ID-5004W: AI in Predictive Maintenance, Reliability, and Warranty
April – July 2023

Home Assignment - 02

Due: Wednesday, May 24th

Instructions

- Make any additional assumptions if needed and justify your assumption.
- Please submit your own work.
- Attach the codes and results for the respective questions if MATLAB or any software is used.

Problem - 1: Step Response

A unit step is applied at t=0 to a first-order system without time delay. The response has the value of 1.264 units at t=100 sec and 2 units at steady state. What is the transfer function of the system?

Problem - 2: Step Response

Let c (t) be the unit step response of a system with the transfer function:

$$G(s) = \frac{K(s+a)}{(s+K)}$$

If $c(0^+) = 2$ and $c(\infty) = 10$, then what are the values of 'a' and 'K'?

Problem - 3: Second-order transient response

The transfer function of the system is

$$G(s) = \frac{100}{(s+1)(s+150)}$$

What is the approximate settling time for the 2% criterion for a unit step input to the system?

Problem - 4: Second-order transient response

Which of the following transfer function will have the greatest maximum overshoot? Give reasons for your choice.

(a) Option 1: $\frac{9}{(s^2+2s+9)}$

(b) Option 2: $\frac{16}{(s^2+2s+16)}$

(c) Option 3: $\frac{25}{(s^2+2s+25)}$

(d) Option 4: $\frac{36}{(s^2+2s+36)}$

Problem - 5: Transient response

The output of the system in response to a unit step input is $c(t) = 1 - e^{-t}$. What is the delay time (t_d)?

Problem - 6: Steady-state error

For the given system in Fig. 1, e_{SS} = -4.45 due to unit step input and unit step disturbance. Find the value of gain K.

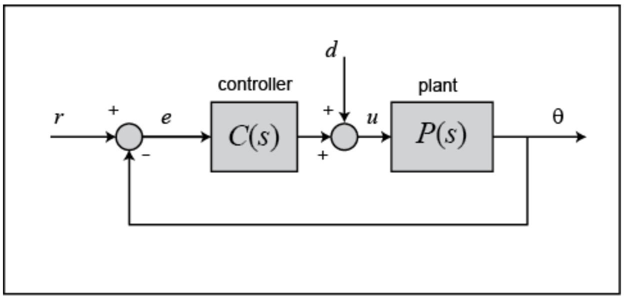

Figure 1: Plant and controller setup

Where, $C(s) = \frac{1}{(s+5)}$ and $P(s) = \frac{K}{(s+2)}$

Problem - 7: Steady-state error

Consider a unity feedback system with a transfer function given by

$$G(s) = \frac{1}{(s+1)(s+2)}$$

What is the steady-state error in the output of the system for a unit-step input?

Problem - 8: Steady-state error

In the given Fig. 1, the plant (P(s)) and the final control element (C(s)) models are given by:

$$P(s) = \frac{2.2}{(1+0.1s)(1+0.4s)(1+1.2s)}$$

$$C(s) = K\,\frac{(1+\,T_1 s)}{(1+\,T_2 s)}$$

The external disturbance input is D(s). It is desired that when the disturbance is a unit step, the steady-state error should not exceed 0.1 unit. What is the minimum value of K?

Problem - 9: Gain and Phase plots

Construct the Gain and Phase plots for the following transfer functions

(a) Real pole $C(s) = \frac{100}{(30+s)}$

(b) Real poles and zeros $C(s) = 100\,\frac{(s+1)}{(s^2+110s+1000)}$

(c) Pole at the origin $C(s) = 10\,\frac{(10+s)}{(s^2+3s)}$

(d) Repeated real poles, a negative constant $C(s) = -100\,\frac{s}{(s^3+12s^2+21s+10)}$

(e) Complex conj. Poles $C(s) = 30\,\frac{(s+10)}{(s^2+3s+50)}$

(f) Multiple poles at origin, complex conj zeros $C(s) = 4\,\frac{s^2+s+25}{(s^3+100s^2)}$

Problem - 10: Gain and Phase

Evaluate Gain and Phase for the given transfer function for w = 2.5 rad/s.

$$C(jw) = \frac{(jw+3)}{(jw+2+\,j1.75)(jw+\,2-j1.75)}$$

Problem – 11: Corner frequency

Obtain the corner frequencies of the following transfer functions

(a) $C(s) = \frac{10}{(0.66s^2+2.33s+1)}$

(b) $C(s) = 10\,\frac{(1+0.2s)}{(1+0.5s)}$

Problem – 12: Time domain and frequency domain

Derive the relationship between the rise time for a second-order system (in the time domain) and the corner frequency (in the frequency domain).