To: Dr. Willy & Dr. Yaramasu

From: Team Turbine Electric: Chris Taylor, Abdallah Alsharrah, Juntong Liu

Date: November 9, 2018

Subject: Brainstorming, Mind Mapping, and Feasibility Assignment

Dr. Willy and Dr. Yaramasu,

We are Team Electric Turbine of the DOE Collegiate Wind Competition project. This project is a combined design by both electrical and mechanical engineering majors. In addition, as electrical engineers our task is to cover the design, build, test and iteration on a small wind turbine to be tested in the wind tunnel at the NWTC in the spring semester abiding by the rules and regulations outlined in the DOE CWC rules document. Our team has met a total of six times now. Two of those times have been with the client. Each client meeting has given us more insight on the scope of the project. As a team we have set up bi-weekly meetings. One meeting will be with Dr. Willy in the engineering building to discuss progress with the mechanical engineering team. The second weekly meeting will be with Dr. Yaramasu in the Siccs building. The meeting with Dr. Yaramasu will be used to work on our prototypes and finalize a design. While meeting with the full design team we will brainstorm ideas of what the scope of the project is. The weekly meeting with Dr. Willy will also be used to discuss problems we might run into and limitation we will face and how best we can avoid any issues.

Ideas of what the project is about

We now know that there are two converters we will need to build. First, we will have to rectify the AC signal that is produced from the 3-phase AC motor attached to the wind turbine. We will then need to use a DC-DC converter to get the voltage within the desired range for the competition. The wind turbine will produce a variable DC signal once it has been converted from AC. Our design will need to be able to accept a wide range of DC input ranges and boost it to a consistent voltage. We have also learned that we will need to power our Arduino and the circuit we build using the wind turbine. We will do this using an ultra-capacitor. We will need to find a way to charge the ultra-capacitor and use that for the powering of the rest of the components. We know that we will need to make our design work with whatever the mechanical engineers design for the actual turbine.

Problems we might run into

There will be a lot of work needed to accomplish this project. The first major part of the project is the programming process, there will be a large amount code needed to make all aspects of our converter work within the scope of this project. The second issue we foresee will be connecting the wires with the printed circuit board which we will be building from scratch. We plan to use screw terminals to minimize the amount of physical connections on our PCB. The third part is the design of the actual circuit board. There are multiple types of boards that can be used, choosing between them will be difficult to get the one that will be suitable for our design. It will be completed by wiring as each wire will be responsible for connecting the components mentioned below in our parts list. If we do not wire our PCB correctly with the Arduino, we will be unsuccessful in creating a boost converter. Only one team member has ever printed a circuit board, so we will need to utilize Dr. Yaramasu when it comes to the design and physical printing of the board.

Limitations

Some limitations of our design will be due to the cost of parts and the time we have to complete the design. This will be the first time any of us will be building anything with real world application and we anticipate that we will burst many capacitors and possibly burn out other devices while prototyping our design. Since our budget isn't limitless we need to be aware of this when we begin prototyping. To maximize cost efficiency, we will first design our circuit on paper and then begin building it on the breadboard. Ideally, we would like to print multiple circuit boards in case there are failures during the competition. All of this will take time and since time isn't on our side we will need to ensure we work out any kinks early. We are required to present a prototype in less than a month, so we will have to physically work on our design early without wasting any time. We will need to be ready to order new parts on demand and we expect we may need to personally order some components such as resistors, capacitors, and inductors to minimize the amount of time needed to receive essential components.

Solutions of approaches

Firstly, as senior engineers it is our job to detect the problems and the team will work on approaching the solutions for major problems in various ways and analyze which approach is best for the project. Our first approach is to get more information from past turbine projects. The team can learn from past calculations that were made for previous wind turbines data. However, these calculation or equations can be modified for our specific design. Another problem we see is our coding for the Arduino Micro Controller. This problem can be approached by selecting which microcontroller model will fit and work on our design. We have found may examples online with working code for the type of converter we will be creating. We will utilize past teams' resources to assist with our coding of the micro controller. Along with this process, we will learn how to make the printed circuit board do the task which the design requires. Furthermore, we should spend more time working on the microcontroller coding to avoid any mistakes on the code that may cause our physical circuit to not perform correctly. While connecting the wires we should be accurate, so we can avoid damaging the circuit and the components. We will use the knowledge from our EE classes to make a functional circuit. With all has been said, the team can always make sure our design is meeting the needs of the client. The client will give us a better approach to get results that will satisfy both engineering and client requirement.

Feasibility analysis

Since this project has been completed in the past we will utilize the resources of previous years teams. We know that this design is feasible because this is a very common technology that is utilized in today's industry. There is nothing that we plan to design that is not feasible, the challenge will come from making everything work together.

Scope of project: what existing technologies will we utilize

We will not need to make our own resistors, capacitors, or inductors since the ones we intend to use are common values that can be purchased for a very low price. We will also purchase a micro-controller. We are still trying to determine if we want to purchase an Arduino or an MSP430. If we were to go with the Arduino, we think it would be best to use an Uno, Nano, or Mega. We also plan to purchase our N-Channel MOSFET. There are three MOSFETs we still need to decide on. Those can be found in our parts list below. We will also need diodes. From our research we have determined that Schottky diodes would work best for our needs. We will use PCB screw terminals to minimize the amount of soldering needed and for ease of replacement when something inevitably fails.

Things we will build from scratch:

Firstly, we need to sketch circuit, then test the circuit on multiset. If feasible, we will prototype using a breadboard; then we will need to create a PCB. We will also need to solder devices to the PCB. Furthermore, we will need to program the microcontroller. We will also need to wire everything ourselves and test to ensure that all connections work.

Alternatives:

If for some reason we can't print our own circuit board, a breadboard would work as an alternative. We would prefer to print our own circuit board because it would look a lot cleaner and take up significantly less space than a breadboard. Moreover, the breadboard has many inputs and outputs to use for the wiring part. Thus, that will be easier for us to complete our project with spare option. Furthermore, our team is used to work with the breadboard in previous classes which were experienced in. However, are goal is to have our own circuit board as it will customized on our design.

How all these parts fit together:

After meeting with Dr. Willy and the mechanical engineering team we have a better idea of how all these components will work together. We learned that the motor the mechanical engineering team will be using is a three phase AC motor. This means that we will have a variable AC signal coming from the turbine motor that when rectified will still create a variable DC signal. This variable DC signal will then need to be boosted to charge our ultra-capacitor and maintain a constant 5V output. Everything will be controlled from one microcontroller.

Other technologies to consider:

We will need to consider the design that the mechanical engineering team will produce. Our design will have to fit within the confines of their design and we will have to make sure that everything integrates correctly with their design. We may also need to incorporate their code with our code on a single microcontroller. We are unsure if the mechanical engineering team will use their own microcontroller.

Major challenges we foresee:

The PCB design, since only one of us has the experience of PCB design. We are all experienced in soldering but as stated before none of us have ever undertaken a project of this scale. It will be hard for us to convert our ideas into use. What's more, which microcontroller we will purchase is also a big challenge for us. We will further discuss this with Dr. Yaramasu but he claims that any microcontroller should operate how we need it to. We are all experienced in circuit design and it will take a lot of testing to ensure that our circuit operates correctly.

Prototyping: Proof of feasibility

1. Understand the customers and intentions

This is the first item in the prototyping process. It is also the most crucial principle. Understanding the customers and understanding the intent of the prototype for prototyping can drive all aspects of the prototyping process. After understanding the customers what is needed for the project will help guide our prototype.

Below is our plan for stage one of prototyping:

I. Determine what is needed for prototyping.
II. Set the appropriate expectations.
III. Determine the appropriate fidelity.
IV. Choose the right tool.
V. Everything comes from the customers, so we start by solving the problem of the customers. Know who is the customers and you can determine what is needed for prototyping.

2. Prototype phase 2

Plan a new design based on what the client told us after our first phase of prototyping. We will then prototype again, and work in an incremental, iterative way to adapt to changing environments. The more work you do in the planning phase, the better you can get started. Each prototype will be inspected by Dr. Yaramasu to ensure accuracy and efficiency.

Simulation:

Simulink is a visual simulation tool in MATLAB. It is a block diagram design environment based on MATLAB. It is a software package for dynamic system modeling, simulation, and analysis. It is widely used in linear systems, nonlinear systems, digital control and in the modeling and simulation of digital signal processing. Simulink provides an integrated environment for dynamic system modeling, simulation, and comprehensive analysis. In this environment, a complex system can be constructed without many writing programs, but with simple and intuitive mouse operation.

PCB design principle:

1. When designing the layout of the PCB, the design principle of placing along the straight line of the signal should be fully observed, and the back and forth should be avoided as much as possible.
2. Avoid direct signal coupling, affecting signal quality
3. When multiple module circuits are placed on the same PCB, digital circuits and analog circuits, high-speed and low-speed circuits should be laid out separately.
4. Avoid mutual interference between digital circuits, analog circuits, high-speed circuits, and low-speed circuits.
5. When there are high, medium and low-speed circuits on the circuit board, you should follow the layout principle in the figure below.
6. Avoid high frequency circuit noise radiating through the interface.
7. Energy storage and high-frequency filter capacitors should be placed near unit circuits or devices with large current changes (such as input and output terminals, fans and relays of power modules).
8. The presence of the storage capacitor can reduce the loop area of the large current loop.
9. The filter circuit of the power input port of the circuit board should be placed close to the interface.
10. Avoid that the filtered lines are recoupled.
11. On the PCB, the filtering, protection, and isolation of the interface circuitry should be placed close to the interface.
12. Effectively achieve protection, filtering, and isolation
13. Robust radiation devices such as crystals, crystal oscillators, relays, and switching power supplies are at least 1000 mils away from the single-board interface connectors.
14. The interference will be radiated directly outward or coupled out on the outgoing cable to radiate outward.
15. The filter capacitors for IC filtering should be placed as close as possible to the power supply pins of the chip.
16. The closer the capacitor is to the pin, the smaller the area of the high-frequency circuit, and the smaller the radiation.

Technology we plan to utilize:

Below are the current parts that we think we will need to complete this project. This list will continually change as we determine what works best for us. We put question marks next to the components we are unsure if we need.

- Arduino (nano or uno)
- N-Channel MOSFET (IRFZ44N) or (IRLZ44N) or (IRFP260N)
- 100-150 uH inductors
- 50-330 uF capacitors (35-200 V voltage rating)
- Resistors
    - 2 x 100k Ohms
    - 2 x 1k Ohms
    - 1 x 2.2k Ohms
    - 1 x 100 Ohms
    - 4 x 4.7k Ohms
- Schottky diode (SR5A0) or (IN5819) x 2
- S8050 NPN Transistor ?????
- 2 x PCB Terminals / Screw Terminals
- Prototype Boards / Breadboards
- Current Sensor ?????
- Ultra-Capacitor
- Custom PCB

How we plan to overcome challenges:

None of us have ever designed our own PCB which is a daunting task. We plan to utilize Dr. Yaramasu for this aspect of the project. We expect that there will be many blown capacitors during our experimentation for which circuit will work best for our boost converter.

Now that we have met with the mechanical engineering team and have a set schedule for meeting times, we feel more confident in our abilities to complete this project. Since this project has been completed many times by teams of previous years, we feel confident we know what is feasible and what isn't. This project is straight forward which made it difficult for us to find things to put on our mind map and brainstorm document. Most of our brainstorming was done within Google Docs on the assortment of documents within our team folder. We will work closely with our clients since they are readily available and ensure that all the requirements are met for the project.

Appendix:

Figure 1: Image of last year’s wind turbine for reference.

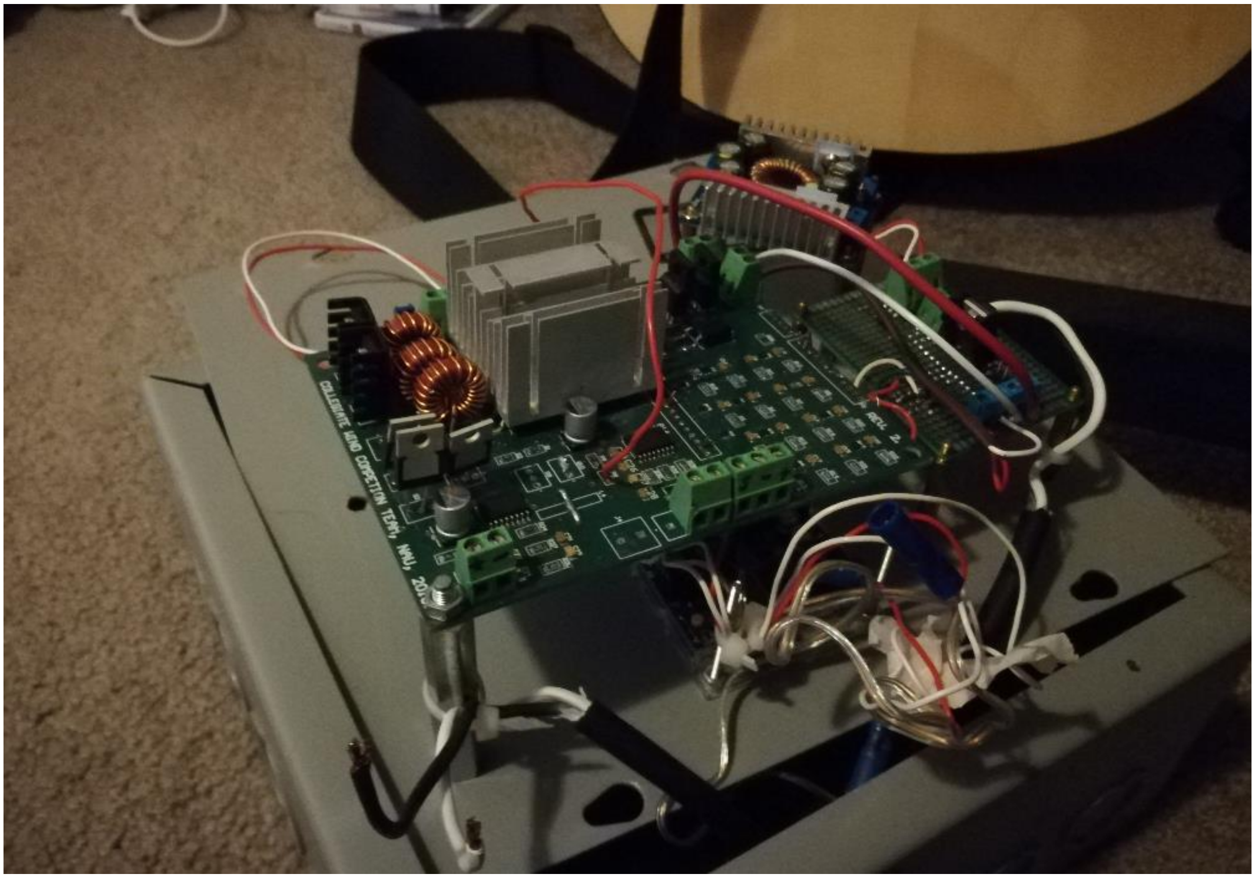

Figure 2: Image of last years EE teams boost converter.

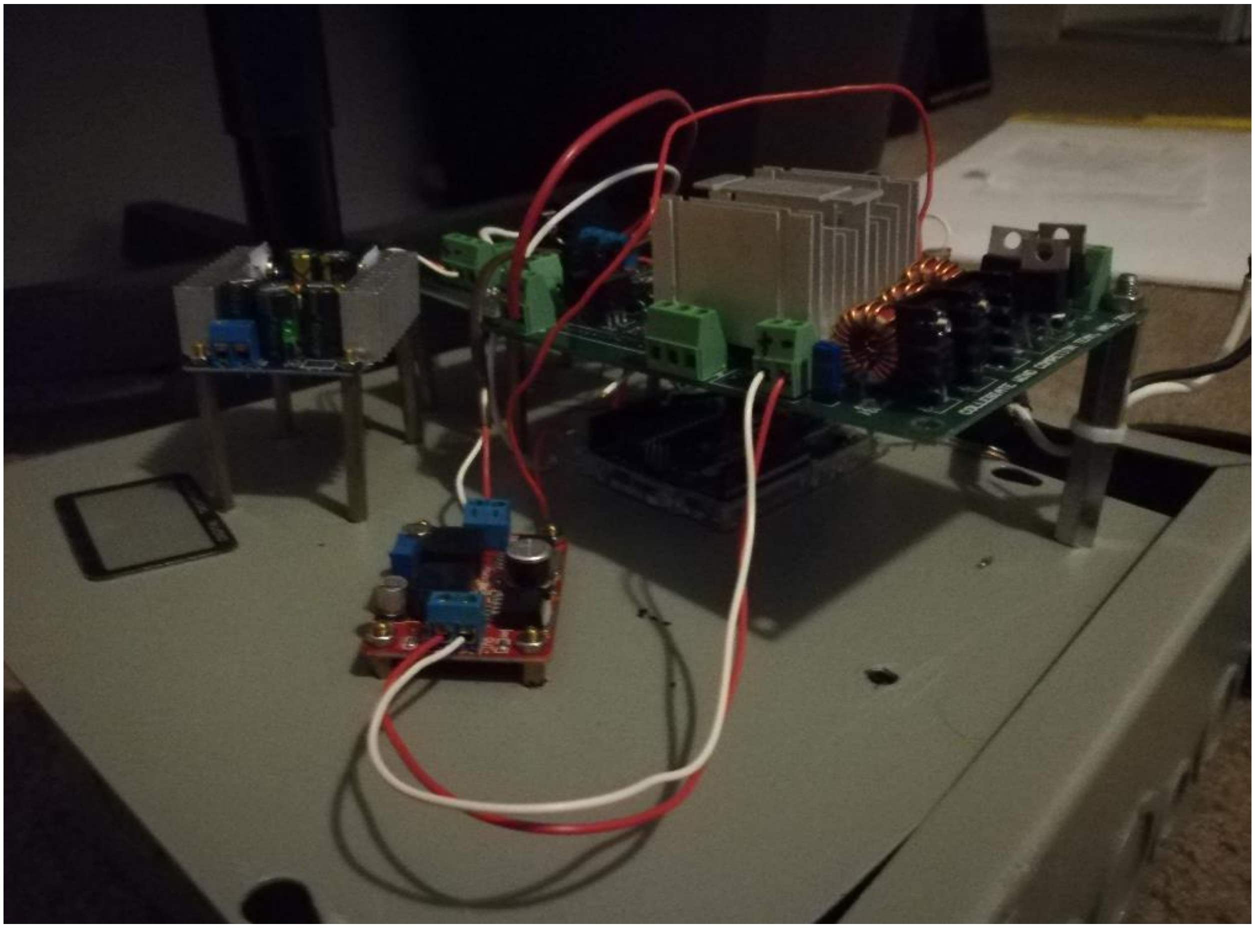

Figure 3: Another image of the EE design from last year.

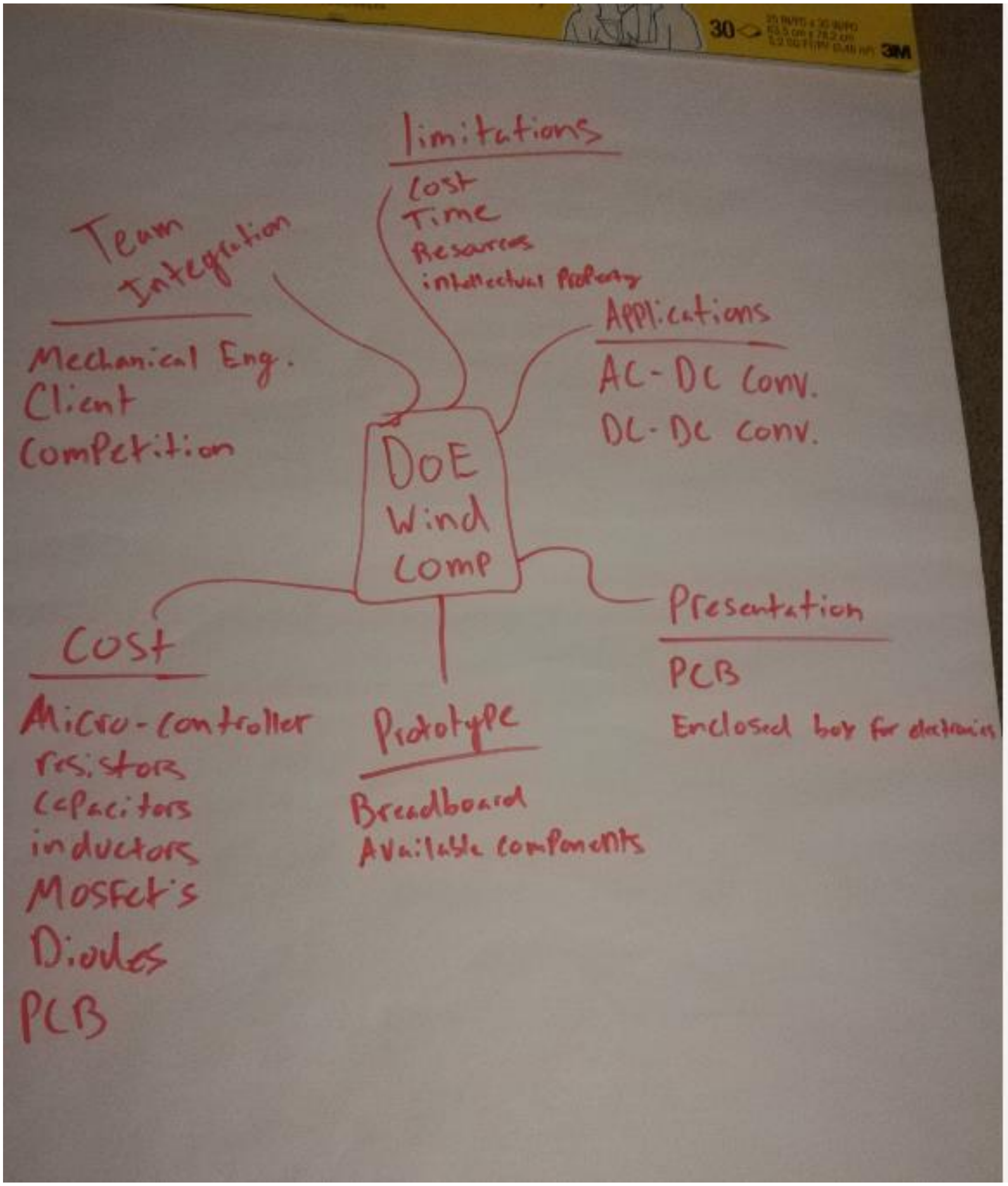

Figure 4: Mind Mapping