

ELEC-E8101 Digital and Optimal Control
Final exam 9.12.2015

- Write the name of the course, your name, your study program, and student number to each answer sheet.
- There are five (5) problems and each one must be answered.
- No other literature except the Table of Formulas is allowed. A function calculator can be used.
- The table of formulas must be returned, if you have received it from the exam supervisor.
- Mark clearly FINAL EXAM on the answer sheet.

1. Explain shortly.

- Regulation problem
- BIBO-stability
- Zero-order-hold
- Alias-effect
- Coloured noise
- LQ and LQG control

2. Assume that the system

$$y(k) - 1.2y(k-1) + 0.5y(k-2) = 0.4u(k-1) + 0.8u(k-2)$$

is controlled by

$$u(k) = -Ky(k)$$

Determine for which values of K the closed-loop system is stable.

3. Consider the process

$$y(k+1) + ay(k) = bu(k) + e(k+1) + ce(k)$$

where a , b and c are constants, $|c| < 1$ and e is zero mean white noise with variance 1.

- Design a minimum variance control law to the system. What is the variance of the closed loop output signal y ?
- It would seem wise to replace the noise terms in the system equation by $e_1(k+1) = e(k+1) + ce(k)$ and to design a minimum variance control law for this. Do so.
Comments?

4. Consider the discrete-time process

$$x(k+1) = \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix} x(k) + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} u(k)$$

$$y(k) = [c_1 \quad 0] x(k)$$

where a_{11} , a_{22} , b_1 , b_2 and c_1 are constants.

- With which values of the constants the system is reachable?
 - With which values of the constants the system is observable?
5. Explain what the *antiwindup* phenomenon in a controller means. What problems does it cause? What can be done to reduce its consequences?