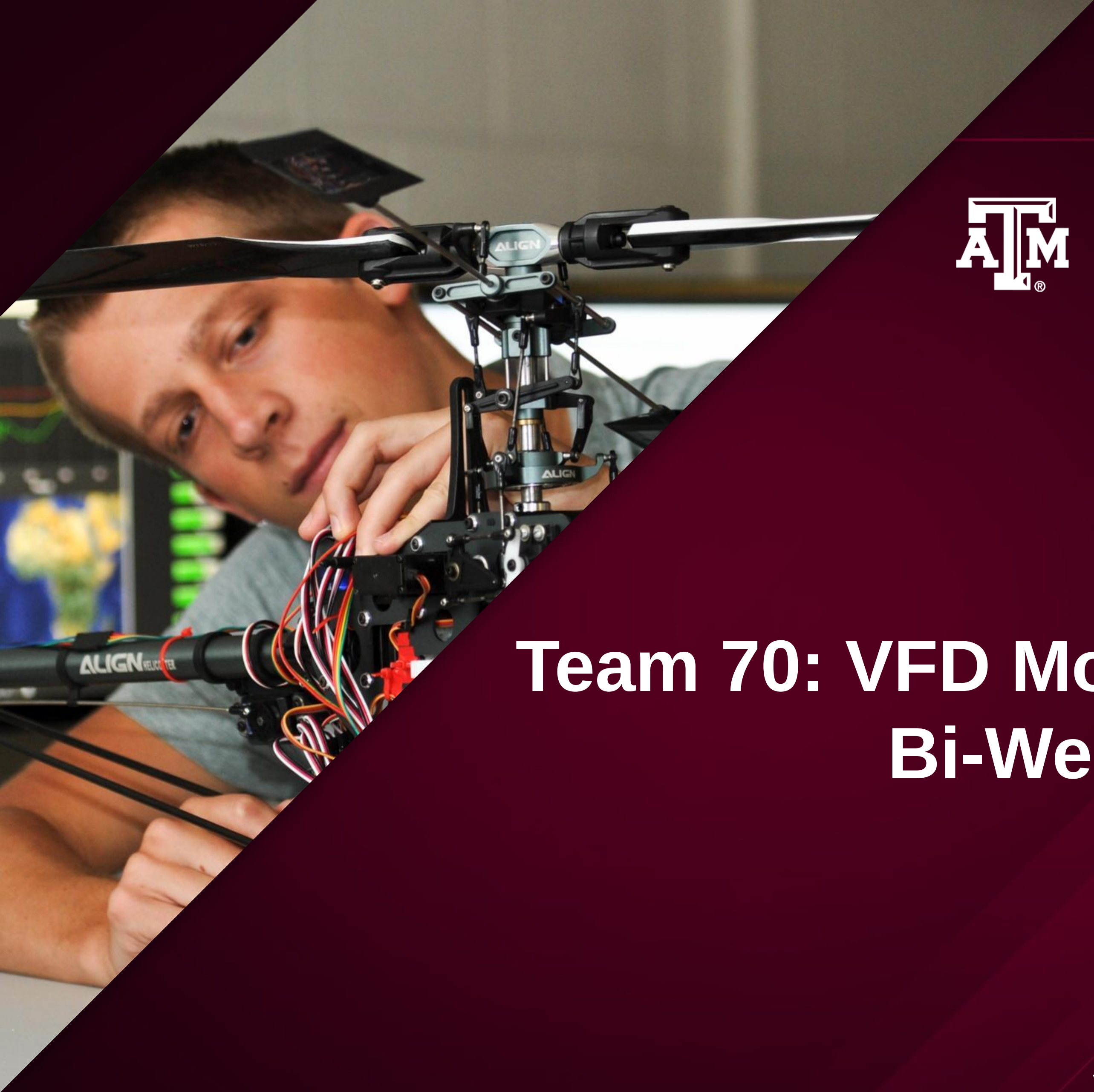

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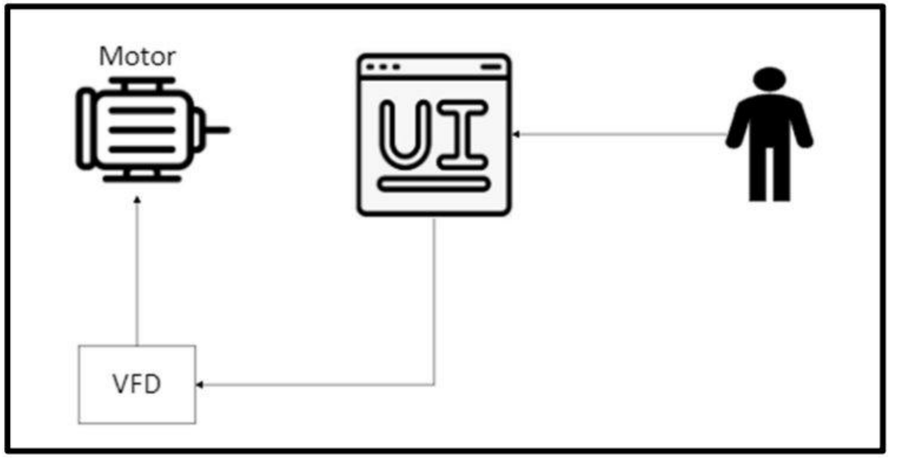
Team 70: VFD Motor Controller Bi-Weekly Update 3

Mackenzie Miller
Andrew Nguyen
Aidan Rader
Ryan Regan
Sponsor: John Lusher
TA: Ali Alenezi

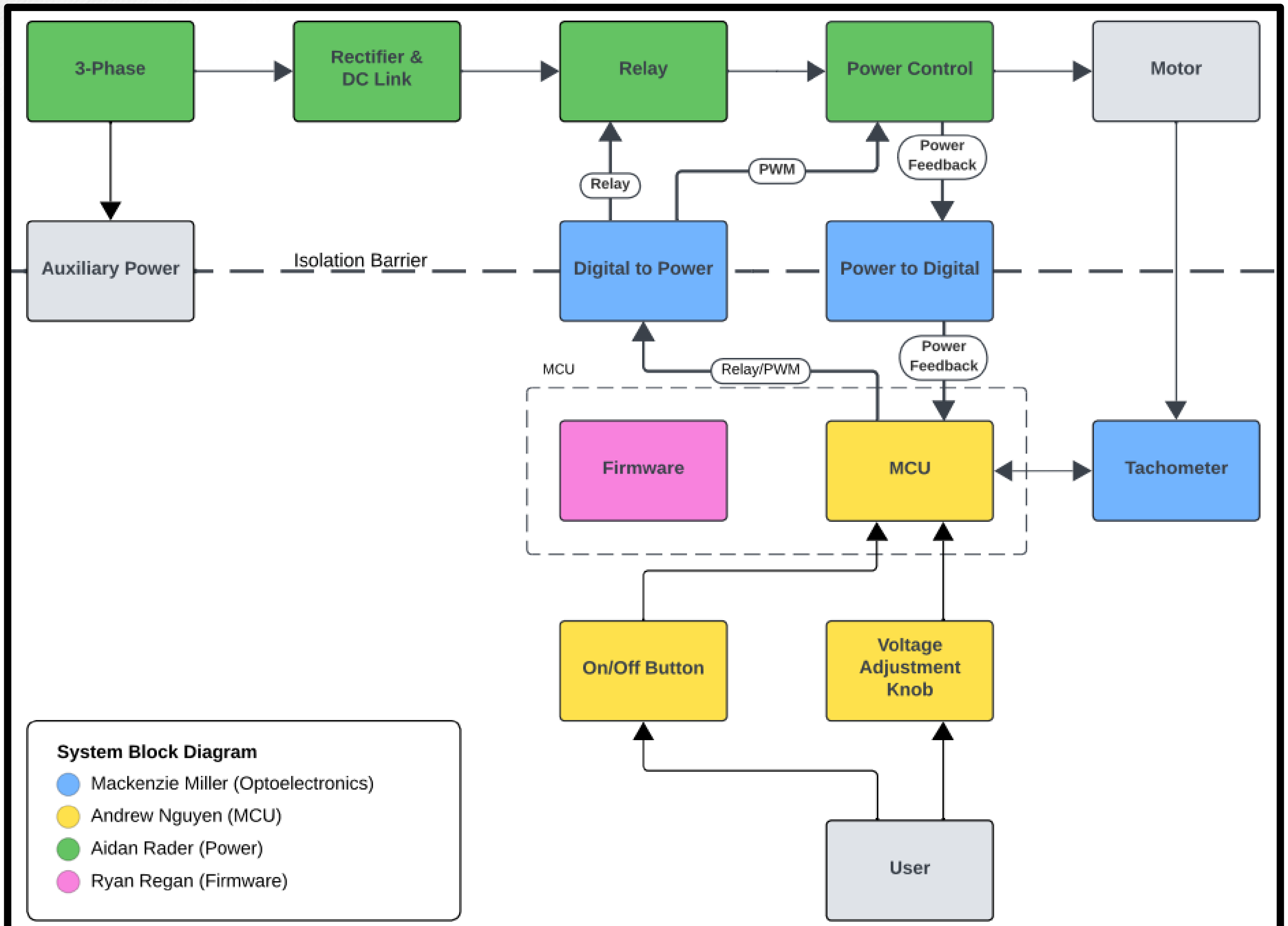
Project Summary

- 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



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 12 hrs of effort	Ongoing progress/problems and plans until the next presentation
- Finished assembling new board - Completed integration with firmware - PWM Control Integration (all three phases high and low)	- Integrate with MCU – next step of PWM Control Integration - Complete PWM integration with power - Start auxiliary power integration - Relay integration

Microcontroller

Andrew Nguyen

Accomplishments since last update 19 hrs of effort	Ongoing progress/problems and plans until the next presentation
- Assembled majority of board - Integrated auxiliary power with power subsystem	- Finish assembling the rest of the board - Ensure the MCU works/integrate for PWM control - Integrate auxiliary power with optoelectronics - Test AC to 15V converter

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Power

Aidan Rader

Accomplishments since last update 43 hrs of effort	Ongoing progress/problems and plans until the next presentation
- Ordered Parts Order 5 - Assembled PCBv1 - Integrated Auxiliary Power with Microcontroller	- Integrating Auxiliary Power with Optoelectronics - Integrating PWM Control with Optoelectronics and Firmware - Testing Auxiliary Power - Integrate PWM Control with Microcontroller - Integrate Relay Control - Integrate Power Feedback

Firmware

Ryan Regan

Accomplishments since last update 12 hrs of effort	Ongoing progress/problems and plans until the next presentation
- Successfully validated integration of each phase of PWM waves (high and low) between firmware and optoelectronics subsystem – relies solely on voltage source without being connected to laptop - Implemented basic Start/stop button functionality (shown b	- Integration with MCU subsystem (ensure all functions of code work with all inputs/outputs of microcontroller PCB) - Finish integrating Power subsystem with PWM control

```
Pot: 2116, Target Frequency: 35
Pot: 2117, Target Frequency: 35
Pot: 2117, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2116, Target Frequency: 35
System Stopped

Line input
```

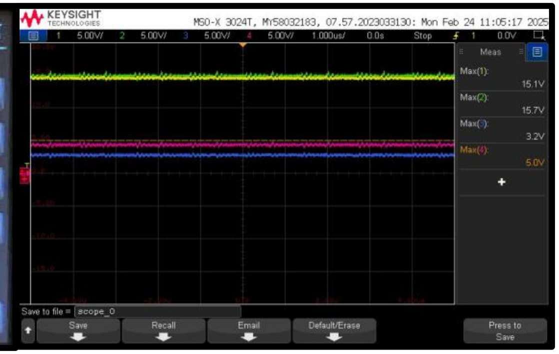
```
System Started
Pot: 2117, Target Frequency: 35
Pot: 2117, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2117, Target Frequency: 35
Pot: 2116, Target Frequency: 35
Pot: 2116, Target Frequency: 35
```

Auxiliary Power Integration

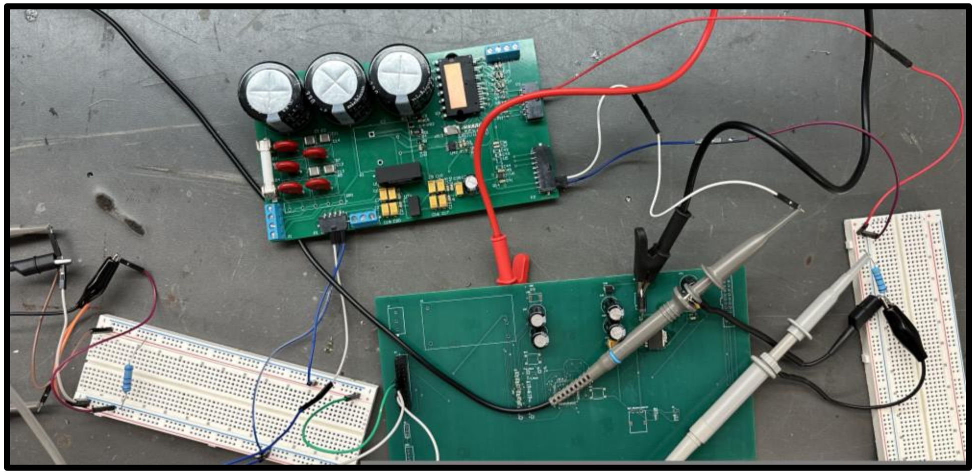
Optoelectronics, Microcontroller, & Power

Mackenzie Miller, Andrew Nguyen, & Aidan Rader

Converter	V_{in} [V]	$V_{out,measured}$ [V]
2-Phase to 15V		
15V to Iso15V	15.0	15.7
15V to 3.3V	15.0	3.2
3.3V to Iso5V	3.2	5.0



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	15.7
Power to Digital	0.0	30.0	15.7
Power Control	14.5	18.5	15.7
MCU	3.0	3.6	3.2
Digital to Power	2.5	5.5	3.2
Digital to Power	2.5	5.5	5.0
Power Control			5.0



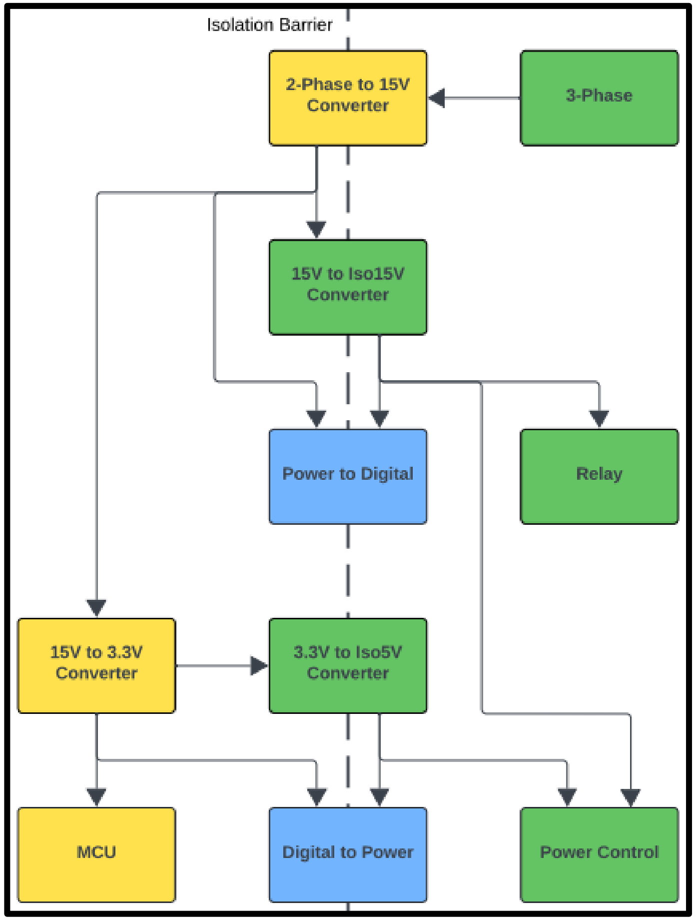
Auxiliary Power Integration Cont. ->

Auxiliary Power Integration

Optoelectronics, Microcontroller, & Power

Mackenzie Miller, Andrew Nguyen, & Aidan Rader

- 2-Phase to 15V Converter:
  - Requires testing, but only above 85 V_{AC}
- With Resistor Loads:
  - Working
- With Component Loads:
  - Not working
  - Power to Digital turns Iso15V from 15.7 V to ~2.9V

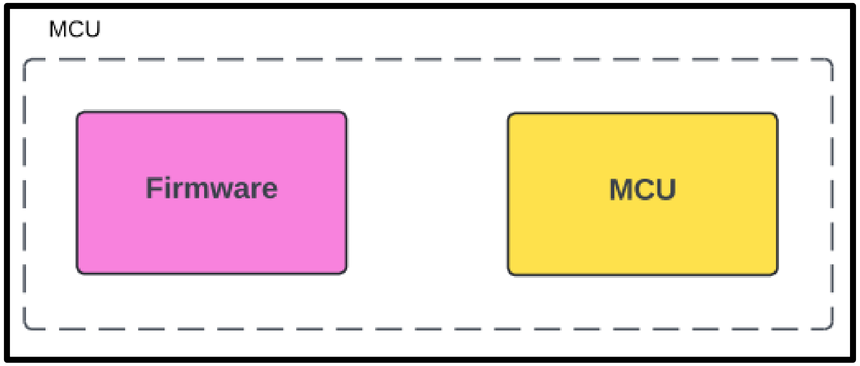


MCU/Firmware Integration

Microcontroller & Firmware

Andrew Nguyen & Ryan Regan

- The MCLR pin was not receiving 3.3V of power
- Had unexpected voltage drop to 1.8V most likely due to a soldering error
- MPLAB is unable to detect/connect to microcontroller through PICKIT to program it
- Unable to integrate with the firmware until new MCU comes in for the new board

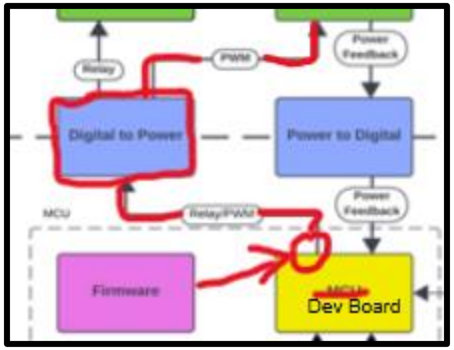


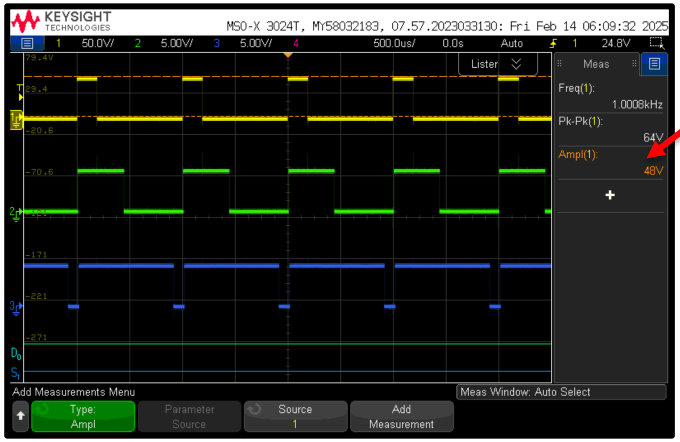
PWM Control Integration

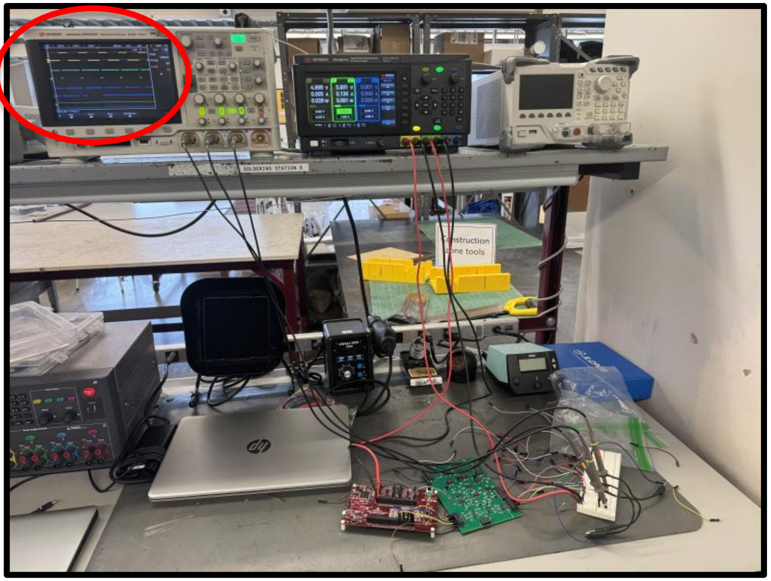
Optoelectronics, Power, & Firmware

Mackenzie Miller, Aidan Rader & Ryan Regan

- Output of all three PWM phases successfully communicated through optoelectronics board
- Dev board outputs 3.3V PWM signals to optoelectronics, which converts the signals to 5V







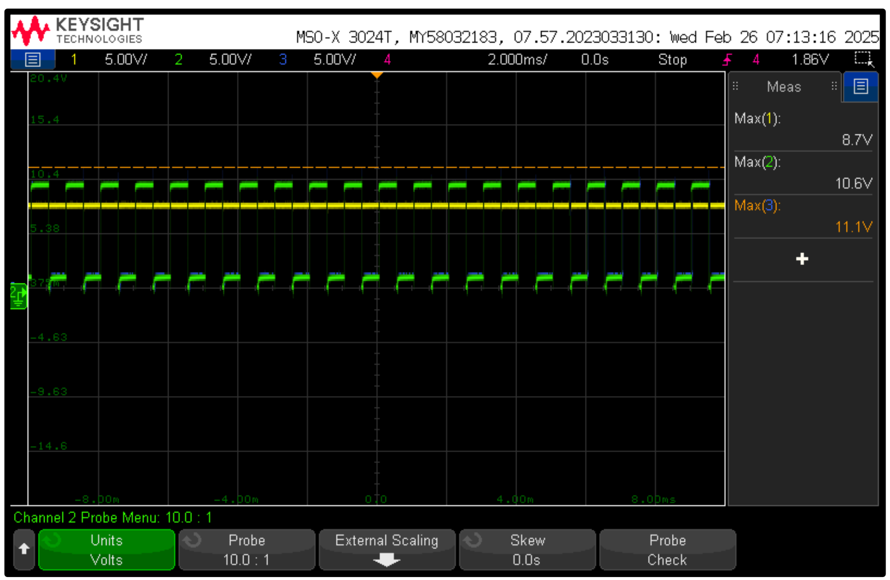
PWM Control Integration Cont. ->

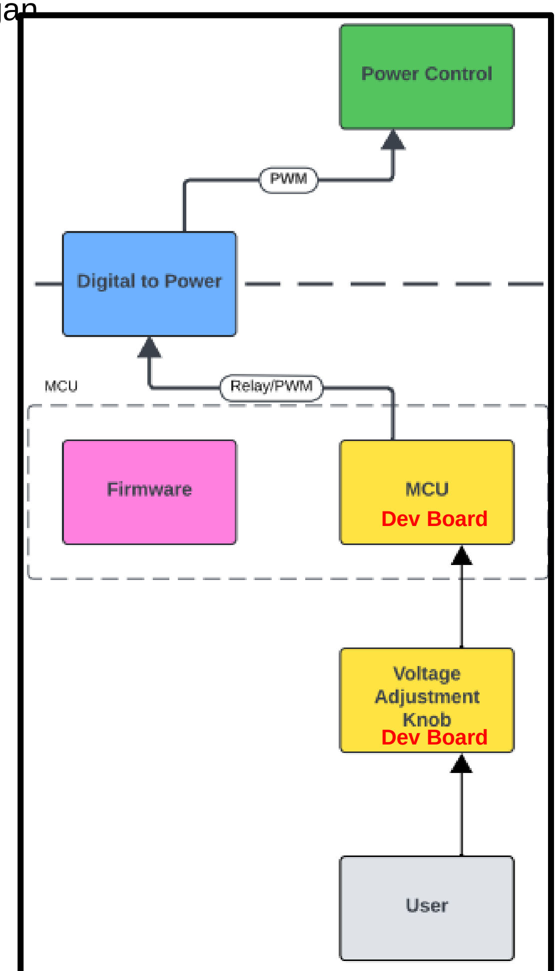
PWM Control Integration

Optoelectronics, Power, & Firmware

Mackenzie Miller, Aidan Rader & Ryan Regan

- Firmware (Dev Board) -> Optoelectronics -> Power:
  - Phase 1: 8.7 V horizontal wave
  - Phase 2: 10.6 V square wave
  - Phase 3: 11.1 V square wave
  - Dev Board PWM low is ~2.79 instead of 3.3 V
  - Power Control trace error





Execution Plan

	1/16	1/23	1/30	2/6	2/13	2/20	2/27	3/6	3/13	3/20	3/27	4/3	4/10	4/17	4/24	Date
PCBv1s Design (Full Design Review)																1/28
Status Update Presentation 1													Not Started			1/29
PCBv1s Order													In Progress			2/6
Parts Order 4													Completed			2/11
Firmware Validation													Behind Schedule			2/12
Status Update Presentation 2																2/12
PCBv1s Assembly																2/12
Auxilary Power Integration																2/19
MCU/Firmware Integration																2/19
PWM Control Integration																2/26
Relay Control Integration																2/26
Status Update Presentation 3																2/26
Power Feedback Integration																3/7
Tachometer Integration																3/7
System Integration																3/19
Status Update Presentation 4																3/19
System Testing																4/2
System Housing Design																4/2
Status Update Presentation 5																4/2
System Validation																4/16
System Housing Fabrication																4/16
Final Presentation																4/16
Final Demonstration																4/24
Engineering Project Showcase																4/25
Final Report																4/28

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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 208VAC.	Measure with multimeter and check if the voltage is 208VAC.	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 rougly 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

Thank you