UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER DECEMBER 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.

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

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

The message signal $m(t) = 3\cos(2\pi \times 10^3 t)$ and the carrier signal $c(t) = 5\cos(2\pi \times 10^5 t)$ are used to produce a DSB-AM signal with a modulation index of 0.75, using the scheme shown in Figure-Q1.

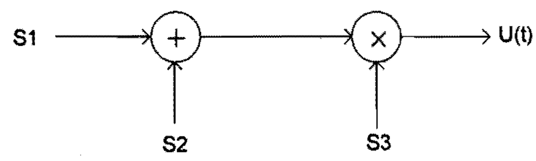


Figure -Q1

(a) Identify the signals $s_1$, $s_2, s_3$ and $u(t)$.

(3 marks)

(b) If $c(t)$ and $m(t)$ signals are used with the scheme shown in Figure-Q1, derive the other two signals.

(5 marks)

(c) Justify that the output signal is DSB-AM using time domain analysis. Find the upper and lower sidebands.

(5 marks)

(d) Derive and sketch the spectrum of the output.

(5 marks)

(e) Calculate the power delivered to a 50Ω load by the output signal. Also find the power incorporated with the carrier and sidebands indicating their percentages to the total power.

(7 marks)

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

A block diagram of a communication system is shown in Figure-Q2, where the message signal $m(t) = 2\cos(2\pi \times 4 \times 10^3 t)$ and the carrier signal $c(t) = 5\cos(2\pi \times 10^5 t)$.

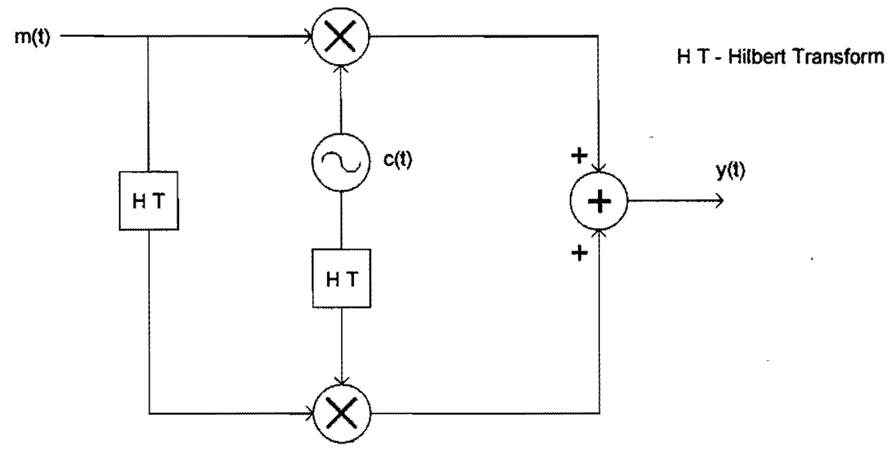


Figure-Q2

(a) Derive the output signal $y(t)$ and identify it.

(6 marks)

(b) Derive and sketch the frequency spectrum of $y(t)$.

(4 marks)

(c) State the advantage of using this scheme over the conventional DSB-AM and DSB-SC systems in multi channel voice communications.

(3 marks)

(d) (i) Draw a block diagram of a demodulator that can be used to recover the message signal $m(t)$ from $y(t)$.

(5 marks)

(ii) Show that how a ' phase offset' of any local oscillator signal can effect the recovered signal by using the method given in (d) (i).

(7 marks)

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

(a) A phase modulation (PM) system uses a carrier signal $c(t) = 10\cos(2\pi \times 10^8 t)$ and the message signal $m(t) = 6\sin(2\pi \times 10^4 t)$. The peak phase deviation is 8 $rad$.

(i) Write the signal expression of the PM output for the above input signals indicating the relevant signal parameters.

(3 marks)

(ii) What is the expression that describes the spectrum of the modulated signal?

(2 marks)

(iii) Find the amplitude and frequency of each signal component in the modulated signal up to and including 3rd side frequency. Any carrier component within this limit must also be considered.

(5 marks)

(iv) Calculate the total power contained with the signal components up to and including the 3rd side frequency and express it as a percentage to the total power of the modulated signal. Any carrier component within the limit must be considered.

(5 marks)

(v) What is the effective bandwidth of the modulated signal?

(3 marks)

(vi) Find the value of the modulator constant.

(2 marks)

(b) Draw the block diagram of a narrow band phase modulator and justify its operation using appropriate signal expressions.

(5 marks)

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

(a) A microwave receiver is shown in Figure-Q4.

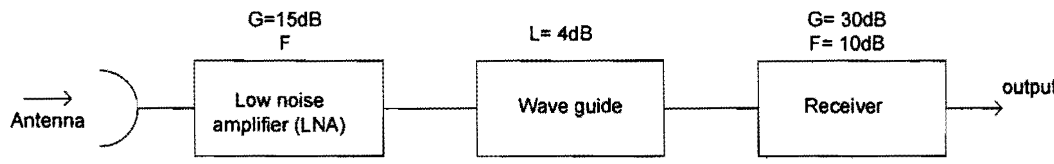


Figure-Q4

Note that the symbols $G$, $F$ and $L$ represent the Gain, Noise Figure and Loss respectively. The output signal power from the antenna is $-80\ dBm$ and the antenna noise temperature is $12^0 K$. At the output, the $\left(\frac{S}{N}\right)$ ratio required is $30dB$.

(i) Find the system noise temperature.

(7 marks)

(ii) Calculate the maximum value of the noise figure of the LNA.

(7 marks)

(iii) Find the $\left(\frac{S}{N}\right)$ ratio at the output of the LNA.

(4 marks)

(b) A wire line channel used for analogue signal transmission has a length of 150 $km$ and an attenuation of $2\frac{dB}{km}$. The repeaters each has a gain of 20 $dB$ and a noise figure of 5 $dB$ are installed at each $10km$ of the line. If the required $\left(\frac{S}{N}\right)$ ratio at the end of the channel is 30 $dB$, find the required transmitter power. Assume that the physical temperature and the noise bandwidth of a repeater are $290^0\ K$ and $4kHz$ respectively.

(7 marks)

**QUESTION FIVE (25 *marks*)**

(a) Draw the block diagram of a DPCM encoder and a decoder.

(4 marks)

(b) In a uniform PCM system, the message signal is band limited to 4 $kHz$ and its amplitude is Limited to $\pm$ 2.5$V$. The input samples are quantized to 64 levels by the quantizer.

(i) Find the quantization error and the number of bits required.

(3 marks)

(ii) If the output bit rate is 57 $\frac{Kb}{s}$ , calculate the sampling frequency and the guard band.

(3 marks)

(iii) Find the mean signal power and the quantization noise power.

(6 marks)

(iv) Calculate the signal to quantization noise ratio in $dB$.

(2 marks)

(v) What is the minimum channel bandwidth required?

(2 marks)

(vi) Suggest a modification to this system to achieve a signal to quantization noise ratio of 45 $dB$.

(5 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

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

## 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 |