Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 440 Post-Mortem for uControl

Dear Dr. Rawicz,

Attached is a document describing the Post-Mortem for the uControl. We at Universal Control Solution aim to create a product which extends far beyond improving the luxury and comfort of the user. We aim to create a device which could potentially be used to control your entire home all the touch of your fingers. Our device aims to take a firm hold of the rapidly expanding tablet market and allow the users to control their lights, heating/cooling systems, and various multimedia systems all at the touch of your fingers from ONE place, your personal computer!

Our team consists of 3 highly talented electronics engineering student Stoyan Petrov, John Kenyon and Sajib Saha, and me, Ivan Petrov, a senior biomedical engineering student who will be responsible for integrating the user interface in a simple and "sexy" way that allows users to quickly access all of our product features. One other major component of our product is that we will attempt to integrate it with an environmental control system and could potentially replace the currently existing X10 systems. This plays a huge factor for assisting those with physical disabilities who have some form of access to a PC.

This document outlines the brief summary of the project, current state of the product, future plans for this system, group dynamics and deviations from the budget and schedule. An individual review of the technical and inter-personal skills developed during the product period by each team member is also included. If you have any questions or comments please contact me at ivp@sfu.ca , or by phone (604) 588-5429. I will convey your message to my fellow team members.

Thank you for attention.
Sincerely,

Ivan Petrov
Chief Executive Officer
Universal Control Solution
ivp@sfu.ca
604-588-5429

Enclosure: *uControl Solutions' Post-Mortem is attached below*

uControl Solutions

uControl: Home Automation System

Project Team:	Ivan Petrov Stoyan Petrov Sajib Saha John Kenyon
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Submitted To:	Dr. Andrew Rawicz Mike Sjoerdsma
Date Submitted:	April 29, 2011

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Introduction

uControl is designed to be an all-in-one home automation solution aimed towards increasing the user's home experience and comfort by focusing on providing in house appliance controls at the touch of a button and integrating the user's entertainment systems. We view the user's experience as primary indicator to the success of this product and by allowing the user to control light/media systems we are creating an all in one solution for a home automation system at a very affordable price.

uControl is meant to be affordable and above all expandable. At any point the time a user can have as many modules as they desire and they could potentially automate their entire home. The UI will be able to accommodate and provide control over these modules at the touch of your fingertips. Everything will be at the user's fingertips and the ever growing tablet market will allow our system to be exposed to even more users. With our system, a tablet PC will communicate with a central unit which in turn communicates with as many modules as the user wishes to purchase. This system is visually represented in the **Figure 1** below.

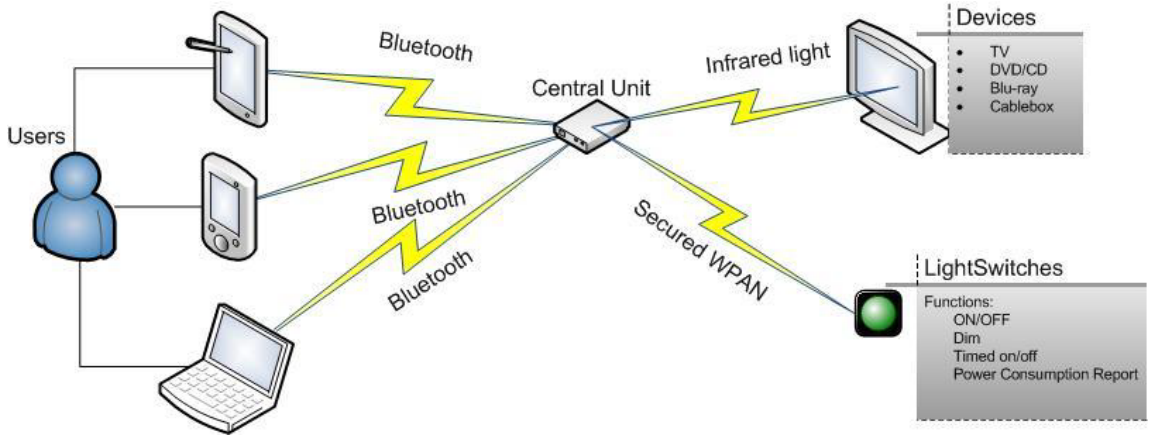

Figure 1: System Overview

Current State of uControl

We feel we met all the requirements we proposed. Functionality wise there are no changes from earlier submitted documents. uControl allows the user to control their TV, currently only 20 commands on a single TV, and allows the user to control their lights. Dimming functionality was achieved as well as and on and off control. Due to time restrictions we opted not to implement all the functions described in Figure 1. This was also mentioned in earlier submitted documents. The TV commands are only 20 because of time restrictions. Infrared communication turned out to be quite difficult and so we limited the commands to only 20. This way we managed to have working prototype in time for the final demonstration.

The User Interface was completed and runs on computers using Linux or Windows as their operating systems. The User interface was designed to be portable to many different devices and so it was written in Java which can be used for all the Android smart phones and tablets and other portable devices.

uControl Future Development

The uControl system can have unlimited future possibilities. For now we would concentrate on developing the User Interface for Android tablets and to keep improving its look and feel to make it even more user friendly (many of the people who would buy this product may not be fully "computer literate" and it would be unfair to assume they are). There are lot of new modules we can add to the system and some features can be added to the existing module. We plan on implementing the timed commands and power consumption in the near future. For new modules a uControl Adapter is planned so that the user can control external lights and other appliances. Also a uControl Thermostat is planned. This would allow the user to wirelessly control the house environment to suite them better.

A lot of improvement is required for the current system in order to meet our future requirements. We plan on redesigning the Central Unit to use a more powerful microprocessor instead of the Arduino Mega. With a more powerful Central Unit we can implement not only Bluetooth but also Wi-Fi control so that the user can remotely control and monitor their home through the internet. A system like uControl should never be static so we plan on implementing a protocol that allows us to automatically update the Central Unit through the internet.

Another of the main areas of improvement we can focus on is reducing the overall cost of our product, mainly by developing our own circuitry to replace the modules currently used in our proof of concept model. The main one to replace would be the Bluetooth module. It has a cost of nearly $80 before tax and we would be able to make our own (albeit with quite a bit of research into Bluetooth) at a very cheaper margin, greatly reducing the cost to mass produce our central unit. Another one is the RF transceiver, the MRF24J40, which is around $10 for one unit. This price could be greatly reduced if we were able to make our own and install it using surface mounting techniques during manufacturing. Although the transceiver is fairly cheap, since we are using it in our light switches some houses may require 20 or more of these, meaning reducing the cost of it will be more beneficial then it may first appear. Finally, replacing the microprocessor with another designed specifically for our product would reduce the cost of manufacturing (our current microprocessor has many features we do not use and would like to pay for) and would be a good investment in the long run.

We plan to follow through with many of these ideas in the coming months. We would like to see how far we can take this product and perhaps one day it could live up to our imagination.

Here is a brief summary on the features we plan on implementing:

- Thermostat Module
- Wi-Fi accessing
- Fully programmable remote control supporting at least 7 remotes
- GUI running on apple iOS and Android mobile phones
- Timing commands
- Power consumption readings

Finances and Schedule

Budget

The following table shows the expected cost vs. actual cost of our project.

Equipment	Estimated cost (rounded to nearest whole number)	Actual cost (rounded to nearest whole number)
Central Unit	$ 162	$ 160
Light Switch (x4) and interfacing	$ 88	$ 143
ZENA Network Analyzer	-	$140
Other Cost (Breadboard, PCB Etching Chemical, Socket, Light Bulb, etc.)	$ 25	$89
20% Contingency Plan	$ 55	-
Total	$ 330	$532

When we started our project we never thought we would be facing financial issues. We estimated our budget to be around $330 with contingency plan of about 20%. This was why we never looked for other sources of financing our project as we received $500 from the ESSEF fund provided by the ESSS. But in the end, even after cutting down our cost a lot, we ended up spending $532 which is about $200 more than the expected cost. Several reasons for the cost to be so high were that at first we thought we would be ordering our PCB boards for the switch to be manufactured at a PCB manufacturing company. But in the end we ended up making those boards on our own. The price of the etching chemicals and boards added to the cost. But we believe that the experience was quite beneficial for us and will help us a lot in the future in the

field of engineering. We also ended up buying an extra AVR programmer for programming the microcontroller so that two people could work on programming the wireless modules for the switches and be able to make more efficient use of everyone's time. The main cost that was incurred during the project which wasn't in the expected cost was the $150 we paid for the ZENA network analyzer. The reason we bought this was because there was no way to test if our wireless modules were transmitting signals. This investment was quite helpful during our project as it let us view our transmitted wireless signal type and plan our algorithm accordingly. Also we ended up spending a lot more on the light switch and interfacing as we bought additional parts just in case if something goes wrong and we run out of parts. But that was actually considered in our contingency plan when we planned our budget.

Timeline

The following figure shows our expected timeline for our project and actual timeline of our project.

ID	Task Name	Duration	Start	Finish
1	Project Duration	74 days	Tue 1/4/11	Fri 4/15/11
2	Research	30 days	Tue 1/4/11	Mon 2/14/11
3	Project Proposal	6 days	Wed 1/19/11	Wed 1/26/11
4	Functional Specificatior	18 days	Mon 1/24/11	Wed 2/16/11
5	Central Unit	42 days	Tue 1/25/11	Wed 3/23/11
6	Light Switches	24 days	Wed 1/26/11	Mon 2/28/11
7	Oral Progress Report	12 days	Thu 2/10/11	Fri 2/25/11
8	Design Specification	10 days	Wed 2/23/11	Tue 3/8/11
9	User Manual	5 days	Tue 3/8/11	Mon 3/14/11
10	Written Progress Repor	10 days	Sun 3/20/11	Thu 3/31/11
11	System Integration	16 days	Wed 3/16/11	Wed 4/6/11
12	Final Testing/Debuggin	4 days	Wed 4/6/11	Sun 4/10/11
13	Presentation Demo	5 days	Mon 4/11/11	Fri 4/15/11

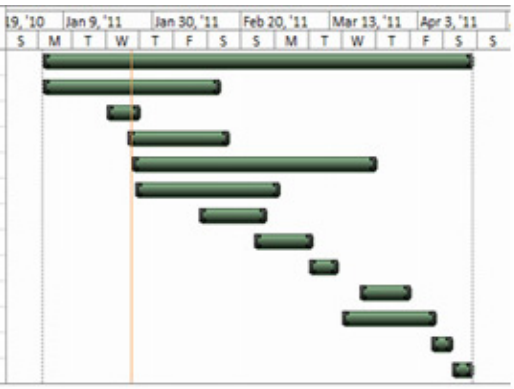

Figure 2: Predicted Timeline

ID	Task Name	Duration	Start	Finish
1	Project Duration	81 days	Tue 1/4/11	Tue 4/26/11
2	Research	53 days	Tue 1/4/11	Thu 3/17/11
3	Project Proposal	4 days	Sat 1/22/11	Wed 1/26/11
4	Functional Specificatior	18 days	Mon 1/24/11	Wed 2/16/11
5	Central Unit	54 days	Wed 2/9/11	Sat 4/23/11
6	Light Switches	39 days	Wed 2/2/11	Mon 3/28/11
7	Design Specification	5 days	Tue 3/8/11	Sun 3/13/11
8	Written Progress Repor	4 days	Sun 3/20/11	Wed 3/23/11
9	System Integration	17 days	Fri 4/1/11	Sat 4/23/11
10	Final Testing/Debuggin	2 days	Fri 4/22/11	Mon 4/25/11
11	Presentation Demo	5 days	Wed 4/20/11	Tue 4/26/11

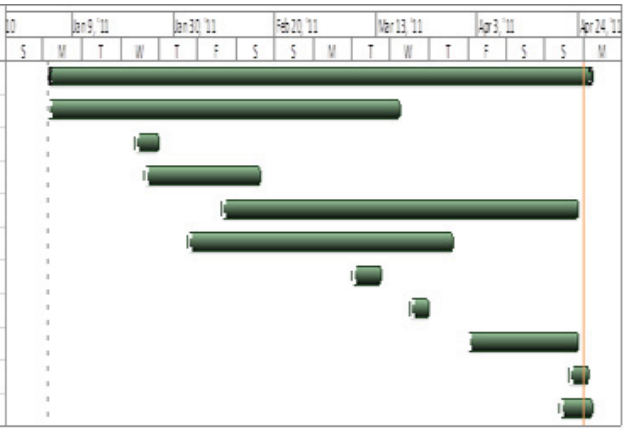

Figure 3: Actual Timeline

The only real discrepancy between the two timelines is the time spent on developing the light switches and the central unit. Though we tried to follow our predicted schedule as much as we could, it was inevitable that we would deviate from it since we had made the timeline well before we knew what we were getting ourselves into. Initially we thought we could finish our project and present our demo by April 15th. However we spent more time making and programming the light switches, previously thought to only take 1 month, which took most of our project time (upwards of nearly 2 months). We also had some problems choosing which wireless modules to use for our light switches as we were looking for something which would give a very high price vs. performance ratio. These are the main reasons as to why our project was delayed.

We also spent a lot more time on the central unit because the learning infrared remote control system took us more time than we initially predicted. But in the end we only spent 10 days more on the project than expected. This was possible because we started working on the user interface and central unit before finishing the light switches. We also didn't have very many problems during system integration and final testing/debugging of the whole system because we kept testing/debugging the smaller parts during the designing and making of them. Furthermore it was because we planned ahead to take into account the possible difficulties of integrating.

Group dynamics

Our group of four engineering students worked very well as a team. Individual tasks were assigning from the start and we performed them impeccably. We worked very well as a team and every time an obstacle was encountered, it was resolved in a very professional manner. Debates were encouraged and it allowed us to ultimately produce a better product and one that the entire team was happy with.

Once the tasks were assigned, we had a established a pecking order in which everyone agreed on. All four of us acted professionally when we disagreed on ideas and implementations and always settled down to the best choice. This was a key factor in allowing us to meet such a tight deadline.

All documentation was synchronized using Google Documents. This allowed us to instantaneously see what each one was of us was working on and greatly reduced the time we spent on creating those documents. Some tasks ultimately proved more difficult than others and in such cases, we as a team helped each other out and performed impeccably.

Inter-Personal and Technical Experiences

Ivan Petrov- Chief Executive Officer (CEO)

During the course of this project, my team members and I went through many ups and downs. More ups than downs and while we may have struggled at times, we managed to succeed and achieve our goal. From the start, we chose a very ambitious project and we would settle for nothing less than success. Blue tooth communication by itself would have been quite the challenge to implement but we decided to create a universal remote control as well. Furthermore, the modules were to communicate with RF to save cost. This means that we were working with three different protocols at the same time. What this meant to us was that there was that each and every one of us had to perform to our best.

From the very beginning, we knew we would have to face many challenges and thus we were committed to working on a set schedule. The first milestone was to research what type of components we should use and whether what we wanted to create is actually feasible. Each one was responsible for researching their respective task and note all the difficulties that could be faced with each approach. One key concept I wanted to stress on was reliability and the fact that if we start off with good practices, we would ultimately end up with a better product. And this researching phase was crucial.

I was in charge of designing the user interface and the communication between the PC and our Central Unit. This was not such an easy task because as an engineering student, I was only familiar with C++ and embedded circuit programming using VHDL or C. This made my first choice easy as I decided on writing everything with C++ even though I had never programmed any graphical user interfaces. Upon further research I opted against C++ because ultimately I wanted the user interface to be as portable as possible and C++ just did not meet the portability of Java. (Especially given that most Android apps are written in Java)

I committed on using Java and because I have never used it before, I spent countless of hours learning the intricacies of the language by reading articles, tutorials, and watching instructional videos. Learning was not the challenge. I love learning. However, with pressing deadlines learning was not so fun. Parallel to my coding, I learned how to program our micro-controller in order to make sure the communication between the PC and the Central Unit work as desired. Towards the end of the project, I also worked on copying and replicating IR signals directly from the Remote Control. I faced many struggles with both the remote control and integrating blue tooth communication with the Java API. Ultimately it was Stoyan who stepped in and completed the remote control module.

We had always worked great as a team and the above is a perfect example. At all stages in development, we would communicate between each other both in person and through emails. Everything we did was noted and we agreed on features together. I truly believe that had it not

been for our team work, this project would have been doomed to fail, at least in the specified time frame.

Every one of us had our unique challenges. Myself I was under tremendous pressure to not only learn something quickly in a very short period of time, but I had to produce something that could jeopardize the success of this project. In the course of these four months I believe that I have applied everything I have learned from my five years of school experience and this experience has made me even better. This project was not simply about knowledge and experience. Completing this involved committed and consistent approach to producing results on a daily basis. Looking at the project as a whole and seeing the short time line could be very discouraging, but the ability to look at a problem and break it down into small pieces is a skill that will serve me for my entire professional career.

I started this course with absolutely no knowledge of Java. As I am writing this report, I am working on creating a user interface to be used with an Android cell phone. This is quite the improvement and while I have much more to go, it is definitely a step in the right direction. If I were to start over from the beginning, there is not much I would change. One thing I would improve on is fully utilizing the tools available to us such as Skype and other means of communication to save on time. Time was the only pressing factor that affected us and while we did utilize Google Documents, there is a vast array of free tools we could and will use in the future. A software control tool for example such as Clear Case is a must.

Technical skills alone are not what I am proud of. Along the way I faced many challenges both personal and with this project. Ultimately it's not only what we do that matters, but how we get there. What we take away from an experience is entirely up to us and I believe that the experience of this project will truly greatly benefit me in the future. I hope we continue development as we have planned and maybe one day we will achieve our vision of providing an in-house automation system at your fingertips at a very affordable price. And maybe one day everyone would be using it.

Stoyan Petrov – Chief Technical Officer (CTO)

Out of the four of us I had the most experience in working with microcontrollers and how to interface them with external hardware so I was in charge of designing the light switches and implementing the embedded software for both the light switches and the Central Unit. I also took charge in designing the PCBs. The hardware design for the light switches was pretty straight forward; however I had to learn about the components I've never used before (TRAICs and opto-isolators.)

One of the first challenges involved in the design process was to convert the 120V AC mains to a usable 3.3V DC voltage without wasting so much power. A few weeks were spent researching

possible solutions and found two possibilities for the power supply; Resistive and Capacitive. The resistive power supplies wasted quite a lot of power while the capacitive could not provide enough current for our circuitry to work. Another method involves using resistors and filtered rectifier circuit, but it also wasted quite a lot of power. The solution I opted to use was a capacitive power supply using a filtered rectifier bridge. Ideal Capacitors do not dissipate heat so in theory no power is lost; in reality little power is lost in the capacitor. The power circuit works quite well and it is very reliable with very little power loss. Once the design was finalized I spend a week or so selecting the best components for the design that met our requirements and kept us in budget. I also ordered components that can be used in the future.

The next challenge was creating the circuitry that can control the TRIAC. This was relatively easy as many books and documents exist on this topic.

Next was to create the embedded software for the light switches and the central unit. The light switch uses two interrupts to drive the TRIAC and initially I thought it would be quite hard to implement. However it turned out to be very straight forward once the datasheets were read with great detail.

The biggest issue we had was with the wireless modules. We needed something reliable. I suggested we use the MRF24J40MA wireless module and turned out to be a great little module. The wireless protocol it uses is quite popular for low power wireless applications and it has a lot of functions, but it wasn't so straight forward to use. It uses SPI (Serial Peripheral Interface) to communicate with the microcontroller and this took us some time to understand. A lot of digging in datasheets and online was required to get the wireless module to work. One of the biggest challenges here was debugging the wireless communication. Initially we had no idea what was happening in the wireless channel. Were we transmitting and not receiving, or does our transmission software not work? We had no way to monitor it. It's like debugging a circuit without an oscilloscope or voltmeter. This is why I decided to order the ZENA network analyzer, which took out about a third of our available funding. At this point we had all the other components so it did not hurt the development of the uControl system. The ZENA turned out to be a great investment as it saved us weeks of blindly trying to fix a very small bug in the software. With the wireless communication working the only thing left was to integrate the software with the User Interface using Bluetooth. This turned out to be very straight forward. This is due to a lot of detail being spent on how we would do the final integration. From day one we knew integration could be quite difficult so I spent a lot of time during the development to make sure I had a plan for the final integration. This allowed us to integrate all the systems without any difficulties.

By the end of the project I acquired a lot of new knowledge and new skills. I learned a lot about the different wireless protocols, more specifically, the IEEE802.15.4 protocol. Getting the IR to work required a lot of research in how the TV receivers work and how remotes communicate with the TV's. During this research I gained a lot of knowledge in a subject we were not thought in our classes. Making PCBs turned out to be quite fun but required a lot of attention to details

and a lot of patience. This class has also exposed me to a lot of components that were also not thought in our classes.

The most important skill I've learn during this project was planning ahead. I feel I managed to finish my contribution to the project because I always planned ahead. Bugs were anticipated and fixed when found. A lot of research went on the selection for the hardware components and because of this I feel we made the project work.

Sajib Saha – CFO (Chief Financial Officer)

My role as the Chief Financial Officer of uControl Solution was to overlook the financial planning of our current products. Throughout the course of this project, I've monitored our budget closely and facilitated the decisions of purchasing components and materials. I am sure the experiences I gathered during the project period will prove to be very valuable and prepared me for my future career goals.

Besides the financial planning responsibilities, I was also part of the designing process of the light switch. From a technical point of view, I gained valuable experiences in complex circuit designing and manufacturing them. One of the great learning during this project was PCB designing and making them. At SFU we were not taught how to these which the reason I had to learn is this all by myself. The online tutorials and videos were very helpful for this. Another crucial part of my learning process during this project was embedded system programming. Initially I had no idea how to program microcontrollers using c programming language.

I was also a small part of the user interface creation process. I had to create the pictures necessary for the background of the user interface along with the pictures necessary for the remote control and light bulb control. For this reason I had to polish my knowledge of photoshop and also learn new ways on how to use effects and the almost infinite possibilities photoshop offers us. I also had to learn how to use other photo creation software such Inkscape and Xara3d. In the initial stage of the project I also learnt how to use visual basic for user interface though in the end we ended up using JAVA programming language as it is more portable. I also designed the company logo using photoshop and some logo creator software's. Besides this experiences I have also learnt about how Wi-Fi-signals and infrared works. For this I had to study a lot of the IEEE protocols and infrared protocols. I also had to lean about SPI because this was the only way to program the wireless modules we used for our light switches.

As for the soft skills I gathered during the project, teamwork was most important. It wouldn't have been possible if all the group members didn't contribute to their outmost limit during the project. Although we all had individual responsibilities, we all helped with each other's job and collaboratively worked on certain problems and made decision together. Another skill I developed during this project was to prioritize works. I had other three 400 level courses along

with 440 and 305. So prioritizing my work and also the great team work enabled me not to be under a lot of stress during these four months.

ENSC 440 was by far the most interesting and practical course I have ever taken throughout my engineering student life. I particularly like how the course blended topics of both hardware and software. Project management, team work and communication were a significant part of this great experience. I am very thankful because I was given the opportunity to work in a wonderful group and I consider this project a great success.

John Kenyon - COO (Chief Operating Officer)

It has been quite an interesting 4 months. Never could I have believed that we would be able to bring something that was once just an idea in someone's head to a final product that works in nearly every way we had initially hoped. It took a team to complete this and a team that was able to maximize our strengths and work around our weaknesses. As a team, we learned how to work together and accomplish our goals with the utmost efficiency. Personally, I gained many different soft and hard skills which will surely help me in University and hopefully in my future career.

This project required a fair understanding of using, including programming and interfacing, microcontrollers, something I did not have in January. I am a 4th year System Engineer and the only hardware programming courses we are required to take are ENSC 215 and ENSC 250/CMPT 250, which I happened to take in my first and a half year. Furthermore, these courses were merely introductory courses and did not provide me with a "real world" experience, where resources are generally limited. For our project, we were trying to keep under a tight budget while attempting to meet the requirements we had set at the beginning of the semester, which meant we had to completely rethink the programming strategy we had been taught. Stoyan was by far the most well versed in our team with microcontrollers, so I often would go to him if I had any questions regarding them. He taught me many of the basics, such as interfacing hardware and using RF transceivers, which he had previous experience using them on his own personal projects. We created our own radio protocol because it would be cheaper from an industry standpoint, we knew we would learn more, and the code took up less memory. What I specifically learned was how to send data packets and how to set up the header of the packet. Our protocol was based off of the 802.15.4 radio protocol and this required me to read many datasheets so I could begin coding. Furthermore I also learned how to interface using Serial Peripheral Interface Bus (SPI). It was definitely one of the more difficult portions of the project as none of us had any experience using it. It required us to do even more extensive reading since we all were starting from scratch and I don't regret it. This project gave me a greater interest in the field of hardware development.

Another area where I advanced my knowledge in was circuitry. For our project we had to convert the high voltage from the wall outlet to a more manageable voltage from which we could power our microcontroller, which was controlling the TRAIC, essentially a current gate, connected directly to the light. In order to reduce size and cost, we did not want to have to use a transformer, something big, bulky, and relatively expensive. Instead we designed the circuit so that it optimally reduced the voltage whit minimal power dissipation. We strived for minimal power dissipation since any power dissipated as waste would still be charged to the customers electrical bill. To do this, we used caps instead of resistors for our voltage divider.

I was already quite skilled in the use of Solidworks, having taken ENSC 489 prior which required a much more intricate design than our product would require, but I learned how to use several more of the Solidworks functions and programs. One such program is Photoview 360. It is an intuitive program that allows the user to render and visualize their creations in real time. It was quite interesting as it enabled me to take high quality views of the design I had made at professional quality. Hopefully I will be able use these additional programs and features in the future on future projects.

I also learned many invaluable soft skills, such as technical report writing, working in a team developing a high tech product, and working with a small budget. This project was very much like owning and working in a small business consisting of only engineers. We all had to work with what we had, get along with each other, and work off one another's strengths and weaknesses. Each of us had to put on many different hats, sometimes it would be businessman's hat, sometimes the accountant's, sometimes the engineer's. I had to use the skills I learned in ENSC 201 (Business of Engineering) to make a feasible business plan, after all, a product will be useless if it cannot make money. All in all I was very glad with what we accomplished and would happily do it again with the same team members.

Wrap Up

We started with an abstract idea of being able to control your entire home at the touch of your finger tips. Just imagine once complete the comfort level that this could bring to families and individuals all across the world. Our product is a reliable, effective and inexpensive solution to the ever expanding home automation field. More and more people are relying on various devices to control different components of their home. What we have created is a way to do all this through a centralized location.

During the course of this project, each and every one us worked together as a team to achieve our requirements and produce a working prototype. We went through many struggles that ultimately allowed us to grow in the process. Our goal is to create a fully functional product that will significantly increase the comfort and efficiency of the users. Our goal is also to help those with physical impairments improve their mobility and hence their independence. At the end of the day every one of us wants to be independent in some way or another and we truly believe that by allowing a person to be more independent their livelihood and well being will increase. There is much work to be done to achieve this goal but just like we did with this project, we will take things one step a time; and what a better way to end this than with a fully functional prototype.