ELEC-E8101 Digital and Optimal Control
Full exam 30. 1. 2017

- *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 (Digital Control) 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 FULL EXAM on the answer sheet.*

Max 6 points / problem

1. A continuous time system is discretized by using the sampling interval h and assuming zero order hold. Let the continuous time system have a pole at point $z_1 = a + jb$, where j is the imaginary unit and a, b are real constants. Where is the corresponding pole located in the discretized system? Discuss different possibilities when a and b vary. Consider especially oscillations and stability. How is the concept *Nyquist frequency* related here? (6 p)

2. Explain briefly the meaning of the following concepts (1 p each)

   a. BIBO stability,
   b. Reachability,
   c. Observability,
   d. Alias-effect,
   e. Causal controller
   f. "Integrator windup"-phenomenon

3. Write a state-space representation for the following discrete-time system and compute a dead-beat controller for it.

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

   (y and u are the output and input variables of the system). (3 p) representation, (3 p) controller

4. Consider the ARMAX-process

$$\begin{aligned} &y(k+3) - y(k+2) + 0.5y(k+1) = \\ &\qquad = u(k+1) + 0.5u(k) + 0.5e(k+3) + 0.4e(k+2) + 0.125e(k+1) \end{aligned}$$

   where $e(k)$ is zero-mean white noise with unit variance. Determine the minimum-variance controller. (6 p)

5. Present the equation of a continuous PID-controller in time and Laplace domains. Compute the discretized version of the controller in time and z-domains. (You can freely choose the discretization method.) (2p) PID equation, (4 p) discretized version