



# CWC 2020: DC-DC Converter

## **Booster Pack:**

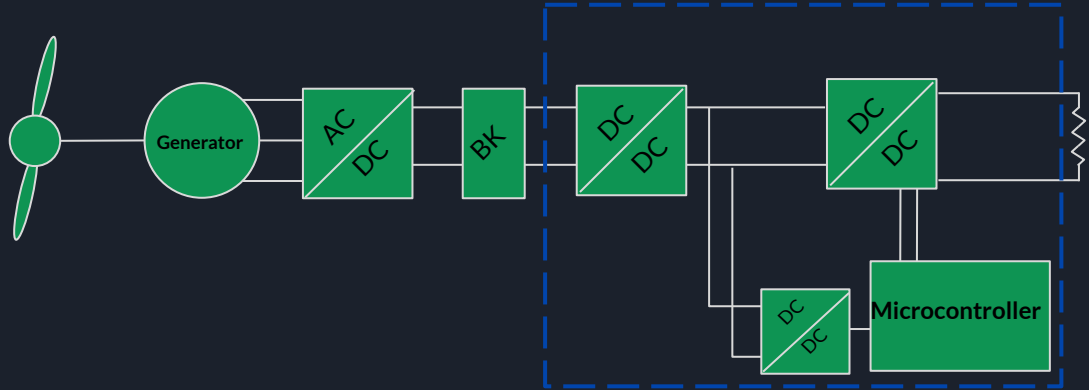
Humoud Abdulmalek

Mohammed Almutairi

Nigel Grey

# Introduction

- Clients
  - Dr. Venkata Yaramasu
  - Mr. David Willy
- Mentor
  - Jason Foster
- Project
  - Collegiate Wind Competition 2020
  - DC-DC Boost converter



# Timeline & Responsibilities

## *Project Overview*

### Project Management

- Define project scope
- Define schedule
- Manage team and collaborator roles

### Converter System

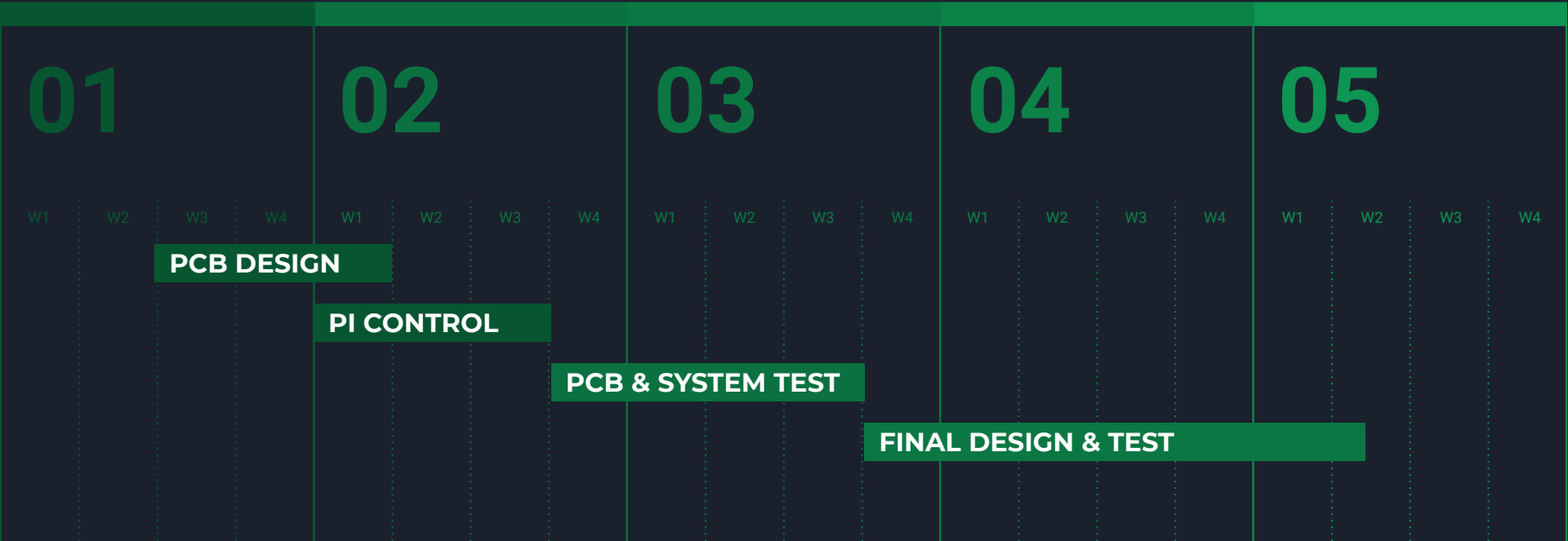
- Design, build, and test DC-DC converter
- Integrate AC-DC converter with DC-DC converter
- Create mechanical to electrical system interface

### Control System

- Design state machines
- Collaborate to program all sense/control circuitry

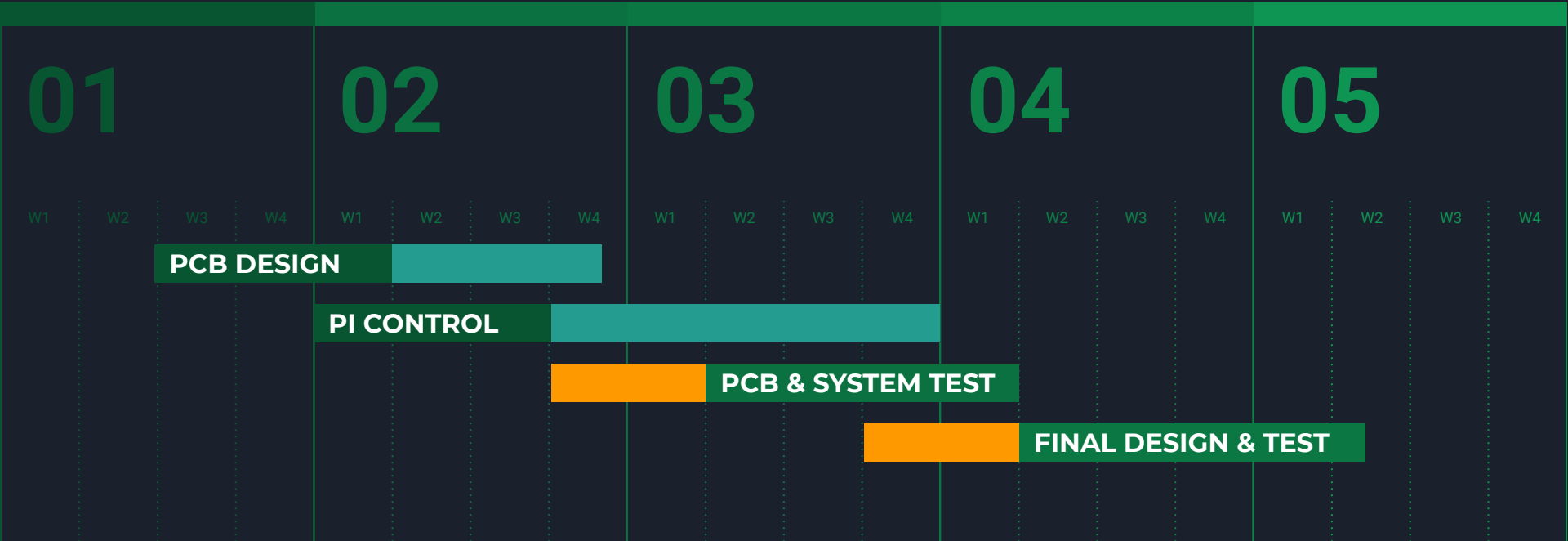
# Spring 2020 Project Overview

*January 13th - May 8th*



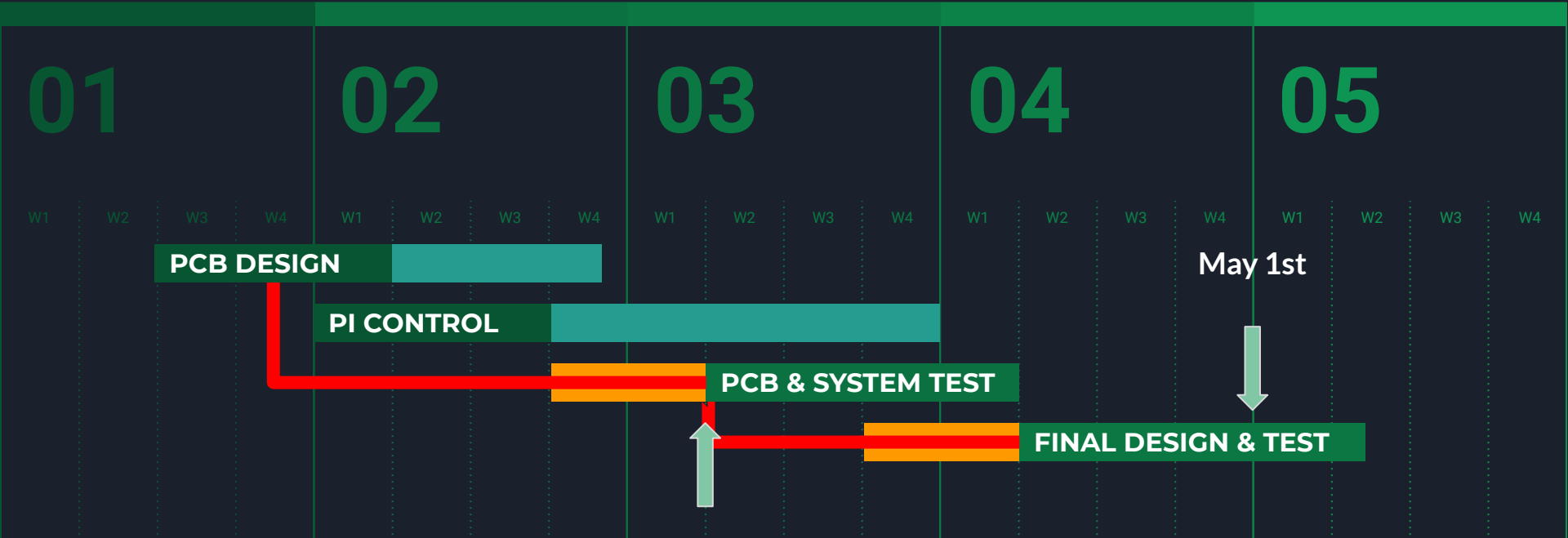
# Spring 2020 Project Overview

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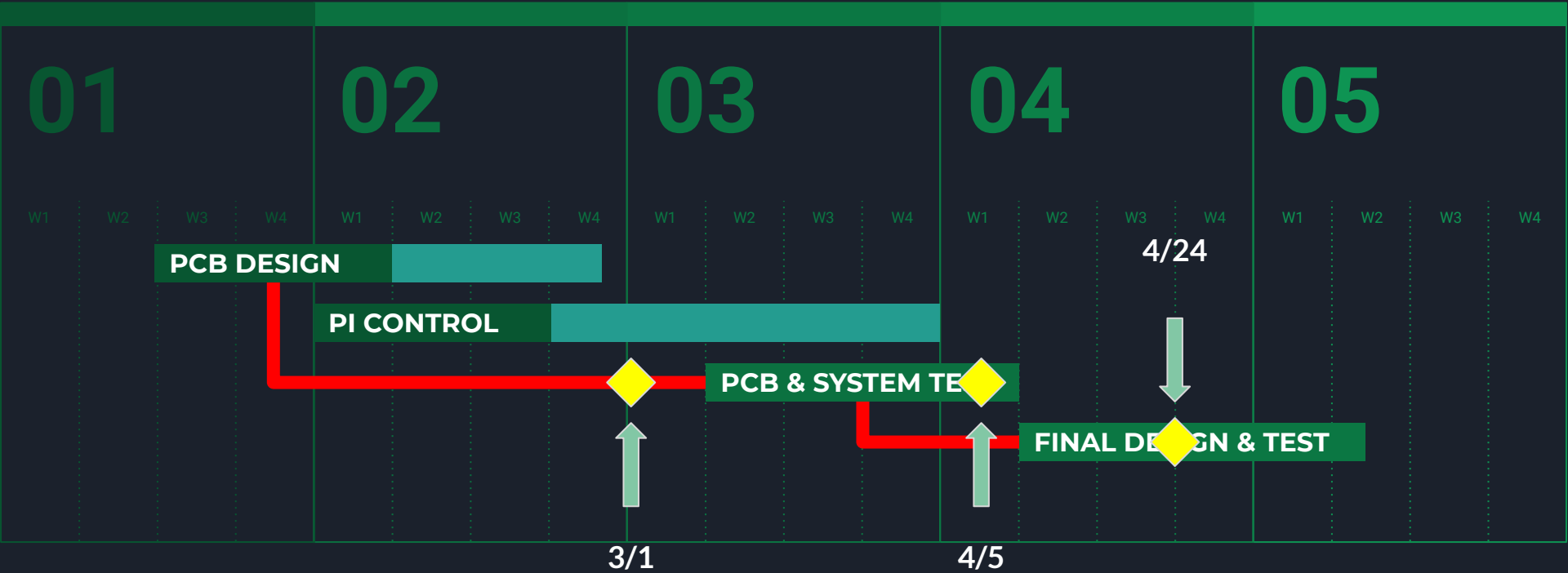


Today

May 1st

# Spring 2020 Project Overview

*January 13th - May 8th*

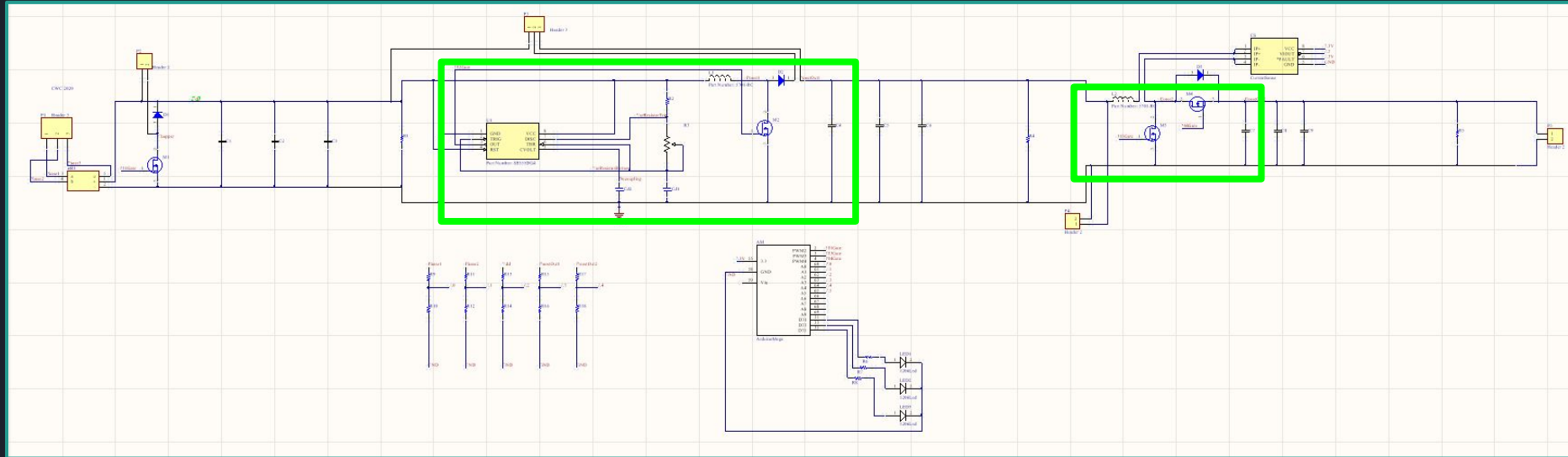






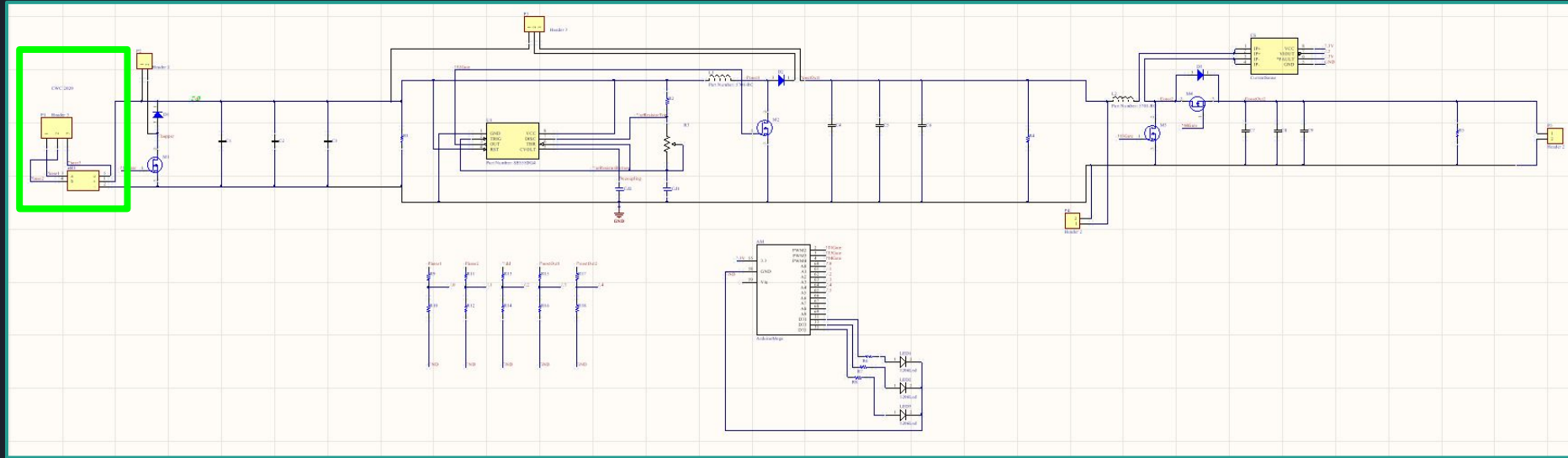
# Converter System: Overview

January 13th - February 20th



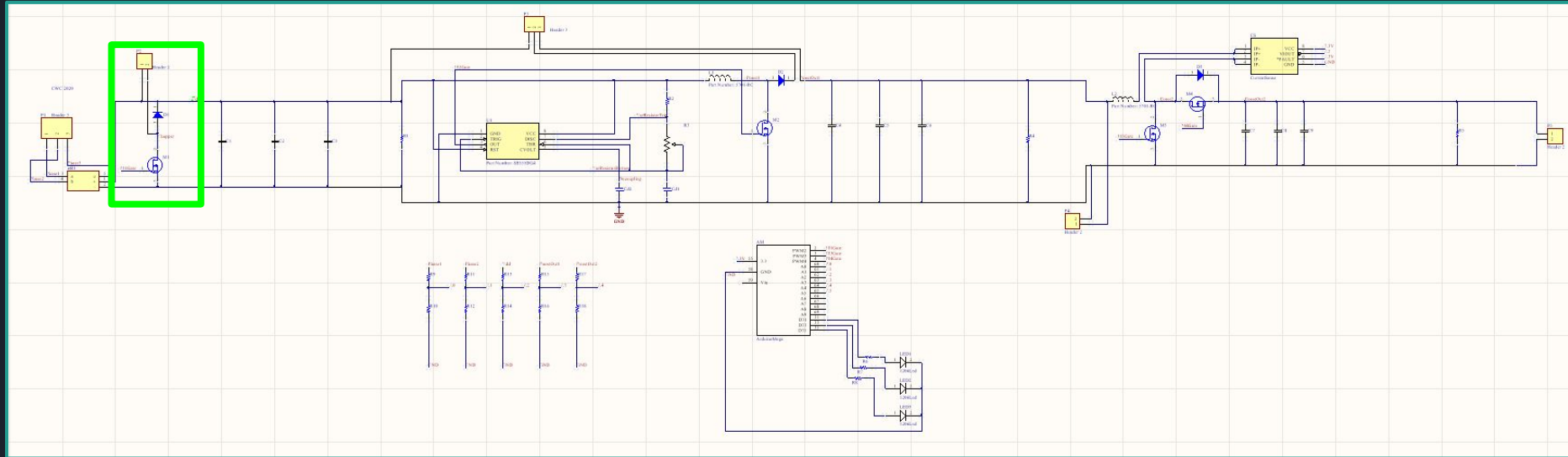
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January 13th - February 20th



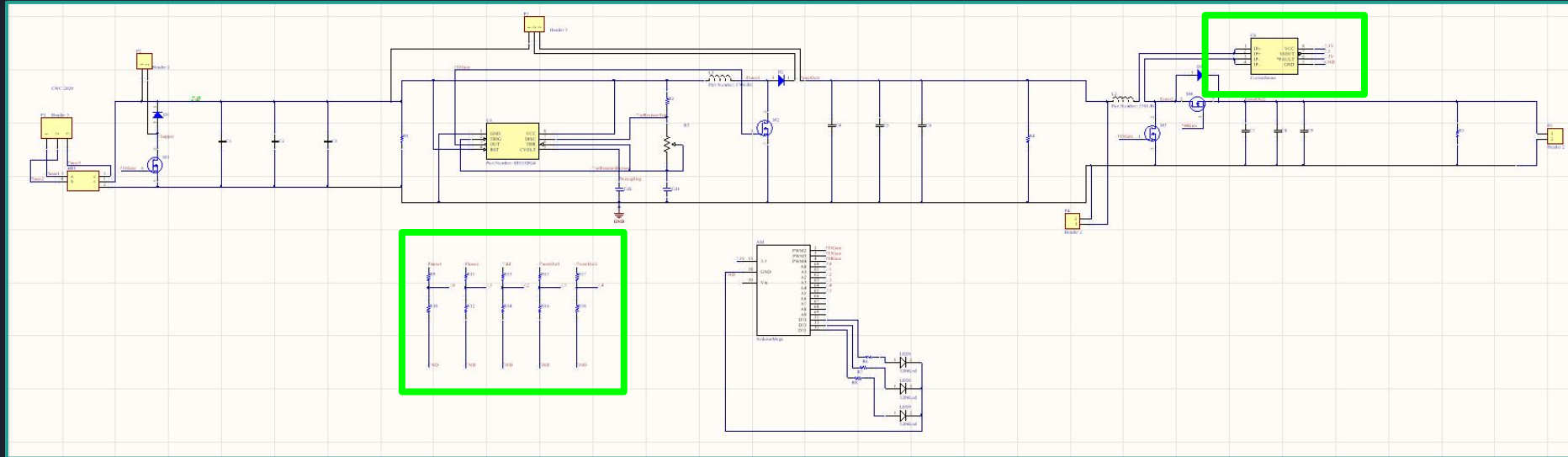
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January 13th - February 20th



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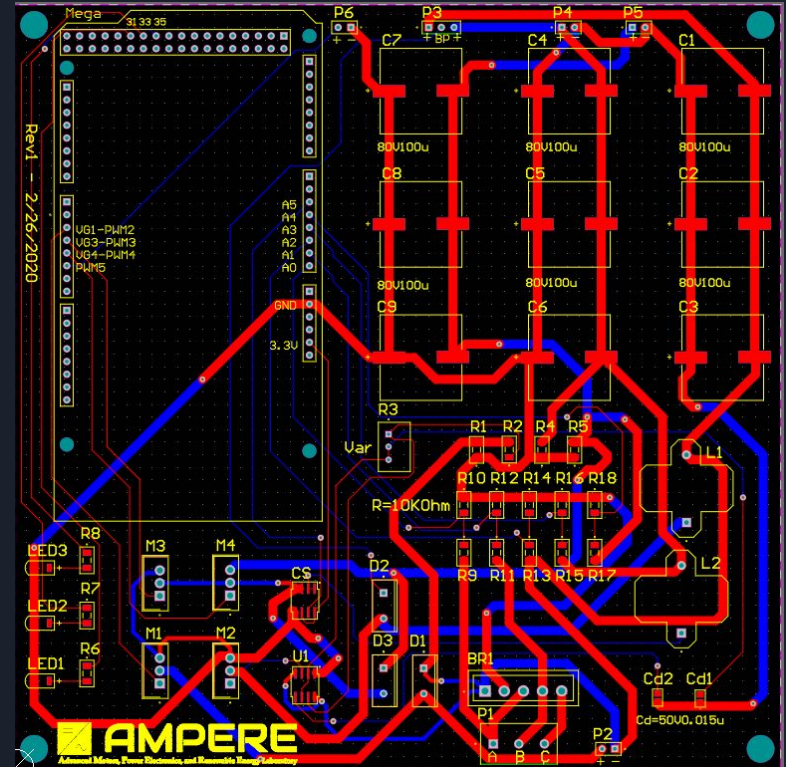




# Converter System: PCB Integration

*January 13th - March 1st*

- Highly collaborative effort between our team and the Aux team
- Built custom footprints
- Labeled all components and connections
- Separated communication components from power components
- Developed net classes to define widths of power lines and communication lines

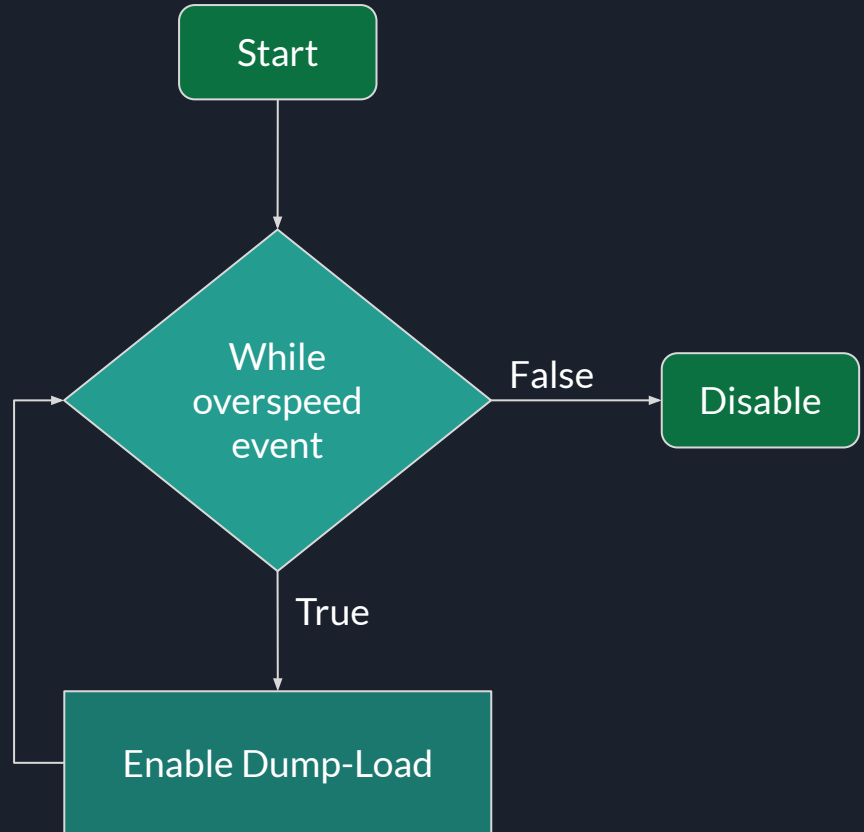


Presenter: Nigel

# Control System: Overview

*February 1st - April 1st*

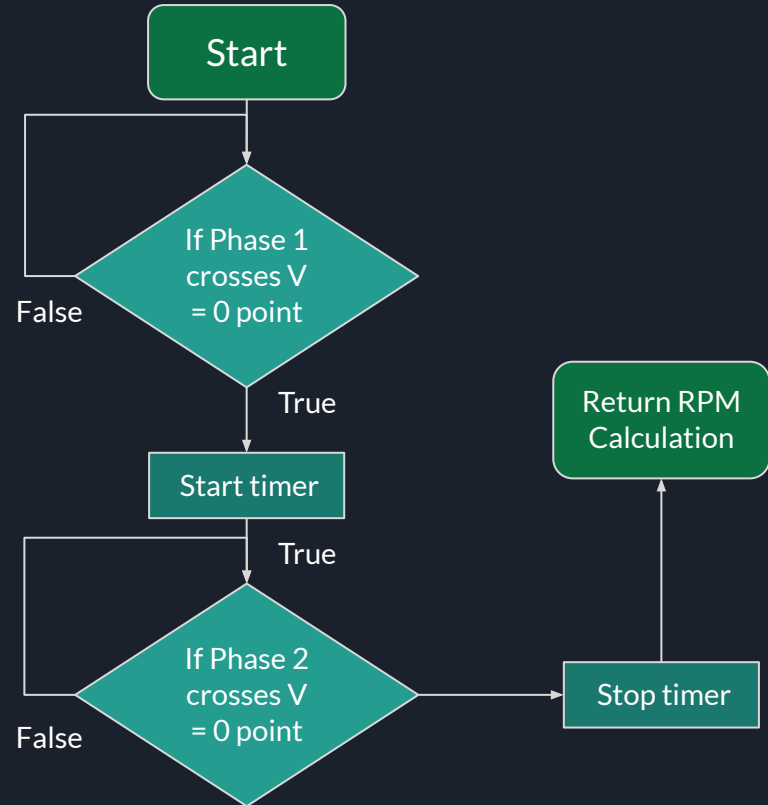
1. Dump-Load Circuit
2. Phase 1-2 Voltage Measurement
3. PI Controller
4. Current Sensor Measurement
5. Stage 2, 3, & 4 Voltage Measurements
6. Actuator Signal



# Control System: Overview

*February 1st - April 1st*

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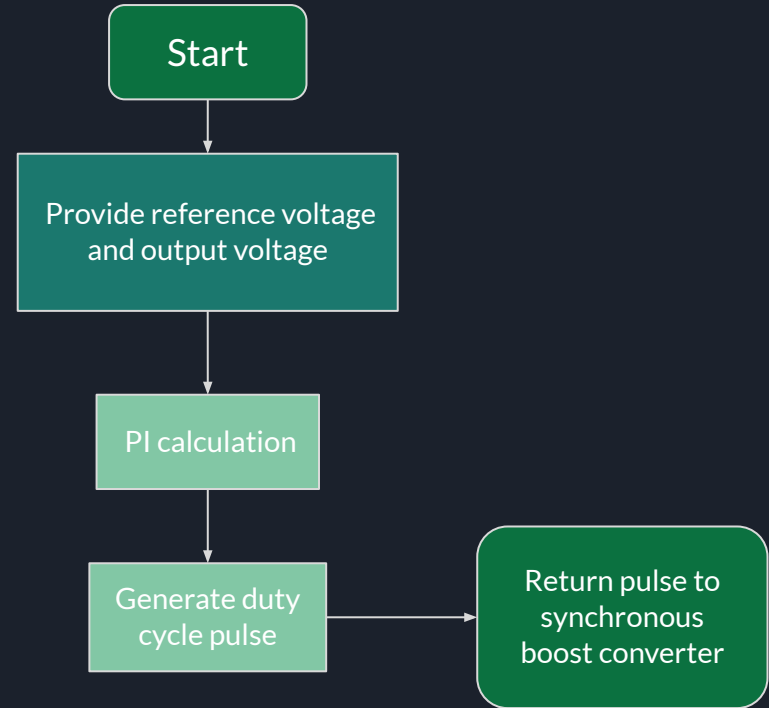
Presenter: Nigel



# Control System: Overview

*February 1st - April 1st*

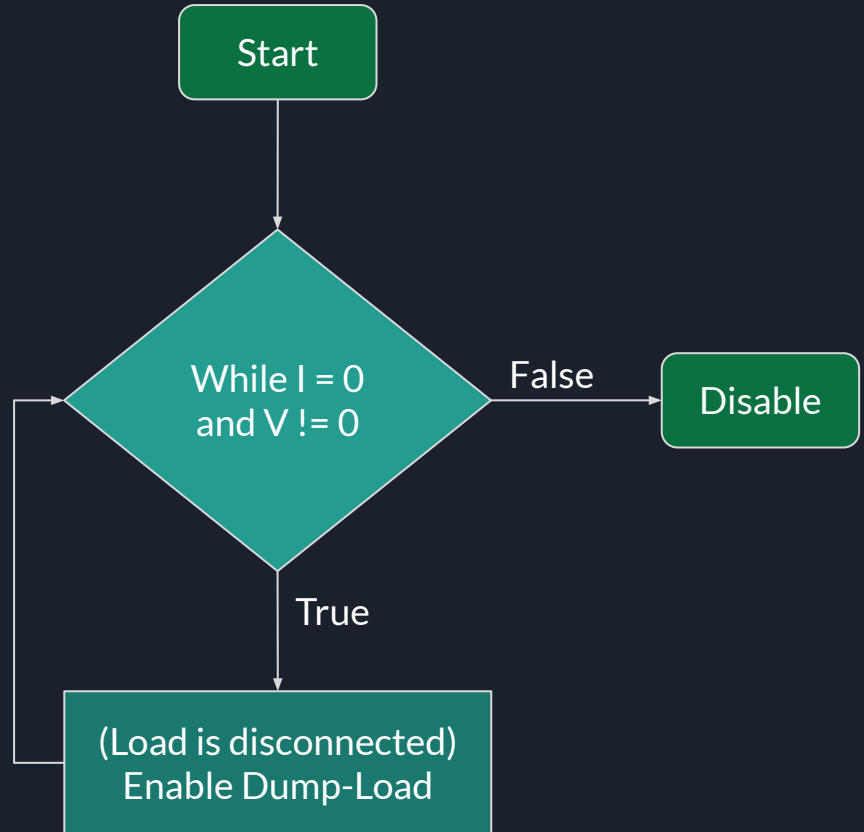
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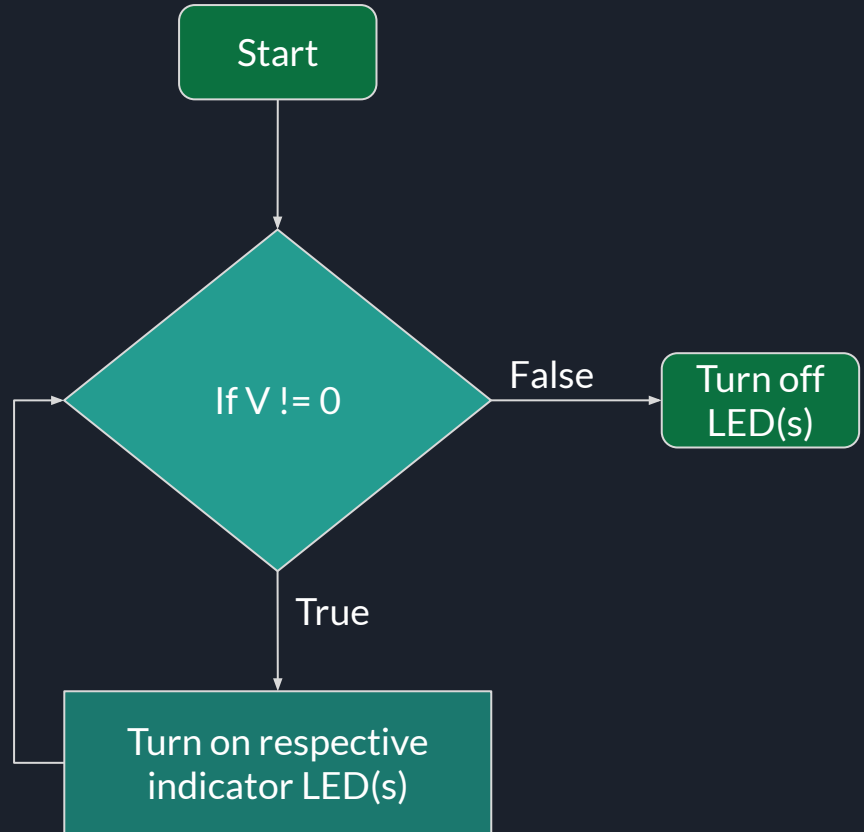


Presenter: Nigel

# Control System: Overview

*February 1st - April 1st*

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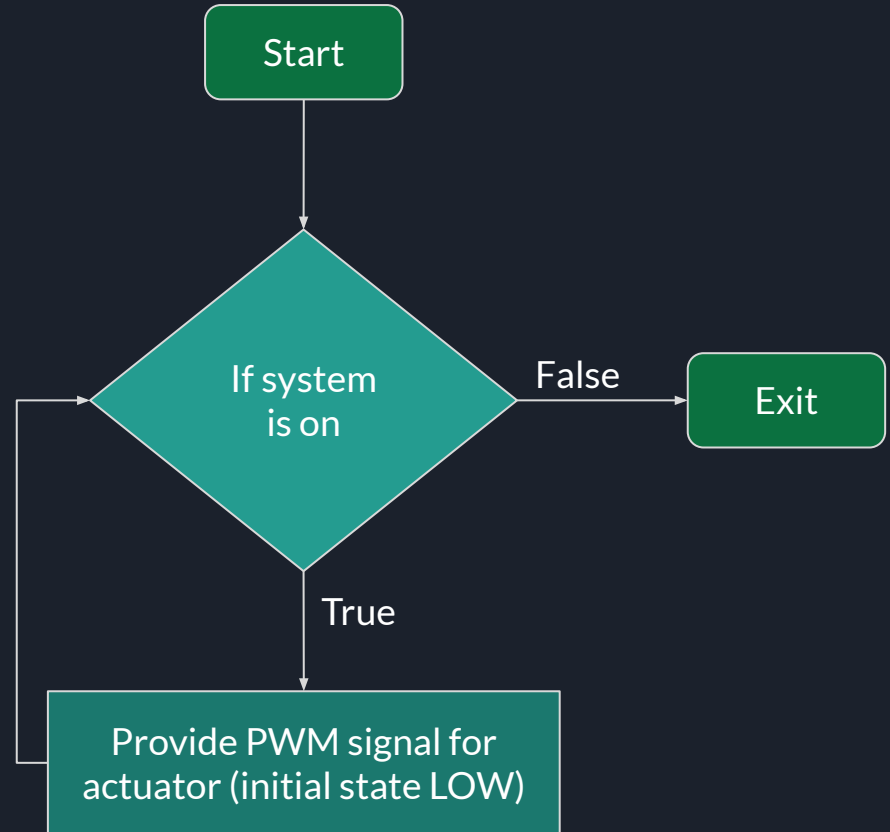


Presenter: Nigel

# Control System: Overview

*February 1st - April 1st*

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Presenter: Nigel

# Proportional Integral (PI) Control

**February 4th - April 1st** (No Dependency)

Tune PI

- Test PI in Simulink
- Fine tune the controller
- Optimum Duty Cycle

Flash to Arduino

- Export Simulink module to Arduino using:
- Hardware support package
  - Simulink Embedded C Code

Test circuit

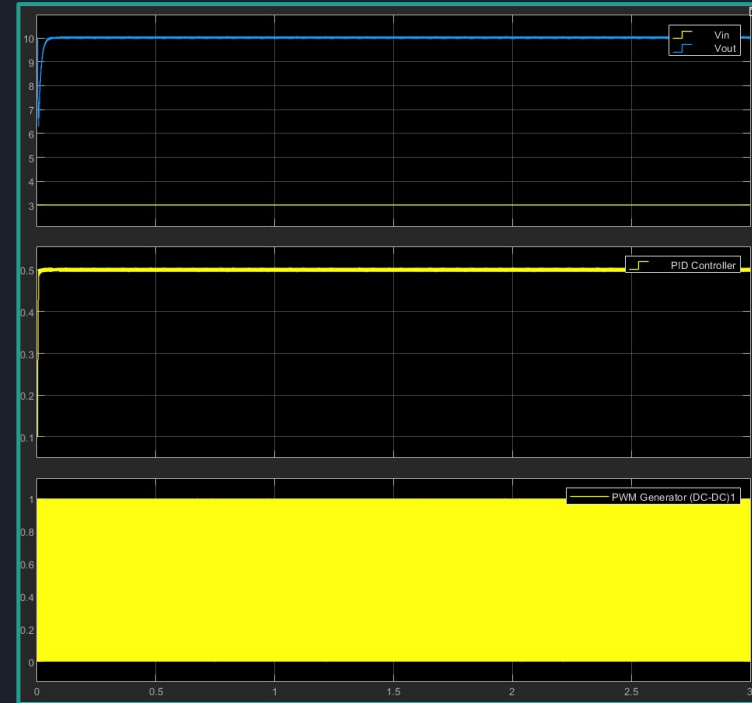
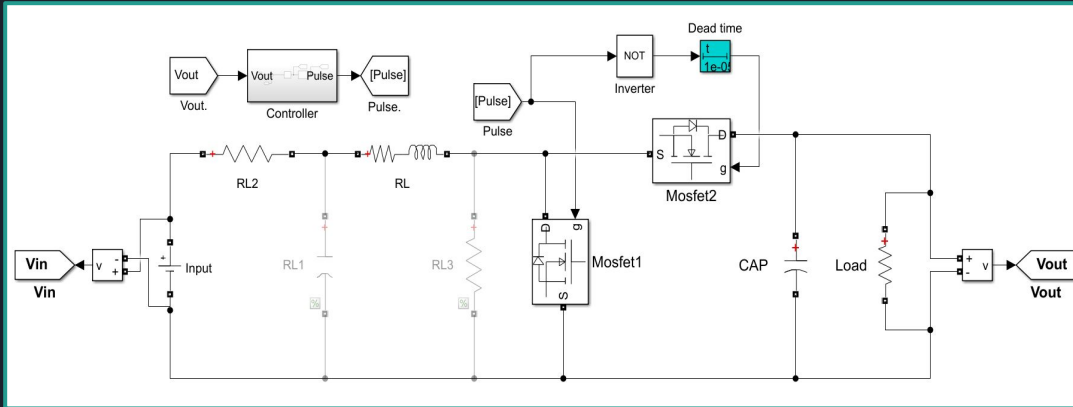
- Test simultaneous boost converter circuit with fixed input voltage and load
- Test with variable input and load

*(Flexible deadline)*

# Tune PI Controller

*February 4th - 19th*

- Try different values for P & I to produce the optimum Duty Cycle
- Optimum Duty Cycle results in higher boost with minimum ripples;  $V_{out} = V_{in} / D_o$

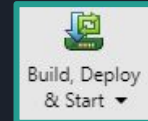
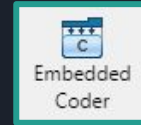


# Flash to Arduino

*February 4th - March 4th*



- Get Simulink Support Package for Arduino Hardware
- The Embedded C Coder will generate [ert.tlc] C for the Arduino
- Use blocks from the Arduino library for pin mapping
- We can (Monitor and Tune) the design while the Arduino is connected to the computer or (Build, Deploy & Start) to upload the generated code to the Arduino



# PCB Test & System Integration

**March 9th - April 5th**

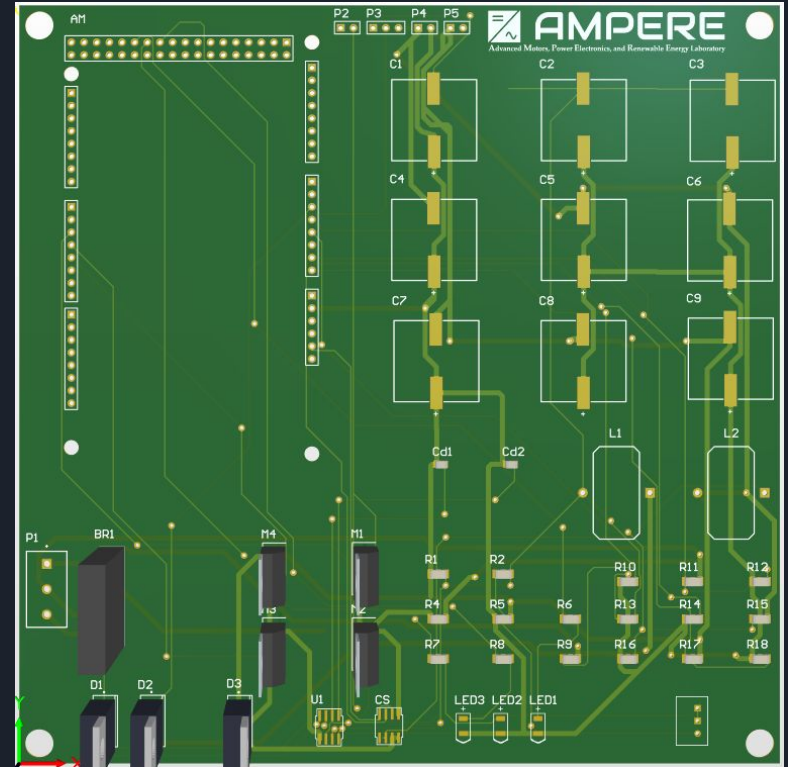




# PCB Soldering & Test

*March 9th - 11th*

- Solder the surface mounted components (capacitors, resistors)
- Solder the thru-hole components by hand along with the Arduino interface pins
- Test to verify our system works as we expect



Presenter: Mohammed

# Website

January 31st - May 8th

- Created a website using HTML
- Styled using CSS & Bootstrap
- Used JavaScript to perform specific functions
- Completed the first two pages ( Splash & Project description)
- Will work on the remaining pages in future

CWC 2020: DCDC Team Capstone Project Team

## Collegiate Wind Competition 2020

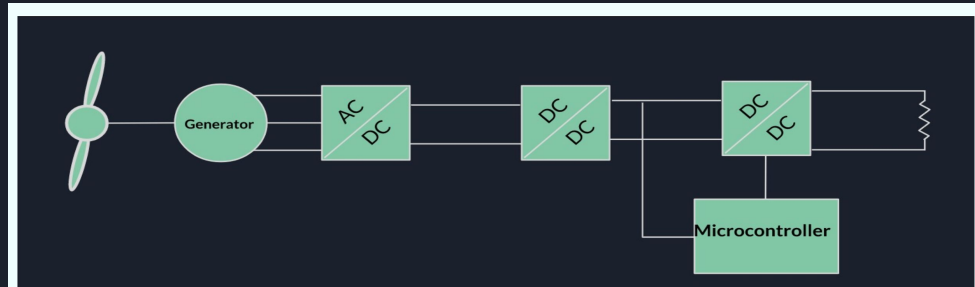
**Competition Purpose:**  
According to the U.S Department of Energy's (DOE) Wind Vision report, wind energy could supply 20% of the nation's electricity by 2030 and 35% by 2035. As more wind energy is incorporated into the U.S. power generation mix, qualified workers are needed to fill related jobs at all levels. The Collegiate Wind Competition (CWC) is organized yearly by the DOE as a challenge for students to design and build a micro-scale non-grid-connected wind turbine, and in the process, become curious innovators in this exciting field. Our team, *Booster Pack*, is tasked with building the DCDC converter system for the wind turbine.

**Sponsors:**  
Dr. Venkata Yaramasu & Mr. David Willy

**Mentor:**  
Jason Foster

**Team Members:**  
Nigel Grey, Humoud Abdulmalek, & Mohammed Almutairi

*Website last updated: 1/31/2020*



## Project

### High-Level Overview

A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades. When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the rotor to spin. The rotor connects to the generator, which ultimately translates aerodynamic force into electricity. As seen in the block diagram above, the generator output is in the form of a three-phase signal, which is rectified into direct current through the ACDC block. Next, a DCDC converter system is used to create a stable power output on the "load" (the resistor in the block diagram). In grid-connected wind energy systems the load is much more

### DCDC Converter Project

In response to the DOE and National Renewable Energy Laboratory's (NREL) annual Collegiate Wind Competition, our Capstone project is to design a DCDC converter system within a micro-scale wind turbine. Specifically, we have decided to explore a synchronous boost converter topology for our system. Thus far, the project has manifested itself with four prototypes: A synchronous boost converter Simulink model, a boost converter with proportional-integral (PI) control Simulink model, and two boost converter breadboard circuits. Our final product will be a model of effective and reliable wind power generation (in a miniature form). Wind turbines have been converting the kinetic energy of wind into electrical energy since 1887. Naturally, there is a long lineage of prior art leading up to

# CWC 2020 Rules

***January 31st - May 8th***

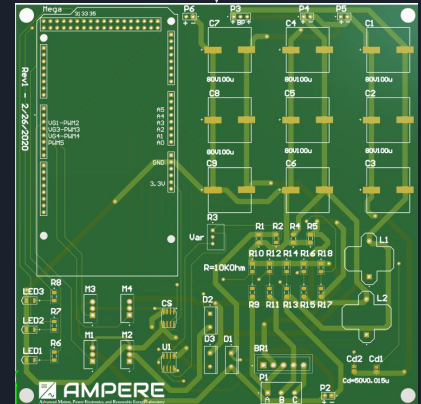
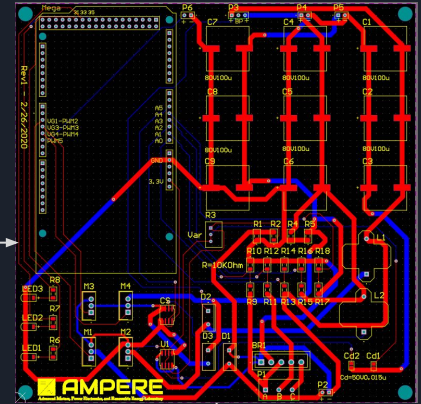
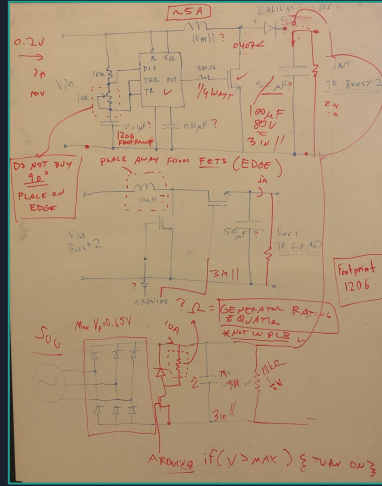
- Voltage must be kept constant and below 48V; we are designing for 20V
- The turbine base plate must be tied to earth ground w/ 100 k $\Omega$  resistor
- All external wired connections must be isolated



# Conclusion

## March 6th - May 8th

- We successfully progressed from the conceptual and simulated world to the physical
- Given the amount of effort and planning dedicated to our first PCB design, it is likely (Dr. Yamasu confirmed this) we will not need to create second revision
- We have three PCBs and ample components, the main risk moving forward centers around the difficulty of running all control modules in parallel

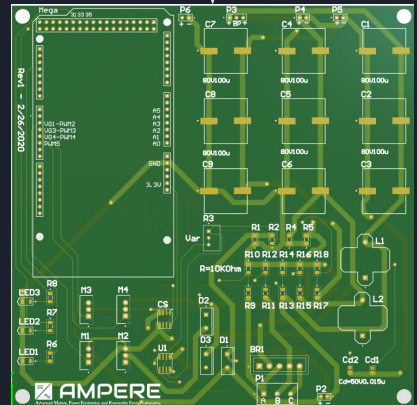
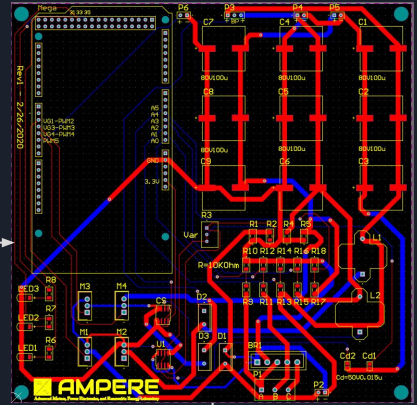
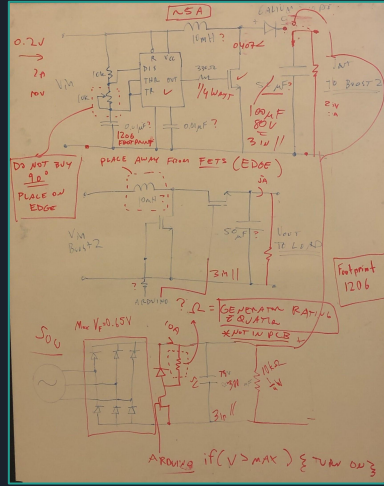


Presenter: Nigel

# Conclusion

## March 6th - May 8th

- Thank you! What questions do you have for us?



Presenter: Nigel