Subjects – System Theory and Automatization – 13.01.2022

Let the control system be characterized by the block diagram given in Fig. 1, where the reference input is $r(t)$ and the control error is $e(t)$.

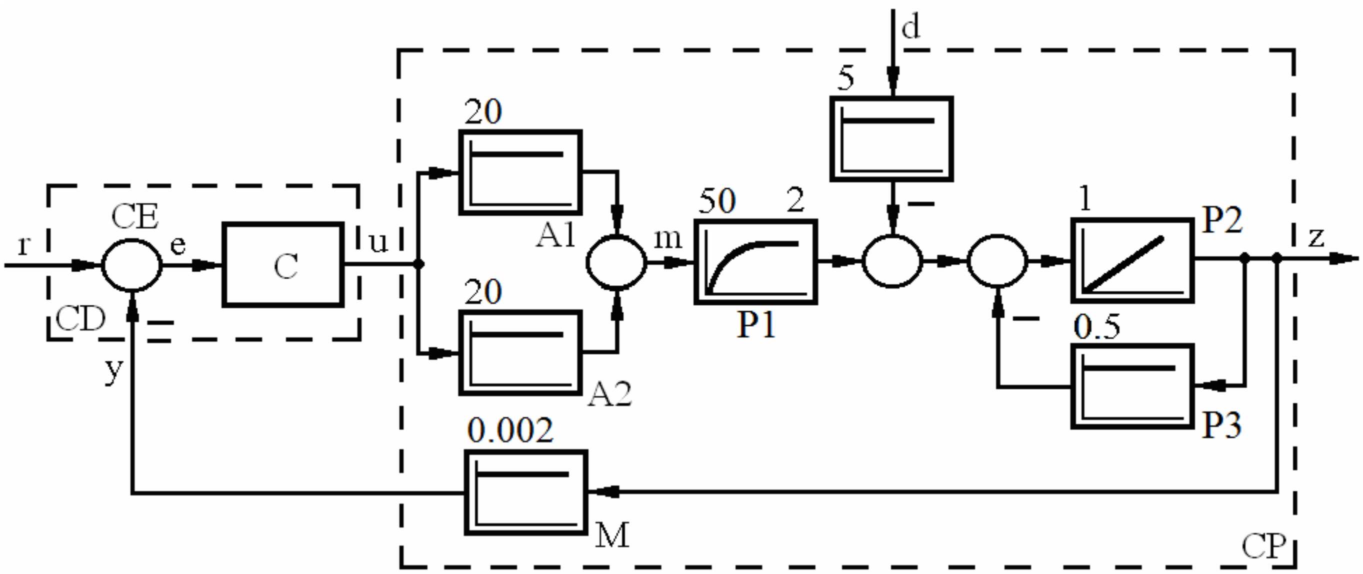

Fig. 1. Block diagram of the control system.

The transfer function of the controller C is

$$C(s) = \frac{k_C\,(1+T_d s)}{1+T_f s}.$$

Tasks:

(1) Calculate the transfer characteristics, i.e., the transfer function with respect to the reference input $H_{z,r}(s)$ (r is the input, z is the output) and the transfer function $H_{z,d}(s)$ with respect to the disturbance input $d(t)$ (d is the input, z is the output).

(2) Considering $k_C > 0$, $T_d = 2.5\,\text{sec}$ and $T_f = 20\,\text{sec}$, investigate the stability of the control system and find the domain of values of $k_C > 0$ that guarantees the stability of the control system.

(3) Using $T_d = 2.5\,\text{sec}$, $T_f = 20\,\text{sec}$, and setting a value of $k_C > 0$ such that the control system is stable, if the steady-sate values of the system inputs are $r_\infty = 5$ and $d_\infty = 200$, calculate the steady-state values $\{e_\infty,\ u_\infty,\ m_\infty,\ z_\infty,\ y_\infty\}$.

(4) Using the controller parameter values at point (3), calculate the open-loop transfer function $H_0(s)$ and the two parameters k_r and k_d of the input-output static map $z_\infty = k_r r_\infty + k_d d_\infty$. Which is the value of the static coefficient?

(5) Using the controller parameter values at point (4) and assuming that a fault happens making the block P3 out of operation, analyze the effects on the point (3) (the control system stability) and the point (4) (the input-output static map).

(6) Determine the values of the parameter b that guarantees the stability of the discrete-time linear system with the transfer function

$$H(z) = \frac{6z^2 - 3z + 0.5}{z^3 - 2z^2 + (1.4 - b)z - 0.1}.$$

Grades: start: 1, (1): 1, (2): 2, (3): 2, (4): 1, (5): 1, (6): 2. Total: 10.