UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
MAIN EXAMINATION, APRIL/MAY 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.

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 ± 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) Figure 1 shows generation of an Amplitude Modulated signal. The oscillator provides a carrier signal at frequency f_c. Using mathematical expressions to describe signals at each point as they change from the sinusoidal message signal, m(t), through to the output,

(i) derive an expression for the output signal. (5 marks)

(ii) What type of modulating signal is represented by the expression for (i) above? (1 mark)

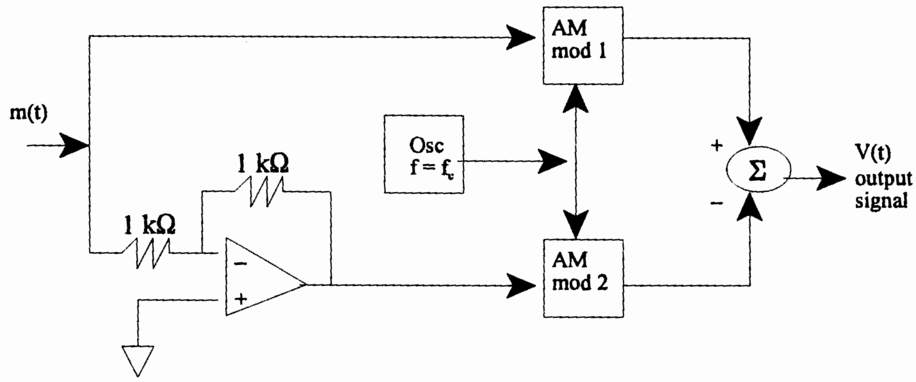


Figure 1

(b) An expression for an amplitude modulated carrier is given as

$$V(t) = \left[1 + 0.5Cos(\pi 10^3 t)\right] Sin(\pi 10^7 t) \ .$$

The carrier component is removed and then re - inserted with a phase displacement of $\pi/2$ radians.

(i) Show that the resulting modulated waveform is phase - modulated. (4 marks)

Determine

(ii) the resulting peak phase deviation, and (3 marks)

(iii) the corresponding peak frequency deviation. (3 marks)

(c) Selection of the step size in Delta Modulation plays an important role in how successful the modulation process will be.

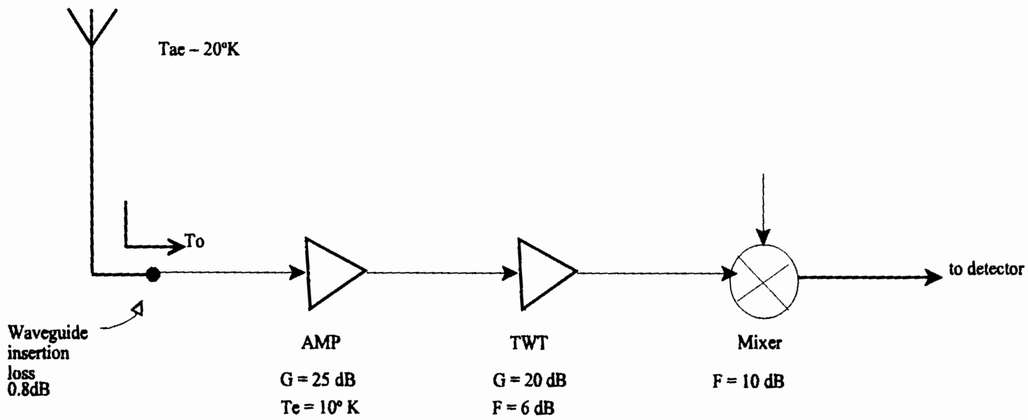
(i) For a sinusoidal input signal, determine the step size δ required to prevent slope overload noise. (7 marks)

(ii) If the Delta Modulator has no input signal, determine its output signal. (2 marks)

QUESTION 2

A receiver used in a satellite ground station has an equivalent noise bandwidth of 20 MHz and consists of the following stages:

An aerial at T_{ant} = 20 °K connected to a maser of gain 25 dB and T_e = 10 °K, by a waveguide with an insertion loss of 0.8 dB; a mixer with a noise figure of 10 dB connected to the maser by a traveling wave tube of gain, 20 dB and noise figure, 6 dB.



The available signal power from the aerial is 7×10^{-13} W. Assuming that all the various stages are matched for maximum power transfer, compute

(i) the total overall effective noise temperature of the system and (19 marks)

(ii) the signal-to-noise power ratio at the detector input. (6 marks)

QUESTION 3

(a) A 2.5 Ghz radar receiver has a local oscillator frequency of 2.55 GHz. Another receiving radar, also using the superheterodyne principle, operates at 2.6 GHz.

(i) Show why there will be interference between the two receivers. (6 marks)

(ii) Re-design the system to eliminate interference problems in the operating band of 2.4 GHz - 3 GHz. (4 marks)

(b) The FM system shown in Figure 2 has a modulator constant of 10 rad/volt/sec. Determine

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

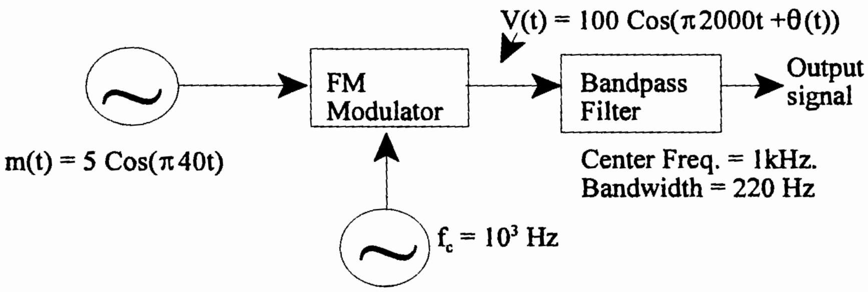


Figure 2

(ii) Sketch the corresponding single - sided line spectrum. (4 marks)

QUESTION 4

(a) A single tone sinusoidal signal is to be quantized using a 10-bit pulse code modulation (PCM) system. The sinusoidal signal can be expressed as $m(t) = \cos 2000\pi t$,

Determine the average signal power and the resulting signal-to-quantization noise ratio. (13 marks)

(b) The PCM signal of (a) is transmitted over a hard wire channel such as 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.

Explain, with a fully illustrated circuit diagram, a commonly used practical solution to this problem. (7 marks)

(c) Consider a diode with a dynamic junction resistance, $r_d = \dfrac{kT}{qI_{dc}}$. The bias current in the device is 1 mA. If the noise is measured in a bandwidth of 10 MHz, compute the noise current and the equivalent noise voltage for the diode.

(5 marks)

QUESTION 5

(a) The letter 'V' in grey, followed by a period '.' in black, are displayed on a TV screen.

(i) Present a single TV raster scan of the letter 'V' in grey and a period '.' in black. (2 marks)

(ii) Translate the scene of (i) into an electrical signal format (black and white video signal) which can be used to transmit the information to a receiver, explaining how it is obtained. (9 marks)

(b) What is flicker? How can it be reduced to an acceptable level? (3 marks)

(c) Frequency modulation can be directly produced by varying the capacitance or inductance of a tuned electronic oscillator circuit by using a non - linear device.

(i) With the aid of a circuit diagram, explain how a special diode can be used to generate a FM signal. (6 marks)

(ii) Using the FM modulator circuit of (i), show how the variation in capacitance δC is related to the frequency deviation Δf. (5 marks)