Practical Assignment № 1

Digital and Microcontroller Devices

Variant number: 6

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Practical Task 1

1) experimental values（Group 6）

1) Table 1 :

Variant	T_1	T_2
6	0.8	1.1

2) Create a system model in the MATLAB/Simulink simulation environment

- **Mathematical Model:**

$$W_c(z) = \frac{z^2 - 1.612z + 0.649}{z^2 - z}$$

- **Simulation Scheme**

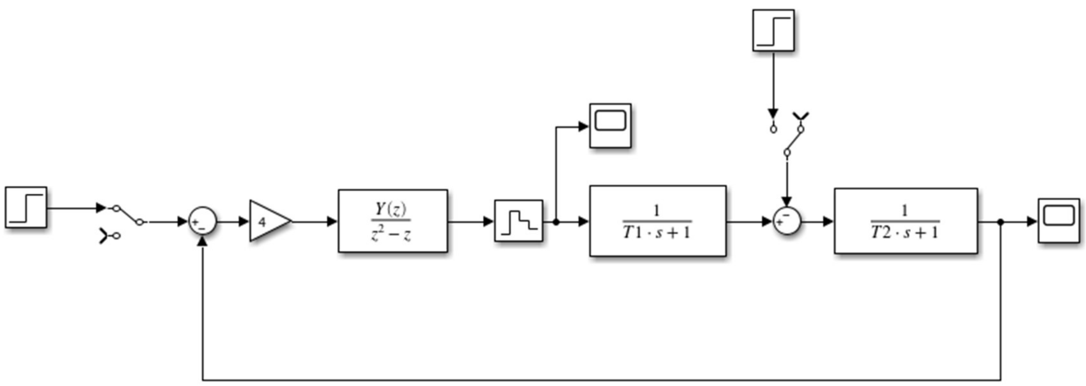

Figure 1: Simulation Scheme.

3) Calculate and set the values of the discrete controller parameters. Find experimentally (by trial and error) the value of the controller gain q_0, at which the system is stable and has weakly oscillatory transients.

- setting the values of the time constants T_1 and T_2 of the control object;

$$T_1 = 0.8 \quad T_2 = 1.1$$

- setting the chosen value of sampling time T;

  Set the value of the sampling time in the zero-order hold as $T = \frac{T_1}{2} = 0.4$

- calculation of the values of the poles $z_1 = d_1 = e^{-\frac{T}{T_1}}$ and $z_2 = d_2 = e^{-\frac{T}{T_2}}$ of the reduced continuous part;

$$z_1 = d_1 = e^{-\frac{T}{T_1}} = e^{-\frac{0.2}{0.9}} \approx 0.60653$$
$$z_2 = d_2 = e^{-\frac{T}{T_2}} = e^{-\frac{0.2}{1.3}} \approx 0.69514$$

- calculation and setting the values of the coefficients of the discrete controller polynomial $\text{num}\,(z) = z^2 + (-d_1 - d_2) + d_1 d_2$

$$\text{num}\,(z) = z^2 + (-d_1 - d_2) + d_1 d_2 = z^2 - 1.30167z + 0.42163.$$

- Find experimentally (by trial and error) the value of the controller gain q_0, at which the system is stable and has weakly oscillatory transients.

  we choose $q_0 = 4$ by trial and error.

- Transfer function of the controller

$$W_c(z) = 4 \cdot \frac{z^2 - 1.301z + 0.421}{z^2 - z}$$

4) Observe and fix the processes at the output of the discrete controller and the system:

- with a stepwise change in the driving force;

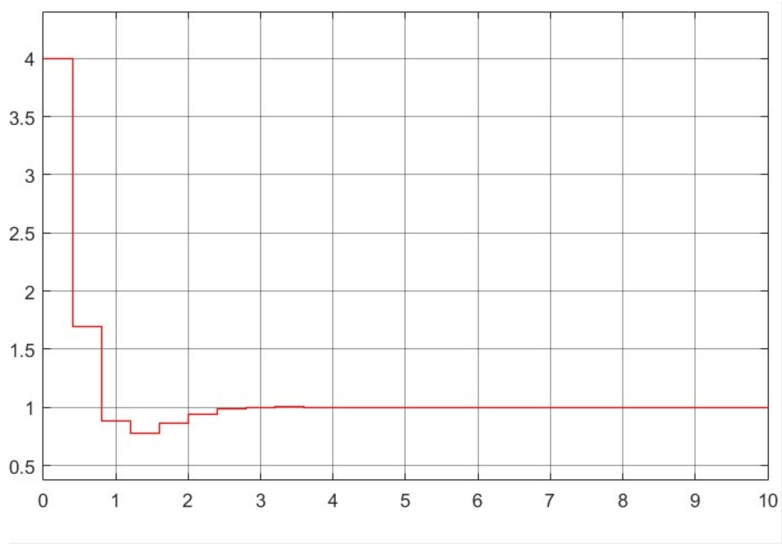

Figure 2: output of the controller only with a stepwise change in the driving force.

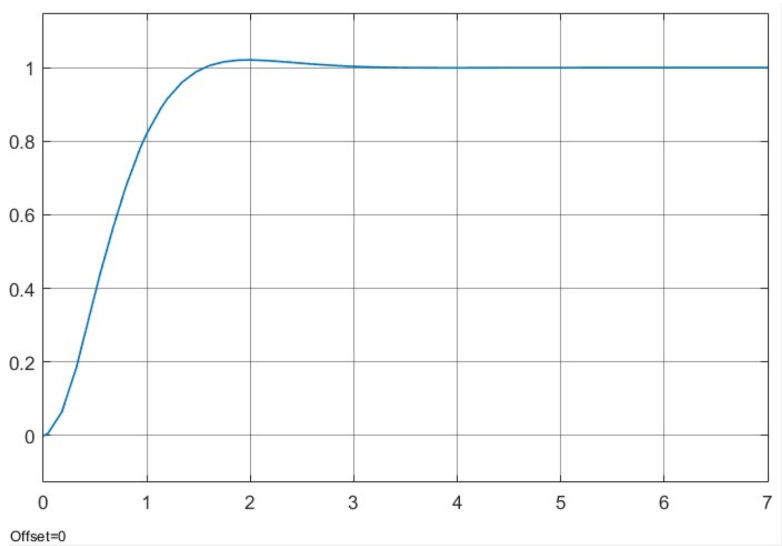

Figure 3: output of the closed system only with a stepwise change in the driving force.

- step change of disturbing influence;

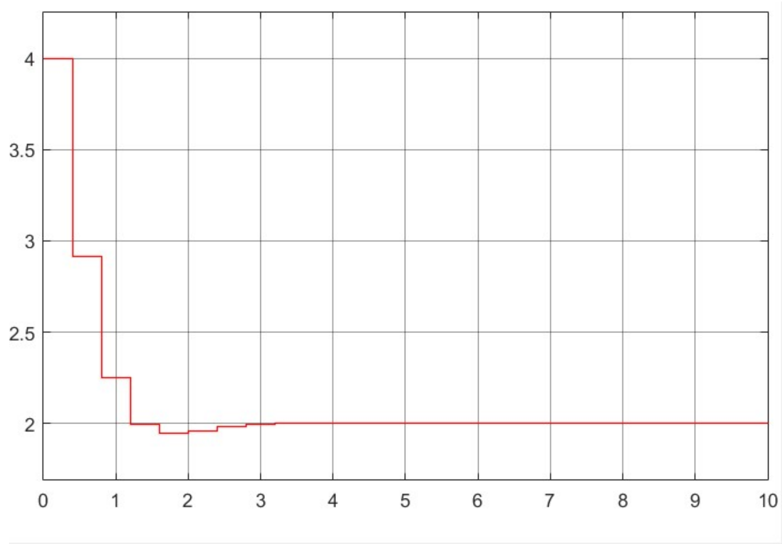

Figure 4: output of the controller with stepwise changes in the driving force and disturbing influence.

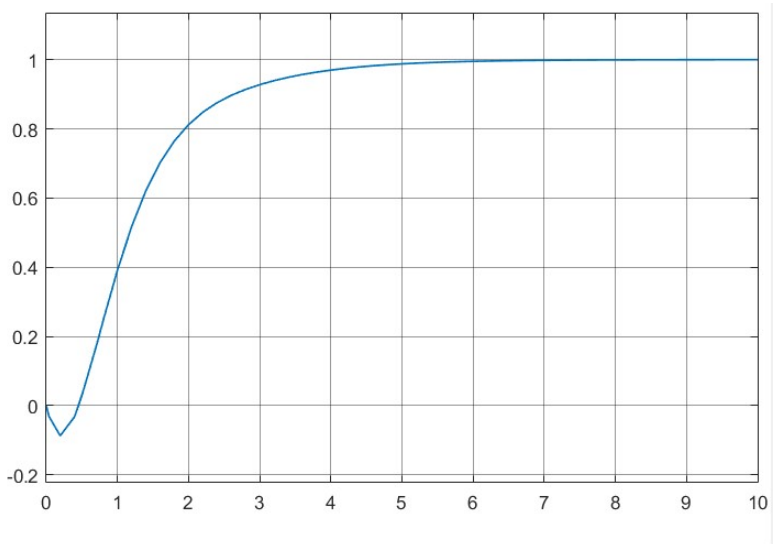

Figure 5: output of the closed system with stepwise changes in the driving force and disturbing influence.

- perturbing action, changing according to a random law.

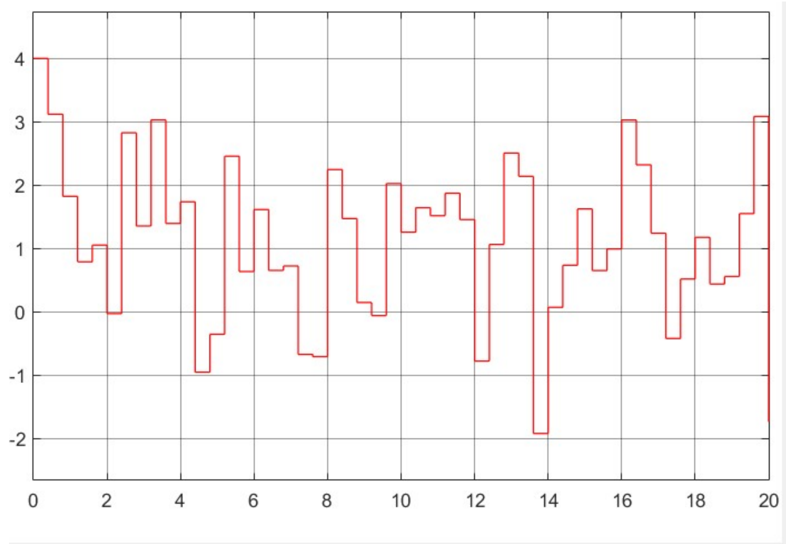

Figure 6: output of the controller with stepwise changes in the driving force and a random perturbing action.

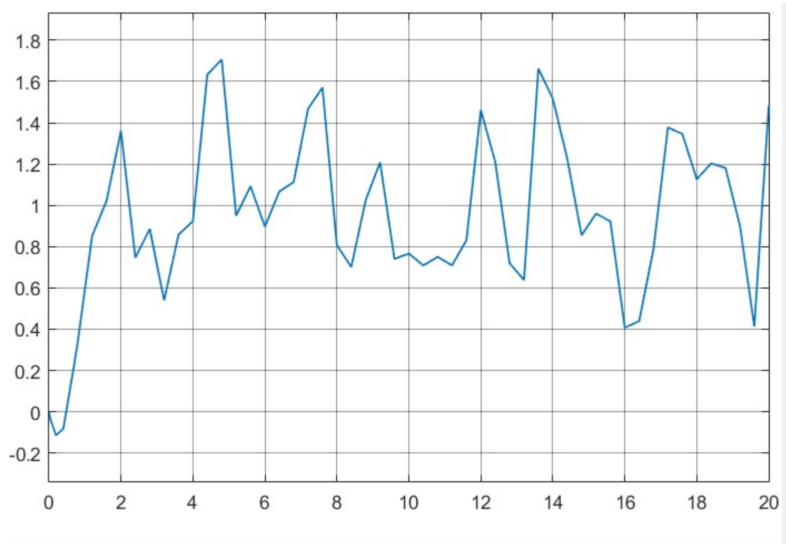

Figure 7: output of the closed system with a stepwise change in the driving force and a random perturbing action.

conclusion:

we get the parameters of the discrete PID controller directly from the discrete model of the control object and the step response of the controller simultaneously meets the specified conditions which are described as $u(0)>u(1)$ and $u(k-1)<u(k)$ when $k\geq2$. Therefore, it’ s properties are similar to those of the continuous PID controller which can be demonstrated by the above simulation results.

5) Investigate the influence of sampling time T on the quality of the control process.

- Change the sampling time to $T = \frac{T_1}{4}$ and q_0 remains unchanging. The new transfer function of the controller:

$$W_c(z) = 4 \cdot \frac{z^2 - 1.612z + 0.649}{z^2 - z}$$

- Simulation results

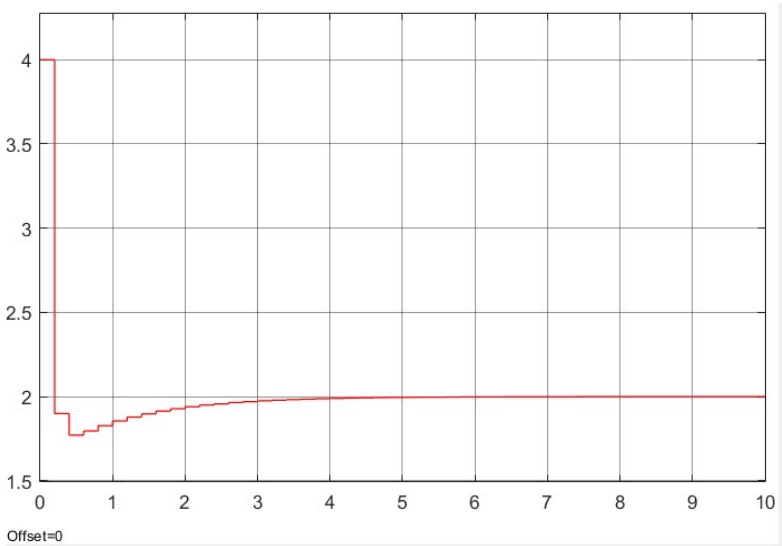

Figure 8: output of the controller with stepwise changes in the driving force and disturbing influence.

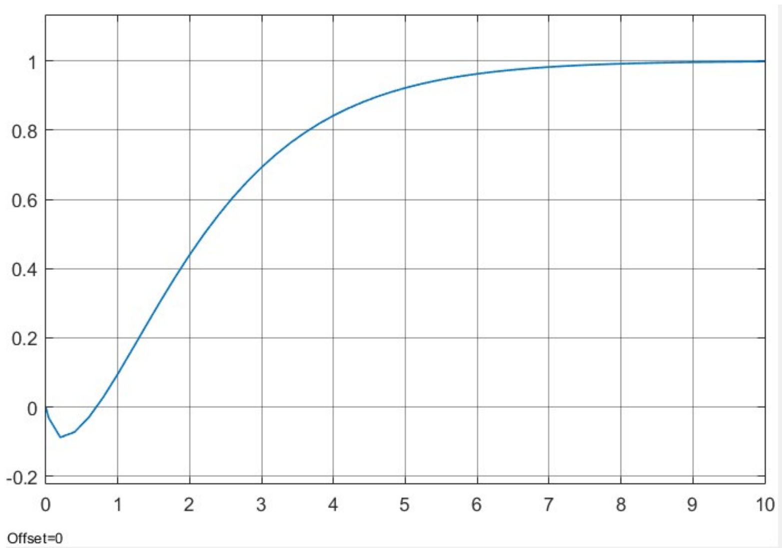

Figure 9: output of the closed system with stepwise changes in the driving force and disturbing influence.

conclusion:

By comparing with the resulting processes of two experiments, it shows that after decreasing the sampling time, the transient time would increase and the control signal would be correspondingly lower.

6) Investigate the influence of inaccuracy of object pole compensation on the quality of the control process

a) Increase the value of the time constant T_2 of control object by 20% to recalculate the parameters of controller.

- Keep the q_0 unchanging. The new transfer function of the controller:

$$W_c(z) = 4 \cdot \frac{z^2 - 1.345z + 0.447}{z^2 - z}$$

- Simulation results

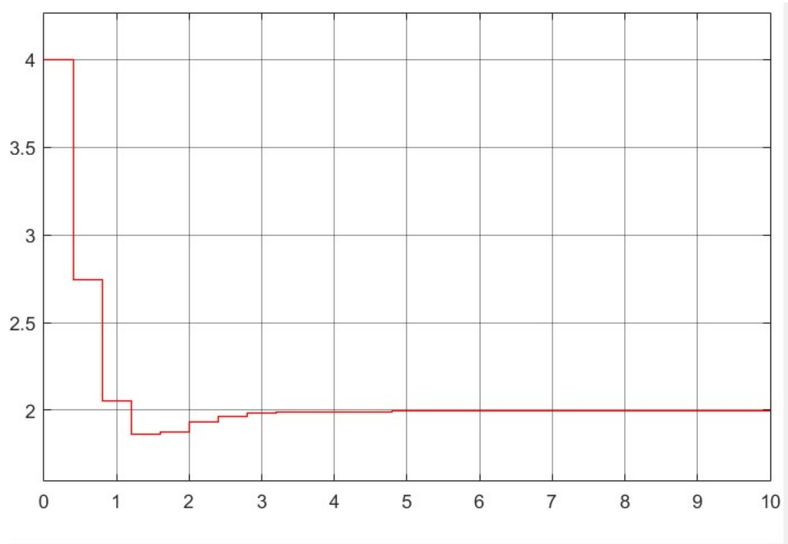

Figure 10: output of the controller with stepwise changes in the driving force and disturbing influence.

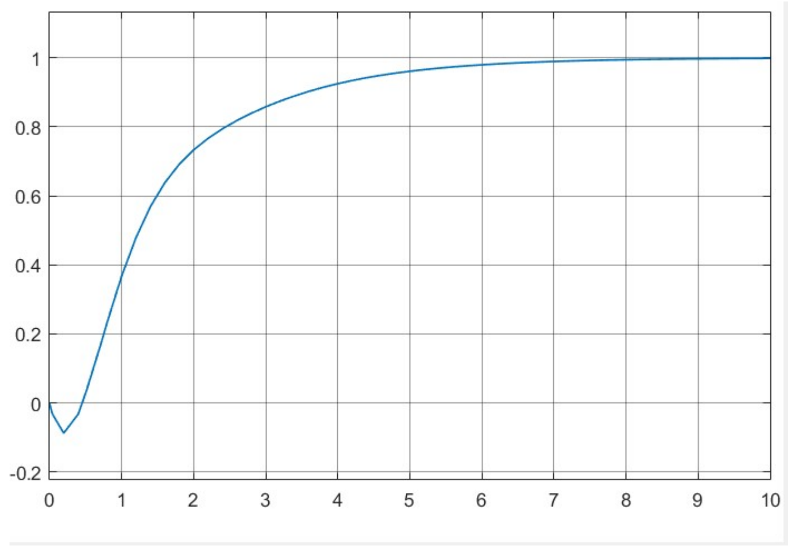

Figure 11: output of the closed system with stepwise changes in the driving force and disturbing influence.

b) **Decrease the value of the time constant T_2 of control object by 20% to recalculate the parameters of controller.**

- Keep the q_0 unchanging. The new transfer function of the controller:

$$W_c(z) = 4 \cdot \frac{z^2 - 1.241z + 0.384}{z^2 - z}$$

- Simulation results

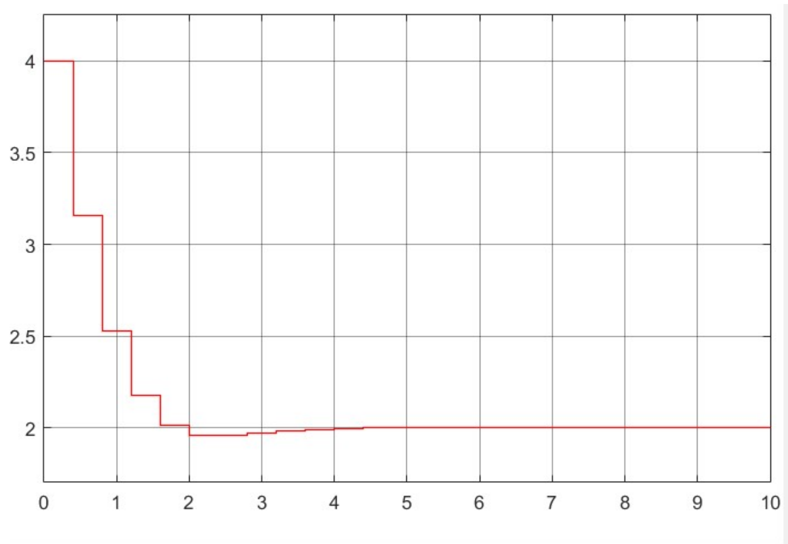

Figure 12: output of the controller with stepwise changes in the driving force and disturbing influence.

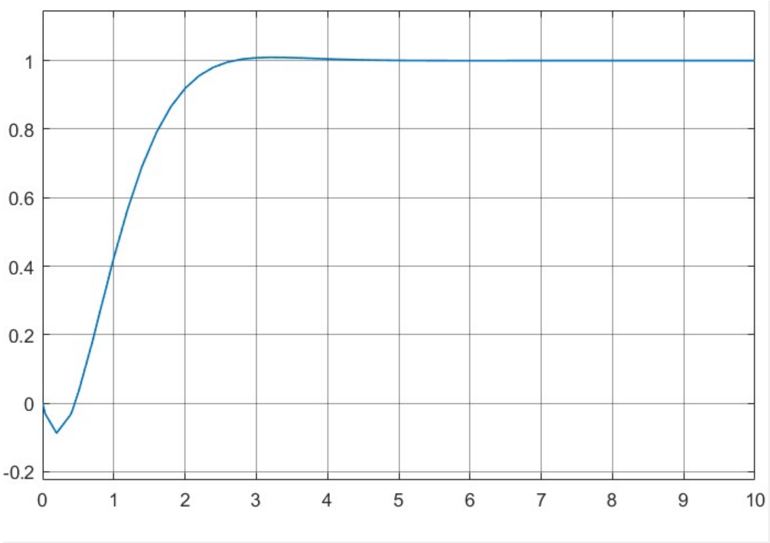

Figure 13: output of the closed system with stepwise changes in the driving force and disturbing influence.

Conclusion:

By comparison, what could be found is that the lager T2 would lead to a slower response speed and a weaker control signal, while the smaller T2 would lead to a quicker response speed and a stronger control signal.