Development of a Control System and User Interface for the Quanser Shake Table II

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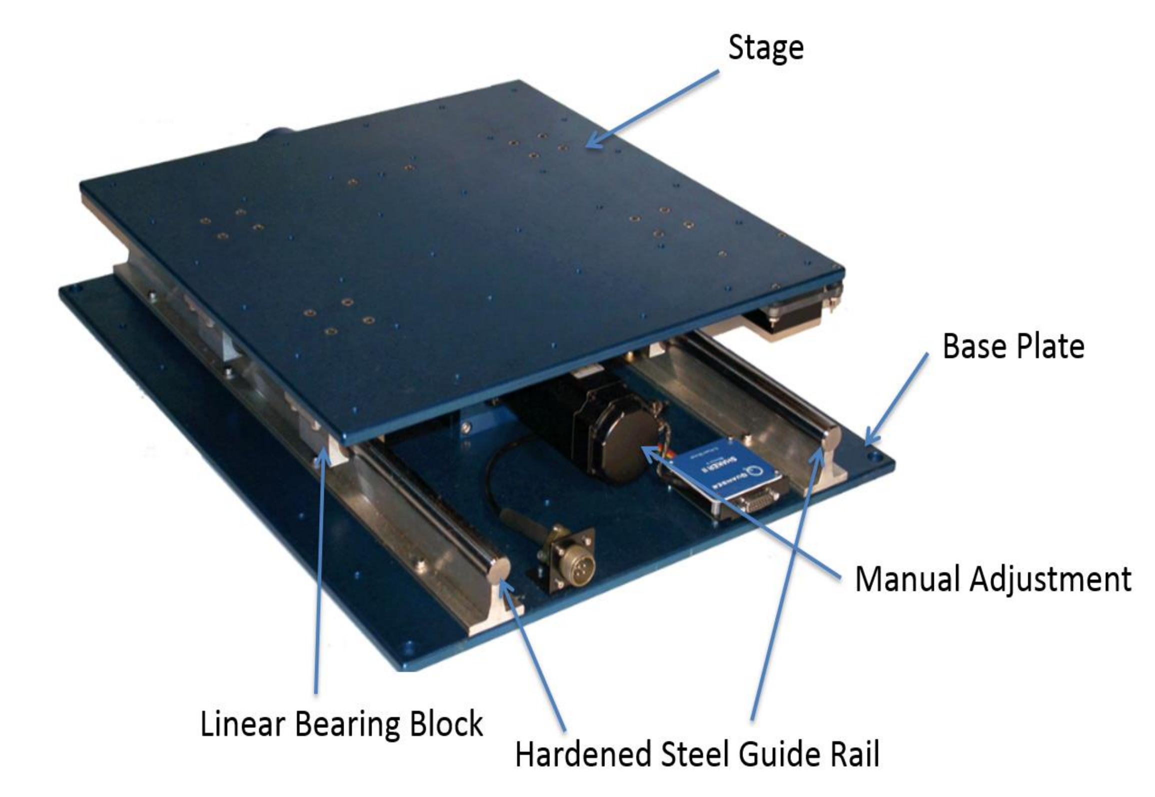


Quanser Shake Table II

Introduction

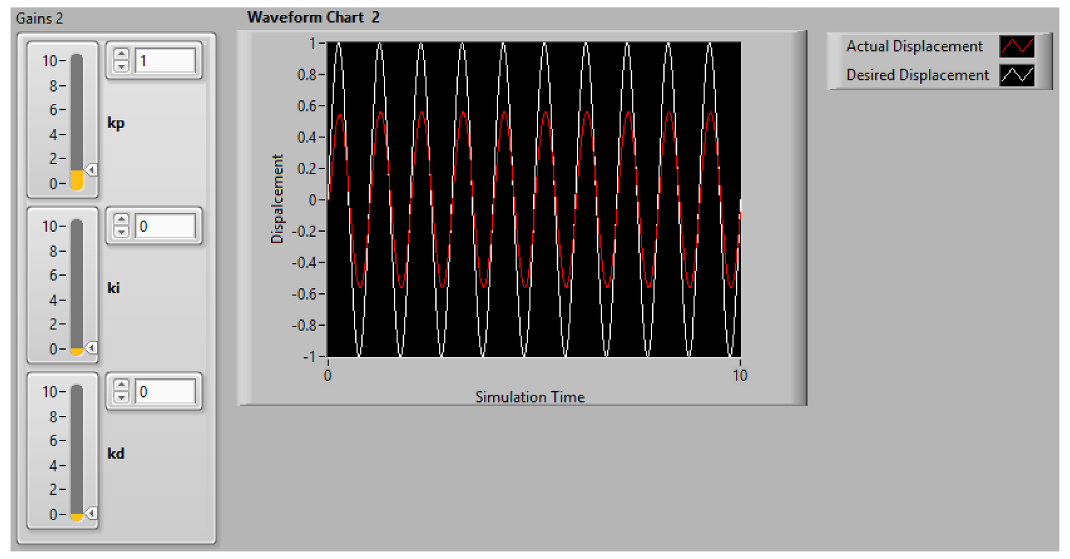
- Shake tables are often used to simulate earthquakes to test the performance of structures under seismic loads. This research focused on implementing the Quanser Shake Table II – a valuable tool for conducting small-scale experimental vibration tests.
- The original hardware and software system has, at best, 12 bits of resolution. However, using the NI compactRIO with LabVIEW, 16 bits of resolution can be achieved. Therefore, using compactRIO and LabVIEW to control the shake table can produce better results for vibration testing compared to the original configuration.
- Without a controller, it would be more difficult to predict how a system responds. Introducing a closed-loop control system allows the user to better predict the shake table response by moving the shake table in the way the user desires.

Goals

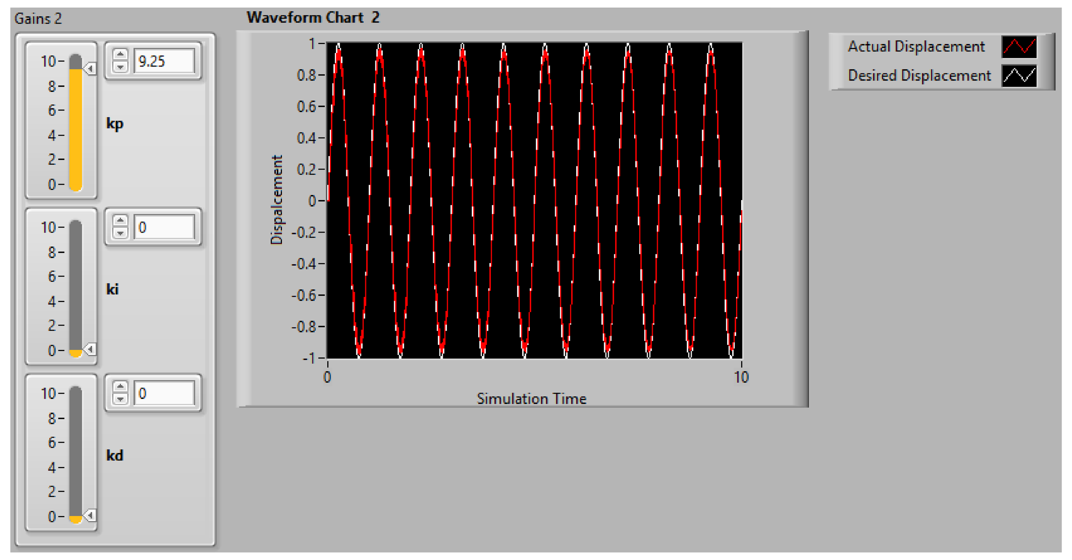
- Simulate displacement-based control system in MATLAB.
- Implement a working control system on the actual shake table.
- Further develop the user interface of the LabVIEW program that allows the user to set the motion of the shake table, such that users can easily input a sine wave, random excitation, or even upload their own input file.
- Enhance programming skills by participating in LabVIEW workshop training and CLAD exam.

Importance of the Closed-Loop System

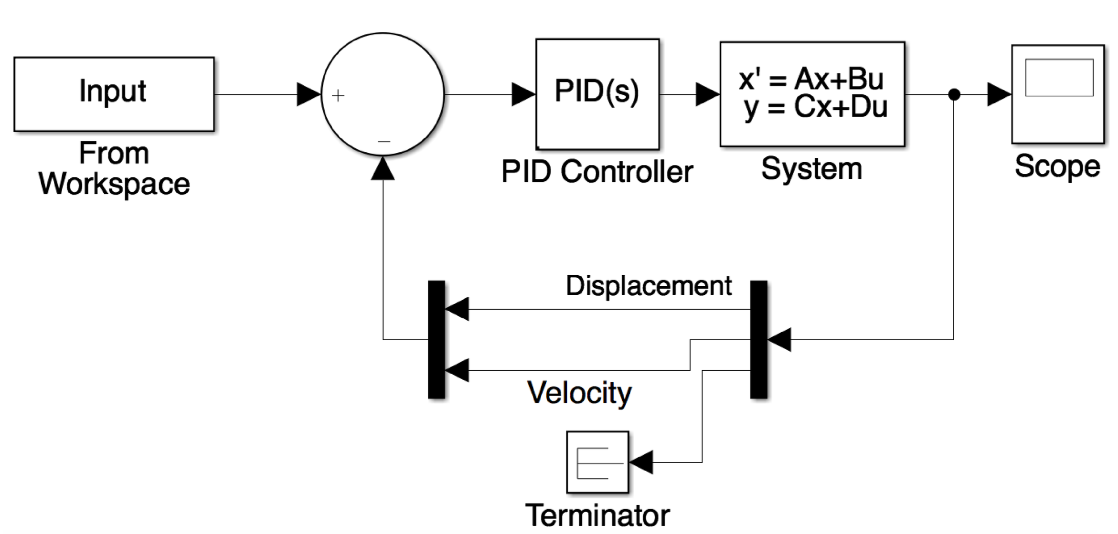
- Allows the system to produce the desired user output



LabVIEW simulation of the desired displacement (white) and actual displacement (red) of a sine wave signal, without a controller



LabVIEW simulation of the desired displacement (white) and actual displacement (red) of a sine wave signal, with a PID controller



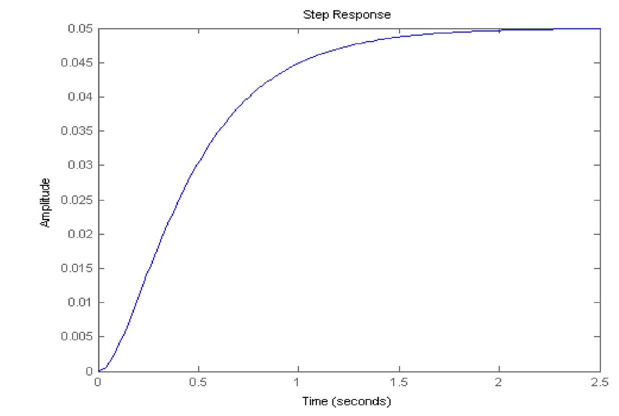
Example of a general closed-loop system with a PID controller using MATLAB Simulink

- A PID controller was implemented, where the main parameters are the proportional (Kp), integral (Ki), and derivative (Kd) gains

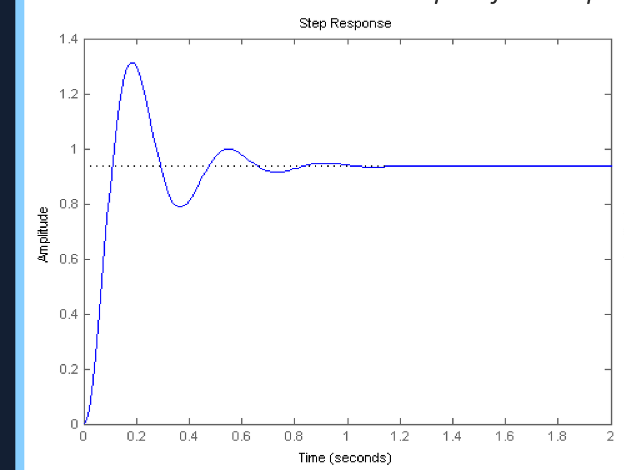
	Rise Time	Overshoot	Settling Time	S-S Error
Kp	Decrease	Increase	Small Change	Decrease
Ki	Decrease	Increase	Increase	Eliminate
Kd	Small Change	Decrease	Decrease	No Change

Effects of PID gains on system response

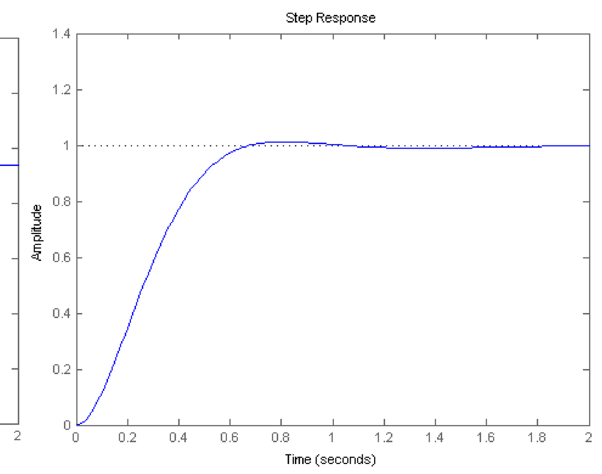
Rise Time, Overshoot, Settling Time and Steady-State Error*



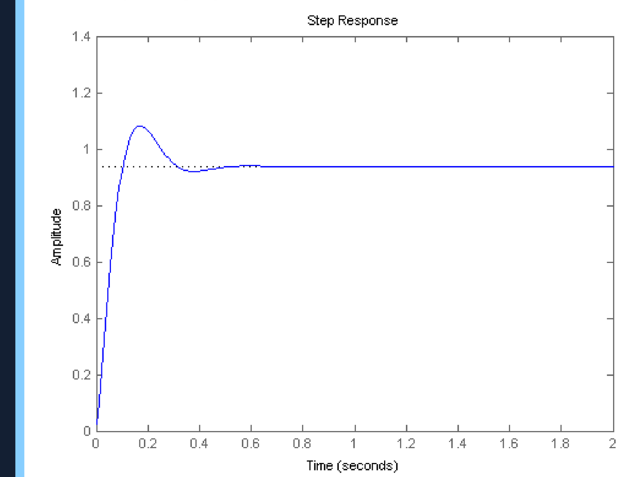
Example of an output without a controller



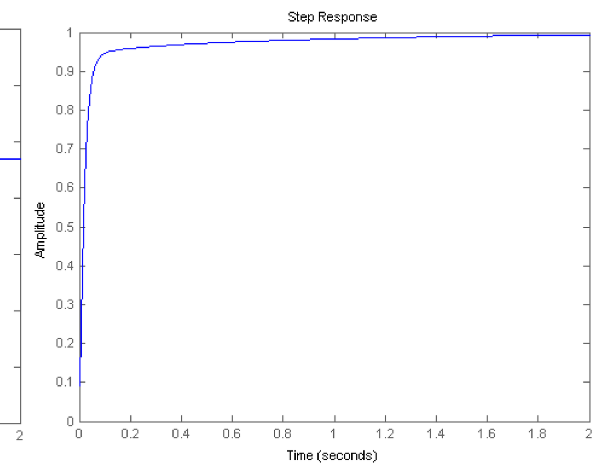
Output of system with P control



Output of system with PI control



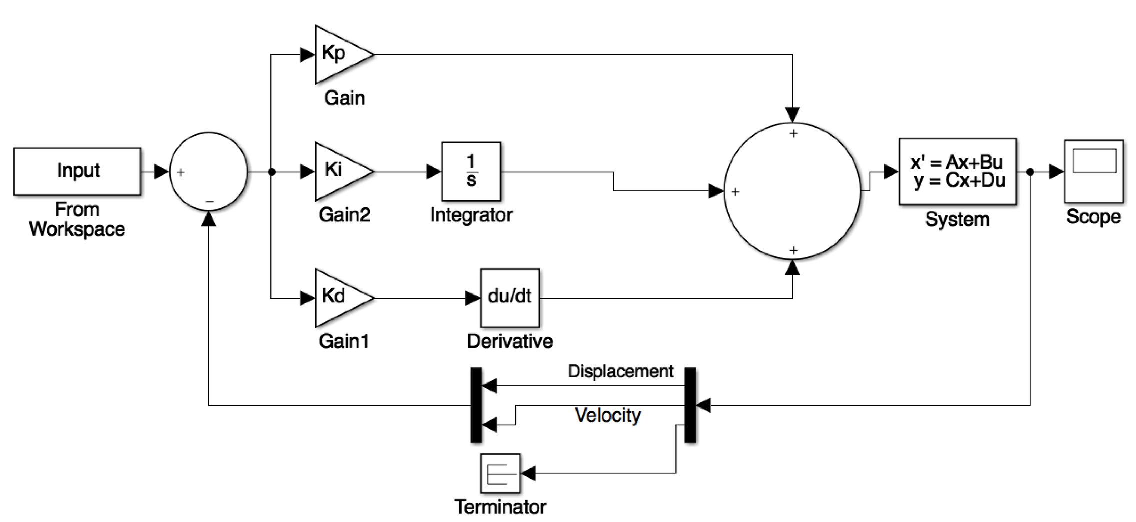
Output of system with PD control



Output of system with PID control

* Source from: MATLAB & Simulink Control Tutorials http://ctms.engin.umich.edu/CTMS/index.php?example=Introduction&section=ControlPID

Simulation of PID Controller via MATLAB Simulink

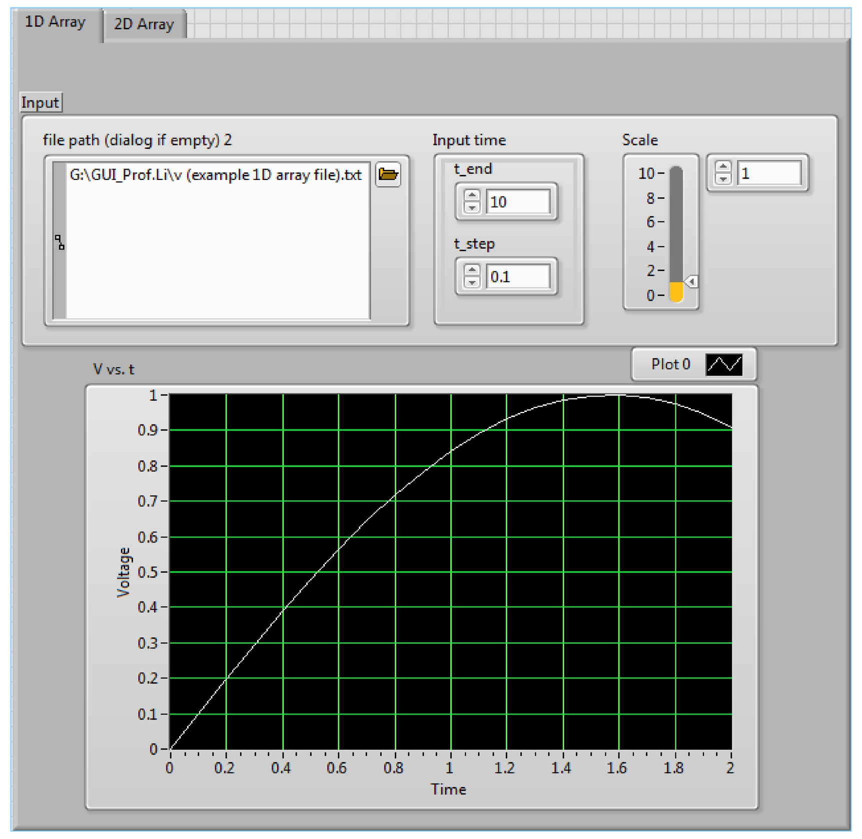


Simulation of a PID controller on a mass-spring-damper system in MATLAB Simulink

- Proper selection of proportional, integral, and derivative gains help drive the system output close to the input.
- The system output is measured and fed back in a loop to compare with the user-defined input.
- The error is then adjusted by the controller and again drives the system output close to the input.

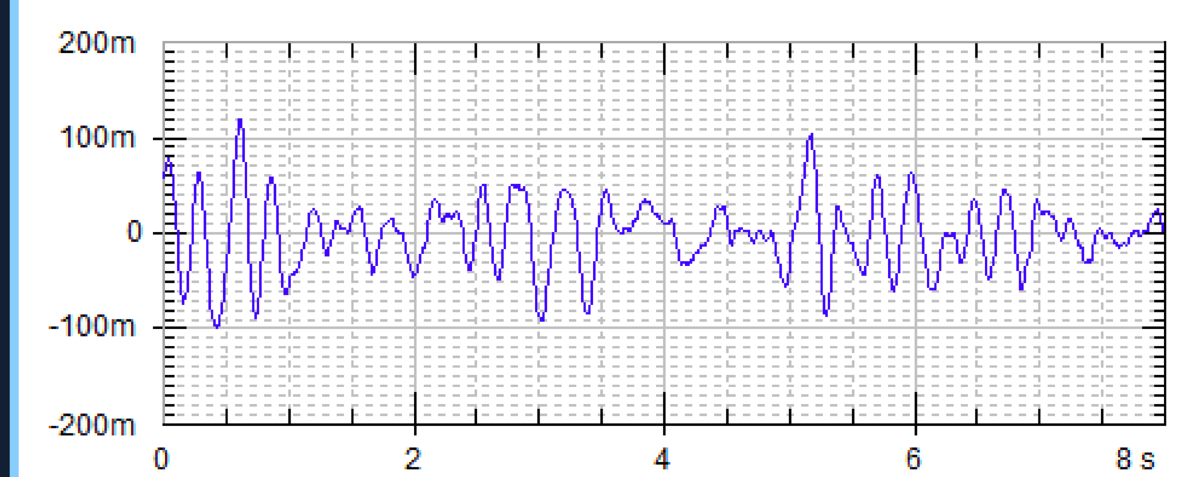
Development of a Graphical User Interface (GUI) in NI LabVIEW

- The GUI makes it easy for a user to input a file and for a corresponding voltage signal to be produced.



Implementation and Results

- With the implementation of a PID controller, the shake table can now move according to the user's input without the stage unexpectedly drifting.



Displacement of shake table stage, acquired from VibPilot

Future work

- Modify the user interface of the main LabVIEW program that handles both the user input and control parameters for the shake table, so that users can can intuitively work with it.

Acknowledgments

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