

Efficient Source and Demand Leveling Power System

Team 10 Pre- Proposal

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Facilitator: Dr. Fang Peng
Sponsor: Keld LLC

Executive Summary:

The project undertaken by design team ten differs from the standard MSU Electrical Engineering Capstone project. The usual sponsor specified design requirements have intentionally been left vague. The facilitator, whose usual roll is as a kind of mentor with little or no experience in the specified field of development, is instead Dr. Fang Peng, the University's lead researcher with regard to the scope of this project. With a budget of \$10,000 the seemingly wide open possibilities for this project are merely an illusion. This project has already been designed by Dr. Peng and has been reduced to a practical application in mathematics. The task left for the team is to calculate the most efficient value of capacitance for an array of supercapacitors in parallel with a rechargeable 48 Volt battery. (figure 1. in conceptual overview) The team will use two different types of rechargeable batteries. First the system will be operated using a Lithium-Ion battery (Li-Ion), and

then using a Nickel Metal Hydride battery (NiMH). Performance will be monitored as power is supplied to a simulated varying load. (See Figure 2. in Conceptual overview)

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Introduction:

The rising cost of energy combined with increasing awareness and acceptance of global warming, has served as kindling for the forge that is now the white hot “green” technology sector. The field of Electrical Engineering is deeply affected by the push for cleaner energy and transportation. The advent of new, high-energy storage capacitors and lighter rechargeable batteries, with greater energy density, has allowed new developments in the clean energy sector. Creating and utilizing these technologies is at the forefront of modern engineering and is sure to create many jobs, driving our economy, our careers, and our vehicles for the foreseeable future.

Background:

Given the broad possibilities of our projects, there were many ideas thrown around on how we can apply this to real life. There were ideas of combining with team 2, using the system to store solar power, using the system for hybrid vehicles, and using the system as a way to supercharge a computer. We were all excited and eager to get started, but we had too many ideas and decided we did not know exactly what a supplier is looking for. After conversing with our facilitator, Dr. Peng, the consensus was to focus on using the system to power a vehicle.

During the recent crisis of price gauging among the different gasoline companies there has been a demand for gasoline free cars. Current Hybrid Electric vehicles (HEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) are just two of the new varieties of automobiles available in the auto market these days. Consumers are scrambling to get any technology they can find and/or afford that will extend the range of their vehicles. A

large part of the cost and limitations of hybrid and electric vehicles is due to the battery systems. Our project will alleviate some of these issues by placing a battery and super capacitor in a cascaded system. The supercapacitor will help extend the range of hybrid and conventional electric vehicles alike. Considering the versatility of our system, it may be used for a range of other ventures in energy conservation. For example, regenerative braking systems, where the supercapacitor handles the instant charge regained by the vehicles kinetic energy and direct it back into the battery.

Modern vehicles have two levels of power demand, high and low priority. These two types of demands call for different types of energy solutions. A low priority demand can easily draw energy from the battery. If, for example, the radio doesn't work perfectly, the result will only cause a minor inconvenience. On the other hand, a high priority power demand will require instant action. Malfunctions in the braking or power steering systems, for example, may cause a life threatening accident if there is a delay in delivery of power to them when it is needed.

Objective

The objective of this project is to investigate energy storage systems that are suitable for Hybrid Electrical Vehicles (HEV) or renewable storage system. Using a pulsed load the circuit will test the performance of a Nickel-metal hydride battery versus a Lithium ion battery to see which battery performs the best under controlled conditions similar to a hybrid electrical vehicle. With the batteries and a pulsed load, super capacitors will be used in various designs in order to get the best efficiency from this system. A final product will be the most efficient battery super capacitor combination that handles a 1 kilowatt load at peak demand and a 200 watt load at average demand.

Design Specifications

The sponsor requires electrical storage technologies (e.g. super capacitors) combined with steady state generation sources for renewable energy power back up systems or transportation power plants. The goal is create an efficient electrical load leveling system that will reduce costs and size. For safety purposes this design will be a smaller scale test model of systems used in HEV and renewable storage systems. The design will consist of:
48 volt rechargeable battery (Nickel-metal hydride and Lithium Ion)

- Lithium ion batteries have the best energy to weight ratio of rechargeable batteries, they have no memory effect and they have a slow loss of charge when not in use. Nickel-metal hydride batteries have a lower volumetric energy density and discharge faster when not in use, but they are advantageous when it comes to high current drain applications due to low internal resistance.

Two Battery Chargers

- The batteries will have to be recharged during the testing.

Super capacitors (size and capacitance to be determined at a later date)

- With high power density but lower energy density, super capacitors are the perfect complement to rechargeable batteries for high efficiency systems. Super capacitors are used as a buffer between the battery and the device. The battery acts as the primary energy storage device in this system.

Small scale turbine

- A small scale turbine will be used to simulate a pulse load. This device will be fed from a DC source and variations in its speed will simulate a pulse load.

Switching circuit

- Integrated circuit programmed to simulate a pulsed demand for the batteries.

Conceptual Overview

Initial research into SPICE and Simulink/Matlab modeling of these batteries has been inconclusive. In order to proceed into the testing phase of this project, computer modeling of these batteries will have to be done for time and cost saving purposes. The team has decided to have a system with all the components placed in parallel with each other. The system will have super capacitors which will be active during peak demand periods (e.g. acceleration) and the battery will provide power during leveled demand periods. Going forward the team will have to decide how many super capacitors will be used. A switching circuit will have to be created to divert power from one source to another. Our load will also be controlled by this switching circuit which will be coded to control the speed of the turbine to simulate variable power demand.

The following questions will have to be answered before a prototype is built:

- How much energy will be use?
- How will the capacitors affect efficiency?
- How do the batteries react to the stress that will be placed upon them?
- How to charge the batteries?
- How much energy do the batteries need?
- How do the capacitors affect the internal resistance of the batteries?

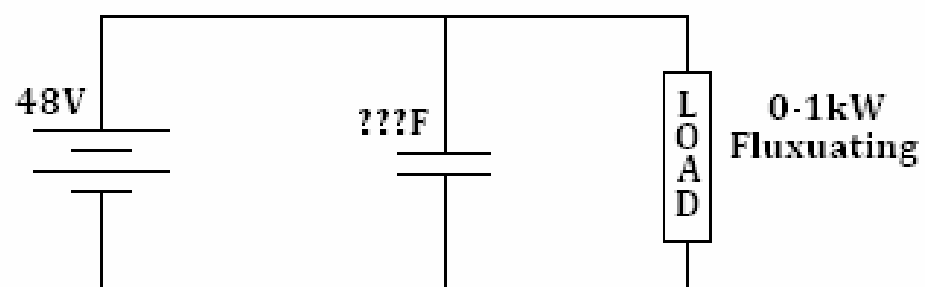


Figure 1.

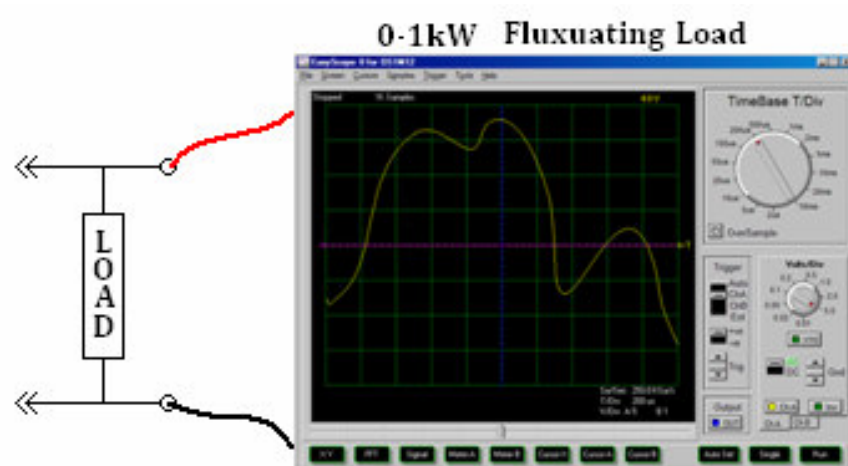


Figure 2.

Risk Analysis:

Lithium-ion batteries are commonly used for the laptop battery. Compared to the Nickel metal hydride cell, Lithium-ion is much smaller and lighter referred to its size. Also, it produces much more energy which almost four times than Nickel metal hydride. Because of that, it can be overheated any time. We should not operate the battery for such long time. It can also be overheated by any other outside sources.

The battery has so many electrolytes which can damage to our human body. Therefore, we should avoid having any contact with that. If it is skin contact, we should rinse with water immediately. For eye contact, we should rinse with water immediately up to 15 minutes.

	Risk			
1	Battery might be overheated(by external sources)	Don't work with that next to fire or stove		
2	Battery might be overheated(by short circuited)	Stop the operation immediately		
3	Cell Leakage(skin/eye contact with electrolyte)	rinse with water immediately		
4	Cell Leakage(having reaction with metals such as zinc)	Prepare the fire fighting equipments)		
5	The capacitor might not be charged/discharged	Try to replace a new one / buy brand -name product		

Project Management Plan:

Team ten is comprised of four electrical engineers. Marvell Mukongolo is the project manager, Chi-Fai Lo is the webmaster, Michael Kovalcik is in charge of documentation and Jamal Adams is in charge of presentation and Lab. Further planning will be included in future proposals.

Budget:

We have a \$10,000 budget, which is provided by KELD LLC.

		Price	
Nickel Metal – Hydrate Cell			
Lithium ion battery			
Ultra capacitor			
Charger			

References

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[Wikipedia might not be a good reference](#)