UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER DECEMBER 2012

FACULTY OF SCIENCE

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.

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE (*25 marks*)

(a) A square pulse signal with 50% duty cycle ($t_{off} = t_{on}$) is shown in Figure-Q1(a). Find the Fourier series for this signal.

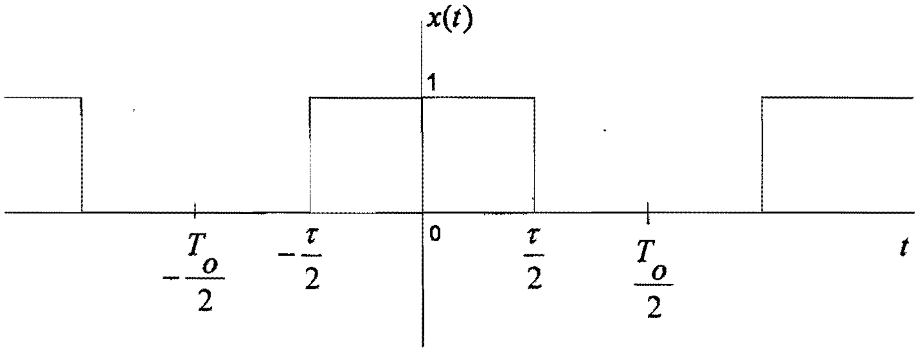

Figure - Q1(a)

(8 marks)

(b) A square wave signal which can be represented by,

$x(t) = \frac{4}{\pi}\sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)} cos[2\pi(2n+1)f_o t]$ is given to the input of a filter. The frequency response function $H(f)$ of the filter is shown in Figure-Q1(b).

(i) Determine the output signal of the filter if the period of the input signal is 10^{-5} seconds.

(12 marks)

(ii) Calculate the power content of the output signal.

(5 marks)

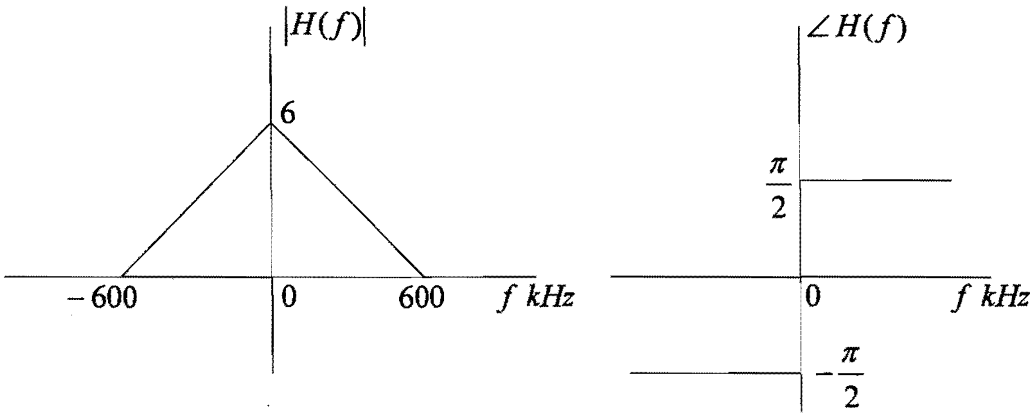

Figure - Q1(b)

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

(a) One method of amplitude modulation (AM) is DSB-SC. Assume the message signal is $m(t) = a\cos 2\pi f_m t$ and the carrier signal is $c(t) = A_c \cos 2\pi f_c t$.

(i) Find the DSB-SC signal and its sidebands.

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

(7 marks)

(b) (i) Derive an expression for the power content of a DSB-SC signal if the message signal is indicated by $m(t)$.

(iii) If $m(t) = 2\cos(2 \times 10^3 \pi t)$ and the carrier $c(t) = 20\cos(2 \times 10^6 \pi t)$, find the power content of the modulated signal and its sidebands.

(8 marks)

(c) Show the block diagram of a DSB-SC demodulator and show its functionality using the signals involved.

(3 marks)

(d) If a message signal $m(t) = \cos(600\pi t)$ modulates a carrier $c(t) = 10\cos(4 \times 10^3 \pi t)$ with a modulation index of 0.5, derive the DSB-AM signal and the sidebands. Also calculate the power content of the modulated signal and its sidebands.

(7 marks)

QUESTION THREE *(25 marks)*

(a) A sinusoidal signal $m(t) = 2\cos(2 \times 10^3 \pi t)$ is used to frequency modulate a signal $c(t) = 5\cos(2 \times 10^5 \pi t)$. Show that the modulated signal $u(t)$ can be expressed by

$u(t) = \sum_{n=-\infty}^{\infty} 5\, J_n(\beta)\, cos[2\pi(10^5 + 10^3 n)t]$

where, β = modulation index

$j_n(\beta)$ = Bessel function of the first kind of order n

(8 marks)

(b) The signal $c(t) = 5\cos(2 \times 10^5 \pi t)$ is frequency modulated by a signal $m(t) = 2\cos(2 \times 10^3 \pi t)$ with a modulator having modulator constant $k = 2\frac{kHz}{V}$.

Find the spectrum (frequencies with their amplitudes) of the modulated signal which will contain 99% of the modulated signal power.

(12 marks)

(c) Draw the block diagram of a narrowband frequency modulator and show the signals in time domain at the input and output of each block.

(5 marks)

QUESTION FOUR (*25 marks*)

(a) Calculate the noise voltage produced in a $10k\Omega$ resistance on a $1MHz$ bandwidth at a temperature of 27^0C.

(3 marks)

(b) An amplifier having a bandwidth of $20MHz$, a gain of $20dB$, generates its own noise power of $7.2 \times 10^{-14}W$ measured at the output. If a signal of $-100dBm$ is applied to the amplifier input with a signal to noise ratio of $20dB$, Assuming a physical temperature of 290^0K, calculate

(i) The noise temperature of the amplifier.

(ii) The signal to noise ratio at the output of the amplifier.

(10 marks)

(c) An UHF receiver system is shown in Figure-Q4.

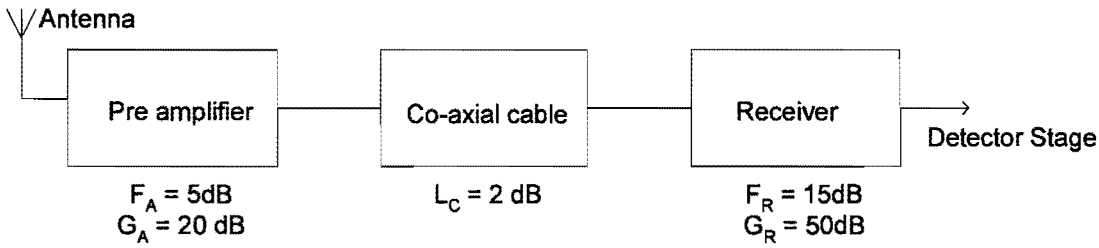

Figure - Q4

Note that F, G and L represent noise figure, gain and loss respectively.

(i) Calculate the overall noise temperature of the system.

(ii) If the input signal power at the antenna is $-50dBm$ and the noise temperature of the antenna is 30^0K, calculate the $\left(\frac{S}{N}\right)$ ratio at the receiver output. Bandwidth of the receiver is $1MHz$.

(12 marks)

QUESTION FIVE (25 *marks*)

(a) (i) A signal $x(t)$ is sampled at a sampling at a frequency of f_S. Show that the spectrum of the sampled signal is given by,

$$X_\delta(f) = \frac{1}{T_S}\sum_{n=-\infty}^{\infty} X\left(f - \frac{n}{T_S}\right)$$

Where,

$T_S = \frac{1}{fs}$ and $X(f) =$ Fourier transform of $x(t)$.

(7 marks)

(ii) If the bandwidth of the signal $x(t)$ is3.4 kHz, sketch the spectrum of the sampled signal and find the sampling frequency required when a guard band of $1.2kHz$ is employed.

(5 marks)

(b) (i) Draw the block diagram of a PCM system

(2 marks)

(ii) A message signal which is distributed within -1 and +1 in amplitude is converted to a uniform PCM signal having 256 levels. Evaluate the signal to quantization noise ratio of the resulting signal.

(7 marks)

(iii) If the signal bandwidth is $3.4kHz$, find the minimum bandwidth required by the PCM channel.

(4 marks)

USEFUL INFORMATION

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

Sin (A ± B) = Sin A Cos B ± Cos A Sin B.
Cos A Cos B = ½ [Cos (A + B) + Cos (A - B)

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

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

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