COMP3721 – Introduction to Data Communications
Assignment Two – Fall 2008

General Instructions

- You may work with one partner for this assignment. Your partner may be from your set or another full-time CST set.
- You and your partner may discuss any and all details of each question freely. You may also discuss questions in broad terms with others, particularly in lab, but ultimately your answers should show sufficient individuation from others' answers reflecting your work in answering the questions.
- All work submitted is subject to the standards of conduct as specified in BCIT Policy 5002.

Submissions

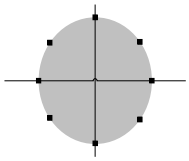
- This assignment is due Monday, October 27, 2008 by 1600 hrs at the latest. Late assignments will not be accepted.
- Submit your assignment to your lab instructor's assignment box in the SW2 connector.
- Your submissions must include a cover page clearly specifying your name, student number and set. If working with a partner, this information should be provided for each partner.

Marking

The assignment consists of 8 questions totaling 40 marks.

Questions

1. Does the following constellation diagram represent ASK, PSK, FSK or QAM modulation? How many levels does this system have? Given bandwidth *H*, what is the maximum data transfer rate possible using this modulation scheme? *[5 marks]*



2. 24 voice signals are to be multiplexed and transmitted over a twisted pair.

   a. What is the bandwidth required for FDM? *[2 marks]*
   b. Assuming a bandwidth efficiency (ratio of data rate to the transmission bandwidth) of 1 bps/Hz, what is the bandwidth required for TDM using PCM? *[3 marks]*

3. You are browsing the Internet at home and click on a link to a server in Sydney, Australia. The HTTP request packet is 2 kB in size and the server response is 4 kB. Assume throughput is 64 kbps between the two sites and that the two sites are more or less directly connected by a fiber-optic cable circumnavigating the ocean floor between Vancouver and Australia (a distance of approximately 12500 km).
   a. Determine the time required before the entire response is received. *[4 marks]*
   b. How does your answer change if the server is located in Toronto? *[1 mark]*

4. A system having four digital signals @ 19.2 kbps, three analog signals @ 4 kHz and one analog signal @ 3.7 kHz is to be TDM multiplexed. Analog samples are quantized using 14 bits/sample.
   a. Show a block diagram for the system specifying data format and bit rates at each point in the system. *[4 marks]*
   b. How much quantization error is introduced into the analog signals? *[1 mark]*

5. A way of visualizing the Nyquist theorem is in terms of periodic sampling of the second hand of a clock which makes one revolution around the clock every 60 seconds. The Nyquist sampling rate here should correspond to 2 samples per cycle, that is, sampling should be done at least every 30 seconds. (5 marks)

1(a). Suppose we begin sampling when the second hand is at 12 o'clock and that we sample the clock every 15 seconds. Draw the sequence of observations that result. Does the second hand appear to move forward?

1(b). Now suppose we sample every 30 seconds. Does the second hand appear to move forward or backward? What if we sample every 29 seconds?

1(c). Explain why a sinusoid should be sampled at a little more than twice its frequency.

1(d). Now suppose that we sample every 45 seconds. What is the sequence of observations of the second clock hand?

2(e). Motion pictures are made by taking a photograph 24 times a second. Use part (c) to explain why car wheels in movies often appear to spin backward while the cars are moving forward!

6. Consider the following parameters for communication over a channel: Character-synchronous transmission, 7-bit characters, 20 control characters per frame, 56 kbps. The data portion of the frame can be 50 or 400 characters. On the average 50 characters frames occur 40% of the time and 400 character frames occur 60% of the time. What is the effective data rate on the channel? *[5 marks]*

7. Most digital transmission systems are "self-clocking" in that they derive the bit synchronization from the signal itself. To do this the systems use the transitions between positive and negative voltage levels. These transitions help define the boundaries of the bit intervals. For the following questions assume that we are transmitting a sequence of 4 consecutive 1s followed by 4 consecutive 0s.

1(a). The nonreturn-to-zero (NRZ) signaling method transmits a 0 with a +1 voltage of duration T, and a 1 with a −1 voltage of duration T. Plot the signal for the sequence n consecutive 1s followed by n consecutive 0s. Explain why this code has a synchronization problem. (2 marks)

1(b). The Manchester signaling method transmits a 0 as a +1 voltage for T/2 seconds followed by a −1 for T/2 seconds; a 1 is transmitted as a −1 voltage for T/2 seconds followed by a +1 for T/2 seconds. Repeat part (a) and explain how the synchronization problem has been addressed. What is the cost in bandwidth in going from NRZ to Manchester coding? (3 marks)

8. A new broadcast service is to transmit digital music using the FM radio band. Stereo audio signals are to be transmitted using a digital modem over the FM band. The specifications for the system are the following: Each audio signal is sampled at a rate of 40 kilosamples/second and quantized using 16 bits; the FM band provides a transmission bandwidth of 200 kiloHertz.

   a. What is the total bit rate produced by each stereo audio signal? (2 marks)

1b. How many points are required in the signal constellation of the digital modem to accommodate the stereo audio signal? (3 marks)