# EE3304 DIGITAL CONTROL SYSTEMS PART II
# TUTORIAL TWO

**Q1**. The transfer function of a pure derivative control is $C(z) = k_d \frac{z-1}{zT}$. It is obvious that the pole at z = 0 adds some destabilizing time lag. Can we remove this time lag by using derivative control of the form $C(z) = k_d \frac{z-1}{T}$? Support your answer with the necessary analysis based on the difference equation.

**Q2.** A revised PID is

$$\frac{U(s)}{E(s)} = k_p + k_i \frac{1}{s} + k_d \frac{s}{1+\frac{s}{N}}$$

where N is a positive integer number.

1) Find its discrete equivalent using backward difference.

2) For a process , $G(z) = \frac{z+b}{(z-a)^2}, |a| < 1$, calculate the position and velocity error constants, hence the steady state errors.

**Q3.** A simple proportional controller, $K$ is used to control a first order plant, $\frac{1}{s+1}$, as shown in Fig. 1. It can be easily verified that the closed loop system is stable for any positive gain. Replace the controller with the digital proportional controller. Consider two cases. For the first case, assuming the sampling period T is fixed, is it possible to make the system unstable by changing the gain K? For the second case, assuming the gain K is fixed, is it possible to make the system unstable by changing the sampling period T?

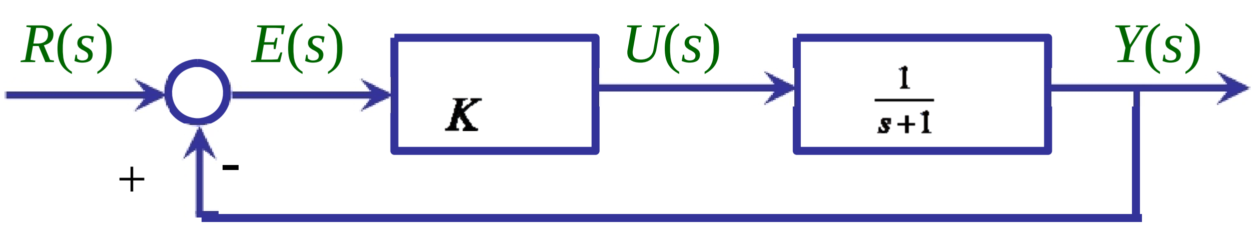


**Figure 1** Digital control system for Q3

**Q4.** An integral controller, $\frac{K}{s}$ is used to control a first order plant, $\frac{1}{s+1}$, as shown in Fig. 2. Find out the range of K for the analog controller such that the closed loop is stable. Assume the sampling period is T=1, replace the analog controller with the digital integral controller which is obtained by backward rule. Find out the range of K such that the closed loop is stable.

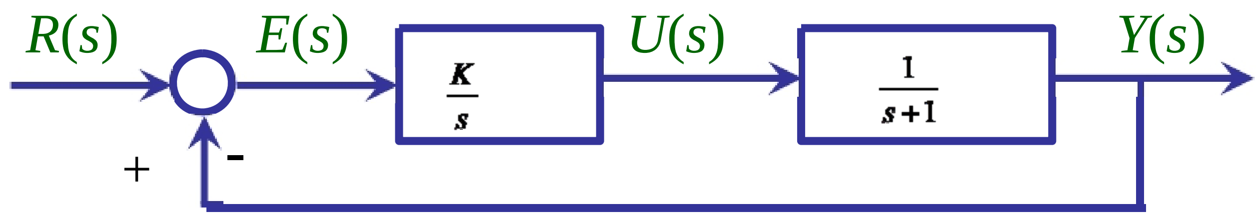


**Figure 2** Digital control system for Q4

**Q5.** Design a digital PD controller C(z) for the plant whose transfer function is $\frac{1}{s^2}$ as shown in Fig. 3. It is desired that the damping ratio $\zeta$ of the closed-loop system be 0.5 and the natural frequency, $\omega_n$, be 4. Choose appropriate sampling period for the digital PD controller, and design the controller.

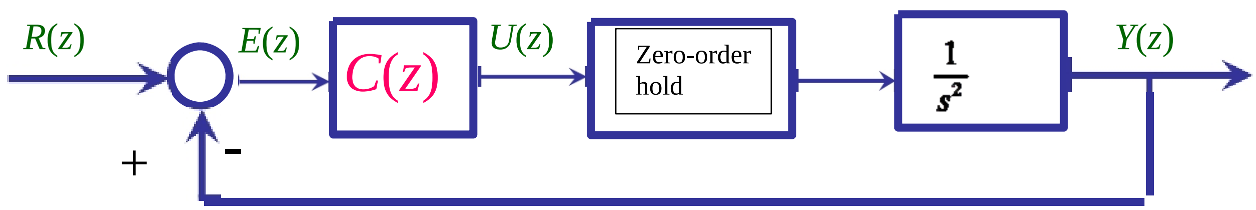


**Figure 3** Digital control system for Q5

**Q6.** Consider the digital control system shown in Fig. 4. Design a digital PI controller C(z) such that the system output will exhibit a deadbeat response to a unit step input. The sampling period is T=1.

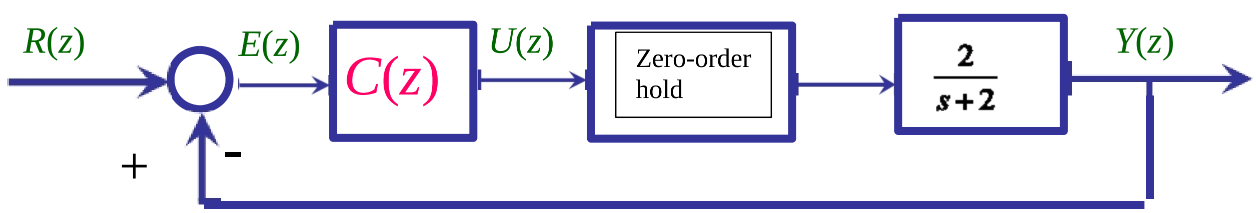


**Figure 4** Digital control system for Q6