

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS / M.Tech(ECE) / SEM-2 / MCE-202 / 2013**

**2013**

**ERROR CONTROL CODING**

Time Allotted : 3 Hours

Full Marks : 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

- Note : (i) Missing data may be suitable assumed.  
(ii) Illustrate your answers with neat sketches wherever necessary

Answer Question No. 1 and any *four* from the rest.

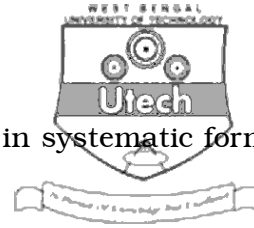
**GROUP – A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for any *seven* of the following :  $7 \times 2 = 14$
- i) An analogue channel perturbed by AWGN has a bandwidth  $B = 25$  kHz and a power signal-to-noise ratio SNR of 18 dB. What is the capacity of this channel in bits per second ?
- a) 150053 bps                      b) 29902 bps  
c) 150000 bps                      d) 450000 bps.







3. a) A binary block code has code vectors in systematic form as given in Table.

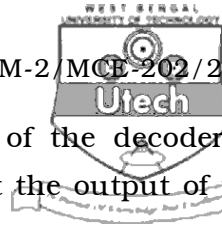
Table : A block code table

0	0	0	0	0	0
0	1	1	1	0	0
1	0	1	0	1	0
1	1	0	1	1	0
1	1	0	0	0	1
1	0	1	1	0	1
0	1	1	0	1	1
0	0	0	1	1	1

- (i) What is the rate of the code ?
  - (ii) Write down the generator and parity check matrices of this code in systematic form.
  - (iii) What is the minimum Hamming distance of the code ?
  - (iv) How many errors can it correct, and how many can it detect ?
  - (v) Compute the syndrome vector for the received vector  $r = ( 101011 )$  and hence find the location of any error. 8
- b) The generator matrix of a binary linear block code is given below :

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

- (i) Write down the parity check equations of the code.
- (ii) Determine the code rate and minimum Hamming distance.



(iii) If the error rate at the input of the decoder is  $10^{-3}$ , estimate the error rate at the output of the decoder. 6

4. a) What is standard array ? Explain how the standard array can be used to make a correct decoding. 5

b) The Hamming block code  $C_b(15, 11)$  has the following parity check submatrix :

$$P = \begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

- (i) Construct the parity check matrix of the code.
- (ii) Construct the error pattern syndrome table.
- (iii) Apply syndrome decoding to the received vector  $r = (011111001011011)$ . 9

5. a) What is meant by a cyclic error-control code ? 5

b) A binary linear cyclic block code  $C_{cyc}(n, k)$  has code length  $n = 14$  and generator polynomial  $g(X) = 1 + X^3 + X^4 + X^5$ .

- (i) If all the information symbols are '1's, what is the corresponding code vector ?



- (ii) Find the syndrome corresponding to an error in the last information symbol. Is this code capable of correcting this error ?
- (iii) Can cyclic codes be non-linear ? 9
6. a) Determine the generator polynomial of the binary BCH code  $C_{BCH}(31, 16)$  able to correct error patterns of size  $t = 3$  or less. 4
- b) (i) Show that the shortest binary cyclic BCH code with the generator polynomial  $g(X) = (1 + X + X^4)(1 + X + X^2 + X^3 + X^4)$  has code length  $n = 15$  and minimum Hamming distance  $d_{\min} = 5$ .
- (ii) Describe the Meggitt or an algebraic decoding method for the above code.
- (iii) Use the decoding method you have described to show how errors in the first two positions of a received vector would be corrected. 10
7. a) Use the BCH bound to show that the minimum Hamming distance of the cyclic code with block length  $n = 7$  and  $g(X) = (X + 1)(1 + X + X^3)$  is 4. What is the minimum Hamming distance if  $n = 14$  and why ? 7
- b) Show that for a double-error-correcting cyclic code,  $s_3 = s_1^2 + s_1^2 \beta l + s_1 \beta l^2$  where  $\beta l = \alpha^j l$  and hence find the errors in the received vector  $r = (000100111111011)$ , given that the transmitted vector is from the cyclic BCH code  $C_{BCH}(15, 7)$  generated by
- $$g(X) = (1 + X + X^4)(1 + X + X^2 + X^3 + X^4). \quad 7$$



8. An extended RS code over  $GF(2^2)$  has the following generator matrix :

$$G = \begin{bmatrix} 1 & \alpha & 1 & 0 & 0 \\ 1 & \alpha^2 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

- a) What is the rate of the code and its minimum Hamming distance ?
- b) Is  $r = (\alpha^2 \ \alpha \ \alpha \ 0 \ 1)$  a code vector of this code ?
- c) The received vector  $r = (0 \ \alpha \ 1 \ \alpha^2 \ 0)$  contains a single error : find its position and value.
9. Write short notes of the following :
- a) BCH code
- b) Fano decoding
- c) Golay code
- d) Reed-Solomon code.
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