ECE/CS 5780/6780
Spring 2007
Myers

Final Exam

- Fill in your name:
- This exam is open book and open notes.
- The exam is 120 minutes and worth 120 points. Spend about one minute per point.
- Explain your solutions well, but you do not need to write an essay.
- The exam is a design problem so some questions are deliberately left open-ended. Be creative.

Question	Score
1	
2	
3	
4	
5	
Total	

You are an engineer at Fast Cars, Inc. in charge of the design of a cruise control system. The user interface includes five pushbuttons:

- On/off
- Set
- Resume
- Accelerate
- Coast

To use the cruise control system, the driver must first press the "on/off" button. When the cruise control system is on, an LED should be turned on to indicate this. Next, the driver must bring the car up to speed manually and press the "set" button to set the cruise control to the current speed. The cruise control takes its speed signal from a speed sensor found on the wheels. The car maintains the selected speed by pulling the throttle cable with a solenoid. The "coast" button can be used to let the speed decrease without braking. Tapping the brakes will also activate coasting. The cruise control also remembers the last set speed so that after braking or coasting, the "resume" button can be pressed to restore the saved speed. The cruise control system can be turned off by pressing the "on/off" button again.

1. **Analog Interfacing (30 points)** The speed sensor produces a voltage between 0 to 10mV with a desired resolution of 0.01mV. The solenoid requires an analog voltage between -12V and +12V.

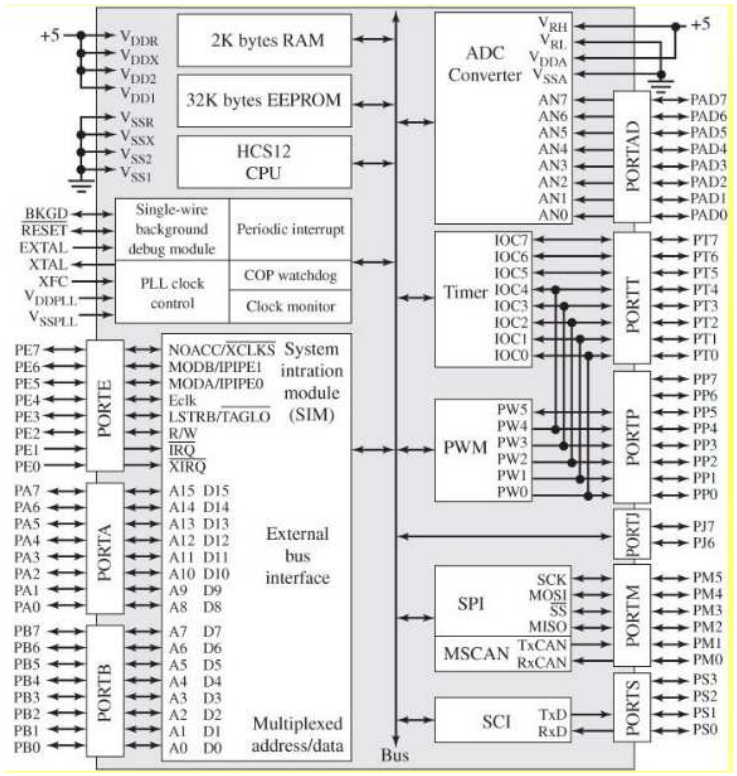
   (a) What is the needed ADC precision? How many bits does the ADC need to be? Will the ADCs on the MC9S12C32 be sufficient?

   (b) What is the needed gain to use the full 0 to 5V range of the ADC. Show the circuit designed with discrete components (i.e., OpAmps, resistors, capacitors, etc.). Assume that you should only use resisters between 10KΩ and 1MΩ. Remember to label resistance and capacitance values.

(c) The cruise control uses a PID (propotional, integral, derivative) controller. Assume that you wish to compute the integral and derivative in hardware. Show the circuits to do this. Note that the input to these circuits should be the output of the amplifier.

(d) Show a detailed schematic for the solenoid interface. Again show all components with labels. You may assume the existance of an integrated DAC chip.

2. **Hardware (20 points)** Draw a schematic for the cruise control system. Include as much detail as possible including all external circuitry and any connections to any pin used. You may show any component whose internal implementation is designed in the previous question as a single block. For this problem, you may assume the existence of any basic component that you need as long as you describe what it does.



3. **Software (20 points)** Answer the following questions about the software for the cruise control system.

   (a) What global data structures would you provide?

   (b) What initialization routines would you provide? What would they do?

   (c) What regular I/O calls would you provide that the client software could use to perform I/O? Describe each in a few words.

   (d) What software support (interrupt handlers) would be needed? Assume that gadfly is not an acceptable option.

4. **Rituals (25 points)** While it is not good style, you have decided to combine all the initializations that you need into a single ritual. Show the C code for this ritual.

5. **ISR (25 points)** Show C code for the interrupt service routine which will periodically obtain the proportional, integrated, and differentiated versions of the velocity. You may assume the existence of a function PID which takes these three parameters and returns the new control voltage for the solenoid.