Chalmers University of Technology
Department of Signals and Systems

ESS101 Modelling and simulation

Examination date August 16, 2011

Time: 14.00 – 18.00

Teacher: Paolo Falcone,

TA: Roozbeh Kianfar, 772 5793

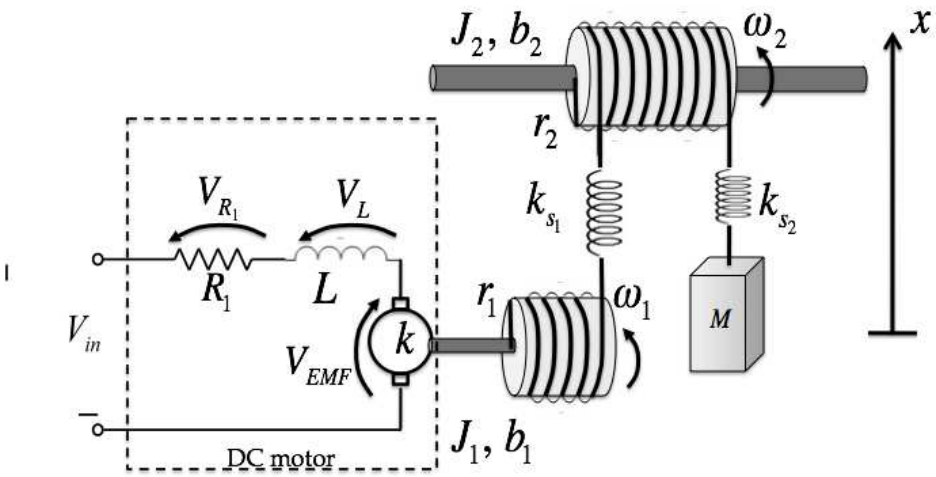
Allowed material during the exam: Mathematics Handbook and small calculator (not a PC).

The exam consists of 4 exercises with a total of 25 points. Nominal grading is according to 12/17/21 points. You need 12 points to pass the exam with grade 3, 17 points to pass with grade 4 and 21 to pass with grade 5. Solutions and answers should be written in English, unambiguous and well motivated, but preferably short and concise.

You can discuss with TAs the grading of your exam on August 25^{th} at 14.00-15.00 at the Department of Signals and Systems.

Exercise 1 (10 p)

Consider the electromechanical system in the figure below,



where the ropes are all inextensible.

(a) Derive a bond graph and mark the causality. (3p)

(b) Derive a state space model. (3p)

(c) Propose a modification of the system (i.e., adding/removing one or more components) such that the resulting model is a DAE. Motivate the answer (4p)

Exercise 2 (5 p)

Consider the system

$$y(t) = 0.1y(t-1) + a_1 \cos y(t-2) + b_1 u(t) + e(t),$$

where $e(t) \sim N(0,1)$.
Show how to use the least squares method to estimate the parameters a_1 and b_1.

Exercise 3 (5 p)

Calculate the spectrum of the rotational speed of a rotating body, with a friction element of $b = 10\ kNms/rad$ and and inertia $J = 10^{-3} Kg\ m^2$, when the input torque is a white noise signal with variance 1.

Exercise 4 (5 p)

Mark with True or False the following statements and provide a brief explanation for the False ones. The indicated points will be awarded only in case of right answer and correct explanation.

1. The *correlation analysis* is a nonparametric identification method where samples of the impulse response of a system are estimated based on experimental data. (1p)

   True ☐ False ☐

2. The periodogram is a deterministic quantity. (1p)

   True ☐ False ☐

3. In the Forward Euler simulation method for ODEs, the *local error* is the error introduced by the method over the whole simulation time. (1p)

   True ☐ False ☐

4. The Prediction Error Method (PEM) is based on the application of the least squares formula. (1p)

   True ☐ False ☐

5. A DAE has differentiation index m, if m is the minimal number of differentiations of the DAE that is necessary in order to solve the DAE itself. (1p)

   True ☐ False ☐