UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SUPPLEMENTARY EXAMINATION, JULY 2009

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 7 PAGES INCLUDING THIS PAGE.

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USEFUL INFORMATION

$Cos(A \pm B) = Cos A Cos B \mp Sin A Sin B$

$Sin(A \pm B) = Sin A Cos B \pm Cos A Sin B.$

$Sin A Sin B = \frac{1}{2}[Cos(A - B) - Cos(A + B)]$

$Cos A Cos B = \frac{1}{2}[Cos(A + B) + Cos(A - B)]$

$Sin A Cos B = \frac{1}{2}[Sin(A + B) + Sin(A - B)]$

Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K

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

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

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) Consider a sinusoidal message signal at frequency f_m = 3 kHz which is to be transmitted using delta modulation(DM).
Sketch a simple DM system which you could use for this purpose, explaining its operation. (5 marks)

(b) (i) A double-sideband amplitude-modulated radio transmitter gives a power output of 5 kW when the carrier is modulated with a sinusoidal tone to a depth of 95%. If, after modulation by a speech signal which produces an average modulation depth of 20%, the carrier and one sideband are suppressed, determine the mean output power in the remaining sideband.

(6 marks)

(ii) Consider a 5-kHz modulating sinusoid with unit amplitude, phase modulating a carrier. If the peak phase deviation is 1 radian, compute the required bandwidth for the modulated signal, using two suitable methods. Which one is the best and why?

(10 marks)

(c) The letter X(in grey) is displayed below the letter V(in black) on a TV screen. Present a translation of a single scan of the scene into an electrical signal which can be used to convey the information to a receiver.

(4 marks)

QUESTION 2

(a) A cascaded system consists of an amplifier with a gain of 10 dB, connected between the aerial and a receiver which has a noise figure of 6 dB. The overall noise figure of the system is then 6 dB. Assume the noise picked up by the aerial has an equivalent noise temperature of 290K, calculate

(i) the noice figure of the amplifier.

(9 marks)

(ii) the overall noise figure if a 6 dB attenuator were to be connected between the amplifier and the receiver. (7 marks)

(i) Consider an LC circuit resonant at frequency f_o. Given that for an increase in tuning capacitance of δC, the frequency decreases proportionately by Δf, derive an expression which can be used to estimate the magnitude of the peak frequency deviation Δf.

(4 marks)

(ii) With the aid of a simple circuit diagram, discuss the operation of a varactor diode frequency modulator. (5 marks)

QUESTION 3

(a) Consider an FM signal, $V_{FM} = 500 \sin\left[12.566 \times 10^{7} t + \sin\left(6.283 \times 10^{3} t\right)\right]$ which is measured across a 50 Ω resistive load. Compute

(i) the voltage in each component of the modulated waveform and (5 marks)

(ii) the total power (3 marks)

(iii) the modulation sensitivity if 100 mV_{pk} is required to achieve the peak frequency deviation of the waveform.. (4 marks)

(b)

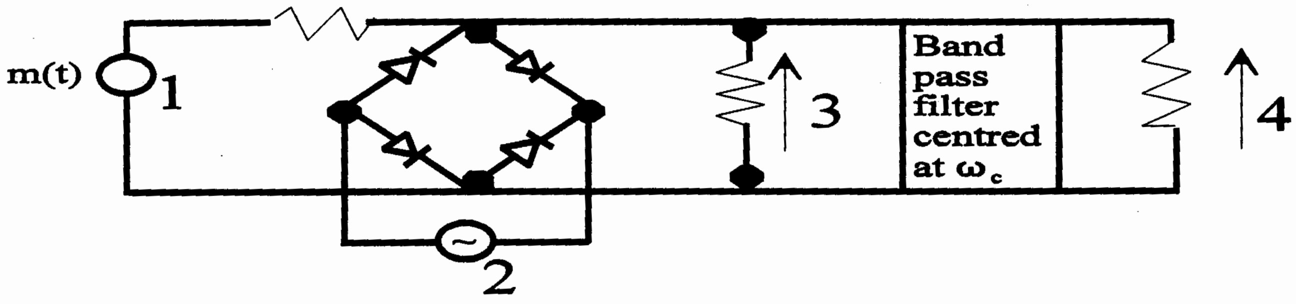

Figure 3

Explain the operation of the circuit shown on Figure 3. Give clearly labelled sketches of V_1, V_3 and V_4. (6 marks)

(c) Consider a ring arrangement of diodes similar to that of Figure 3 such that their switching action in response to the applied message signal m(t) is given by $V_s = \frac{4}{\pi}\left[\text{Sin}\omega_c t + \frac{1}{3}\text{Sin } 3\omega_c t + \ldots\right]$.

(i) What type of output signal will be produced given that the audio signal is $V_m \text{ Sin } \omega_m t$? Show your computations. (4 marks)

(ii) Give the frequency spectrum of the output signal. (3 marks)

QUESTION 4

(a) A 3-kHz audio frequency sinusoidal tone amplitude modulates a 1 MHz radio frequency carrier signal. The modulated carrier voltage is 30 $V_{max\text{-}p}$ and 15 $V_{min\text{-}p}$ across a 100 Ω resistive load impedance. Determine

(i)	the zero modulation rf carrier voltage	(2 marks)
(ii)	the modulation factor	(2 marks)
(iii)	the carrier power	(3 marks)
(iv)	the total power and	(3 marks)
(v)	the transmission efficiency.	(3 marks)

(b) The input signal to an FM receiver has a noise voltage of 10 μV superimposed on its carrier frequency. The amplitude of the carrier waveform is 50 μV. For a modulating frequency of 15 kHz and a maximum frequency deviation of 75 kHz, compute the overall SNR improvement from input to output, assuming no other noise contribution to the system.

(10 marks)

(c) Can uniform quantization be used for voice signals? Explain your answer.

(2 marks)

QUESTION 5

(a) A waveform $x(t) = 10\cos\left(1000t + \pi/3\right) + 19.9\cos\left(2000t + \pi/6\right)$ is to be uniformly sampled for digital transmission.

(i) What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction? (3 marks)

(ii) If x(t) is to be transmitted using PCM with quantisation interval width of about 0.087 V, compute the required transmission rate. (8 marks)

(iii) Discuss the effects of a low and a high sampling frequency on transmission and reception of audio signals.
Discuss the effects of a low and a high sampling frequency on transmission and reception of audio signals.
(4 marks)

(b) (i) How can a 0.5 V_{pk} cosinusoidal analogue signal be converted to a digital signal using a 2-bit Analogue -to-digital converter, given a clock frequency of 3 kHz? (5 marks)

(ii) A bandpass channel can transmit signals in the range 100 kHz - 130 kHz. Determine a suitable carrier frequency which can match an audio signal occupying a frequency range of 100 Hz - 15 kHz, to the given channel. Assume that the audio frequency signal is to be transmitted using double sideband large carrier modulation. (5 marks)