ECE Project 1, Installfest:
Configuring a Real-Time Workstation and Introduction to the Laser Cutter

Group 3 “No Induction Needed”
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Executive Summary

Implementation of MATLAB software Simulink Realtime, SRT, allows model development of control systems with assorted settings and parameters that can be manipulated to perform real-time test experimentation. Performing loopback testing through xPC Target Experimentation demonstrates the successful assembly of the workstation while also illustrating possible applications. One function is illustrated through an exchange of data from the “Host,” a personal laptop, and the “Target,” a desktop workstation with computer terminal and Q4 Data control boards. The Quanser Q4 Data Acquisition board is supplied inside the Target and works with the openly residing Q4 Interface board. Group-assembled cables, permitting data transfer, connect the Input and Output Ports. The results provide specific output frequencies to be displayed and analyzed. Graphs of the output plots are shown to provide visual support of effective execution.

Figure 1: Block Diagram of Interfaced Workstation

Materials and Methods

Analog cable: RCA plug to RCA plug
AutoCAD 2015
Digital Output to Analog Input cable: 2 wires from 16 Pin Ribbon to RCA plug
Digital Output to Encoder Input cable: 2 wires from 16 Pin Ribbon to 5 Pin DIN connector
Ethernet cable
Quanser Q4 H.I.L control board
Quanser Q4 Interface board
MATLAB R2014b with Simulink Realtime
Microsoft Visual Basic C++

Project 1 began by configuring the group’s Host computer. This was a personal laptop, requiring MATLAB with Simulink and Visual Basic C++ installation, to enable the real-time control workstation. The MATLAB “Host –to-Target communication” property set the compiler to C++ and after defining the type of communication, drivers and addresses a “Boot Disk” is created and loaded onto the workstation’s desktop computer, designated the Target. An Ethernet cord connects the Host and Target through ping tested Local Area Network (LAN) configured settings.

The modified and constructed cables connecting the devices permit information transfer. Analog Output 0 was connected to Analog Input 1 by mean of a constructed RCA-RCA cable. Here two wires, one red and one white, were independently soldered to the RCA plug at each end. The first 2 wires of a 16 Pin Ribbon wire were soldered to a 5pin DIN connector and the next two wires were soldered to a RCA.

To confirm the proper installation of software and cable management, loopback testing was performed in the following steps using xPC target, mirroring the provided model (Figure 2).

Figure 2: Simulink model diagram for 100Hz and 2000Hz sine wave

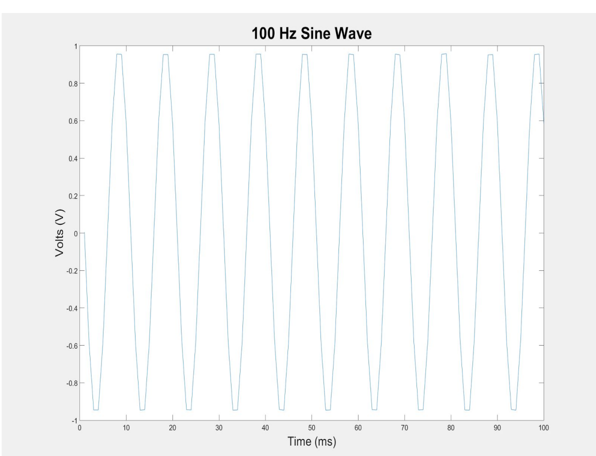
Figure 3: Simulink model diagram for 100Hz square wave with Analog Input and Digital Output

Figure 4: Simulink model diagram for 100Hz square wave using an incremental encoder

1. A sinusoidal output of 100Hz from Analog Output 0, measured by Analog input 1 (Figure 5).
2. A sinusoidal output of 2000Hz from Analog Output 0, measured by Analog input 1 (Figure 6).
3. A square-wave output of 100 Hz from Digital I/O 0 measured by Analog Input 0, after the Signal Generator block replaced the Sine Wave block (Figure 7 and Figure 3, respectively).
4. A 100 Hz square-wave output from Digital I/O 0, provided by a new Simulink model (Fig 4). An “Encoder In” tool is added to the model’s input and a Target Scope added to the model’s output. The Encoder’s “Quadrature Vector” value is set to zero, and the Target Scope has a “numerical” function established. The target display’s scope area offers numerical display.
5. The provided encoder is connected to Encoder Input 0 and measured with Encoder Input 0. The encoder’s shaft is turned by hand and the display graphs the movement.

The last element of this project was the laser cut piece. AutoCAD was installed to design the team’s part. The part demonstrates cutting by the shape and pattern it possesses and etching through the defining images and characters on the piece. The various shapes and lines creating the tiger’s body prove that most any mechanical part can be prototyped for future work, while the etching proves labeling is also possible.

Results and Discussion



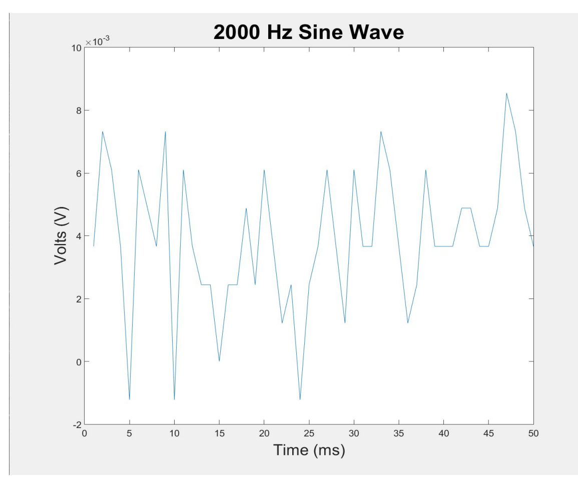


Figure 5: 100Hz sine wave analog-analog connection

Figure 6: 2000Hz sine wave analog to analog connection

Successful installation and software implementation is proven with the generated graphs. Looking more closely at the individual plots provides more informative outcomes.
The wave in Figure 5 shows a waveform with a frequency of 100Hz and is a function of time, in milliseconds. The image in Figure 7 also depicts a 100 Hz waveform and is a function of time in milliseconds. The two offer varying shapes, Figure 5 is a typical sine wave while Figure 7 illustrates a square wave. The difference stems from the square wave's signal being generated and transferred through a digital input into an analog output using the 2 pins from the ribbon cable to the RCA. Conceptually this can be viewed as a clipping distortion. The sine wave shown in Figure 5 was generated by an analog input transmitting to an analog output, physically carried through a cable with RCA plugs on each end. This transmission allows for a flowing, continuous time signal.

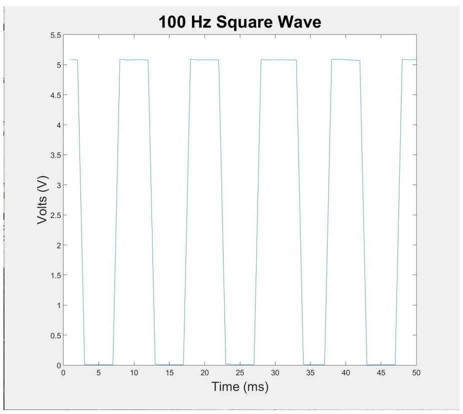
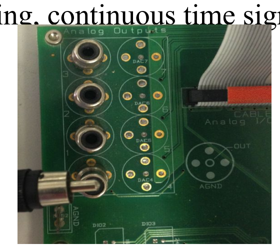


Figure 7: 100 Hz digitally output square wave



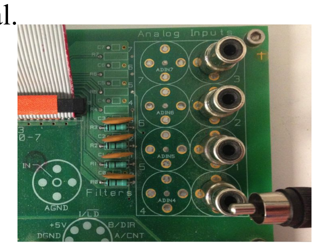
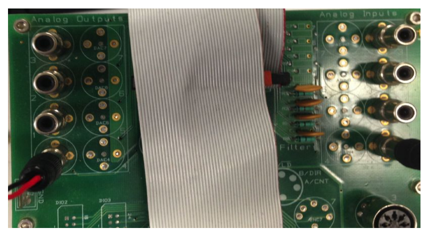


Figure 8 (top left): Analog output with RCA. Figure 9 (top right) shows analog input with RCA. Figure 10 (bottom) shows the Analog Output RCA to Analog Input RCA connected.



Another pair of contrasting images are Figure 5 and Figure 6. Figure 6 is the 2000 Hz sinusoid wave, but is not well portrayed. There are limitations in the technology prohibiting precise display at certain frequencies when compared to a function of the same time (milliseconds) but has drastically different voltage measurements (three order of magnitude).

For step 4, the model seen in Figure 4 was created in Simulink. This model allowed us to see if the encoder on our board was functioning correctly. After building and running the simulation, a numerical display appeared on the target scope that rapidly counted in the negative direction. This model was also used in step 5 to measure the output of the motor provided to us by the TA's.

In Step 5 a group member physically turned the shaft with his hand and the graph showed a real-time moving sine wave. This was not as the original instructions asked. Due to missing materials groups were given alternative instructions. This illustrated the application in a different way. By rotating the shaft clockwise versus counter clockwise, the graph performed in opposition. Visually, one method produced a sine wave, the other a cosine wave. Numerically this would be like a counter, moving up or down.

Conclusions

This initial project proves the workstation is properly assembled, and MATLAB model simulations supplied graphs indicating reliability. Moreover, the project demonstrates a loopback system is a viable means to test equipment, assuring all devices are appropriately coordinated. Testing has also shown how distortion can be found, and accurate readings are a function of the parameters set. Lastly, the ability to communicate between mechanical and electrical mediums is apparent and will be useful in later experimentation.

References

1. A Kapadia (2015, Fall), *ECE 4950- Integrated System Design, Project 1*, [Online] < http://people.clemson.edu/%7Eakapadi/ece4950files/Project1ConfiguringTools.pdf>
2. A Kapadia (2015, Fall), *ECE 4950- Integrated System Design, Setting up and using Simulink RealTime* < http://people.clemson.edu/%7Eakapadi/ece4950files/xpcTutorial.pdf>

Group Name and Members: ____

Score	Pts		ABET Outcomes
	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. (5 pts)	g
	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

	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
		Page 6: Grading Sheet	
	25	**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