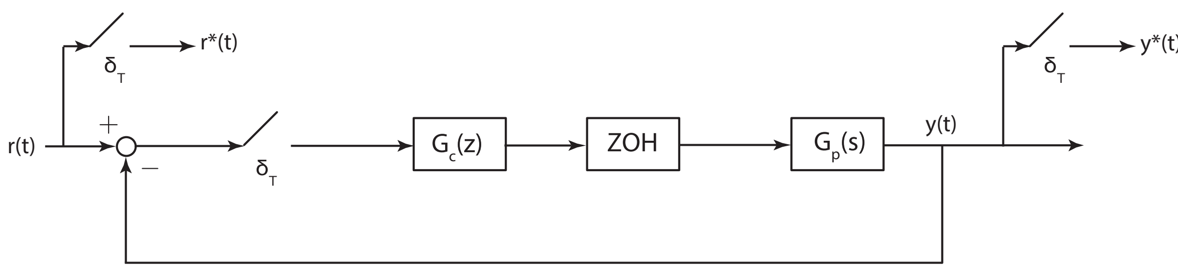
EE402 Mini Project 5

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

Due: 9-May-2018, @15:40 PM

Important: In this mini project, you are supposed to perform some computations in MATLAB, perform simulations in MATLAB or Simulink, and plot some results using MATLAB and Simulink. 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 fundamental discrete time control system block given in the Figure below. Let



$$G_P(s) = \frac{1}{s^2 + s - 2} \quad , \quad T = 0.1s$$

Then

(a) Design two different digital Phase-Lead compensators such that

- closed-loop system is stable (for both controllers),
- steady state error to the unit step response is less than %10 (for both controllers),
- and phase-margin requirements for the compensated systems are
  - $\phi_{m,1} \in [15^o \ , \ 20^0]$,
  - $\phi_{m,2} \in [30^o \ , \ 35^0]$.

After the design of compensators provide the (discrete-time) bode plots of both cases (on the same Figure) and label the phase margin values on the bode plots.

(b) Using MATLAB or Simulink, plot the step responses of both closed-loop systems and compare the results in terms of steady-state error, over-shoot, and settling-time.

2. Consider the following transfer function of a discrete time controller/filter.

$$G(z) = \frac{0.2 - 0.4z^{-2} + 0.2z^{-4}}{1 - 0.9z^{-1} + 0.6z^{-2} - 0.3z^{-3} + 0.2z^{-4}}$$

(a) Find the minimal state-space realization of the discrete time transfer function in

- Reachable canonical form
- Observable canonical form

(b) Compute the eigenvalues of both realizations and compare them to the poles of $G(z)$,

(c) Compute the transfer functions using both state-space realizations and compre the results.

(d) In MATLAB, write a function (m-file) which takes the following variables as inputs

- A, B, C, & D matrices of a state-space form
- $x0$, initial condition of the state-vector
- K, final time/index of the output.

where as the output of the function is y which is the output sequence from $k = 0$ to $k = K$. Input sequence $u[k]$ is assumed to be unit-step input. Using this custom function perform following tests

i. When initial conditions are zero, compute the unit-step response for both reachable and observable canonical forms. In addition to these, also compute the step-response of $G(z)$ in MATLAB using the *step* command. Plot all three responses on the same Figure.

ii. Let $x_0 = x[0] = [1 \ \cdots 1]^T$, then under this condition compute the unit-step response for both reachable and observable canonical forms and plot both responses on the same Figure.

iii. Comment on the performed tests and associated results.