UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
SUPPLEMENTARY EXAMINATION 2008

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 ± B) = Cos A Cos B ∓ Sin A Sin B

Sin (A ± B) = Sin A Cos B ± Cos A Sin B.

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

Cos A Cos B = ½ [Cos (A + B) + Cos (A - B)]

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

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

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

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

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) The input signal to an FM receiver has a noise voltage of 10 μV superimposed on its carrier frequency whose amplitude 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)

(b) A 12 MHz sinusoidal carrier output signal from a distortionless frequency modulator has a peak amplitude of 5 V in the absence of an input signal. A signal $V = 1.5 \sin 6280t$ Volts, applied to the input causes a frequency deviation of 25 kHz per volt.

(i) Derive an expression for the modulated signal at the modulator output. (3 marks)

Compute

(ii) the peak phase deviation of the modulated signal, (5 marks)

(iii) the rate at which this deviation occurs, (2 marks)

(iv) the peak phase and frequency deviations if the input signal frequency is halved and (3 marks)

(v) the resulting modulation index, β. (2 marks)

QUESTION 2

(a) An audio signal comprising of the sinusoidal term $m(t) = \cos 200\pi t$, is to be quantized using a 10-bit pulse code modulation (PCM). Determine the average signal power and the resulting signal-to-quantization noise ratio.

(13 marks)

(b)You are required to generate a dual-polarity pulse amplitude modulated (PAM) signal. Present a circuit diagram for generating the signal, explaining how the signals are generated. Show both the input and output signals.

(8 marks)

(c) Briefly discuss the two main causes of cross-talk in communication systems.

(4 marks)

QUESTION 3

(a) A carrier signal, 4 sin (10^4t) volts, is amplitude modulated by an audio frequency signal, 2 sin(10^2t) + cos(2 x 10^2t) volts. Compute the depth of modulation

(6 marks)

(b) Vestigial Sideband (VSB) modulation technique is often chosen to be used in certain applications like television broadcasting.

(i) Why is VSB often chosen instead of Double Sideband and Single Sideband modulation schemes? (4 marks)

(ii) Briefly explain how a VSB signal can be generated. (5 marks)

(c) A message signal occupying a frequency band of 100 Hz to 3 kHz, amplitude modulates a 100 kHz carrier. Two crystal oscillators at 2 MHz and 26 MHz are used in the frequency translation process to raise the carrier frequency to the desired RF level of 28 MHz.

(i) Present a well labelled block diagram of a dual-conversion filter-type SSB transmitter which can be used. Include all frequency spectrum diagrams at each node. (8 marks)

(ii) Name two advantages of this method over double-sideband suppressed carrier modulation. (2 marks)

QUESTION 4

(a) Explain how a 0.5 Vpk analogue signal can be converted to a digital signal using a 2-bit A/D converter, given a clock frequency of 3 kHz. Show all computations. (5 marks)

(b) The modulation for an FM wave with a peak carrier amplitude of 2 V is increased until the amplitude of the carrier frequency component just disappears for the first time. If the modulation frequency of 3 kHz is used, compute the

(i) 2^{nd} and 3^{rd} order sideband amplitudes and (5 marks)

(ii) the peak frequency deviation under the given conditions. (5 marks)

(c) Television is a method of reproducing fixed or moving visual images by the use of electronic signals. Give a detailed explanation of how a composite video waveform is produced. Include diagrams, blanking and synchronization. (10 marks)

QUESTION 5

(a) A telecommunication receiver has a 3.5-dB noise figure, a noise bandwidth of 1000 kHz and an input resistance of 50 Ω. Calculate the rms signal input that yields an output signal-to-noise ratio of unity when the amplifier is connected to a 50 Ω input at 290 °K.

(10 marks)

(b) Present a phasor representation of the envelope of an AM signal over a full cycle of the modulating signal. Explain your diagram.

(5 marks)

(c) What is overmodulation? How does it affect the modulation process (give two points).

(5 marks)

(d) The unmodulated pulse train can be represented by

$$P_T(t) = \frac{V\tau}{T} + 2\frac{V\tau}{T}\sum_{n=1}^{n=\infty}\frac{\sin n\pi \tau/T}{n\pi \tau/T}$$ Cos $n\omega_s t$, where T is the pulse width.

(i) Derive an expression for the pulse amplitude modulated (PAM) waveform if m(t) is the modulating signal.

(3 marks)

(ii) Suggest a method you would employ to recover the modulating signal from the received waveform.

(2 marks)