UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
MAIN EXAMINATION 2005/2006

TITLE OF PAPER : COMMUNICATION SYSTEMS

COURSE NUMBER : E410

TIME ALLOWED : THREE HOURS

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

THIS PAPER HAS 8 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 = 1.38×10^{-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) A discriminator can be used to demodulate an Angle Modulated signal. Given that a Phase Modulated signal is represented by $v_{PM}(t) = V\cos(w_c t + k_p m(t))$, design a simple discriminator which can be used to recover the message signal m(t). Give a detailed explanation, including all the diagrams. All symbols have their usual meaning.

(10 marks)

(b) A distortionless Frequency Modulator has a 5 Vpk, 12 MHz sinusoidal carrier output signal in the absence of an input signal. A signal $V = 1.5Sin(\pi 2 \times 10^3 t)$ Volts, causes a frequency deviation of 25 kHz per volt when applied to the input of the modulator.

(i) Give an expression for the modulated signal at the modulator output in terms of the modulation index. (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.

(2 marks)

QUESTION 2

(a) A 3 kHz sinusoidal message signal is to be transmitted using Delta Modulation (DM).

(i) Sketch a simple DM system which can be used to achieve this goal. (4 marks)

(ii) Derive an expression for the peak message signal amplitude at which slope overload will occur. (5 marks)

(iii) What value of sampling frequency will be used? (3 marks)

(iv) The output DM signal is transmitted through a twisted-pair telephone line. The signal-to-noise ratio of the signal is observed to be 10% less than the value needed to maintain the specified overall probability-of- bit-error, 100 km from the transmitting station. Suggest a practical solution to this problem. (6 marks)

(b)A radio receiver is tuned to 850 kHz and the LO frequency is on the high side of the carrier frequency. Signals are present at the RF input of the radio, at 1305 kHz, 1760 kHz and 910 kHz. Is any of the signals likely to cause interfere with the desired signal(show all your calculations)? Explain. (4 marks)

(c)Can DSB-AM and SSB modulation schemes be used for the video signal in commercial television transmission? Explain your answer. (3 marks)

QUESTION 3

(a) A channel with a 200 kHz bandwidth in the VHF band is available for transmission of a high quality sound occupying a frequency range of 300 Hz-15 kHz. What value of modulation index should be used? Discuss important considerations which will optimize bandwidth utilization. (8 marks)

(b) Consider a PM modulator with output

$$Y_{PM}(t) = 100Cos(2\pi 1000t + MpSinw_m t) .$$

The modulator operates with k = 1 rad/sec and has the input message signal $m(t) = 5Sin2\pi 10t$. The modulator is followed by a bandpass filter with a centre frequency of 1 kHz and a bandwidth of 56 Hz.

(i) Determine the power at the filter output. (11 marks)

(ii) Sketch the corresponding single-sided amplitude spectrum. (6 marks)

QUESTION 4

(a) Give two main advantages of Pulse Position Modulation over other Pulse Time Modulation schemes. (2 marks)

(b) Pulse Code Modulation is to be used to transmit a 4 Vpk sinusoidal message signal at 32 kps. If the quantization error is to be kept at 0.25 V, compute

(i) the bandwidth of the message signal (9 marks)

(ii) the average signal power and (3 marks)

(iii) the resulting signal to quantization error ratio (s.q.e.r.). (3 marks)

(c) What modifications will you incorporate in the system of (b) to ensure that the s.q.e.r. at the quantizer output exceeds 60 dB?

(8 marks)

QUESTION 5

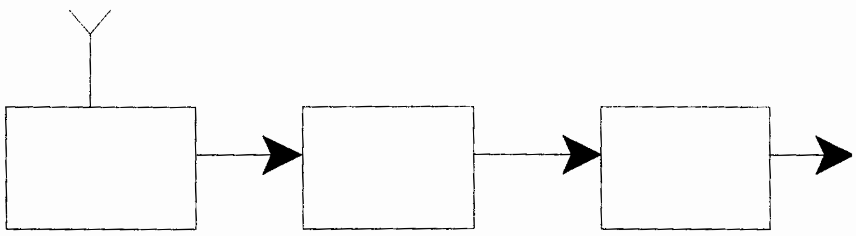
(a) (i) Briefly explain the two main types of noise. (4 marks)

(ii) Normally, the noise factor NR is defined, measured and quoted with reference to $To = 290\ ^{0}K$. When the source is at a temperature $Ts \neq To$, the degradation is different, hence the computation of NR has to be modified to that of the effective noise factor NR_{eff}. Derive an expression for NR_{eff} in terms of NR and Ts. Note that the amplifier is at To, while the source is at Ts.

(6 marks)

(b) The antenna is often mounted on a tall mast and a long cable used to connect the antenna and receiver, in TV reception. A pre-amplifier can be mounted on the antenna to overcome the effect of the lossy cable as shown on Figure 5. Typical parameter values are also shown.

Antenna



To detector circuits

Pre-amplifier $F_1 = 6dB$ $G_1 = 20dB$

Lossy network $F_2 = 3dB$

Receiver front end $F_3 = 16dB$ $G_3 = 60dB$

Figure 5

Compute the overall noise figure of the system. (9 marks)

(c) Consider a narrowband FM receiver with an overall signal-to-noise ratio (SNR) improvement of 15 dB from input to ouput. Compute the maximum phase deviation caused by the noise, for a maximum modulation frequency of 3 kHz and an output SNR of 20 dB.

(6 marks)

QUESTION 6

(a) A radio transmitter can deliver a power output of 10 kW when the carrier is modulated to a depth of 95% by a sinusoidal signal using Double-Sideband Amplitude Modulated (DSB-AM).

(i) Determine the radiated power when after modulation to a depth of 40% by a speech signal, the carrier component is reduced by 20 dB. (11 marks)

(ii) Compare the efficiencies of the DSB-AM and the DSB-AM reduced carrier systems, both modulated to a depth of 40%. (5 marks)

b) Single-sideband (SSB) transmission is commonly used in point-to-point transmission and multichannel line telephony.

How can a SSB signal be generated using the phase discrimination technique? Include relevant diagrams and mathematical verifications. (6 marks)

(c) One problem with radio receivers is that an unwanted RF signal can get through the RF amplifier and appear along with the desired signal at the intermediate frequency. How can this be minimized in AM or eliminated in FM receivers?

(3 marks)
