ECE 4950 Project 3 (September 15, 2015):
Whack-A-Mole Sensor Subsystem and Website Design

Team W8: Bode, Bode, Bode, Bode Plotting Everywhere

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I. Executive Summary

The purpose of project 3 was to design and construct a working sensor and actuator subsystem to prove our Quanser Q4 board could read values from and output to third party equipment. Verifying this functionality is integral for the final design. For our actuator-sensor subsystem we decided to use a compressor microphone sensor connected with our pull type solenoid actuator. The idea of including these two items in our subsystem was that once the microphone sensor read a sound input it would send a signal that would in turn cause the solenoid to fire. The solenoid purchased will also possibly be useful as part of an actuator subsystem in our final design. In addition to designing our subsystem, a group website at the URL http://people.clemson.edu/~phg/home.html was constructed, which will be used to present all of the group projects, reports, and videos made during the entire process of the course.

II. Requirements for Sensor Subsystem

Customer Requirements	Engineering Requirements	Tests
Read QR Codes	Relay QR Code data back to software	Provide different QR codes to read
	Have software identify the QR code from the other areas of the captured image	Read QR codes from different distances to identify the ideal area of accuracy
Locate active LEDs	Send image information back to software	Run the sensor over LEDs
	Able to span the breadth of the game board	Operate the sensor across our board curtailed to our overall system design
	Travel across board and capture LEDs in time constraints	Test how long it processes a lit up LED and record timing
Differentiate LED colors	Relay LED color information to software	Set up multicolored LEDs to process
	Identify specific colors of LEDs from others	Program if statements based upon parameter returned from sensor (RGB/hex/etc) and return color based on numeric configuration, scan multiple LED color patterns
Operate accurately and quickly	Software able to identify QR patterns and LED lights/colors effectively	Scan different QR codes and LED colors for accuracy
	Processing streamlined and flow of data concise for speed	Program a print screen (better yet a count) to console after the scan process is done and time it
	Wiring is simplified and effective	Test all wiring for shorts and review design repeatedly looking for improvements

Figure 1. Sensor Requirements.

As shown in Figure 1, the main requirements on the sensor subsystem are that it can read the input QR code to the system, locate LEDs on the game board, differentiate LEDs in different sections, and operate quickly and accurately. Before a "Whack-a-mole" game starts, the robot must be able to read a QR code that will tell it the light sequence to hit. Once the game starts, it needs to quickly and effectively identify LEDs that light and the sections they light in so the software can determine whether or not to engage the motor to strike the mole. The colors it senses must not ever be confused for another color if the design is to achieve optimal runtime.

III. Design Details

Initially we intended to use a RGB sensor (TSC34725) from TAOS which would scan a color and reproduce it on a color LED on the chip as well as use an ADC to send the information to the host PC. However, as can be seen in Figure 2 there were multiple inputs into the RGB sensor we did not account for such as the clock (SCL) and interrupt (INT) ports and the spec sheets did not effectively communicate how these would affect the performance of the chip. In addition to these problems we recognized that processing the I^2C signal we were receiving from the data output port (SDA) would take a large amount of software resources. So in the interest of time we have postponed our work with this hardware for future projects and opted to use an old electret condenser microphone as our sensor for this prototype.

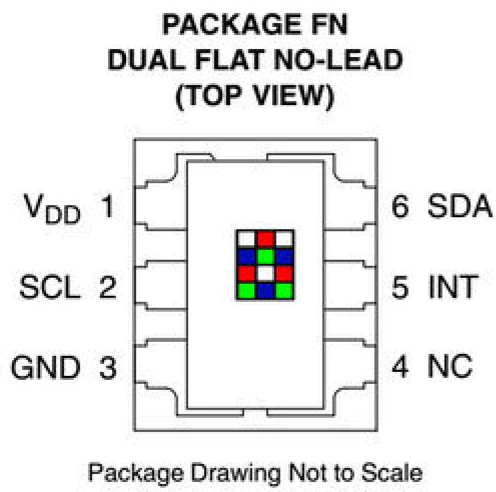

Figure 2. TSC34725 Sensor Pinout [2].

The electret condenser microphone we ended up using was a CMA-4544PF-W microphone from CUI which can be found on Digikey and can be seen in Figure 3. This specific microphone requires an operational voltage range from 3-10V and a max current draw of 1.6mA [3]. As stated in the previous report, our condenser was quite old and the group found that the best way to consistently trigger it was to tap it. Further, because the microphone did not have any connections for amplification circuitry and put out low voltages by default (on the order of tenths to thousands of millivolts), we used changes in the signal from the microphone to trigger other voltages to the actuator from the Q4 board in the final subsystem circuit.

Figure 3. CMA-4544PF-W Microphone [3].

We used a ZHO-420S solenoid actuator from Zonhen as seen in Figure 4 to physically show our software was processing our interactions with the microphone in our prototype. The solenoid has an operational supply voltage range from 3.8-5V and a max current draw of 1.1A [4]. The solenoid would activate when the microphone was pressed and pull outwards, since it was only a pull we had to prime the solenoid for actuation by pushing in the spring.

Figure 4. ZHO-420S Solenoid [4].

Now that we had components that were simple yet effective enough to design a prototype that would register from a sensor and actuate, it was time to construct our circuit. We connected the solenoid to the digital output pins of the Q4 Quanser board and the microphone to an RCA input port of the same board. All of our voltages were processed and regulated via the Simulink software and supplied to the Q4 Quanser board. The final circuit can be seen in the Figure 5 and the circuit specifications in Figure 6.

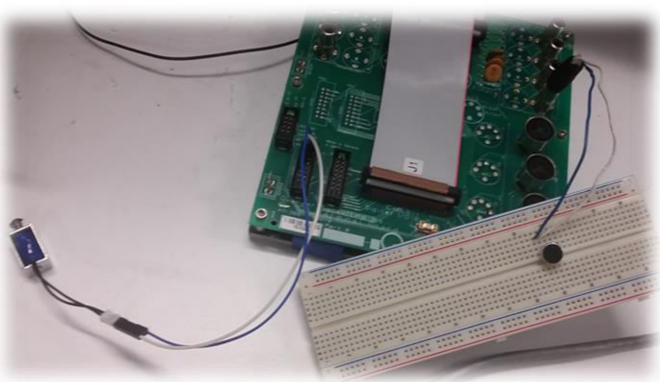

Figure 5: Circuit Functionality.

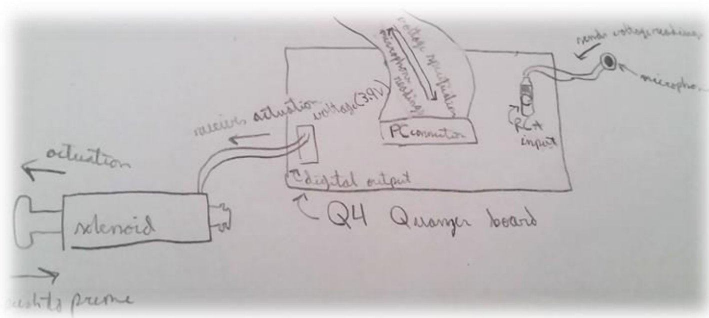

Figure 6. Actual Prototype Circuit.

The only real assembly required as can be seen from the Figures 5 and 6 above was wiring the solenoid to the digital output and cutting the RCA-to-RCA plug used in the last project in half to use to wire the microphone on a breadboard.

IV. Prototype Demonstration and Testing

For our sensor subsystem prototype we had to meet all of the requirements mentioned in the section two of this report as well as meet certain actuator requirements. For example, the actuator could not be a motor and the actuator must be compatible with the Quanser Q4 board. After building the subsystem, which consisted of the solenoid and mic being connected, the subsystem was integrated with the Q4 board and tested. Figure 7 depicts the voltage across the microphone with ambient noise, which centered around 0.05 millivolts. Figure 8 depicts the voltage when the microphone was tapped, which centered around 0.1 millivolts.

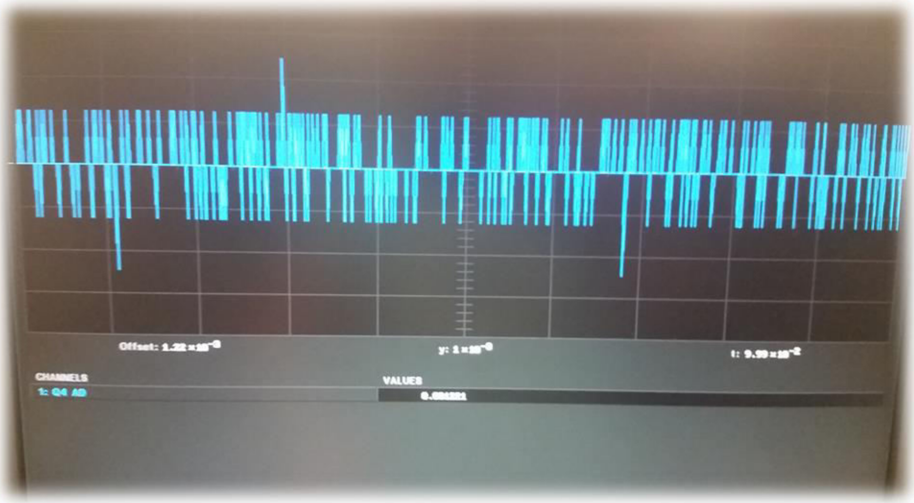

Figure 7. Ambient Microphone Output

Figure 8. Microphone Output when Tapped.

V. Conclusion

As requested by the customer, we designed and tested a sensor and actuator subsystem by interfacing third party components with the Quanser Q4 board. We proved that our Q4 can read input from a CUI compressor microphone and drive a five volt actuator. Knowing we will be able to use other components with the Q4 board is a significant step toward our final design. In particular, getting our board working with an actuator is significant progress, since we plan on using a push type actuator in our final design to “whack moles”.

Though we did not end up fully incorporating it with our board, use of the TAOS RGB sensor was still great insight into what it will take to use an RGB sensor with the Q4 board in the future. Because using an RGB sensor is one method of reading the lights on each section of Whack-a-mole game board, incorporating our TAOS sensor into the final design is possibility. Using the sensor educated the engineers on I2C format and gave them an idea of the MATLAB code it would take in combination with Simulink to decode it.

In conclusion, the customer initially requested we design an actuator and sensor subsystem which took input from the sensor and caused the actuator to fire when a condition was met. The sensor could not be on/off discrete, an Arduino board could not be used as an intermediary, and the actuator used could not be a motor. We meet all of these design constraints by designing a circuit that used a compressor microphone to trigger a pull type solenoid when the microphone was tapped. The circuit was tested and is functional as described in sections III and IV of this report. The customer may now proceed with manufacturing. Thank you for consulting our engineering team and please visit http://people.clemson.edu/~phg/home.html to view any other records of our business with you.

VI. References

[1] A. Kapadia. ECE 4950 - Integrated System Design [Online]. Available: http://people.clemson.edu/~akapadi/ece4950_references.html. Cited: 9/22/2015.

[2] TAOS Inc. - TCS3472 Color-To-Digital Converter with IR Filter [Online]. Available: http://www.adafruit.com/datasheets/TCS34725.pdf. Cited. 9/22/2015.

[3] CUI Inc. - CMA-4544PF-W Electret Condenser Microphone [Online]. Available: https://www.adafruit.com/datasheets/CMA-4544PF-W.pdf. Cited. 9/22/2015.

[4] Zonhen - ZHO-420S Open Frame Solenoid [Online]. Available: http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Robotics/ZHO-420S.pdf. Cited. 9/22/2015.

ECE495 – Research Project 3

Group Name and Members: ____

Score	Pts		ABET Outcomes
	5	General Report Format - Professional Looking Document a) Fonts, margins (11pt, times new roman, single spaced. 1" margins all sides). b) Spelling and grammar are correct c) Layout of pictures – all figures have captions and are referenced in the text d) Follows the page limitations below. e) References. Use IEEE reference format.	g
	5	**Page 1: Title, Group Name, Group Members, and Date** **Executive Summary** (1 well written paragraph) Provide an overview of this project. Briefly what did you do and what did you learned.	g
	20	**Page 2: Engineering Requirements** (~1 page) Considering only the Sensor subsystem, make a three column table that lists Customer Requirements in the first column, the resulting Engineering Requirements in the second column, and the third column describes the Tests that will be done on the prototype to verify that your design meets each requirement. Note: One customer requirement may branch to multiple engineering requirements.	b
		The following should be a narrative report that describes your design decisions and final design, e.g., don't just have a flowchart without text that explains it.	
	20	**Pages 3-4:** **Electrical Design Details** (~2 pages) Describe the system including: a) Calculations b) Simulation Results c) Circuit schematics **Mechanical Design Details** (~1 page) a) Assembly drawings	c
	10	**Pages 5: Prototype Demonstration and Testing** (1 page) Build a physical prototype that demonstrates that your design will meet all of the customer requirements. Present the results of your testing, which should consist of graphs and explanations.	b
	5	**Page 6: Conclusion** (1 page) Tell the Customer that you have completed the design, it achieves the desired objectives as demonstrated in the prototype testing (use the specific metrics defined in your testing plan), and that your design is complete and they can proceed to manufacturing.	g
	15	Laboratory demonstration of your prototype	b
	20	General Format of Website a) Aesthetics b) Completeness a. Included the Team Description - No personal information that would be embarrassing to you or your teammates. b. Included Report 1. c. Outline of future sections c) Use of Graphics d) All links relative to starting directory so that it can be moved to ECE site. Follow the website guidelines, including, accessibility compliance, at http://www.clemson.edu/ces/crb/ece495/References/website_design.htm	g