SUN SMART School of Engineering Science, Burnaby, BC, V5A 1S6

April 12, 2009
Dr. Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: Post Mortem for a Portable UVB Monitoring System

Dear Dr. Leung:

Please find attached the post mortem document for *Portable UVB Monitoring System*. In this document we outline the design and implementation of the project. We then talked about the final budget and timeline of the project. We also elaborate on each member's personal experiences and mention the valuable lessons learnt that helped us finish this project on-time and successfully.

The goal for Sun Smart *Portable UVB Monitoring System* project was to build a portable finished product that informs the user of the UV index and help the user stay protected by applying the suggested SPF sunscreen. The project was done successfully and a working prototype was made as proposed.

Sun Smart consists of three fourth and fifth-year engineering students: Nima Edelkhani, Kimia Nassehi and Daryoush Sahebjavaher. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604) 992-1364 or by e-mail at nedelkha@sfu.ca.

Sincerely,

Nima Edelkhani

Nima Edelkhani
Sun Smart Inc.

Enclosure: *Post Mortem for a Portable UVB Monitoring System*

SUN SMART

Post Mortem for the

Portable UVB Monitoring Device

Project Team: Nima Edelkhani
Kimia Nassehi
Daryoush Sahebjavaher

Contact Person: Nima Edelkhani
nedelkha@sfu.ca

Submitted to: Dr. Patrick Leung – ENSC440
Steve Whitmore – ENSC305
School of Engineering Science
Simon Fraser University

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GLOSSARY

PCB	Printed Circuit Board
BOM	Bill Of Material
PUMS	Portable UV Monitoring System
JTAG	Joint Test Action Group

1. INTRODUCTION

This document will represent the efforts of Sun Smart group which has been working on the Portable UVB Monitoring System for 3 months. In this post mortem document we provide proof of concept that a device, small enough to fit on a regular wrist watch, can be made and mass produced which can show exact level of UVB at any time and location. This device will help users get informed of the UVB index in addition to providing them with the appropriate amount of SPF to be applied. This device can also be used as a module and can be implemented on many other electronic devices like cell phones, GPS or manufactured as a clip-on to many types of equipment like tents, backpacks, barbeques and etc. This system is required by public since it can help general public be more aware of the environment surrounding them and the hazards that threat their health. Skin cancer is a big health risk that affects many North Americans daily therefore having a device that can help us protect our body more efficiently has a great value.

In this document we will briefly go through the system overview and describe how it operates, then we will talk about group dynamics and later we will discuss what we learnt during this project and how things would be changed and improved in our system.

1.1 INTENDED AUDIENCE

The intended audience for the Portable UV Monitoring System post mortem document is the course instructor for evaluating our team's progress during this semester. In addition, this document is prepared for use of Sun Smart group members and engineers for further reference on how the device can be improved in future. It also provides the progress report and also a general overview of the system.

2. CURRENT STATE

In this section we will elaborate on the latest version of the PUMS in terms of electrical, mechanical, software and overall assembly aspects. Currently, we have a functioning PUMS which is in the form of a wrist watch and is able to show the time, the UV index and recommend an appropriate SPF level.

2.1 ELECTRONICS AND PCB

The electronics circuitry has been implemented successfully onto a 2cm x 3.7cm PCB board, with two electrical signal layers and components hand-assembled on both the top and bottom side. Figure 2.1 shows the latest schematic of our design:

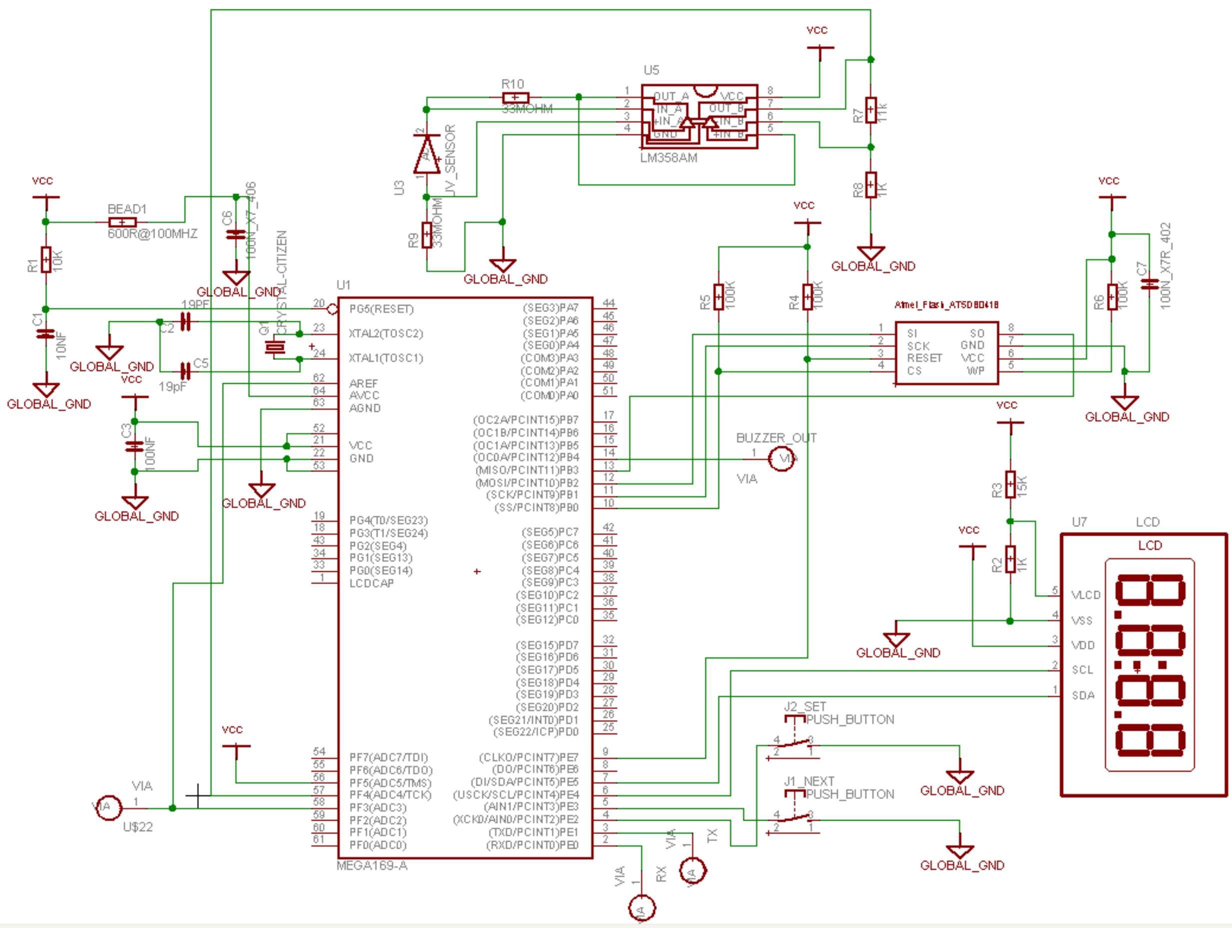

Figure 2.1 Detailed Electronic Schematic

The circuit consists of five major components: The UV sensor and corresponding analog circuitry, the microprocessor and flash, the push buttons, the LCD and the battery. The microprocessor detects the push of the buttons and also receives the analog signal from the analog circuitry that originated from the UV photo diode sensor. The processor converts this analog signal from analog to digital via an internal analog to digital convertor and does the calibration mapping. Next, depending on the state of the device and buttons pushed, the micro processor sends the right output to be displayed in I2C protocol format to the LCD.

Figure 2.2-2.4 show the final PCB layout and PCB assembly with all components hand assembled. The LCD, microprocessor, switches, flash, op-amps, UV sensor are on the top layer and the battery and some passive components are mounted on the bottom. This module is able to show the UV index, SPF level and the clock as originally proposed.

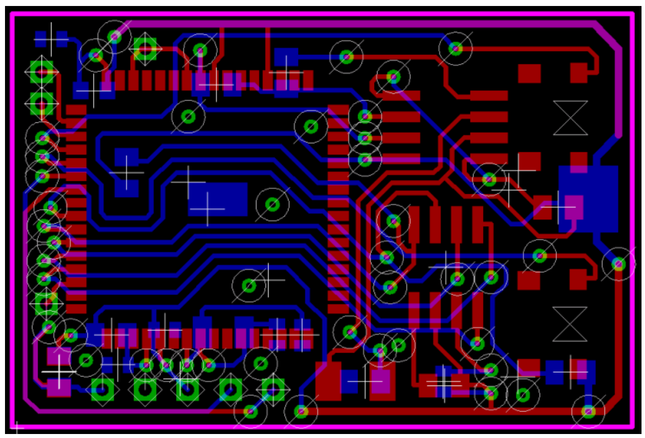

Figure 2.2 Two Layer PCB

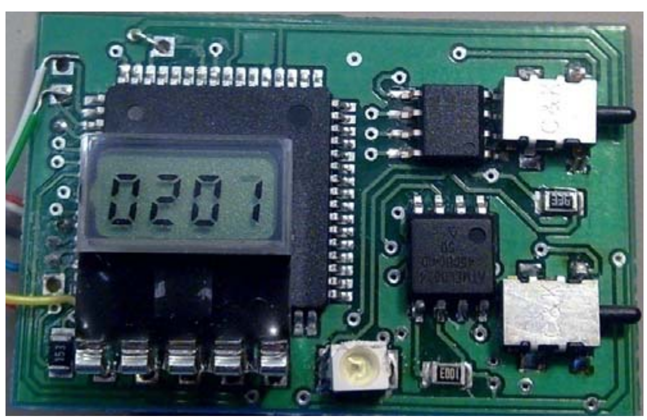

Figure 2.3 PCB Assembly- Top

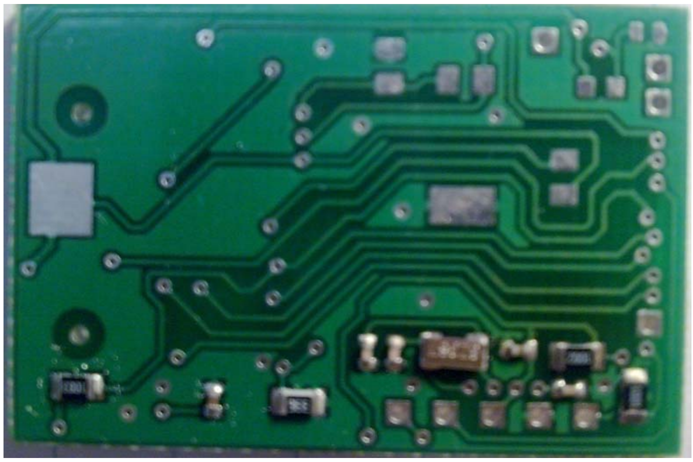

Figure 2.4 PCB Assembly- Bottom

2.2 SOFTWARE

About half the effort put in this project was in writing the program incorporated in the ATMEGA 169 microprocessor. This program performs important tasks such as enabling analog to digital conversion, calibration mapping, detecting external interrupts (push of buttons), communicating to the LCD via I2C protocol, calibrating the internal oscillator and calculating the clock, and determining the right output.

Figure 2.5 shows a simplified state diagram of the operation of the PUMS, depending on the push of button A or B the LCD informs the user of the appropriate output. User can easily choose between viewing the time, UV index or SPF level.

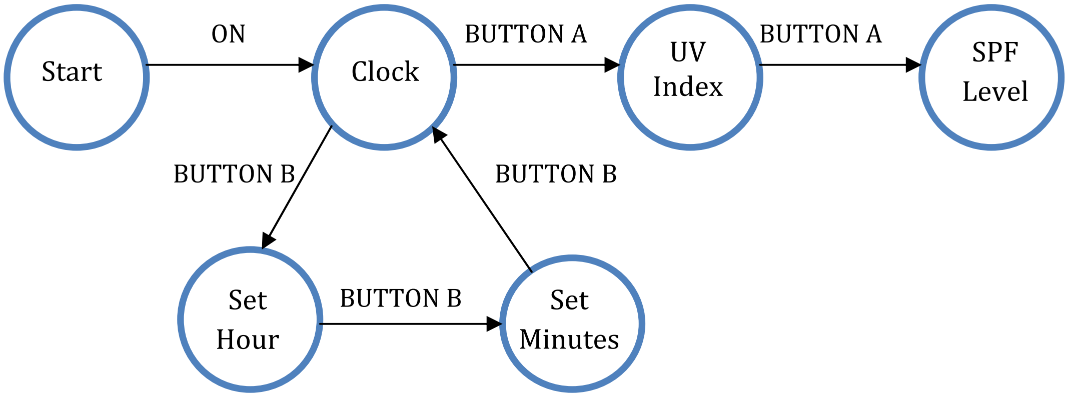

Figure 2.5 State Diagram

2.3 MECHANICS AND OVERALL ASSEMBLY

Figure 2.6 in represents the functioning PUMS prototype as a wrist watch. After milling the inside of a commercial watch case by the dimensions shown, the PCM assembly was fit inside. This prototype works with an coin sized battery and is able to show the Clock, UV index and SPF levels with a simple push of a button.

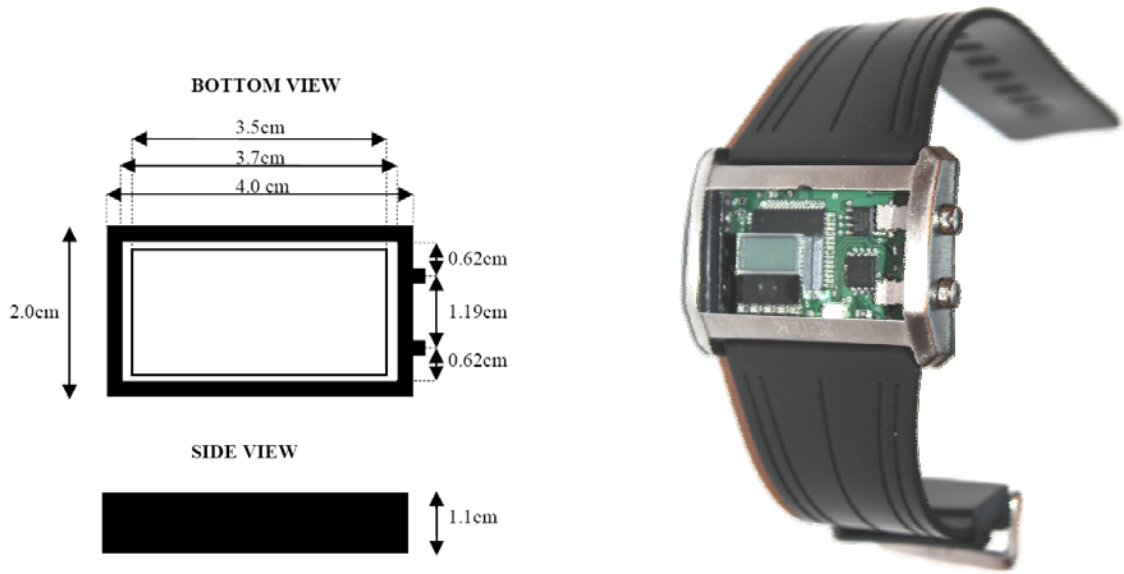

Figure 2.6 Final Assembly

3. FUTURE DEVELOPMENT

The PUMS shown in this document is one of the many forms that this device can be built. There are two main categories in which PUMS devices can evolve: in from of portable devices (e.g. wrist watch, cell phone and iPods) or as a stand alone module (e.g. a chip or miniature PCB with input and output). Although we intend to develop this product in both categories, the modular version or portable device version have the same basics which need to be improved. Our prototype can be improved in electronics, software and mechanics:

3.1 ELECTRONICS AND PCB IMPROVEMENTS

The current prototype is able to last only for a few days for each battery and the power consumption is rather high. The power consumption can be drastically reduced by using a smaller microprocessor with lower processing power, disabling the UV sensor and the analog circuitry when not used, not using any voltage dividers, finding more power efficient electronic components and using a battery with higher capacity. In case many case, a solar panel can be used to recharge the battery. Power monitoring capability could be added so that the device can go into power saving more when not in use or in case of low battery.

By finding smaller components, redesigning the PCB in a multilayer layout and machine assembly the size of the device will be reduced by a large factor. The durability of the device should be improved as well such that it can last more in hot, humid environments and outlast reasonable vibration.

The accuracy of the UV index in our current prototype is estimated to be 10%. This number can be improved if a better UV sensor is used and more appropriate steps are taken to calibrating the device. A buzzer or vibrator can be implemented to warn the user when the UV is high or to remind them to apply sun screen.

3.2 SOFTWARE IMPROVEMENTS

The software can be written more efficiently such that it occupies less space in the microprocessors memory. Also many of the electrical improvements overlap with software. For example, any changes in power consumption have to be handled by the microprocessor thereby altering the software. Moreover, many functions can be added to the device such as having calendars, reminders, temperature, maps, UV maps, weather forecast, GPS and UV logging for all which software is required.

3.3 MECHANICS AND OVERALL ASSEMBLY IMPROVEMENTS

Overall, the PUMS prototype can be improved in size and user interface. For example, the current 4 character LCD can be replaced by a custom made color LCD with bars of UV and SPF levels and graphs of UV history.

The Glass shield of the watchcase absorbs the low wavelength ranges of the UV light and was therefore removed from our prototype. If this glass is replaced with quartz entirely or the part in front of the UV sensor is replaced by quartz, the device will have a better durability and better look.

4. TIMELINE AND BUDEGET

Figure 4.1 shows the proposed timeline in blue and the actual completion of each task in red. Our group was able to follow the schedule very closely despite the many unaccounted challenges that we faced. The only task that took us much longer than expected was the integration of the new custom made LCD for the second phase of the project which due to poor documentation, company support and low level debugging consumed an extra week of time.

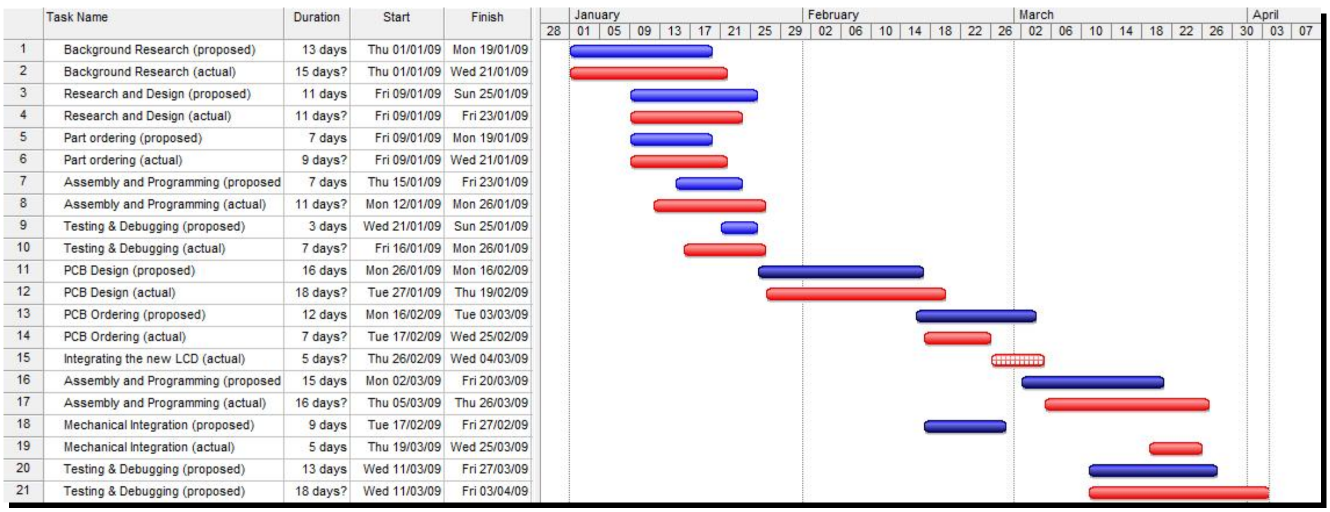

Figure 4.1 Proposed V.S. Actual Schedule

Due to unexpected problems, small specialized components and PCB the cost of the prototype was almost twice of what was initially estimated. Table 4.1 shows the details:

Quantity	Item	Cost
Various	Electronic Parts	$287.18
3	PCB Board	$224.41
1	AVR Butterfly	$88.68
1	Milling Bid	$33.60
1	LCD	$51.33
1	Solder tip	$10.87
1	Watch Case	$27.91
1	Black Lamp	$22.39
1	Serial to USB cable	$51.51
Total		$797.88

Table 4.1 Project Cost

5. INTERPERSONAL AND TECHNICAL

NIMA EDELKHANI

I would like to share with you some of my personal experiences and comments that were gained through an intense, tough and remarkable journey called the "ENSC 440/305". The way our group decided to maintain meeting was very simple. We decided from the begging to have meetings everyday, all day. This way we put our absolute maximum effort on the project and I think this was one of the reasons why we were able to finish the project successfully and on-time.

During the project we faced many technical and non-technical problems and I intend to mention some of them in this section. One of the challenges we faced in this project was *parts*. For example, we required a Butterfly evaluation board for our first phase of the project. We bought one on-line very early in the semester but all the distributors had run out of those and they kept postponing the shipment date. We were lucky, because Patrick had one of those boards and he lent it to us. The board that we bought on-line took 3-months to be delivered. That is all the time we had for the project! We kept wondering that had Patrick not lent us the board we might have ended up killing a lot of time just waiting on that one part to come and that would delay the whole project. Things like that happen all the time. So a valuable tip here would be: *"Always pay attention to the lead-time delays"*. A perfect part might not be suitable for the project if it may take months to be delivered. So we should always try to stick to the vendors who we know deliver fast and reliably.

One of the other problems we face was when we wanted to start designing our PCB. We knew that there is very sophisticated and well-respected software called "Altium" that is used widely for PCB designs. But we could not get a hold of a stable working version of the software. We ended up spending a lot of time trying to make that software work for us but we could not. So then we decided we are going to use Eagle Professional software that we have in the lab. Eagle worked for us very well. So a very important tip here would be: *"Use a software/tool that has just about enough features as you need"*. In other words, extra features in a software/tool that you are not going to use can only bring you trouble and make everything that much more complicated.

Another challenge that we faces was when we wanted to program our microprocessor on the PCB. We thought that we can use RS232 method for programming but we were wrong. Apparently the microprocessor that we had lacked a bootloader program and therefore an alternate method of programming should have been used to program it. Again we were lucky enough to find the appropriate programmer (with the help of Jamie Westell) and use that to program our chip. This was just an example of times when foreseeing the future would help us not get into trouble. So the last tip from me would be: *"Try to foresee the problems you may face in the future and plan your way around it"*. Now this is impossible most of the times but it is a good way of thinking.

Finally I am going to concentrate on the inter-personal aspect of this group project. We were a group of three and we were friend way before we got into this project. We also managed to come out of it as friends and this is valuable. To be able to do this one should pay attention that the last month of the project is very stressful. So when you find yourself or another member of the group very stressed and frustrated on the project. It is always good to take a break, and try to stay calm. This way a lot of unhealthy inter-personal conflictions can be avoided.

KIMIA NASSEHI

Although we all worked on the project together, my contributions to the team were mainly on the microelectronics and documentation parts. During the process of building out product every one of us had some ideas on how things could have been done differently. What this experience showed me was that miniaturizing is a very complicated process. Having only 3 months for a proof of concept and building a functioning final product is a very limited time. It would be much better to have 3 months to design and order parts and another 3 months to build and debug. This made me think that we should have started earlier and maybe worked on the project starting from the previous semester. Other option (which we talked about with our instructors) is to have this project course extended into two semesters. That way there is more time, less stress and therefore much better projects can be presented.

At the beginning of semester we thought that the expenses will not be breaking the bank but I learnt that minimizing and having everything custom designed can be very expensive. That was the case with our project. I also learnt that we should try and order parts in bigger chunks. Sometimes that comes to free shipping or at least paying one shipment instead of multiple shipment fees.

On the technical side things could have been handled differently as well. We bought an Atmel Atmega169 as our processor but we never looked into the details to see if the processor comes with a boot-loader or not. This issue had us stuck for 3 days since we couldn't talk to our microprocessor and we didn't know why. I have learnt that it's very important to know if the processor is pre-loaded or not. Also we had lots of trouble with our custom LCD since it didn't have a detailed data sheet and we had to find the pin mappings by testing. It's very essential to purchase a part with proper and complete data sheet.

Our group dynamic was very good. I believe each one of us put more that hundred percent effort on this project and that is why we were able to finish this project on time. We worked on this device every day for long hours but we never had any issue with any one's behaviour. At the end I believe this project was a great learning experience for me and is one of the best projects I have completed so far. Of course if it wasn't with the help of our instructors and TAs neither the writing part nor the technical part would be completed successfully.

DARYOUSH SAHEBJAVAHER

As mentioned before our group meetings were every day all day, since all three members were electronics engineering students with the same background and interests. Each member spent a tremendous amount of time into this project and without the help of any one this project would not have been possible. Although each members experience was largely overlapping with one another, the minor differences from co-op and past project were also valuable. My contributions to the project were mainly in the PCB design, software and mechanics. From my previous two coop semesters I was familiar with the PCB design process of component selection, creating BOM and using the software Altium (or Protel). Unfortunately, we could not get a working version of Altium and lost a few days trying to do so until we finally decided to work with EAGLE. There was a learning curve for all of us in the PCB design process as the board was very small and we were new to eagle. Although all members were very involved in the PCB design, my contribution in this part was to help the process go more efficiently.

The most challenging part of this project was the problems we encountered with custom four characters LCD. The LCD had a very poor documentation and the company which made it had a terrible customer service, offering no help. We were stressed trying to get the LCD to work as it shifted us behind schedule and involved low level debugging. It was at this point of the project at which I appreciated every member in our group. We stayed focused and put all of our energy into fixing the problem, and each member found bugs that the others had overlooked, leading to the resolution. At this part of the project, team work was essential and the problem would never have been fixed in time if each member had not contributed all they could.

This project was very valuable in terms of experience both on the technical side and team work. On the technical side I learned about programming micprocessors in C, learned to work with EAGLE, gained experience in PCB design and learned how LCDs work. I also improved my team work skills and have more experience in terms of meeting a timeline and budget requirements.

There are many things I would do differently:

- Always take my time when selecting components and read their documents carefully to make sure they are compatible and have all the necessary information.
- Double-check lead times.
- Have extra vias and test points on the PCB to leave room for debugging
- Expect surprises and prepare by leaving extra time in the project schedule
- The team has to take time to rest, independent of stress levels as this will dramatically increase group efficiency

6. CONCLUSION

A functioning PUMS has been developed in the form on a wrist watch that can inform the user about the UV index, SPF levels and Clock as proposed. In future the device will be improved in terms of reliability, power consumption, size, accuracy and user interface. The project met the timeline requirement, but the budget two times larger than the estimated budget that was proposed due to customized parts and miniature components. Sun Smart intends to patent this product and find the financial support necessary to introduce this product into the market in the coming years.