Name ______________________

Real Time Computing Systems
EE 4770
Final Examination

15 May 1998, 17:30-19:30 CDT

Problem 1	________	(30 pts)
Problem 2	________	(30 pts)
Problem 3	________	(20 pts)
Problem 4	________	(20 pts)
Exam Total	________	(100 pts)

Alias ______________________

Good Luck!

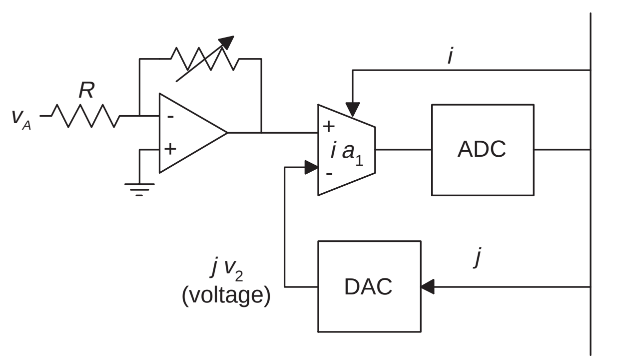
Problem 1: Precise temperature measurements over a 3 °C range are to be made using a thermistor. Though the range is 3 °C, it can fall within 250 K to 350 K, that is, it might be [250 K, 253 K] for one set of measurements and [302 K, 305 K] for another. Design a circuit to convert the temperature, $x \in [250\,\mathrm{K}, 350\,\mathrm{K}]$, into floating point number $H(x) = x/\,\mathrm{K}$ to be written to variable `tee` so that two consecutive measurements that fall within a 3 °C range are made precisely, as described below.

To achieve the high precision over a narrow range the circuit will use an instrumentation amplifier with an adjustable gain and a digital-to-analog converter (DAC) as a bias source, as shown below. The gain of the amplifier is set to $i \times a_1$ from the interface routine by calling `setGain(i)`, where $i \in [1, 256]$ and a_1 is a chosen value for the amplifier. The voltage is set to $j \times v_2$ by calling `setVolt(j)`, where $j \in [0, 2^{16} - 1]$ and v_2 is another chosen value. See the sample code below.

The thermistor has model function $H_{t2}(T) = R_0 e^{\beta/T}$, where $\beta = 3000\,\mathrm{K}$ and $R_0 = 0.059\,\Omega$. The circuit uses a 16-bit, 10-volt ADC. Resistor $R = 9289\,\Omega$ and voltage source $v_A = -10\,\mathrm{V}$.

- Except for a_1 and v_2 the circuit is already designed. **Do not** find values for R and v_A, use the values specified above.
- For partial credit find an interface routine (to write `tee`) assuming a fixed gain for the instrumentation amplifier (choose a convenient value) so that the entire temperature range can be measured ([250 K, 350 K]). Also choose a convenient value for v_-.
- For full credit the interface routine must provide the high precision for small changes from call to call. The routine should remember the previous gain and bias setting used. If the current temperature can be measured using those values they won't be changed before reading the temperature. If the temperature can't be measured (it falls outside of the range previously used) new gain and bias values should be chosen so that the current temperature is at the center of a new 3 °C range (or as close as possible), and the temperature should be measured using the new values. (The ADC output is zero for negative values and is $2^{16} - 1$ for values above 10 volts.) Be sure to provide values for a_1 and v_2. (30 pts)

```
/* Sample code. */
setGain(3); /* Set amp gain to 3 * a_1 */
setVolt(4); /* Set DAC output to 4 * v_2 */
r=readInterface();  /* Read ADC output.. */
```



Use next page for solution, schematic and data repeated.

Problem 1, continued.

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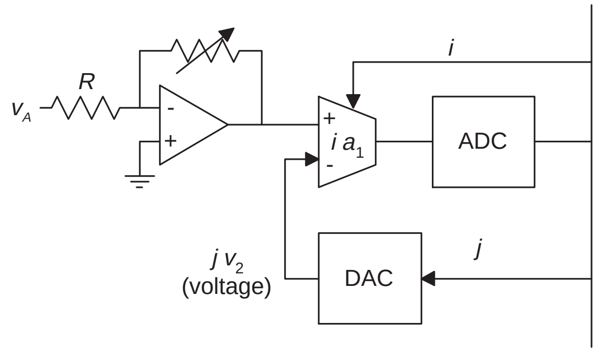

Problem 2: Events and their handlers are described in the first table below. Fill in the blank tables. (30 pts) To be eligible for partial credit, show the event sequences used.

Event Name	Strong Priority	Weak Priority	Handler Run Time	Occurrence
A	3	3	$4\,\mu$s	Periodic, $25\,\mu$s period.
B	3	2	$20\,\mu$s	Periodic, $150\,\mu$s period.
C	3	1	$30\,\mu$s	Periodic, $200\,\mu$s period.
D	2	1	$300\,\mu$s	$\geq 400\,\mu$s spacing, ≤ 2 in any 2 ms period.
E	1	1	40 ms	At initialization and 40 ms after each E response.

Event	Latency	Actual Run Time	Response Time
A			
B			
C			
D			
E			

Event	Load	Load Set	Loading Factor	Loaded Duration
A				
B				
C				
D				
E				
Total System Load:				

Problem 3: The table below describes tasks that run on a system with task-preemptive scheduling. R1 and R2 are resource names.

Task	Priority	Arrival	Activity
A			Compute for 10, lock R1, comp. for 10, unlock R1, comp. for 10, exit.
B			Compute for 15, lock R2, comp. for 15, unlock R2, comp. for 15, exit.
C			Compute for 11, lock R1, comp. for 11, unlock R1, comp. for 11, exit.
D			Compute for 17, lock R2, comp. for 17, unlock R2, comp. for 17, exit.

(*a*) Suppose the system does not employ any locking protocol. Assign priorities and arrival times so that one of the tasks suffers priority inversion. Show CPU activity and task states for these assignments, identify the suffering task. (Not all tasks have to be used.) (7 pts)

(*b*) Show CPU activity and task states with the arrival times and priorities chosen above but for a system using a priority inheritance protocol. (6 pts)

Problem 3, continued.

(*c*) Add another task that would have a lower blocking time with a priority ceiling protocol (either ceiling protocol) than with a priority inheritance protocol. Specify the task's priority and activity and any other necessary data. Explain how the ceiling protocol helps, execution (CPU activity and task states) do **not** have to be shown. (7 pts)

Problem 4: Answer each question below.

(*a*) How is the schedulability test below used? What does it mean when the relation holds, and when it does not hold? (5 pts)

$$L < N(2^{1/N} - 1)$$

(*b*) Describe a similarity and a difference between a phototransistor and a photomultiplier. The similarity should be other than they both measure light. The difference should not refer to physical structure. (For partial credit, mention physical structure.) (5 pts)

(*c*) What is the difference between the running of an interrupt handler and a task? What are some restrictions that might be placed on an interrupt handler that would not be placed on a task? (5 pts)

(*d*) What is the difference between irradiance and illuminance? What is the difference between irradiance and radiant flux? (5 pts)