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SCHOOL OF INFORMATION TECHNOLOGY AND ENGINEERING

**COURSE:** SEG3155  
**SEMESTER:** Winter 2011

**PROFESSOR:** Jiyong Zhao  
**DATE:** February 17, 2010  
**TIME:** 17:30 to 19:00

**MIDTERM  
EXAMINATION**

**NAME and STUDENT NUMBER:** \_\_\_\_\_ / \_\_\_\_\_

**Mid-Term Exam**

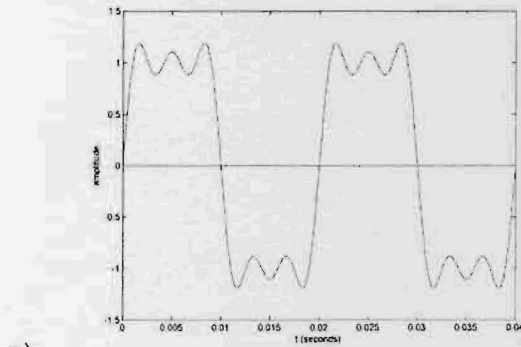
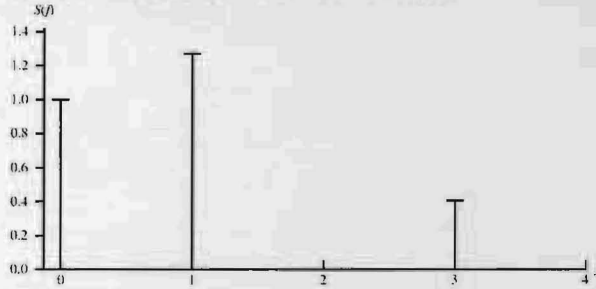
1. There are two (2) types of questions in this examination.

<b>Part 1</b>	<b>Multiple choice</b>	<b>20 marks</b>	
<b>Part 2</b>	<b>Short answer</b>	<b>45 marks</b>	
<b>Total</b>		<b>65 marks</b>	

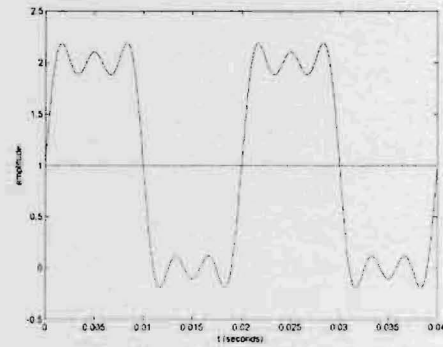
2. Answer briefly and to the point. The space allocated for each question is limited. In case of necessity you may use the other side of the pages to continue.
3. Initial all the pages.

▪ **Part 1 - Multiple choice questions [2 marks each]:**

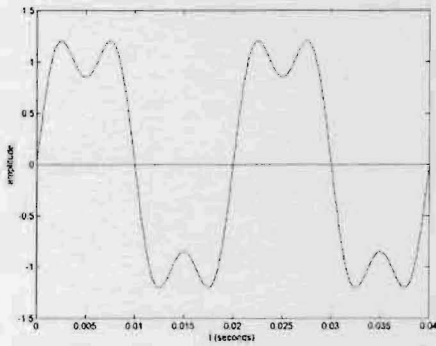
1 Refer to the frequency components  $S(f)$  of a signal. Which of the following is most likely the corresponding signal in time domain?



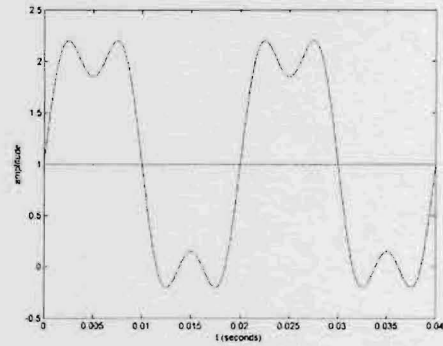
a)



b)



c)



d)

2 The following defines  $Power_{dBW}$  and  $Power_{dBm}$ .

$$Power_{dBW} = 10 \log \frac{Power_W}{1W}$$

$$Power_{dBm} = 10 \log \frac{Power_{mW}}{1mW}$$

0 dBW = \_\_\_\_\_ dBm.

- a) 0
- b) +30
- c) -30
- d) 1000

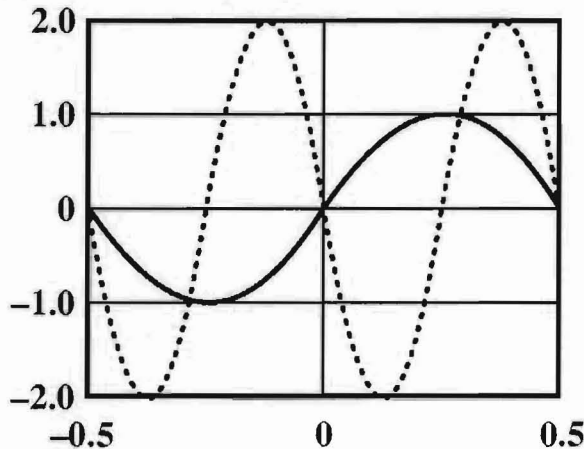
3 Only 3 pins of EIA-232 are used. Which of the following is correct for a simplest NULL-MODEM pin connection?

- a) 2 ←→ 3, 3 ←→ 2, 7 ←→ 7
- b) 2 ←→ 2, 3 ←→ 3, 7 ←→ 7
- c) 4 ←→ 5, 5 ←→ 4, 7 ←→ 7
- d) 4 ←→ 4, 5 ←→ 5, 7 ←→ 7

- 4 The HDLC frame (01111110 00001111 10001011 FCS 01111110) is sent from a primary to a secondary. Which of the following is correct?

- a) The address of the secondary is 00001111.      b) The address of the primary is 10001011.  
 c) The frame is an I-frame.      d) The address of the primary is 00001111.

- 5 Refer to the following figure. If the solid curve represents  $\sin(2\pi t)$ , what does the dotted curve represent? That is, the dotted curve can be written in the form of  $A\sin(2\pi ft + \phi)$ . What are  $A$ ,  $f$ , and  $\phi$ ?



- a) 2, 2,  $\pi$       b) 2, 2,  $\pi/2$   
 c) 2, 1, 0      d) 1, 2,  $2\pi$

- 6 If the frequency spectrum of a signal has bandwidth of 500 Hz with the highest frequency at 600 Hz, what should be the sampling rate according to the Nyquist theorem?

- a) >200 samples/second      b) >500 samples/second  
 c) >1000 samples/second      d) >1200 samples/second

- 7 Using the Shannon formula to calculate the data rate for a given channel, if capacity is equal to bandwidth, then \_\_\_\_\_

- a) The signal is less than the noise.      b) The signal is greater than the noise.  
 c) The signal is equal to the noise.      d) Not enough information is given to answer the question.

- 8 Frames 0, 1, 2, ..., 6 are in the sender's sliding window. The sender sends out frames 0, 1, 2. After receiving these three frames, the receiver will send back acknowledgment. Which of the following are not correct?

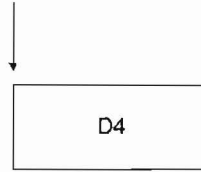
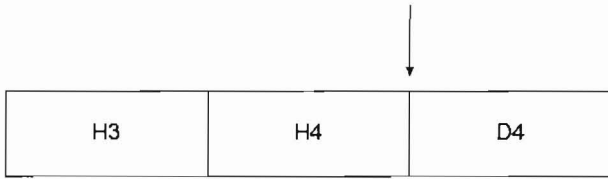
- a) RR 1      b) RR 2  
 c) RR 3      d) RR 4

- 9 A telephone line is known to have a loss of 20 dB.  $G_{dB} = 10 \log_{10} \frac{P_{out}}{P_{in}}$ . The input signal power is

measured as 0.5 W, and the output noise level is measured as 4.5  $\mu$ W. What is approximately the output signal-to-noise ratio in dB?

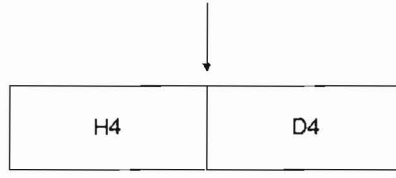
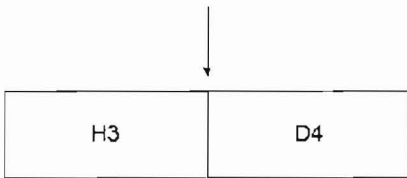
- a) 10      b) 20  
 c) 30      d) 40

10 Encapsulation/decapsulation. As the data packet moves from Layer 4 to Layer 3, which of the following is correct?



(a) Layer-3 header is added.

(b) The header of Layer 4 is removed.

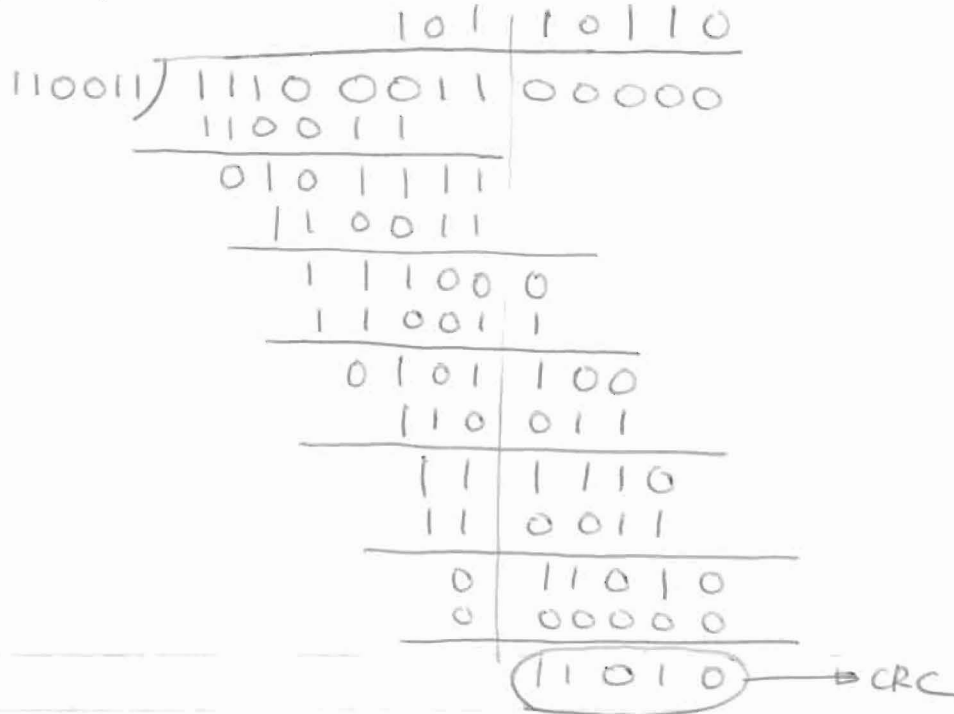


(c) The header of Layer 4 is replaced by the header of layer 3.

(d) There is no change to the Layer 4 packet (the layer 4 packet will be passed on to Layer 2 as it is).

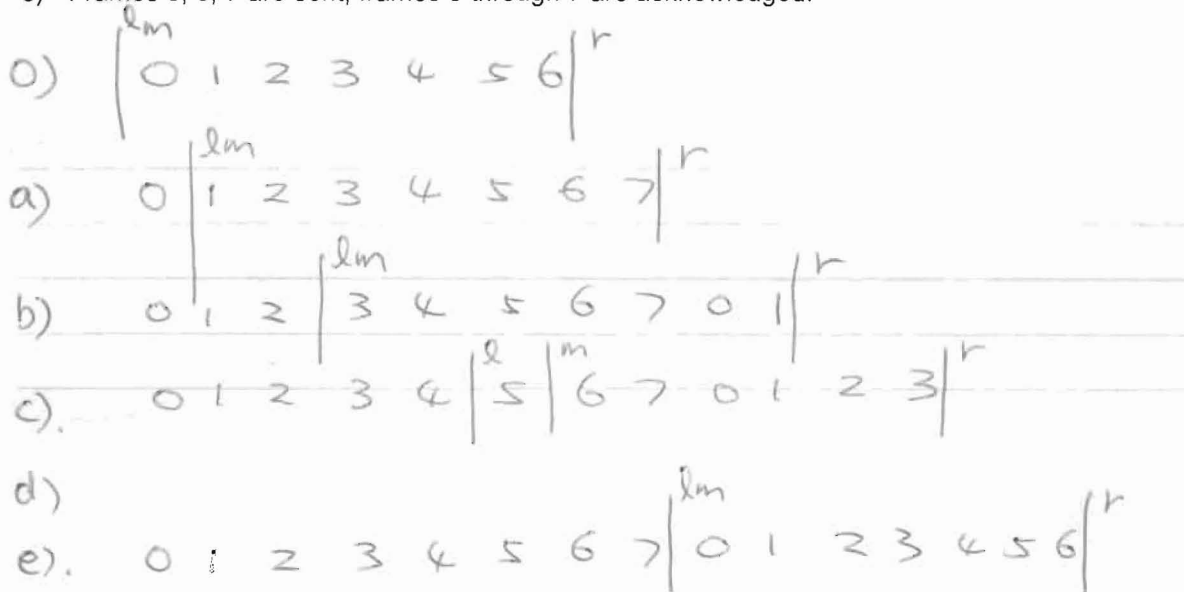
**Part 2 - Short-answer questions**

11 [6 marks] The data unit is 11100011 and the divisor is 110011. Calculate the CRC (remainder).

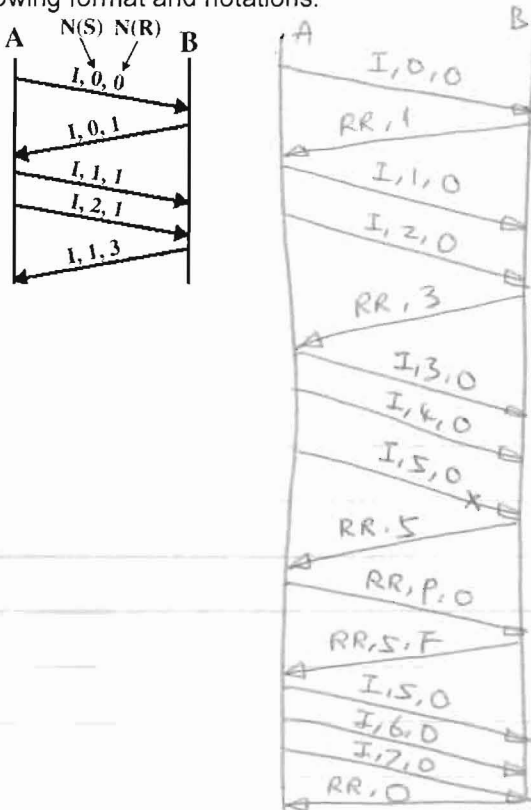


12 [6 marks] HDLC is used. The control field is 8-bit. Go-Back-N ARQ is used. Suppose that initially the sender's sliding window contains frames 0, 1, 2, 3, 4, 5, 6. Draw the sender's sliding window by clearly identifying the left wall, middle wall, and right wall, for each of the following steps:

- Frame 0 is sent; frame 0 is acknowledged.
- Frames 1 and 2 are sent; frames 1 and 2 are acknowledged.
- Frames 3, 4, and 5 are sent; frame 4 is acknowledged; timer for frame 5 expires.
- Frame RR with P bit set is sent to receiver; receiver replies by acknowledging frame 4.
- Frames 5, 6, 7 are sent; frames 5 through 7 are acknowledged.



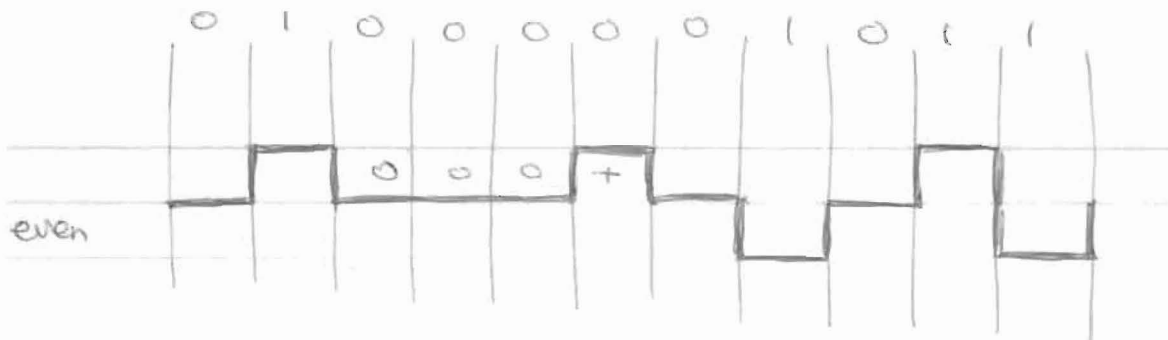
13 [6 marks] Refer to Question 12. There is no data sent from B to A. Draw the HDLC operations using the following format and notations.



14 [6 marks] Use HDB3 scheme to represent 0100001011. If needed, proper assumptions can be made.

**Table 5.4 HDB3 Substitution Rules**

Polarity of Preceding Pulse	Number of Bipolar Pulses (ones) since Last Substitution	
	Odd	Even
-	000-	+00+
+	000+	-00-



- 15 [6 marks] Suppose that the spectrum of a channel is between 3 MHz and 4 MHz, and  $\text{SNR}_{\text{dB}} = 24$  dB. What is the capacity of the channel?

$$B = 4 - 3 = 1 \text{ MHz} \quad \text{SNR} = 10^{2.4} = 251$$

$$C = B \log_2(1 + \text{SNR}) = 1 \times 10^6 \times \log_2(1 + 251) = 7.98 \times 10^6 \text{ bps} \\ = 7.98 \text{ Mbps}$$

- 16 [5 marks] We use a sampling rate of 22 kHz to digitize a mono audio stream, whose dynamic range is from -5V to +5V. Each sample is coded with 8 bits. At one particular sample point, the voltage of the audio signal is 3V. What is PCM (pulse code modulation) code for this sample point?

$$\frac{3 - (-5)}{5 - (-5)} \times 255 = \frac{8}{10} \times 255 = 204 = 01100100 \\ = 11001100 \text{ B}$$

17 **[10 marks]** In the following figure, frames are generated at node C and sent to node A through node B. Determine the minimum data rate required between nodes B and A so that the buffers of node B are not flooded, based on the following:

- The distance between A and B is 4000 km.
- The distance between B and C is 1000 km.
- The data rate between C and B is 150 kbps.
- The propagation delay is  $5\mu\text{s}/\text{km}$  for both lines.
- There are full duplex lines between the nodes.
- All data frames are 1000 bits long: ACK frames are separate frames with negligible length.
- Between B and A, a sliding window protocol with a window size of 3 is used. For simplicity, assume  $W < 1 + 2a$ .
- Between C and B, stop-and-wait is used.
- There are no errors.

Hint: In order not to flood the buffers of B, the average number of frames entering and leaving B must be the same over a long interval. In other words, the effective data rate between B and A should be the same as the effective data rate between C and B.

Note:

$$a = \frac{t_{prop}}{t_{frame}}$$

For stop-and-wait flow control, the maximum possible utilization of the link can be calculated as

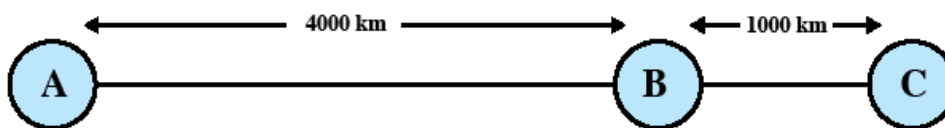
$$U = \frac{1}{1 + 2a}$$

For error-free sliding-window flow control with a window size of  $W$ , the maximum possible utilization

of the link can be calculated as 
$$U = \begin{cases} 1 & W \geq 1 + 2a \\ \frac{W}{1 + 2a} & W < 1 + 2a \end{cases}$$
.

For both stop-and-wait and sliding-window, the effective data rate (actually how many bits of data can be transmitted per second) can be calculated as  $R_e = R \times U$ , where  $R$  is the given nominal data rate.

For example, in this question, between node C and node B,  $R=150$  kbps.



① C → B, stop-and-wait

$$U_{CB} = \frac{1}{1 + 2a_{CB}}$$

$$a_{CB} = \frac{T_{prop}}{T_{frame}} = \frac{5 \times 10^{-6} \times 1000}{1000 / (150 \times 10^3)} = \frac{5 \times 10^{-3}}{\frac{1}{150}} = 0.75$$

$$U_{CB} = \frac{1}{1 + 2 \times 0.75} = 0.4$$

$$U_{eCB} = 150 \times 10^3 \times 0.4 = 60,000 \text{ bps}$$

② B → A, sliding window,  $w=3$ , assume  $w < 1 + 2a_{BA}$

$$U_{BA} = \frac{w}{1 + 2a_{BA}}$$

assume the nominal bit rate between B and A is  $x$  bps

$$a_{BA} = \frac{T_{prop}}{T_{frame}} = \frac{5 \times 10^{-6} \times 4000}{1000/x} = 20 \times 10^{-6} x$$

$$U_{BA} = \frac{3}{1 + 2 \times 20 \times 10^{-6} \cdot x} = \frac{3}{1 + 40 \times 10^{-6} \cdot x}$$

$$U_{eBA} = U_{BA} \cdot x = \frac{3x}{1 + 40 \times 10^{-6} x}$$

③  $U_{eCB} = U_{eBA}$

$$60,000 = \frac{3x}{1 + 40 \times 10^{-6} x}$$

$$3x = 60,000 + 2.4x$$

$$0.6x = 60,000$$

$$x = 100,000 \text{ bps} = 100 \text{ kbps}$$