ECE 2305: Introduction to Communications and Networks

Quiz #4

3:00-3:30 PM, 17 April 2014

Name: Solutions

Box #: _____

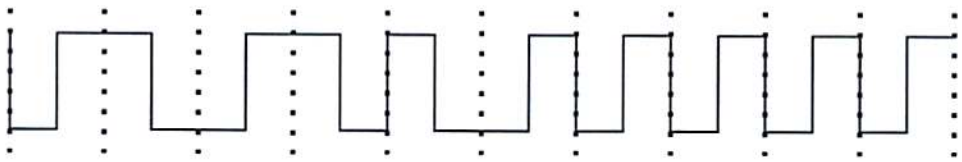
Instructions:

- Do not open this quiz until you are instructed to do so.
- This quiz is closed book, but you are permitted to bring one two-sided 8.5" by 11" sheet of notes.
- Calculators are permitted.
- Laptops or other electronic devices with wireless capability are *not* permitted.
- No collaboration is permitted; the WPI academic honesty policy is in effect.
- You have 30 minutes to complete the quiz.
- No partial credit is awarded for multiple choice problems (mark your answer unambiguously).
- Please submit your sheet of notes when you turn in your quiz.

Problem	Points	Score
1	5	
2	5	
3	5	
4	4	
5	6	
6	10	

Good luck!

1. **(5 pts)**. Given the Manchester encoded signal shown below, determine the corresponding bit sequence. The dotted lines correspond to the beginning and end of each bit interval. Your answer should have 10 bits.



1 0 1 0 0 1 1 1 1 1

Low-to-high transition → 1
High-to-low transition → 0

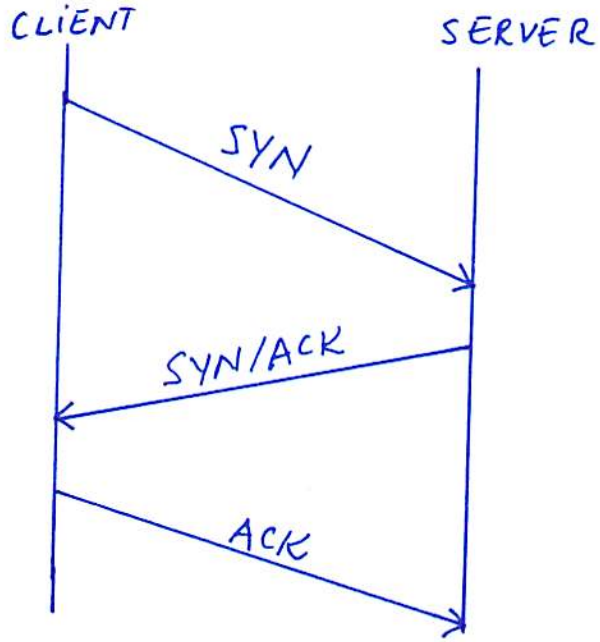
2. **(5 pts)**. Recall that, for a fixed $\mathcal{E}_n/N_0$, NRZ and Manchester encoded signals have the same probability of bit error (BER). List one advantage of Manchester encoding with respect to NRZ and list one advantage of NRZ with respect to Manchester encoding.

Manchester encoding can synchronize on the bit time transitions. In addition, there is no DC component and it has inherent error detection.

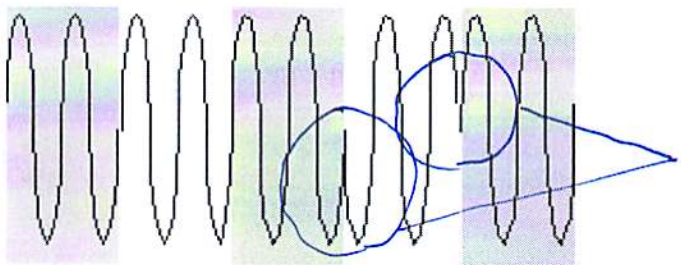
NRZ requires a modulation rate that is half that of Manchester for the same data rate.

3. **(5 pts)** What is the "three-way handshake" in TCP? Be specific about the types of messages that are used.

Client sends
① SYN request
Server replies with
② SYN / ACK response
client sends back
③ ACK
Connection is established.



4. **(4 pts)** The signal below represents the bit sequence 11101 encoded with which of the following modulation techniques?



π phase shift → BPSK

(a) Differential Phase Shift Keying
(b) Multilevel Phase Shift Keying with $M = 16$
(c) Binary Frequency Shift Keying
(d) Binary Phase Shift Keying
(e) None of the above

5. **(6 pts)** Referring to the table and figure below from your textbook, put a **circle** around the modulation technique (a) – (d) with the best bandwidth efficiency and put a **box** around the modulation technique (a) – (d) with the best energy efficiency.

   (a) Binary Phase Shift Keying

   (b) Multilevel Phase Shift Keying with $M = 8$

   (c) Binary Frequency Shift Keying

   (d) Multilevel Frequency Shift Keying with $M = 8$

Bandwidth efficiency R/B Table 5.5:

	$r = 0$	$r = 0.5$	$r = 1$
ASK	1.0	0.67	0.5
Multilevel FSK			
$M = 4, L = 2$	0.5	0.33	0.25
$M = 8, L = 3$	0.375	0.25	0.1875
$M = 16, L = 4$	0.25	0.167	0.125
$M = 32, L = 5$	0.156	0.104	0.078
PSK	1.0	0.67	0.5
Multilevel PSK			
$M = 4, L = 2$	2.00	1.33	1.00
$M = 8, L = 3$	3.00	2.00	1.50
$M = 16, L = 4$	4.00	2.67	2.00
$M = 32, L = 5$	5.00	3.33	2.50

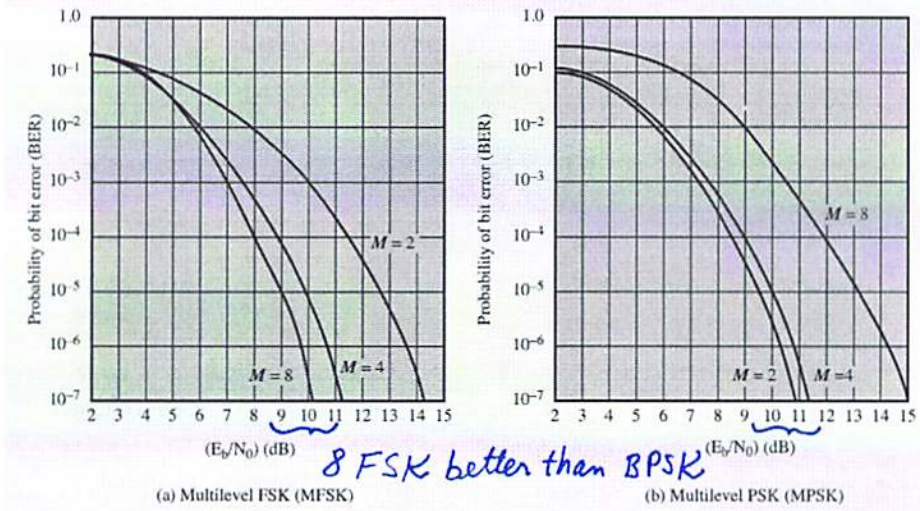


Figure 5.13 Theoretical Bit Error Rate for Multilevel FSK and PSK

6. **(10 pts)** Suppose you have a CRC check with generator polynomial $P(x) = x^2 + 1$ or, equivalently, $P = 101$. The frame

$$T' = 110110$$

is received (this is shown in the usual bit order with the MSB on the left). Should we accept or reject this frame?

Modulo 2 division

```
101 | 110110
      101
      ---
      0111
       101
       ---
       0101
        101
        ---
        0000  ← Remainder = 0
```

Accept frame

Polynomial division

$T'(x) = x^5 + x^4 + 0x^3 + x^2 + x + 0$

$P(x) = x^2 + 1$

$$\begin{array}{r} x^5 + x^4 + 0x^3 + x^2 + x + 0 \\ \hline x^5 + 0x^4 + x^3 \\ \hline x^4 + x^3 + x^2 + x + 0 \\ x^4 + 0x^3 + x^2 \\ \hline x^3 + 0x^2 + x + 0 \\ x^3 + 0x^2 + x \\ \hline 0 \end{array}$$

Remainder = 0 ← Accept frame