EECE 5610 hw4, Due 10/14/2025, Turnitin

1. Problem 6.2.1 text

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6.2-1

Consider the closed-loop system of Fig. P6.2-1.

(a) Calculate and plot the unit-step response at the sampling instants, for the case that $D(z) = 1$.

(b) Calculate the system unit-step response of the analog system, that is, with sampler, digital controller, and data hold removed. Plot the response on the same graph with the result of part (a).

(c) For the system of Fig. P6.2-1, let $D(z) = 1$ and $T = 0.4\,\mathrm{s}$. Calculate the unit-step response and plot these results on the same graph used for parts (a) and (b).

(d) Use the system dc gains to calculate the steady-state responses for each of the systems in (a),(b) and (c). Why are these gains equal?

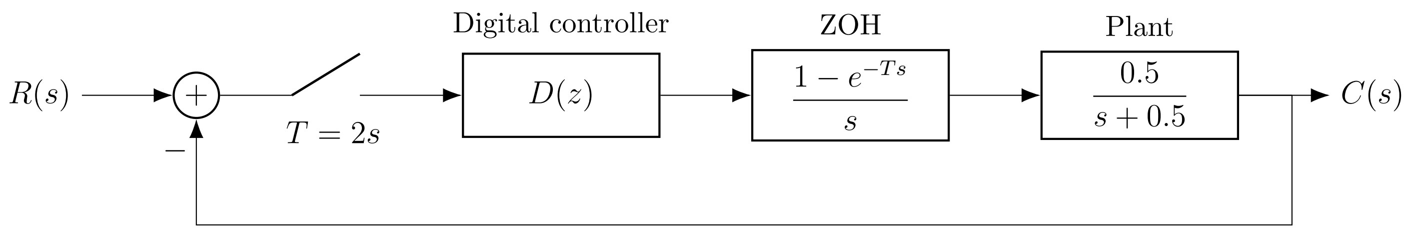

FIGURE P6.2-1 System for Problem 6.2-1

6.2-7

The block diagram of a control system of a joint in a robot arm is shown in Fig. P6.2-7. This system is discussed in Section 1.6. Let $T = 0.1\,\text{s}$ and $D(z) = 1$.

(a) Evaluate $C(z)$ if the input is to command a 20° step in the output and $K = 10$. Note that the system input must be a step function with an amplitude 1.4 V. Why?

(b) Assuming the system to be stable, find the steady-state system output.

(c) Find the (approximate) time required for the system response to reach steady state.

(d) Simulate the system to verify the results in parts (b) and (c).

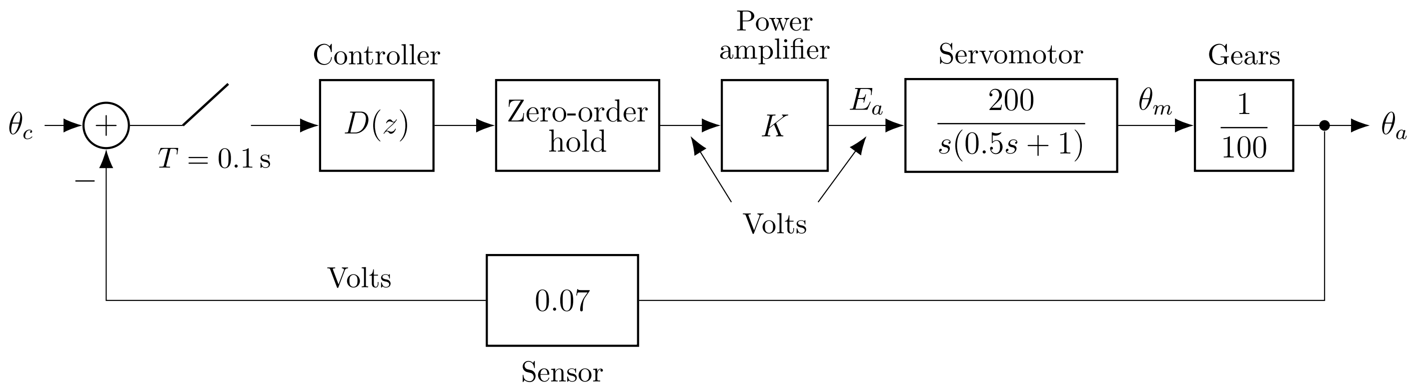

figure P6.2-7 Robot-joint control system (discrete controller with ZOH, amplifier, motor, gears, sensor).

6.4-1

The block diagram of a control system of a joint in a robot arm is shown in Fig. P6.2-7. Let $T = 0.1$ s, $K = 10$, and $D(z) = 1$. The results of Problem 6.2-7 are useful in this problem if these results are available.

(a) Find the damping ratio ζ, the natural frequency ω_n, and the time constant τ of the open-loop system. If the system characteristic equation has two real zeros, find the two time constants. These values can be solved by inspection. Why?

(b) Repeat part (a) for the closed-loop system.

(c) Repeat parts (a) and (b) for the system with the sampler, digital controller, and data hold removed, that is, for the analog system.

(d) Use the results in parts (b) and (c) to find the percent overshoot in the step responses for the sampled-data closed-loop system and for the analog closed-loop system.

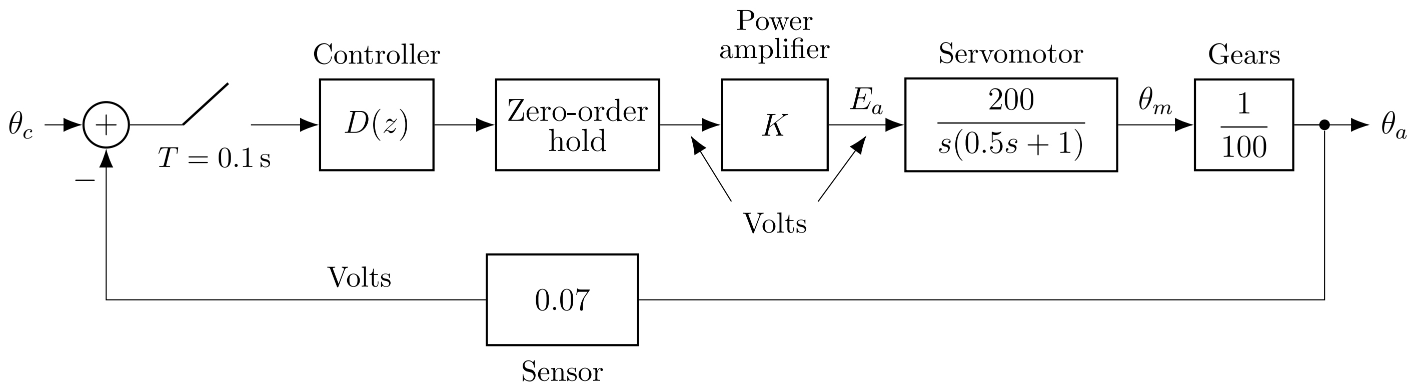

figure P6.2-7 Robot-joint control system (discrete controller with ZOH, amplifier, motor, gears, sensor).

7.2-5

Consider the system of Fig. P7.2-5 with $T = 1\,\text{s}$. Let the digital controller be a variable gain K such that $D(z) = K$. Hence $m(kT) = Ke(kT)$.

(a) Write the closed-loop system characteristic equation.

(b) Determine the range of K for which the system is stable.

(c) Suppose K is the lower limit from part (b) so the system is marginally stable. Find the natural-response term that illustrates the marginal stability.

(d) Repeat part (c) for the upper limit of the range of K.

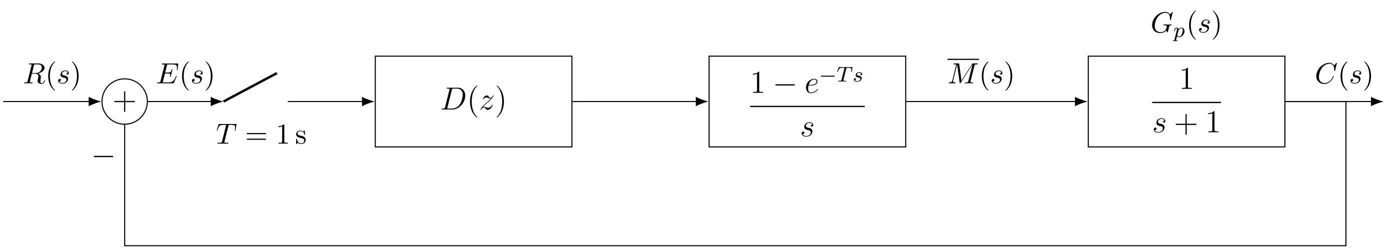

FIGURE P7.2-5 System for Problem 7.2-5 (discrete gain K, ZOH, first-order plant).

7.2-6

Consider the system of Fig. P7.2-5 and let the digital controller be a variable gain K such that $D(z) = K$. Hence $m(kT) = Ke(kT)$.

(a) Write the closed-loop system characteristic equation as a function of sample period T.

(b) Determine the ranges of $K > 0$ for stability for the sample periods $T = 1\,\text{s}$, $T = 0.1\,\text{s}$, and $T = 0.01\,\text{s}$.

(c) Consider the system with all sampling removed and with $G_p(s) = \dfrac{K}{s+1}$. Find the range of $K > 0$ for which the analog system is stable.

(d) Comparing the ranges of K from parts (b) and (c), give the effects on stability of reducing the sample period T.

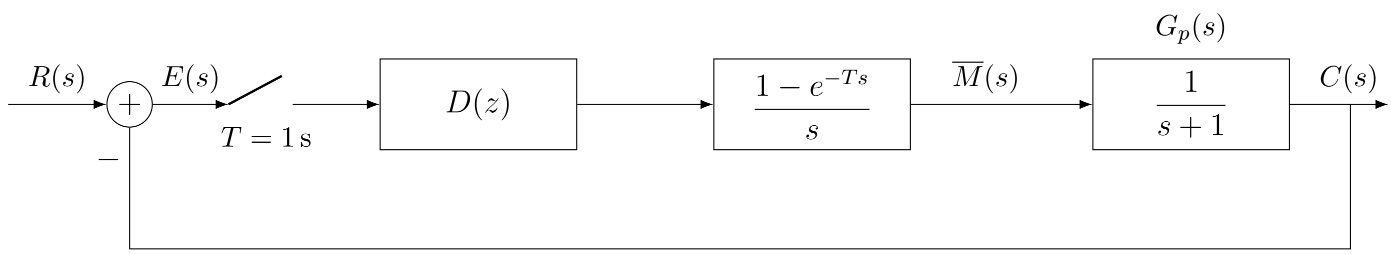

FIGURE P7.2-5 System for Problem 7.2-6 (discrete gain K, ZOH, first-order plant).