CWC23—Team Cyclone

School of Informatics, Computing, and Cyber Systems

Electrical Engineering Team

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Abstract

Our capstone project is a part of the Collegiate Wind Energy Competition (CWC) that occurs yearly to promote innovation and learning of the applications of wind turbines in real world experiences [1]. Renewable energy has become increasingly popular with the worldwide goal of reducing global warming and fossil fuel usage. The purpose of our project is to design and build a complimenting electrical system that works together with mechanical engineering's turbine design to efficiently convert wind power to electrical power, with the main goal of stability. The primary components of our design are the following: generator, AC/DC rectifier, DC/DC converter, microcontroller, and load. Our design and participation in the CWC will inspire future students in continuing the push for innovative solutions in renewable energy.

Requirements

- Utilize a boost converter.
- Open circuit voltage should not surpass 48V.
- Permanent magnet synchronous generator must be used.
- Load needs to be designed and built by the team.
- Load and turbine electronics must be in two separate enclosures.
- No batteries are allowed on load side.
- Restart for any wind speed above 5m/s.

Acknowledgements

We would like to thank the Department of Energy and National Renewable Energy Laboratory for making this competition possible. We would also like to thank Dr. Yaramasu and Dr. Willy for mentoring and supporting us during this design process.

System Overview

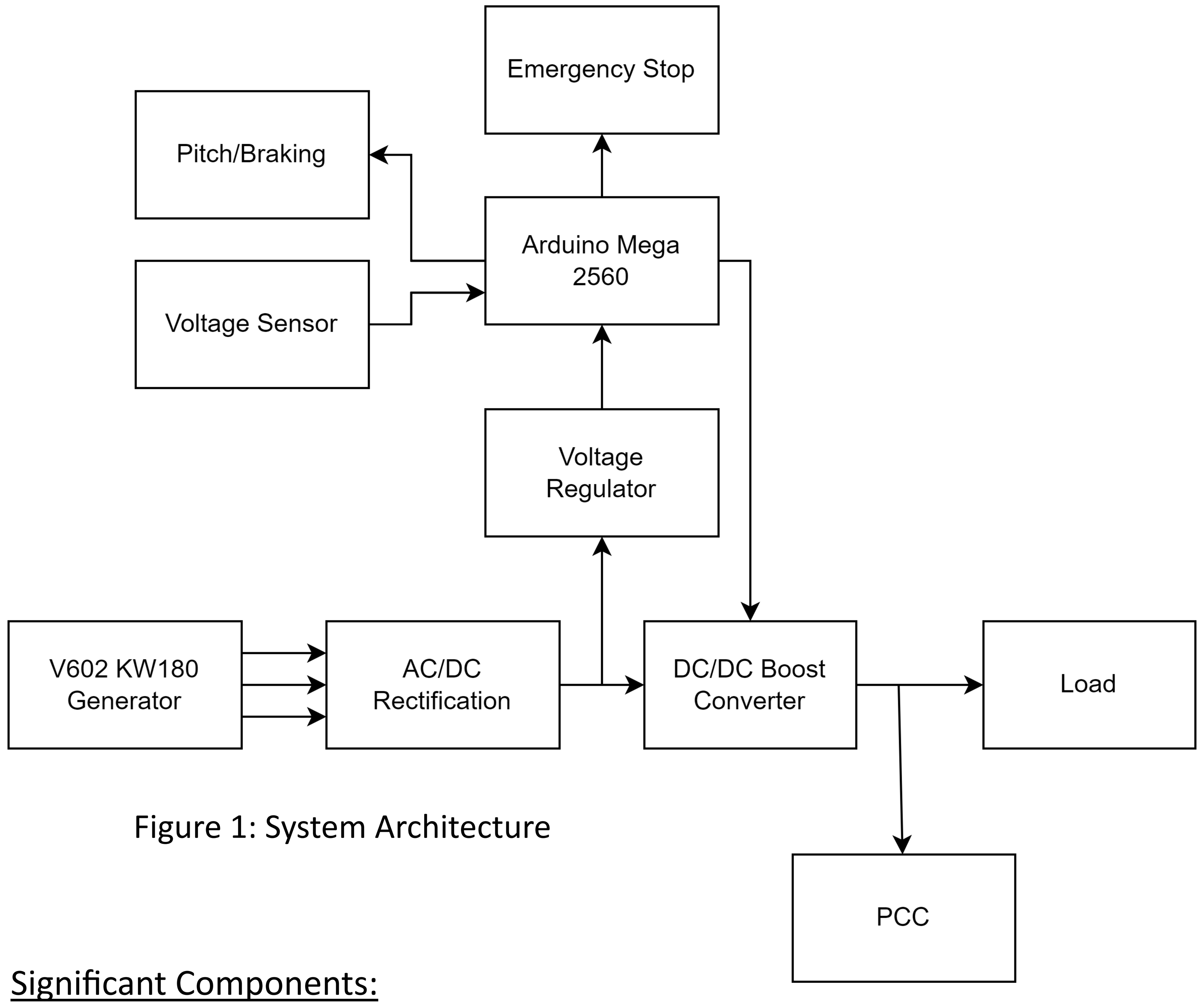

Figure 1: System Architecture

Significant Components:

- **Generator:** V602 KV180 Motor, 3–phase AC Brushless Motor.
- **AC/DC Rectification:** Full Bridge Rectifier, FUS45-0045B.
- **DC/DC Boost converter:** Single stage, designed with 47uF capacitor, 100uH inductor, Schottky diode, and a MOSFET.
- **Voltage Sensor:** Voltage divider built by team.
- **Voltage Regulator:** Output 5V at 1.2A.

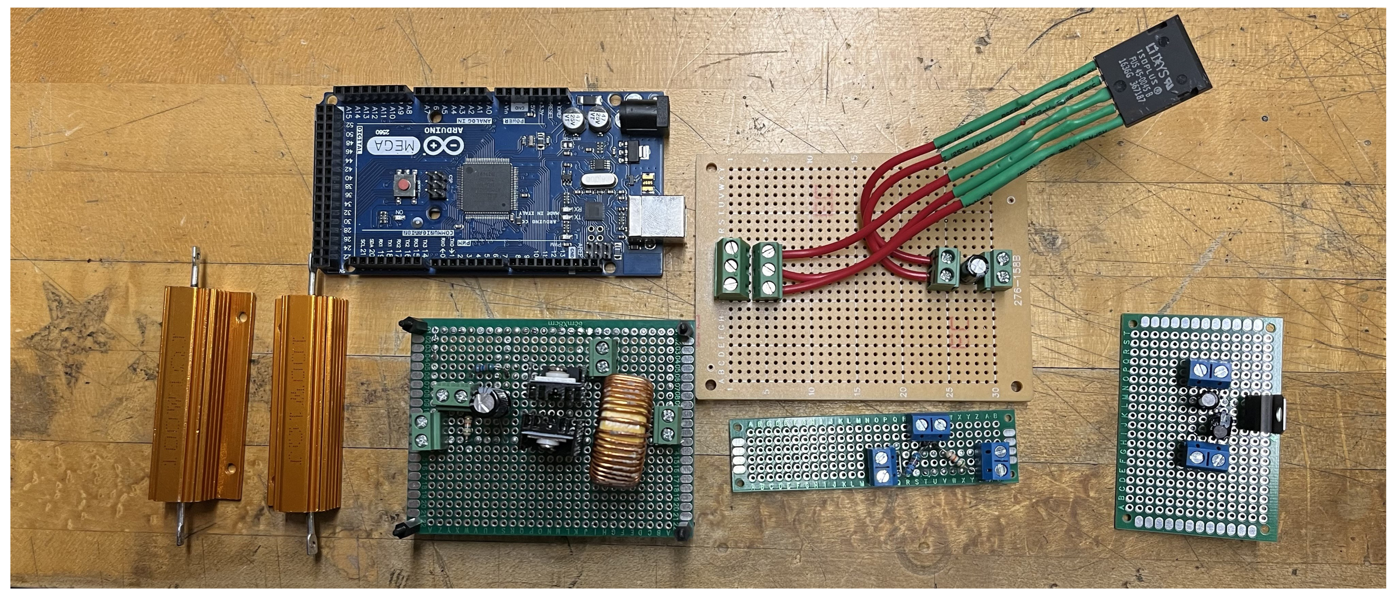

Figure 2: System Components

Testing and Results

Unit Test: AC/DC Rectifier

- Instrumentation: Function Generator and Oscilloscope
- Input: 1 - 10V AC 60 Hz
- Output: 1-10V DC

Unit Test: DC/DC Boost

- Instrumentation: DC Power Supply and DC Programmable Load
- Input: 1-20V DC
- Output: 20-40V DC

Table 1: DC/DC Boost Converter Data

Input DC Voltage	Duty Cycle	Input Current	Input Power	Output Voltage	Output Current	Output Power	Efficiency
5	78%	0.51	2.555	21.825	0.1	2.19	85.71%
6	78%	0.53	3.179	26.431	0.099	2.62	82.42%
7	78%	0.54	3.78	31.095	0.099	3.08	81.48%
8	78%	0.55	4.394	35.683	0.099	3.53	80.34%
9	77%	0.54	4.865	39.387	0.099	3.9	80.16%
10	71%	0.48	4.8	39.136	0.099	3.87	80.63%
11	63%	0.43	4.725	39.128	0.099	3.87	81.90%
12	56%	0.39	4.676	39.147	0.099	3.87	82.76%
13	51%	0.36	4.68	39.107	0.099	3.87	82.69%
14	46%	0.33	4.616	39.175	0.099	3.88	84.06%
15	42%	0.3	4.5	39.174	0.099	3.88	86.22%
16	39%	0.28	4.48	39.195	0.099	3.88	86.61%
17	36%	0.26	4.42	39.166	0.099	3.88	87.78%
18	32%	0.24	4.32	39.189	0.099	3.88	89.81%
19	29%	0.23	4.37	39.247	0.098	3.85	88.10%
20	27%	0.22	4.4	39.193	0.099	3.88	88.18%

Unit Test: Voltage Regulator

- Instrumentation: DC Power Supply
- Input: 4-19V DC
- Output: Constant 5V

Table 2: Voltage Regulator Data

Input Voltage	Expected Output Voltage	Output Voltage
4	5	3.06
5	5	3.91
6	5	4.84
7	5	5.02
9	5	5.01
11	5	5.02
13	5	5.03
15	5	5.02
17	5	5.02
19	5	5.02

References

[1] US Department of Energy, "Collegiate Wind Competition 2023," 2022, pp. 1–26.