University of Colorado - Boulder

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# Milestone 1 Report

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## Project Development

*ESP32 Controller and Serial Communication*

A significant portion of the work involved creating a robust and modular program to manage serial communication between the ESP32 and Python scripts. The `esp32_communicator.py` script plays a crucial role in this setup. It includes functions to test the serial port connection and read ADC data from the ESP32. The `read_adc_data()` function sends voltage commands to the ESP32 and logs the ADC readings into a CSV file for further analysis.

*Testing Helper Functions*

The `testing_helper.py` script includes essential functions for running various tests on the ADC. The `Testing_Helper` class is designed for modularity and ease of use, allowing different test functions to be executed iteratively. The `linear_step_test()` function, for instance, performs a linear step test by setting incremental voltages using the AD2 Wavegen and capturing the corresponding ADC values from the ESP32.

*AD2 Controller Integration*

The `ad2_controller.py` script facilitates interaction with the AD2 device, handling tasks such as setting output voltages and measuring noise. The `AD2Controller` class includes methods like `set_voltage()` for precise voltage control, crucial for the accuracy of ADC characterization tests.

*Analysis Helper Functions*

The `analysis_helper.py` script provides foundational structures for analyzing the collected data, although its implementation is ongoing. Future updates will focus on detailed data analysis and Figure of Merit (FOM) calculations.

## Additional Activities

*VSCode Serial Plotter Plugin Development*

Brief work was done using TypeScript and JavaScript to develop a VSCode Serial Plotter plugin, it gave me ample flexibility for controlling how to display serial port information on the fly during development phases of my project. However, continued development is not feasible.

*Moth Car Project*

Efforts were also directed towards building the Moth Car, an initiative to improve instructional materials for the Capstone workshop and provide a tangible example for future students.

*GitHub Organization*

A GitHub organization was established to manage and share project repositories. Further work is needed to organize the repositories and encourage collaboration among peers.

## Future Work

*Integration with Keysight DMM*

Plans are in place to integrate the `AD2Controller`'s `set_voltage()` function with the Keysight Digital Multi-Meter (DMM). This integration aims to ensure that the Wavegen output is as accurate as possible, providing reliable

voltage inputs for ADC characterization.

*Characterization Tests*

Building on the initial tests, further characterization and of the ADC will be performed through several methods:

- **Incremental Step Tests:** These tests increment voltage steps to determine the accuracy and input range of the ADC. The `linear_step_test()` function has been pivotal in these tests, providing a clear understanding of the ADC's performance across different voltage levels.
- **Decremental Step Size Tests:** To determine the resolution of the ADC, tests with decreasing step sizes will be conducted. These tests will help identify the smallest voltage change that the ADC can accurately detect.
- **Sample Rate Tests:** The goal is to measure how quickly data can be received, which is crucial for applications requiring high-speed data acquisition. By pushing the limits of the ADC's sampling rate, we can better understand its capabilities and limitations.
- **Constant Voltage Tests:** These tests will help determine the noise characteristics of the ADC. By maintaining a constant input voltage, the noise level can be quantified, providing insights into the stability and reliability of the ADC readings.

*Oversampling Techniques*

Future work will also explore the impact of oversampling on ADC performance. By sampling the input signal at a higher rate and then averaging the results, it is possible to reduce noise and improve the effective resolution of the ADC. This technique will be evaluated to understand its benefits and trade-offs, particularly in terms of noise reduction and sampling rate.

*DAC's and External Devices*

Although most of my work thus far has been for the internal adc of the esp32, I plan on using these same models and scripts I have developed for the internal DAC as well as the external ADC's and DAC's that require testing. The tests will remain modular and be very easy to implement in any setup with the proper small changes.

## Conclusion

The progress thus far has laid a solid foundation for the characterization of ADCs and DACs using the ESP32 QTPY and AD2 devices. The modular approach in developing the control and testing scripts ensures flexibility and scalability for future enhancements. Upcoming work will focus on integrating additional tests, refining data analysis, and expanding the capabilities of the developed tools.