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Indian Institute of Technology Kanpur
CS637 Embedded and Cyber-Physical Systems
Homework Assignment 3
Deadline: September 16, 2022

Instructions:

Total: **40 marks**

1. Write the answers **neatly** in the given boxes.
2. You may discuss the solutions with the other students, but you have to write them in your own words.

Problem 1. (10 points) Provide the state-space representation of the dynamics of a DC Motor. Assume that there is no additional load on the motor. Next, Design a Simulink model to capture the dynamics and simulate the model for an input PWM voltage signal with magnitude 1V, frequency 1 kHz and duty cycle 0.1. Assume that the kinetic friction of the motor is negligible. Take the values of the other parameters from Example 7.13 in [LS15].

[LS15] Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, http://LeeSeshia.org, ISBN 978-1-312-42740-2, 2015.

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Problem 2. (20 points) Consider the vehicle steering control problem in Example 6.4 in [AM09]. Assume that $k_1 = 1$, $k_2 = 1.6$, and $k_r = 1$. Model the control system in Simulink using double precision floating point arithmetic. Now replace the model of the controller with the ones that use 16 bit and 8-bit fixed-point arithmetic. In each case, determine the fixed-point data types precisely. Plot the difference between the first state for the floating-point controller and that for the fixed-point controllers. Generate code for both the floating point controller and the fixed-point controllers using different optimization options. Describe your experience with code generation.

[AM09] K. J. Astrom and R. M. Murray. Feedback Systems: An Introduction for Scientists and Engineers. Princeton University Press, 2009.
http://www.cds.caltech.edu/∼murray/books/AM05/pdf/am08-complete_22Feb09.pdf.

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Problem 3. (10 points) Work out Problem 1 in the Exercises of Chapter 9 in [LS15].

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