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| **MEMORANDUM** | |  | |
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| **To:** | Hans Mayer, Lecturer, Department of Mechanical Engineering, Cal Poly SLO | | |
|  | hmayer@calpoly.edu | | |
| **From:** | Rahul Goyal & Keyanna Henderson | |
| **Date:** | March 11, 2019 | | |
| **Subject:** | Hydraulic Positioning System | | |
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This document summarizes the results of the Hydraulic Positioning System experiments performed during late-February to early-March of 2019. The objectives of these experiments were to create a closed-loop Simulink model reflecting the behavior of a hydraulic positioning system, observe the effect of different controllers on system behavior, and analysis of the system’s transfer function via block diagram algebra and root locus. The experimental apparatus consisted of a compressed air supply, servo valve, piston, and the mass to be moved. A Sinulink-based controller was used to output a voltage to the servo valve (via a servo amplifier) such that the piston, and therefore the position of the mass, could be controlled.

The methodology in developing a Simulink model that accurately represents the system involves determining a few gains and model parameters experimentally. With the system depressurized, data was collected at a range of input voltages to increase accuracy and account for bias when determining the potentiometer and flow rate gains. The slopes of the best-fit lines were input in a model that controls variables based on deviation from steady-state. To determine the model parameters, namely the ratio of the bulk modulus of the fluid to the total volume of fluid (β/Vt) and flow to pressure gain (Kce), the system was pressurized and run with a P-only controller. The proportional gain was increased incrementally until the hydraulic positioning just barely reached instability – this point was considered to be marginally stable, and data collected with this system was assumed to have a damping ratio of 0 in subsequent analysis. This reasonable assumption allowed for an adequate simplification of developed equations which, in turn, allowed for the calculation of β/Vt and Kce. With all gains and model parameters determined, the Simulink model was completed and verified with other controllers against experimental results for accuracy.

Analysis of the system's open loop transfer function shows that it is a type 1 system when using a P-only or PD controller. Adding an integral component to the controller changes the system to a type 2 system. As expected for a type 1 system, the results show no steady-state error regardless of the controller used for a step input, but a finite steady-state error for a ramp input unless an integral component was present in the controller. Noticeably, using a derivative component helped improve the response time of the system due to its derivative kick. It also allowed for higher proportional gains without driving the system to instability. Thus, we found the best controller for a system expecting step inputs to be a PD controller and the best controller for a system expecting ramp inputs to be a PID controller.

[CONCLUSION]

Best controller?

Root locus?