MEC-E5002 - Mechatronics Project

Aalto University
School of Engineering

Hardware-In-the-Loop Test Setup for Tuning Semi-Active Hydraulic Suspension Systems

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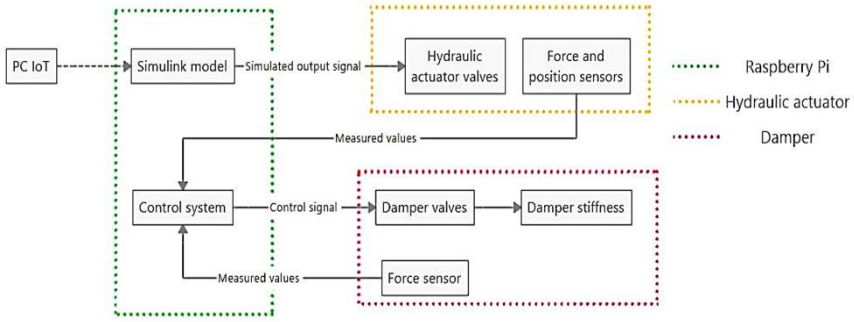
Background:
Semi-active control strategies for hydraulic dampers have been developed to enhance the performance of the passive suspension systems. In order to test and tune the suspension systems, the characteristics of the system hardware must be obtained. Software-only test setups have challenges to achieve accurate simulation results because of phenomena like friction or hysteresis of the hydraulics which are difficult to simulate. On contrary, hardware-only test setups are accurate but they are substantially costly and time consuming. Thus, Hardware-in-the-loop (HIL) simulation system as a compromised solution is applied to the test setup for tuning semi-active hydraulic suspension systems. In HIL simulations hard-to-simulate components of the simulation systems are replaced with real hardware in order to get more accurate results.

HIL simulations are commonly made using high-performance electronic platform Field-programmable gate arrays (FPGA). However, the FPGAs require PC add-on cards for efficient communication interfaces for simulation which are significantly more costly than single board computers (SBC) such as Raspberry Pi boards.

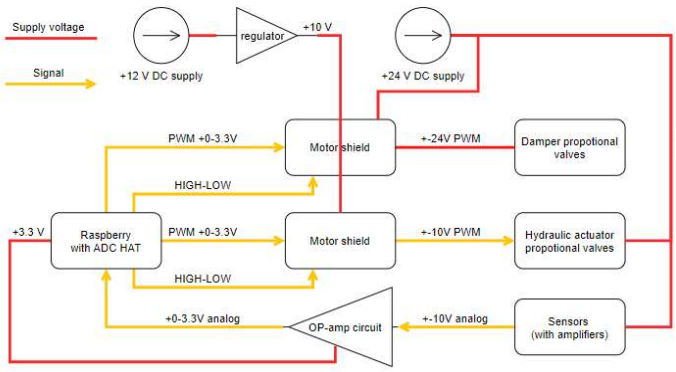
Objective:
Design a light SBC based HIL test setup to enable easy implementation of a low-cost control system for semi-active hydraulic damping.

Methods:
Hydraulic test bench was built and tested through RPi. The control unit was designed and its parts were validated separately. A simple simulink model was created for the control.

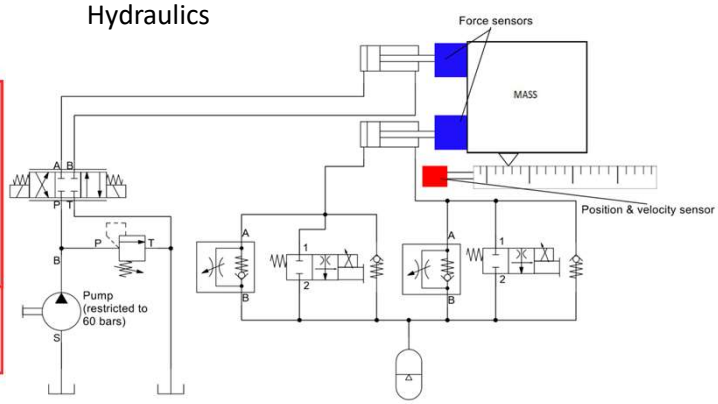
System principle



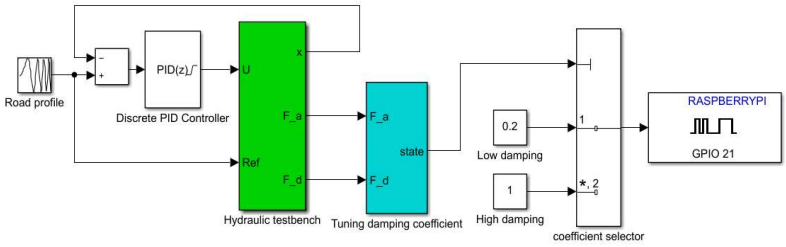
Electronics



Hydraulics



Simulink model



Results:

- The hydraulic test bench was validated by driving the hydraulic actuator with test Simulink models running on the RPi
- IoT capability was validated by uploading and running Simulink model on the board and tuning model parameters during control system simulations.
- The level shifter OP-amp circuit was tested with a force sensor circuit of the test bench. The functionality of the OP-amp circuit was successfully validated