COMP 3721: Assignment #2

General Instruction

- To receive any credit, the answers for this assignment must be **handwritten** and need to be legible by the grader.
- When you solve a problem, show all the steps and add comments as necessary to make sure your answers are clear and unambiguous to the grader.
- You may discuss questions in broad terms with others but ultimately your answers should demonstrate your own individual thought process and effort.
- All work submitted is subject to the standards of conduct as specified in BCIT Policy 5104.

Submission

- This assignment is due at the **beginning of lecture** on either **Feb 13, 2020 (Burnaby sets)** or **Feb 14, 2020 (DTC sets)**. No late assignments will be accepted.
- Your submissions must include a **cover page** clearly specifying your **name**, **student number** and **set**.

Marking

- This assignment consists of **4 questions** totaling **40 marks**.

Problems

(1) [8 marks] Draw the following line coding schemes, as defined in Forouzan, B.A., Data Communications and Networking, 5th Ed. New York, NY: McGraw-Hill, 2013, for the 16-bit data stream **1001110001101110**. Use **+V** for the positive voltage, **-V** for the negative voltage. If applicable, assume that the previous data bit transmitted prior to this 16-bit data stream was **0** at **+V**.

a) [2 marks] Polar NRZ-L
b) [2 marks] Polar NRZ-I
c) [2 marks] Polar biphase Differential Manchester
d) [2 marks] Bipolar Pseudoternary

(2) [10 marks] Suppose the following composite analog signal has a bandwidth of 240 kHz and is sampled for digital transmission using Pulse Code Modulation (PCM).

$$s(t) = \sin(2\pi ft) + 1/3\sin(6\pi ft) + 0.2\sin(10\pi ft)$$

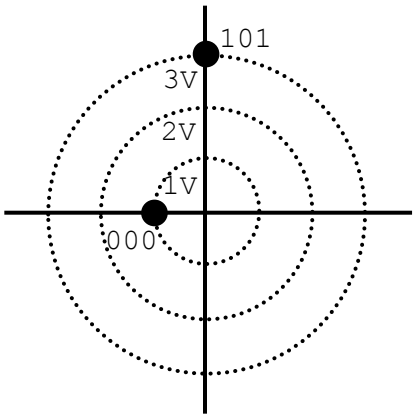
a) [4 marks] Determine the minimum sampling rate required such that the original analog signal can be accurately reproduced.
b) [1 mark] If 16 uniform levels are used to quantize each sample obtained in (a), determine the data rate, in bps, of the PCM signal.
c) [2 marks] Determine the SNR required, in dB, if the PCM signal obtained in (b) is to be transmitted over a noisy channel with a bandwidth of 0.5 MHz.
d) [3 marks] Assuming all other factors remain the same, determine the SNR increase required, in dB, to allow the doubling of the PCM signal data rate obtained in (b).

(3) [16 marks] Quadrature amplitude modulation (QAM) is a modulation technique that transmits data by changing the amplitude of two carrier signals that are 90° out-of-phase with each other. Consider the following 8-QAM modulation scheme defined by

$$s(t) = \begin{cases} \cos(2\pi f_c t + \pi), & \text{for data bits = 000} \\ 3\cos(2\pi f_c t + \pi), & \text{for data bits = 001} \\ \cos(2\pi f_c t + \frac{3\pi}{2}), & \text{for data bits = 010} \\ 3\cos(2\pi f_c t + \frac{3\pi}{2}), & \text{for data bits = 011} \\ \cos(2\pi f_c t + \frac{\pi}{2}), & \text{for data bits = 100} \\ 3\cos(2\pi f_c t + \frac{\pi}{2}), & \text{for data bits = 101} \\ \cos(2\pi f_c t), & \text{for data bits = 110} \\ 3\cos(2\pi f_c t), & \text{for data bits = 111} \end{cases},$$

where f_c is the carrier frequency. Assume f_c = 8 Hz and the baud rate = 4 symbols/s.

a) [9 marks] Complete the following signal constellation diagram for this modulation scheme. Label the axes and for each symbol, indicate the associated data bits.



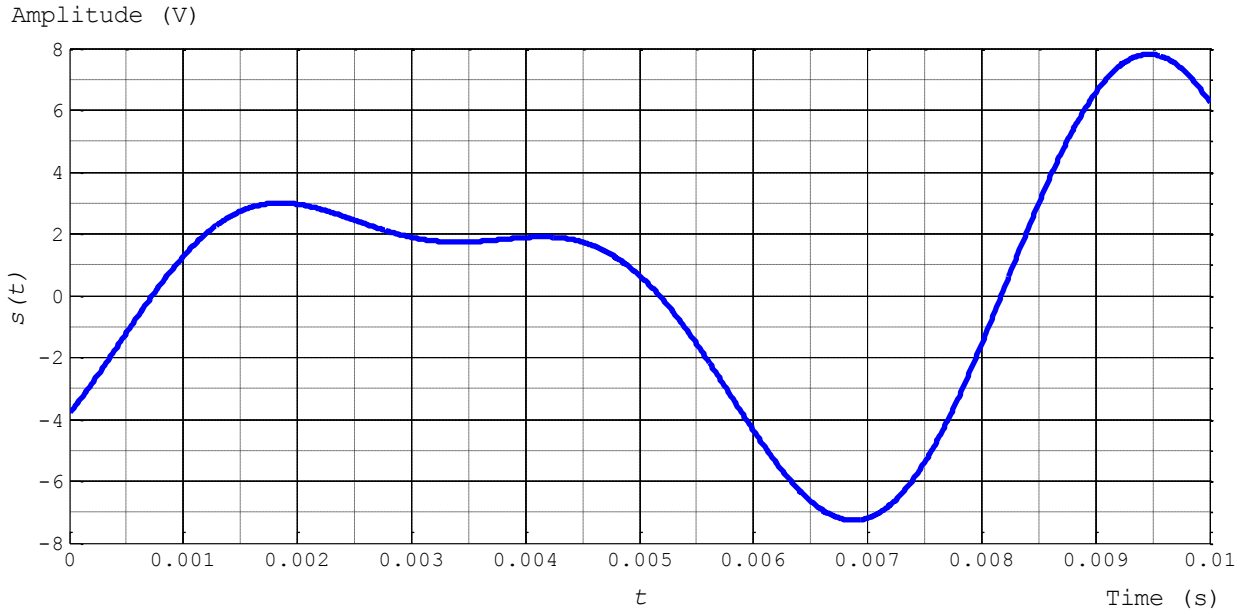
b) [1 mark] Determine the period of the carrier signal.

c) [1 mark] Determine the symbol duration.

d) [4 marks] Plot the modulated signal for the data stream **101110000111**. Clearly indicate the beginning and the end of each symbol and the associated data bits in the plot.

e) [1 mark] Determine the bit rate of the modulated signal.

(4) [6 marks] Consider the following analog signal, $s(t)$, with minimum and maximum amplitudes of -8 V and +8 V, respectively. The signal, $s(t)$, is sampled for digital transmission using Pulse Code Modulation (PCM) with a sampling rate of 400 samples/s and 8 uniform quantization levels.



Assuming that the first sample is taken at 0.001 s, determine both the quantization codes and the resulting encoded words of the PCM signal for t = [0, 0.01] s.