Progress Report #1

Design and Build a DC-DC Convertor for Charging Electric Vehicle Batteries

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Table of Contents

Chapter 1: Designing and Building of a DC-DC Converter for Charging Electric Vehicle Batteries

Proposed Project:

Project Title: Designing and Building of a DC-DC Converter for Charging Electric Vehicle Batteries

Supervisor: Ashoka Bhat

The project selected will be to design a charging system for electric vehicle battery packs. Motivation for selecting this project stems from its obvious real-world applications and its commercial potential. With environmental consciousness becoming more and more prevalent in the world many of the companies producing new technologies are steering there designs towards “greener” solutions. All members of this group are very environmentally conscious and hope to apply our education and experience in the electrical engineering field to design a system that supports the “green energy” initiative.

In addition to its environmental applications the rising popularity of hybrid and plug-in Electric Vehicles (EV’s) presents a rapidly expanding market for EV chargers. According to Alec Tsang, a representative from BC Hydro at the 2009 EMC Conference, electric vehicle adoption within BC is expected to eclipse 1 million vehicles by 2030, as advancements in charging technology make EV’s more accessible to average consumers this number will likely rise even higher.

DC charging stations allow for much faster charging than would otherwise be possible using the vehicles on-board system. This is because weight and size restrictions prevent the bulky transformers and rectifiers from being permanently installed on the vehicle so smaller slower chargers are used to ensure consumers are never left stranded with no way of charging their vehicle. An external DC charging station bypasses the internal charger, flowing much higher currents and voltages allowing the batteries to be charged at a greater rate.

The aim of the project will be to develop a fast and efficient method for charging electric vehicles using an LCL type resonant converter configuration. A clamping type high-frequency transformer will be magnetically coupled to the vehicle for added safety. An intuitive and easy to use charging process will be accomplished by using a microcontroller, which controls the power output of the charger and monitors the charging state of the battery.

Summary:

The system must have the following parameters for proper operation:

- Charger Input: 3.3KV DC, 12.5A
- Charger Output: 412.5V DC, 100A
- Switching Frequency: 100 kHz

The process for creating a DC-DC converter with these desired parameters is outlined step by step in the scope.

Scope:

Before commencing the design process it is important to research any existing technologies of a similar nature in order to learn from their strengths and weaknesses. By researching current technologies incite can also be gained into exactly what the market is for a DC-DC converter of this type. The background research will also include identifying the major components needed for the converter and how they work individually as well as how they interface with one another.

Once the preliminary research is completed and a strong understanding is gained regarding the components needed and how they will interface, the design process can begin. The conceptual design will lay out the major components previously researched and outline how they will interface in general using a single line diagram and average size measurements taken from manufacturer specifications. The conceptual design will also outline how the converter will interact with the vehicle and what voltages and currents are required.

The completed conceptual design will clearly layout what parameters are most critical when selecting the major components for the converter and also what specifications the microcontroller will need to meet. By comparing different components and different manufacturers of those components the design can be optimized to meet not only the requirements of the vehicle, but also ensure as compact of a design as possible while maintaining a reasonable overall materials cost.

After the parts have been selected to meet the parameter criteria they will be added into the design to confirm proper theoretical operation of the system and a draft of the final design will be produced for the DC-DC converter to clearly layout the component interaction and demonstrate the expected output of the system when interfacing with the vehicle.

With the draft of the final design completed with specific parameters the next step will be to program the microcontroller to interface with the DC-DC converter in order to maintain coherent operation at all times to ensure maximum operating efficiency. By writing pseudo code originally to outline how the controller will interface with the DC-DC converter and then expanding that into the required language it will ensure that all required aspects are accounted for in a logical order.

Lastly, once the microcontroller has been programmed and the design has been finalized the final report will be written. The final report will include all design specifications and parameters along with all necessary wiring diagrams and the size expectation of the design, along with the code for the microcontroller (if the project gets to the programming phase). The report will also include a summary of the project with a conclusion outlining the theoretical output of the system when interfacing with an electric vehicle and lastly any recommendations for how to further optimize the project.

Table 1: Key Project Milestones

Background Research	Conceptual Design	Parameter Specification	Final Design Draft	Controller Interfacing	Final Report
June 1	June 15	July 1	July 15	July 25	Aug. 2

Deliverables:

1. Progress Report 1
2. Progress Report 2
3. Poster & Demonstration
4. Project Website
5. Final Report

Chapter 2: Biographies

Allen Houle

I am a 4th year Electrical Engineering student at the University of Victoria. My first passion in life has been cars; building, racing and anything 12V related. I purchased my first vehicle when I was 14 and spent the next 2 years fixing it before obtaining my license. That car has undergone extensive modifications under my hand, starting with the restoration of the rusted body, and then an engine swap where I became intimately familiar with vehicle electrical systems as I wired it myself. I have since rebuilt that engine from the ground up and improved the drive train.

During My first Coop through UVic I was employed by Canadian Electric Vehicles where under the tutelage of my supervisor I learned a great deal about electric drive systems and AC drive motors.

I have also applied my passion for music to a more technical pursuit. For a final project in my electronics class in high school I designed and built an Electrostatic Loud Speaker. Electrostatic speakers use potential across a small air gap to vibrate a thin membrane instead on the conventional current carrying coil of wire/magnetic field employed in a conventional speaker. This involved stepping up the voltages in my amp to ~4kV and constructing a bias supply to provide a constant charge to the vibrating membrane.

Currently I am pursuing my passion for electronics with Arduino microcontrollers, constructing programmable light arrays and looking into using the microcontrollers to accomplish home automation tasks.

Brayden MacDonald

I am a fourth year electrical engineering student at the University of Victoria. I am currently working on specializing in electrical energy systems and electronics. My career interests lie in the field of power systems and utilities. My previous BC Hydro job experience in the Generation Protection and Controls department confirmed this as I really enjoyed programming PLCs and learning about Protection and Control design. My favorite day at work was the field trip to Stave Lake Generating Station. It was thrilling to go inside of a dam, and I look forward to going to some of the larger, more impressive generating stations.

I also learnt a lot from my first work term at Stantec Consulting about cabling and voltage drops for various pieces of industrial equipment as well. I learnt about oil-sands pipeline pumping stations and the many components required to power and run the pumping station safely and efficiently. My most recent work term at Alcatel-Lucent provided me with lots of hands on electronics experience. I developed my soldering skills and my circuit debugging skills in addition to learning much more about the telecommunication industry.

Assembling service router line cards at my last job inspired me to build my own desktop PC with parts I bought on the internet. I do enjoy working on electronic project for school and on my free time, and I look forward to further developing my soldering skills.

Jason Small

I am Jason Small currently in my fourth year of electrical engineering at the University of Victoria, my interest in engineering and sciences started at an early age. My parents believed it started with my love for Lego. I would often play for hours each day constantly building and creating new things, this naturally progressed to being interested in building/designing things at an older age like forts outside and wood working and shop classes in high school. Along with those hands on skills in school I also took a wide range of sciences. I enjoyed my classes in math physics and calculus. However I was undecided as I graduated and took general sciences for 2 years before deciding to apply to the electrical engineering program at UVic.

I was drawn to UVic for its coop program as it is a true advantage after graduation, already having relevant work experience is a huge asset. The smaller school size was also a bonus.

My two coops were at Gibraltar Mine in Williams Lake BC. It is the second largest open pit mine in BC. There on my first coop I worked under the Electrical superintendent of the entire mine, there I focused on the maintenance of the AC motors of the 240 ton haul trucks on site, the maintenance of the motors was extremely important to the through put of the mine and downtime could not be tolerated. I learnt much about the design and construction the AC drives used to power the trucks.

On my second work term I worked under the electrical planner, who was in charge of power distribution to the pit and mine site. I learned about power transformation on site. Power must be stepped down on the main site substation, then as it is directed to different mine equipment, such as shovels and drills, at has to be stepped down again to their respective voltages. This was important again to the throughput of the mine. Safety was also a primary concern on the site, and we developed safe procedures for unit substation and cut off house maintenance.

My goal is to work in a setting similar to Gibraltar, I enjoyed learning about the high energy systems on site, and that is why I chose a specialization in electrical energy systems.

Nathan Bellmore

I am currently in my last semester at UVic and will be getting my bachelors in Electrical Engineering in December 2012 after completing my last work term. I have always had a strong interest in computers and other electronics, which has helped motivate me for many of my undergraduate classes. I chose not to specialize my degree, but after doing 3 sequential work terms in the power distribution field I decided to take all the power courses offered at UVic.

My first work term was at Teck Coal Ltd. working with an Electrical Engineer in the engineering maintenance department. I began mostly updating and creating single line and 3 wire CAD drawings, but ended up assisting in many new installations by researching and selecting components that met the required specifications and were in accordance with the Canadian Electrical Code. Next I did a second work term at the same job, but primarily worked with various programmable logic controllers and HMI screens around the mine site. In September of 2011 I worked at the Canadian Forces Base in Esquimalt in the Engineering Project management department shadowing one of the electrical PMs and began managing a backup power upgrade in one of the older buildings. This included working with consultants to get a power quality analysis done as well as a full options analysis. Due to the time constraints I was only able to see the project through the initial phases and passed it off to one of the PMs when I left.

I look forward to working on a project that supports “green” energy and I am excited to expand my knowledge of how electric vehicles operate. My education and experience in the power distribution field will be a strong asset to the team and will hopefully prove useful for a project relating to power electronics.

Neil Hindle

I began my post secondary schooling enrolled in the Physics Department where I spent two years. During my second year I had taken Physics 220 – Electrical Properties on Materials, which is the same course offered by the Electrical Engineering department ELEC 220. After completion of this course and an utter love of the material I decided that my studies should be focused towards my interests and my strengths, thus the logic solution was to transfer into Electrical Engineering Program to finish out my post secondary career.

My specialization fields are Communications and also Electromagnetism and Photonics. My career goal has been directed towards communications ever since my first cell phone and was further inspired by my two work terms at Capital Region Emergency Service Telecommunications.

I was born in Kindersley, Saskatchewan and was raised in Duncan, British Columbia. My youth was spent outdoors doing activities such as hiking, biking, fishing, and skateboarding. Electronics was a large part of my child hood as I had child starter electronics kits and also many video game systems. I had an older brother that always had an intense interest in computers which allowed me to learn and work with computers at an early age, during my high school years he completed his doctorate in Computer Science jointly at UVic and at Waterloo. Having a role model such as my brother I have always strive to contribute to the technical industry and with graduation coming in a year's time I believe I will.

Chapter 3: Summary of Seminars

Fortinet -Real Time Network Protection

This presentation was given by the employees of Fortinet which provides hardware and software for worldwide coverage of network protection. This protection is done by using the Fortiguard Distribution Network (FDN) which is made up of their routers and gateway products.

Fortinet's products offer a Zero Day Vulnerability which entails role out protection of vulnerability fixes. This consists of employing ethical hackers; these hackers probe programs, websites, and all facets of computers architecture to find weaknesses to attacks, holes in code, and all access points for non-ethical hackers. Once vulnerability is found there is a strict protocol set out by Fortinet to follow:

1. Notify vendor within 24 hours of the weakness detection.
2. Confirm with vendor for solution.
3. Notify Public of issue.

The engineering tasks taken on by this company consist of creating their own hardware to programming their own firmware and software to combat issues in protection. Hardware sold by Fortinet comes under the name Fortigate and are routers, servers, and serial cards with built-in hardware level protection such as firewalls and intrusion detection, as for software it is their FortiOS. The microchips are designed under FortiASK which creates Network on Chip, System on Chip and Protocol on Chip; these products are all designed in house under the Fortinet umbrella.

Fortinet does as much as possible in house, which leads to job opportunities in firmware, software, hardware and RD. This large company has thousands of products all over the globe with offices all over the country but close by in Vancouver and another in Sunnyvale, CA.

Library Research Seminar

Having the engineering librarian do a seminar allows for the vast information gathering resources to be displayed for the engineering student body. The library brings multiple resources to the student body at no direct charge to the students. One of the most used features by the group and also past employers is the IEEE database; this contains protocol papers, standards, journal entries and much more. By using Google scholar through the UVic Library website one has access to all the subscriptions the university holds and also the material that is initially free from Google Scholar. It is good practice to access all databases from the UVic library website as from the other resources it will also ensure access to full texts, ebooks, journals and other documents. The databases offered for the field of electrical engineering are as follows:

- ACM Digital Library
- IEEE Xplore
- Inspec and Compendex
- Business Source Complete
- Springer-Link / Science-Direct / Computer Science Index

For researching patents one can search esp@cenet – World Patents, Google Patents, and IEEE Standards. Patents are handy when implementing new systems and or designing something completely new, by knowing what is already out there and also what is patented one can create something innovative and completely legal.

To maintain a full and complete bibliography one can use Refworks or End Note, these programs can import articles you are using and create an easy reference. During the research period one collects many different sources of data and that data can be hard to reference, but these programs also store where the information was obtained and allows for easy follow up.

Over all seminars went over resources and useful skills for utilizing the UVic library for obtaining research. When in doubt one can always fall back onto the contacts on the website which directly links you to the librarians via messenger, email or phone. This seminar will benefit me while researching for this project and also the other projects that I will encounter during my final year in Electrical Engineering at UVic.

Chapter 4: Textbook Review

The System Developments Life Cycle

The first chapter in System Analysis and design focuses on the Systems development life cycle (SDLC). This is a tool used to understand how a system of information can support business processes of designing, creating and delivering a system. This is an important tool needed to increase efficiency and communication of business processes in modern corporations. SDLC is used to reduce abandonment of programs, increase the throughput of company therefore increasing the efficiency of delivering projects on time and on or under budget.

The key role in successful SDLC is the systems analyst. TA good systems analyst will analyze business situations, notice opportunities for improvement, and design a system model to capitalize on those improvements using a an information system. A systems analyst must be effective by understanding how an information system fits into the organizations goals, current business processes and how to provide value based on the organizations definition of the word.

The systems development life cycle is broken down into four distinct processes; each process is then further broken down and elaborated. The processes are planning, analysis design, and implementation. Each process may hold different values in a company’s outlook, however all four phases are present in any model. In most projects, these phases proceed in the logical order.

Planning is the important process of determining why an information system should be used and how the project team will build it. The planning phase contains two phases.

Project initiation is the process of identifying the system's value to the business. The value is defined by the business which leads it to be mostly profit. The initiation then breaks down into technical, economic, and organizational, feasibility. All questions have to be answered if the project is to advance.

Project management: Once the questions of feasibility the project manager creates a work-plan, staffs the project and implements management techniques to guide the project and team the entire SLDC method.

The analysis phase looks at who will use the information system, what it will be used and when. The process of this phase involves looking at current systems, noting opportunities for improvement, and using these observations in designing a new system. This phase has 3 steps.

Analysis strategy is a developed guide to the project's team. Requirements gathering is this process will lead to the concept for a new project through interviews and questioning of the projects requirements.

The System Proposal is presented to the project sponsor and decision makers who then decide if the project moves forward.

The design phase of the SDLC process determines how the system is to operate with respect to hardware, software network infrastructure, also the user interface, forms , and reports with the specific programs, databases, and files that will be needed. The design phase is concisely broken down into four steps.

Design strategy: Once developed this strategy will make clear whether the system will be outsourced or down within the company, or purchase existing software.

Architecture design is what the design strategy leads to, and describes the hardware, software and network infrastructure. Also the interface design will specify how users can progress through the system.

Database and file specifications are the next steps in the design stage. As it says this defines where data will be stored, and specify which data.

The final stage in the design stage is progress design. This defines what programs need to be written and what they will do.

The final stage in the SDLC process is Implementation. This is the stage where the system is actually built (assembled, or purchased). This is the most developed stage and usually takes the most time. Implementation puts emphasis on system construction, where the system is built and tested for bugs. Then the system is installed, this is where the old system is turned off and the new one is initialized.

This then moves on to a Systems development method. This is a methodology to the approach of initializing a SDLC. These methods can vary in steps, emphasis and formality, depending in the circumstances. This is then further broken down into structured design. Waterfall development this develops a linear step by step process, progress from planning to analysis to design, then implementation, then the final system.

Another development method is parallel development, which attempt s to take on stages simultaneously. This attempt to decrease the time spent between the analysis phase and delivery of the product. Other methodologies, attempt to address different problems or delays within the SDLC. Each has their own pros and cons, and must be carefully decided based on the specifications of the project and its time constraints. This leads into criteria for selecting the best methodology. This takes into account system complexity, system reliability, short time schedules, and schedule visibility.

The project team's roles and skills are just as important as the methodology of information system implementation. The skills of the team must be varied as to cover all aspects of the program and system. As well the analysts must have a wide range of skills, including communication skills, technical, management, and ethics. Some analysts can be more specialized in their own areas, where it is necessary and beneficial to the project.

These specialized analysts can be broken down into systems analysts, focusing on information systems issues in the system. Business analysts focus on business issues around the system which include value, defined by the customer or company. Next there are infrastructure analysts who ensure the system conforms to infrastructure needs and standards. Change management analyst's developed and executes user training plans. Finally there is the project manager who manages the team of analyst's programmers, technicians, and is the primary contact for the project.

Conclusion:

In order to increase responsible, sustainable energy usage in society and to capitalize on the current popularity of green products, our team has decided to design and build a DC-DC converter for charging Electric Vehicle batteries. The rising demand for electric vehicles needs to be met with an increase in accessible and convenient charging stations. Due to the strict space constraints for the on-board charging system the demand for a DC charging station capable of delivering much more current and voltage to the batteries is needed which will result in faster charge times. Using an LCL type resonant converter configuration, this project hopes to accomplish this goal of a faster and more efficient battery charge. A microcontroller will be used for the user interface and a clamping type high-frequency transformer will be magnetically coupled to the vehicle for an increased measure of safety.

By studying existing technologies on the market we can provide the team with current knowledge of components and technology needed to implement this project. The design stage will provide a single line diagram as well as the physical layout of the components. The conceptual design stage will detail the major components as well as the micro controller specifications. This will maximize the compactness of the design while ensuring a reasonable cost for materials. The final design stage will produce a draft of the final design with a clear layout of the components, as well as the anticipated electrical output of the charger to a vehicle battery. This will be followed by programming the microcontroller to communicate with the charger at all times. This will be accomplished by first developing a complete pseudo code to ensure that all deliverables are met.

Following the software development and the finalization of the design, the final report will be produced, thoroughly documenting all specifications, diagrams, and code. This will be followed by a project summary and conclusion with the theoretical electrical output as well as recommendations for further developments into our design.