UNIVERSITY OF SWAZILAND
SUPPLIMENTARY EXAMINATION
SECOND SEMESTER - JULY 2013

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: COMMUNICATION SYSTEM PRINCIPLES

COURSE CODE: EE442

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. There are five questions in this paper. Answer any FOUR questions. Each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.
3. Some useful data can be found on the last page.

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(25 marks)***

(a) In a DSB-SC communications system, the message signal $m(t) = A_m \cos(2\pi f_m t)$ and the carrier signal $c(t) = A_c \cos(2\pi f_c t)$.

(i) Show how a DSB-SC modulated signal is produced .

(3 marks)

(ii) Find the sidebands of the modulated output.

(2 marks)

(iii) Derive and sketch the spectrum of the modulated signal.

(3 marks)

(iv) Derive an expression for the power content of the DSB-SC output signal.

(6 marks)

(v) If the message signal $m(t) = 3\cos(4\pi \times 10^3 t)$ and the carrier

$c(t) = 10\cos(2\pi \times 10^6 t)$, calculate the power delivered to a 50Ω load by the DSB-SC output. (2 marks)

(b) (i) A synchronous demodulator for a DSB-SC receiver, is having local oscillator signal $cos(2\pi f_c t + \emptyset)$. Derive an expression for the demodulator output.

(6 marks)

(ii) Find the amplitude of the demodulated signal if the transmitted signal is generated from $m(t) = 3\cos(4\pi \times 10^3 t)$ and $c(t) = 10\cos(2\pi \times 10^6 t)$. Assume that the transmission channel is ideal and the $\emptyset = \frac{\pi}{6}$.

(3 marks)

QUESTION TWO ***(25 marks)***

(a) In a DSB-AM system, the message signal $m(t) = 3\cos(200\pi t) + 2\sin(300\pi t)$ and the carrier $c(t) = \cos(2\pi \times 10^5 t)$. If the modulation index is 0.8, find

(i) the modulated signal.

(5 marks)

(ii) the power content of the modulated signal, carrier component and the sidebands.

(10 marks)

(b) A power law DSB-AM modulator uses a non linear device having the transfer characteristics of $v_o = a_1 v_i + a_2 v_i^2$.

(i) Draw the block diagram of the modulator.

(5 marks)

(ii) Derive the output signal and verify your block diagram.

(3 marks)

(iii) State the conditions for proper operation of the modulator.

(2 marks)

QUESTION THREE ***(25 marks)***

(a) A frequency modulated (FM) signal is generated from a carrier

$c(t) = 10\cos(2\pi \times 9 \times 10^7 t)$ and modulated by a message signal

$m(t) = 5\cos(2\pi \times 10^4 t)$. The peak frequency deviation is $20kHz$.

(i) Express the modulated signal in the form of $u(t) = A\cos[2\pi f_1 t + B sin 2\pi f_2 t]$ specifying the values A, B, f_1 and f_2.

(3 marks)

(ii) Write the expression which describes the spectrum of the modulated signal, defining any symbols used.

(2 marks)

(iii) Find the amplitude and frequency of each individual signal component in the modulated signal, which has a power of at least 10% of the total power. Show clearly the relevant steps of the calculations.

(10 marks)

(iv) Estimate the effective bandwidth of the modulated signal.

(3 marks)

(v) Determine the modulator constant?

(2 marks)

(b) Draw the block diagram of a narrow band frequency modulator and show using appropriate expressions that it produces a narrow band FM signal.

(5 marks)

QUESTION FOUR ***(25 marks)***

(a) An amplifier has a gain of $20dB$ and a bandwidth of 1MHz. An input signal having a power of $-67dBm$ is applied to the input with a $\left(\frac{S}{N}\right)$ ratio of $60dB$. The total noise power at the output, due to input noise and the amplifier noise, is $-85dBm$. For this amplifier, calculate the

(i) noise temperature. (7 marks)

(ii) noise figure in dB. (3 marks)

(b) A radio receiver system is shown in Figure-Q4.

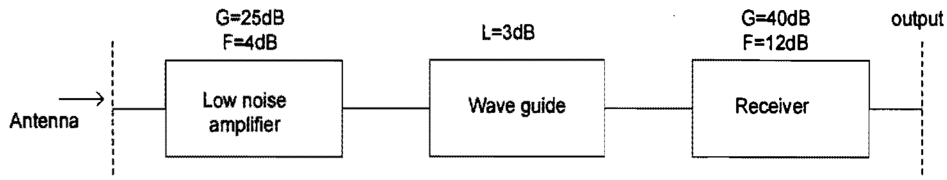

Figure-Q4

The symbols F, G and L represent noise figure, gain and loss respectively.

(i) Calculate the system noise temperature.

(10 marks)

(ii) Find the input signal power from the antenna if the signal to noise ratio at the output is $50dB$. Assume that the antenna noise temperature is $15^0 K$ and the system bandwidth is $1MHz$.

(5 marks)

QUESTION FIVE (25 *marks*)

(a) Draw a block diagram of a uniform PCM system.

(2 marks)

(b) A message signal is band limited to $4kHz$ and the amplitude limited to $\pm 2\ V_{pk}$. This signal is transmitted using uniform PCM and the quantization error is kept to $62.5mV$. Determine the following.

(i) The number of quantization levels and the minimum number of bits required.

(3 marks)

(ii) The sampling rate for a guard band of $1kHz$ and the resulting output bit rate.

(3 marks)

(iii) The mean signal power.

(3 marks)

(iv) The quantization noise power and the signal to quantization noise ratio in dB.

(3 marks)

(v) The minimum channel bandwidth required for the transmission.

(3 marks)

(vi) How would you modify this system to achieve a minimum signal to quantization noise ratio of $60dB$? Derive the optimum requirements necessary for this modification.

(8 marks)

USEFUL INFORMATION

$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$

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

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

$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B.$

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

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

$\int Sin ax\, dx = -\frac{1}{a} Cos ax$ $\quad \int Cos ax\, dx = \frac{1}{a} Sin ax$

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