Chalmers University of Technology
Department of Signals and Systems

ESS101 Modelling and simulation

Closed book and notes exam[1]

Examination date January 3, 2015

Time: 14.00 – 18.00

Teacher: Paolo Falcone, 0761 25 7050 (consulting only over the phone from 14.45-15.15 and 16.45-17.15)

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

The exam consists of 5 problems worth 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.

Exam review date will be posted on the course homepage.

[1] Textbook, personal notes and printouts of the course slides are ***not*** allowed.

Exercise 1 (10 p)

Consider the system

$$\dot{x}(t) = \begin{bmatrix} -1.5 & 1 \\ 0 & -1 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t),\ x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix},$$

with $x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$.

(a) Simulate the system and calculate $x(2)$. Motivate the choice of the used simulation method. (3p)

(b) Assume now that the system is subject to the constraint $x_1(t) - x_2(t) = u(t)$. Can you calculate $x(2)$ as done at point **(a)**? Motivate your answer. (2p)

(c) Calculate $x(2)$ when the system is subject to the constraints at point **(b)**. Verify that the constraint $x_1(t) - x_2(t) = u(t)$ is satisfied for $t = 1,\ 2$. (5p)

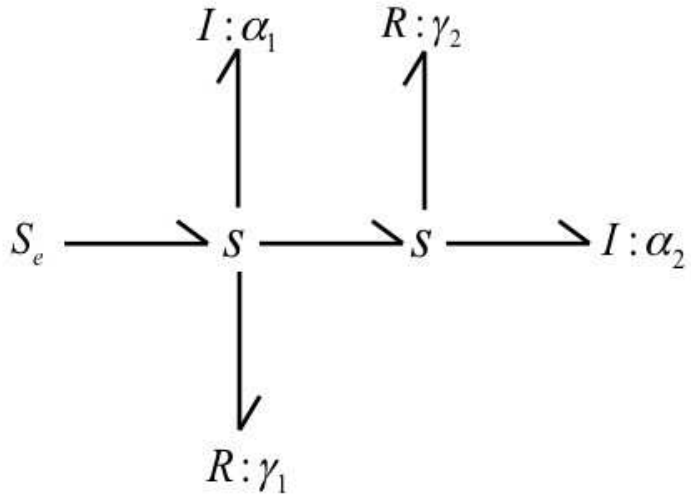
Exercise 2 (5 p)

(a) After collecting data to solve your system identification problem, you find out that $\hat{R}_{\varepsilon u}(\tau) \neq 0,\ \tau < 0$, where the symbol $\hat{(\cdot)}$ denotes the estimate, ε is the prediction error and $u \in N(0, \lambda)$ is the input signal. What does this mean? (2p)

(b) After collecting data to solve your system identification problem, you find out that $\hat{R}_{\varepsilon u}(\tau) \neq 0$, for a positive τ. Does this information provide any useful suggestion in the choice of the model? (3p)

Exercise 3 (5 p)

(a) Show an example of third order physical system whose bond graph has a causality conflict. Explain the causality conflict in terms of the physics of the system. (2p)
(b) Mark the causality of the system (1p)



(c) Derive a system of ODE describing the system at point **(b)**. (2p)

Exercise 4 (5 p)

Answer the following questions and mark with True or False the following statements also providing a brief explanation. The indicated points will be awarded only in case of right answer and correct explanation.

1. The cost minimized in the PEM has a global, finite minimum point. (1p)

   True ☐ False ☐

2. What is the periodogram? (1p)

3. Explain the difference between global and local errors in a simulation method. (1p)

4. The least squares formula can only be applied under well defined conditions on the input signal. (1p)

   True ☐ False ☐

5. Illustrate the stability regions of the two Euler methods. (1p)