Chalmers University of Technology
Department of Signals and Systems

ESS101 Modelling and simulation

Closed book and notes exam[1]

January 12, 2012

Time: 14.00 – 18.00

Teacher: Paolo Falcone, 772 1803

Allowed material during the exam: Mathematics Handbook and a Chalmers approved calculator[2,3].

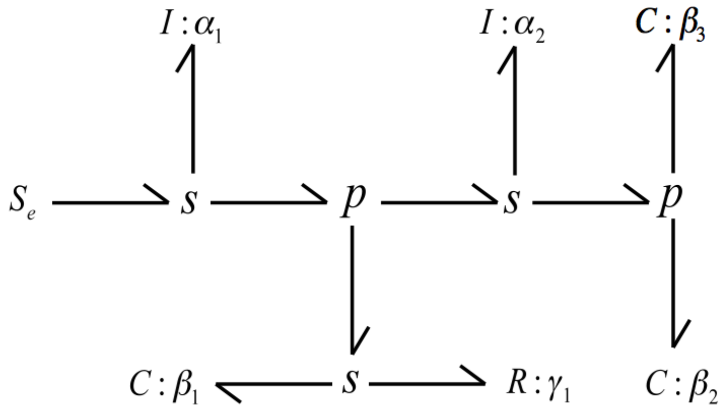
The exam consists of 4 exercises with a total of 25 points. Nominal grading is according to 12/17/21 points. You need 12 points to pass the exam with grade 3, 17 points to pass with grade 4 and 21 to pass with grade 5. Solutions and answers should be written in English, unambiguous and well motivated,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

You can discuss with TAs the grading of your exam on January 27th at 14.00-15.00 at the Department of Signals and Systems.

[1] Textbook, personal notes and printouts of the course slides are ***not*** allowed.
[2] See https://student.portal.chalmers.se/en/chalmersstudies/Examinations/Pages/Examinationroominstructions.aspx
[3] A limited number of Chalmers approved calculators are available at Madeleine Persson's office, located at the fifth floor of the E-building.

Exercise 1 (10 p)

Consider the following bond graph,



(a) Mark the causality. (1p)

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

(c) Sketch an electrical system corresponding to the bond graph above. (2p)

(d) The bond graph has a causality conflict and the corresponding state space model should be a DAE.

1. Refer to the electrical system at point c) and explain which physical elements generate the causality conflict and why. (2p)
2. Propose an equivalent bond graph and find the corresponding electrical system, without any causality conflict. (2p)

Exercise 2 (5 p)

Consider the system

$$y(t) + ay(t-1) = bu(t-1) + e(t)$$

where $e(t)$ is white noise.
Estimate the parameters a and b, by assuming that

1. the data used for parameters identification is generated through the system

$$y(t) = 0.1u(t-1) + 0.2u(t-2) + v(t)$$

   where $u(t)$ and $v(t)$ are white noises with variances 1 and 2, respectively, and uncorrelated,

2. the number of samples tends to infinite.

Exercise 3 (5 p)

We want to simulate the system

$$\dot{x}(t) = \begin{bmatrix} -\lambda & 1 \\ -1.7\lambda^2 & 0.7\lambda \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t),\ \lambda \in \mathbb{R}^+$$

with the Forward Euler's method and step size $h = 1$.
Calculate the maximum value of the parameter λ such that the FE method is stable.

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. A parametric system identification problem can always be solved through the LS formula. (1p)

   True ☐ False ☐

2. In a parametric system identification problem, the variance error of the estimate can be reduced by reducing the number of samples in the data set. (1p)

   True ☐ False ☐

3. The correlation analysis method can efficiently solve the problem of estimating the impulse response of a system working under a feedback control law. (1p)

   True ☐ False ☐

4. In a parametric system identification problem, by *identifiability issues* we mean the problem of collecting data. (1p)

   True ☐ False ☐

5. A necessary condition for applying the LS formula is the persistent excitation of the input signal. This is an invertibility condition of the input covariance matrix. (1p)

True ☐ False ☐