DESIGN, IMPLEMENTATION AND ANALYSIS OF A CONTROL SYSTEM

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Executive Summary

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1 Methodology

A test rig (see figure 1) controlled by two brushless DC motors is subjected to a 20° step input.

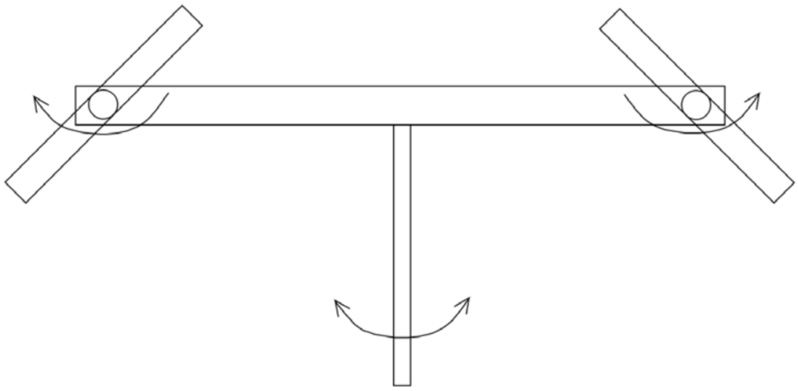

Figure 1: A front view of the test rig system (Hann, 2019).

A feedback control system was designed and implemented to meet the following design specifications:

$$\xi > 0.1 \qquad M_p\% < 15\%$$

$$e_{ss} < 1.5^\circ \qquad t_r < 0.8\text{s}$$

$$1 \leq K_p \leq 2.5 \qquad \frac{K_d}{K_p} < 0.7$$

The predetermined gain values were found using an iterative approach. The transfer function (see equation 1), with the suggested parameters $\alpha = 1.6$, $\beta = 2.9$, $\gamma = 1.3$ and $\tau = 0.34$, was used with MATLAB to predict how output would be affected by the gains and the step input.

$$\frac{X}{R} = \frac{\beta K_p s + \beta K_i}{s^3 + s^2(\alpha + \beta K_d - \beta K_p \tau) + s(\gamma + \beta K_p - \beta K_i \tau) + \beta K_i} \tag{1}$$

Three sets of predetermined gain values were ultimately decided on:

$$\begin{aligned} &\text{P Controller}: && K_p = 1.20 \\ &\text{PD Controller}: && K_p = 1.20 && K_d = 1.20 \\ &\text{PID Controller}: && K_p = 1.20 && K_d = 0.72 && K_i = 0.84 \end{aligned}$$

By using three different controllers, we were able to analyse the differences between them and to better understand the relationship between the step input, the gains, and the output.

The P Controller would be expected to overshoot the target angle and then overshoot in the other direction, oscillating until it comes to a rest near the target angle. This would be an example of an underdamped system. The PD Controller would be expected to slowly converge upon the target angle with little or no overshoot (depending on the damping coefficient). A relatively large steady-state error (e_{ss}) would be expected. This would be an example of an overdamped system. The PID Controller is expected to overshoot but then quickly converge towards the target angle. This would be an example of a critically damped system.

2 Results

3 Discussion

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4 Conclusion

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