NAU Collegiate Wind Energy Competition

Noah Bell, Aidan Nash, Benjamin Allen, Nolan McNeil, Evan Kramer

NAU NORTHERN ARIZONA UNIVERSITY
College of Engineering, Informatics, and Applied Sciences

Abstract

The Department of Energy (DOE) supported an annual Collegiate Wind Energy Competition (CWC) at the American Wind Energy Association (AWEA) CLEANPOWER conference. The problem is as more wind energy was incorporated into the U.S. power generation mix, qualified workers are needed to fill related jobs at all levels. The goal of the CWC was to prepare students from multiple disciplines to enter the wind energy workforce by providing real-world technology experience. The NAU team consisted of one electrical, and two mechanical engineering subteams. These three teams worked together to design, build and test an effective mechanical, electrical, and aerodynamic wind turbine and load design that is safe and reliable for testing in an on-site wind tunnel. The team was responsible for all electrical components and enclosures from the turbine to the load. This included a three-phase generator, an AC/DC converter, a DC/DC boost converter to raise the voltage, a microcontroller (MCU) circuit to regulate the output voltage, and a resistive load.

System Architecture

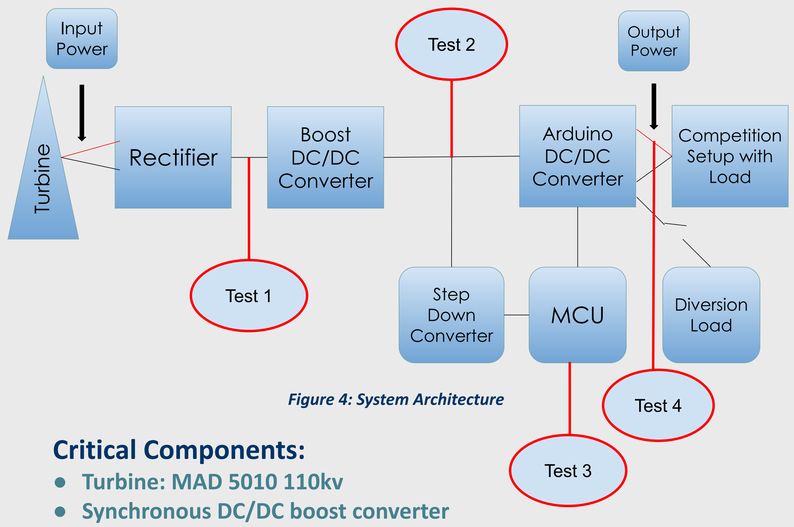

Figure 4: System Architecture

Critical Components:

- Turbine: MAD 5010 110kv
- Synchronous DC/DC boost converter
- Microcontroller(MCU)
  - Arduino Mega

Testing

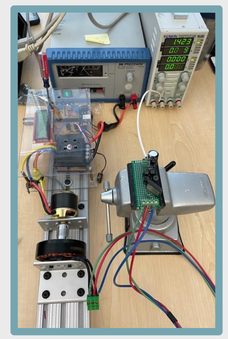

Figure 9: Rectifier Test Circuit

Test 1: Rectifier

- Requires 3 phase turbine to provide power input
- Tests performed with and without load
- Gradually alter rpm using the wind speed
  - Dynamometer for testing
- The voltage output of the rectifier must be less than 48V

Test 2: Boost Converter

- Solder wires onto the perf board or PCB at the positive side of the inductor
- Use power supply to increment voltage
- Verify that voltage boosts to 40V with only 10% variance of power

Test 3: Microcontroller

- Connect the Power supply to the Arduino/PCB system and load
- Connect an oscilloscope to PWM
- Read the PWM from the oscilloscope and check LED lights
- Depress the pushbutton

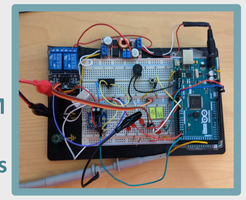

Figure 10: Microcontroller Circuit

Test 4: System Integration

- Test setup requires full bridge rectifier, boost converter and dynamometer
- Dynamometer used to mimic any RPM level up to 6000 RPM
- Connect DC programmable load to output of boost converter
- Read output values such as current, voltage and power

Generator Selection

- Selection criteria for generator:
  - Cogging Torque
  - Power output at low rpm
- Turbine selected: MAD 5010 110 kv
  - kv = rpm/volt
- Open circuit test shows the max possible output voltages (Figure 1)
- Fixed RPM Voltage Control test (Figure 2)
- Variable RPM Current Control test to limit load at 1A (Figure 3)

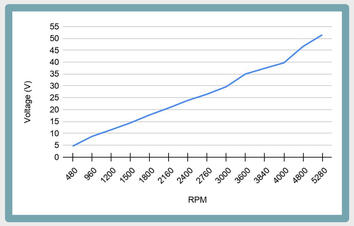

Figure 1: Open Circuit Test

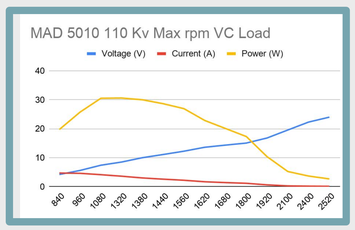

Figure 2: Voltage Control test

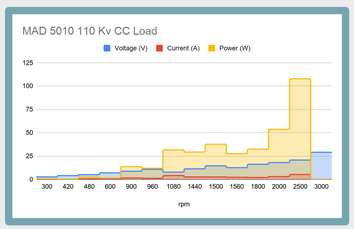

Figure 3: Current Control test

Peripherals

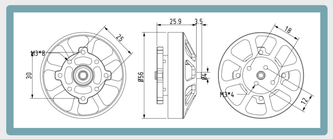

Figure 5: Generator

A 3-Phase generator provides the input energy to the system. This generator, or turbine, is powered by a dynamometer for testing purposes.

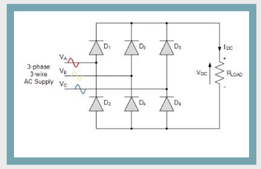

Figure 6: Three Phase Rectifier

The rectifier serves as the AC/DC converter in the system. It receives its input from the 3-phase turbine previously described.

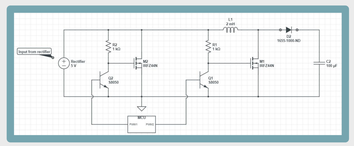

Figure 7: Boost Converter

The hardware boost is one of the most important pieces in regard to the competition. The electrical team is judged partially based on the amount we are able to boost the input voltage.

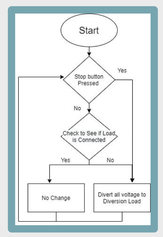

Figure 8: Emergency Stop Button

The input signal from the Software boost controller (Arduino) will flow into the emergency stop button. Depending on the state of the emergency stop button, the input signal will either cut to the diversion load if the button is pressed or the signal will carry on to the main load.

Acknowledgements

The team would like to offer special thanks to our client, Dr. Venkata Yaramaus, for his expertise and for the use of his lab, the AMPERE lab.
Also, the team would like to thank David Willy for his assistance and support throughout the project, as well as his work to register the NAU CWC team for the competition.
Finally, the team would like to thank Mahsa Keshavarz for acting as a team mentor throughout the process.

AMPERE
Advanced Motors, Power Electronics, and Renewable Energy Laboratory