ME46085 Mechatronic System Design - 2022/2023 Q2
Assignment – Dynamic Error Budgeting (Part 3)

In this part of the assignment, the plant model (P) of the ideal motion system (transfer function $\frac{x_2}{F_1}$ derived in Q3, Part 1) is considered. The general block diagram of the system is presented in Fig.1.

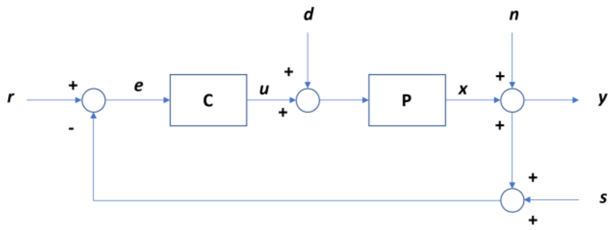

Figure 1: Block Diagram of the System

Mandatory Part: (5%)

It is given that a reference signal (**r**) of *1mm*, process disturbance (**d**), and output disturbance (**n**) of *1N* and *1mm* act on the closed-loop system, respectively. Here, two different cases for the controller will be considered.

Case 1:

1. Design a tamed-PID controller (no additional terms) for a bandwidth of 100 Hz, using the rules of thumb.
2. Compute the total error of the system at 10 Hz.

Case 2:

3. Suggest at least two methods to reduce the total error of the system obtained in Q2.
4. Modify the controller from Case 1 (by adding additional elements) to reduce the total error of the system at 10 Hz by 1/10th the magnitude obtained in Q2.
5. Examine and comment on the pros and cons of the solution implemented in Q4.

Bonus Part: (5%)

It is recommended that students go through **Lecture 8**, **Chapter 8.1**, and **DEB Mikroniek_2011-2.pdf** provided on Brightspace to understand and attempt this part.

Now, three different signals (acting simultaneously on the system) are considered:

- a multi-sine signal corrupted with noise as process disturbance (**d** (N)),
- a random output disturbance (**n** (mm)),
- and a white sensor noise (**s** (mm)).

The signals are provided in the file **DEB_Part3.mat** in the order [d, n, s]. The sampling frequency is 8000 Hz. The closed-loop system with the two controllers designed (Case 1 and 2) will be considered separately and **compared**.

6. Plot the provided time signals in the time and frequency domain.
7. Compute and plot the single-sided power spectral density (PSD) of each of these three signals (**d, n, s**).

8. Compute and plot the cumulative power spectrum (CPS) for each of the three signals (**d, n, s**), and calculate their error contribution.
9. Compute and plot the combined PSD of the output signal (**y**) using the PSDs of signals obtained in Q7 and their corresponding closed-loop transfer functions.
10. Compute and plot the cumulative power spectrum (CPS), for the output signal (**y**) of the closed-loop system. Calculate the total error of the signal.
11. Comment on the differences observed between the results corresponding to the two controller cases considered.
12. Determine the different frequency components of the multi-sine in the process disturbance signal.
13. What is the physical interpretation of the PSD and CPS computed in previous questions?
14. Suggest methods to reduce the total output error of the system, based on the knowledge of the system from Part 1 of the assignment.