Team 5: NAU CWC '20-21 EE Team

Requirements Specification
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This document outlines the Requirements and Rules of the collegiate wind competition for 2020-2021 along with all the specifications, constraints, and expectations described by the team's client. The document should provide a good understanding of what the team is expected to complete this year.

Section 1: General rules of competition:

The turbine must be designed, and loads analyzed to withstand continuous winds of up to 22 meters per second (m/s) but no testing will be done beyond 13 m/s. Each turbine prototype must be designed for testing inside the Collegiate Wind Competition wind tunnels.

Section 1.1: Size Requirements

Within practical limits, there is no size restriction for components located outside the tunnel.

Section 1.2: Rule changes

An important change in the rules for the 2020-2021 collegiate wind competition (CWC) is that teams are required to clearly describe what materials and designs they have referenced and used for this year's design. This rule is important due to last year's competition being changed to a virtual platform as a result of COVID-19.

Section 2: Project breakdown

The project has been divided into five subtasks outlined below. Each subtask is led by a single team member and supplemented by supporting team members.

Section 2.1: Subtask 1 - Auxiliary connections

Noah Bell is the team lead for this subtask. This subtask has a limited workload, simply selecting the enclosure for the components and making sure all wires and connectors are rated for the correct amperage.

Section 2.2: Subtask 2 - Purchasing

Evan Kramer is the team lead for this subtask. This subtask involves the research and purchasing of any and all components.

Section 2.3: Subtask 3 - PCB design

Nolan McNeil is the team lead for this subtask. The PCB design will be based off of tests done on the PCB from the cancelled ‘19 - ’20 competition.

Section 2.4: Subtask 4 - Arduino Coding

Benjamin Allen is the team lead for this subtask, supported by Noah Bell and Aidan Nash. This subtask is heavily involved. The Arduino needs a DC/DC converter that outputs max 5 V. This responsibility will also fall under this subtask. This subtask also involves testing of the DC/DC circuit design using simulink.

Section 2.5: Subtask 5 - DC/DC Converter

Aidan Nash is the team lead for this subtask, supported by Noah Bell and Evan Kramer. This is the most demanding and crucial part of the project. This subtask consists of designing and implementing a rectifier (AC/DC converter) and two DC/DC converters (one hardware and one software).

Section 3: Subtask 1- Auxiliary Connections

Section 3.1 Input/Output connections

All input and output connections use Anderson Power Pole Connectors shown below in Figure 1.

Figure 1: Anderson Power Pole Connectors

The output voltage must be less than or equal to 48 volts direct current (DC) at all times.

The output current must be in the range 15 - 45 Amps and the Anderson power pole connectors should be rated accordingly.

All of the input and output wires should be in the range 10 - 20 AWG (American Wire Gauge).

Section 3.2 Turbine connection

All the wires that connect to the turbine should exit at the turbine base.

All cable pass throughs in enclosures must use cable glands or other similar devices that provide both strain and chafe protection. Tape is not considered adequate sealing of penetrations or pass throughs in the enclosure.

Each cable connection from the turbine to the enclosure should employ a quick-attach connector, such as an Anderson power pole connector.

The turbine base plate shall be tied to earth ground. The turbine electrical system ground(s) must be electrically tied to this base plate with a 100 kΩ or lower resistance connection.

Bulk energy storage on the turbine side of the PCC is not allowed.

All electrical cables leading from the turbine to the electronic components located outside the tunnel must be in cable form (no individual strands) and have connectors. Individual strands or bare wires will result in disqualification from testing until remedied.Twisting two or more strands together is permissible as long as the resulting multi strand cable has a connector on the end. Multistrand cables are encouraged when used in a logical way. For example, there could be one cable for all power wires and one cable for all control wires.

Section 3.3 Point of common coupling (PCC)

Wires exiting the base of the turbine must be at least 1.5 meters in order to reach the competition testing point of common coupling (PCC).

The turbine electronics must be in a separate enclosure from the load in order to clearly differentiate load and the control during inspection by judges as shown in Figure 1.

Teams can use the load to power the turbine but the load (a capacitor bank) must not be charged at the beginning of the competition.

The enclosure should be outside the turbine and the wires should be long enough to reach the electrical enclosure and terminated with a single red and single black anderson power pole connector shown in Figure 2.

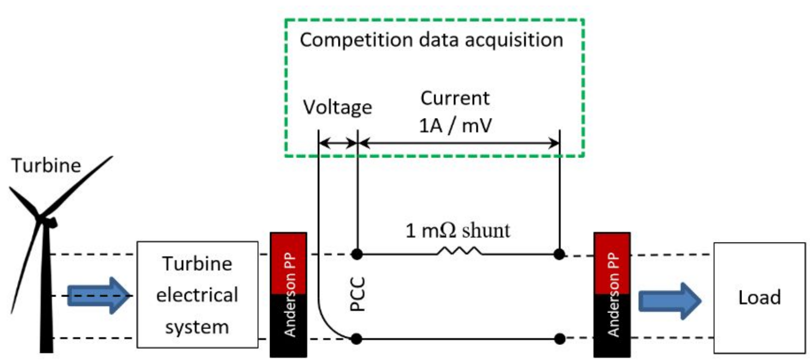

Figure 2: System architecture for competition testing

Section 3.4 Electrical enclosure

Enclosures are constructed for indoor use to provide a degree of protection for personnel against access to hazardous parts and to provide a degree of protection for the equipment inside the enclosure against ingress of solid foreign objects (should not be able to insert fingers or tools through the enclosure when closed). It is important that the intent of the NEMA 1 rating be preserved once all connectors and/or passthrough devices are installed.

All electrical components must be incorporated into closed enclosures that are fire safe and meet or exceed a National Electrical Manufacturers Association (NEMA) Type 1 rating.

All components must be electrically insulated from the enclosures.

All electrical components shall be mechanically secured to the enclosure.

Section 4: Safety Requirements

Teams must follow Occupational Safety and Health Administration rules for safety equipment based on expected activities (see NREL/university subcontract, Appendix B Clause 8: Worker Safety and Health Requirements, for more information). Organizers may issue a stop work order at any time during the project if a hazardous condition is identified:

- Safety glasses (student provided)
- Hard hats (competition provided)
- Steel-toe boots if expecting to handle heavy loads6(student provided)
- Electrical personal protective equipment if electrical voltage demands it (student provided)
- Hearing protection for use in areas that are near the wind tunnel during operation (student provided)

Section 5: Subtask 3 - PCB design (Nolan McNeil)

The PCB integration will be designed through the software, Altium. All components and connections on the PCB layout will be labeled. In order to define widths of power lines and communication lines, net classes will be made to avoid error within the PCB board. Close communication between the auxiliary team with PCB design will be integrated to ensure compatibility of the components.

Section 6: Subtask 4 - Arduino Coding (Benjamin Allen)

Section 6.1: Client constraints

The arduino mega should be used to automatically adjust the second DC/ DC converter.

Matlab Simulink should be used to model arduino and converters in operation.

A smaller DC/DC converter must be used to power the arduino with 5 volts.

Section 6.2: Competition Requirements:

The competition does not have any requirement on microcontrollers. A microcontroller isn't even required to be used in the converter system.

Section 7: Subtask 5 - DC/DC Converter (Aidan Nash)

Section 7.1: Client Requirements:

We must test the previous team's circuit, and base the Boost converter off of this. Since the previous team did not compete, the PCB was not finished so our client would like us to put together the previous team's and test the hardware.

Section 7.2: Competition Requirements:

Cannot use capacitor > 10J of energy

Power quality measurement test, deliver within a certain variance. Within any 5 second interval we can have a +-10% max average power variability.

Deliverables(As per CWC rules):

- Submit a single page write-up plus images that includes details on the instrumentation used to measure the power signal and the methodology used to characterize the amplitude of the noise on that signal.
- Include a time series of power measured at a frequency of at least 200 Hz and compare that signal to the stability criterion in Section 3.5.2. If present, discuss any filtering (either digital or physical) on that signal. If the time series does not meet the prescribed stability criterion, discuss plans to clean up the power output of the turbine.

Appendix A: System Architecture

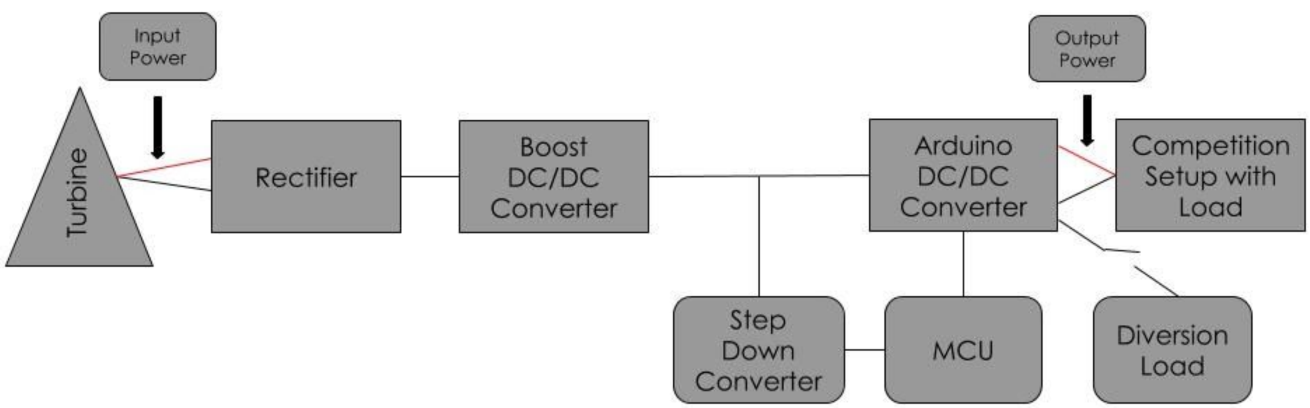

Figure 1: Overview - System Architecture