Restated Project Definition and Updated Project Scope

Team Number: 2 Electrical Vehicle Optimization

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Abstract

Dr. Michael Hays of Cummins is directing group 2 in its efforts to maximize the operable range of an electric vehicle in extreme weather conditions. Cummins would like to develop a “hotel system of charging” that can be integrated with their diesel engines used in semi-trucks. This will consist of a battery engine mechatronic system, which will use the engine to recharge the batteries if the batteries are depleted to a certain threshold. The design team will develop this system for the electric golf cart provided by Cummins in efforts to apply this to the ISX-15 diesel engine. Group 2 is working in tandem with a group of electrical engineers. The electrical engineers are going to handle battery selection, circuit analysis, as well designing an AC to DC convertor. The mechanical team will be responsible for integrating the electrical components into the mechatronic system as well as selecting the generator that will simulate the ISX-15 diesel engine. A battery monitoring system will be integrated to control when the generator is turned on and off, based on the battery voltage. This system will send a signal to shut off the generator when the batteries are fully charged. Since the battery output is largely dependent on the temperature, a heating element will be integrated to ensure the batteries remain at an operable temperature. The design team has conducted research on possible routes for the project; however some of the programming aspects require more research. These programing concepts will remain the same for the semi-truck model; the difference is the secondary power source is the ISX-15 engine instead of a generator.

1 Introduction

The scope of this design project includes designing a “hotel system of charging” for an electric golf cart, provided by Cummins, in efforts to apply these designs to an ISX-15 diesel engine. Semi-truck drivers are faced with getting a hotel or sleeping in the truck cabin. These cabins consist of a bed, TV, as well as heating and AC. This produces a potential threat in harsh weather conditions. In order to stay warm as well as not deplete the batteries, the drive must keep the engine running through the night. The team has been faced with designing a mechatronic system to prevent this issue. Rather than designing this for a semi-truck, Cummins has provided the team with an electric golf cart as well as a generator to simulate the truck engine. The major constraints the team was given include that the vehicle must operate at -30 degrees, as well as charge the batteries while the vehicle is running. The team set out a few objectives to ensure the designs integrity. The team will integrate a battery monitoring system, integrate the generator, and code the software to ensure proper operation. The mechatronic system will be developed to ensure the batteries remain at an operable temperature by integrating heating pads, thus allowing operation in harsh weather conditions. A microcontroller will regulate the battery voltage and temperature and determine when the generator and or heating pads need to be utilized. These designs will then be up-scaled and modeled for the ISX-15 diesel engine.

2 Project Definition

Semi-truck drivers have been faced with a potential issue in harsh weather conditions. Rather than getting a hotel room, truck drivers will sleep in the cabin. These cabins usually consist of a bed, TV, heating and AC. However, harsh weather impedes the battery output, which is powering these electronics. The driver must keep the engine running through the night to ensure that the battery does not drain as well as stay warm. Cummins would like to develop a system that utilizes the engine power to recharge the batteries when necessary, in order to prevent the engine from running all night.

2.1 Need Statement

This project is sponsored by Cummins under the supervision of Dr. Michael Hays along with the assistance of Dr. Claus Daniels from Oak Ridge National Laboratory. The team's faculty advisor is Dr. Juan Ordonez. At present the electric vehicle cannot operate at cold temperatures, and its range is more limited that is desired. The purpose of this project is to simulate the issue of semi-truck cabins draining the battery. The design team needs to modify the current golf cart system by utilizing a secondary power source. This power source will represent the ISX-15 diesel engine. Dr. Hays informed the team that Cummins would be providing them with a generator to implement in their design. Since this is a small-scale simulation, Dr. Hays has provided the team with two issues with the current golf cart. The range needs improvement and the vehicle does not operate in harsh cold weather. As such Team 2 has formulated a need statement for the project:

"Semi-truck cabin electronics drain the batteries, and force the driver to keep the engine running. This is translated down to an electric golf cart, verifying the current range is unsatisfactory and needs to operate in cold weather conditions."

2.2 Goal Statement & Objectives

From the meetings with the sponsor the goal of the project was formulated. Dr. Hays desired that a generator be installed into the golf cart to serve as the charging power source for the battery. He also desired that the generator activate when the battery level drops below a certain threshold, and that the generator deactivate when the batteries are charged. In addition to the automization of the generator charging system he requested that a battery monitoring system also be implemented. Additionally all of these modifications would be made in efforts to apply this to semi-trucks. The project's goal statement was developed by generalizing these requirements and is given below:

"To increase the current range and operable conditions of the electric vehicle by utilizing a secondary power source in efforts to apply this to semi-trucks."

Objectives:

- **Increase the lower temperature limit to -29˚C.**
- **Document current system performance.**
- **Incorporate a generator.**
- **Integrate a battery monitoring system.**
- **Ensure that the golf cart can charge and be in operation simultaneously.**
- **Model design for the ISX-15 diesel engine.**

2.3 Constraints

- **The system must operate at -29˚C.**
- **Project budget is $2,000.**
- **Primary power source must be the 48V battery set.**

3 Project Update

The team has begun ordering parts, and will begin testing soon. The circuits controlling the heating pad and charger must be designed; however the remaining mechatronic control circuit is nearing completion. A main component to the system includes programming the software. Since temperature is a major constraint to this project, the team will test the voltage of the batteries on a scale of temperatures. This will help determine a relationship between temperature and voltage in order to accurately program the software. Another major aspect to this project includes integrating the generator. The mechatronic system must regulate the voltage of the batteries, and once depleted to a certain threshold (to be determined after testing), the generator will turn on to recharge the batteries. This integration will include reverse engineering the generator to ensure proper connections to the microcontroller. Due to unexpected delays with the delivery of the generator, the team has not been able to begin this portion of the design process. In order to properly complete the mechatronic design, turning on the generator with relays will pose a potential challenge to the team. Under short time constraints, most of the initial testing components have been purchased, however testing these components include the integration of the generator. The team hopes to receive the generator in the following few days in order to complete the design and begin testing.

4 Methodology

In order to improve the overall range of the vehicle, a methodology of how to accomplish the ultimate goal was developed. The steps in the process are highlighted below.

- **Perform general research on charge while running and low temperature operable batteries.**
- **Document performance of the vehicle.**
- **Formulate proposed design.**
- **Design generator mounting system**
- **Conduct heat transfer analysis on heating pad interface**
- **Develop mechatronic system**

- **Order components**
- **Assemble prototype.**
- **Document final performance of the vehicle.**

4.1 Schedule

In order to ensure that the project be completed in a timely manner a schedule was developed in the form of a Gantt chart. The arrows on the chart show the relationship between tasks, the arrows indicate that the earlier task must be completed, or at least underway before the proceeding deliverable can be started. The team meetings were not included in the Gantt Chart.

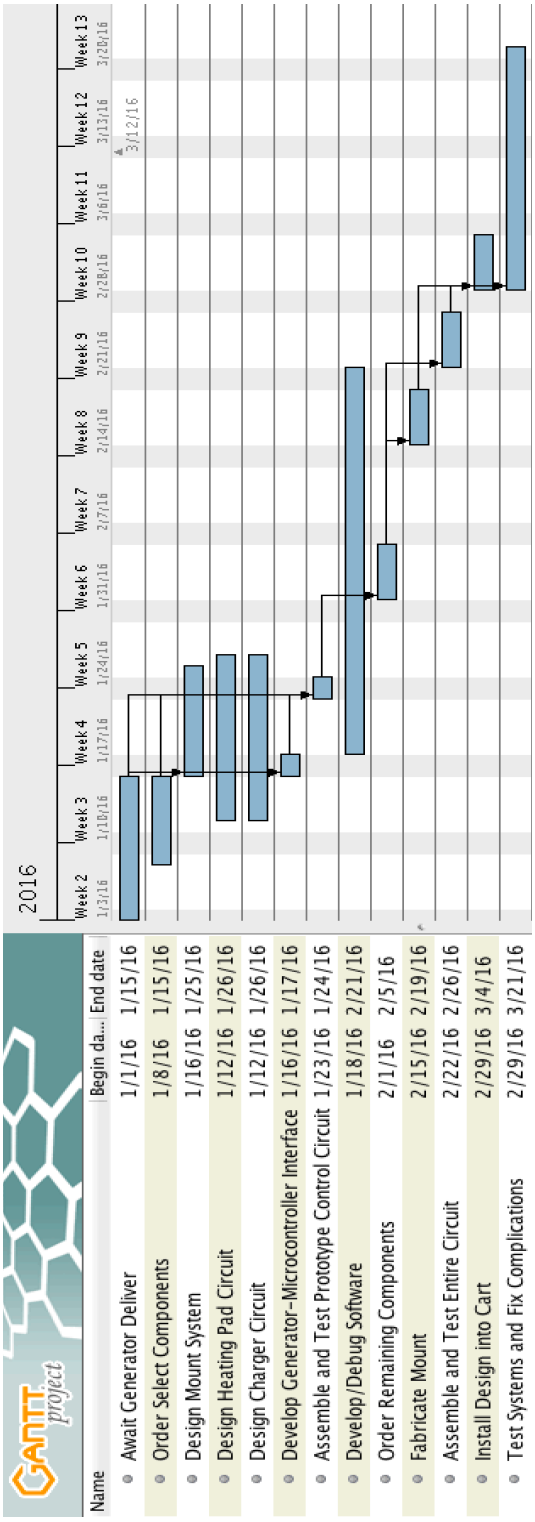

Figure 1. Gantt chart showing the various project tasks.

4.2 Resource Allocation

While the Gantt Chart is a good representation of the schedule it does not include who is assigned to each task. Table 1 shows which team member is assigned which task. In addition to their specified tasks team members have also been assigned general roles.

Jakob Consoliver-Zack is the Project Leader. He manages the team as a whole; develops a plan and timeline for the project, delegates tasks among group member according to their skill sets; finalizes all documents and provides input on other positions where needed. He keeps the communication flowing, both between team members and Sponsor. The team leader takes the lead in organizing, planning, and setting up of meetings. Finally he gives or facilitates presentations by individual team members and is responsible for overall project plans and progress.

Samantha Beeler is the team Treasurer. She manages the budget and maintains a record of all credits and debits to project account. Any product or expenditure requests must be presented to the advisor, whom is then responsible for reviewing and the analysis of equivalent/alternate solutions. They then relay the information to the team and if the request is granted, order the selection. A record of these analyses and budget adjustments must be kept.

Tyler Mitchell is the lead ME. He takes charge of the mechanical design aspects of the project. He is responsible for knowing details of the design, and presenting the options for each aspect to the team for the decision process. Keeps all design documentation for record and is responsible for gathering all reports.

Jeremy Randolph is the team Webmaster and Historian. He is responsible for maintaining website and electronic records. Any and all digital documentation will be filed, stored, and catalogued electronically for easy access through the webpage. In addition, he is responsible for keeping a record of all correspondence between the group and ‘minutes’ for the meetings. Lastly the historian distributes the meeting minutes to the group via email.

Eugene Moss is the Electrical Engineering Liaison. He is in charge of the electrical engineering team that is working independently from the mechanical engineering team. He is responsible for communication between teams to ensure that no design modifications by either team inhibit the other.

Table 1. Assigned Tasks

Task Name	Duration	Start	Finish	Resource Names
Team Meeting 1	1	1/12/16	1/12/16	Jakob, Jeremy, Samantha, Tyler
Team Meeting 2	1	1/14/16	1/14/16	Jakob, Jeremy, Samantha, Tyler
Team Meeting N	1	As Needed	As Needed	Jakob, Jeremy, Samantha, Tyler
Await Generator Deliver	14	1/1/16	1/15/16	Jakob, Jeremy, Samantha, Tyler, Eugene
Order Select Components	10	1/8/16	1/15/16	Samantha
Design Mount System	9	1/16/16	1/25/16	Tyler
Design Heating Pad Circuit	14	1/12/16	1/26/16	Samantha and Jeremy
Design Charger Circuit	14	1/12/16	1/26/16	Samantha and Jeremy
Develop Generator-Microcontroller Interface	1	1/16/16	1/17/16	Jakob
Assemble and Test Prototype Control Circuit	1	1/23/16	1/24/16	Jakob and Eugene
Develop/Debug Software	34	1/18/16	2/21/16	Jakob and Eugene
Order Remaining Components	4	2/1/16	2/5/16	Samantha
Fabricate Mount	4	2/15/16	2/19/16	Tyler
Assemble and Test Entire Circuit	4	2/22/16	2/26/16	Jakob and Eugene

Install Design into Cart	4	2/29/16	3/4/16	Jakob, Jeremy, Samantha, Tyler, and Jakob
Test Systems and Fix Complications	21	2/29/16	3/21/16	Jakob, Jeremy, Samantha, Tyler, Eugene

5 Conclusion

The final design will utilize a mechatronic system to activate and deactivate an installed Cummins QG2800 generator based on the measured voltage of the 6 8V batteries. In order to ensure that the batteries output enough power at cold temperatures, heating pads powered by the generator will be added. The current charger will be used in order to ensure that the vehicle can operate and charge simultaneously. The mechatronic system must be able to switch the power source of the golf cart for the generator to power the electric motor while the batteries are being charged. The mechatronic system will also include a battery monitoring system to inform the user of the current charge level of the batteries.