EECS 461 Winter 2009, Problem Set 6[1]

issued: Wednesday March 18, 2009 due: Wednesday March 25, 2009

1. Consider the 2nd and 4th order Runge-Kutta methods for numerical integration. In this problem we will write a Matlab m-file to numerically integrate a first order state equation using each of these methods, and compare the solutions we get to those obtained from Simulink simulations with the same integration techniques specified. Specifically, modify the Matlab file "Prob2_PS6.m" to simulate five seconds of the response of the first order system

$$\dot{x} = -2x + 2u$$

to zero initial state, $x(0) = 0$, and a unit step input $u(t) = 1, \forall\, t \geq 0$. Use an integration step size $T = 0.1$ seconds. Compare these results to simulations obtained from the Simulink diagram shown in Figure 1.

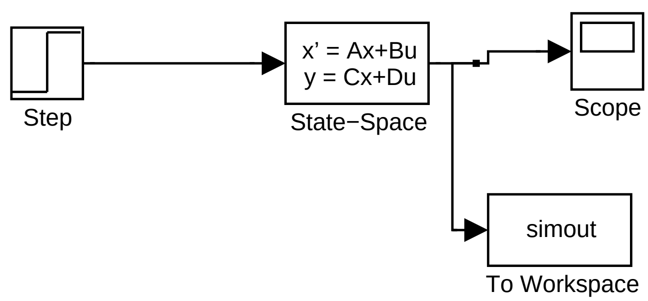

Figure 1: Simulink model to test numerical integration. Set the "Save format" option of the "To Workspace" block to "Array".

HAND IN: Your algorithms and the corresponding Matlab code, together with the detailed plot showing that the simulations agree.

[1]Revised March 16, 2009.

2. Consider the CAN network in the lab, with 6 lab stations implementing haptic interfaces in 3 pairs. Each lab station will read the encoder every T seconds, and write this value to the network. The partner lab station will take the encoder value, use it to compute a reaction torque, and transmit the reaction torque to the network. The duty cycle value will be received by the original lab station, and used to update the PWM duty cycle that controls the motor. With a virtual wall implemented on all 6 lab stations, it will thus be necessary to transmit 12 messages on the CAN bus every T seconds.

   Recall that a CAN message containing the maximum 64 bits of data will actually be 108 bits long due to overhead bits. Successive CAN messages must be separated by 3 recessive bits, so that 111 bits are required to be transmitted for each 64 bits of data. We will ignore the effects of bit-stuffing. Assume that it takes $2\mu\text{s} = 0.002$ msec to transmit 1 bit on the CAN bus.

   (a) Suppose that all 12 CAN messages use the maximum 64 bits of data. How much time is required to transmit the messages, including the required between-message bits??

   (b) If the CAN message uses only 32 bits of data, how much time will it take to transmit all 12 messages?

   (c) Again suppose that the 12 CAN messages use 32 bits of data. What is the minimum sample period T that will achieve 25% bus utilization?

   (d) Suppose that the sample period must satisfy $T < 4$ msec in order to achieve a good virtual wall. What is the maximum number of virtual walls that can be implemented on the network with no more than a 25% bus utilization? Assume 32 bits of data per CAN message.