

Noise Reduction in ALPHA-g Magnet Control System

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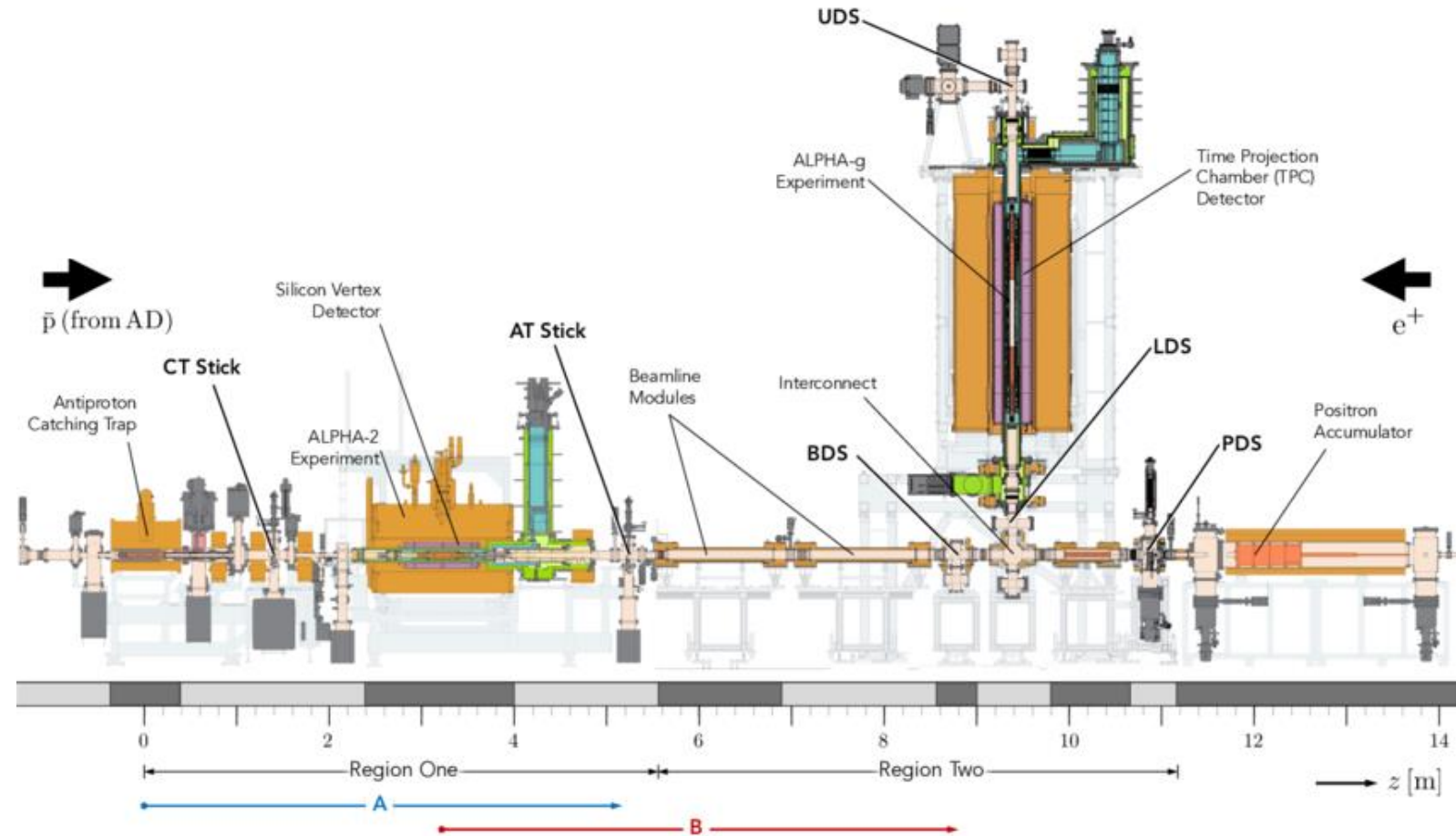
8 August 2024



Figure from C.J. Baker et al., *Design and Performance of A Novel Low Energy Multi-Species Beamline for the ALPHA Antihydrogen Experiment*

ALPHA Apparatus

- ALPHA-2 (spectroscopy) and ALPHA-g (gravitational studies)
- Measured gravitational affects on \bar{H} to put limits on CPT
 - Undergoing modifications for better measurements



ALPHA-g Magnet Control System

- Quench Protection System (QPS) disperses heat from quench
 - Reading from DCCT needs to be precise to determine quenches
 - Adding magnets increases noise
- Goal: Design/build circuit to reduce noise when additional magnets are added

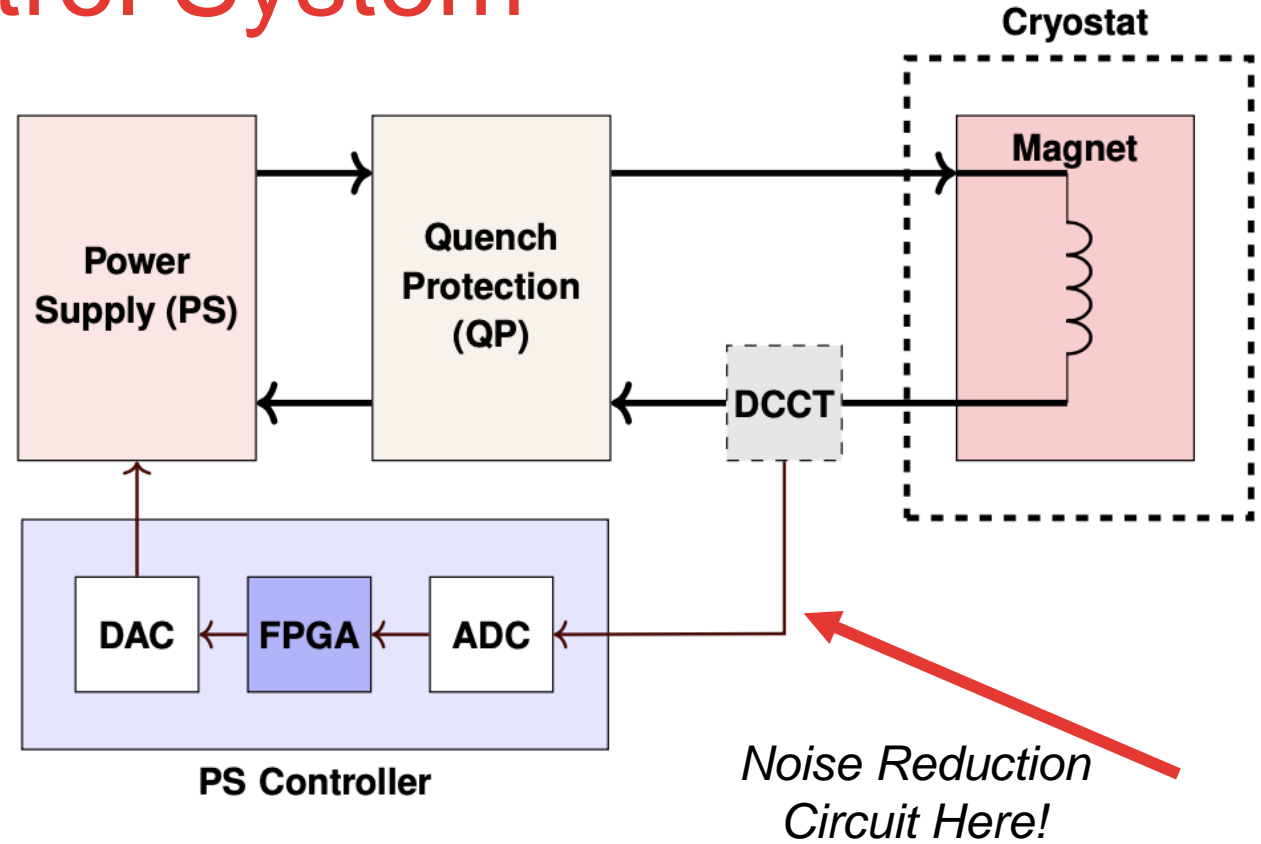
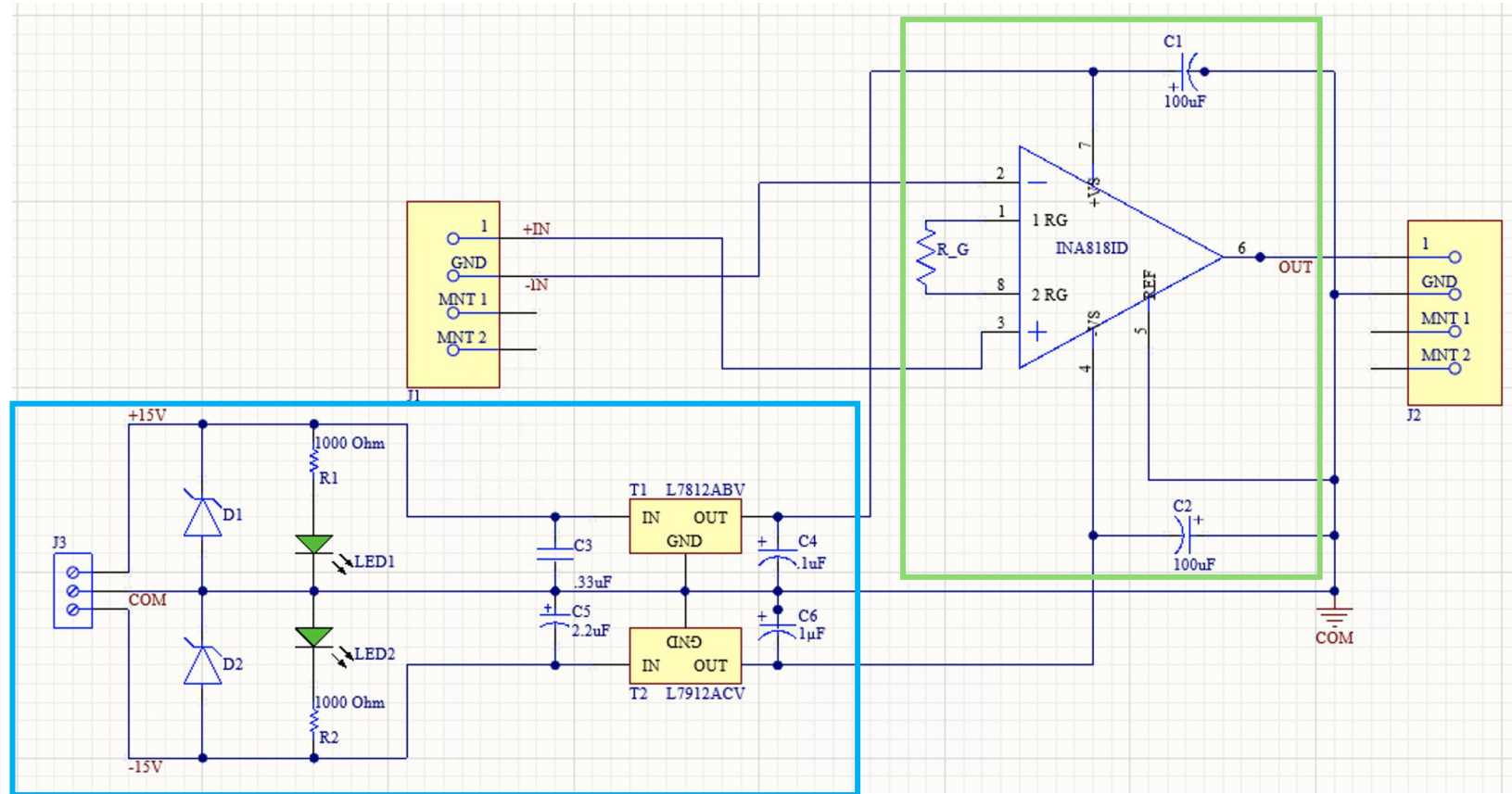


Figure from J. Singh. *Fundamental Tests of Antimatter Gravitation with Antihydrogen Accelerators*

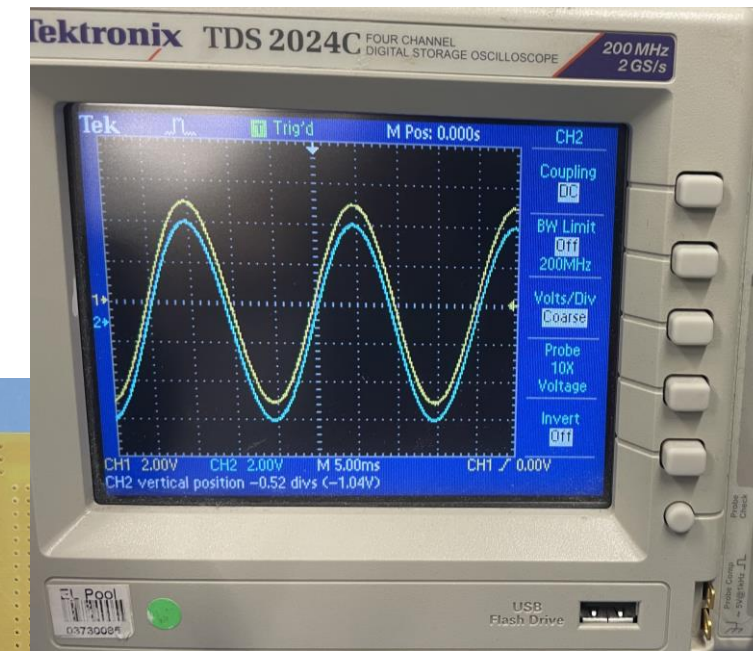
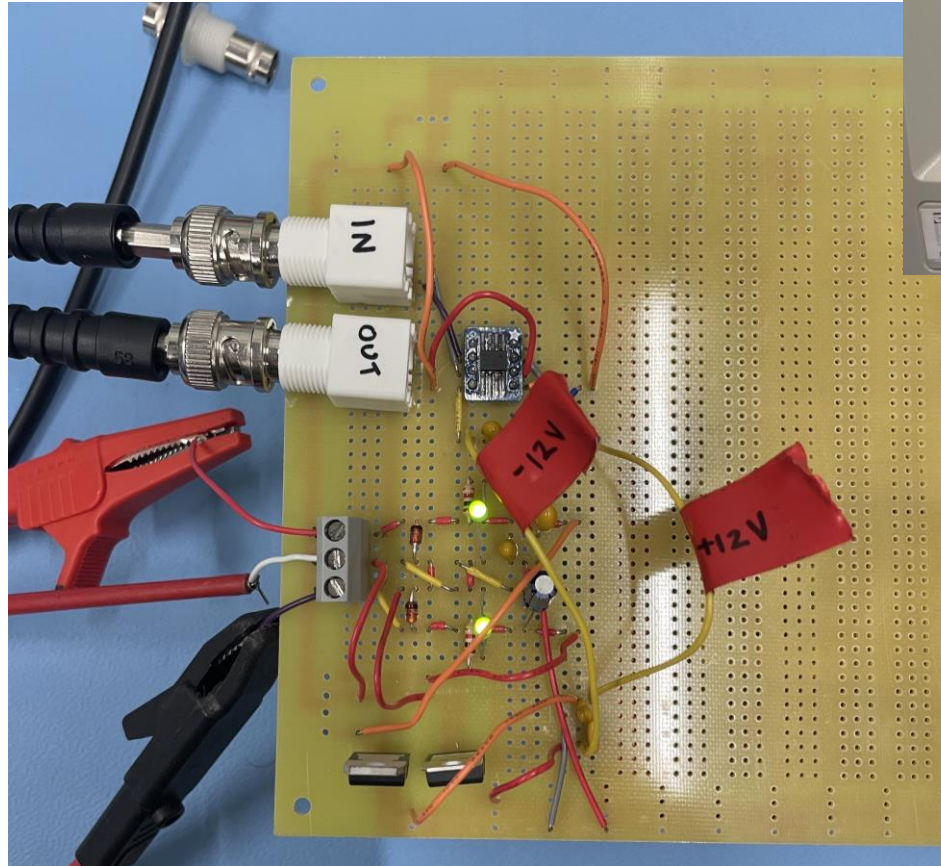
Design Specifications

- Overall Goal: Noise reduction
 - IC with no gain
 - Decoupling capacitors reduce noise in chip and provide high current
- Protection for polarity swapping and overvoltage
 - Diodes prevent reversed polarity damages
 - Voltage regulators keep RHS circuit to ± 12 V



Prototype Circuit

- Soldered parts onto perf board
- First tested LHS from previous slide, then added RHS
 - LEDs indicate circuit behaves correctly
- Scope output shows signal was not distorted through circuit
 - Traces offset because perfectly overlap

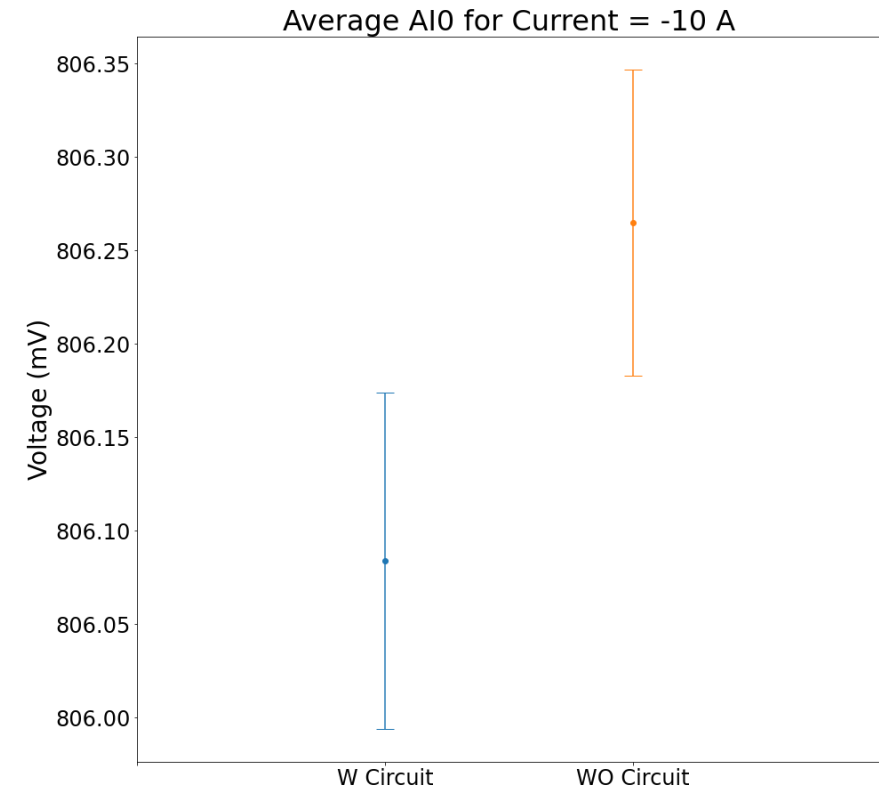
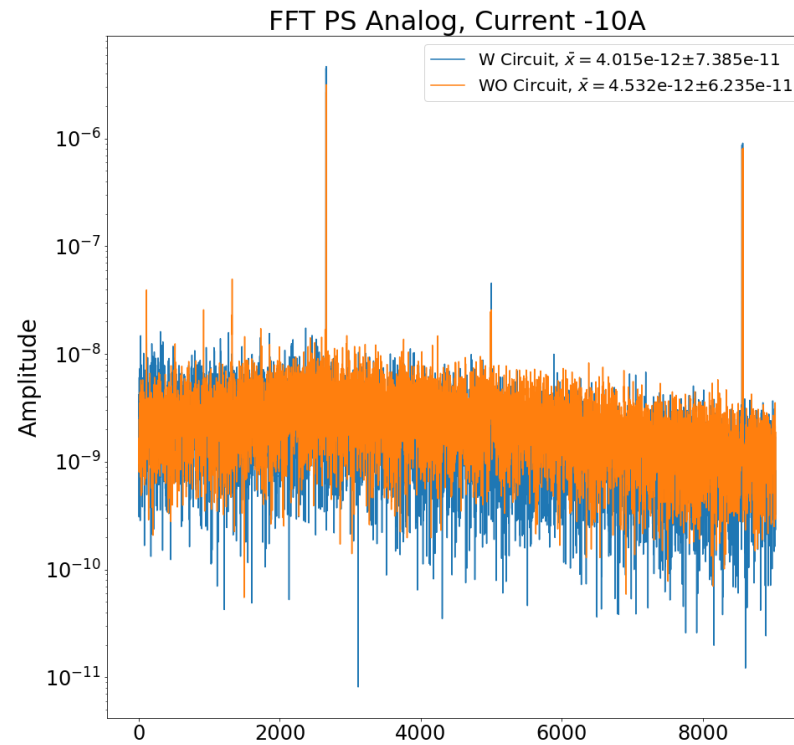
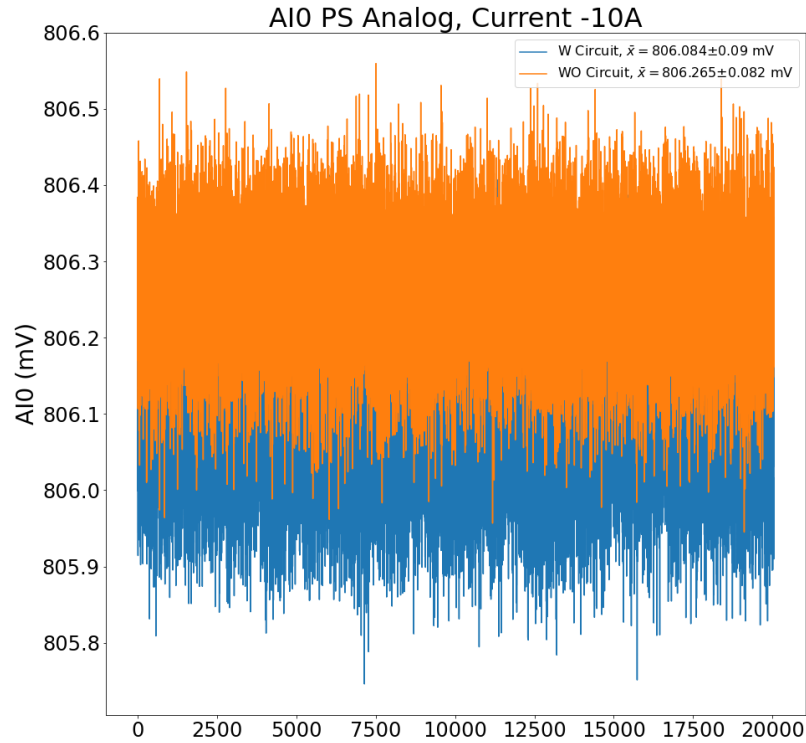


Input = Yellow
Output = Blue

Magnet Control System Test Setup

- Tested at 6 different current settings
 - 0 A (PS controlled), 0 A (cRIO controlled), ± 10 A, ± 50 A
- Measured voltage output from DCCT with and without circuit
 - Plotted average voltage for comparison
- Performed FFT to determine noise sources from circuit

Results for -10 A



Circuit decreases noise by .0225%

Conclusions and Future Tests

- 0 A (PS Controlled) had best percent decrease of 4.968%
 - Very large standard deviation
- 50 A had worst percent decrease of .0039%

- PS had many problems
 - Floating ground
 - Parasitic capacitance?
- Add bypass resistors to RHS circuit
 - Help prevent output current from IC chip
- Use digital multimeter for voltage readings

Thanks for Listening! Questions?

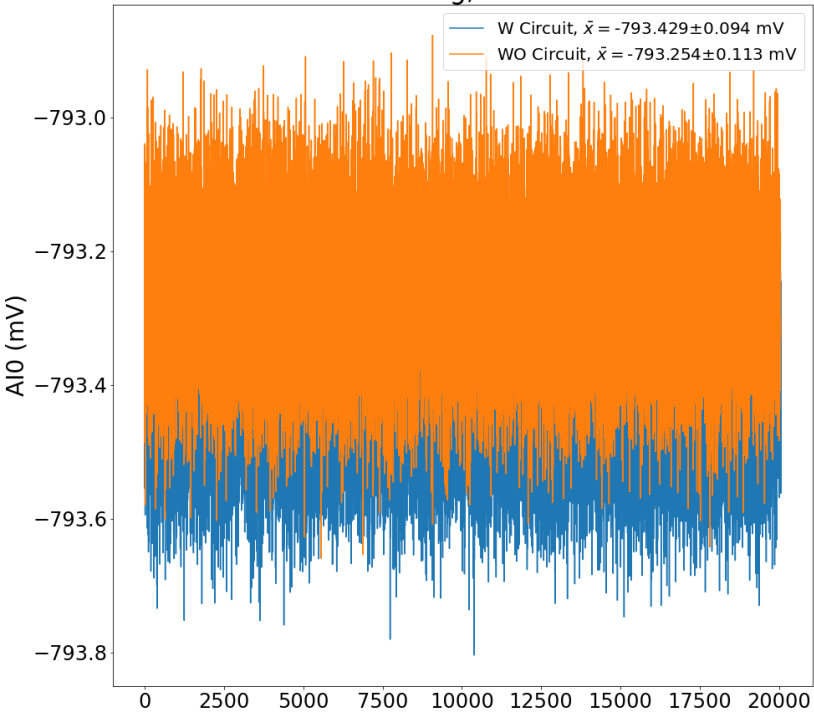
A huge thanks to the University of Michigan and the NSF for this opportunity.

Thank you to Álvaro de Nunes Oliveira, Jaspal Singh, and Reece Sumner Stefanyshyn for their help with everything this summer.

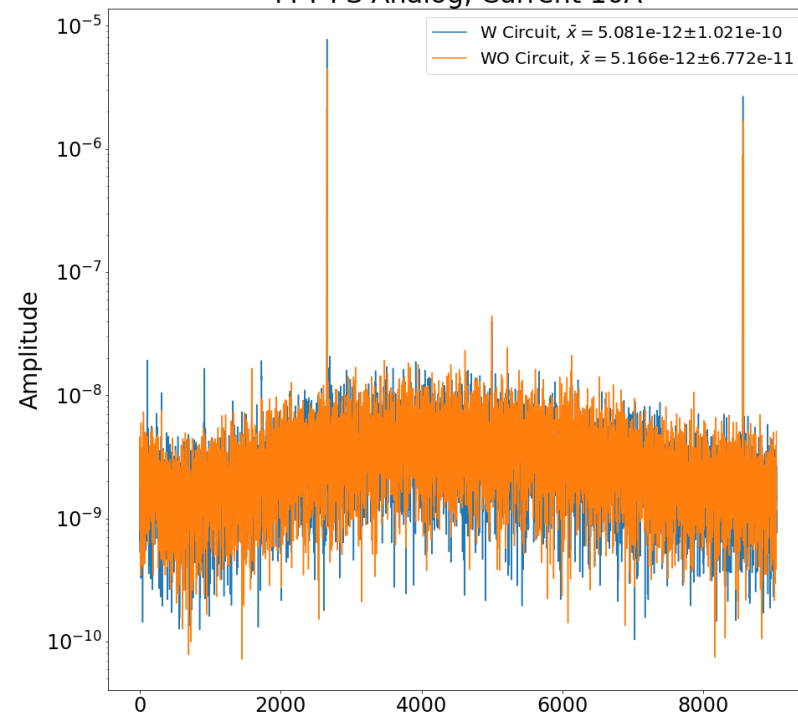
Backup Slides

Results for +10 A

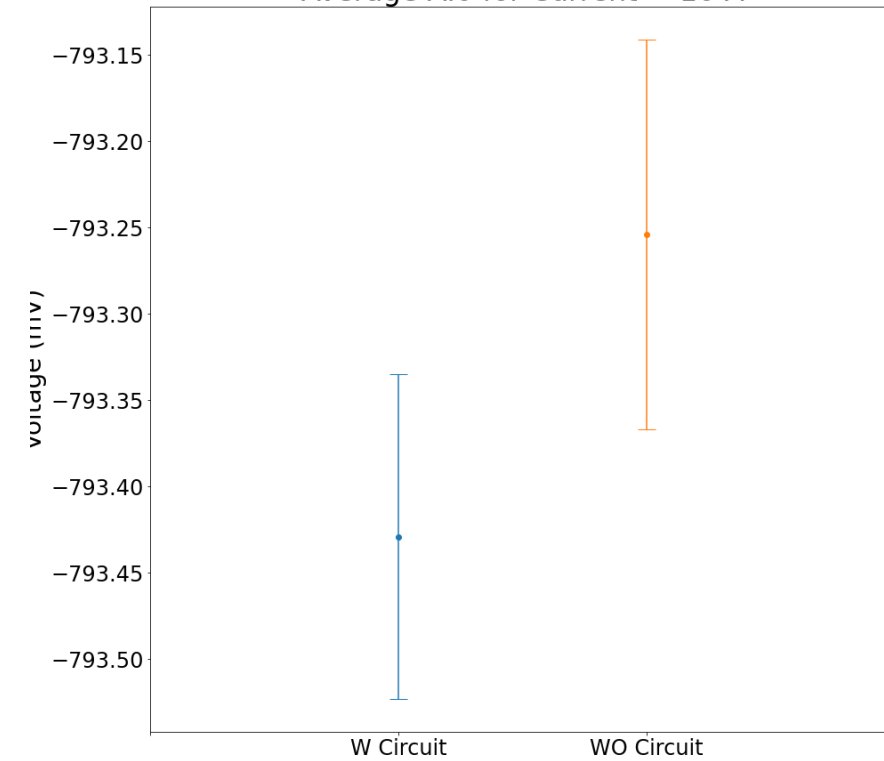
AI0 PS Analog, Current 10A



FFT PS Analog, Current 10A

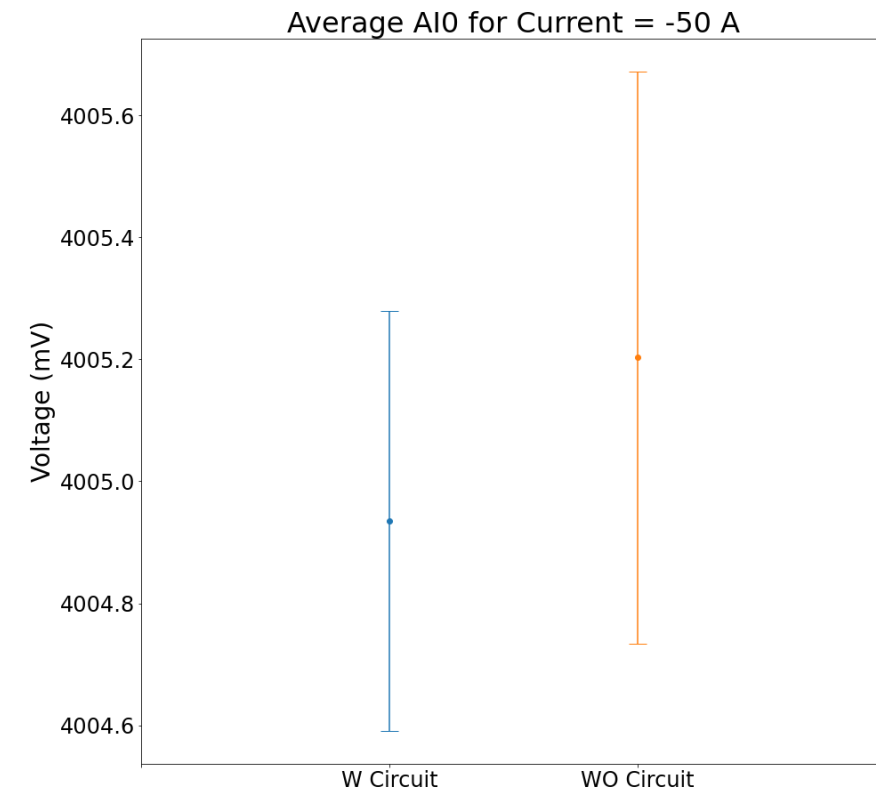
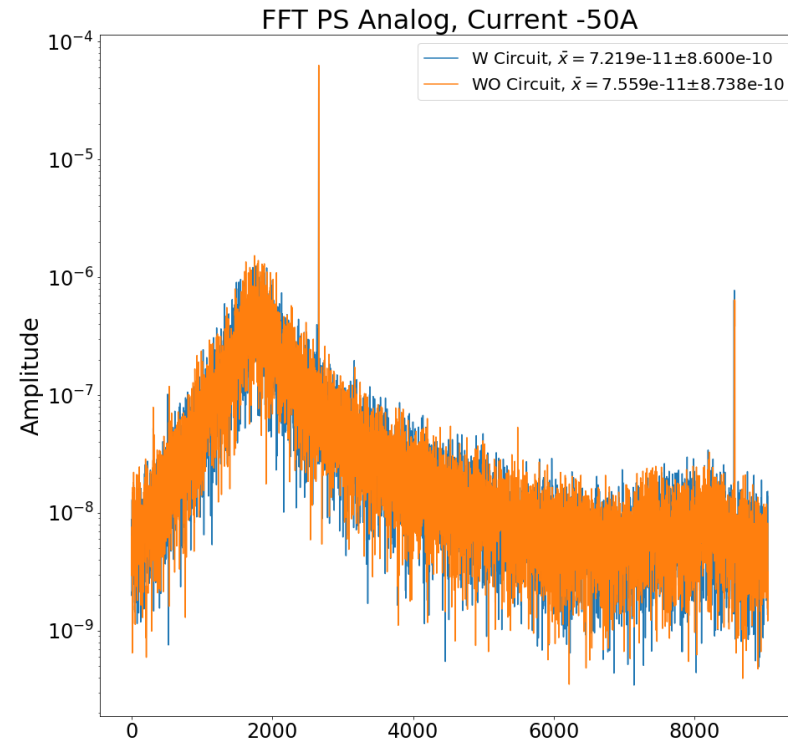
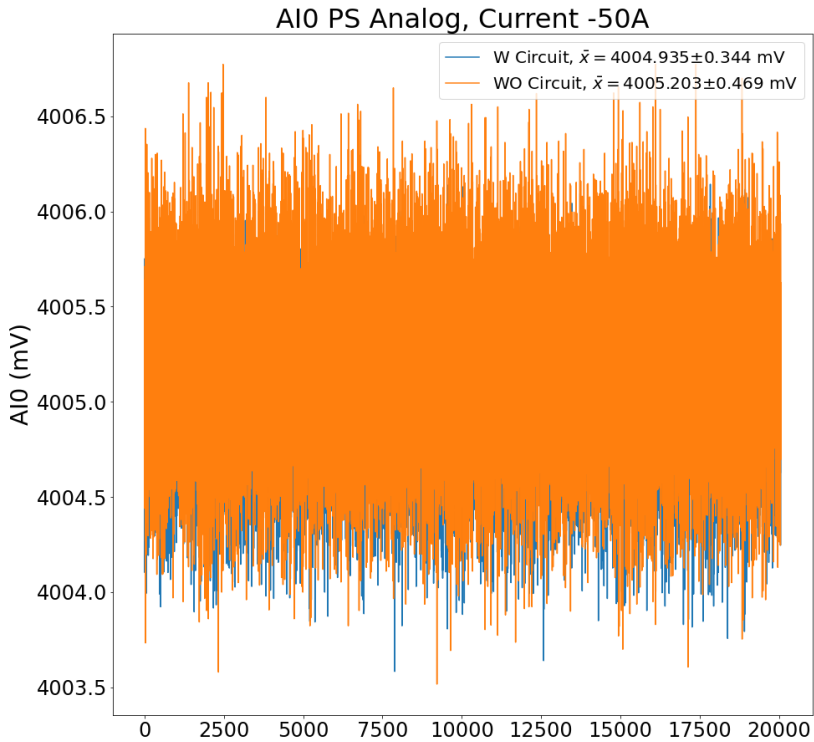


Average AI0 for Current = 10 A



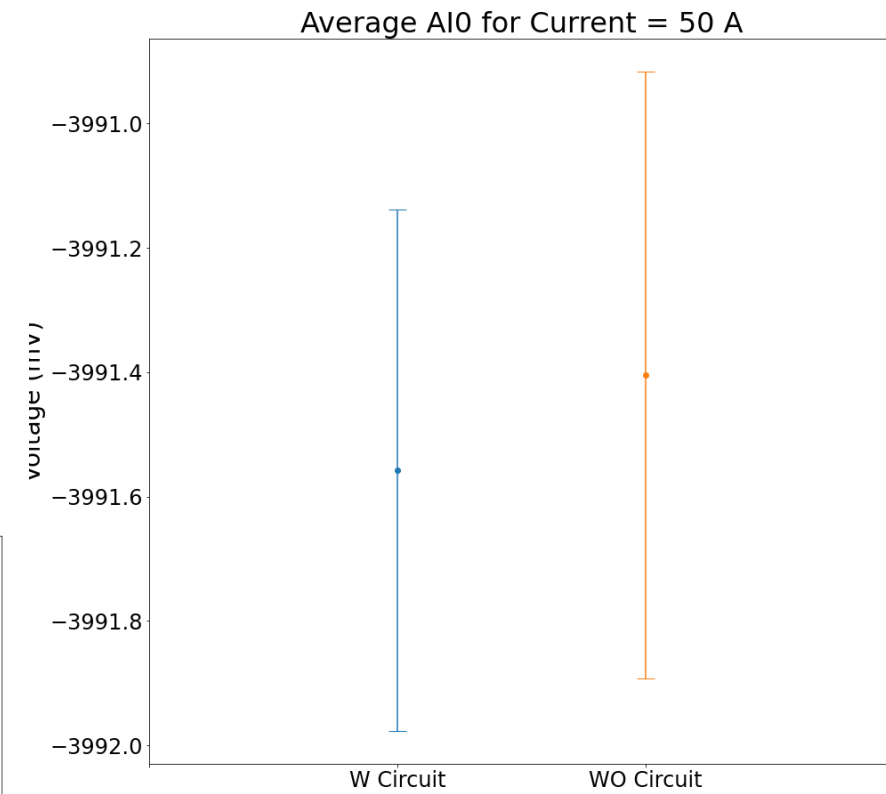
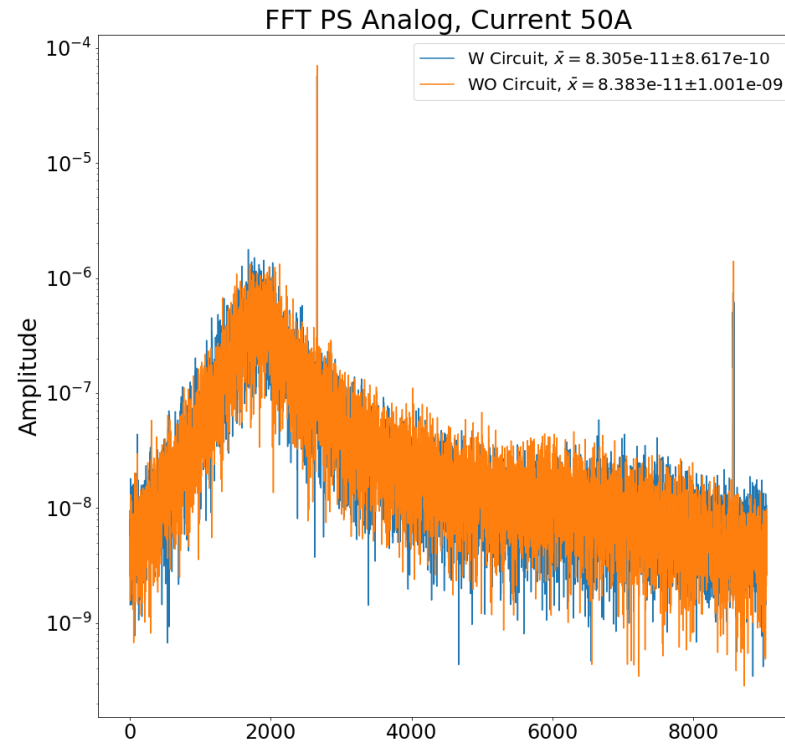
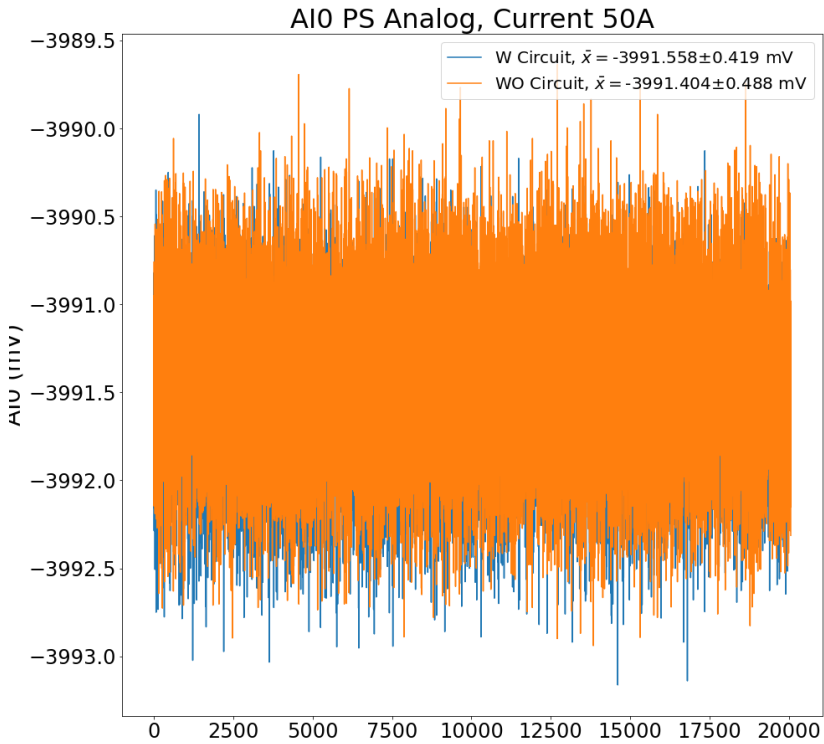
Circuit decreases noise by .0221%

Results for -50 A



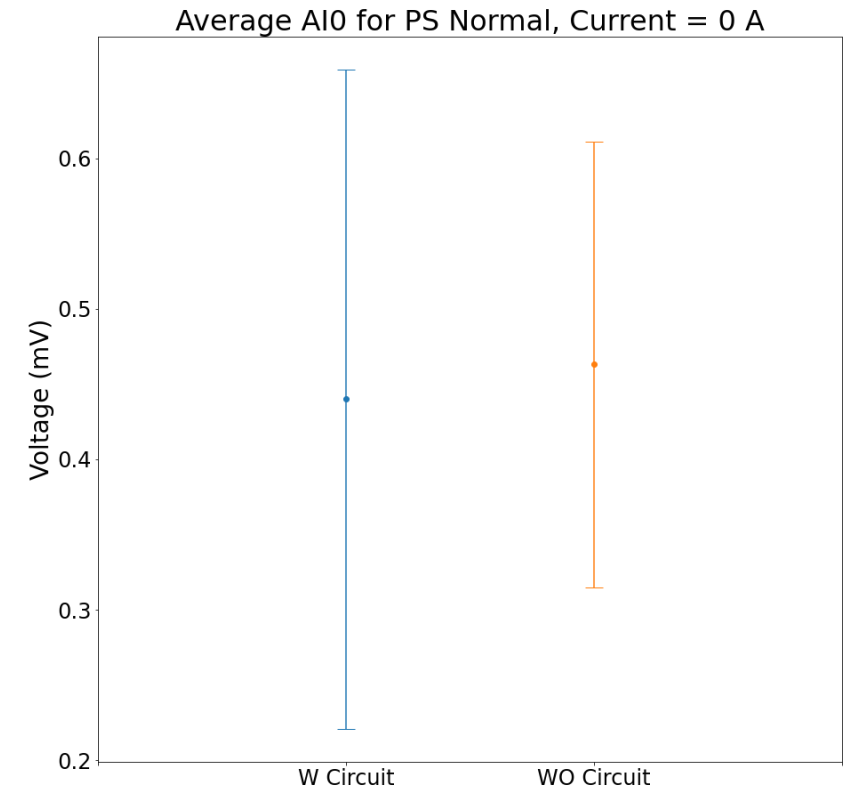
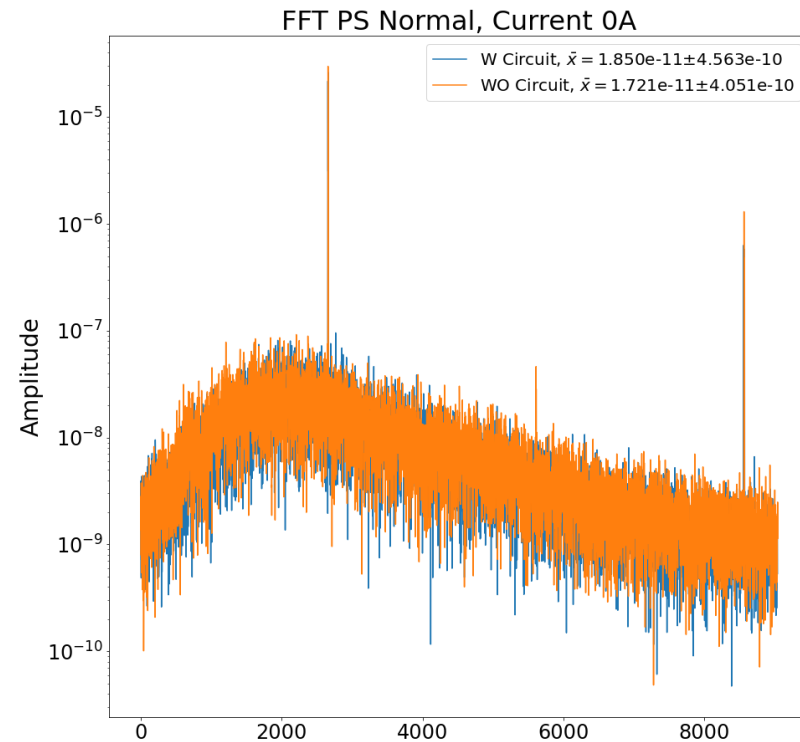
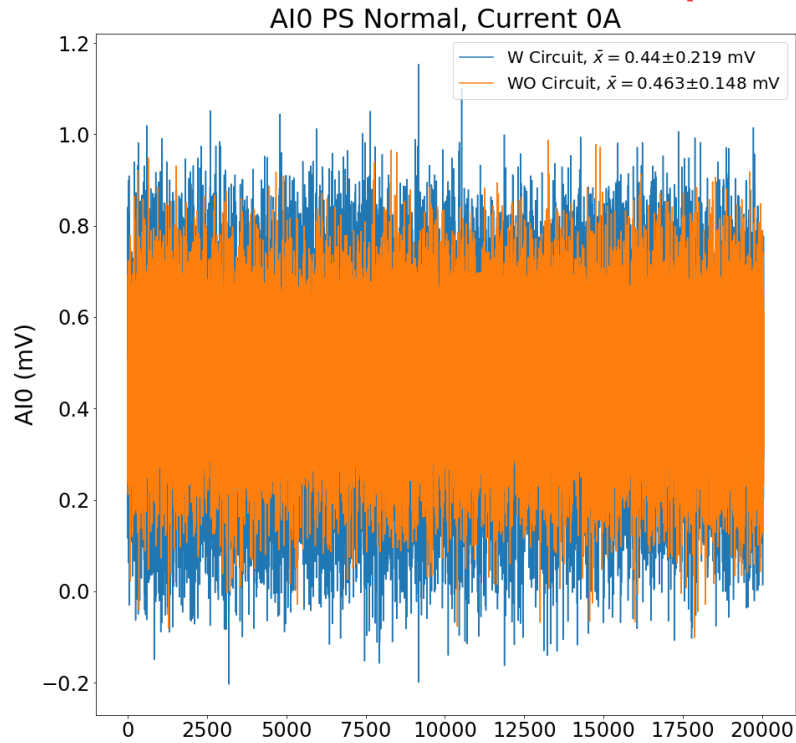
Circuit decreases noise by .0067%

Results for +50 A



Circuit decreases noise by .0039%

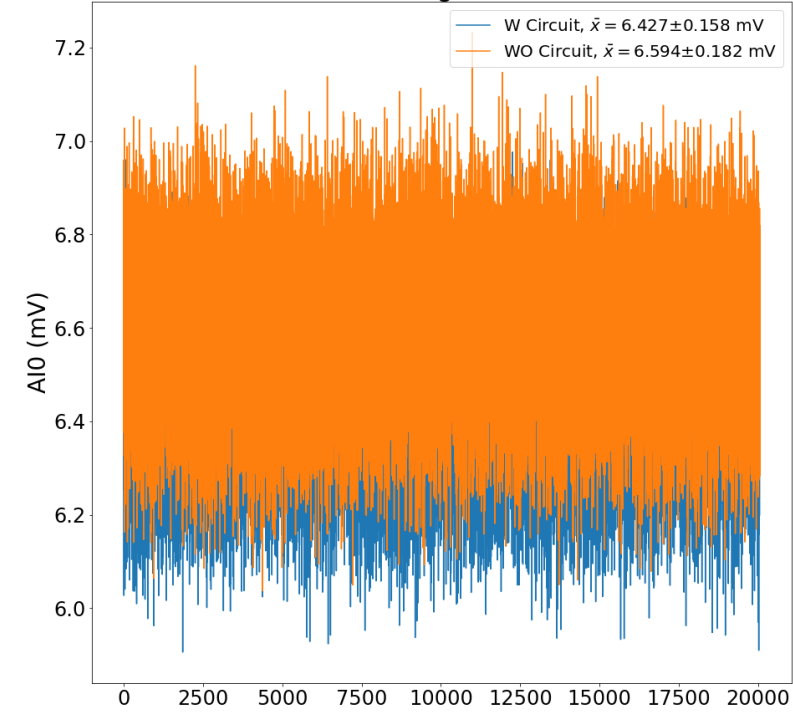
Results for 0 A (PS Controlled)



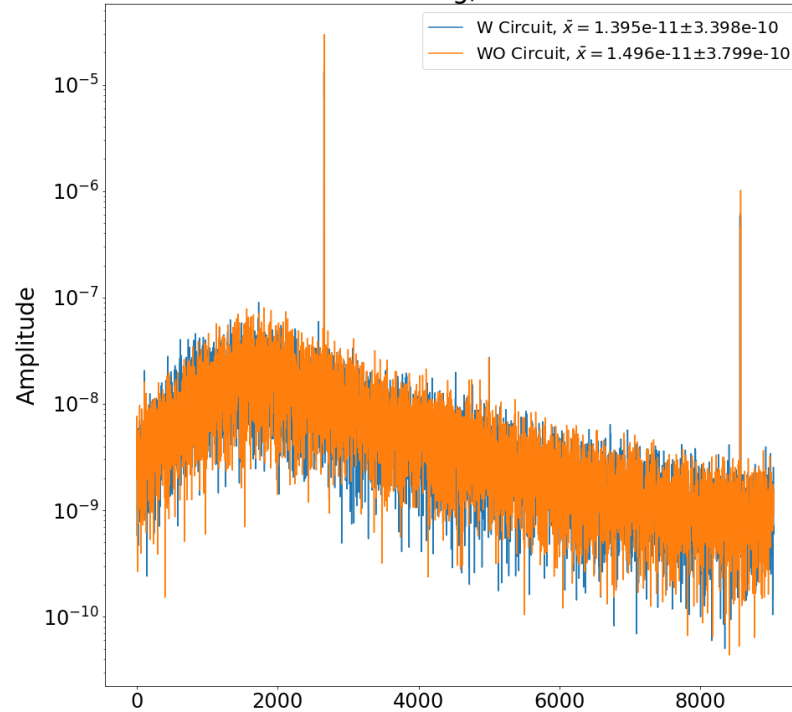
Circuit decreases noise by 4.968%

Results for 0 A (cRIO Controlled)

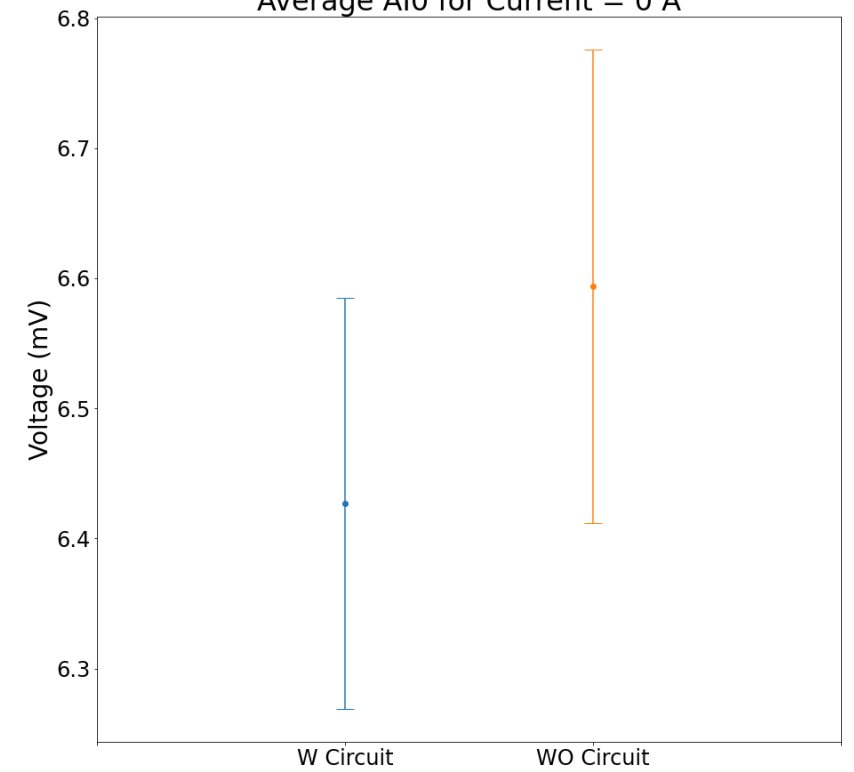
AIO PS Analog, Current 0A



FFT PS Analog, Current 0A



Average AIO for Current = 0 A



Circuit decreases noise by 2.533%