ME 576 Homework #6 Due: 4/15/2021 Name :

1. A controller for a CNC system is to be designed. The continuous transfer function of the axis dynamics is represented by

$$G_p(s) = \frac{5}{s(s+5)}$$

The discrete control system is shown in Figure below with sample time T of 0.1 seconds.

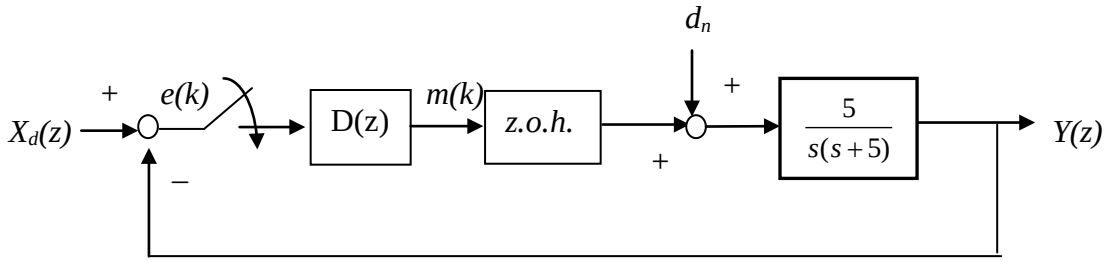

Figure: A discrete control system of a CNC axis.

(a) Design a discrete controller that will yield "dead-beat" response for this system
(b) Using the direct design method, design a digital controller such that the closed loop system has zero steady state error after two sampling intervals (at k=2) for a unit step input. (Hint: Choose the order of the closed loop transfer function as 2).

2. A continuous system dynamics is represented by

$$G_p(s) = \frac{2}{s(s+2)}$$

Hint: The desired first order response can be obained from

$$T_d = \frac{K(1-\delta)z^{-1}}{1-\delta z^{-1}} \qquad \delta = e^{-T/\tau}$$

(a) Design a discrete controller without feedforward control in order to have approximately first-order response with zero steady state error to a step input with a time constant of 0.06 s and a sample period of 0.01 s.
(b) Generate the response of the controlled closed system response for a unit step input.

3. This problem is based on the example problem 4.11 (pp. 148-149) of the Bollinger's book. After following the problem carefully, answer the following questions.

(a) Design a feedback controller without feedforward control in order to have a zero steady state error for a ramp input of 0.1 m/s.
(b) Calculate the steady state error for the system shown in Figure 4.17 when a 5kg load is added to the arm as a step disturbance.

(c) Suggest a possible scheme to have zero steady state error for a ramp input of 0.1 m/s and a step disturbance of 5 kg.

4. A milling process is to be controlled by a discrete feedforward controller as shown in the Figure 1 with the sampling time of 0.02 seconds. The plant model is given by

$$G_p(s) = \frac{0.6K}{(\frac{s}{35}+1)(\frac{s}{4}+1)}$$

(a) Design a discrete feedforward controller for the system shown in Figure 1 for K=40.

(b) Assume that K_p=0.01 and simulate the response of the system for K=40 for a unit step input with and without feedforward control.