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UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING
SUPPLEMENTARY EXAMINATION 2004/2005

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.

QUESTION 1

(a) (i) Define the terms shot noise and equivalent noise temperature of a linear network.

(2 marks)

(ii) Derive an expression relating the noise figure of an amplifier to its equivalent noise temperature T_e. Assume that only thermal noise is present.

(6 marks)

(iii) An amplifier has a noise bandwidth of 500 kHz and input resistance of 50 Ω when connected to a 50 Ω input at 290 °K. Calculate the input rms noise voltage.

(4 marks)

(b) Consider an antenna having an effective noise temperature of 50 °K connected via a 0.8 dB loss waveguide, to a maser amplifier with an effective noise temperature of 4 °K. Determine the total effective noise temperature at the input to the waveguide.

(7 marks)

(c) A diode has a thermal voltage of 26 mV and a dc bias current of 1 mA. If its noise is measured in a bandwidth of 10 MHz, compute both its

(i) noise current and (2 marks)

(ii) equivalent noise voltage (4 marks)

QUESTION 2

(a) (i) Present a simple design of a delta modulator explaining its operation. Include all relevant diagrams. (5 marks)

(ii) In delta modulation (DM), low distortion is realized if the system has the ability to closely follow the changes of the analogue signal. What are the consequences of using an incorrect step size? (3 marks)

(iii) You are required to convert a 5 - V_{peak} 4 - kHz sinewave to a digital signal by delta modulation. The step size must be 10mV. What will be the minimum clock rate that will allow the DM system to follow exactly the fastest input analogue signal change?

(7 marks)

(b) A PCM system using linear quantization with 256 intervals and constant-length code words has a signaling rate of 150 kbit/s, calculate

(i) the highest input frequency that the system can handle and (4 marks)

(ii) the signal-to-quantization error ratio for a full-range 1 kHz sine wave input signal. (3 marks)

(c) Explain the following:

(i) pulse code modulation(PCM), (1 mark)

(ii) delta modulation(DM) and (1 mark)

(iii) pulse modulation(PM)? (1 mark)

QUESTION 3

(a) Consider a receiver antenna with an output voltage of 10 μV (carrier only) when connected to a 50 - Ω receiver.

(i) Calculate the power level in dBW and dBm. (4 marks)

(ii) The receiver of part (a) has one RF amplifier with 10 dB of gain, a mixer with 6 dB of conversion loss, followed by a multipole filter with 1 dB of insertion loss. If available IF amplifiers have 20 dB of gain each, determine the number of IF amplifiers necessary to provide at least O dBm (1 mW) to the detector. (6 marks)

(iii) Sketch a block diagram of the superheterodyne AM receiver (refer to section (ii)) showing the power level in dBm, at each block. (3 marks)

(b) Explain the function of

(i) a synchronizing pulse and (2 marks)

(ii) a blanking pulse (2 marks)

(c) Describe the following with reference to television systems.

(i) The chroma signal. (3 marks)

(ii) Generation of a vestigial sideband signal (include diagrams). (5 marks)

QUESTION 4

(a) Present a circuit diagram of a commonly used non-coherent linear detector for AM signals, explaining its operation.

(5 marks)

(b) An AM signal with $V_i(min) = 0.5$ V, $V_i(max) = 1.5$ V is fed into an envelope detector with R = 2 kΩ and diode junction voltage of 0.2 V. Compute

(i) the total power delivered to the detector circuit if the input impedance is 1 kΩ,

(8 marks)

(ii) the output dc, minimum and maximum voltages, and

(3 marks)

(iii) the average current at the output.

(2 marks)

(c) A single sideband suppressed carrier (SSBSC) signal can be produced from a double sideband suppressed carrier (DSBSC) signal by suppressing the unwanted sideband by a side-band filter.

(i) Give two merits of a SSBSC system and one main disadvantage of a DSBSC system. (3 marks)

(ii) Consider two AM systems, system 1 and system 2. The signal $f_1(t) = \cos \omega_m t$ is applied to the input of a DSBSC modulator and then a carrier term $A \cos \omega_c t$ is added after the modulation in system 1. In system 2 the signal $f_2(t) = a + f_1(t)$ is applied to the input of the DSBSC modulator.

Compare the results. Can a dc level in the input be distinguished from the carrier in the AM waveform? Explain.

(4 marks)

QUESTION 5

(a) (i) Present a block diagram of a narrow-band phase modulator (NBPM) using a balanced AM modulator and sideband phase shift. (2 marks)

(ii) Show that if the crystal-controlled carrier oscillator signal in (i) is a sinewave, the output of the modulator will be a narrow-band phase modulated signal. Assume the message signal is also a sinewave. (5 marks)

(iii) Include a clearly labeled corresponding vector diagram, explaining how the phase changes with the modulating signal.

(6 marks)

Table 5 .0 Modulation function chart

m_f	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}
0.00	1.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0.25	0.98	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—
0.5	0.94	0.24	0.03	—	—	—	—	—	—	—	—	—	—	—	—
1.0	0.77	0.44	0.11	0.02	—	—	—	—	—	—	—	—	—	—	—
1.5	0.51	0.56	0.23	0.06	0.01	—	—	—	—	—	—	—	—	—	—
2.0	0.22	0.58	0.35	0.13	0.03	—	—	—	—	—	—	—	—	—	—
2.4	0	0.52	0.43	0.20	0.06	0.02	—	—	—	—	—	—	—	—	—
2.5	−0.05	0.50	0.45	0.22	0.07	0.02	0.01	—	—	—	—	—	—	—	—
3.0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—	—	—	—	—
4.0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—	—	—	—	—
5.0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	—	—	—	—	—	—
6.0	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	—	—	—	—	—
7.0	0.30	0.00	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02	—	—	—	—
8.0	0.17	0.23	−0.11	−0.29	−0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03	—	—	—
9.0	−0.09	0.25	0.14	−0.18	−0.27	−0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01	—
10.0	−0.25	0.05	0.25	0.06	−0.22	−0.23	−0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01

(b) An FM signal expressed as $V(t) = 1000 \cos (2\pi\ 10^7 t + 0.5 \cos 2\pi\ 10^4 t)$ is measured in a 50 - Ω antenna.

Compute the following:

(i) the total power, (2 marks)
(ii) the modulation index, (1 mark)
(iii) the peak frequency deviation, (2 marks)
(iv) the amplitude spectrum and (6 marks)
(v) the information bandwidth. (1 mark)

USEFUL INFORMATION

$\text{Cos}(A \pm B) = \text{Cos}\,A\,\text{Cos}\,B \mp \text{Sin}\,A\,\text{Sin}\,B$
$\text{Sin}(A \pm B) = \text{Sin}\,A\,\text{Cos}\,B \pm \text{Cos}\,A\,\text{Sin}\,B.$

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

Binomial (for $x^2 < 1$)

$$(1 \pm x^2)^n = 1 \pm nx + (\tfrac{1}{2}!)n(n - 1)x^2 \pm \ldots$$

$$(1 \pm x^2)^{-n} = 1 \mp nx + (\tfrac{1}{2}!)n(n + 1)x^2 \mp \ldots$$