**ES3350**

**THE UNIVERSITY OF WARWICK**

**Third Year Examinations: Summer 2011**

**COMMUNICATIONS SYSTEMS**

**SECTION A**
**SECTION B**

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**Candidates should answer FOUR QUESTIONS.**

**Time Allowed: 3 hours.**

**Only calculators that conform to the list of models approved by the School of Engineering may be used in this examination. The Engineering Databook and standard graph paper will be provided.**

*Read carefully the instructions on the answer book and make sure that the particulars required are entered on each answer book.*

**PLEASE USE A SEPARATE ANSWER BOOK FOR EACH SECTION**

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## SECTION A

1. (a) Give the general expression for a time-varying sinewave radio frequency signal at a frequency **ω** at an amplitude of **A** volts and with phase Φ. Explain which parts of the signal may be modified for amplitude modulation, which parts for frequency modulation, and which parts for phase modulation.

(5 marks)

(b) An audio signal, consisting of a sinewave, in the range between 250 Hertz and 4 KHz, is to be sent out on a carrier at 170 MHz. Amplitude modulation is to be used, and the audio signal lies between ± 2 volts. The carrier amplitude is 5 volts, peak-to-peak.

Determine the power transmitted in the carrier, and the power transmitted in each sideband, if the signals appear across a 50 ohms load resistance. Hence determine the maximum amount of wasted power as a proportion of the whole transmitted power.

(10 marks)

(c) Explain what is meant by VSB, and why, in television and other applications, it might be regarded as advantageous to SSB. Discuss the main advantages and disadvantages of SSB in comparison to the standard full form of AM.

(10 marks)

**Continued…**

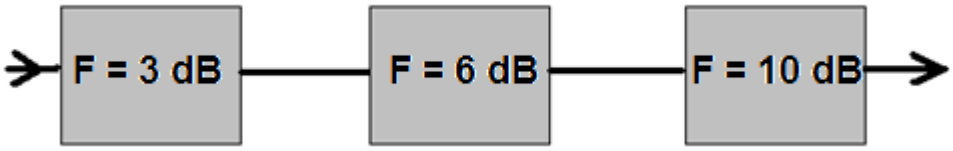
2. (a) Explain shot noise in general terms, without going into exact mathematical derivations, and state the formula relating this noise to the current passing through an electronic device.

(6 marks)

(b) From the formula for thermal noise: $\mathbf{i^2 = 4\,kTG\,df}$ , determine *the available noise power* from a resistor **R**, where **G = 1/R**, defining all the terms in the formula above.

(7 marks)

(c) Calculate the SNR at the output of a communication system consisting of three signal processing blocks as shown in Figure 1, if the signal to noise ratio at the input to the first amplifier is 30 dB, and the system components have the following specification:-




Power Gain = 40 dB  Power Gain = 26 dB  Power Gain = 12 dB

**Figure 1**

If the first stage went faulty and its gain dropped to 30 dB, and its noise figure became 10 dB, suggest how you might rearrange the order of the amplifiers in order to achieve best overall noise figure.

(12 marks)

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**Continued…**

3. (a) A standard analogue television channel employs "gamma correction". Explain why this is necessary and why it has an effect on monochrome compatibility.

(8 marks)

(b) A TV camera is aimed at a coloured surface defined by the normalised primary signal values of R = 0.3, G = 0.6, and B = 0.4. Firstly, determine the true luminance if the luminosity coefficients are {l1, l2, l3} = [0.3, 0.6, 0.1], respectively. Secondly, find the transmitted luminance, the colour-difference signals, and the normalised luminance on a monochrome TV display for a gamma of value 2.0.

(10 marks)

(c) Explain how the chrominance signals are transmitted in the current UK analogue PAL system, and how they are detected.

(7 marks)

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**Continued…**

## SECTION B

4. (a) Explain what is meant by the terms *baseband transmission* and *modulated transmission*.

(2 marks)

(b) For two baseband line codes of your choice, sketch the signal waveforms over time if the transmitter generates the bit stream:-

$$[0 \quad 1 \quad 0 \quad 1 \quad 1 \quad 0 \quad 1 \quad 0 \quad 0]$$

(4 marks)

(c) Explain the signal to noise ratio benefits obtained through the use of frequency shift keying (FSK) or phase shift keying (PSK) rather than amplitude shift keying (ASK). Indicate which method is likely to be the optimum choice when bandwidth is also a design consideration.

(5 marks)

(d) A 1 Mbps digital signal is transmitted in a noisy environment by means of a 5V peak sinusoidal carrier. Estimate the mean time between errors for coherent transmission using ASK, FSK and PSK when the rms noise voltage is 0.7V. You may use the approximation $erfc(x) \approx \exp(-x^2)/x\sqrt{\pi}$.

(9 marks)

(e) Explain the advantage of M-ary transmission for modulated date using a limited bandwidth channel. Sketch the constellation diagrams for binary PSK, QPSK and 16-QAM.

(5 marks)

**Continued…**

5. (a) Discuss the technique of algebraic coding and explain how the inclusion of redundant bits enables errors to be corrected.

(3 marks)

(b) Explain what is meant by a 3-bit repetition code and discuss why such an approach to error correction is inefficient.

(3 marks)

(c) Outline how the addition of parity check bits to a block of data produces an error correction method that is more efficient than the code in part (b).

(3 marks)

(d) Considering the block code generated by the matrix.

$$\mathbf{G} = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Determine:

(i) The number of code words in the code and the rate of the code.

(2 marks)

(ii) Find the parity check matrix and hence the syndrome for the received code word.

$$\mathbf{R}^{\mathrm{T}} = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 1 & 0 \end{bmatrix}$$

(7 marks)

(iii) Indicate from the syndrome why $\mathbf{R}^{\mathrm{T}}$ is corrupted and, assuming that it is unlikely that more than one bit is in error, find and correct the error.

(7 marks)

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**Continued…**

6. (a) Describe what is meant by the terms *prefix code* and *uniquely decidable (UD)*.

(2 marks)

(b) A discrete memoryless source (DMS) has the output alphabet $\{A, B, D, C, E\}$ having the probabilities of appearance given by:

$P(A) = 0.4$

$P(B) = 0.3$

$P(C) = 0.15$

$P(D) = 0.1$

$P(E) = 0.05$

i. Determine the Huffman Code for this system.

ii. Determine the Entropy of the DMS

iii. Determine the code length and comment on it in relation to the entropy of the source

iv. Determine the compression ratio.

(10 marks)

(c) If a system designer were to implement both compression and encryption features within a system, should they implement the encryption stage before or after the compression stage and why?

(3 marks)

(d) Describe the operation of the RSA public Key Cryptosystem, and how suitable public and private keys *p* and *s* are derived from two large primes *q* and *r*.

(10 marks)

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**END**