# CSE 466 Exam I 11 February 2008

Name: ______________________________ ID#: ____________________________

Please read through the *entire* examination first! This exam was designed to be completed in 50 minutes. There are 3 problems for a total of 100 points (a problem may have multiple parts). The point value of each problem is indicated in the table below. There will be partial credit, so do make sure to get to every problem.

Each problem is on a separate sheet of paper. Write you answer *neatly* in the space provided. Do not use any other paper.

Good luck.

| Problem | Max Score | Score |
|---|---|---|
| 1 | 40 | |
| 2 | 30 | |
| 3 | 30 | |
| TOTAL | 100 | |

## 1. General concepts (40 points)

Define the following terms related to features of your Atmega16 microcontroller. Provide a sentence or two explaining the concept, which unit in your microcontroller embodies this feature, and an example of when the feature was used in your lab assignments. If you didn't use it, explain why it was not needed.

a) Input capture

b) Pulse-width modulation

c) Interrupt enable flag

d) Serial-peripheral interface (SPI)

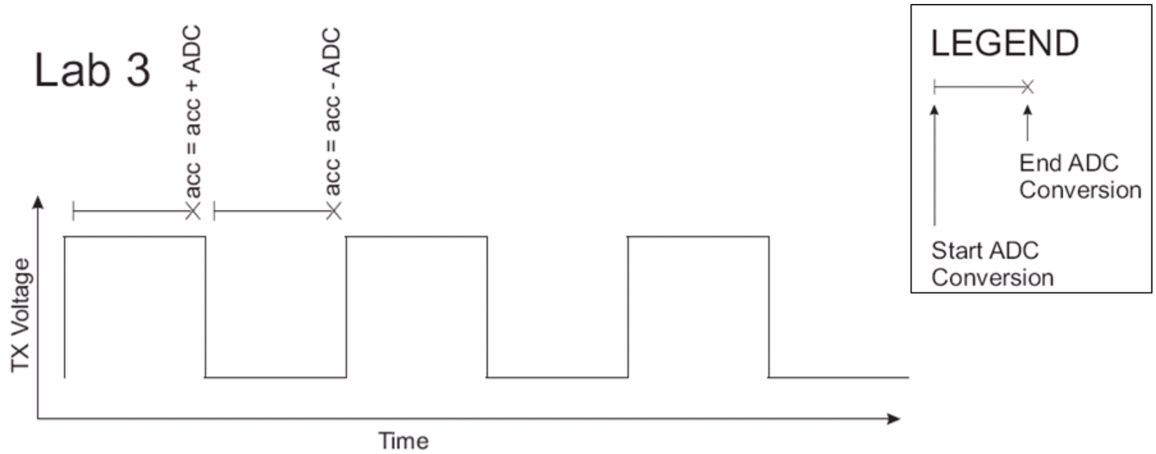
## 2. A-to-D Conversion and Interrupts (30 points)

a) What is free-running mode on the analog-to-digital converter? When might you want to use it? When might you not want to use it? Cite specific examples from the labs (this should require on the order of 1-2 paragraphs to explain).

b) Why is it important for interrupt service routines to be short? What problems might occur if they are not?

## 3. Data Communication (30 points)

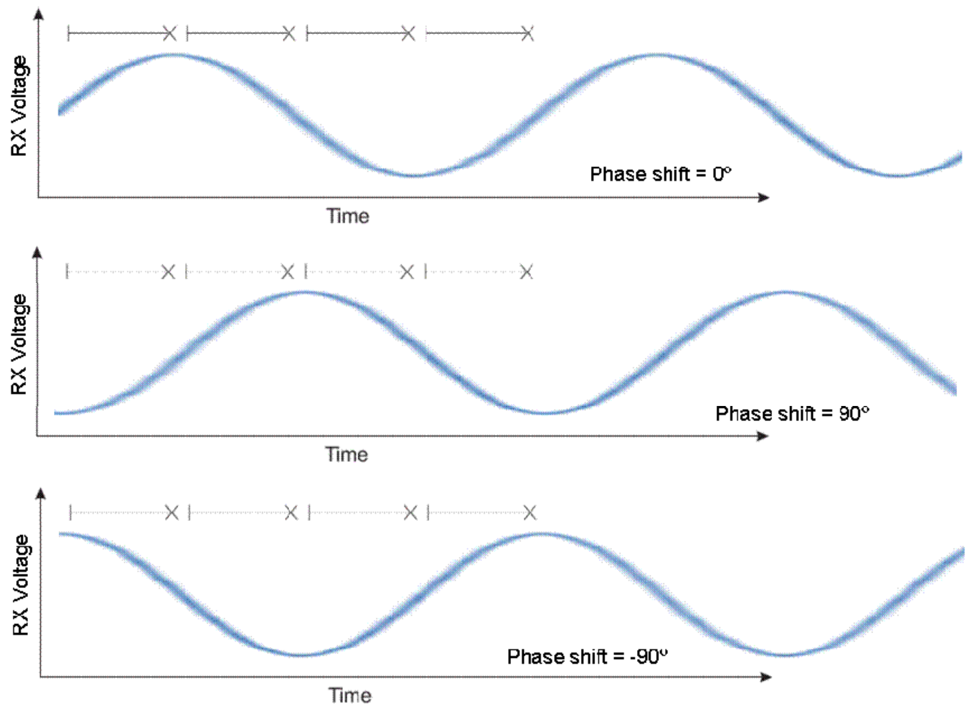
In lab 3, you generated a square wave, and demodulated on the same phase and frequency as the transmitted square wave.




The phase offset between the transmitted signal and the received signal (demodulation channel) is 0 degrees.

It is also possible to demodulate with a different phase offset between transmit and receive. And, it is possible to take the same received signal and demodulate it in more than one way. By measuring on the same phase (0 degrees) and also on a different phase (90 degrees off), it is possible to measure phase shifts: for example, a 45 degree phase shift will make equal contributions to the 0 degree and the 90 degree channel. This can allow you determine whether the impedance between the transmit and receive signal electrodes is capacitive, inductive, resistive, or a combination of these. (If there is no phase shift between transmit and receive signals, this corresponds to a real impedance, i.e. a pure resistance. If the received current is phase shifted by +90 degrees, it corresponds to a pure inductance [positive imaginary impedance]; if the received current is phase shifted by -90 degrees, it indicates a pure capacitance [negative imaginary impedance.]) The simultaneous use of the 0 degree and the 90 degree channel (called “in-phase” and “quadrature” channels) is also used to increase the throughput of communication systems.

The figure below shows three versions of the received signal – shown as a sinusoid to approximate the received waveform (the sinusoid shown has the same frequency as the square wave) – the top one has 0 degree phase shift, the second has +90 degrees shift, and the third has -90 (or 270) degrees phase shift.




Write pseudo-code to generate a TX square wave (at half the transmit frequency of lab 3) and demodulate it using two separate accumulators, one for a 0 degree phase shift (the "inphase" accumulator), and one for a 90 degree phase shift (the "quadrature" accumulator). Write this code on the **NEXT PAGE**.

The result of your pseudo-code should be accumulated samples in these two accumulators.

Recall that a resistance is called a real impedance, and causes no phase shift between the transmitted voltage and received current. An inductance is called a positive imaginary impedance (+90 degree phase shift). A capacitance is called a negative imaginary impedance (-90 degree phase shift). For example, let's agree that when the impedance between the TX and RX is purely capacitive, the in-phase signal will be approximately zero, and the quadrature signal will be large and negative.

At the end of your sampling loop, *in terms of the two accumulator variables*, specify how you would determine (you can use terms such as "approximately 0" and "large and positive" as in the example above) that the impedance is:

a) mostly resistive

b) mostly inductive

**FOR YOUR PSEUDO-CODE:** Do not be concerned with syntax. In fact, you can use English (e.g., "read timer0 value). Assume that you have a "readADC" function that returns the current value on the receive electrode and that the ADC is already configured appropriately. The complete answer should easily fit on this single page.