Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2012-13 (2.0 hours)

EEE6410 Data Coding for Communications and Storage 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** Contrast asynchronous and synchronous communications, giving suitable applications where each might be used. **(3)**

b. An RS232 asynchronous transmission connection is set up with even parity and 8-bit data between a Start and a Stop bit. The master clock is set to run at a nominal rate that is 8 times the baud rate. What is the minimum tolerance that the receiver and transmitter master clocks must have, assuming worst case conditions. **(6)**

c. Describe the key parameters that need to be considered when devising or evaluating a particular data line coding scheme in the context of baseband synchronous communications. **(3)**

d. For the two line coding schemes illustrated in Fig.Q.1.a, and Fig.Q.1.b below, derive the bit pattern sequence that corresponds to both of the timing diagrams shown. Contrast the two codes explaining their advantages and drawbacks and what applications each might be suitable for. **(8)**

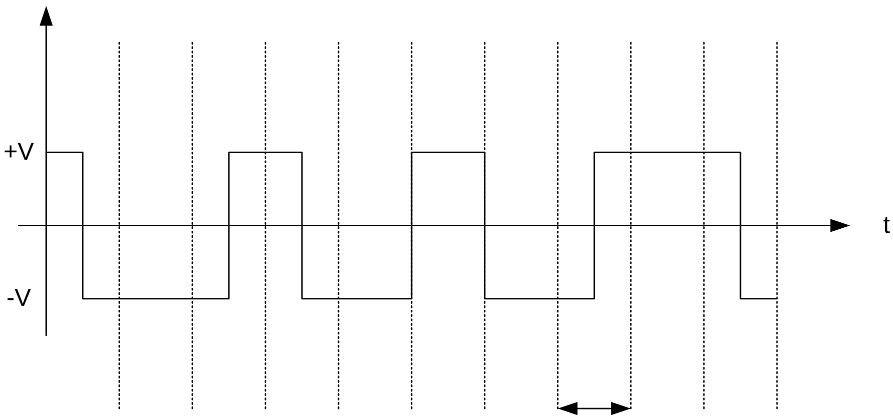

Figure Q.1.a

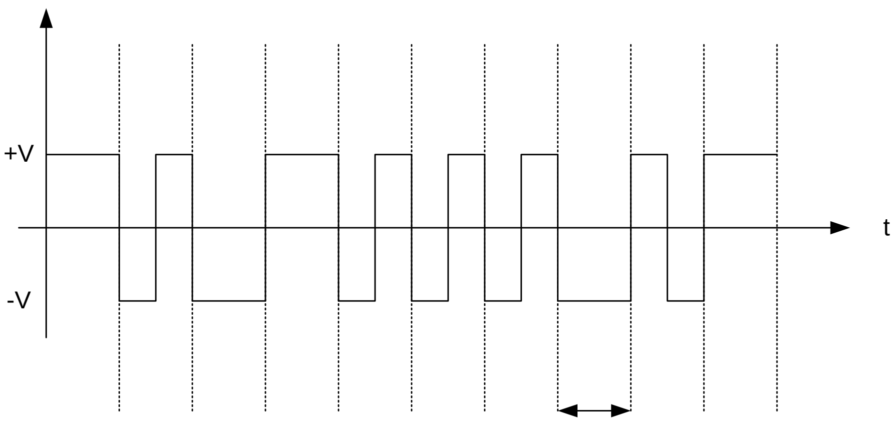

Figure Q.1.b

2. **a.** The 4 information bits **0110** are coded into a 7-bit codeword using a (7,4) cyclic block code generated using the generator polynomial $\boldsymbol{g(x) = x^3 + x^2 + 1}$.

i) Derive the resulting codeword. **(4)**

ii) The error pattern **0100000** corrupted the codeword during transmission; illustrate, using actual calculations, how a Meggitt decoder would correct such error. **(8)**

b. A message encoded using a ***(15,7)*** primitive ***BCH*** (Bose-Chaudhuri-Hocquenghem) code defined over Galois Field $\boldsymbol{GF(2^4)}$ using the primitive polynomial $\boldsymbol{p(x)=x^4+x+1}$, is received after transmission over a noisy channel as

$\boldsymbol{r(x)=x^{13}+x^{11}+x^9+x^7+x^2+x}$ with 2 errors that have affected two of the 4 most significant bits (MSBs). Using algebraic decoding, derive the corrected codeword given that for a double error correction the coefficients of the error locator polynomial $\boldsymbol{\sigma(x)}$ are expressed in terms of the syndromes as follows: **(8)**

$$\sigma_1 = S_1 \quad \text{and} \quad \sigma_2 = \frac{S_3 + S_1^3}{S_1} \quad \text{where S denotes a syndrome.}$$

3. **a.** What are the main steps involved in the frequency domain approach for encoding and decoding of ***RS*** (Reed-Solomon) codes. **(4)**

b. Sketch a diagram for the recursive extension circuit that can be used to complete the error spectrum in frequency domain decoding of double-error correcting RS codes and explain its operation. **(4)**

c. An ***(n,k) RS*** (Reed-Solomon) code defined over Galois Field $\mathbf{GF(2^3)}$ using the primitive polynomial $\boldsymbol{p(x)=x^3+x^2+1}$, is used to encode a 3-symbol message $\boldsymbol{m(x) = x^2+\alpha = (1,0,\alpha)}$ before transmission over a noisy channel so that any 2-symbol errors can be corrected.

i) List all of the elements of the $\mathbf{GF(2^3)}$ above in both binary and polynomial format. Sketch a circuit that generates all of the non-zero elements of this field. **(3)**

ii) Define the parameters n and k of the code and hence the required number of parity check symbols to be added to the message, to enable the double error correction capability. What form can the corrected errors take in this case? **(2)**

iii) Using the frequency domain encoding approach, derive the **RS** codeword for the message $\boldsymbol{m(x)}$ **(7)**

4. **a.** Compare block codes and convolutional codes, as applied to error correction, giving typical situations where each one might be employed. **(3)**

b. A binary data sequence was encoded using the convolutional encoder circuit shown in Figure Q.3 below, transmitted, in the order (Q_1Q_0) from left to right, through a noisy channel and received at the Viterbi decoder with no more than 3 bit errors as: **00 01 01 00 00 11 10 01 00**

i) Correct the received sequence. Hence determine the original transmitted data. **(6)**

ii) In Viterbi decoding, situations can arise where two or more equally likely codes are obtained. Suggest in this case, how you might select the right code. **(2)**

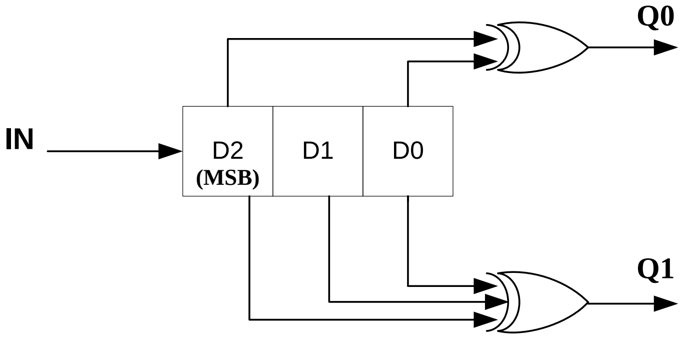

Figure Q.3

c. Describe what is meant by transform-based compression and explain why the Discrete Cosine transform (DCT) is attractive in this respect. **(2)**

d. A 4x4 block of samples of an image is compressed using the DCT. At the decoder the block is first de-quantised resulting in the following matrix:

$$\begin{bmatrix} 200 & 50 & 0 & 0 \\ 20 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Derive the first 2 rows of the original (4x4) data block. **(7)**

The *k*-th/*n*-th **DCT/IDCT** pair of an *N*-sample block input is given by:

$$X_k = \sqrt{\frac{2}{N}} \sum_{n=0}^{N-1} \alpha_k x_n \cos\left[\frac{(2n+1)k\pi}{2N}\right] \qquad \alpha_0 = \frac{1}{\sqrt{2}}, \quad \alpha_k = 1 \quad (k \neq 0)$$

$$x_n = \sqrt{\frac{2}{N}} \sum_{k=0}^{N-1} \alpha_k X_k \cos\left[\frac{(2n+1)k\pi}{2N}\right]$$