ECE 4950 Research Project 1

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Executive Summary

The purpose of this project is to configure a real-time workstation and test the configuration with a series of loop-back experiments. Completing these tests shows that our group has a host computer, target PC and Quanser Q4 Interface board that are functioning and communicating properly. The Quanser board is used in control systems to measure and communicate information to a PC. A wide variety of devices with analog and digital sensors can be connected to the board. The xPC target is used to manage the real-time system based on the data collected. The host computer uses Matlab/Visual C++ software to allow a user to interact with the real-time system.

The second part of the experiment was to create a small, acrylic part using the laser cutter. The design was created using the AutoCad program.

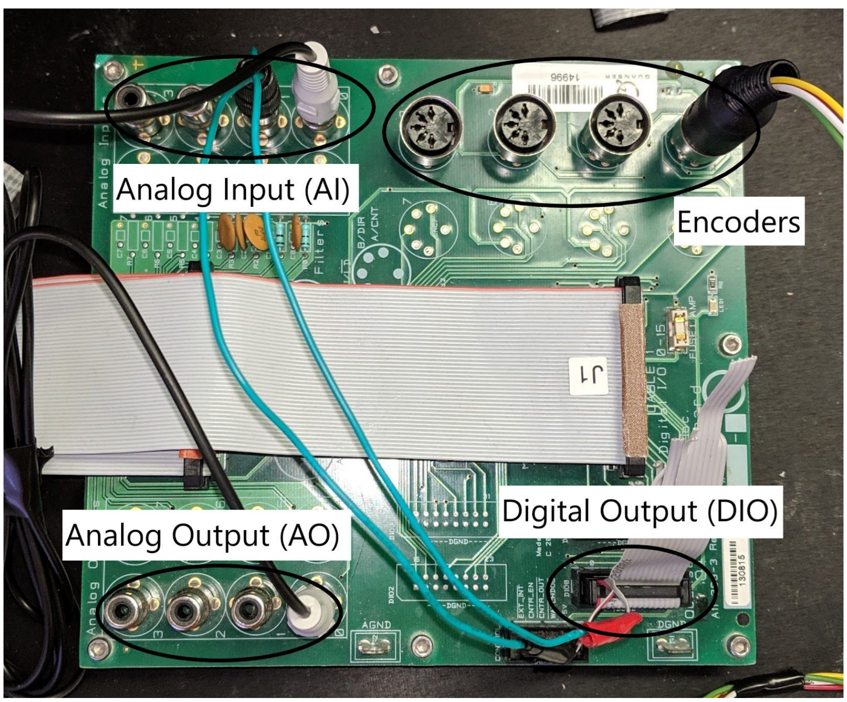


Figure 1: Q4 HIL Board

Materials and Methods

Equipment Used

- Quanser Q4 interface board
- Target PC with Quanser Q4 card
- Ethernet Crossover cable
- Host laptop with MATLAB 2017a installed
- Simulink Real-Time boot disk
- Laptop Computer with AutoCad installed
- x2 RCA cables with RCA male ends
- 10-pin ribbon cable with 5 DIN male and RCA male connector ends
- Tohoku DC motor with encoder

Procedure

The loopback experiments consisted of a host PC, a target PC and the Q4 data acquisition system. Running the experiments verified that the Q4 analog inputs and outputs, digital inputs and outputs, and encoders worked correctly. The host computer was a Toshiba laptop running MATLAB 2017a/Simulink. The target PC was equipped with a Quanser Hardware-In-The-Loop Card, which allowed the target PC to communicate with the Q4 interface board. The Q4 interface board contains all of the analog and digital inputs and outputs. The target PC communicates with the host computer and MATLAB/Simulink in real time via an Ethernet crossover cable. We constructed models in Simulink that allowed us to provide an input from the host computer and see the output on the target computer. The Q4 board connections can be seen in **Figure 1**. Connecting analog output 0 to analog input 1, via the RCA cables we made, gave the physical connection we needed to see the sine and square waves that we used as input on the host computer. We also used encoder 0 as an input by connecting a 5 DIN connector with a motor shaft connected to the other end. Turning the shaft adds or subtracts the from the previous position to obtain the new position.

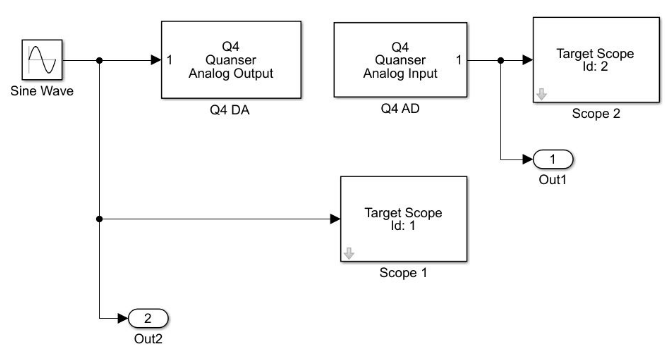


Figure 2: Example Simulink Model (Analog to Analog)

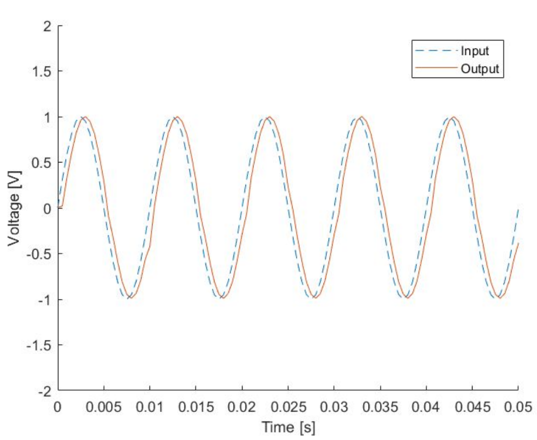
Results and Discussion

The first test results in the input to the quanser board closely mirroring the 100 Hz sine wave generated by the board with a slight delay in the signal, which can be seen in Figure 3. This delay was due to the time that it takes the signal to propagate through the RCA cable from the output to the input. As expected, five waveforms appear in the 50 millisecond sample in Figure 3 because a 100 Hz signal has a period of 10 milliseconds. The second test used the same physical setup, but the sine wave was generated with a frequency of 2000 Hz. The resulting input and output waves can be seen in Figure 4. The 2000 Hz test needed a sample frequency increase. At higher frequencies, the necessary increase in samples will be limited by the computer CPU.

The third test results in the input and output waveforms appearing in Figure 5. The input signal is controlled by a 1 Volt signal sent through the DIO port. The DIO sends 5 Volt pulses in response to the 1 Volt pulse because digital logic deals with binary, high and low voltages.

In the fourth test, the motor encoder was connected to an encoder input. Figure 6 and Figure 7 displays the angular position of the motor's rotor as we manually rotated it. Rotating clockwise results in an increase in the angular position measured by the encoder, whereas counterclockwise rotation results in a decrease.

The 'Input' and 'Output' legend labels in the following figures indicate input and output with respect to the block diagram in Simulink. 'Input' represents the signal generated by the quanser board and 'Output' represents the signal read by the quanser board.



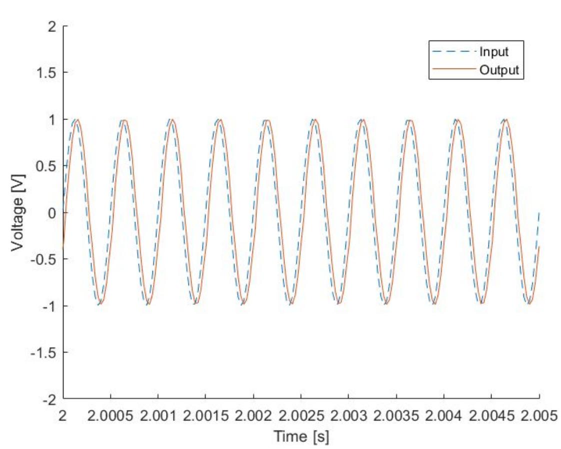


Figure 3 and 4: Analog Scopes of 100 Hz (left) and 2000 Hz (right) Sine Waves

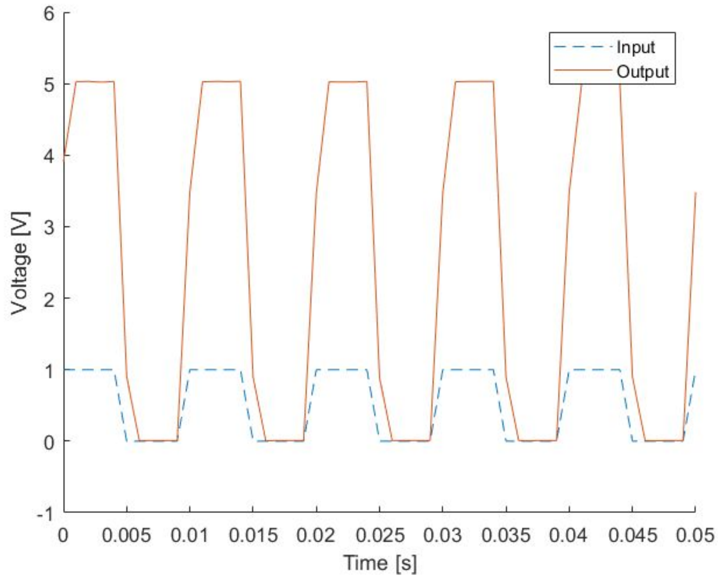


Figure 5: Analog Scope 100 Hz Square Pulse

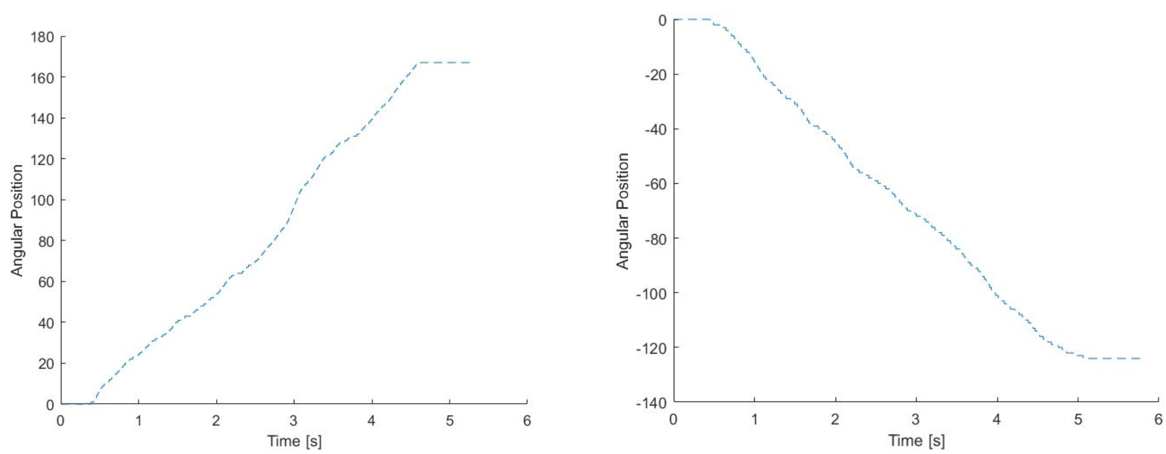


Figure 6 and 7: Angular Position of Motor during Manual Clockwise (left) and Counterclockwise (right) Rotation

Conclusions

All five of our experiments produced the desired results. This indicates that we have correctly configured the host and target PCs, and that our Q4 Quanser board is working properly and will work as we desire during the length of our project. These experiments have given our team an understanding of how we can make use of Matlab/Simulink to interact with the Q4 board. Having real time analog inputs and outputs will be of great use when we use sensors, motors, and actuators to control the automated system for our next project assignment. However, this equipment can be limiting to a large scale or more precise application that needs fast computing and quick feedback. This is clear when looking at the delay of the signal and the limitations in computing high frequencies. For the Laser Cutting portion of the project, the parts that we design and develop in Autocad will help our successive projects ahead, especially when designing components for an automated system. For that reason, we decided to design the planetary gear system. It demonstrated both the use of gears to move parts and possible ways of securing parts together.

References

[1] ECE 4950 Laser Cutter design template and instructions [Online]. Available: http://akapadi.people.clemson.edu/ece4950_references.html . Cited: 5/31/2016. [2] Quanser Consulting (Sep. 2011) Q4 Data Acquisition System User's Guide. Available: http://akapadi.people.clemson.edu/ece4950_references.html . File: quanser_q4_manual.pdf. Cited: 5/31/2016. [3] D. Graffox. (Sep. 2009). IEEE Citation Reference [Online]. Available: http://www.ieee.org/documents/ieeecitationref.pdf. Cited: 5/31/2016.

ECE 4950 Project 1 – Research Report Rubric

Each group will create a report that will eventually become a section in the "**Research**" section of your final project website. Use the guidelines below to complete your report and add at the end of your report.

Group Member Last Names: Marini, Holmes, Thomas, Jonakin, Dunn

Score	Pts		Performance Indicators
	15	**General Format - Professional Looking Document/Preparation (whole document)** a) Fonts, margins (11pt, times new roman, single spaced. 1" margins on all sides). b) Spelling and grammar are correct c) Layout of pictures – all figures need numbers and captions and must be referenced in the text d) Follows the page limitations below. e) References. Use IEEE reference format. f) This grading sheet is included as the final page.	g.1
	20	**Page 1: Title, Group Name, Group Members, and Date** **Executive Summary** (~1/3 of the page) Provide a brief summary of the whole experiment. Use language that targets **a non-technical audience**. An important skill for an engineer is to communicate complex technical information to a general audience that may be involved in decision making, e.g. marketing. Important criteria: a) Can a non-technical audience (~ high-school degree) read this section and understand your goals, procedures, and conclusions? b) Use simple words and graphics to help explain	g.1
	40	The next sections of the report follow the standard **laboratory report format.** **Page 2: Materials and Methods for the Loop-back Experiments (don't need to describe the laser cutter)** (< 1 page) You are establishing the credibility and usefulness of your results by providing all the details so that someone else could repeat your experiment. As an example, MATLAB 2011a may behave differently than MATLAB 2010b – the software version information which would be required to reproduce your result should be included. This section should answer the following: a) What equipment is used (i.e. real-time workstation), include software versions. b) How were the experiments conducted? How is the equipment connected and used? Describe the instrumentation, cables, connections, and experiments using diagrams and photos. You should have drawings (pin connection and connector part numbers) for any special cables, an RCA-RCA cable is well known and you would not need to make a drawing for this cable. **Pages 3-4: Results and Discussion for the Loop-back Experiments** (< 2 pages) Describe what you have done. Include plots (from MATLAB, not photos of the Target screen) for each of the four loop-back experiments and a brief discussion of how you interpret the result. Describe the results of the encoder experiment. Did you demonstrate (through your documentation) that the equipment has been configured and used correctly? **Page 5: Conclusions and References** (< 1 page) a) Based on this experiment, do you recommend this equipment for use in a robot control project? What are the possible limitations? Your results and observations should be the basis for your conclusions. (~1/2 page) b) What are the possible uses for the laser cutter in your projects? (~1/4 page) c) Use IEEE format [3], at least cite the class website http://people.clemson.edu/~akapadi/ece4950_references.html.	k.2 k.2 k.2
	5	**Page 6: This Grading Sheet**	g.1
	20	**Laser Cut Part** (turn in with printed report) Grading based on: a) How well does this part demonstrate the capability of the laser cutter to make prototype parts for an automated (robotic) system? b) Originality and creativity	k.2 i.1