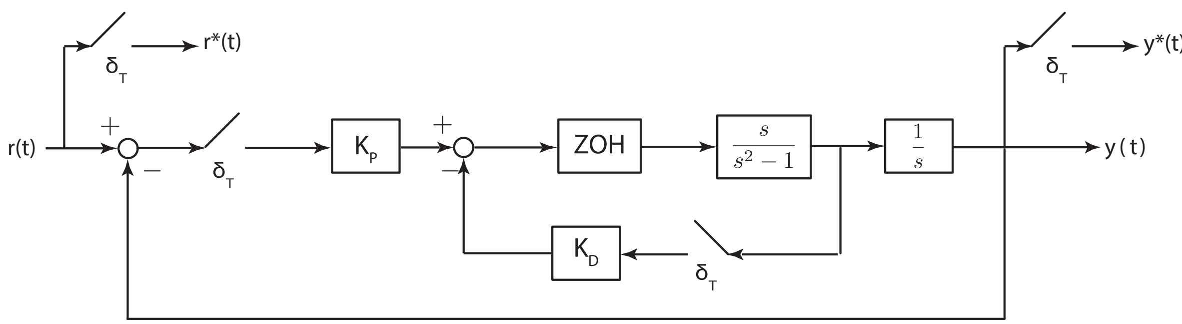
EE402 Mini Project 4

M. Mert Ankarali*
Department of Electrical and Electronics Engineering
Middle East Technical University

Due: 14-Dec-2018, @15:40 PM (D-226) (There will be a box to drop the Mini Projects in front of D-226. The box will be REMOVED after 15:40 PM.)

Important: In this mini project, you are supposed to perform some computations in MATLAB, perform simulations in Simulink/MATLAB, and plot some results using MATLAB. You should provide all of your source codes, Simulink models, and graphical results with your hard copy submission. For Simulink models a snapshot figure of the model is satisfactory.

1. Consider the discrete time control system block given in the Figure below.



Then answer/solve the following questions regarding this system representation.

(a) Let $T = 0.5$ s and $K_D = 0$. Draw the root-locus of the closed-loop system with respect to P gain K_P,

i. by hand following the procedures in the lecture notes (or textbook),

ii. as well as in MATLAB using the *rlocus* command.

Compare your hand solution and MATLAB output.

(b) Let $T = 0.5$ s and $K_D = 2$. Draw the root-locus of the closed-loop system with respect to P gain K_P,

i. by hand following the procedures in the lecture notes (or textbook),

ii. as well as in MATLAB using the *rlocus* command. In MATLAB version label important points and associated gains.

Compare your hand solution and MATLAB output. In MATLAB version label important points and associated gains.

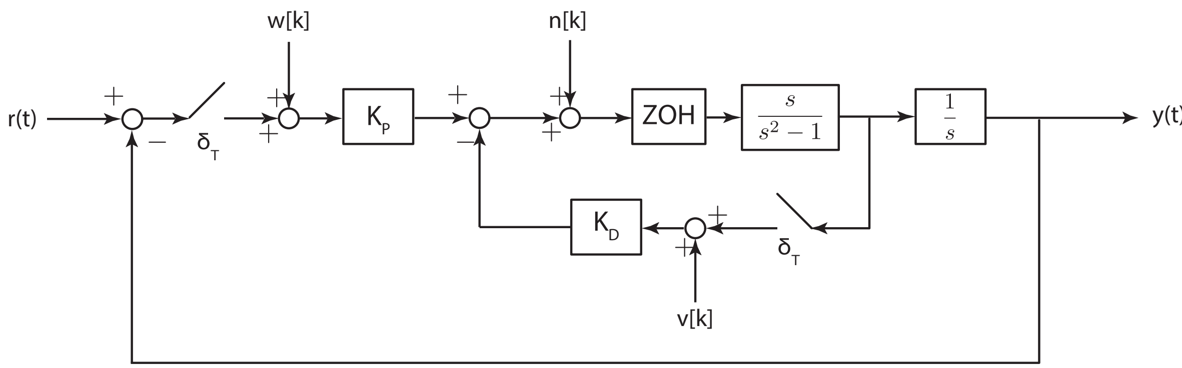
(c) Let $T = 0.5$ s and $K_P = 2$. Draw the root-locus of the closed-loop system with respect to D gain K_D. In this part you don't need to draw by hand (but you can do it if you want to be sure). However, root locus plot via MATLAB is mandatory.

(d) Referring to these root locus plots, select a (K_P, K_D) such that the closed-loop system is stable and output does not show oscillatory behaviour.

(e) Verify that your selected (K_P, K_D) pair results in a stable closed-loop system and output of the system does not yield any oscillations. In order to verify this, perform a closed-loop step-response simulation in Simulink or MATLAB.

(f) Based on your selected (K_P, K_D) gain estimate the settling time of the closed-loop hybrid (CT-plant controlled with a DT-controller) system. *Hint:* You can use the mapping $z = e^{Ts}$ & $s = \ln(z)/T$ to make a connection between z-domain poles and continious-time performance specifications. Now estimate the settling time using the simulation that you performed for the previous part. Compre both estimates.

2. Consider the modified version of the discrete time control system block which is given in the Figure below. In this problem take $T = 0.5\ s$.



In this block diagram representation $y(t)$ (or $y[k]$) is the output, $r(t)$ (or $r[k]$) is the reference signal, where as $w[k], v[k], n[k]$ are disturbances/noises that enters the system from different locations. Let's assume that we know the range of (K_P, K_D) values such that closed loop system is stable. For a given (K_P, K_D) pair in this range answer/solve following questions.

(a) $r(t)$ is a unit-step input and all other inputs to are equal to 0. Compute the steady-state error, e_{ss} in terms of K_P and K_D.

(b) $w[k]$ is a unit-step input and all other inputs are equal to 0. Compute the steady-state response, y_{ss} in terms of K_P and K_D.

(c) $v[k]$ is a unit-step input and all other inputs are equal to 0. Compute the steady-state response, y_{ss} in terms of K_P and K_D.

(d) $n[k]$ is a unit-step input and all other inputs are equal to 0. Compute the steady-state response, y_{ss} in terms of K_P and K_D.

(e) Comment on the effects of K_P and K_D on the steady-state error and disturbance rejection performance.

(f) Now let (K_P, K_D) pair be equal to the one that you selected in Problem 1(d). Then "simulate" (MATLAB or Simulink) all four cases (Parts (a)-(d)) separately, and compare your results found in parts (a)-(b) and simulation results (for the selected (K_P, K_D) pair).