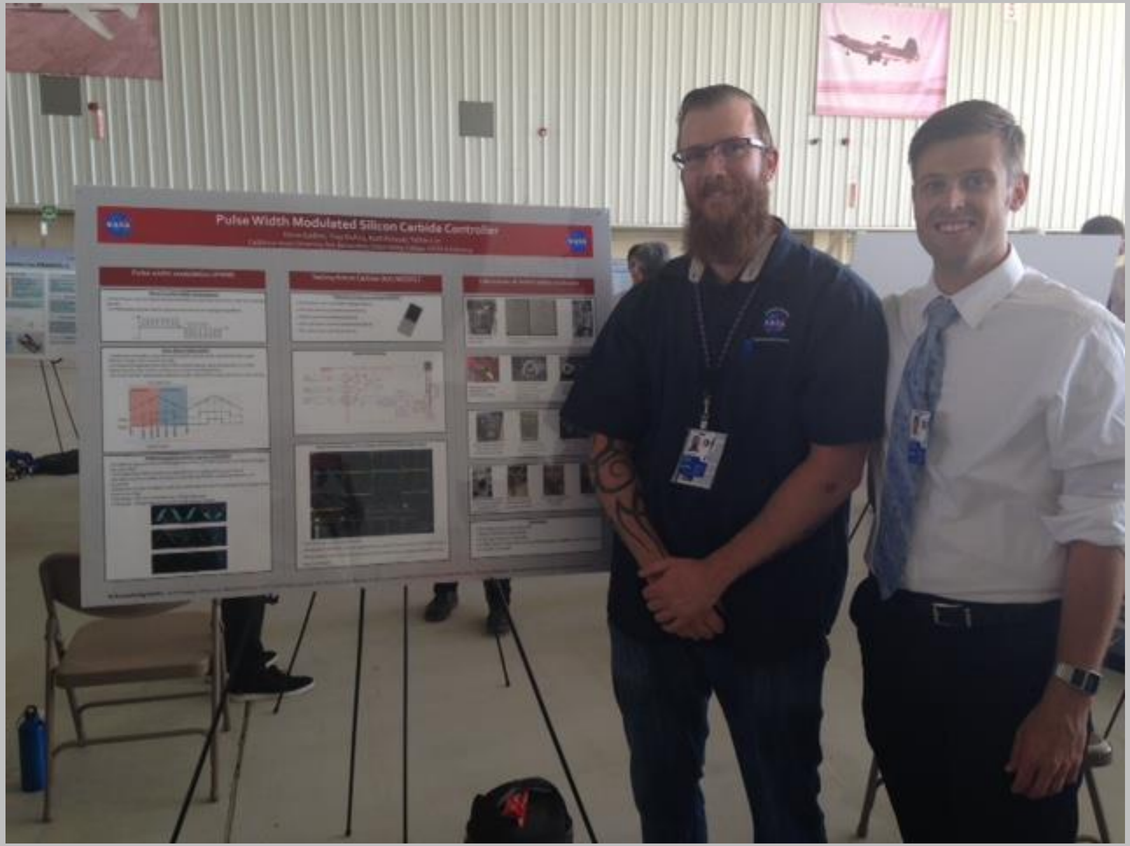
INVESTIGATING THE PERFORMANCE VALUES OF SILICON-CARBIDE TECHNOLOGY

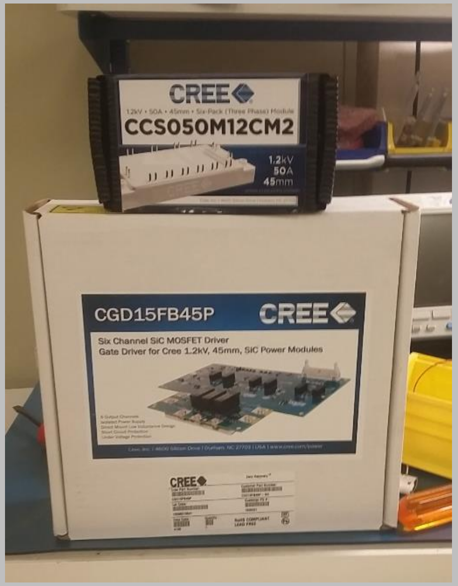
- Can Sustain up to 10X higher voltages than Si
- Can carry almost 5X more current than Si
- Higher temperature tolerance than Si
- Up to 3X higher thermal conductivity than Si
- Can switch up to 10X faster than Si



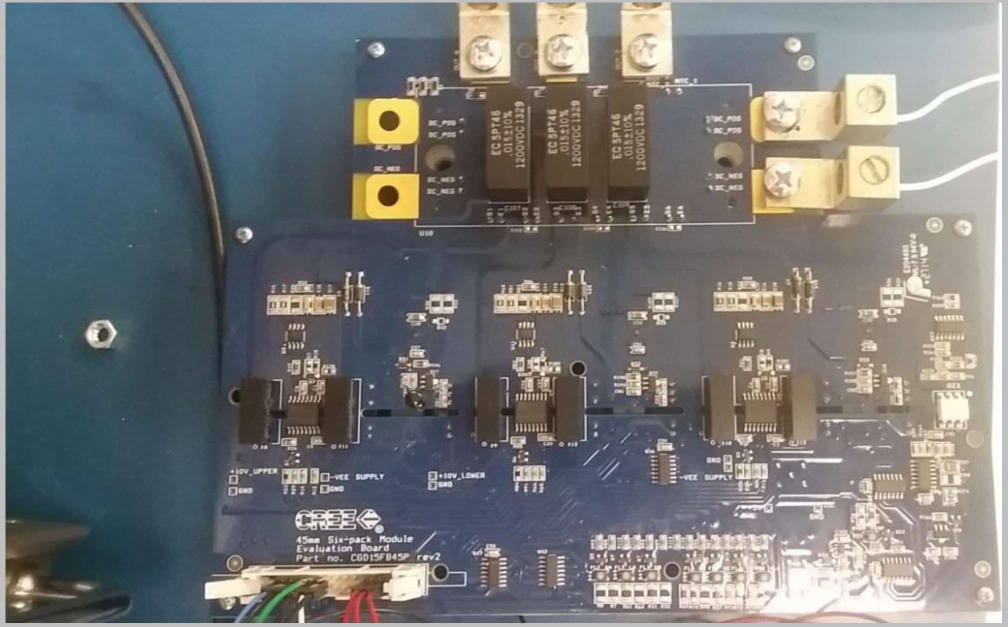
EXPERIMENTATION OF JOBY MOTOR CONTROL

- **Troy T. Kuhns**
- **Victor Valley College**
- **Sophomore**
- **Mechanical Engineering**
- **Yohan Lin & Kurt Kloesel**
- **Rt Vehicle Integration and Test**
- **H.E.I.S.T. Project**
- **Welder/Fabricator**

CREE 6-CHANNEL GATE DRIVER AND SILICON CARBIDE SIX-PACK

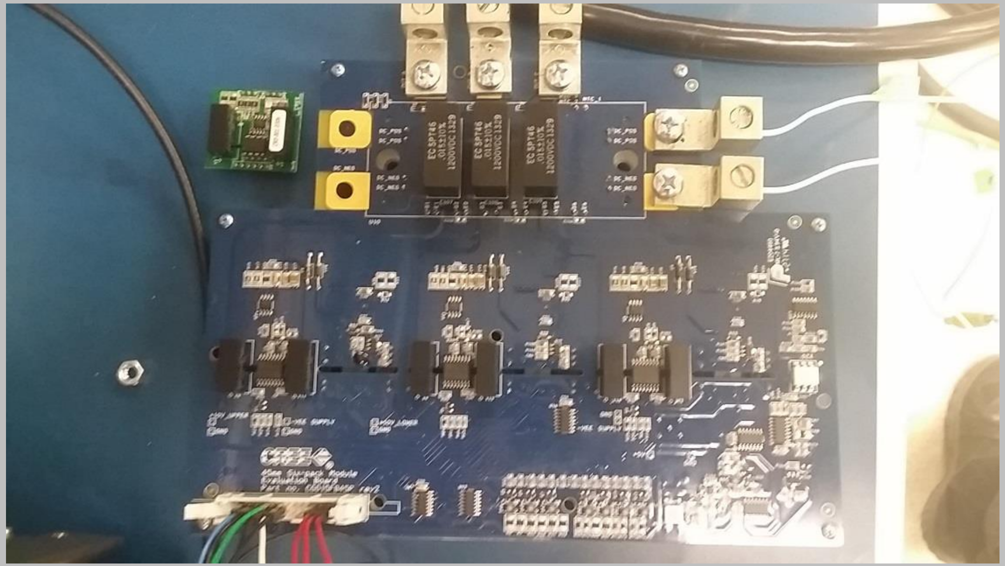


- This is the board that we would experimentally test to investigate its possibility of controlling the JOBY motor.
- Capable of creating 3-phase power.
- A/C TO D/C POWER CONVERSION
- OUPUT OF 900VDC
- BIG BOARD WITH LOTS OF COMPONENTS
- ALSO EXPENSIVE WITH THREE-PHASE MODULE ATTACHED
- INSTEAD OF EXPERIMENTING WITH THIS…….



LEARNING TO CONTROL AND UNDERSTAND SIC MOSFET GATE DRIVER

- **Single gate driver = smaller compact simpler design, as compared to six-channel, = cheaper price point if, and we did, burn it up.**
- **New to circuit board function testing and understanding.**
- **Good insight on output values with respect to input values**
- **Great for developing a working knowledge of individual components like the gate and opto-isolator.**

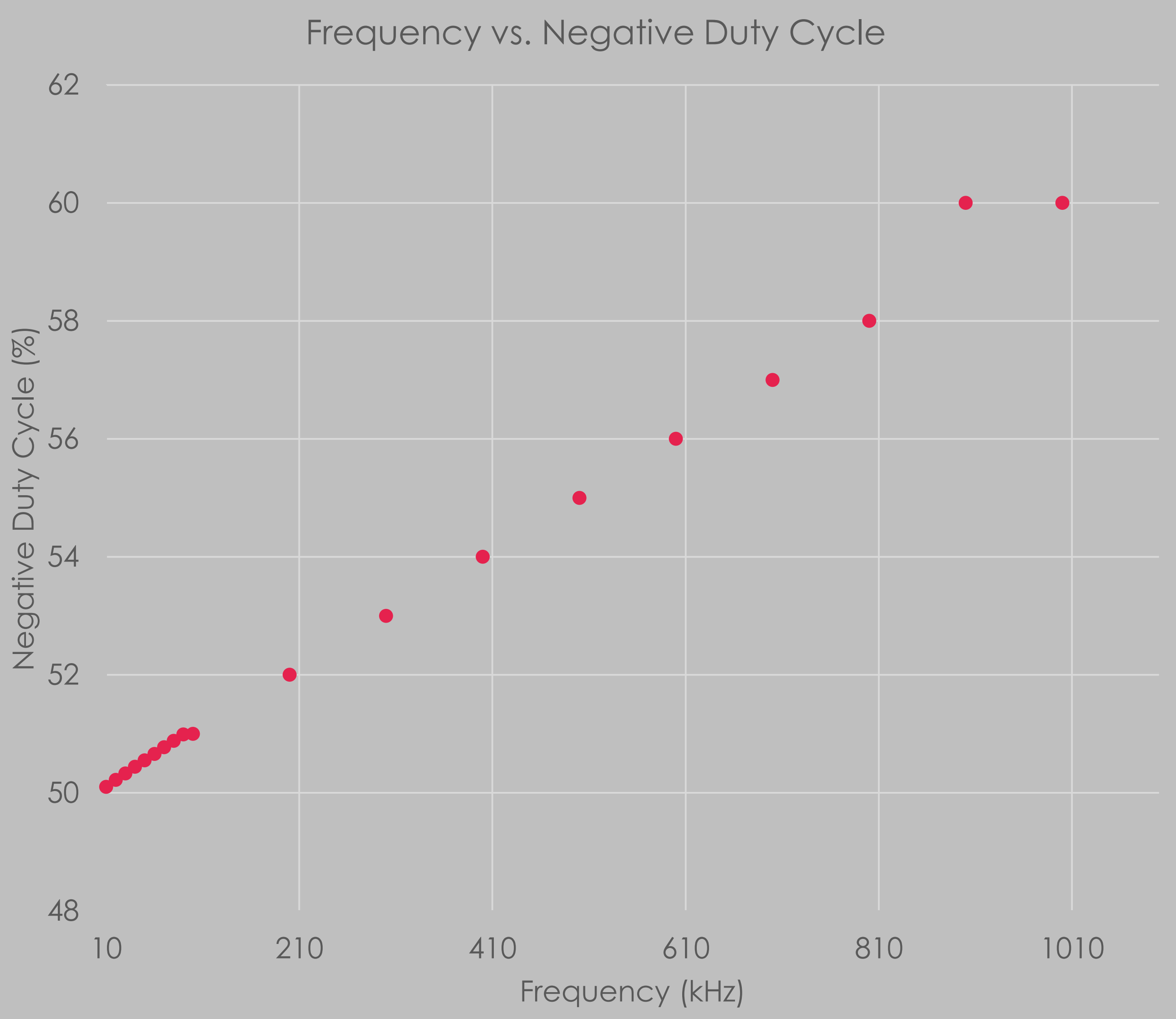


TESTING SETUP OF THE CREE CRD-001

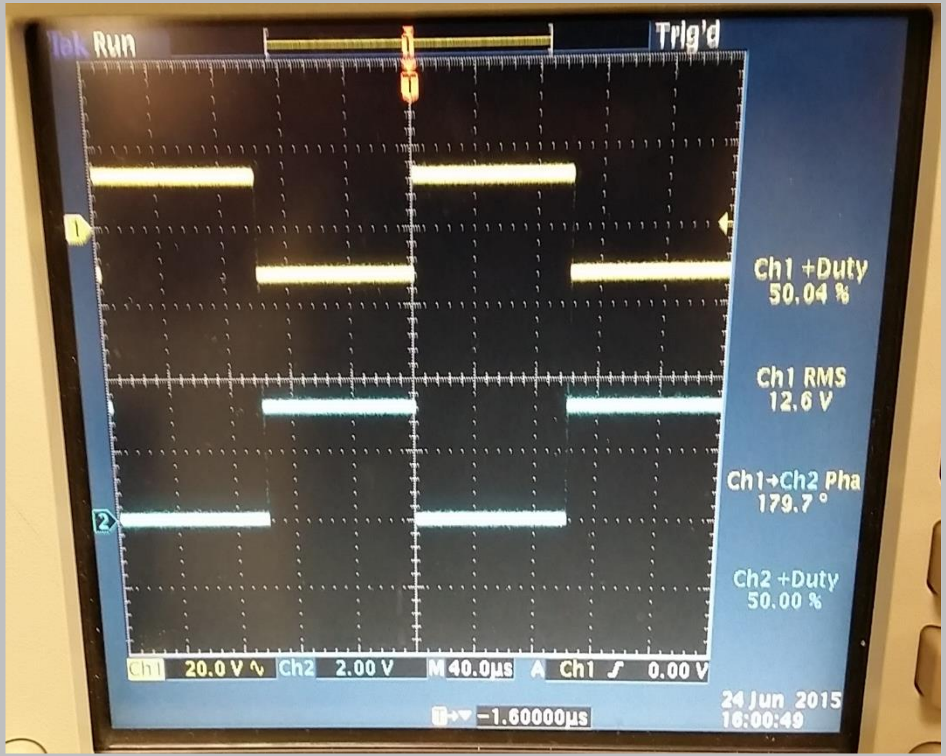
- Two different power sources to control the high and low input voltages.
- Signal generator used to control input square wave through amplitude, frequency and voltage.
- Recording data on the oscilloscope, looking predominately at duty cycle.

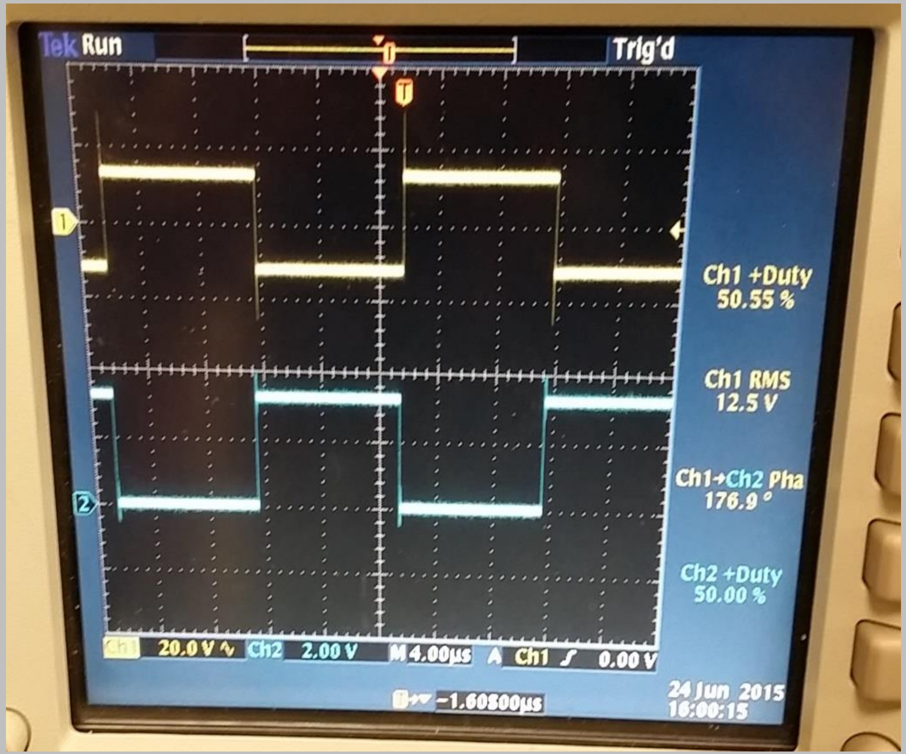
DUTY CYCLE PERFORMANCE WITH INCREASING FREQUENCY

- **Cree CRD-001 SiC MOSFET Gate Driver**
- **VCC High 10.0 Volts**
- **VCC Low 10.0 Volts**
- **Signal Generator Amplitude 5Vrms**
- **Offset 0 Volts**
- **+1% (-) Duty Cycle Change per 100 (kHz)**
- **-0.1V RMS for every +200kHz up to 1Mhz**
- **Signal Failure at 3.11MHz**



FREQUENCY V.S. DUTY CYCLE

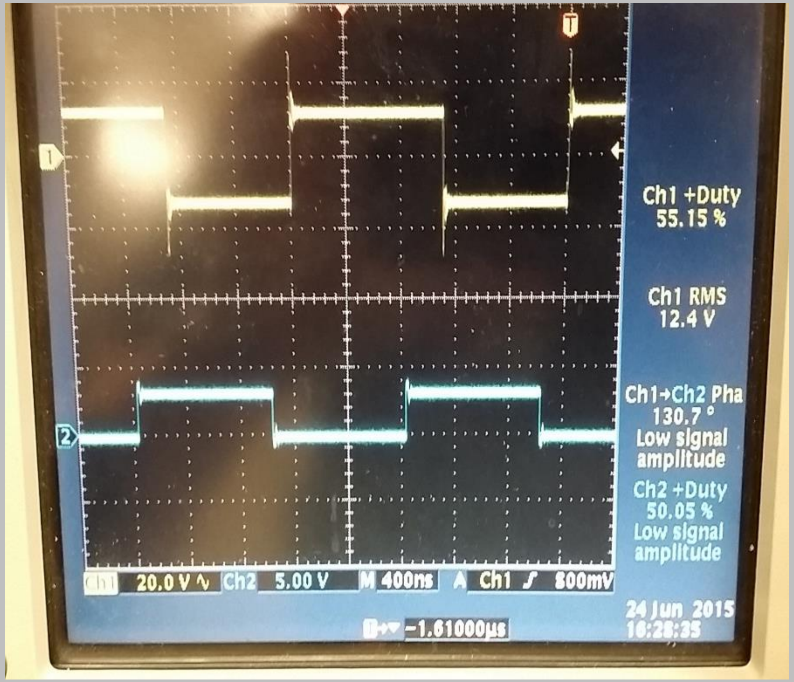




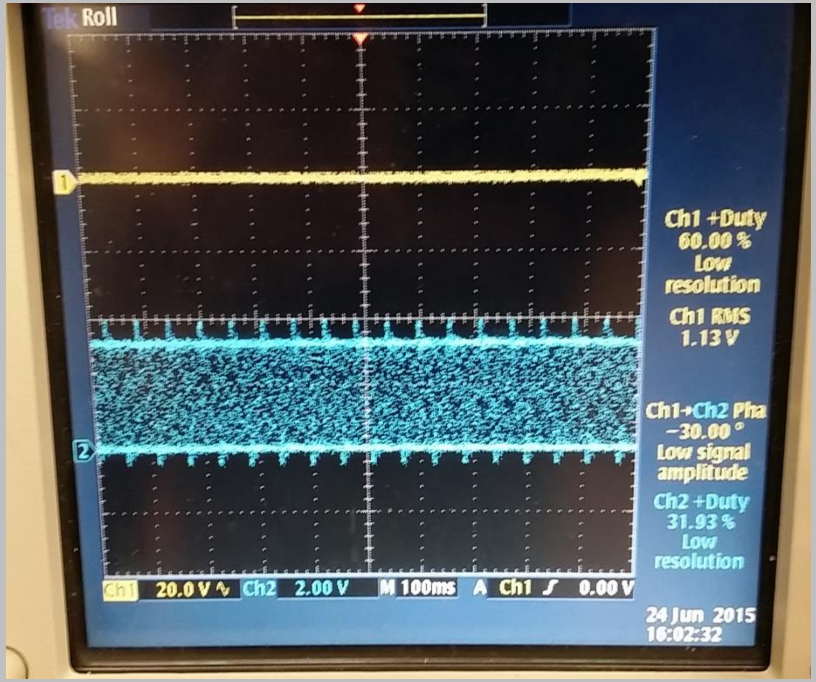
5 KHZ

50 KHZ

FREQUENCY V.S. DUTY CYCLE



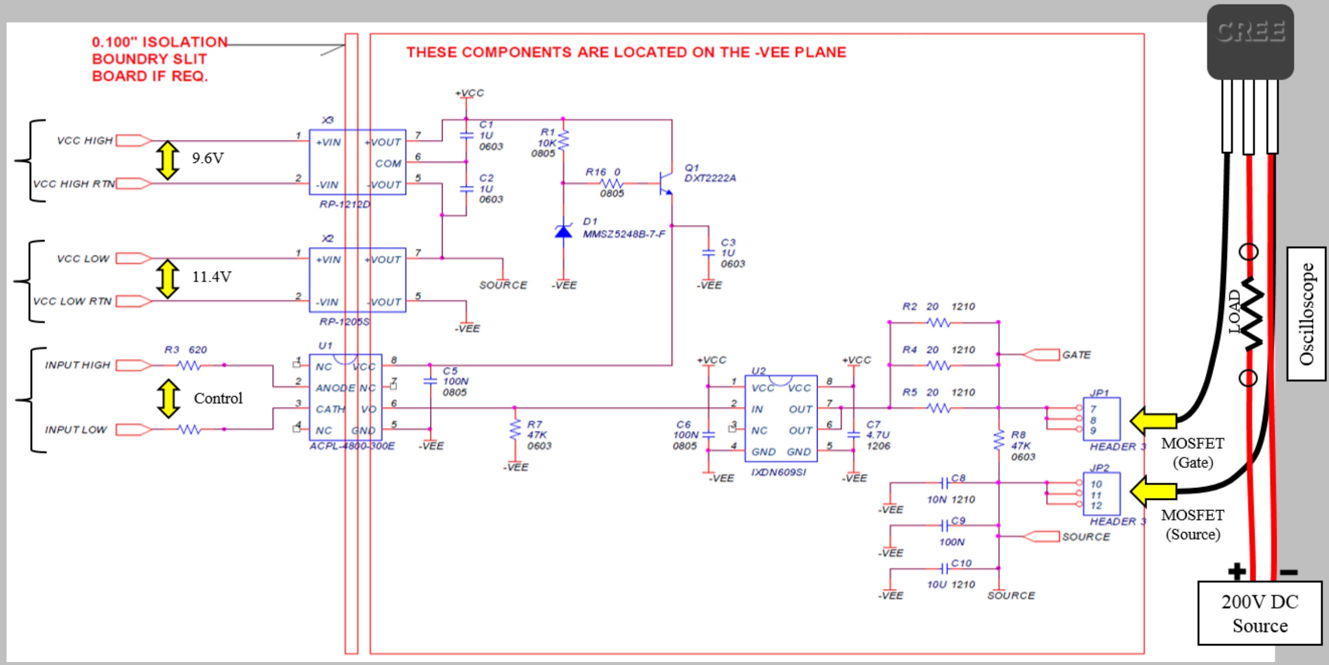
500 KHZ



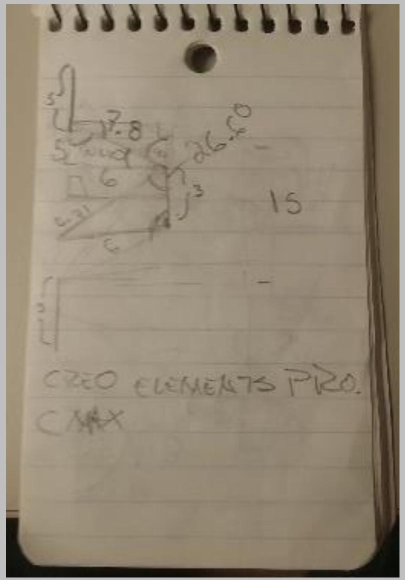
5 MHZ

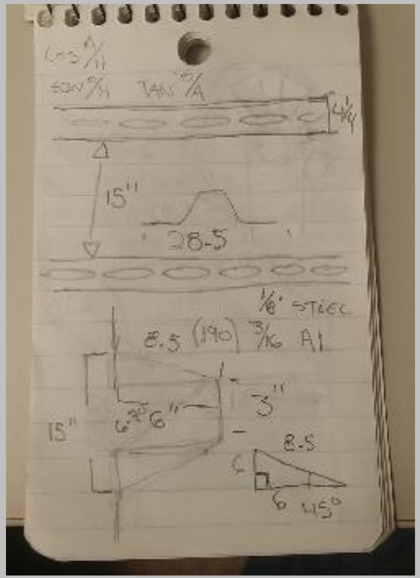
CREE CRD-001 WITH CREE C2M0025120D MOSFET

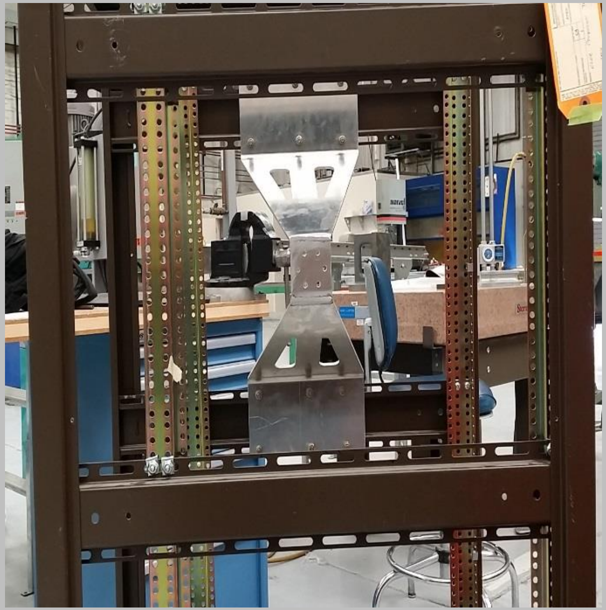
- Using the Cree CRD-001 to power the Cree mosfet to test and record the performance values.
- Using two power supplies, the first with two separate channels to control the high and low voltage input for the board and the second to power the mosfet on.
- Signal generator to create the square wave and oscilloscope to record output values.
- Load bank for the drain leg of the mosfet.



FABRICATION OF MOTOR TEST STAND

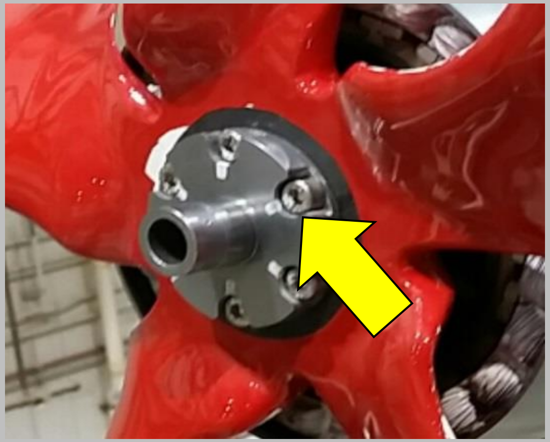


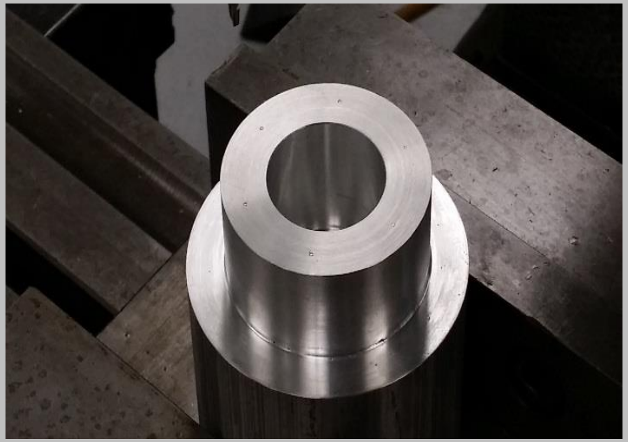




- Repurposing an old server rack unit to fabricate a safety test enclosure for the JOBY motor and propeller to be used for testing the SiC driver board.
- Initial design drawings of the motor mount.
- Motor mount made from 6061 T-6 Aluminum cut out with a water jet and bent to shape with hydraulic press. Keeping the center of mass located along the X and Y axis of the enclosure.

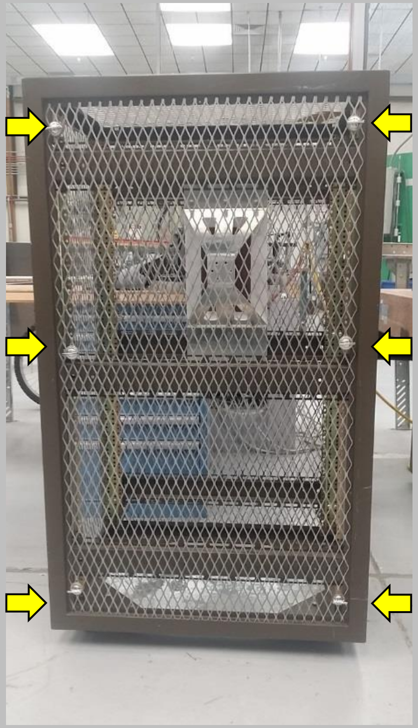
FABRICATION OF MOTOR TEST STAND






- When inquiring about torque specs for propeller bolts I noticed this bushing. To equally distribute the bolt head pressure on the propeller I had created a bolt head pressure distribution washer.
- Started off with a solid 3” piece of 6061 T-6 Aluminum round stock.
- On the lathe we turned it down to a O.D. of 2.165” and using a center bore cutting in an I.D of 1.215”.
- Using the mill to find centricity we plotted and drilled the hole pattern.
- Finally taking our piece back to the lathe we cut out 3 different washers of varying thicknesses.

FABRICATION OF MOTOR TEST STAND



Left Side: Motor test cage enclosed 3/5 of the way with expanded metal. For easy access to front and back of test motor I used ¼ quick turn cam locks.

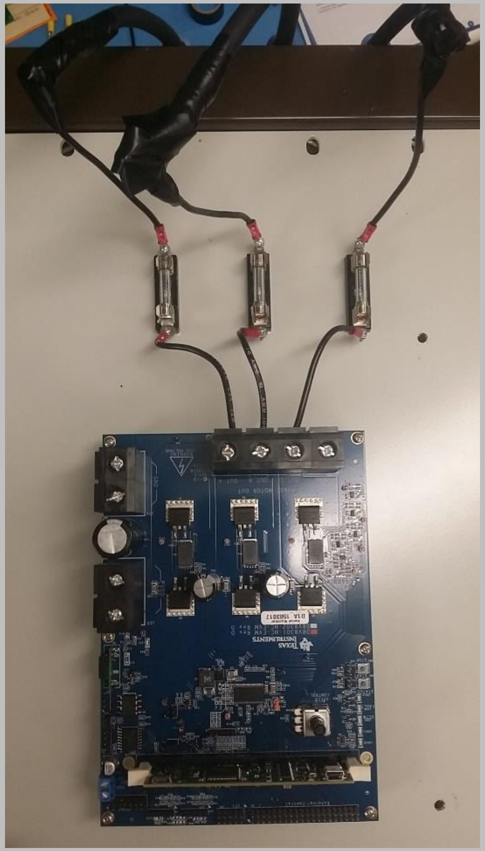
Right Side: An Aluminum frame housing a phenolic block to electrically isolate each motor terminal lug. Lugs on both sides allow for quick connect/disconnect with out removal of rear panel.

FABRICATION OF MOTOR TEST STAND

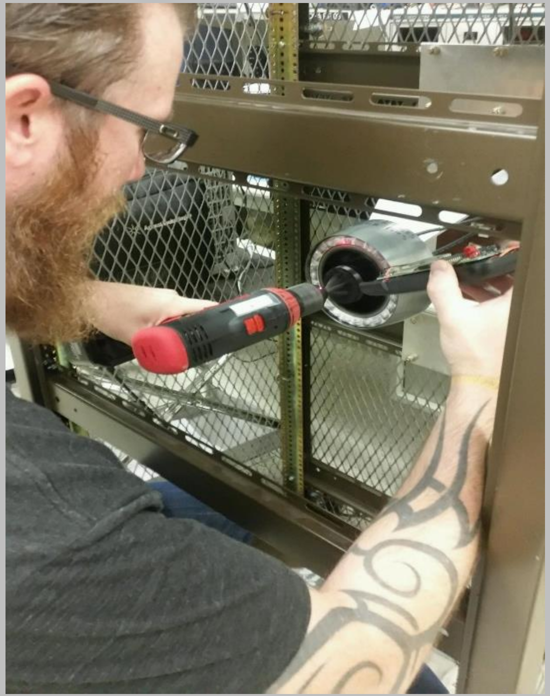
- A few pictures of the completed motor stand with front panel attached and removed.
- Using a piece of sheet metal on the bottom of test cage to act as an active ballast support system.

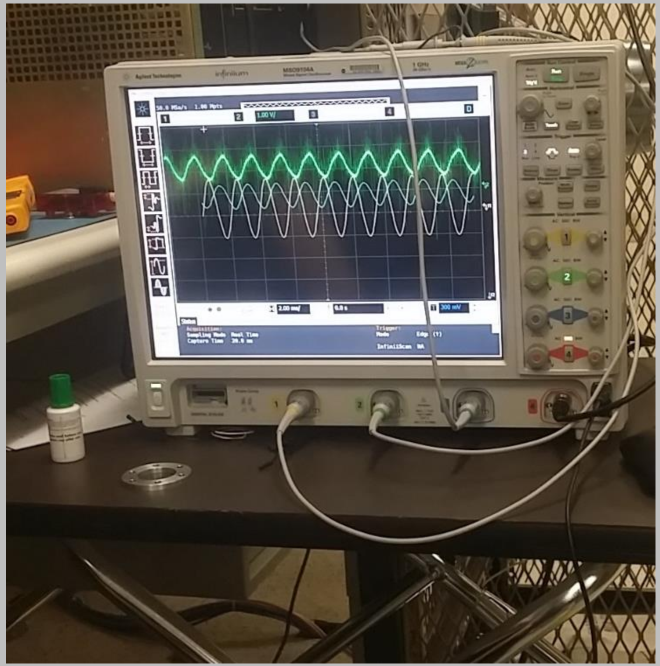
MOUNTING TI CONTROLLER BOARD TO TEST ENCLOSURE

- Using a Texas Instruments DRV 8301 motor controller board we could gather some initial data.
- Mounted the board to a rack shelf and mounted the shelf to the top of the motor cage.
- Inline fuses to thermally and electrically protect the board from to much current.



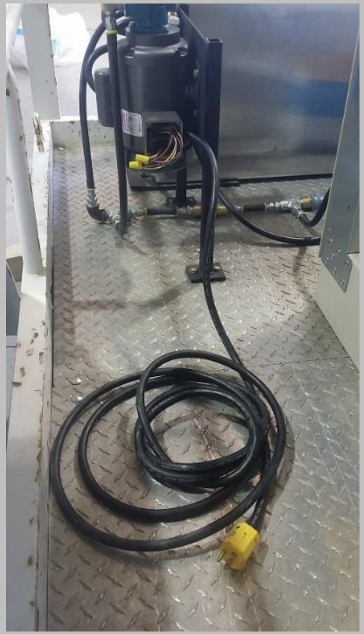
JOBY MOTOR IN ACTION WITH SIGNAL OUTPUT



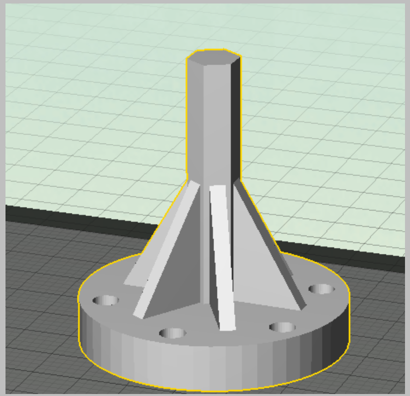


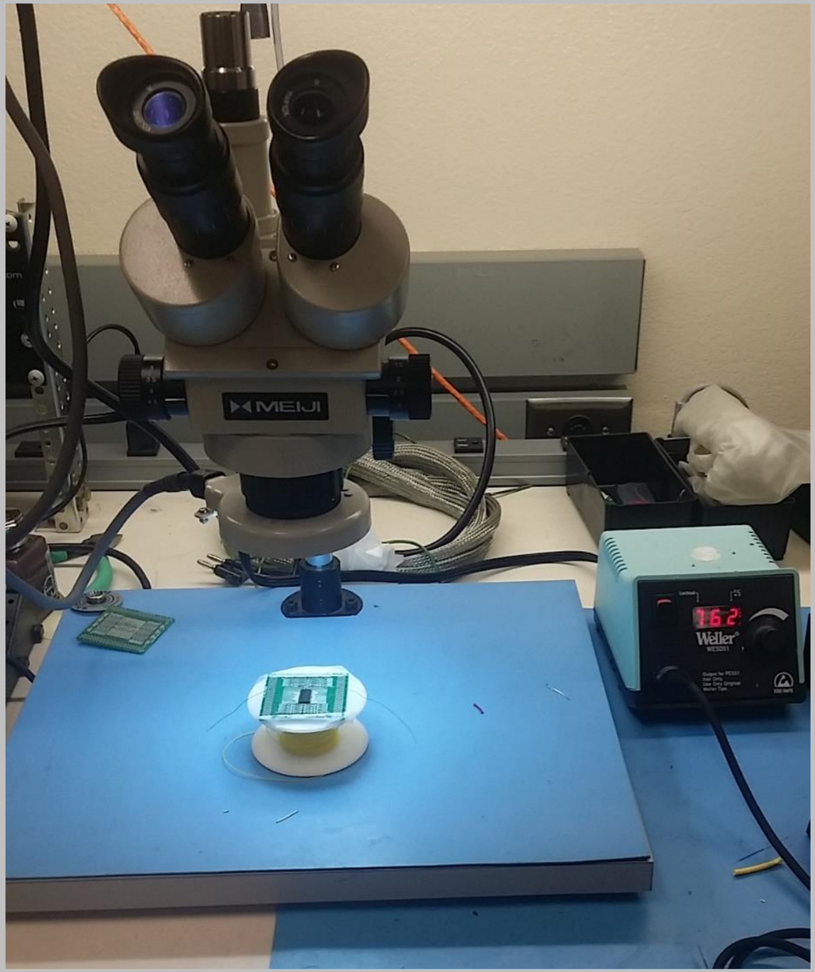
- **Controlling the JOBY motor with micro-controller and manual methods for data capture and analysis.**
- **Using a chuckable 3-D printed motor adaptor, cordless drill, and tachometer to compare RPM to Voltage variables.**

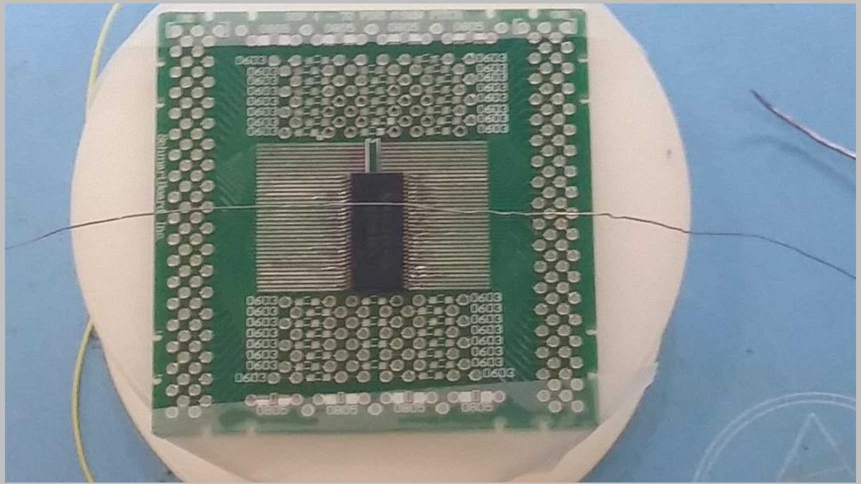
CAPSTONE WIRING PROJECT

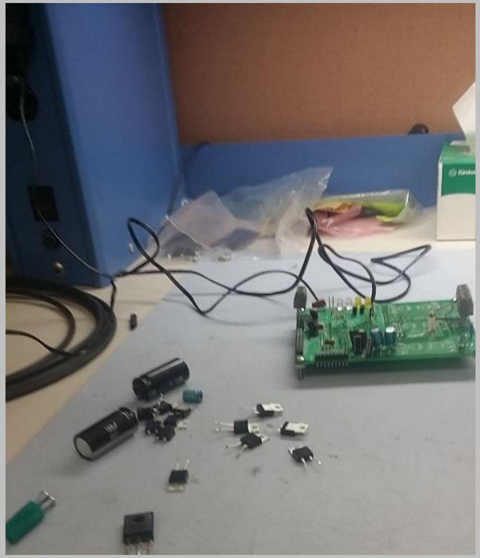


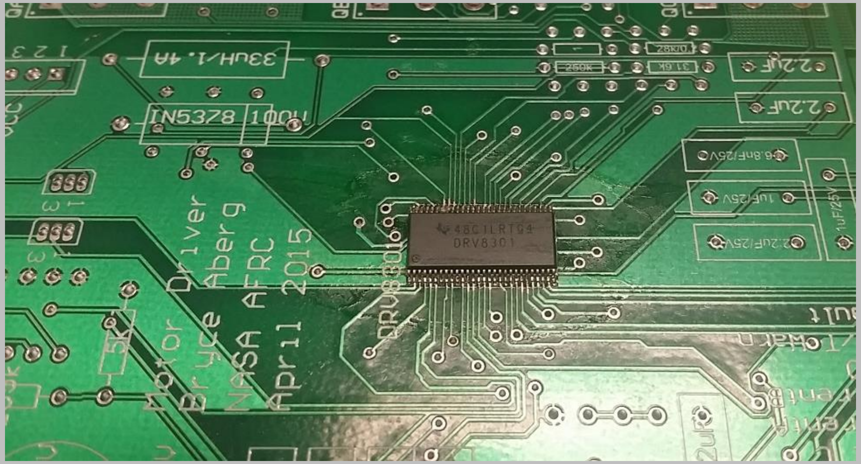
OTHER PROJECT TASKS I WAS INVOLVED WITH





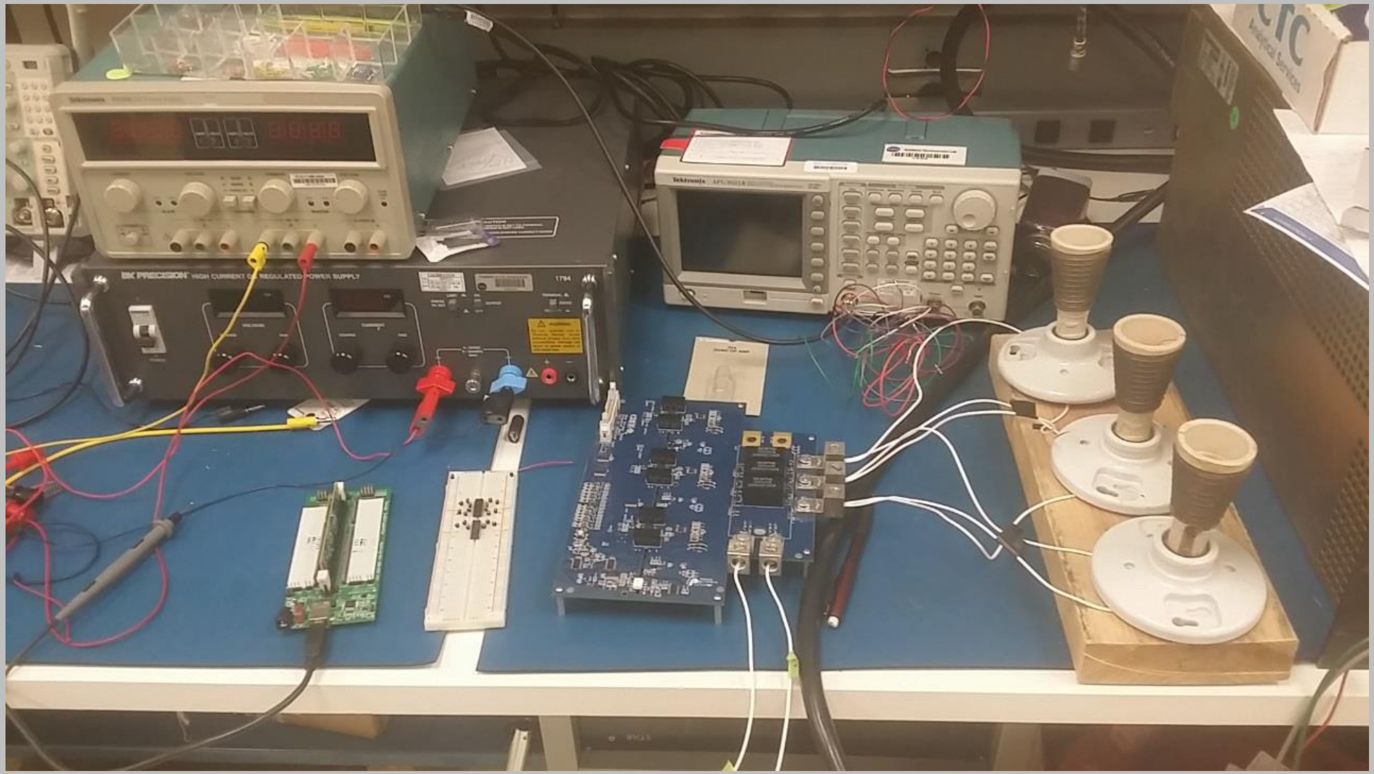






BACK TO THE SILICON-CARBIDE

- Connected a 3-Phase load to the CREE board.
- Tested and triggered individual transistors.
- The Texas Instruments 28335 Delphino micro-controller has a 3.3V output.
- The CREE board needs 5V per channel to switch on.
- Set up a series of 5V op-amps in between to help power board.



ACKNOWLEDGMENTS

- Becky Flick
- The Aero Institute
- NSF Crest Grant #1345163
- Yohan Lin & Kurt Kloesel
- Michael Butros & Khalid Rubayi
- Jim Murray
- Bob Novy, Brent Bieber, Dennis Pitts
- Ed Swan, Andy Blua, Daryl Lott, Keith Day, Don Whitfield, Eric Nisbet, Kyle Whitfield, Bill Stanfield, Jerry Cousins, Jason Preece, Andy Ohmit, Rick Pokorski, Jeff Requist