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Canada's university

University of Ottawa
Faculty of Engineering

School of Electrical Engineering
and Computer Science

COURSE: SEG3155/CEG3185
SEMESTER: Summer 2016

PROFESSOR: Miguel A. Garzón
DATE: June 9, 2016
TIME: 11h30 to 13h00

MIDTERM EXAMINATION

NAME and STUDENT NUMBER:_____/_____

Mid-Term Exam

1. There are two (3) types of questions in this examination.

Part 1	**Multiple choice questions**	**15 marks**	
Part 2	**Short questions**	**30 marks**	
Part 3	**Application question**	**5 marks**	
Total		**50 marks**	

2. Answer briefly and to the point**. Answer part 2 and 3 in the exam booklet provided.**
3. Initial all the pages.
4. The exam annex provides equations and other information.
5. Use the **Scantron sheet** for questions of Part 1.

- **Part 1 - Multiple choice questions [1 mark each]:**
  USE SCANTRON SHEET FOR PART 1

1. In _____ transmission signals are transmitted in only one direction; one station is the transmitter and the other is the receiver.
   a) half duplex
   b) simplex
   c) full duplex
   d) multipoint

2. The _____ of a signal is the distance occupied by a single cycle.
   a) bandwidth
   b) frequency
   c) wavelength
   d) amplitude

3. A _____ converts digital data to analog signal so that it can be transmitted over an analog line.
   a) modem
   b) decoder
   c) router
   d) receiver

4. If digital signaling elements all have the same algebraic sign, all positive or all negative, then the signal is _____.
   a) polar
   b) unipolar
   c) baseband
   d) differential

5. Which field is not part of the of the UDP header?
   a) Source port
   b) Checksum
   c) Destination port
   d) Acknowledgment number

6. If the frequency spectrum of an analog signal has a bandwidth of 500 Hz with the lowest frequency at 100 Hz, what should be the sampling rate according to Nyquist theorem?
   a) 200 samples per second
   b) 500 samples per second
   c) 1000 samples per second
   d) 1200 samples per second

7. We measure the performance of a telephone line (4 KHz of bandwidth). When the signal is 10V, the noise is 5 mV. What is the maximum data rate supported by this telephone line?
   a) 43,866 bps
   b) 64,256 bps
   c) 12,000 bps
   d) 4,000 bps

8. If the data unit is 100111, the divisor is 1010, and the remainder is 110, what is the dividend at the receiver?
   a) 111111011
   b) 100111110
   c) 100111
   d) 100111000

9. In 64-QAM, there are 64 _____.
   a) Amplitudes
   b) Combinations of phase and amplitude
   c) Phases
   d) bps

10. As data moves from the physical layer to the application layers, PDU headers are _____.
    a) Added
    b) Removed
    c) Rearranged
    d) Modified

11. Which of the following is not a responsibility of the data link layer in the TCP/IP model?
    a) Framing data bits
    b) Data rate control
    c) Process-to-process message delivery
    d) Detection and correction of damaged lost frames

12. What is minimum Hamming distance for **correction** of 2 errors?
    a) 2 b) 3
    c) 4 d) 5

13. A simple parity-check can detect _____
    a) up to 2 errors b) an odd number of errors
    c) a burst error of any length d) an even number of errors

14. V.32 9600 modem uses 16-QAM and supports a bit rate of 9600 bps. What is the baud rate?
    a) 800 b) 1600
    c) 2400 d) 9600

15. PCM (Pulse Code Modulation): which of the following quantization levels results in a bigger signal-to-quantization-noise ratio (SQNR)? ($SQNR_{dB} = 6.02n + 1.76\ dB$)
    a) 4 b) 8
    c) 16 d) 32

Part 2 - Short-answer questions

1 **[6 marks]** In CRC, the data unit is $x^9 + x^7 + x^4 + x^3 + x^2 + x^1$ and the divisor $x^4 + x^2 + x + 1$. Show the generation of the **codeword** at the sender site (using binary **or** polynomial division).

In order to perform the operations required when using the polynomial form we must first multiply the dataword by x4 (equivalent to adding the 4 zeros in the binary division method). This yields the new polynomial as: x13 + x11 + x8 + x7 + x 6 + x5 we now proceed to divide this by the divisor obtained above: x 4 + x2 + x + 1.

$$
\begin{array}{r}
x^9 + x^6 + x^5 + x^3 + x^2 + x^1 \\
x^4 + x^2 + x^1 + 1 \overline{)\, x^{13} + x^{11} + x^8 + x^7 + x^6 + x^5} \\
\underline{x^{13} + x^{11} + x^{10} + x^9} \\
x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 \\
\underline{x^{10} + x^8 + x^7 + x^6} \\
x^9 + x^5 \\
\underline{x^9 + x^7 + x^6 + x^5} \\
x^7 + x^6 \\
\underline{x^7 + x^5 + x^4 + x^3} \\
x^6 + x^5 + x^4 + x^3 \\
\underline{x^6 + x^4 + x^3 + x^2} \\
x^5 + x^2 \\
\underline{x^5 + x^3 + x^2 + x^1} \\
x^3 + x^1
\end{array}
$$

Codeword is: x13 + x11 + x8 + x7 + x 6 + x5 + **x3 +x1**

2 **[6 marks]** Consider an audio signal with spectral components in the range 450 to 5000 Hz.

a) For quantization noise SNR_{dB}=42 dB, what is the number of quantization bits (uniform levels) needed?

SNRdb = 6.02n + 1.76
n = (42 -1.76) / 0.02 = 6.68 = 7 bits required

2^7=**128 levels needed**

b) If the minimum required sampling rate is used, what data rate is required?

Sampling rate = 2 f_h = 2 (5000) = 10000 samples/s
Date rate= 10000 samples/s * 7 bits/sample = **70 kbps**

c) If the dynamic range of the signal is -6V to +6V, what are the PCM code for voltage level +4.2V and -4.2V?

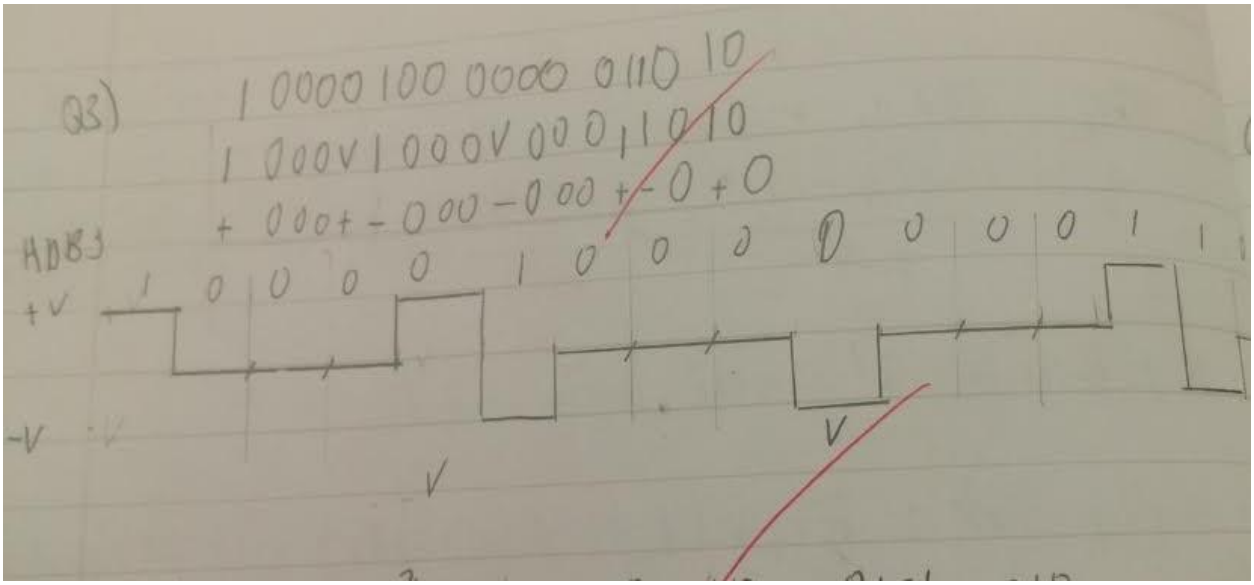
Delta = (6v – (6V)) /128 = 0.09375

PCM (4.2) = 4.2 – (-6) / 0.09375 = 108.8 = 109 = **1101101**

PCM (-4.2) = -4.2 – (-6) / 0.09375 = 19.2 = 20 = **0010100**

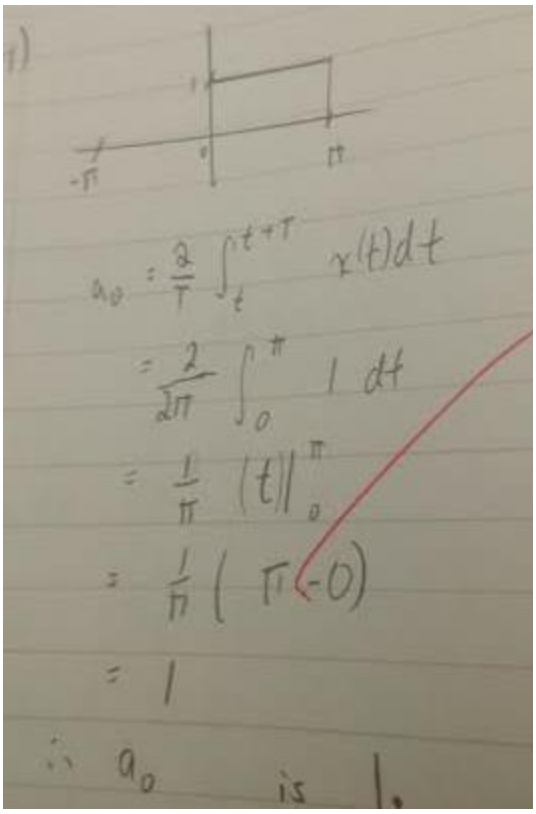
PCM code must contain exactly 7 bits.

3 **[4 marks]** Draw the following line coding of the binary data 1000010000000011010 using **HDB3**. Assume that the number of 1s so far is even and the first 1 is positive.



4 **[4 marks]** Find the Fourier coefficient a_0 of the square-wave function ***f*** defined by:

$$f(x) = \begin{cases} 0 & \text{if } -\pi \leq x < 0 \\ 1 & \text{if } 0 \leq x < \pi \end{cases} \quad \text{and} \quad f(x + 2\pi) = f(x)$$



A_0 =1

5. **[5 marks]** Given the 11-bit **dataword** 00100101010, generate the corresponding 15-bit Hamming **codeword**. Assume that least significant bit is leftmost and that we are using an **odd**-**parity**.

P1 = XOR OF (0,0,0,0,0,0,0) = 1
P2 = XOR OF (0,1 ,0 1, 0,1,0) = 1
P4 = XOR OF (0,1 ,0 1, 0,1,0) = 1
P8= XOR OF (0,1 ,0 1, 0,1,0) = 1

Codeword: **1 0** 0 **0** 0 1 0 **0** 0 1 0 1 0 1 0

6. **[5 marks]** A sender needs to send two data items 0x3456 and 0xEEE. Find the checksum at the **sender** site (16 bits are used for each data item).

```
  3456
  EEEE
 -----
  12344
```

Wrapped sum: 2344 + 1 = 2345
1's complement: FFFF – 2345 = **DCBA**

Checksum is then DCBA

Codeword transmitted 3456 EEEE DCBA

Part 3 – Application Question

1 **[5 marks]** Your task in this question is to analyze a link between two computer systems and recommend a configuration. One system is located in Halifax and the other in Vancouver. A service provider of a physical link, that includes two modems, has provided the following information:

- The length of the physical link is 5500 km.
- The signal travels across the physical link at a speed of 200 km/ms (meters/millisecond).
- Additional delays occur in the physical network which adds 25 ms.
- The provider guarantees a minimum SNRdB=30 dB.
- The provider guarantees a maximum BER=10-9.
- The provider guarantees a minimum bandwidth of 45000 Hz (in each direction).
- The modems use QAM-64.

Hint: Use only the necessary information to answer the question below ☺

In your analysis you have been requested to determine the following:

1) The maximum **baud rate** and **data rate** of the modems. (Assume that the maximum capacity of the channel may not exceed 85% of the Shannon capacity).

With Shannon we find the theoretical data rate:

$C = B \log_2(1 + SNR) = 45000 \log_2(1 + 1000)$
$= 448525.18$ bps

Maximum data rate = 448525.18 * 0.85 = 381 246 bps

Modems use QAM 64, so 6 bits per level.

The **baud rate** is 381246 bits/sec * (1/6 bits) = 63541 bauds