Control Systems: Competition 2
Due: 2020/1/3 12:00

Problem Description

The frequency responses of an open-loop plant $P(s)$ is shown in Fig. 1(a). $P(s)$ is assumed as a minimal phase system with no poles and zeros on the RHP. Fig. 1(a) indicates the output response of a 1 mm sinusoidal input with different frequencies. The raw data and source code generating Fig. 1(a) are given in *FreqDataP.mat* and *main.m*, respectively.

The architecture of the closed-loop feedback control system is shown in Fig. 1(b). Please design a feedback controller $C(s)$ and a feed-forward controller $F(s)$ to track the given reference signal and to optimize the tracking performance according to the given cost function J as defined below, i.e., design the controller $C(s)$ and $F(s)$ that minimizes the cost J. Note that the control input is limited between 200 and -200, and there exist input disturbance $w(t) = 0.1sin(5\pi)$. The reference generation, the control simulation, and the computation of the cost function can be done by directly running *main.m*.

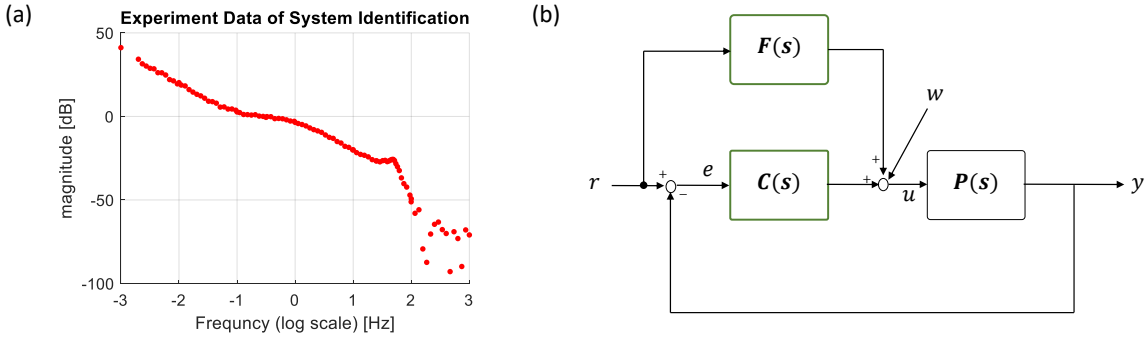

Figure 1: (a) The experiment data. (b) The architecture of feedback and feedforward control.

Hint

1. The optimal design of the feedforward controller is $F(s) = P^{-1}(s)$;
2. To make $F(s)$ be causal (i.e., the degree of the denominator is greater or equal to that of the numerator). Thus, $F(s)$ should be modified as $F(s) = Q(s)P^{-1}(s)$, where $Q(s)$ is a low-pass filter.

Cost Function

$$J := 1000\sqrt{\frac{\sum_{k=1}^{N} e^2(k)}{N}} + \frac{\sum_{k=1}^{N} u^2(k)}{10^7} \tag{1}$$

where $e(k) := r(k) - y(k)$ is the error signal, $u(k)$ is the control input, $k = 1, ..., N$, N is the length of the reference and k is the discrete time index.

The evaluation of this assignment is based on the final cost you get, as illustrated in Fig. 2. Note that if your controller is designed as $C(s) = 0$ and $F(s) = 0$, the competition score will go zero no matter what cost you get.

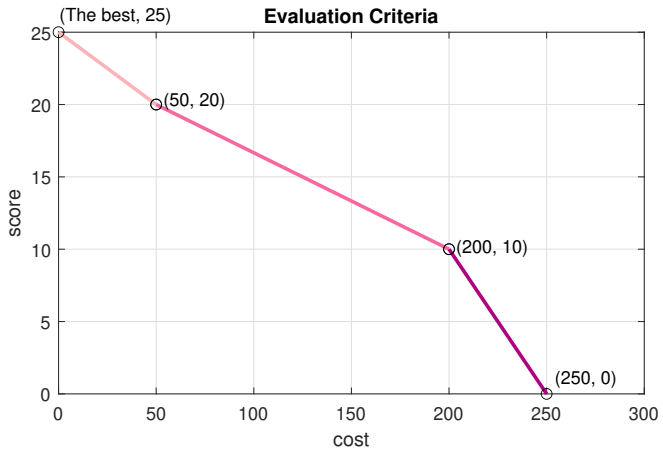

Figure 2: The evaluation criteria.

Submission

1. Please describe how you designed the controller $C(s)$ and $F(s)$. If your controller is designed as $C(s) = 0$ and $F(s) = 0$, the competition score goes zero no matter what cost you get.
2. Save your report in PDF format, zip it together with your .m files and upload to NTU COOL. Name your file as [Student ID]_competition2.zip .

Warning: If you plagiarized other's design, the competition score goes zero.