Post-Mortem for a Dynamic Pupil in a Prosthetic Eye

January 14, 2005

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

Re: ENSC 340 Post-Mortem for a Dynamic Pupil in a Prosthetic Eye

Dear Dr. Rawicz:

The attached document, *Post-Mortem for a Dynamic Pupil in a Prosthetic Eye*, outlines the current and future states of our product, including different problems we had to tackle throughout the project, problems we hope to fix, time and budget management and our personal experiences.

Our team, Dyno I, consists of four talented, enthusiastic and hard-working forth year engineering students. These individuals include: Nima Kokabi, CEO; Houman Hatamian, CFO; Ali Taheri, CTO; and Arash Taheri, COO. Please feel free to contact us at ataheri@sfu.ca if you have any questions.

Sincerely,

Nima Kokabi

Nima Kokabi
CEO
Dyno I

Enclosure: *Post-Mortem for a Dynamic Pupil in a Prosthetic Eye*

Post-Mortem for Dynamic Pupil in a Prosthetic Eye

Members: Nima Kokabi
Houman Hatamian
Ali Taheri
Arash Taheri

Contact Person: Arash Taheri
ataheri@sfu.ca

Submitted To: Dr. Andrew Rawicz-ENSC 340
Mike Sjoerdsma
Scott Logie
School of Engineering Science
Simon Fraser University

Date of Submission: January 14, 2005

Post-Mortem for a Dynamic Pupil in a Prosthetic Eye

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1. Introduction:

Prosthetic eyes have been used to replace fatally diseased human eyes since the beginning of the 19^{th} century. Even though the cosmetic aspects of the artificial eyes have come a long way since its inception, a major short coming still exists in modern designs of these eyes. Ocularists, people who custom-make the prosthetic eyes, have quite improved the cosmetic aspects of these eyes as far as color matching between the real eye and the artificial eye in a patient is concerned, both in the eye ball and the iris. Being able to utilize a dynamic pupil in an artificial eye would tremendously improve the esthetic of such eye and make them very similar to a functioning healthy human eye.

We at Dyno I propose to design a dynamic pupil that will be utilized in a prosthetic eye. This pupil will consist of a custom-made LCD. Furthermore, to control the intensity of the ambient light, we utilize a super small micro controller which will be programmed in a way that when used in conjunction with LCD, the overall system would replicate the functionality of a real pupil.

We, at Dyno I, concluded that our project would offer the following benefits over the existing solutions:

- Small size of the system does not occupy lots of space.
- Easy to use as no training would be required for the patient.
- The device is able to last for almost two years before replacing it again.

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2. Present State of the System

This section of the document provides the current state of our system design at Dyno I. Figure 2.1 below illustrates the overall high level design of our dynamic pupil system in a prosthetic eye. The operation begins with a light sensor monitoring the intensity of ambient light around the eye. In fact, the diode converts the light intensity to an electrical signal that can be constantly monitored by a control unit. The control unit in turn controls the LCD that replicates the pupil. This pupil effectively opens up and closes similar to a real pupil according to the intensity of the ambient light. The higher the intensity of the light, the smaller the pupil becomes; as a result, less light is allowed to enter the eye. Similarly the lower the intensity of the light, the larger the pupil diameter becomes which causes more light to enter the eye.

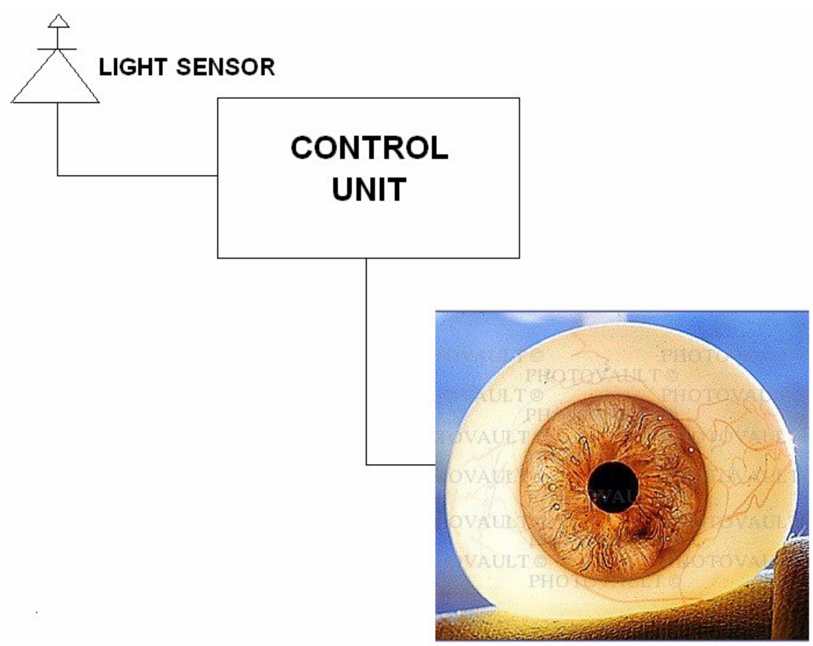

Figure 2.1: Overall High Level Design of the Dynamic Pupil System

Figure 2.2 illustrates how a typical eye would look at different ambient lights. The eye on the left side is situated in a dim ambient light which has caused the pupil to open up a great deal. On the other hand, the same eye when placed in a bright environment shows a very small pupil. This is shown in the eye on the right hand side of figure 2.2.

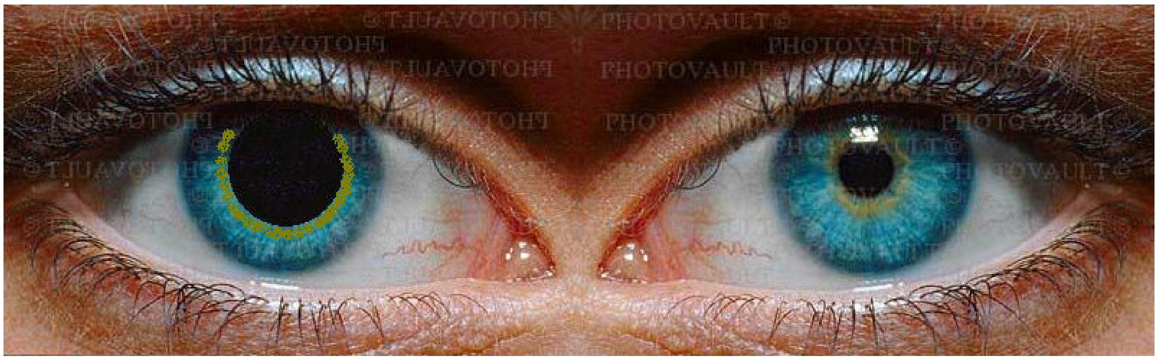

Figure 2.2: Illustration of a typical eye at different Ambient Lights

The uniqueness of the dynamic pupil prosthetic designed by Dyno I is that the entire circuitry is so incredibly small that it can be situated in the front portion of the prosthetic eye. The circuitry is also designed to be heat sensitive so that when placed in the initial mold of the artificial eye, it can be easily cured along with mold at high temperature for sterilizing purposes. The small size of this system also bears the advantage of this system being easy to be used by patients. They can use the same procedure used to clean current prosthetic eyes without worrying about any external components or connections.

Figure 2.3 on the next page illustrates the overall flow chart of our design. As the figure represents, the photodiode acts as a light sensor, detecting light from the surroundings. The microcontroller monitors the different intensities of the ambient light. When the intensity of light increases, microcontroller notices this difference and forces the size of the pupil to decrease. Furthermore, decreasing the intensity of ambient light forces the size of pupil to increase by the aid of the microcontroller. However, when intensity of light stays constant, no difference is detected by the microcontroller; as a result, size of the pupil stays the same. Moreover, after the first search mode is complete and the necessary action is taken place, the system goes back to its original monitoring mode in order to be able to detect a different intensity of ambient light.

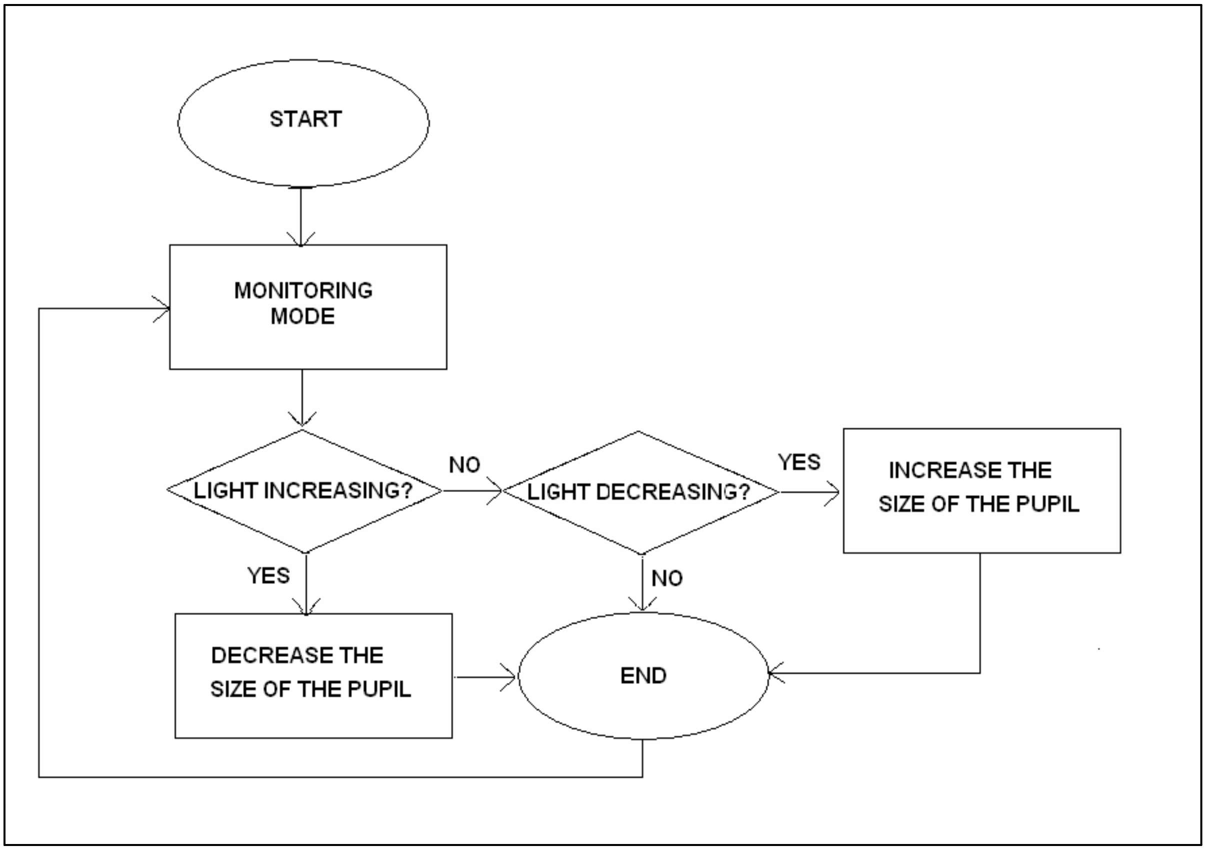

Figure 2.3: Overall Flow Chart Design of the Project

3. Remaining Issues:

The device works perfectly as explained earlier in both Functional and Design Specification documents; however, there still exist several issues that should be resolved.

3.1. Overall Size of the Device:

The biggest complication faced by our group in designing the dynamic pupil system is that we have to design the whole system, including the battery and the circuit board, small enough that it can be fit into the mold that forms the front of the artificial eye. Figure 3.1.1 shows the major components of an artificial eye, which consists of an orbital implant as well as the front portion of the artificial eye, which is mainly made by plastic mold, custom-built to fit individual patients.

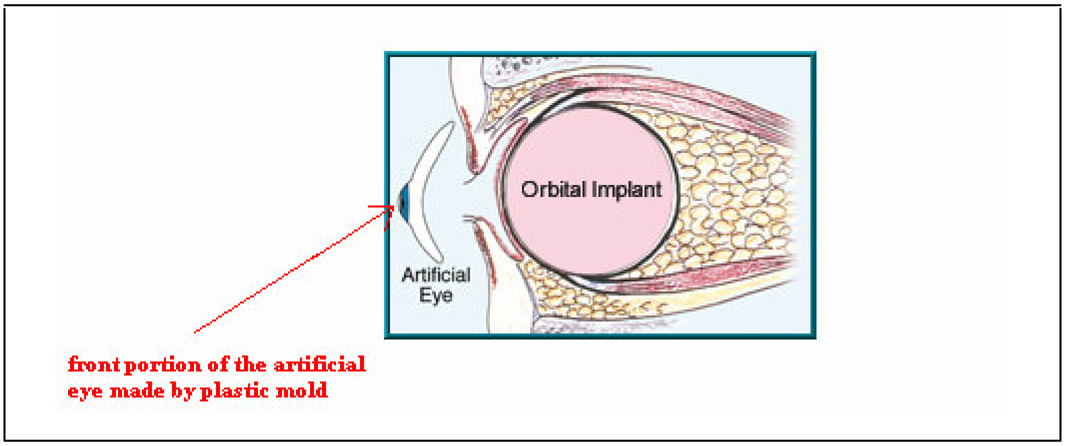

Figure 3.1.1: Major Components of an Artificial Eye

As you can see from the above figure, the front portion of the artificial eye has a very limited space to work around with. As a result, we at Dyno I, had to design the whole device to fit in such small space.

As mentioned in past documents as well, one of the best features of our product at Dyno I is its practicality. This means that we can no longer demo our project on bread boards, as it will not make it practical. As a result, we worked with very professional software called "PowerPCB" or "PowerLogic". By the aid of the mentioned software, we were able to make our schematic design in PowerLogic. Later, we were able to link our design from PowerLogic to PowerPCB in order to make a very small PCB.

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Figure 3.1.2 below, represents the schematic diagram of our final design, taken from PowerLogic:

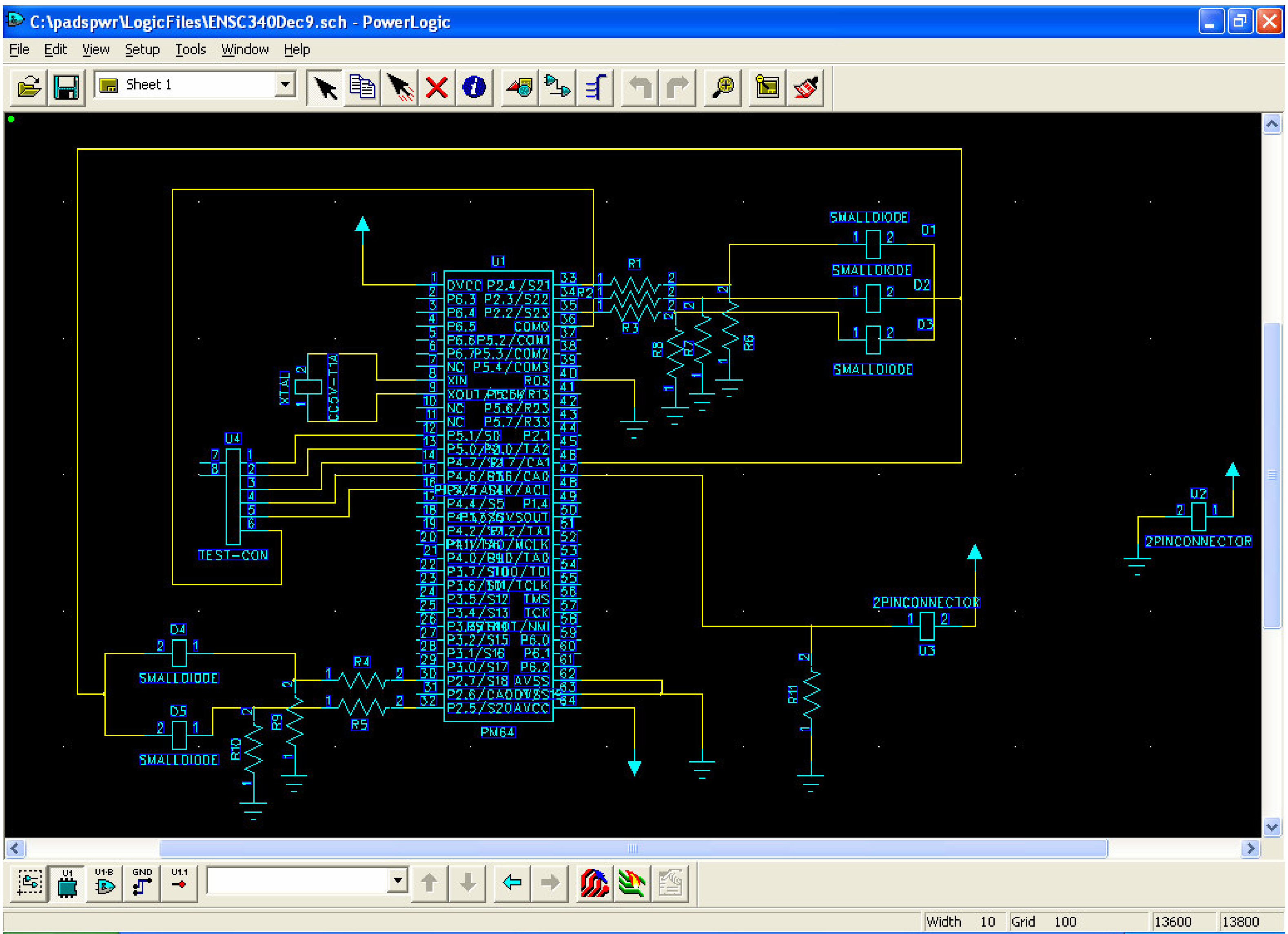

Figure 3.1.2: Overall Schematic Design taken from PowerLogic

In order to be able to fit the whole system inside an artificial eye, we were forced to choose our components such as LCD, battery, resistors, and so many other devices as small as possible. The size of our PCB was designed to be 15 mm by 15 mm. Figure 3.1.3 illustrates the final design of PCB taken from PowerPCB software:

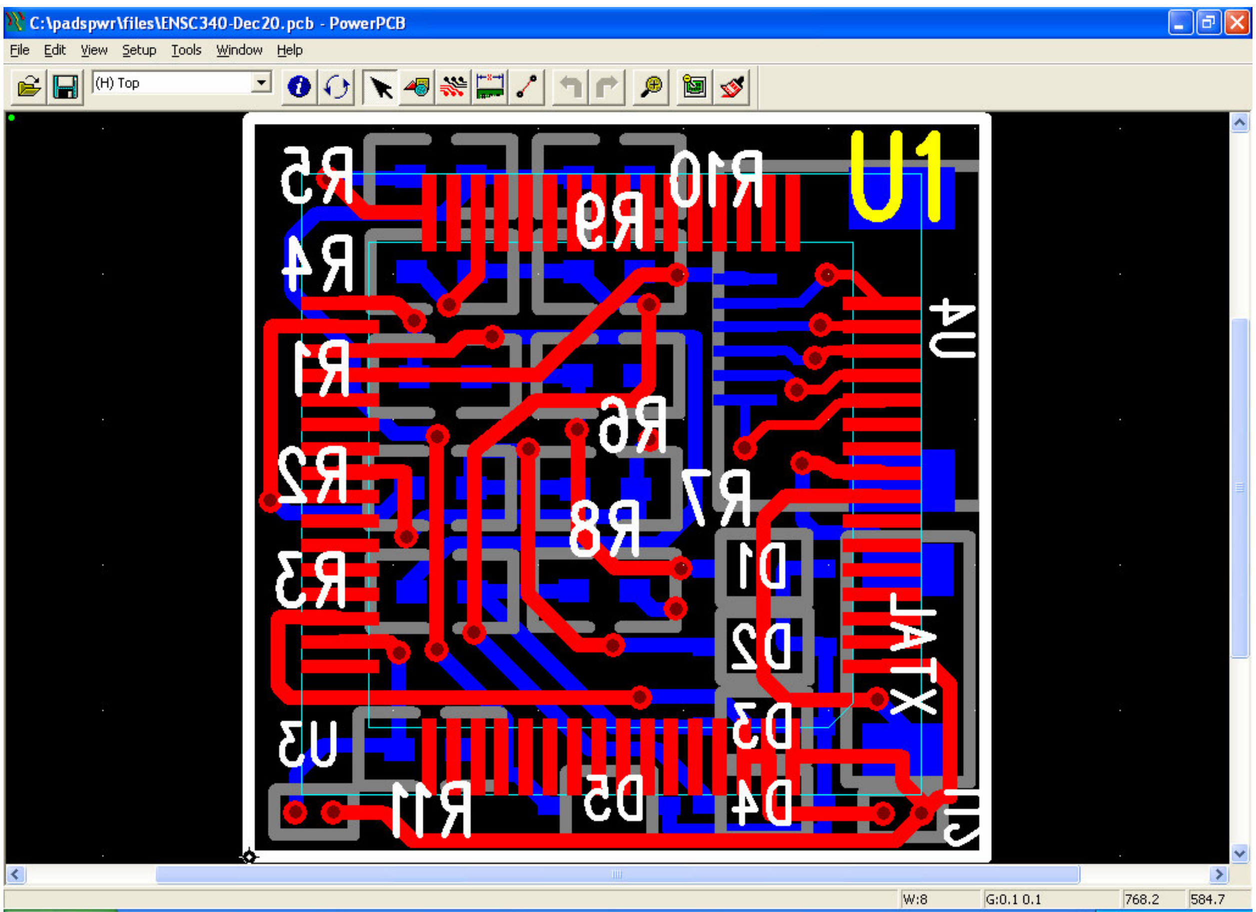

Figure 3.1.3: Final Designed PCB taken from PowerPCB

It is important to mention that the red color represents connections made on the top layer, and the blue color illustrates the connections made on the bottom layer of our designed PCB.

3.2. Routing

One of the main difficulties of making such small PCB relied in making the connections between different components, or in other words “routing”. Due to the space constraint of the device, it is very important to use each small space of the board effectively and the routings must be done accurately. Due to the fact that all the components are located near each other, careful placements should be decided in order not to short any parts of the circuit together.

The PCB designed by “Dyno I” contains two different layers called “Top Layer” and “Bottom Layer”. MSP430 Microcontroller that is being used by our company is considered as the biggest device used in our design. As a result, due to space limitations, it was decided to locate the microcontroller on the “Top Layer” and the rest of the components on the “Bottom Layer” of the PCB. Figure 3.2.1 and 3.2.2 represent the routings taken place on “Bottom” and “Top” layers of the PCB respectively.

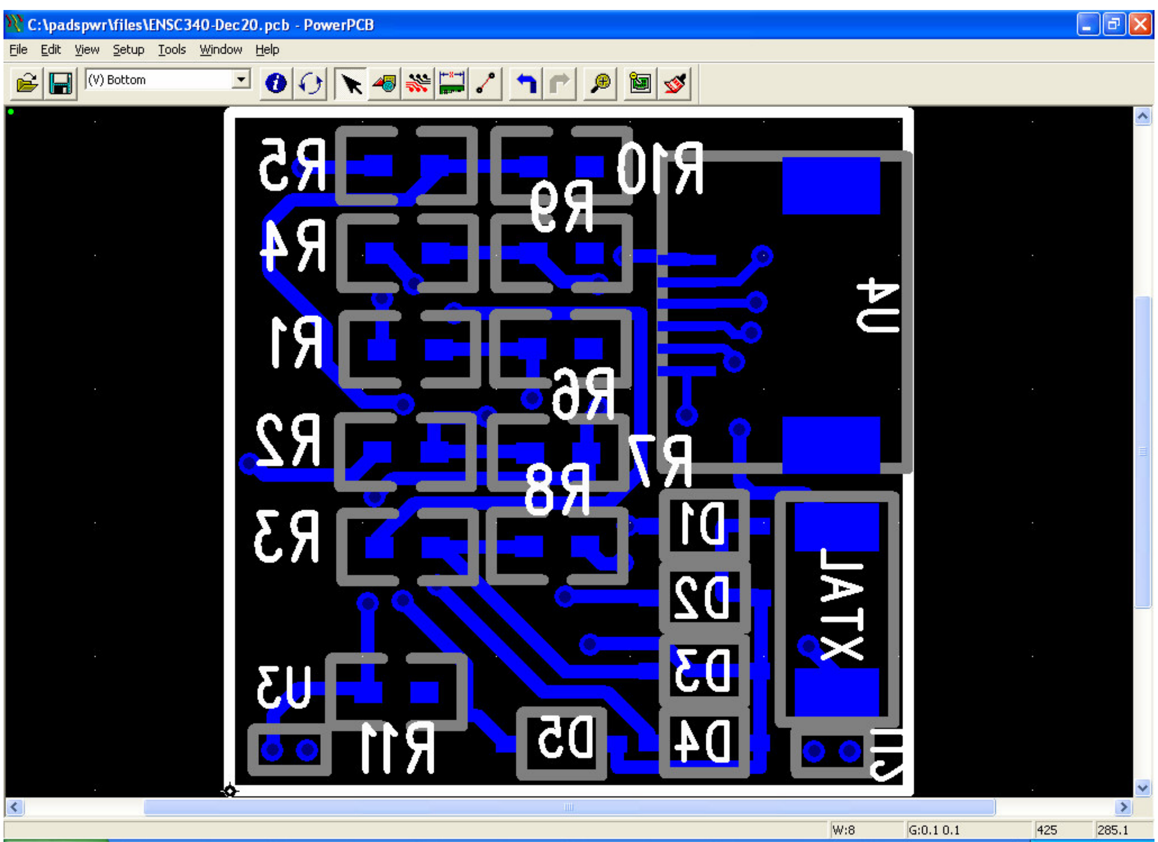

Figure 3.2.1: Routings taken place on the Bottom Layer of PCB

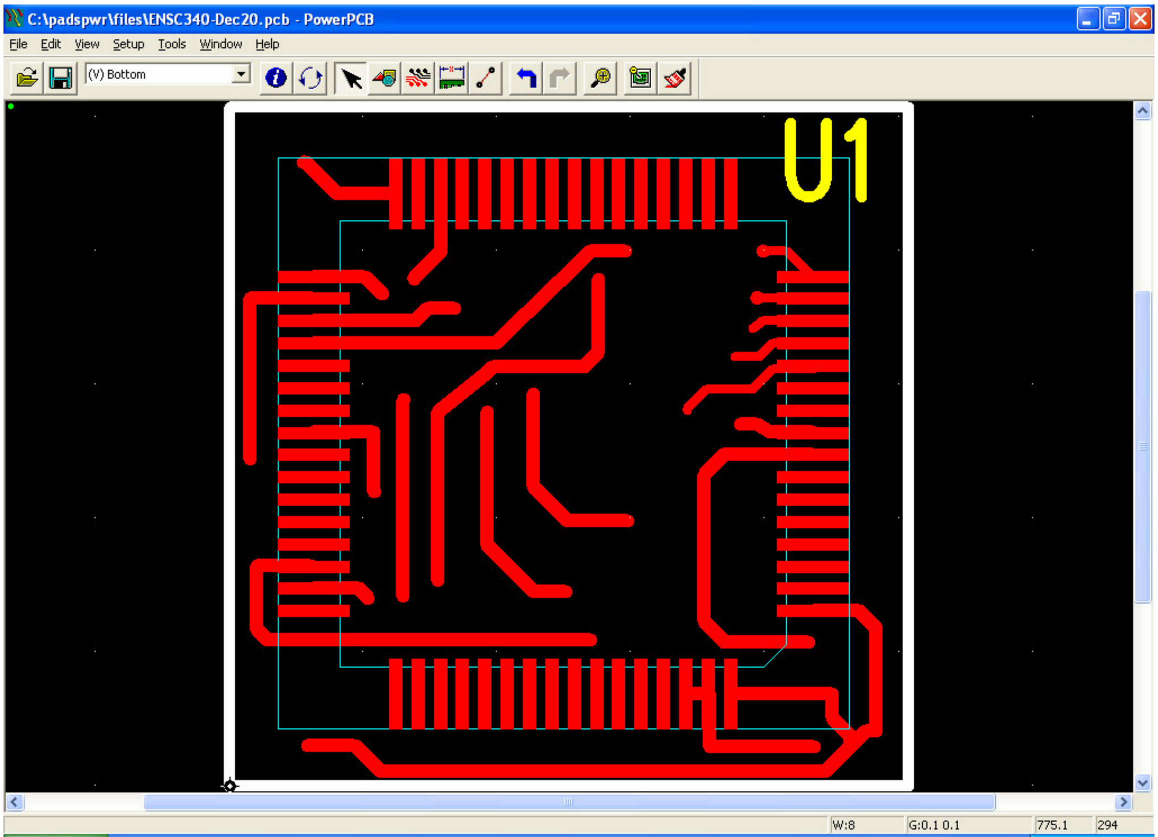

Figure 3.2.2: Routings taken place on the Top Layer of PCB

3.3. Soldering the Components and Assembling the Board

After finishing the design of the PCB by using "PowerPCB" and "PowerLogic", Dyno I took one step further in making the actual PCB by the aid of "Dyco Circuits" Company. Figures 3.3.1 and 3.3.2 on the next page represent the bottom and top layers of the PCB made by "Dyco Circuits". As illustrated in the diagrams as well, the top layer is used to place the microcontroller and the bottom layer contains the rest of the components used in the unit.

As it is apparent by looking at these two figures, the PCB is very small in size and the connections are separated from one another by a very small space. As a result, the most difficult task is to solder all the components, such as microcontroller and resistors, on the PCB.

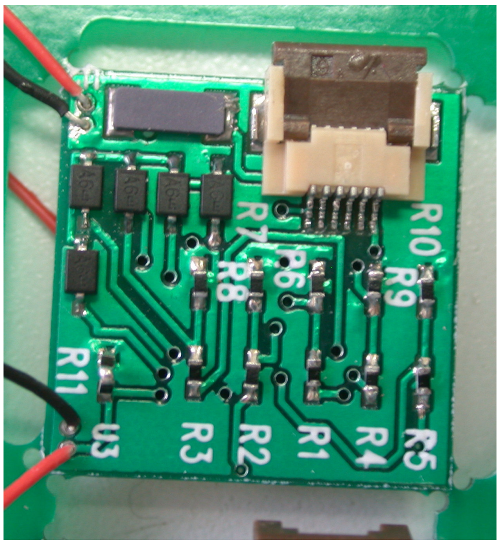

Figure 3.3.1: Representing the Top Layer

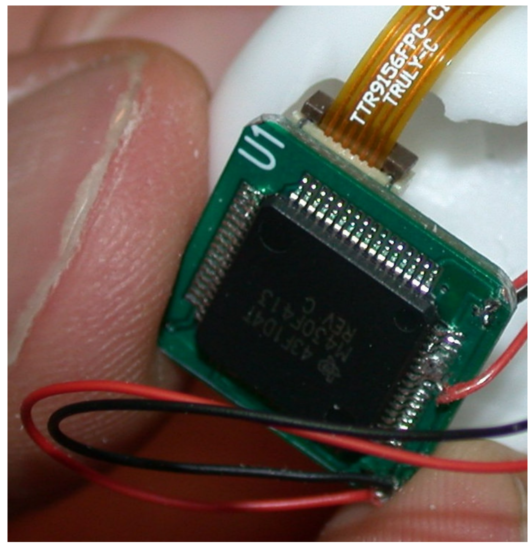

Figure 3.3.2: Representing the Bottom Layer

As figure 3.3.3 shows, the components used in our circuit are really small and soldering them on the PCB requires a very professional job. As a result, "Dyno I" used the help of professional people in soldering technique at "Dyco Circuits" in order to be able to finish the task in a very professional manner. Figure 3.3.3 illustrates just how small the components are and how accurately they need to be installed on the PCB in order to avoid any kind of damage both to the board and the components.

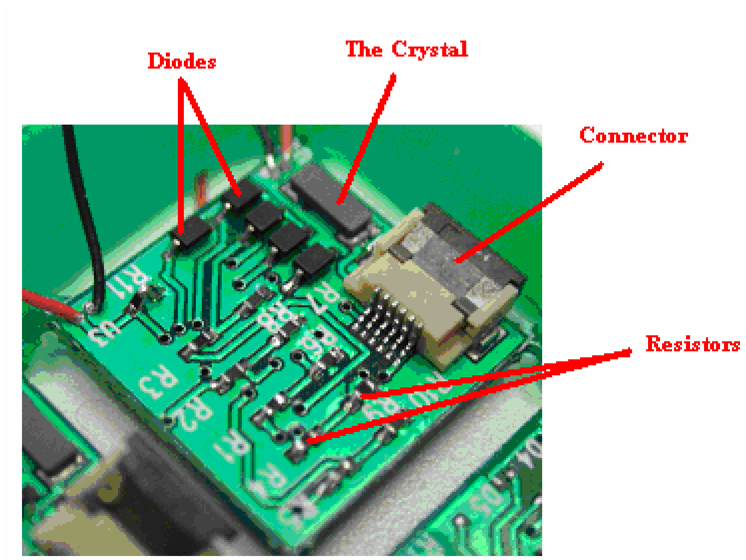

Figure 3.3.3: Comparing the size of the Components with the board

Knowing the fact that the whole circuit is about 15 mm by 15 mm, it is clearly evident just how small the diodes and the resistors are and how hard it would be to solder them on the PCB.

3.4. Finishing the Final Product

The final and one of the most challenging steps of the project was to place the final product inside a made artificial eye. This was a very hard task to accomplish, due to the lack of having so much space inside the artificial eye. However, we at "Dyno I" were able to overcome this last problem facing us in making the final product. Figure 3.4.1 below represents the overall system, containing both the artificial eye and the PCB placed inside it.

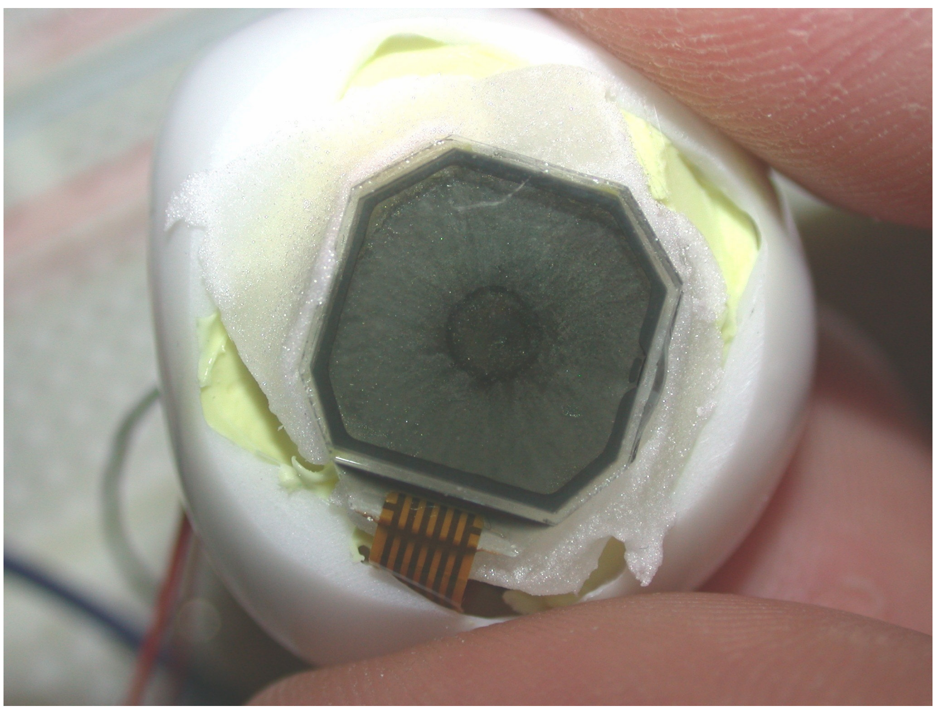

Figure 3.4.1: Representing the Overall System inside the Artificial Eye

Figure 3.4.2 illustrates the scheme of the project from making the PCB to actually placing it in an artificial eye for the use of patients.

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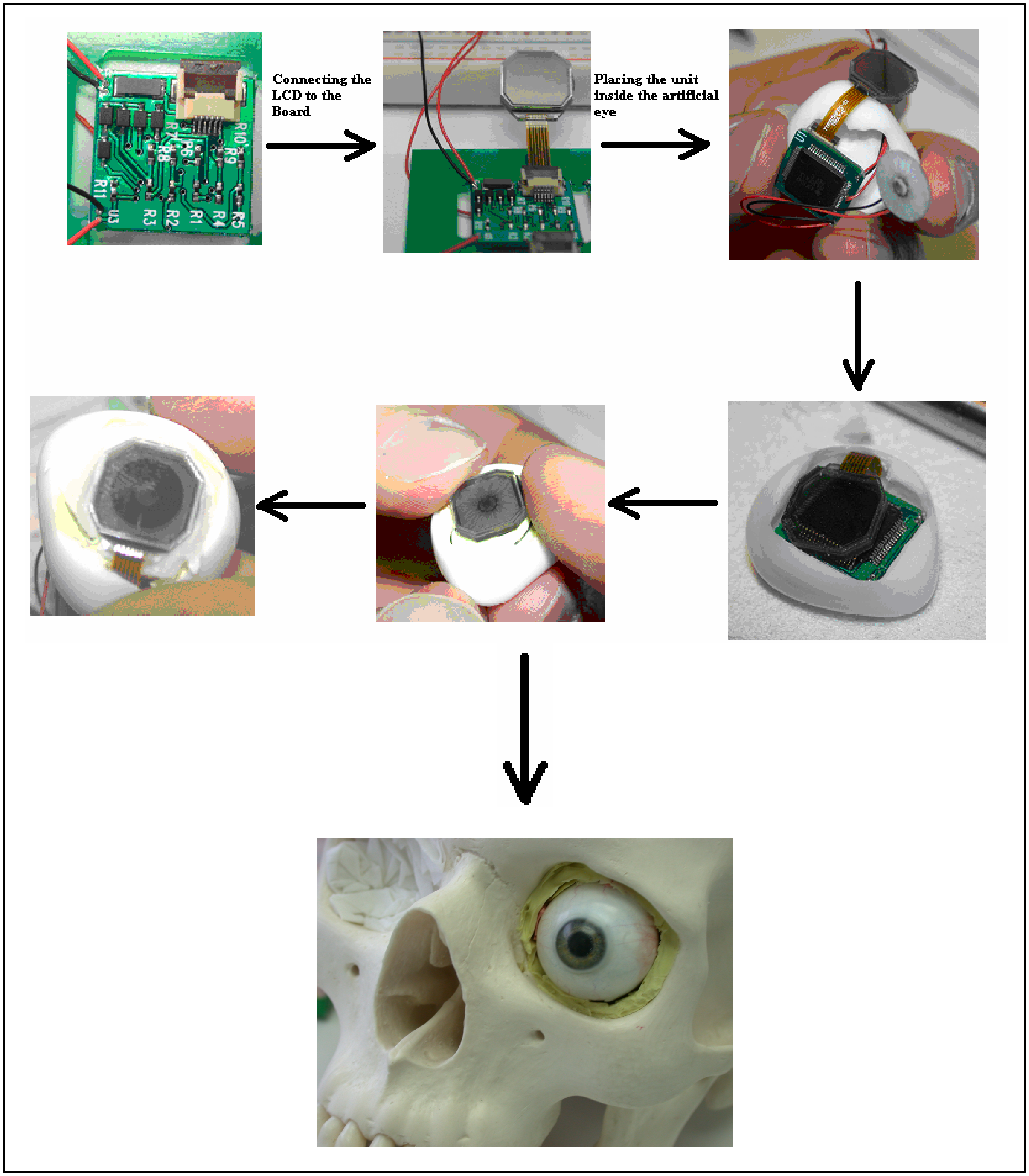


Figure 3.4.2: Flow Scheme of the Project in making the Artificial Eye

4. Budget and Time Constraints

In this section of the document, budget and time constraints of the project throughout the term will be discussed.

4.1. Budget

Table 4.1.1 illustrates the comparison between the proposed coast and actual spending of the project.

Table 4.1.1: Estimated Versus Actual Costs

Required Material	Estimated Costs	Actual Costs
MP430X Microcontroller	$10 USD	$20 USD
Flash Emulator Tool (FET)	$ 150 USD	$ 99 USD
Transparent Clock	$ 20 CND	$ 15 CND
Custom-Made LCD	$4000 USD	$4350 USD
PCB	$600 CND	$300 CND
Light Sensor(photodiode/pack of 10)	$ 100 CND	$ 50 CND
Battery(pack of 10)	$ 20 CND	$ 50 CND
Material Supplies(Books and Guides)	$ 250 CND	$ 350 CND
Crystal (pack of 100)	$50 CND	$200 CND
Resistors and Diodes	$50 CND	$100 CND
Subtotal	$6082 CND	$6429
Contingency Cost	$300 CND	$250 CND
Total Budget	**$6382 CND**	**$6679 CND**

The actual costs that are shown above are tentative due to the fact that we will be going to the 2005 WECC Competition in Winnipeg, Manitoba during the last week of January. As a result, additional costs may include transportation and some extra activities during this important event.

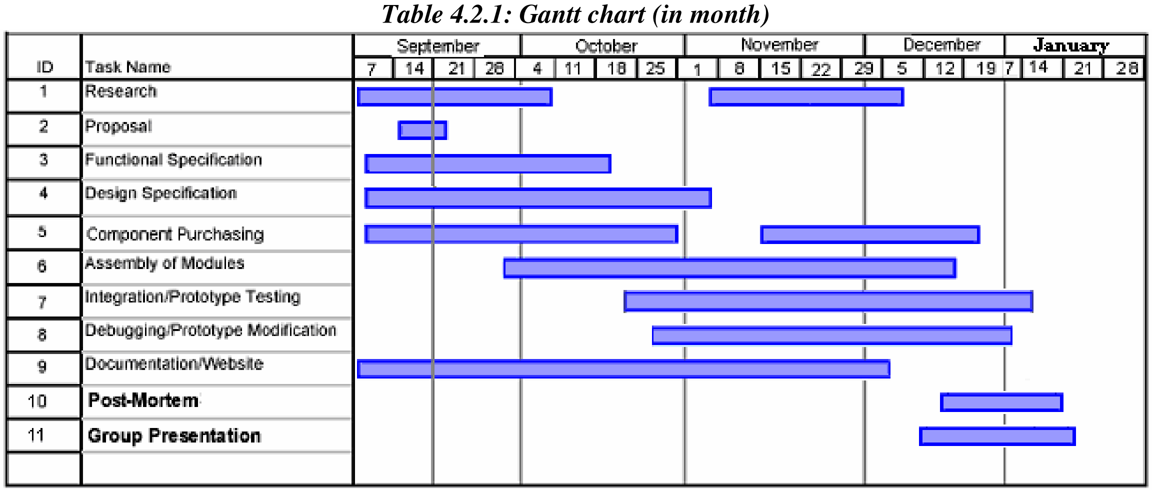
During the course of this project, the members of “Dyno I” were able to reduce the costs on the microcontroller and emulator by getting additional discounts from their companies.

Furthermore, we were able to obtain ten extra microcontrollers for free of charge from Texas Instruments. Moreover, as indicated in the proposal of this project, we at "Dyno I" are working with Dr. Peter Dolman, who overcomes a lot of financial needs of the company. The wiring and cables were obtained from the Engineering Science Lab at Simon Fraser University.

4.2. Time

The final Gantt chart for the course of this project is shown in the following table:

Table 4.2.1: Gantt chart (in month)



it is important to mention that selecting the necessary components and purchasing them took more time than it was expected originally due to the fact that some certain modules required careful considerations. For example, soldering the components on the PCB took more than about 20 days, due to the fact that some companies were not able to either do the job or did it wrong.

Furthermore, designing the actual product and implementing it required much more time than we expected. This delay was due to the fact that understanding the difficulties and complexity of some certain stages of the device, such as programming the microcontroller, was time consuming.

Overall, finishing the project took about a month more that it was expected at the beginning of the project. This delay was mainly because of ordering a very special custom-made LCD by the company. We at "Dyno I" ordered the special LCD in the middle of October 2004; however, the company was able to finish the job by the middle of

December 2004. Furthermore, as indicated earlier throughout this document, making the double-layer PCB and soldering the components on it happened by the aid of two different companies. As a result, due to fact that all companies were closed for the holidays, we were not able to finish the project by the middle of December. However, the company geared up and was able to finish the job successfully by the first week of classes in January 2005.

5. Inter-personal and Technical Experiences

Nima Kokabi

As one of the most important courses of my engineering studies, ENSC 340 was a great experience for me as it provided me with the opportunity to test my skills in the fields of leadership and organization. As the leader of the team, my most important job was to divide our project into many mini-projects and distribute them to the members of the group, considering the fact that each task should be given to the members of the company according to the profession of them.

Learning how to achieve a balance between accomplishments of goals and learning, is one of the most important experiences that I gained by managing this project. Because, by maximizing the learning, there was a chance of not being able to finish the project and by maximizing the accomplishments, only a few members of the company were able to learn new things.

By assigning different mini-projects with different levels of difficulty among the members of the team, I had to resolve some group dynamic issues in order to be able to keep the group running at full strength.

Last of all, my cooperation with "Dyno I" has helped me to gain an idea of how much our technical learning at Simon Fraser University can have such a profound effect on a great portion of our community.

Arash Taheri

I would like to start by mentioning that I was looking forward to work on ENSC 340 with my team members even before the start of fall 2004. Due to the fact that I used to work with the same team members most of the times in my courses throughout these four years, I knew what to expect from them; as a result, we were so comfortable working together as a team. Since we all knew each other's strength, interest, and personalities, we were able to save time from the beginning and assigned appropriate tasks to each other, according to the profession of each other. By taking this course, I realized how important it is to learn as much as possible from each course that we take from the first year of our studies to the end. ENSC 340 helped me in great extent to tie many fields of engineering studies for a better understanding of engineering work.

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Post-Mortem for a Dynamic Pupil in a Prosthetic Eye

I was given different tasks to accomplish during the different stages of the project, according to the fields of my profession. During the early stages of the project, I helped Nima in ordering different components for our circuits by phoning different companies in Canada and in the United Stages and purchasing the necessary materials from them. One of the most important tasks of mine was to be in charge of designing and building a double-layer PCB, using PowerPCB and PowerLogic software, to be placed inside the artificial eye. Furthermore, I was in charge of ordering the PCB's to be made through "Dyco Circuits" Company. Moreover, Ali helped me in finishing most of the documentary part of the course.

By finishing this project, I have been able to increase my knowledge of circuit design, software programming, and PCB designing. I believe such knowledge will become handy in my future researches. Moreover, I feel that group dynamics problems are able to be prevented from happening if every one knows the current stage of the project and the stages that the project will be heading to. Also, most important of all, I have learned that as a team, it is possible to accomplish anything.

Houman Hatamian

ENSC 340 was one of the most memorable and useful course that I have ever taken. I was able to learn more than any other courses that I have taken so far at SFU. I was able to gain the experience of working in a team and I am sure that such experience will help me in great extent later in my life.

On of my biggest interests is in the field of computer programming. In fact, I always want to learn new techniques in programming, and that could be the reason why most of the programming sections of the project were expected to be done by me. My most important job in company was to program a super-small microcontroller in order to control the size of the pupil of an artificial eye with respect to different intensities of ambient light. The pupil of the artificial eye that is designed by our company is formed by a custom-made LCD. As a result, my role was to make a computer program, using C, in order to be able to control the number of rings of the LCD with respect to the different intensities of light in the surroundings.

ENSC 340 thought me that working in groups, not only helps individuals to achieve their goals, but also improves the timeline of the project as it speeds up different stages of the project.

Ali Taheri

I really have to confess that ENSC 340 was one of the most challenging, but enjoyable courses that I ever took at SFU. This course was challenging due to the fact that we were faced with both technical and timing issues.

During the course of this project, I was mostly responsible to help Arash in finishing the documentary portion of the course. I was also involved in preparation of the needed components in finishing the project. Furthermore, my other role was to help nima in making the overall hardware design of the project. In fact, ENSC 340 helped me in learning how to apply my previous knowledge from other courses to overcome all the difficulties faced in a big project.

In a nutshell, I am very satisfied by the excellent results taken at the end of the project. But, it is important to mention that this achievement could not be possible without the help and full support of the School of Engineering Science, the instructor, and the TA's. I learned how to contribute to a team effort and I realized how sharing other people's knowledge would be informative in achieving our future plans.

6. Conclusion

In conclusion, it should be mentioned that "Dyno I" has been able to form a powerful design group throughout the course of this project. We, as the team members of Dyno I, have been able to improve our hardware, software, and documentary skills. Furthermore, we have been able to improve our understanding of customer relations and user centric design.

By accomplishing the task wanted at the end of the project, it is logical to expect a bright future for Dyno I. Moreover, we will continue to improve our product together as much as possible, in order to be able to improve the cosmetic aspects of artificial eyes to serve our society.

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