



Dwight Look College of

ENGINEERING
TEXAS A&M UNIVERSITY

Team 70: VFD Motor Controller Bi-Weekly Update 5

Mackenzie Miller

Andrew Nguyen

Aidan Rader

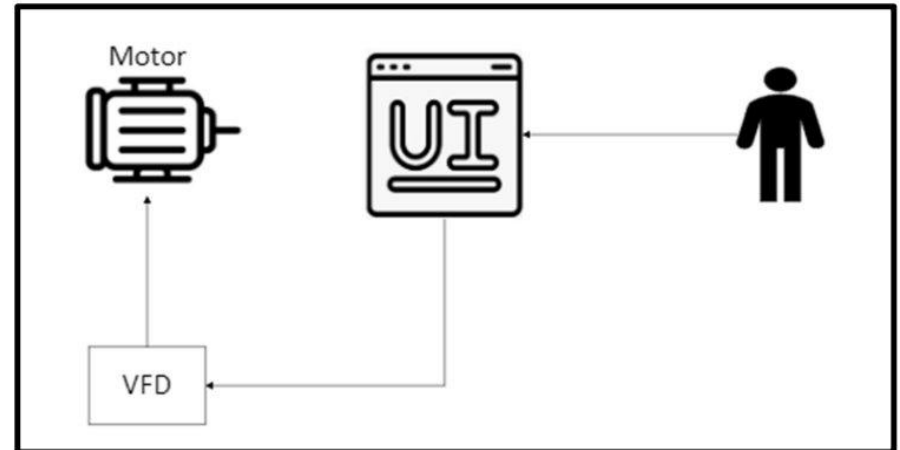
Ryan Regan

Sponsor: John Lusher

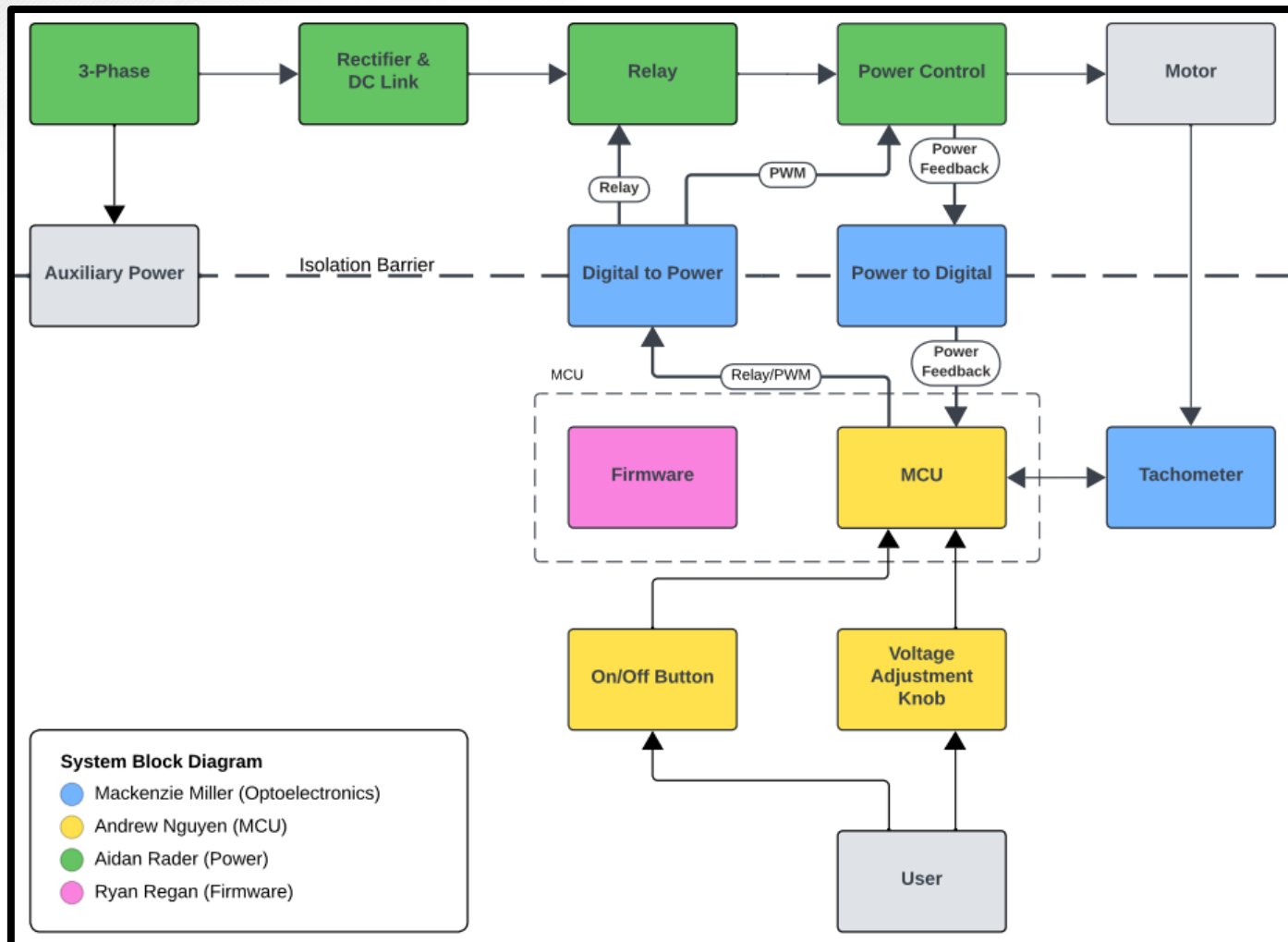
TA: Ali Alenezi

Project Summary

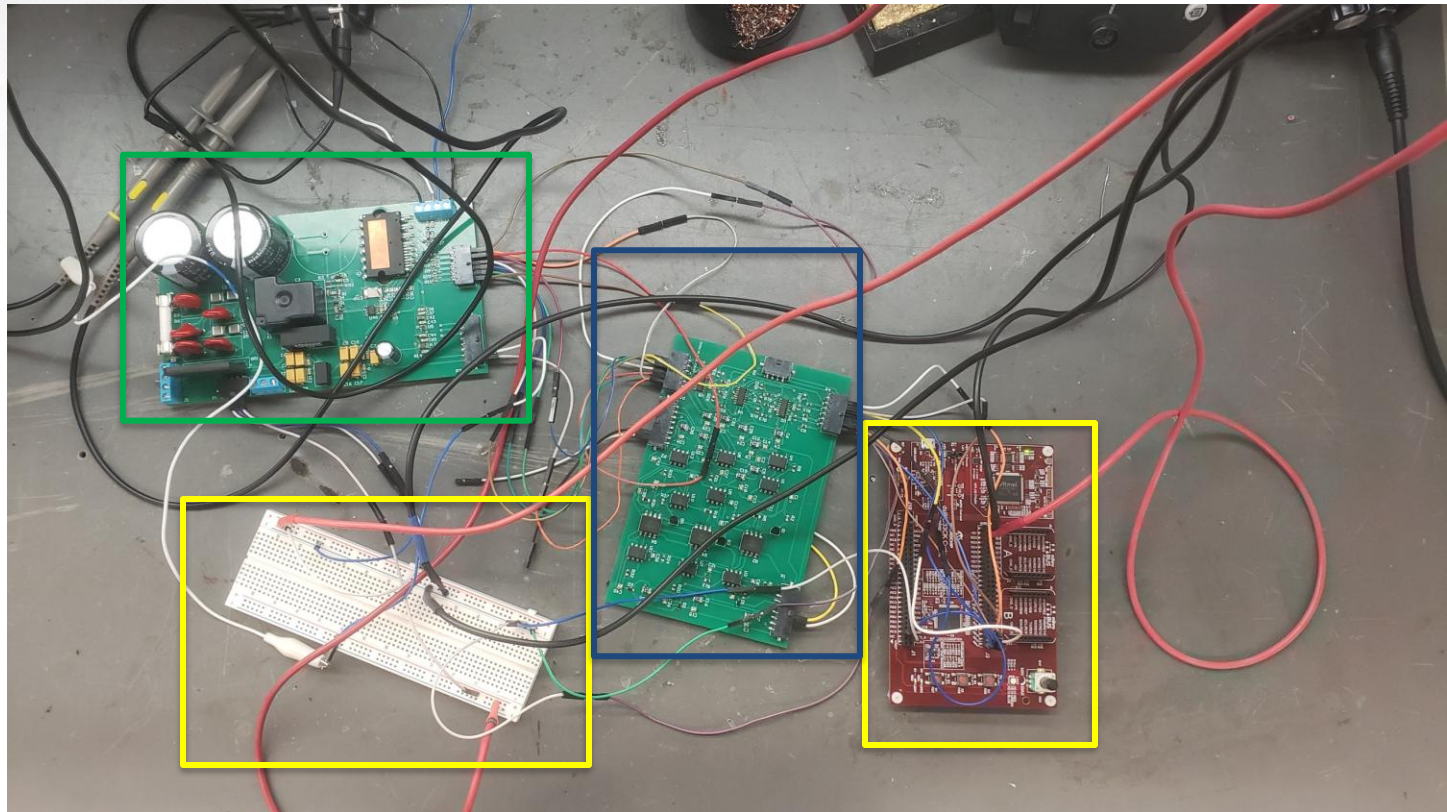
- Problem: Traditional motor control systems cannot adjust to varying load demands, resulting in poor energy efficiency, excessive heat generation, and premature component failure
- Solution: Develop a Variable Frequency Drive (VFD) motor control system to adjust frequency and voltage to load demands



Project/Subsystem Overview



Integrated System Diagram





Project Timeline

2/12	2/19	3/7	3/19	4/2	4/16	4/28
Subsystem PCBv1 Design, Assembly, & Testing	Auxiliary Power & MCU/Firmware Integration	PWM Control Integration	System Integration	System Testing	System Validation	Demo, Showcase, & Report



Optoelectronics

Mackenzie Miller

Accomplishments since last update 39 hrs of effort	Ongoing progress/problems and plans until the next presentation
<ul style="list-style-type: none">- Designed and populated new board- Cut traces and blue wire old board- Complete auxiliary power- Tested power feedback circuit	<ul style="list-style-type: none">- Test new isolators- Fully integrate pwm and relay with new components- Complete power feedback integration



Microcontroller

Andrew Nguyen

Accomplishments since last update 23 hrs of effort	Ongoing progress/problems and plans until the next presentation
<ul style="list-style-type: none">- Ordered and assembled final board- Flashed code onto new board- Tested auxiliary power with the power subsystem- Ensured potentiometer works properly	<ul style="list-style-type: none">- Fully integrate with optoelectronics and power subsystems



Power

Aidan Rader

Accomplishments since last update 27.5 hrs of effort	Ongoing progress/problems and plans until the next presentation
<ul style="list-style-type: none">- Tested Rectifier under 120 V_{AC}- Integrated Auxiliary Power with Optoelectronics- Integrated- Blue-wired fried traces- Research ribbon cables- Routed pcbv2<ul style="list-style-type: none">- Updated EGND traces- Updated blue-wire traces- Adjusted connectors	<ul style="list-style-type: none">- Integrating PWM Control with Microcontroller- Integrating Relay Control with Microcontroller- Fried Rectifier- Fried Relay or MOSFET- Reintegrating with Optoelectronics- Integrate Power Feedback<ul style="list-style-type: none">- Needs PWM Control Integrated- System Integration/Tests- Update Validation Plan/Tests



Firmware

Ryan Regan

Accomplishments since last update 23 hrs of effort	Ongoing progress/problems and plans until the next presentation
<ul style="list-style-type: none">- Fixed Problem with PWM Frequencies being too slow (print statements slowing the iterations)- Helped to find problem with MCU LEDs and Potentiometer- Helped desolder parts for optoelectronics- Flashed code onto new MCU board – potentiometer works now	<ul style="list-style-type: none">- Help other subsystems with soldering/desoldering new parts/boards- Full system PWM control integration- Test with motor- Help integrate power feedback

Auxiliary Power Integration

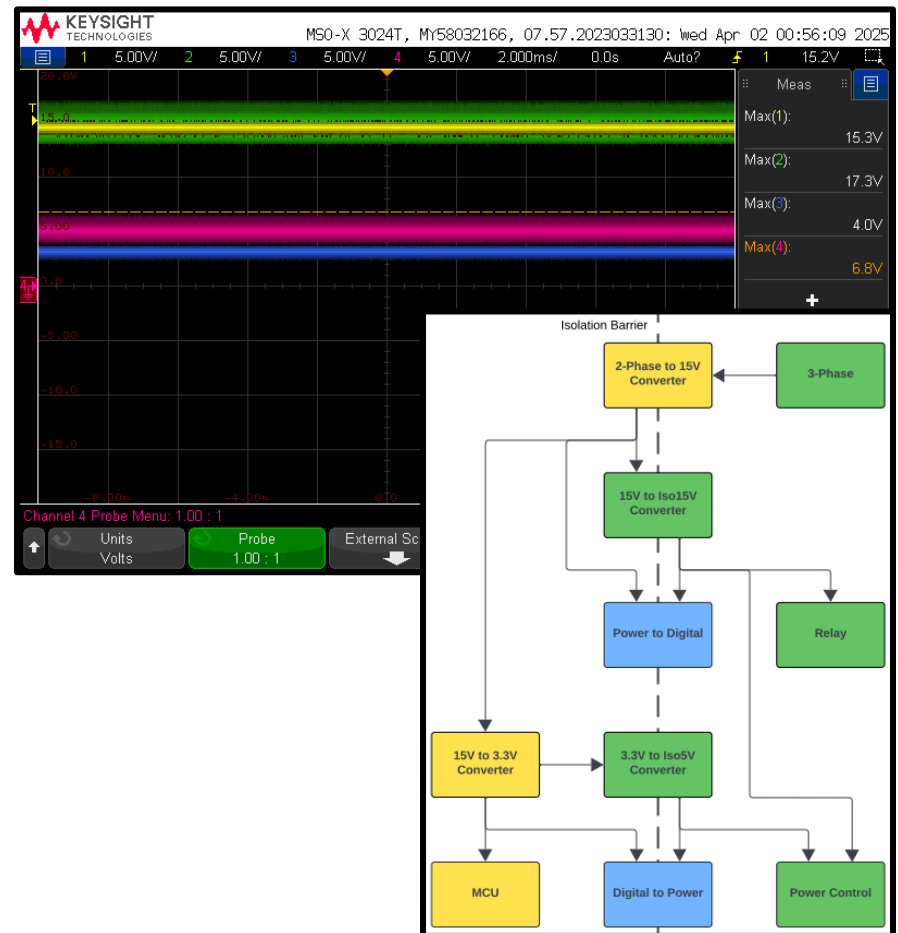
Optoelectronics, Microcontroller, & Power

Mackenzie Miller, Andrew Nguyen, & Aidan Rader

- **With Component Loads:**
 - Working with slight voltage differences

Converter	V _{in} [V]	V _{out,measured} [V]
2-Phase to 15V	120.0 Vac	15.3
15V to Iso15V	15.0	17.3
15V to 3.3V	15.0	4.0
3.3V to Iso5V	3.2	6.8

Component	$V_{in,min}$ [V]	$V_{in,max}$ [V]	$V_{in,measured}$ [V]
Power to Digital	0.0	30.0	
Relay	11.25	16.5	
Power to Digital	0.0	30.0	
Power Control	14.5	18.5	
MCU	3.0	3.6	
Digital to Power	2.5	5.5	
Digital to Power	2.5	5.5	
Power Control			

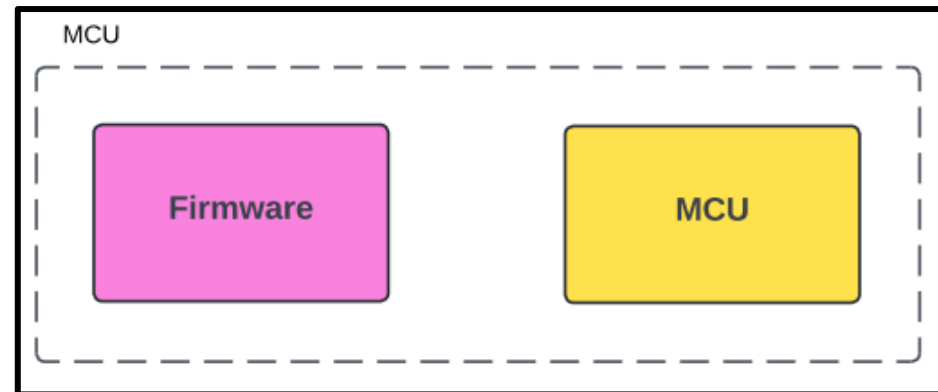


MCU/Firmware Integration

Microcontroller & Firmware

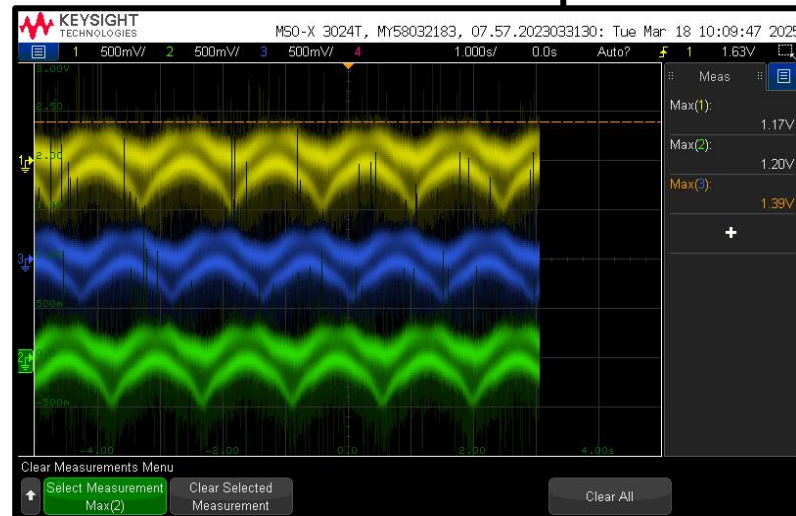
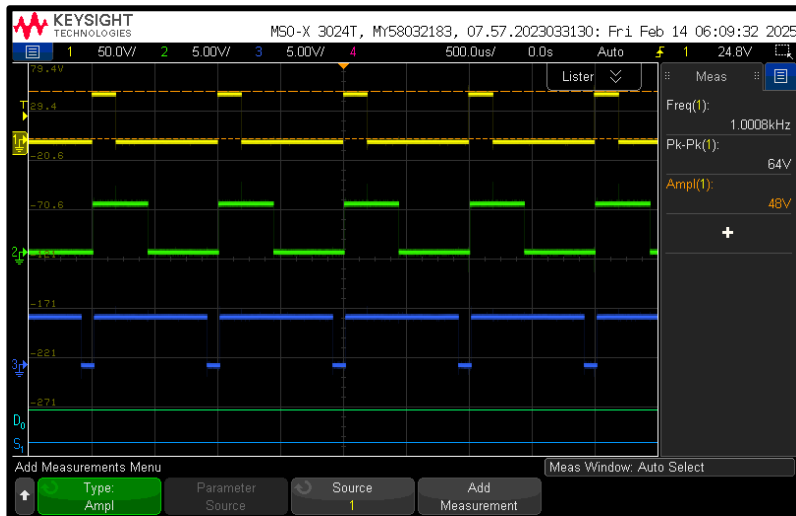
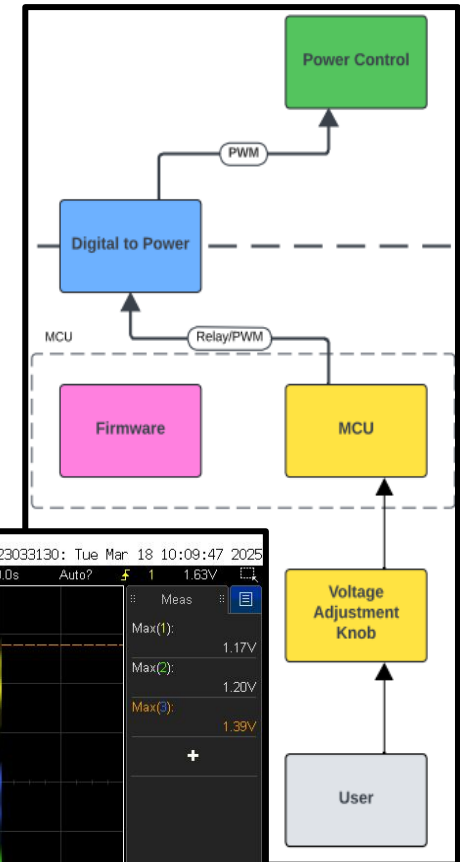
Andrew Nguyen & Ryan Regan

- New MCU Board
 - Fixed AVDD pin connection to 3.3V
 - Code flashed onto new board and correctly outputs all PWM waves and the relay signal
 - Potentiometer works now



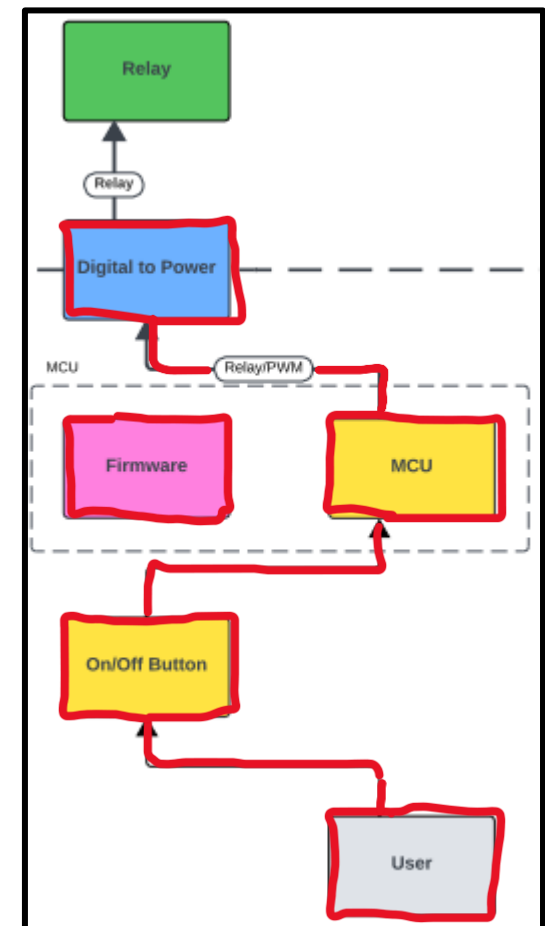
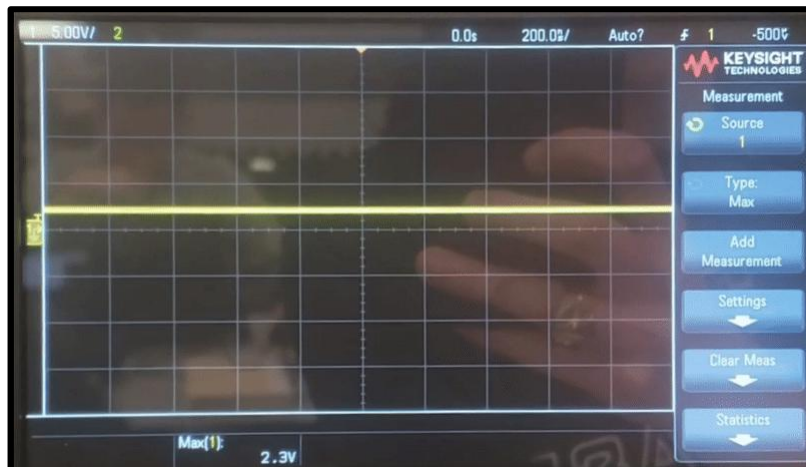
PWM Control Integration

- Microcontroller/Firmware-> Optoelectronics -> Power:
 - 3.3V Square Wave: working
 - 5V Square Wave: not working
 - 3-Phase Sine Waves: not working
- Firmware (Dev Board) -> Optoelectronics -> Power:
 - 3.3V Square Wave: working
 - 5V Square Wave: previously working
 - 3-Phase Sine Waves: previously working
- Optoelectronics:
 - Previously working, but not currently: fried components



Relay Control Integration

- Microcontroller -> Power:
 - Not working
- Firmware (Dev Board) -> Optoelectronics -> Power:
- Optoelectronics:
 - Previously working, but not currently: fried components
- Power:
 - Previously working, but not currently: fried components



Execution Plan

[illegible]



Validation Plan

Paragraph #	Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
3.2.1.1	Speed and Torque Requirement	Motor shall operate within speed range of 0RPM to 1800RPM and torque range of 0lb-ft to 0.729lb-ft.	Input motor with voltage and check if it achieves 0RPM and 0lb-ft . Repeat for 300RPM, 600RPM, 900RPM, 1200RPM, 1500RPM, 1800RPM.	Untested	Andrew, Ryan
3.2.1.2	Frequency Requirement	System shall operate within frequency range of 5Hz to 60Hz.	Input system with frequency generator set to 5Hz and check if the motor runs smoothly. Repeat for 10Hz, 20Hz, 30Hz, 40Hz, 50Hz, 60Hz.	Untested	All
3.2.1.3	Temperature Requirement	System shall operate within temperature range of 0 °C to 70 °C.	Place system in freezer set to 0 °C and check if the motor runs smoothly. Repeat with oven set to 70 °C.	Untested	All
3.2.3.2	Input Voltage Level	System input voltage shall be 208V _{AC} .	Measure with multimeter and check if the voltage is 208V _{AC} .	Untested	Aidan
3.2.3.3	Input Noise and Ripple	System shall not exceed ripple range of 0V to 0.165V.	Measure with multimeter and check if the voltage exceeds 0V to 0.165V.	Untested	Andrew
3.2.3.4	External Commands	External commands shall be documented in appropriate ICD.	Show to teaching team and check with them for approval.	Untested	All
3.2.3.5	Visual Output	Oscilloscope displays each of the three phases of the PWM sine wave.	Connect oscilloscope probes to the set output pins for the PWM signals, ensure that the signals' duty cycles span from 0-100% and are roughly separated by thirds.	Tested	Ryan
3.2.3.6	Connectors	System shall use terminal blocks for power and signal connections.	Observe power and signal connections and check if they are are terminal blocks.	Untested	Mackenzie, Andrew, Aidan
3.2.3.7	Overtemperature Shutdown	System shall automatically shut down if sensor exceeds temperature range of 0 °C to 70 °C.	Place sensor in freezer set to -1 °C and check if sensor is triggered. Repeat with oven set to 71 °C.	Untested	Mackenzie
3.2.3.8	Built in Test	System shall generate and evaluate test signals to assess failure status.	Compare generated values with known values and check if the failure statuses match. Repeat for six additional sets of values.	Untested	All
3.2.3.9	Optoelectronics Voltage Constraint	The optoelectronics subsystem shall convert the voltage it receives down to a voltage in the range of 15-20 V.	Test at full power where the opto receives ~60 V. Use a multimeter to measure voltage level on other side of opto barrier.	Untested	Mackenzie
3.2.3.10	Digital to Power Continuity	The digital to power opto-isolators shall have a voltage of 0V across each component when connecting input to output.	Use a multimeter to ensure that the voltage across each digital isolator is zero.	Tested	Mackenzie



Validation Plan

Paragraph #	Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
3.2.3.11	Power to Digital Continuity	The power to digital opto-isolators shall have a voltage of 0V across each component when connecting input to output	Use a multimeter to ensure that the voltage across each power isolator is zero.	Tested	Mackenzie
TBD	Inputs	The parameters are within the expected range.	Confirm that all electrical parameters (voltage, current, power) remain within safe and expected ranges under varying conditions.	Untested	All
TBD	Firmware Code Compiles	MPLab firmware successfully compiles without errors or warnings	Attempt to compile code in MPLab and examine output logs to check for errors or warnings	Tested	Ryan
TBD	Controller Performance	Motor spins according to user defined parameters.	Validate that the system operates efficiently and delivers accurate motor control across the expected range of operating conditions.	Untested	All
TBD	MCU Voltage Step Down	MCU converts the voltage it is given to 3.3V.	Measure the voltage of the signals being sent to the MCU and measure that the MCU converts it to 3.3V.	Untested	Mackenzie, Andrew
TBD	Rectifier Full System	System input voltage shall be rectified from 208V _{AC} to 295V _{DC} .	Measure with multimeter and check if the voltage after the rectifier is 295V _{DC} .	Untested	Aidan
TBD	Rectifier Power Subsystem	System input voltage shall be rectified from 5V _{AC} to 7.1 V _{DC} .	Input 5V _{AC} at differing angles of 120° on three waveform generators. Measure with multimeter and check if the voltage after the rectifier is 7.1 V _{DC} .	Tested	Aidan
TBD	Isolated 15V Conversion	System shall convert 15V _{DC} to isolated 15V _{DC} .	Input 15V _{DC} on a dc power supply. Measure with multimeter and check if the voltage after the converter is 15V _{DC} .	Tested	Aidan
TBD	Isolated 5V Conversion	System shall convert 3.3V _{DC} to isolated 5V _{DC} .	Input 3.3V _{DC} on a dc power supply. Measure with multimeter and check if the voltage after the converter is 5V _{DC} .	Untested	Aidan
TBD	User Interface	User is able to change the speed of the rotating PWM values by turning the potentiometer.	Change potentiometer position to lowest, highest, and middle notch to observe that the target frequency of the system is close to 60, 10, and 35 respectively, and the rotating PWM values change pace accordingly	Tested	Ryan
TBD	Frequency Testing	Code properly changes the frequency of the PWM signals	Use oscilloscope or a timer to measure the PWM waves to ensure that the program's target frequency is similar to the actual frequency of the PWM signals.	Untested	Ryan
TBD	Debugger Connection	The Microcontroller shall be able to properly communicate with Pickit4 debugger	Connect the Pickit4 Debugger to microcontroller PCB using the 5 pin connector and ensure that MPLAB X IDE can recognize the device.	Untested	Andrew



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Thank you