Data Communications CS420/520
Fall 2002

Axel Krings, PhD

Midterm 1

Last Name: ___________________________ Student ID: __________________________

This is an *closed* book, *closed* note exam. You may use a calculator but **no computers**. Show **ALL** your work to get full or partial credit for the problem. You have 50 minutes.

Show all derivations. Answers without derivations are not acceptable.

Problem	Total	-Points
1	20	
2	10	
3	20	
4	15	
5	15	
6	10	
7	10	
Total:	100	

1) (20 pts) Some general questions

a) (5pts) Name the 7 layer of the ISO/OSI Reference Model in order, starting with the lowest level.

b) (5pts) How does one compute the data rate of a T1 line? Recall it was 1.544Mbps.

c) (5 pts) We want to use Huffman encoding of the characters A,B,C,D, which have respective relative occurrences of 0.5, 0.25, 0.125, and 0.125. Derive the Huffman tree for this code.

d) (5pts) Given the message AABBCD, what saving in terms of bits does using Huffman encoding give us compared to a 7 bit ASCII representation of the characters? Give the actual number of bits saved and not the percentage.

2) (10 pts) With respect to error correction:

a) (3) Define the Hamming distance of a code (not a code word).

b) (2) What is the Hamming distance of the following code?

000000 000111 111000

c) (3) How many errors can be corrected when using the code in part b)?

d) (2) Now we add the words 010101 and 101010 are added to the code of part b). Does this change how many errors can be corrected? Justify your answer.

3) (20) With respect to error detection:

   a) (5) Given message M=100111 and generator polynomial $G(x) = x^4+x+1$, compute the FCS.

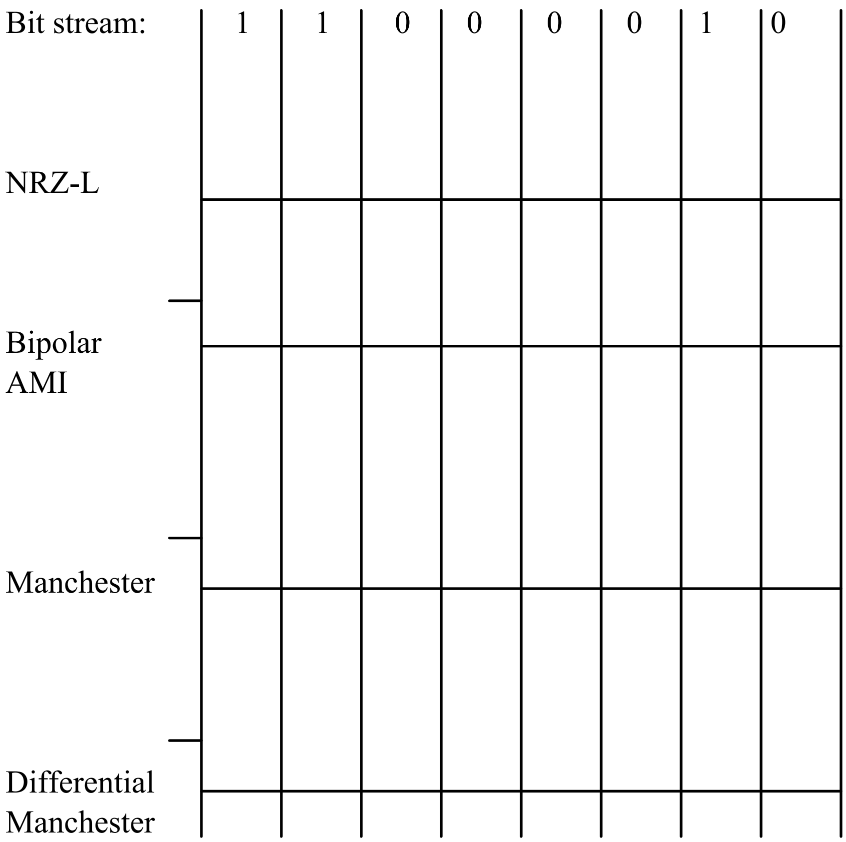
   b) (5) Message 110001110 (which is unrelated to the message of part a) arrives at the receiver which uses the generator G(x) of part a), i.e. $G(x) = x^4+x+1$. Has there been an error? Justify your answer.

   c) (5) Draw the hardware implementation for $G(x) = x^4+x+1$. Clearly identify the register cells and the mod 2 adders (e.g. XOR).

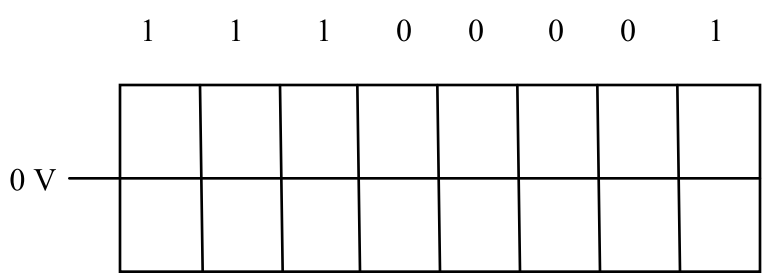
   d) (5) Are cyclic redundancy checks effective in the presence of malicious act? Another way to ask the same question is "Can a malicious identity tamper with our transmitted message so that CRC does not (in general) catch it? Justify your answer.

4) (15 pts) With respect to signal encodings:

a) (11) Encode the following bit stream. Note, that the previous signal levels are indicated when appropriate.



b) (4) Using HDB3 to encode the following bit string (You may assume that this is the very first sequence of 4 zeros)

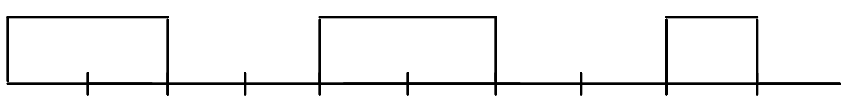


5) (15) With respect to modulation:

a) (5) Draw the frequency spectrum for ASK and label <u>all</u> frequency components assuming we use the fundamental and 3rd harmonic. Label the fundamental frequency f_0.

b) (4) What is the difference between the spectrum of ASK and that of PSK.

c) (6) What are the modulated signals for the sample signal below? (You can choose the carrier frequencies, but make sure they are distinguishable).

Signal 

ASK ______________________________

FSK ______________________________

PSK ______________________________

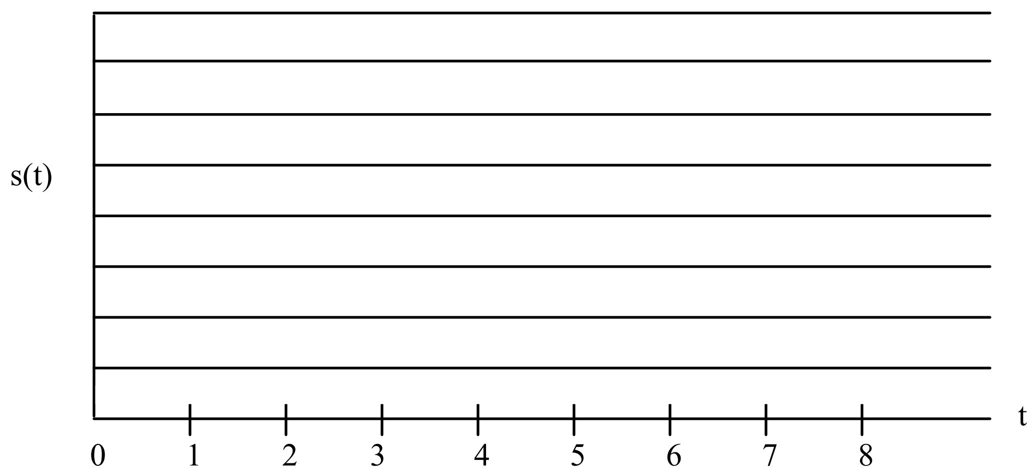
(Use Phase Coherent PSK, i.e. 1 = no phase change, 0 = phase change)

6) (10 pts) With respect to analog to digital conversions

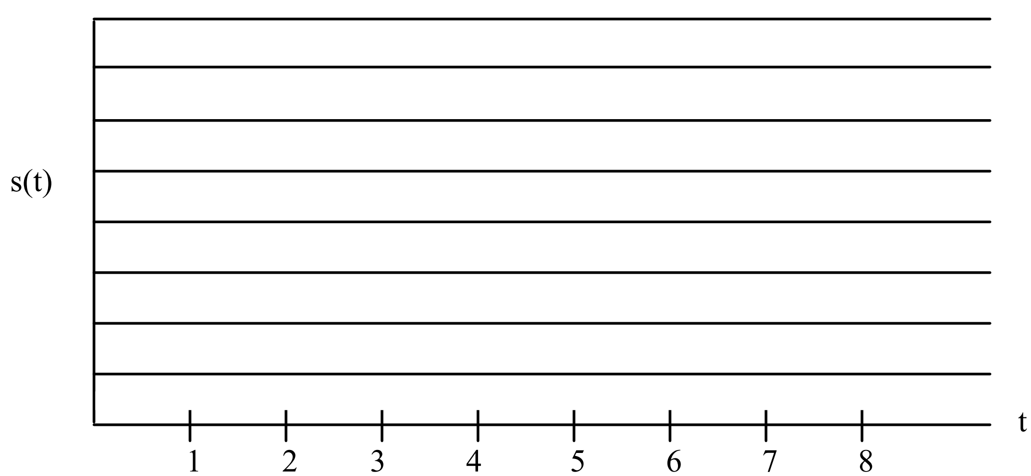
a) (6) Assume we use pulse code modulation (PCM) and we use 3 bits, which lets us differentiate 8 levels. (There are no polarity bits). The following bit string has been received at time t = 0.

100101111101001000001100011

Sketch the analog signal that is represented by the string



b) (4) What would the PAM (Pulse Amplitude Modulation) signal look like?



7) (10 pts) We were hired to study the design of a 56Kbps modem (K = 1024).
   a) (6) How many signal levels would we need, assuming an available bandwidth of 4000Hz?

   b) (4) If we can use PSK with 8 different phases, how many voltage levels would be required using the result of part a).