Embedded Systems (CS 503/591C)
Homework 4 Solutions

December 2, 2003

This homework assignment is due Thursday, December 11. Feel free to discuss this assignment with the TAs, the instructor, or your fellow students. But - the work that you hand in must be your own.

**Question 1: Op-Amps**

1. What are three characteristics of an ideal operational amplifier?

2. How does an actual op-amp differ from each of these ideal characteristics?

3. Consider the following circuit:

![Circuit Diagram]

If $R_1 = 10k\Omega$, what is the value of $R_2$ required to produce a circuit with gain of 25?
4. Consider the following circuit:

Draw the output \( V_o \) for a sine wave with a 2.5V peak and a -2.5V trough at the input \( V_i \)

**Question 2: ADC and DAC**

1. Consider the following 2-bit digital-to-analog converter:

For the four possible digital inputs (to \( X_0 \) and \( X_1 \)), give the output voltage.
2. Consider the following successive approximation analog-to-digital conversion circuit:

![Diagram](image_url)

$V_{in}$ is the input voltage; $A_0...A_7$ are the digital outputs from your PIC ($A_0$ is the LSB); and $X$ is a digital input to your PIC.

Give a successive approximation algorithm in pseudo-code.

### Question 3: Asynchronous Serial Protocols

1. Explain in brief how asynchronous serial protocols differ from synchronous ones.

2. Give a pseudo-code implementation of `read_bit()` from the lecture. You may assume that a timer ISR is incrementing a globally-visible counter.

3. Give a (simple) pseudo-code implementation of `wait_for_start_bit()` from the lecture.