EE 554 – Homework Chapter 3

3.3 Many chemical processes can be modeled by the following transfer function:

$$G(z) = \frac{K}{\tau s + 1} e^{-Tds}$$

Where K is the gain, τ is the time constant and Td is the time delay. Obtain the T.F. Gzas(s) for the system in terms of the system parameters. Assume that the time delay Td is a multiple of the sampling time T.

3.5 For an internal combustion engine, the transfer function with injected fuel flow rate as input and fuel flow rate into the cylinder as output is give by

$$G(s) = \frac{\varepsilon\tau s + 1}{\tau s + 1}$$

where τ is a time constant and ε is known as the fuel split parameter. Obtain the transfer function Gzas(z) for the system in terms of the system parameters.

3.9 For the unity feedback system shown in Figure P3.9, we are given the analog subsystem

$$G(s) = \frac{s + 8}{s + 5}$$

The system is digitally controlled with a sampling period of 0.02 s. The controller T.F. was selected as

$$C(z) = \frac{0.35z}{z - 1}$$

(a) Find the z-transfer function for the analog subsystem with DAC and ADC.
(b) Find the closed-loop T.F. and characteristic equation.
(c) Find the steady-state error for a sampled unit step and a sampled unit ramp. Comment on the effect of the controller on steady-state error.

3.11 For the following systems with unity feedback, find
(a) The position error constant.
(b) The velocity error constant.
© The steady-state error for a unit step input.
(d) The steady-state error for a unit ramp input.

(i) $G(z) = \frac{0.4(z+0.2)}{(z-1)(z-0.1)}$

(ii) $G(z) = \frac{0.5(z+0.2)}{(z-0.1)(z-0.8)}$

3.13 For the system of Problem 3.9
(a) Obtain the T.F. for the analog subsystem DAC and ADC.
(b) Obtain the step response of the open-loop analog system and closed loop digital control system and comment on the effect of the controller on the time response.
© Obtain the frequency response of the digital control system, and verify that 0.02 s is an acceptable choice of sampling period. Explain briefly why the sampling period is chosen based on the closed-loop rather than the open-loop dynamics.

3.14 Consider the internal combustion engine model of Problem 3.5. Assume that, for the operational conditions of interest, the time constant τ is approximately 1.2s, whereas the parameter ε can vary in the range 0.4 to 0.6. The digital cascade controller

$$C(z) = \frac{0.02z}{z-1}$$

was selected to improve the time response of the system with unity feedback. Simulate the digital control system with ε=0.4, 0.5, and 0.6, and discuss the behavior of the controller in each case.