Master study
Systems and Control Engineering
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SCE1106 Control Theory

Exercise 7

Introduction

We will in this task study the theory of frequency analysis. In particular definitions as; frequency response, polar form of the frequency response, magnitude and phase shift are studied. We will also compute the phase crossover frequency, ω_{180}, Gain Margin, GM, gain crossover frequency, ω_c, and Phase Margin, PM. We will also design a PI controller such that the closed loop feedback system obtain a prescribed Gain Margin, GM. Finally, the closed loop is simulated and compare the settings found from frequency analysis with the Skogestad settings found in Exercise 6.

Task 1

Consider a system/process described by the model

$$y = h_p(s)u \tag{1}$$

$$h_p(s) = \frac{e^{-2s}}{s^2+3s+2}. \tag{2}$$

which is to be controlled by a PI controller of the form

$$u = h_c(s)e \tag{3}$$

$$e = r - y \tag{4}$$

$$h_c(s) = K_p\frac{1+T_is}{T_is}. \tag{5}$$

where r is a specified reference signal. Note that this system is the same which was studied in Task 1, Exercise 6.

a) We will in this task chose the integral time constant, T_i, equal to the dominant time constant in the process. The reason for this choice is to simplify the loop transfer function, $h_0 = h_ph_c$. The dominant time constant in the process is usually the largest time constant in the process, $h_p(s)$. Find the integral time constant, T_i.

b) We shall in this subtask define and compute the following:

1. Define the loop transfer function, $h_0(s)$.
2. Define the frequency response of the loop transfer function, $h_0(s)$

3. Write the frequency response on polar form. In particular define the magnitude, $|h_0(j\omega)|$, and the phase shift $\angle h_0(j\omega)$.

c)

1. Compute the phase crossover frequency, ω_{180}.
2. Compute K_p such that the gain Margin becomes, $GM = 2$.
3. For this choice of K_p compute the gain crossover frequency, ω_c.
4. What is the Phase Margin for the closed loop system, PM ?

d) Simulate the closed loop system after a unit step response in the reference signal, r. Compare the settings with the PI-controller settings found by the Skogestad method in Exercise 6.