**L-2 (Using the RS-232 serial on PC-104)**

**Task 1:** Use the program of Experiment 1 and transmit the values to a second PC-104 using the RS-232 serial port. The results should be plotted on the screen by the second PC-104. Use the serial send and receive modules from the obsolete v1.1 toolset under xPC in Simulink library.

Q1. What is the fastest baud rate possible?

Q2. If you reduce the baud rate what kind of modifications in sampling time and or pulse wavelength do you need?

Q3. What is the parity and length of data bits used for this part of the experiment?

**Task 2:** Modify the program of Experiment 1 to receive the square wave amplitude from the host PC through the serial port. The program should also transmit the values to the host PC using the RS-232 serial port. The results should be plotted on the screen by the host PC.

Q4. What is the highest baud rate supported in this case?

Q5. What is the fastest sampling time?

Q5. Using this setup what is the maximum possible number of variables can you send at each interval?

**Task 3:** Instead of building a standalone project and copying the files to the flash drive from the computer, build the file from Exp1.mdl in DOSloader mode and have the file downloaded to the system via the RS-232 port. Use xPC to get a screenshot of the scopes running on the PC-104

Q6. Can configurations such as baud rate, parity etc of the serial link on the board be configured online?

**L-3 (Design of a car Cruise Control system)**

**Task:** Refer to http://tsakalis.faculty.asu.edu/notes/models.pdf . The third model is that for a simplified dynamics of a car. Read the description carefully to understand how the car was modeled. Create a continuous time linearized model from the non-linear one provided.

Q1. What is the time constant of the system?

Q2. Compare the step response of the linear and non-linear plant. What is the maximum step size that the linear plant tolerates before there is an error of more than, say, 10% from the non-linear plant?

**Task 2:** Design a continuous-time controller for the system such that the CL system BW is 1/10 rad/s at a PM of 60°. Discretize both the plant and the controller then Implement the controller on one PC-104 and the plant model on another and put them in a feedback loop to test performance at an initial condition of 50 mph and apply step input after a couple of seconds such that it brings the speed up to 55 mph. leave the angle of incline of the plane at 0° for the time being.

Q3. What sampling time did you use?

Q4. What are the PI parameters used?

**Task 3:** Add an angle of 10° incline to the plane. Implement this model and test the performance of the controller.

Q4. Was the controller able to reject the disturbance? How long did it take to settle?

**L-4 (Design of a Heat transfer Control system)**

**Task**: Create a virtual experiment of a heat transfer process with the data given below. The experiment should use the DAC to output a voltage proportional to the temperature. It should also use the ADC to read a voltage proportional to the applied heat. The process should be controlled by a PI or PID, reading temperature data and supplying heating power through the ADC/DAC channels.

**Comments:** A simple heat balance equation is

$$mc_p\dot{T} + hA(T - T_{amb}) + \sigma FA(T^4 - T_{amb}^4) = q$$

where m = mass, cp = specific heat, h =convection heat transfer coefficient, A = area, σ= Boltzmann constant, F = view factor, Tamb = ambient temperature in K, q = supplied heat.

Some ball-park numbers are (in SI) m = 0.034, cp = 1000, h = 2, A = 0.0063, F = 1, σ = 5.675e-8. A reasonable supplied heat is in the order of several hundreds. These data correspond roughly to a heating element heated by electric power.

The continuous-time Simulink model for this process is supplied in exp5.mdl. For its real time simulation, a fixed-step solver should be used and a discrete integrator should replace the continuous time one. For the discretization, the sampling time should be small enough, in the order of seconds or fraction of seconds so that the difference between continuous and discrete simulation is small. This means that the sampling time should be small relative to the system time constant. To ensure the realistic behavior of the simulated system make sure that the supplied power is saturated between 0 and qmax (e.g. 1000), regardless of the request of the controller.

The feedback control objective is to follow changes in the temperature set-point and attenuate external disturbances. A good model for the disturbances is as an injection of a constant or low frequency perturbation at the element input. To determine their amplitude, assume that their uncontrolled effect can be in the order of 50 deg.

**For a simplified version of this experiment, consider the linearized model of the above system at 600 degC, having a transfer function 0.0147/(s + 0.028). Design the PI/PID controller to achieve a closed-loop time constant of 6 sec (Bandwidth 1/6 rad/min), approximately. Use a sampling time of 0.2 sec.**

Q1. What PI parameters did you use?

Q2. What is the time constant of the system?

Q3. Compare the frequency response of the CT and DT system on the same plot.

Q4. What happens to the delay in the system when you sample faster (0.02 sec)?

Q5. Try sampling at 2 sec instead and see what happens. Correct for the sampling delay by redesigning the controller to incorporate the delay.