TCOM 370

1 Hr. 15 Min. | **Exam 2** | **March 24, 1998**

Closed Book | **One Info. Sheet Allowed**

All problems equally weighted

Problem 1

(a) For each of the following line coding schemes, apart from synchronization considerations, ***state*** one characteristic that is considered desirable, and one that is considered undesirable:

B8ZS, differential Manchester

(b) Explain ***briefly*** the basic principle of receiver clock synchronization that is associated with (i) the B8ZS code and (ii) with the differential Manchester code.

Problem 2

In a serial synchronous transmission scheme, transmit and receive clocks are operating at a nominal 5 MHz rate and the transmit bit rate is nominally 5 Mbps. The nominal bit duration is $\frac{1}{5} \times 10^{-6}$ seconds = 0.2 μs. A data bit is received correctly if its corresponding pulse is sampled within the middle 0.1 μs of its duration. Each clock has a maximum drift of 0.6 ms per minute. Transmitter and receiver clocks are in synchronism at the beginning of each frame. What is the maximum time duration of each frame to ensure correct recovery of the entire frame?

Problem 3

A **cyclic redundancy check** (15,11) code for eleven-bit messages generates a 4-bit frame check sequence (FCS) using the generator polynomial $G(X)=X^4 + X + 1$

(a) Determine the transmitted *codeword* for the message word [10 000 000 111]

(b) *Write down* (without further detailed computation) *the FCS* for the following message words: (i) [10 000 100 000] (ii) [00 000 100 111]

(c) Let bit position 14 be the most significant bit in a transmitted codeword. Determine if error occurring simultaneously in the 14th, 8th and 6th bits will be detected.

Problem 4

In a (5,3) linear block code, if $[d_2, d_1, d_0]$ is the message word, the codeword is formed by appending the bits $[p_1, p_0]$ to it. These appended bits are generated as the *modulo-2 sums* $p_1=d_2+d_1$ and $p_0=d_1+d_0$.

(a) What is the minimum Hamming distance d_{min} for this code?
(b) How many errors is it guaranteed to detect? to correct?
(c) What is the generator matrix G for this code?
(d) Is this a cyclic code?

Problem 5

The systematic Hamming (7,4) code for which d_{min}=3 is modified to generate codewords for a **(11,4) linear block code** as follows:

If a codeword of the (7,4) code is [**d**, **p**] = [d_3, d_2, d_1, d_0, p_2, p_1, p_0], then the codeword of the (11,4) code is obtained by *preceding* it with the message bits **d**=[d_3, d_2, d_1, d_0], forming codeword [**d**, **d**, **p**]

Let the *received* word be [**r**, **s**, **q**]. Here **r** and **s** are each 4 bits long, and **q** is 3 bits long. Without errors, [**r**, **s**, **q**] =[**d**, **d**, **p**]. Consider the following decoding rule:

Decode using *either* the last 7 bits [**s**, **q**] only, *or* the first 4 and last 3 bits [**r**, **q**] only, depending on which of these two 7-bit words is closer to a legitimate Hamming (7,4) codeword. If both are equally close to different codewords, an error is declared to have been detected only.

(a) For this rule, what patterns of two errors within its 11-bit codeword will the (11,4) code be able to *correct* ?

(Example answer: "one error in the first 2 bits and 1 error in the next 5 bits, or 2 errors in the 6th through 10th bits, will be corrected." *This is just an illustration, to indicate the nature of the answer that you should provide.)*

(b) Given that each bit is subject to error with a fixed probability independently of other bits, and *given* that 2 errors have occurred in a codeword, what is the probability that the 2 errors will be corrected?