (i) into an electrical signal format (black and white video signal) which can be used to transmit the information to a receiver. Include blanking and synchronization. (8 marks)

(b) What is flicker? How can it be reduced to an acceptable level? (4 marks)

(c)From the sampling theorem information contained in a band-limited signal can be conveyed by sending a finite number of discrete samples. These discrete samples can be used to vary a parameter of the pulse waveform in Pulse Modulation. For a pulse train represented by

$$V_i(t) = \frac{\tau}{T} + \frac{2\tau}{T}\sum_{n=1}^{n=\infty}\frac{\sin\left(n\omega_s \tau/2\right)}{n\omega_s \tau/2} \times \cos n\omega_s t$$

and a modulating signal of the form

$V_m = mV \sin\omega_m t$,

present (i)the modulated transmitted carrier pulse train and (4 marks)

(ii) the corresponding frequency spectrum up to n = 3. (3 marks)

(iii) suggest a method you can use to recover the modulating signal from the signal of part (i). (3 marks)

QUESTION 2

(a) (i)A 100 μV input signal to an FM receiver has a noise voltage of 25 μV superimposed on its carrier frequency. For what maximum modulating frequency f_m, will the noise voltage produce a peak carrier frequency deviation of 0.759 kHz? (5 marks)

(ii)An amplifier used to process a frequency division multiplexed channel group, operates over a frequency range from 60 to 108 kHz. The input impedance has a resistive component of 10 kΩ and the equivalent noise voltage at the input is 0.8 μV. Compute the operating temperature. (5 marks)

(iii) Three matched amplifiers are to be used in cascade to amplify a low-level signal. Their characteristics are given in Table 2. 0.

Table 2.0 Characteristics of amplifiers

Amplifier	1	2	3
Gain	6 d B	12 dB	20 dB
Noise factor	1.7	2.0	4.0

How can the amplifiers be cascaded to give the lowest overall noise ratio?
(5 marks)

(b) (i) A linear quantizer must achieve a signal-to- quantization noise ratio not less than 40 dB when a full-range sine wave is used as input. How many quantization intervals are necessary? (6 marks)

(ii)If the sine wave has a peak amplitude of 2 V, what will be the maximum quantization error for this system? (3 marks)

QUESTION 3

(a) An AM station transmits an average carrier power output of 40 kW, using double-sideband large - carrier. If after modulation to a depth of 70.7 %, the carrier power is attenuated by half, determine

(i) the total average output power and (4 marks)

(ii) the transmission efficiency . (3 marks)

(iii) The amplitude of the modulating tone is decreased in the above problem until the total power is 45 kW. Compute the new modulation index and efficiency, assuming the carrier power remained constant. (5 marks)

(iv) What is the peak output carrier voltage for the case of (iii) ? (2 marks)

(b) (i) A carrier signal $Cos\omega_c t$ is amplitude modulated and transmitted using a Single Sideband-Suppressed carrier (SSB-SC) station. At the receiver, a locally generated carrier signal for the demodulation of the SSB-SC is observed to have a phase error, θ and a frequency error, $\Delta\omega$. Can this locally generated carrier be used to recover the audio signal? Show your working. Give the output signal for no frequency and phase error. (6 marks)

(ii) Music from the Defence Force Band is observed to occupy a frequency range of 100 Hz to 14.5 kHz. The available channel for live broadcast of the music in the HF band has a bandwidth of 200 kHz. For proper transmission, without compromising the quality of the sound, using frequency modulation, what value of modulation index will you use? Give a detailed explanation. (5 marks)

QUESTION 4

(a) A phase- modulated wave has an instantaneous voltage $V = 8\ Sin(2\pi10^8\ t\ -\ 15\ Cos\ 4\pi10^3\ t\ )$ volts at time t. Explain how the practical bandwidth can be determined and estimate its value. (5 marks)

(b) A message signal m(t) is used to modulate a 2.5 kHz carrier to a depth of 64 %, producing the signal $v_i(t)$. The circuit of Figure 4 is to be designed for distortionless operation when its input is the AM signal of $v_i(t)$.

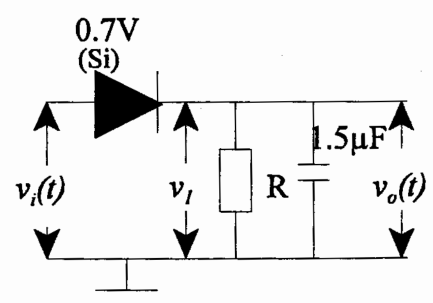

Figure 4

(i) Show how you will determine an expression for the correct value of the time constant. (7 marks)

(ii) Determine the value of R in ohms that will give the correct time constant. (4 marks)

(iii) Sketch the waveforms v_1 and $v_o(t)$. (5 marks)

(vi) How can the message signal be recovered from the output waveform of Figure 4? (4 marks)

QUESTION 5

(a)

(i) A system consisting of an antenna with an output power level of 10^{-9} mW is connected to a receiver input with an equivalent noise temperature of 27°C. What should the equivalent noise temperature of the antenna be to ensure the system noise figure does not exceed 4.3 dB? (7 marks)

(ii) If the receiver of part (b) has an RF amplifier with 12 dB gain, a mixer with 8 dB of conversion loss, followed by a filter with 1 dB of insertion loss, how many IF amplifiers are necessary to provide at least 1 mW of power to the detector? The available IF amplifiers have 20 dB of gain each. (8 marks)

(b) An FM transmitter is modulated with a single sinusoid. The output for no modulation is 100 W into a 50 Ω resistive load. The peak frequency deviation of the transmitter is carefully increased from zero until the first sideband amplitude in the output is 0.44. Under these conditions, determine the average power

(i) at the carrier frequency ; (4 marks)

(ii) in all the remaining sidebands. (3 marks)

(iii) What is the required receiver bandwidth? (3 marks)

THIS IS THE END OF EXAMINATION QUESTIONS