An Arduino Feedback Infrastructure for Monitoring and Controlling DC Power Source

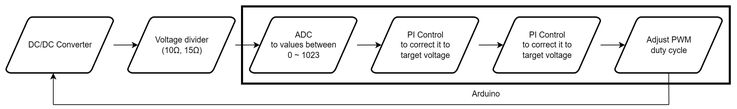
Dr. John Ciezki & C3C Junhyung Park
United States Air Force Academy

Introduction / Background

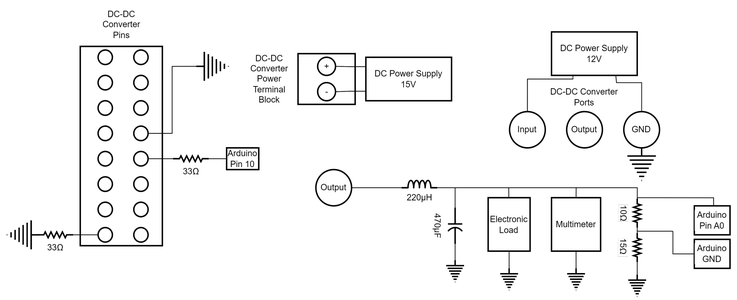
- Variable voltage output from renewable sources can be regulated using a controllable supply.
- A DC power supply output can be controlled by adjusting the duty cycle of the PWM signal.
- This research investigated the possibility and limitations of cheap Arduino in power control.

Methods

Architecture



Design

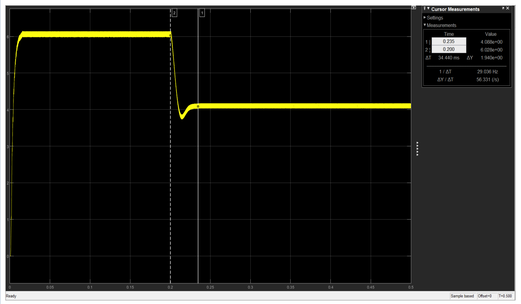


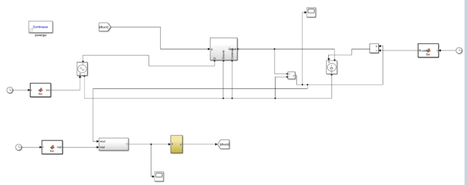
Experiment

- Simulate and develop an infrastructure that monitors output voltages and performs PI control on the duty cycle of the PWM signals from Arduino to match the changing target voltage.

Results

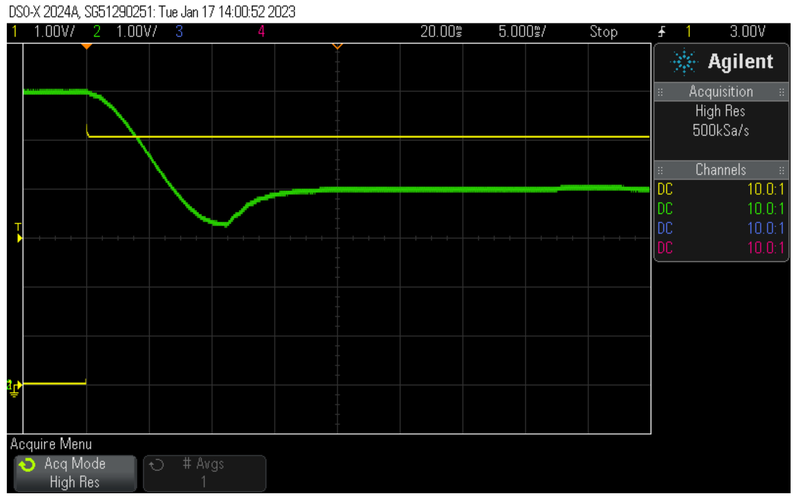
Simulation





- The target output voltage is initially set to 6V and changes to 4V after 0.2s in Simulink simulation to measure the voltage correction time and visualize the correction characteristics.
- Time it took for the output voltage to stabilize to 4V: 30~35ms

Prototype



- A digital signal from Arduino triggered the oscilloscope at the moment that the target output voltage changed from 6V to 4V.
- Time it took for the output voltage to stabilize to 4V: 17~20ms

Key Findings

- Programming duty cycle correction of PWM signal every 1ms cycle successfully regulated output voltage and provided consistent output.
- The voltage correction time differed by around 10ms, the smallest difference based on multiple approaches using interrupts and loops.

LIMITATIONS TESTING

PWM Frequency	Cycle Time	6V (V)	4V (V)	Time
20kHz	1ms	6.00 ~ 6.01	4.00 ~ 4.01	20ms
40kHz	1ms	5.96 ~ 5.97	3.93 ~ 3.94	5ms
80kHz	1ms	5.85 ~ 5.86	3.95 ~ 3.96	6ms
20kHz	0.5ms	5.91 ~ 5.92	3.98 ~ 3.99	20ms
20kHz	0.25ms	5.88 ~ 5.89	3.87 ~ 3.90	15ms

Conclusion

- An undergraduate level can research power grids more cheaply and easily with Arduino.
- The inconsistent and inaccurate outputs from limitations testing indicate that further research with a higher-powered system is necessary.
- Expansion of architecture:
  - A current feedback infrastructure for bulk charging the battery at a consistent current.
  - A charge counter to manage the charging and discharging rate of the battery.

References

[1] M.G. Feemster, "A Systematic Approach for Development and Simulation of Digital Control Algorithms using SIMULINK," *120th ASEE Annual Conference & Exposition*, June, 2013. Available: https://monolith.asee.org/public/conferences/20/papers/7900/view. [Accessed August 2022].
[2] "The Do's and Don'ts of Using Arduino Interrupts," March, 2022. [Online]. Available: https://www.digikey.com/en/maker/blogs/2022/the-dos-and-donts-of-using-arduino-interrupts. [Accessed August 2022].
[3] W. Ewald, "Timer and PWM – Part 2 (16 Bit Timer1)," November, 2020. [Online]. Available: https://wolles-elektronikkiste.de/en/timer-and-pwm-part-2-16-bit-timer1. [Accessed August 2022].