January 9, 2012

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

Re: ENSC 440 Project Proposal for a Smart Dimmer

Dear Dr. Rawicz,

The following proposal describes the project which will fulfill our ENSC 440 requirement at Simon Fraser University. This project aims to design and prototype a smart dimmer switch for light fixtures which will create an atmosphere with constant illumination despite changes in the external environment. It will do this while maximizing the external lighting contribution and minimizing the contribution from the fixture.

The proposal will introduce the existing problem and present the details of our proposed solution. It will give a detailed breakdown of costs and schedule to show how we propose to accomplish this goal within our specified budget and by the deadline of April 16th.
Finally we will elaborate on why our team has the specific skills and experience necessary to successfully execute this project.

Thank you for your time and please feel free to contact me with any questions about this proposal by phone at 604-291-1721 or email jka37@sfu.ca.

Sincerely,

J. Kehler

Jonathan Kehler
Project Director
Smart Light Solutions

Enclosure: *Proposal for a Smart Dimmer*

Smart Light Solutions

Project Team: Aram Grigorian
Jonathan Kehler
Larry Zhan
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Submitted to: Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

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1 EXECUTIVE SUMMARY

Conserving energy is something that concerns us all. Luckily, in our society we are seeing a paradigm shift in the way people view and use energy. We are moving to cleaner energy sources with a mind on conservation. This shift is occurring alongside a surge in technical capabilities unsurpassed by any previous. At this pivotal point we must harness this force and focus it towards the goal of building a sustainable future for our entire planet. At Smart Light Solutions we are working diligently towards this goal by designing an innovative new product that will save energy in homes and business' and push an initiative for smarter more economical buildings which maximize natural light, increasing efficiency and saving energy.

The problem we strive to solve is the massive waste of energy spent to "over-illuminate" public and private spaces. Buildings of all size and purpose are provided with a constant illumination regardless of changes in external brightness. This leads to wasted energy that, while small on the scale of an individual light bulb, compounds dramatically across rooms across buildings across cities across the country.

Our solution to the problem of "over-illumination" is the "Smart Dimmer". This device will save energy without complicating current user models or requiring restrictive discipline measures. The "Smart Dimmer" will work not only with incandescent lighting but will also interface reliably with fluorescent fixtures. Our "Smart Dimmer" will measure the overall brightness in an area, this will be a combination of the lighting fixtures and the external light. It will use this information to control the fixtures and produce only the exact amount of illumination required to achieve the desired overall brightness set by the user. In operation, the "Smart Dimmer" will maintain a desired brightness in an area utilizing natural external light maximally whenever available. But whatever the external brightness the overall brightness will remain at a constant, user set level; imposing no complications on the user for this extraction of energy savings. It's the best kind of savings... the kind you don't notice.

With a moderate budget for this project of $468.12 we have already procured $600 from the Engineering Student Society Endowment Fund and expect to cover any extensive contingencies through the Wighton Fund.

Our schedule proposes a set of external Milestones corresponding to the documentation requirements of this project. In addition we outline a flexible framework of deadlines without too much restriction and while allowing for creative freedom. The most important factor in the successful execution of any project is the right people, and in this team we believe we have it. Our group consists of five proven and capable engineering students with a diverse background of both technical and non-technical skills. Aram Grigorian, Jonathan Kehler, Larry Zhan, Thomas Plywaczewski and Waris Boonyasiriwat are strongly motivated, meticulous individuals with high standards of professionalism.

2 INTRODUCTION

Consider the problem of providing illumination to a structure, a home, office building or warehouse. There are two main sources available though both originate from the same source, the sun. Figure 1 below illustrates how artificial and natural light both originate from the sun. As we can see, the energy from the sun moves through several forms before it produces artificial lighting: it has gone through the ocean, clouds, mountains, dams and generators before finally arriving at the light bulb. On the other hand, the natural light from the sun requires no transformation!

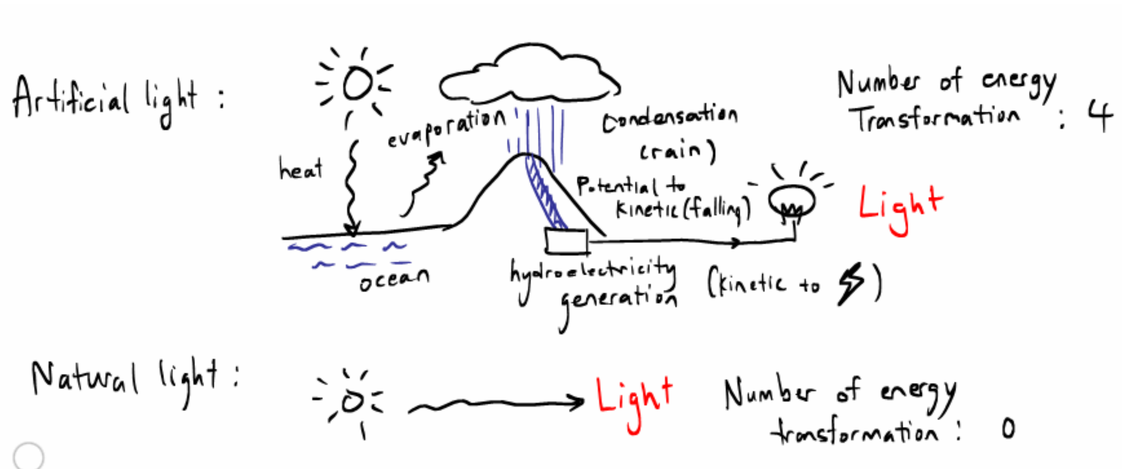


Figure 1: Comparison between the origins of artificial light to that of natural light.

Now which source would it make more sense to maximize? The latter, right? By maximizing the contribution from natural light we 'cut out the middle man' in a very significant way. Such is the goal of our product, the "Smart Dimmer" – a semi-automatic dimmer which cuts off unnecessary lighting whenever possible and without altering overall brightness!

With an increasingly green mindset the design of buildings are focusing on the maximal utilization of natural light through the use of glass and open design styles. We at Smart Light Solutions are aligning ourselves with this philosophy as we design a smart dimming switch which will take full advantage of the naturally available light in a space. While this revolution in building design will allow more light into structures, parts of the construction design are still stuck in the old ways. While installed lighting is needed for the evenings, it is used in excess to provide a constant "over-illumination" during the brightest parts of the day. This waste of energy is what we at Smart Light Solutions intend to solve. With our smart dimming switch we will reduce energy expenditures at times when external light can contribute to the overall desired illumination of a space, and most importantly we will do this without adding any complications to the user.

3 SYSTEM OVERVIEW

Imagine its early morning before sunrise. You wake up and turn on the lights to an appropriate level near maximum brightness as the sun is still down. As the day goes on and the sun rises it begins to assist in lighting your room. As the sun's contribution increases, the "Smart Dimmer" will turn down your lighting fixtures further as much as it can while still maintaining the overall level of brightness you specified that morning. So although you never notice any change in the overall brightness in the room you have saved energy throughout the day.

In a nutshell, the "Smart Dimmer" is a semi-automatic dimmer switch with awareness of the ambient light. This dimmer works in conjunction with the ambient light in order to achieve the desired brightness. In other words, it adds a closed-loop control to conventional dimmer switches, as illustrated in Figure 2. As we can see in Figure 2 (a), conventional dimmers are "open-loop" systems that dim the light according to some user input. Our "Smart Dimmer", on the other hand, introduces a feedback loop which controls the dim level based on the ambient light, as shown in Figure 2 (b).

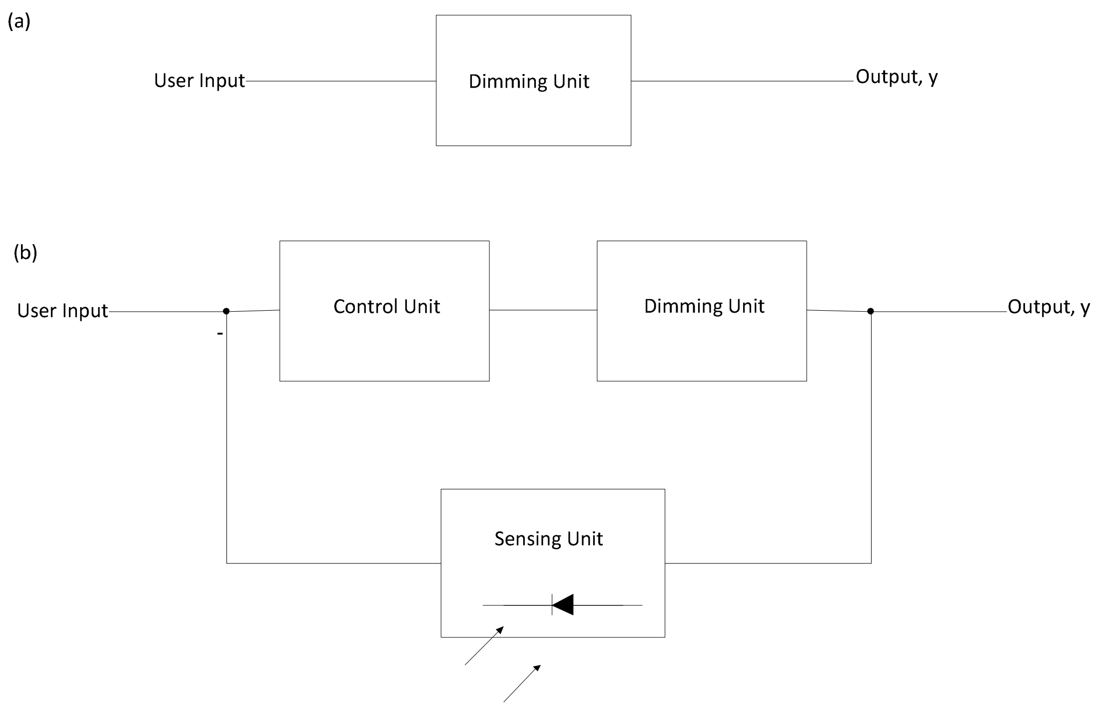


Figure 2: The system comparison between (a) conventional dimmer switch and (b) our Smart Dimmer. The conventional dimmer is an open-loop system which configures the light directly from human input, while out Smart Dimmer takes into account the overall brightness of the room.

The system can be considered to consist of 3 subsystems (see Figure 2). The first subsystem, the dimming unit, is very much like a conventional dimmer: it sets the amount of dimming according to some input. A slight modification from the conventional dimmer is that the input is electrical instead of mechanical. The second subsystem, the sensing unit, reads the brightness in the area, and sends this information to the third subsystem, the control unit. The control unit represents the intelligence of our system. By comparing the reference value to the ambient value, the control unit tells the dimming unit to compensate for the ambient light.

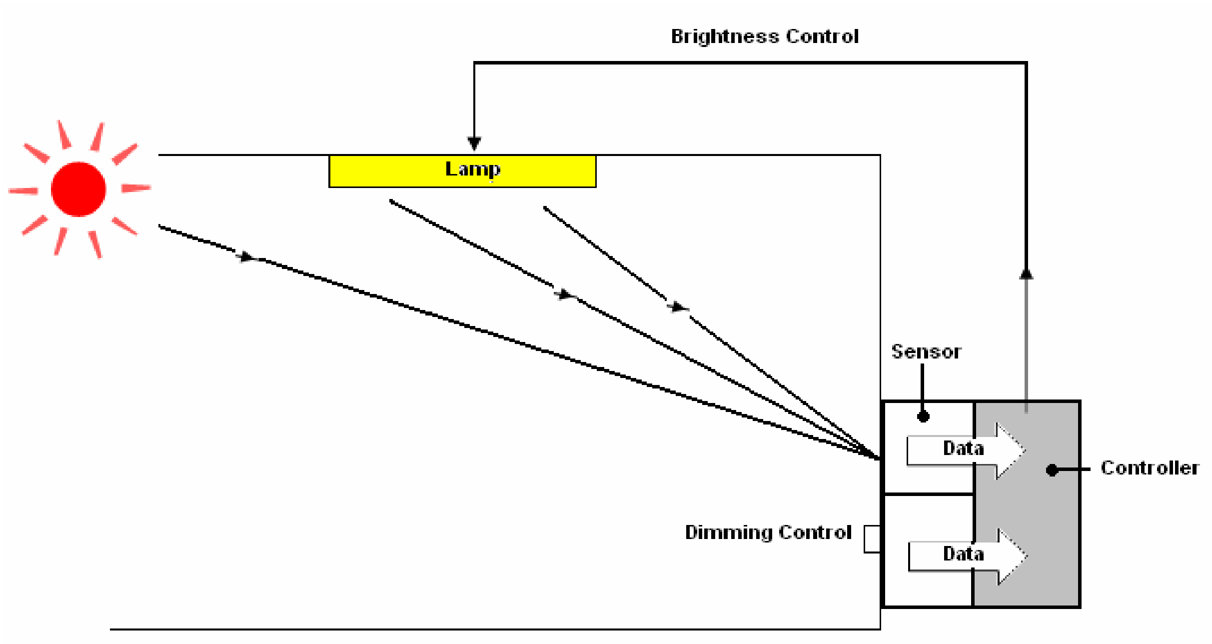


Figure 3: The physical overview of the system.

Figure 3 shows the physical layout of this system. As we can see, the sensor is located in the room in which the light is controlled. Information from both the dimmer switch and the sensor are then sent to the controller unit, which instructs the dimmer unit to dim the light/lamp to the optimum level.

4 EXISTING DESIGN SOLUTION

4.1 Ergolight

Ergolight is a form of "smart-lighting" that has a motion sensor detector built into every fixture. Each fixture is meant to be installed above every office cubicle for direct individual fluorescent lighting. The light can turn on two ways: by motion sensor detecting motion, or by user controlling the fixture via software on their computer. Individual dimming can also be controlled via software on the user's computer. The fixtures automatically turn off after about 10 minutes of inactivity.

While Ergolight is not a direct design solution of our “energy saving by dimming” concept, we would like to acknowledge how it saves energy by manipulating fluorescent lighting – something we desire to emulate.

5 PROPOSED DESIGN SOLUTION

5.1 The Thyristor Dimmer

Before describing our proposed design solution, we believe it is important for the reader to be familiar with the Thyristor Dimmer. Thyristor dimmer is a very commonly used implementation for conventional dimming in households. It dims the light by modifying the duty cycle of the AC voltage. This dimmer was brought to our attention in an article explaining how dimmers work by HowStuffWorks.com [1]. This design, whose schematic is shown in Figure 4, will be used for the "dimmer unit" described in Section 3.

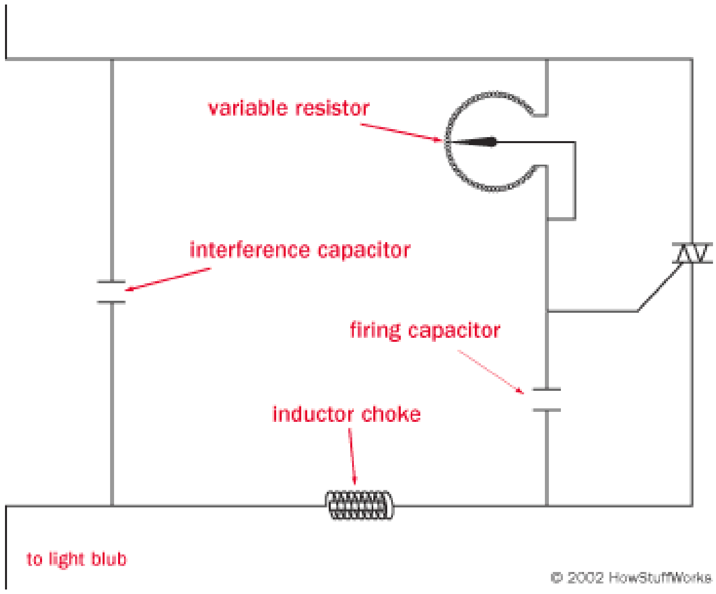


Figure 4: The schematic diagram of the Thyristor dimmer

5.2 Proposed Design

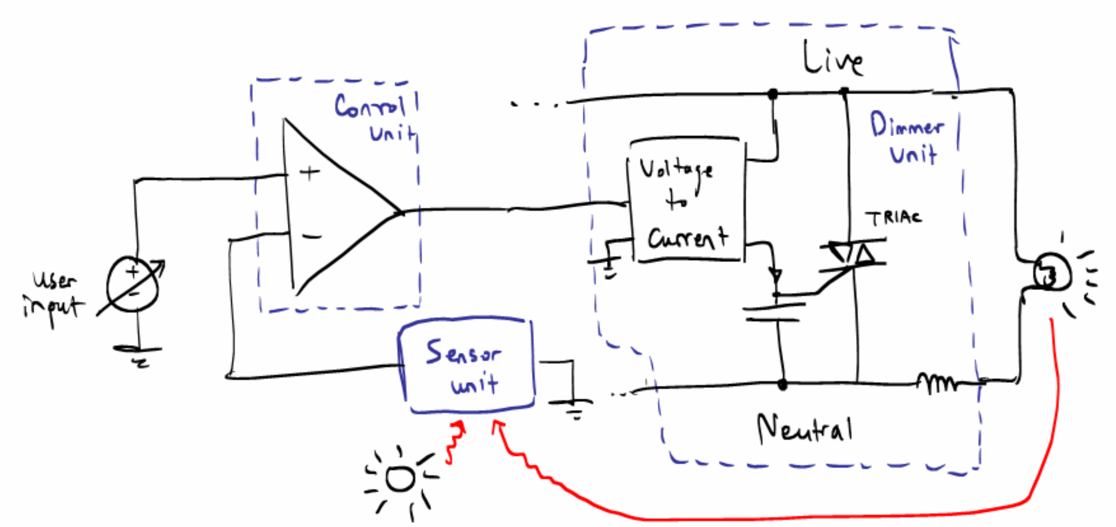


Figure 5: The circuit diagram of our all-analog design solution. The control unit is an op-amp negative feedback circuit, the sensing unit consists of a sensor which outputs a voltage to the op-amp, and the dimmer unit is the Thyristor dimmer implementation.

Our proposed design solution is an all-analog control system, as shown in Figure 5. As we can see in the figure, the dimmer unit is the Thyristor dimmer circuit described in Section 5.1. However, the mechanical variable resistor is replaced by a voltage-controlled current source. This allows the control unit to electronically vary the dimmer. The control unit is an electro-optical negative-feedback circuit. This circuit has 2 inputs: the user input and the sensor input. The output of the circuit is the voltage difference between the two inputs. However, a feedback loop is generated when the light from the artificial light source is picked up by the sensing unit.

We decided to use a purely analog control system as the intelligence needed in this circuit is very simple: it only involves subtraction of two signals. We realized this simple operation does not require the intelligence of a microcontroller. Using analog components not only reduces the overall cost of the system, but also provides seamless integration with the analog Thyristor dimmer.

6 SOURCES OF INFORMATION

Dr. Albert Leung of the School of Engineering Science, SFU, has provided us with great suggestions on how to implement the Thyristor circuit and the analog feedback control unit [2]. It was also him who brought our attention to the fact that dimming a fluorescent light bulb is much less straight-forward than dimming an incandescent light bulb. His pointers allowed us to discover the concepts of ballasts, compact fluorescent lamps (CFL) and dimmable CFL [3, 4].

7 FINANCE

7.1 Budget

Equipment List	**Estimated Cost**
PIC12F1840 Microcontroller and Programmer Board	$36.45
PQ1060SA-ND Potentiometer	$16.69
Semiconductor Devices (op-amps, transistors, triodes, diodes)	$10.00
Intersil ISL29001IROZ-T7xxx-ND Light Sensors (8)	$23.52
BluePlanet Dimmable Lightbulbs and mounts (6)	$53.97
120-to-12 V AC Step Down Transformer, BPE2E-ND	$26.13
Kill-A-Watt Energy Meter	$20.28
General Tools ™ Digital Light Meter	$99.00
Circuit Board for Prototyping	$18.60
Shipping and Handling (Digi-Key)	$50.00
Subtotal	$354.64
Contingency (20% of Subtotal)	$70.93
HST	$42.56
Total Cost	**$468.12**

7.2 Funding

We have already obtained $600 from the Engineering Science Student Endowment Fund. We expect to cover any contingencies with the Wighton Fund near the end of the project. We have also reached out to several companies marketing related products in the hopes of obtaining support and establishing a relationship. These relationships may be leveraged to potentially profit from our design upon completion.

8 SCHEDULE

Due to their large size, the project schedules are located in the Appendix (Section 12). They consist of a Project Schedule and a Project Milestones.

9 TEAM ORGANIZATION

At Smart Light Solutions we believe in a more interactive organizational structure. We believe strict hierarchical organization is never necessary because when you have the right people - and we believe we do - they don't need to be managed, only nudged.

On a relatively small project with a short time frame we believe efficiency should be maximized as much as possible. We aim to achieve this by assigning tasks by sub components of the project design, rather than by task type. For example we will assign groups of individuals to design, implement, debug, and unit test sub components of the project design - processes we are all familiar with. The advantage of this style is that each sub group need only worry about the technical details of their sub component which will save them time. The main disadvantage of this method will be at system integration time. This difficulty will be mitigated by developing strict integration parameters as early as possible. That is to say each sub group has the freedom to design and implement their sub systems in any way but MUST comply to rigorously defined input/output parameters. The Project Director will monitor to ensure that groups are conforming to these parameters and communicating any required deviations. For this purpose we will meet a minimum of once a week and focus on this specific issue frequently.

Also to increase efficiency administrative tasks will each be assigned to a single person. All document templates, graphics and designs will be the responsibility of Thomas as the Communications Director. In addition he will ensure all documents are submitted on time and in correct format. This will reduce the load of all the other group members so that while the authors of a document will be in charge of finishing a document, only Thomas needs to be aware of the details of submission.

John, playing the part of Project Director will focus on keeping the sub groups organized, ensuring they are organized and progressing at a reasonable pace. He will ensure when progress slows that solutions are found so it can get back on track for a timely completion of the project. John will also be mindful of impending system integration and will ensure communication flow between subgroups so that vital information is forwarded to ensure smooth integration of sub components.

Waris will be in charge of all parts sourcing, ensuring all subgroups have adequate equipment to complete their tasks. This will reduce any overhead the sub groups may otherwise face when attempting implementation of their sub components and allow them to simply focus on the execution.

Having our product meet any legal requirements and accepted standards will be the responsibility of Larry. He will ensure our design and implementation is within any standards for such a product - to the best of our capability. This will ensure the final design is a saleable product.

With a system that aims to save energy, we must ensure optimum efficiency both in power consumption and cost. As our Optimization Director, Aram will ensure that we use all electrical components to their maximum efficiency and with the least amount of energy possible.

With this overall organization we hope to achieve the effect of minimizing administrative, managerial and organizational overhead for individuals as they work on the technical portions of the project.

Finally, in keeping with the theme of efficiency we intend on limiting documents to two authors each. In our experience the most time consuming portion of writing collaborative documents is merging tone, style and formatting. We will reduce the load on the two authors by doing group brainstorming and proofing of each document, thought actual writing will be done by the authors. This will focus the load of documentation on group members to a short period of time, freeing them up to focus on technical development during the times they are not authoring a document.

10 COMPANY PROFILE

Jonathan Kehler - Project Director

John is a fourth year Computer Engineering student with a focus on embedded systems. He has practised organizational and management experience in addition to extensive industry experience. Having a strong attention to detail and a tendency to see the higher level view, John will be vital in ensuring all parts of the project integrate and function smoothly as he takes on the role of Project Director.

Aram Grigorian – Optimization Director

Aram is a fourth year Computer Engineering student with advanced firmware and software experience. He has experience in digital design, microcontroller applications and extensive software programming. With a variety of personal projects ranging from a popular iPhone app to a custom built, walking robot Aram's motivation and expertise will be invaluable as he takes on his role as our Optimization Director.

Thomas Plywaczewski - Communications Director

Thomas is a fourth year Engineering Physics Honors student. In addition to his experience with physical systems and electronic circuits he has strong skills in marketing and communications. Thomas' time as an executive member of the Simon Fraser Student Marketing Association and his personal time as a DJ give him a strong sense of design aesthetics. His previous role as a Reliability Compliance Co-op at BC Hydro focused heavily on communication and documentation management and Thomas will bring this expertise to his role as the Communications Director.

Waris Boonyasiriwat - Technical Director

Waris is a fourth year Engineering Physics Honors student focusing on optics relating to human vision. His experience includes eight months researching, sourcing and building advanced prototype circuits and working with laser and optical systems. Waris brings this extensive experience with advanced technologies to his role as Technical Director.

Larry Zhan - Compliance Director

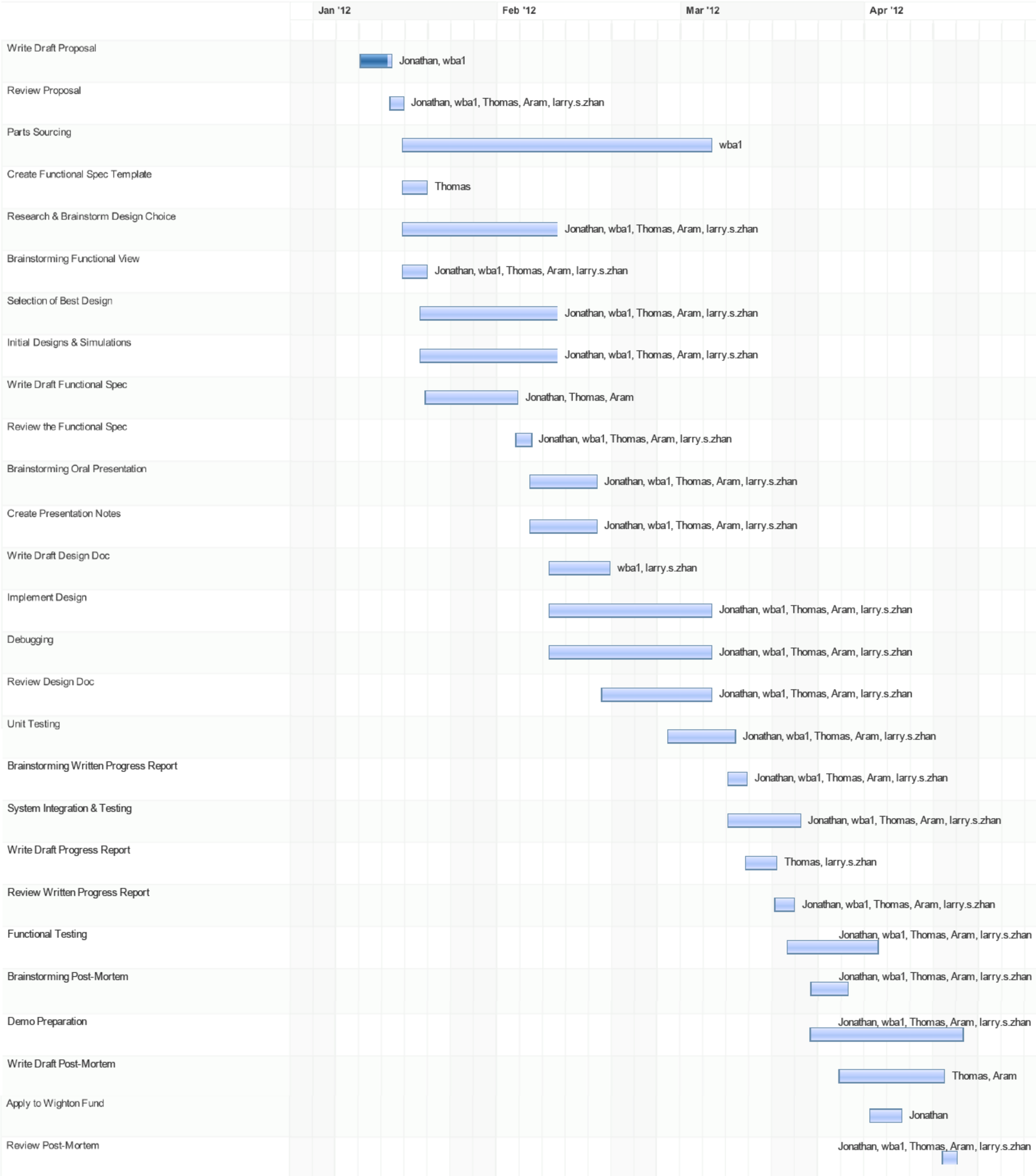
Larry is a fifth year Electronics Engineering student with extensive hardware experience. Larry is well versed in properties and functionality of electronic components as well as being experienced in building and analysing both analog and digital circuits. Most recently he is learning to design switch-mode power converters for large analog systems. Larry will bring this experience as he takes on the role of the Compliance Director.

11 CONCLUSION

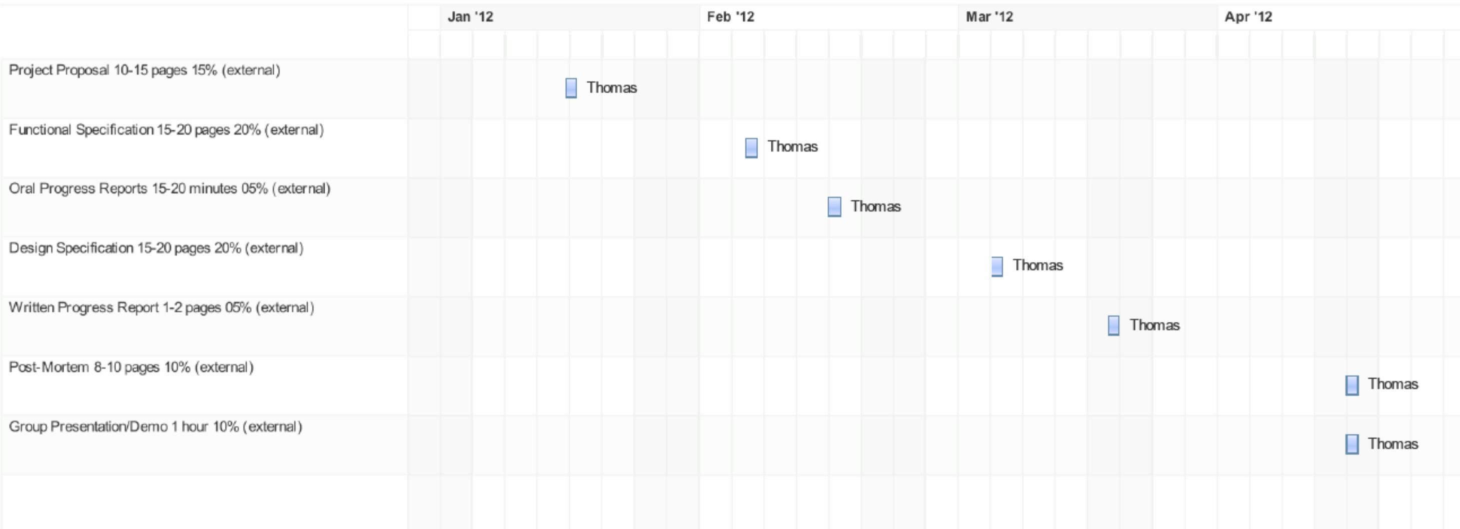
In closing, we have defined a significant problem that is the waste of energy in the "over-illumination" of homes and offices all over the world. We have provided a solution which will integrate easily with current usage models, imposing no additional requirements on the user. We have also shown how we can accomplish this in only four months and with a budget under $468.12. And we have shown that our team has the necessary skills and the vision to see this project through to a successful end. We anticipate no major obstacles and expect to have a functioning prototype by April 16, 2012. Thank you for your time in reviewing this proposal and hope you will seriously consider approving it. Please don't hesitate to contact us for more information.

12 APPENDIX

Project Schedule



Project Milestones



13 REFERENCES

[1] Harris, Tom. "How Dimmer Switches Work". HowStuffWorks.com. http://home.howstuffworks.com/dimmer-switch4.htm. Accessed Jan 13, 2012.
[2] Leung, Albert. Meeting Conversation. Noted in Zohoprojects. Jan 11, 2012.
[3] "Light Guide: Fluorescent Ballasts". Light Guide. http://www.lightsearch.com/ resources/lightguides/ballasts.html. Accessed Jan 9, 2012.
[4] Ribarich, Tom. "How compact fluorescent lamps work – and how to dim them". http://www.eetimes.com/design/power-management-design/4010360/How-compact-fluorescent-lamps-work-and-how-to-dim-them. Sept 3, 2009. Accessed Jan 9, 2012.