Midterm I: Conceptual Design

Team Number: 2 Electrical Vehicle Optimization

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Table of Contents

Abstract iv

1 Introduction 1

2 Project Definition 1

2.1 Background research 1

2.1.1 History of the Electric Car 1

2.1.2 Modern Technology 2

2.1.3 Hotel System of Charging 3

2.2 Need Statement 3

2.3 Goal Statement & Objectives 4

2.4 Constraints 5

3 Preliminary Design 6

3.1 HOQ 6

3.2 Concept Generation and Evaluation 7

3.2.1 Selection Criteria 7

3.2.2 Generator Location 8

3.2.3 Battery Warming Method 10

3.2.4 Ensuring Generator Operation 11

3.2.5 Charging System 12

3.3 Selected Design for Golf Cart 14

3.4 Adapting the Design for Semi-Trucks 15

3.5 Generator Selection 16

4 Challenges and Risks 17

5 Methodology 18

5.1 Schedule 18

5.2 Resource Allocation 21

6 Conclusion 24

7 References.. 24

8 Appendix A: Risk Assessment A-1

Table of Figures

Figure 1 Impact of Temperature on range tested on a Nissan Leaf. 2

Figure 2 House of Quality.. 6

Figure 3 Photograph of the back of the golf Cart. ....**Error! Bookmark not defined.**

Figure 4 Carriage Design Concept..**Error! Bookmark not defined.**

Figure 5 Heating Pad Design Concept. ....**Error! Bookmark not defined.**

Figure 6. System Diagram of Golf Cart Design ....**Error! Bookmark not defined.**

Figure 7. System Diagram of Adapted Semi-Truck Design. ....**Error! Bookmark not defined.**

Figure 8 Cummins QG2800 Generator ....**Error! Bookmark not defined.**

Figure 9 Gantt Chart of Project Timeline ....**Error! Bookmark not defined.**

Table of Tables

Table 1 Generator Location Pugh Matrix 10
Table 2 Battery Heating Method Pugh Matrix 11
Table 3 Ensure Generator Operation Pugh Matrix 12
Table 4 Charging System Pugh Matrix 13
Table 5. Assigned Tasks 22

Abstract

Dr. Michael Hays of Cummins is directing group 2 in its efforts to maximize the efficiency of an electric vehicle in extreme weather conditions. The designs generated for the electric golf will be up scaled and modeled on 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, and charger selection, whilst the mechanical engineers are responsible for the rest of the project. This includes generator selection and integration as well as modifying the incorporation of a battery monitoring system that will control when the generator is turned on and off based on the battery output. Once the battery gets to a certain threshold, a microcontroller will send a signal to turn on a generator to charge the batteries. The generator will then shut off when the batteries are fully charged. 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 objective of the project is to enhance the system by improving the current range and operable temperatures of an electric vehicle, and then to model the improvements on an ISX-15 diesel engine. The team is looking to optimize the vehicle with the potential implementation of a secondary power source, minimizing weight, and ensuring that all of the additions to the vehicle are cost effective. The implementations done are the golf cart will be scaled appropriately and modeled for semi-trucks. The problem that the group has been faced with is that the vehicle must be operable in very low temperatures and have its range increased beyond its current amount. This is cause for background research on battery technology and ways to regenerate power while in motion in order to meet the necessary design objectives for the vehicle. The team intends to document the current range and operating capacity of the vehicle and then use that data as a benchmark for further improvement.

2 Project Definition

2.1 Background research

2.1.1 History of the Electric Car

The concept of a battery powered vehicle dates back to the 1800's, where inventors from different countries were playing with the idea of electric locomotion. Robert Anderson, a British inventor, is accredited with generating a small scale battery powered vehicle. From there, electric vehicles transformed, and by the 19th century, electric cars were so popular that New York City had a fleet of 60 electric taxis. [1] The movement of the personal car played a big role in this evolution; however the electric car was competing with gasoline powered vehicles. The first vehicles that were developed in the early 1700's either ran off of steam or gasoline. [1] Soon, it was clear that steam would be impractical if applied to a small personal car, however gasoline seemed promising. Nonetheless, electric cars didn't possess the same harmful side effects of gasoline powered vehicles. This includes pollutants from exhaust to the drilling of natural gases and oil. Electric cars provided a quiet, safe, and efficient way to travel around the city on short trips, and with the rise of availability in electricity, electric cars became more readily used. The fall of electric cars came with the production of the Model T. Henry Ford developed a highly efficient manufacturing line that lead to extremely affordable gasoline cars. [1] By 1912, the electric car cost more than double what the Model T did, and with this, the electric car industry took a small fall due to supply and demand. [1] Once oil was discovered in Texas, electric cars began to disappear, and by 1935 there were no electric cars on the roads.

2.1.2 Modern Technology

With the recent shortages in oil reservoirs, electric cars are making a comeback. Clean energy is becoming a highly advanced technology that is being utilized for many applications, including transportation. Some of the leading transportations companies in the United States are moving towards a cleaner, efficient way of travel. With that being said, Cummins has provided the design team the opportunity to take part in improving the current operation of a small scale electric vehicle. The concept of an electric powered vehicle is not farfetched, given that many companies today have electric cars on the road. However, a big challenge in the design process is

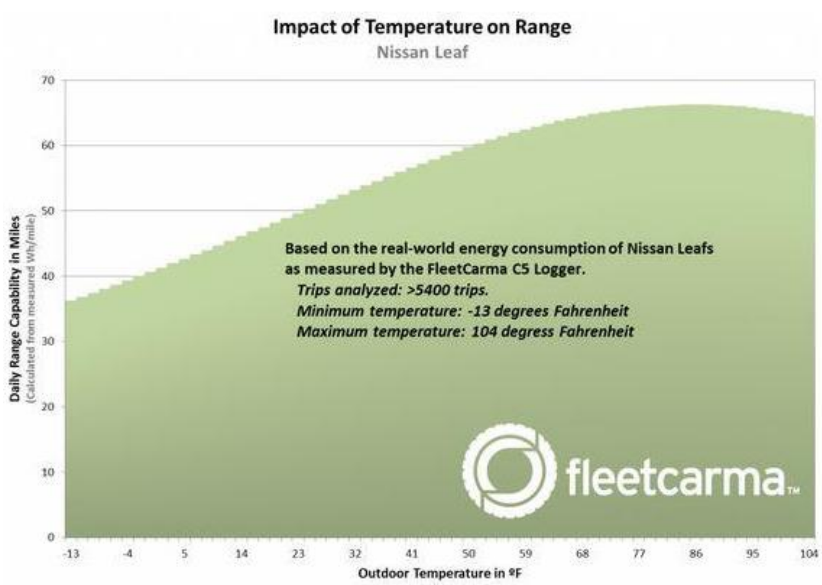


Figure 1 Impact of Temperature on range tested on a Nissan Leaf.

the operation of these batteries in low temperatures. The design team was told the vehicle must start and remain fully operation in -29˚C conditions. Current electric vehicles were researched in order to understand how temperature can affect the range of the vehicle. Figure 1 below shows that as the outside temperature decreases so to does the daily range of the vehicle. [2]

2.1.3 Hotel System of Charging

Semi-truck cabins can be custom equipped with all the essentials for living. A standard cabin will include a bed, TV, heating, AC, and small bathroom. However some cabins can be extremely elaborate with gaming systems, fully functioning kitchens and outdoor grills.[3] These cabin electronics run off the truck battery, however there is a risk with draining the battery. Harsh cold weather conditions also pose a potential threat to the battery. As temperature decreases, the output voltage of the battery drastically decreases. To prevent over draining the battery, truck drivers will run the truck engine the entire night. This allows the battery to charge up and the cabin heating. Cummins would like to develop a "Hotel System of Charging", which would include a battery and engine package. The idea is that the cabin electronics would run of the battery, once the battery voltage reaches a certain threshold, a microcontroller will signal to turn the truck engine on to charge up the batteries. Once the batteries are charged, the engine shuts off. This prevents the driver from running the engine all night. [4]

2.2 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."

2.3 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:

Goal Statement:

"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.**

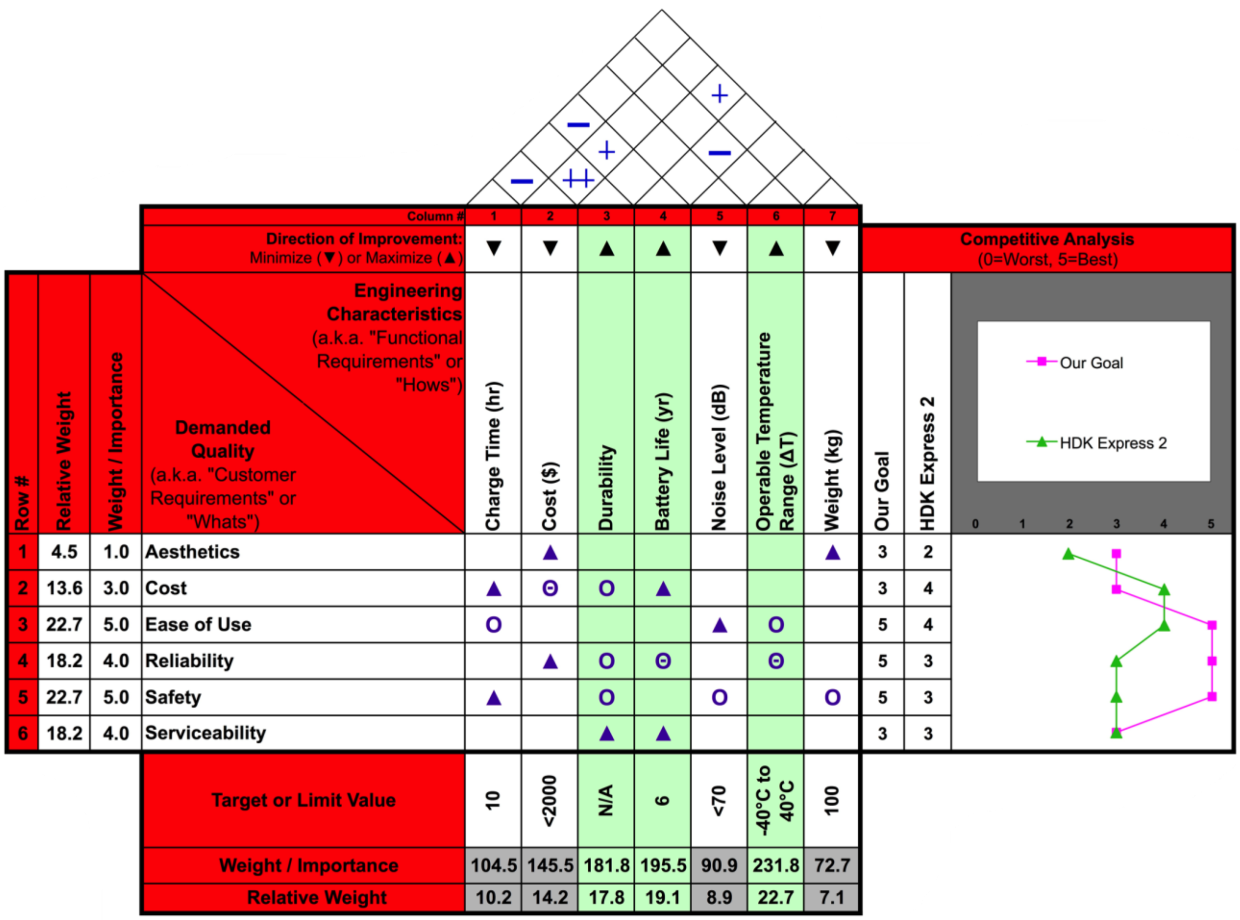
2.4 Constraints

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

3 Preliminary Design

3.1 HOQ

When deciding on what aspects of a design are the most integral to the success or quality of a project, it is important to have some quantifiable measure that can be used to assess the relation between a customer's requirements and the necessary design functionality. In terms of design methods, a common method to determine this intricate relation is called a house of quality or HOQ for short, pictured in Figure 2. This tool allows an easy visual aid to quickly see the correlation between customer requirements alongside the firm engineering characteristics. In order to determine the most important customer requirements, the team spoke with Dr. Hays and asked him to rank his customer requirements on a scale of one to five; with five being the highest



Row #	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Engineering Characteristics (a.k.a. "Functional Requirements" or "Hows")	Charge Time (hr)	Cost ($)	Durability	Battery Life (yr)	Noise Level (dB)	Operable Temperature Range (ΔT)	Weight (kg)	Our Goal	HDK Express 2
			Column #	1	2	3	4	5	6	7		
			Direction of Improvement: Minimize (▼) or Maximize (▲)	▼	▼	▲	▲	▼	▲	▼		
1	4.5	1.0	Aesthetics		▲					▲	3	2
2	13.6	3.0	Cost	▲	Θ	O	▲				3	4
3	22.7	5.0	Ease of Use	O				▲	O		5	4
4	18.2	4.0	Reliability		▲	O	Θ		Θ		5	3
5	22.7	5.0	Safety	▲		O		O		O	5	3
6	18.2	4.0	Serviceability			▲	▲				3	3
			Target or Limit Value	10	<2000	N/A	9	<70	-40°C to 40°C	100		
			Weight / Importance	104.5	145.5	181.8	195.5	90.9	231.8	72.7		
			Relative Weight	10.2	14.2	17.8	19.1	8.9	22.7	7.1		

Figure 2 House of Quality

value, and thus signifying the criteria which is of the most importance to the customer. The customer requirements included the following: aesthetics, cost, ease of use, reliability, safety, and serviceability. The customer requirements with the greatest importance, were ease of use and safety which were both given a rank of five. Next up with ranks of four were serviceability and reliability. And with ranks of three and one respectively were cost and aesthetics. The engineering characteristics that were selected as firm aspects of the design were charge time, cost of improvements, durability, battery life, noise level, operating temperature, and weight. The benchmark which can be seen on the right is the average golf cart on the market which is the HDK Express 2 golf cart. Team two compared the design goal with the HDK Express 2 and found that while the benchmark did cost less due to a lack of a generator, the design of team two was favorable in reliability, ease of use, and safety. The chart shows that there is a strong correlation between durability and battery life. As such it would make sense that more expensive materials will prove more durable and battery packs that have longer battery life will generally have a higher price as well. Once weights were given to the relationships between the characteristics, the relative weights were calculated along with the customer requirements. With this knowledge in tow, the highest ranked characteristics are operating temperature, battery life, and durability. As such, these shall be the most important parameters when attempting to improve the current system.

3.2 Concept Generation and Evaluation

3.2.1 Selection Criteria

The design was developed using the morphological method, which breaks up the overall design problem into simpler subproblems and solution concepts are generated for them. [5] The subproblems or parameters for this design include: where to locate the generator, how to warm the batteries to an operable temperature, how to ensure the generator will operate at -29°C, and what charging system will be used. Three possible solutions were developed for each of the problems and the best solution was chosen using a Pugh chart. The first option for each problem was set as the datum that the other solutions were weighed against. The solutions were rated using four criteria that are based on the project goals, objectives, constraints, as well as customer requirements. The four criteria are cost, weight of modification, noninvasiveness, and safety.

- **Cost:** Although the cost was not one of the most important of customer requirements it is a defining constraint of the project, which is why it was chosen as one of the criteria for the design selection.
- **Weight:** The HOQ shows that the weight is not one of the most important engineering characteristics, however to heavy of modifications would increase the strain on the batteries and in turn reduce the overall performance of the vehicle. Since improving the performance/increasing the range is one of the project objectives the weight was chosen as a design selection criteria.
- **Noninvasiveness:** This selection parameter was chosen primarily due to the project time constraint of two semesters. The more complex the design is the more time it will take to develop, therefore it was decided that the simplest solutions would be the best.
- **Safety:** One of the two most important customer requirements was the safety of the design therefore it is an important selection criteria.

A “+” indicates that the particular aspect is superior to the datum, a “-“ indicates that it is inferior to the datum, and an “S” indicates that the option is neither better nor worse. The total number of minuses was subtracted from the total number of pluses to obtain the score of the solution concept, with a positive score being the most favorable.

3.2.2 Generator Location

One possible location for the generator is under the back seat of the golf cart, as seen in Figure 3. The generator would be placed in this recessed region and would be mounted to the golf cart frame that runs under the rear seat and under the black plastic flooring. Figure 3 also shows another possible solution, which is that the rear seat could be removed and the generator mounted in its place. This of course eliminates the functionality of the rear seat which is not desirable. The third and final solution concept is that the generator could be placed on carriage, similar to that pictured in Figure 4, that would be pulled behind the cart. This solution presents a safety issue as the carriage could fishtail and potentially cause an accident.

Figure 3. Photograph of the back of the golf cart.

Figure 4. Carriage design concept.

Table 1 is the Pugh matrix for the generator selection, and it shows that the best location for the generator is under the back seat with a score of 0 as compared to -4 and -1 for options 2 and 3, respectively. Not only is this solution the least invasive, it is also the safest because it is well secured and is well separated from the user.

Table 1 Generator Location Pugh Matrix

Criteria	Under Back Seat	On a Carriage	In Place of Back Seat
Cost	S	−	S
Weight	S	−	+
Noninvasive	S	−	−
Safety	S	−	−
Total	0	−4	−1

3.2.3 Battery Warming Method

Another sub-problem is the method of heating the battery up to an operable temperature. A possible solution is to use the generator exhaust to heat them. This solution would involve the

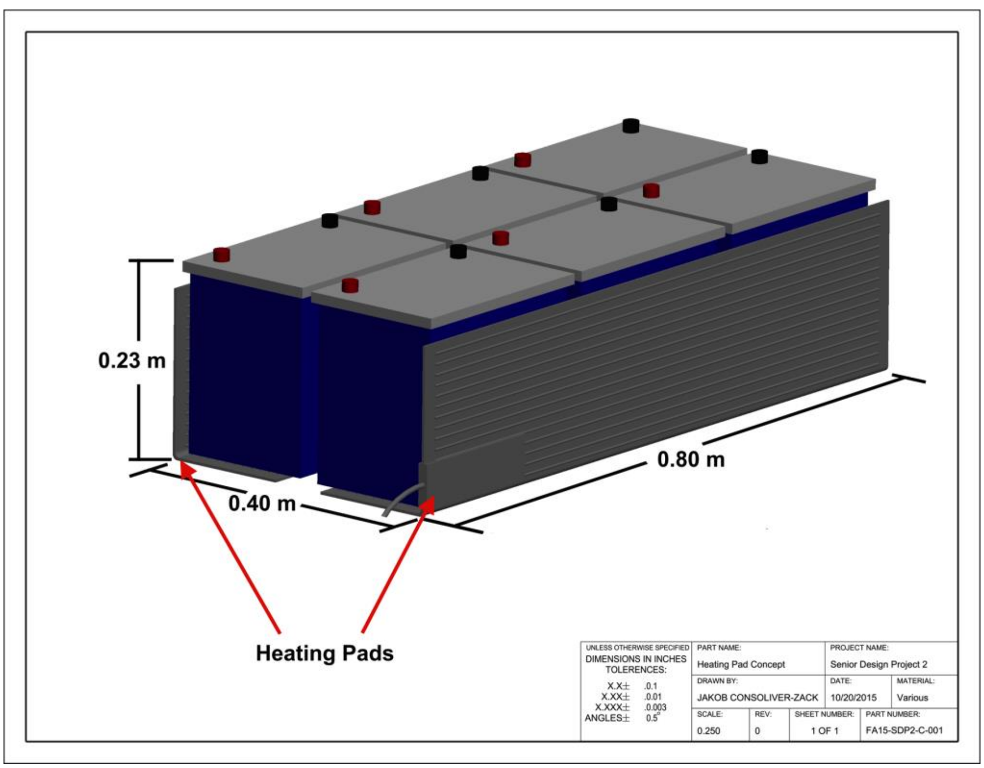


Figure 5 Heating Pad Design Concept.

design of a system of tubing to maximize the amount of heat transferred from the exhaust to the batteries. Careful time intensive design would be needed with this solution so that the exhaust does not melt the battery casings. Another possible solution is the use of heating pads, which would be attached to the surface of the batteries, as seen in Figure 5 on the previous page. The last solution to this sub-problem is to encase the batteries in an insulating material. This method is the simplest of the three, however it is not as effective as the other two since the heat in the batteries will eventually dissipate given enough time.

The Pugh matrix for the selection shows that both the heating pads and the insulation are both better than using the exhaust. Although the heating pads and the insulation scored equally well, based on the selection criteria, it was decided to go with the former since it would be more effective due to the previously stated reasoning.

Table 2 Battery Heating Method Pugh Matrix

Criteria	With Generator Exhaust	With Heating Pads	With Insulation
Cost	S	+	+
Weight	S	+	+
Noninvasive	S	+	+
Safety	S	+	+
Total	0	+4	+4

3.2.4 Ensuring Generator Operation

The third problem to be solved is how to ensure that the generator would operate in subzero conditions. After speaking with Dr. Hollis about this matter he informed the design team that the most likely modes of failure would be an improper air-fuel ratio, the battery powered ignition system not operating, and the oil becoming to viscous. Although the specific choice of generator had not been decided when developing these design concepts it was known that the generator would be from Cummins. The vast majority of Cummins generators designed for mobile applications and recreational vehicles include an automatic choke, eliminating the first problem. Additionally the generators are also rated down to -29°C, which eliminates the second issue, leaving only the oil viscosity problem. [7] One possible solution is to use a synthetic oil that is rated down to the subzero temperature required. The other two solutions involve heating the oil with a device such as an oil dipstick heater or an oil pan heater. These two options however require a power source and present a safety hazard due to the high temperatures that they operate at. The Pugh matrix below shows that the best option is to use synthetic oil.

Table 3 Ensure Generator Operation Pugh Matrix

Criteria	Use Synthetic Oil	Use an Oil Pan Heater	Use an Oil Dipstick Heater
Cost	S	−	−
Weight	S	−	−
Noninvasive	S	−	−
Safety	S	−	−
Total	0	−4	−4

3.2.5 Charging System

The final sub-problem is the charging system that the golf cart will use. One of the primary objectives of the project is to have the generator activate when the battery charge drops below a certain level. At present the cart is equipped with a delta Q QuiQ Model: 921-48xx AC to DC charger. The charger works by suppling the batteries with power until it detects no increase in the voltage meaning they are fully charged and the charger shuts off. This presents a problem since an objective is to run the vehicle and charge at the same time. The rate at which the batteries are charged is less than the rate at which they are depleted, which means that the battery voltage will be slowly decreasing. The charger would then detect that the batteries are full and would stop even though they are not at full capacity. The second solution is that a new charging system would be designed. This solution would use a new on-board charger that uses a different mechanic that allow the voltage to decrease yet continue charging. The third option would be to modify the present charging system. This would be cheaper than developing a new system, because the currently equipped charger would be reprogrammed to meet the design needs. The problem with this solution is that the reprogramming poses a safety risk as various safety features could inadvertently be overridden. Additionally the manufacturer of the charger has not responded to emails and phone calls which makes getting the necessary information to modify the present charger next to impossible. All three of the solutions would include a microcontrolled system that would activate/deactivate the generator based on the measured voltage of the batteries. The Pugh matrix below shows that the second solution is the best of the three.

Table 4 Charging System Pugh Matrix

Criteria	Use Present Charging System	Develop New Charging System	Modify Present Charging System
Cost	S	–	–
Weight	S	S	S
Noninvasive	S	+	+
Safety	S	+	-
Total	0	+1	+0

3.3 Selected Design for Golf Cart

By determining the best solutions for the four subproblems the initial design was developed. The design would store the generator under the back seat, warm the batteries with heating pads, the generator would use synthetic oil, and a new charger would be developed to meet the design goals. Below is a system diagram of the proposed design for the golf cart.

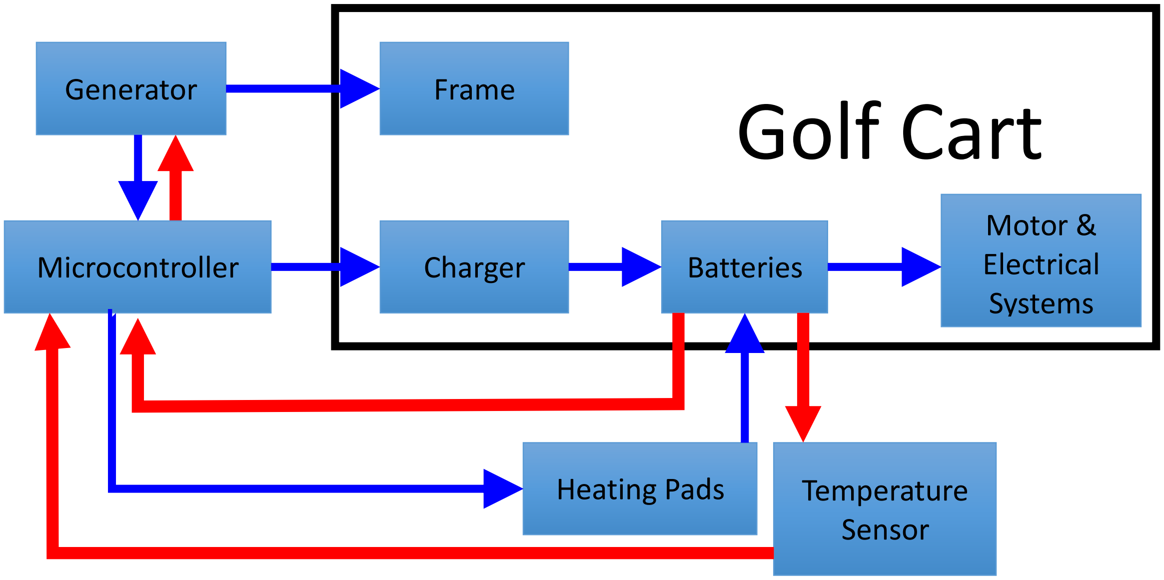


Figure 6. System Diagram of Golf Cart Design

Everything contained in the black box represents the golf cart in its present state. The charger is connected to the batteries which in turn are connected to the golf carts electrical system and motor. The proposed design would mount the generator to the golf cart frame underneath the back seat. Connected to the generator is a microcontroller that measures the voltage of the batteries, measures the voltage from a temperature sensor, and controls the power supplied to the heating pads. When the batteries voltage drops below a certain threshold the microcontroller will send a signal to the generator turning it on. Once the generator is on, and the batteries are warm enough, the charger will follow suit and begin charging the batteries. The temperature sensor will measure the battery temperatures, and if they get too hot the microcontroller will turn off the generator and the heating pads if the latter are on. Additionally the mechatronic system will include a battery monitory system so that the user will know the current level of charge/the remaining operational time of the cart.

3.4 Adapting the Design for Semi-Trucks

One of the overall goals of this project is to be able to adapt this design for semi-trucks, specifically trucks with the Cummins ISX-15 diesel engine. The adapted system is very similar to that used by the golf cart however there are several differences, see Figure 7. Instead of the generator the ISX-15 engine will be the primary charging power source, additionally the charger will be replaced by the trucks' alternator. Heating pads are not needed in the adapted design because the battery will be warmed by the heat put off by the truck engine. Since the battery is needed to start the engine it is important that the charge threshold level at which the engine turns on is set high enough so that the battery will still have enough power to activate it. The required level of charge changes based on the temperature of the battery which is why the temperature sensor will still be used. The exact relationship between the battery power output and the temperature will have to be determined experimentally. Below is the system diagram for the adapted design for the semi-truck. As was the case with the golf cart design, the adapted design will also include battery monitoring systems letting the user know the level of charge.

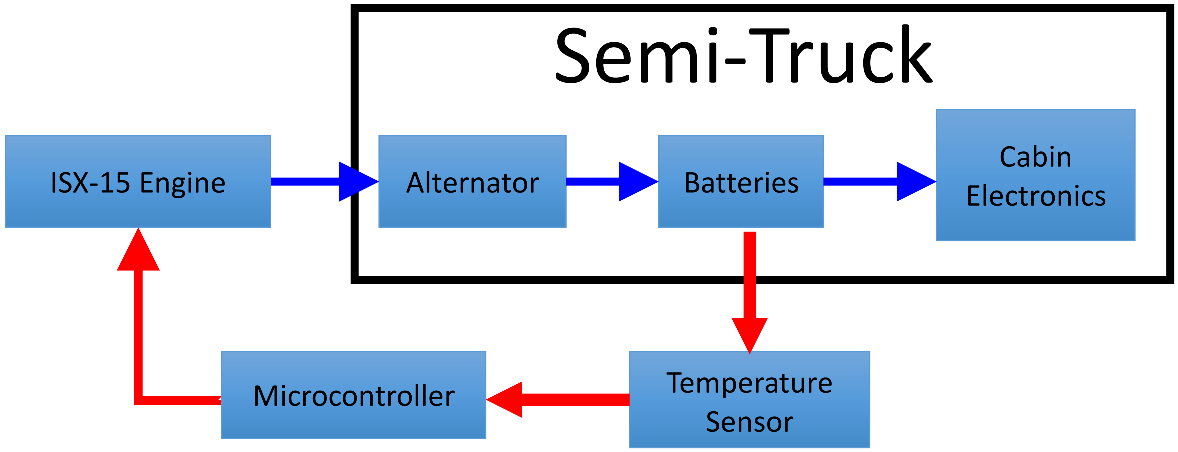


Figure 7. System Diagram of Adapted Semi-Truck Design

3.5 Generator Selection

To meet the requirements set for us by our project advisor, Dr. Hays, group two is retrofitting a Cummins generator to the golf cart. The generators purpose is to improve the range of the current golf cart. Cummins is supplying our group with a generator of our choice. The generator must be able to operate within the desired temperature range, -29° C. Operation at this extreme temperature is the most important requirement that needs to be satisfied. Secondly, power output of the generator must be sufficient to run the system we plan to implement. The installed onboard battery charger uses 1200 W of power to charge the battery, and although a new charger will be implemented this value is considered a good estimate of the necessary power. The generator must also power the heating pads which have been estimated to require approximately 400 W in total. These estimations were made so that a generator could be chosen without having to complete the entire design. The estimations are conservative and most likely overshoot the actual power requirements which ensures that the selected generator can supply at least the power required. The generator must also be able to fit in the recessed region underneath the back seat, which means that its dimensions should not exceed 685 mm x 360 mm x 400 m. The operating temperature range, power output, and size are the three main requirements that need to be fulfilled when selecting a generator. Secondary criteria for the selection are that the generator should be relatively inexpensive and lightweight. These last two criteria are more of guidelines for the selection rather than constraints.

Exploring generators supplied by Cummins, they come in multiple sizes and power outputs. With the three main constraints described above, group two decided on a small self-regulating gasoline generator, Cummins model number: QG2800 pictured in Figure 8 on the following page. This generators operable temperature meets our -29° C range. It is rated also with a max output of 2800 W, thus supplying more than sufficient power needed for the design selected. This generator is also fairly small and compact with dimensions of 560 mm x 415 mm x 325 mm. The width of the generator does exceed the initial size constraint however the region underneath the seat is made of plastic and the space can be increased by cutting away material. This will not affect any of the golf carts other systems. This generator is also fairly light, weighing 56.7kg, the lightest of any Cummins generator. With the main requirement criteria fulfilled and our secondary criteria optimized, the Cummins QG2800 is an ideal fit for our design.

Figure 8. Cummins QG2800 Generator

4 Challenges and Risks

Like any design project, there have certainly been challenges up to this point for team two. The first challenge that the team had to surmount was the fact that the golf cart came with batteries that were not in operable condition. The batteries, which should have all been able to output eight volts each in peak condition were only showing one volt or less after being charged for hours. Due to this, it wasn't possible to actually test the golf carts current performance since the current batteries are incapable of powering the cart no matter how long they're charged. Due to this setback, similar batteries had to be borrowed from Dr. Harvey in order to at least ensure that other functions of the cart work properly. New batteries will be chosen by the EE team, and purchased in order to complete the baseline testing of the system. All other challenges that team two face are down the road in the design process and are more so potential risks. One potential risk is that the system can be short circuited by several different factors if any problems occur with the wiring or other integral systems. As such, it is crucial to conduct a detailed FMEA analysis of the system. Another potential issue that will have to be addressed later on in testing the new system additions is that the system must be tested at the low temperature of -29˚C. Due to the team being based out of Florida, the temperature outside will never actually be that low so one way that the team can do this is to maybe place the batteries in a freezer and then install it in the cart to see if the system can still function as intended. Also of note, is that straining of the batteries can possibly occur from having to charge and discharge them at the same time so a solution to this problem will have to be attained in order to keep the reliability of the system high. Lastly, the system must be compatible with a Cummins ISX-15 diesel engine although we are testing with a smaller generator since that is the intended, real world application for this project. Due to this constraint, it is important that the requirements of this engine must always be considered during the design and integration of all other components. Since the project is near the end of the conceptual design phase there have not been too many risks other than those few listed. Despite this a risk assessment has been generated for the proposed design and is found in Appendix A. The assessment is rather simple as the details of the design have not yet been worked out, but when they are the risks will be revaluated.

5 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.**

5.1 Schedule

In order to ensure that the project be completed in a timely manner a schedule was developed. The schedule is in the form of a Gantt chart, which includes ME deliverables and

Team deliverables. ME deliverables are items that team 2 will turn in for a grade, such as reports and presentations. These items are in red on the Gantt Chart. Team deliverables are items that must be completed however they are not directly turned in. Tasks such as, performing general research, begin detailed design, and order components all fall into this category. The team deliverables are in blue on the Gantt Chart. The arrows on the chart show the relationship between tasks, the arrows indicates that the earlier task must be completed, or at least underway before the proceeding deliverable can be started. The Gantt Chart does not include team meeting which occur throughout the project. It was decided to omit the meetings because there are a large number of them and their inclusion would muddle the Gantt Chart.

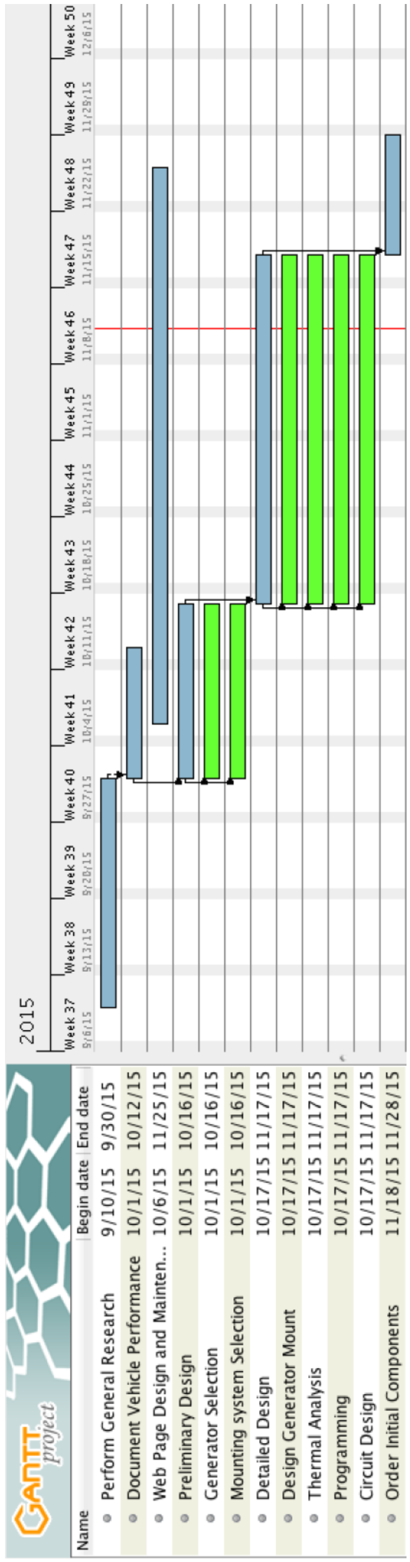


Figure 9. Gantt Chart of Project Timeline

5.2 Resource Allocation

While the Gantt Chart is a good representation of the schedule it does not include who is assigned to each task. Table 5 shows which team member is assigned which task. For ME deliverables every member of the team will work equally to complete them, however certain team deliverables and presentations, will be completed by specific team members. 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 5. Assigned Tasks

Category	Task Name	Duration	Start	Finish	Resource Names
Team Meeting	1	1	9/1/15	9/1/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	2	1	9/3/15	9/3/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	3	1	9/8/15	9/8/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	4	1	9/15/15	9/15/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Meeting	5	1	9/22/15	9/22/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	6	1	9/24/15	9/24/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Meeting	7	1	9/29/15	9/29/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	8	1	10/6/15	10/6/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	9	1	10/8/15	10/8/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	As Needed	1	As Needed	As Needed	Jakob, Jeremy, Samantha, Tyler, Eugene
ME Deliverable	Code of Conduct	6	9/5/15	9/11/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Perform General Research	20	9/10/15	9/30/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Needs Assessment Report	4	9/21/15	9/25/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Project Plan Report	9	10/1/15	10/10/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Document Vehicle Performance	11	10/1/15	10/12/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Preliminary Design	15	10/1/15	10/16/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Generator Mount Location	15	10/1/15	10/16/15	Tyler
Team Deliverable	Generator selection	15	10/1/15	10/16/15	Tyler
ME Deliverable	Midterm Presentation I: Conceptual Design	7	10/9/15	10/16/15	Jakob, Tyler

ME Deliverable	Midterm Report 1	13	10/17/15	10/30/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Detailed Design	23	10/17/15	11/17/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Conduct Thermal Analysis	23	10/17/15	11/17/15	Samantha
Team Deliverable	Design rear mount system	23	10/17/15	11/17/15	Tyler
Team Deliverable	Microcontroller selection and system design	23	10/17/15	11/17/15	Jakob, Jeremy
Team Deliverable	Circuit Design	23	10/17/15	11/17/15	Eugene
Team Deliverable	Initial Web Page Design	9	10/6/15	10/15/15	Jeremy
ME Deliverable	Final of Webpage Design	41	10/15/15	11/25/15	Jeremy
ME Deliverable	Midterm Presentation II: Interim Design	10	10/31/15	11/10/15	Samantha, Tyler
Team Deliverable	Order Components	10	11/10/15	11/20/15	Jakob, Jeremy, Samantha, Tyler, Eugene
ME Deliverable	Final Design Poster Presentation	11	11/20/15	12/1/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Fall Semester Final Report	15	11/16/15	12/1/15	Jakob, Jeremy, Samantha, Tyler

6 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 does not meet the desired design criteria therefore a new one will be designed in order to ensure that the vehicle can operate and charge simultaneously. The mechatronic system will also include a battery monitoring system to inform the user of the current charge level of the batteries.

7 References

[1] The History of Electric Car. The United States Department of Energy. September 15, 2014. energy.gov/articles/history-electric-car

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[3] "Custom Sleeper Design, Truck Sleepers Manufacturer, Custom Truck Products - Truck Sleeper." *Custom Sleeper Design, Truck Sleepers Manufacturer, Custom Truck Products - Truck Sleeper*. Indian Custom Truck, n.d. Web. 29 Oct. 2015.

[4] Dr. Michael Hays. *Conference Call*. 21 Oct. 2015.

[5] Dieter, George E., and Linda C . Schmidt. "6.6 Morphological Methods." *Engineering Design*. New York: McGraw-Hill, 2013. 217. Print.

[6] *Ironton Utility Trailer Kit*. Digital image. *Norther Tool + Equipment*. Norther Tool + Equipment, n.d. Web. 28 Oct. 2015.

[7] "Cummins Generators." *Cummins Power Generation*. Cummins, n.d. Web. 29 Oct. 2015.

8 Appendix A: Risk Assessment

Risk Assessment
Safety Plan

Project information:

Electric Vehicle Optimization	10/30/2015
Name of Project	Date of submission

Team Member	Phone Number	e-mail
Jakob Consoliver-zack	(850) 405-4102	Jic13@my.fsu.edu
Samantha Beeler	(904) 287-1279	Smb11g@my.fsu.edu
Tyler Mitchell	(813) 924-1594	Tm13c@my.fsu.edu
Jeremy Randolph	(305) 499-0274	Jsr13e@my.fsu.edu

Faculty mentor	Phone Number	e-mail
Juan Ordonez		

I. Project description:

The purpose of this project is to integrate a Cummins generator onto a golf cart. When the golf carts batteries drop below a certain charge level the generator will turn on and begin charging the batteries, and when the batteries are charged it will turn off. Also to be included in this design are heating pads that will be used to warm the batteries to a temperature at which they can operate. The batteries in the golf cart are also going to be replaced, the new batteries are being selected by an independent team of EEs. The Final objective of the project is to adapt cart design for a Cummins ISX-15 diesel engine powered semi-truck.

II. Describe the steps for your project:

1. Mount the generator to the rear of the vehicle
2. Attach the heating pads and temperature sensor to the batteries.
3. Install microcontroller and necessary circuitry.

III. Given that many accidents result from an unexpected reaction or event, go back through the steps of the project and imagine what could go wrong to make what seems to be a safe and well-regulated process turn into one that could result in an accident. (See examples)

When mounting the vehicle, any power tool being used can pose potential risks. The electrical components of the project can Possibly shock you if you're not careful when handling and modifying the system. Overheating the batteries could cause an Explosion.

IV. Perform online research to identify any accidents that have occurred using your materials, equipment or process. State how you could avoid having this hazardous situation arise in your project.

Lithium ion batteries have been known to explode when overheated, although they do not burn at a very hot temperature, the Explosion can send metal chunks flying through the air. To prevent this, the team will be utilizing a temperature sensor to ensure The batteries do not exceed a certain temperature.

V. For each identified hazard or "what if" situation noted above, describe one or more measures that will be taken to mitigate the hazard. (See examples of engineering controls, administrative controls, special work practices and PPE).

A team member must be monitoring the temperature sensor when operating the system, to ensure the temperature does not Exceed a certain point.

VI. Rewrite the project steps to include all safety measures taken for each step or combination of steps. Be specific (don't just state "be careful").

When mounting the generator, ensure that team members are wearing protective eyeware and pay close attention to their work.
When implementing heating pads for the batteries, the team memebers will be monitoring the battery temperature to ensure no Overheating.

VII. Thinking about the accidents that have occurred or that you have identified as a risk, describe emergency response procedures to use.

Stay calm and immediately contact 911 for emergencies. Then contact advisors.

VIII. List emergency response contact information:

- Call 911 for injuries, fires or other emergency situations
- Call your department representative to report a facility concern

Name	Phone Number	Faculty or other COE emergency contact	Phone Number
All Group Members		Dr. Gupta	(701) 306-1189
		Dr. Shih	

IX. Safety review signatures

- Faculty Review update (required for project changes and as specified by faculty mentor)
- Updated safety reviews should occur for the following reasons:
  1. Faculty requires second review by this date:
  2. Faculty requires discussion and possibly a new safety review BEFORE proceeding with step(s)
  3. An accident or unexpected event has occurred (these must be reported to the faculty, who will decide if a new safety review should be performed.
  4. Changes have been made to the project.

Team Member	Date	Faculty mentor	Date