MiNT
the refreshing technologies

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Sept 6, 2001

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

Re: ENSC 340 Process Report: Dancing Orpheus Musical Suit

Dear Dr. Rawicz,

The attached document, *Process Report: Dancing Orpheus Musical Suit*, summarizes the experience of MinT, Inc. This document outlines the process we endured in designing and completing a musical instrument that can be played while the performer dances.

The purpose of this document is to describe the final status and deviations of the device, our plans for future developments, our budgetary and time constraints, and our inter-personal and technical experiences.

MiNT consists of five innovative third year engineering students – Sharon Chang, Eddy Chiu, Tony Leung, Robert Sin, and Lydia Tse. If you have any questions or concerns about our design specifications, please feel free to contact me by phone at (604) 420-3628 or by email.

Sincerely,

Eddy Chiu
MiNT, Inc.

Enclosure: *Process Report: Dancing Orpheus Musical Suit*

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Process Report:
Dancing Orpheus Musical Suit

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Dr. Andrew Rawicz – ENSC 340
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1 Introduction

The five members of MiNT, Inc. have worked conscientiously over the past sixteen weeks on implementing the *Dancing Orpheus Musical Suit*. This document reviews the development of the *Dancing Orpheus* from a conceptual to a functional product. The current state of the device, modifications of the device as compared to previous documentation, and potential future improvement will be discussed. As well, technical and interpersonal skills gained by each of the five members would be provided.

2 Current State of the Device

2.1 Sensor Gear and Signal Transmission

Signal transmission is provided by eleven transmitter modules, of which seven control the different tones – C, D, E, F, G, A, B, and four control the tone configuration – octave up, octave down, sharp, flat. The tone controlling transmitter modules are implemented with the motion sensor gear, while the tone configuration transmitter modules are mounted on a pair of gloves that the user will wear.

The schematic of the transmitter module is shown below in Figure 1.

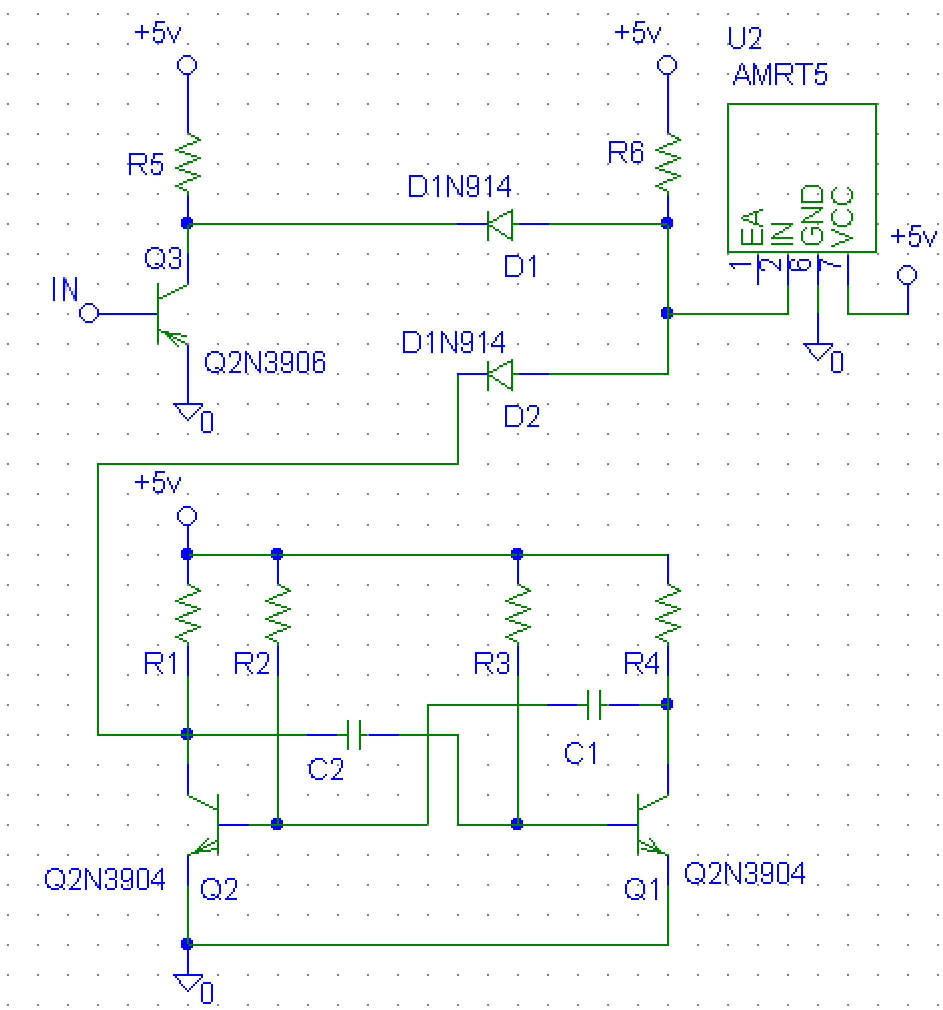


Figure 1: Transmitter Circuit

Each transmitter module consists primarily of a transmitter, a multi-vibrator circuit and a logic comparison gate. We selected two different signal transmission frequencies for the transmitter, 315kHz and 433kHz, for the tone control and configuration, respectively. To differentiate between each signal, each sensor is assigned a characteristic oscillatory frequency, as shown in Table 1.

Table 1: Sensor Characteristic Frequencies

Tone/Configuration Signal	**Frequency**	**Joint**
C	3kHz	Right elbow
D	4.5kHz	Right shoulder
E	6kHz	Left shoulder
F	7.5kHz	Left elbow
G	9kHz	Right knee
A	10.5kHz	Left knee
B	12kHz	Neck
Flat	2.5kHz	Left index finger
Sharp	3.5kHz	Left middle finger
Octave Up	5.5kHz	Right index finger
Octave Down	8kHz	Right middle finger

2.2 Signal Processing Unit and Sound Generation

Figure 2 shows a sketch of the sound generator.

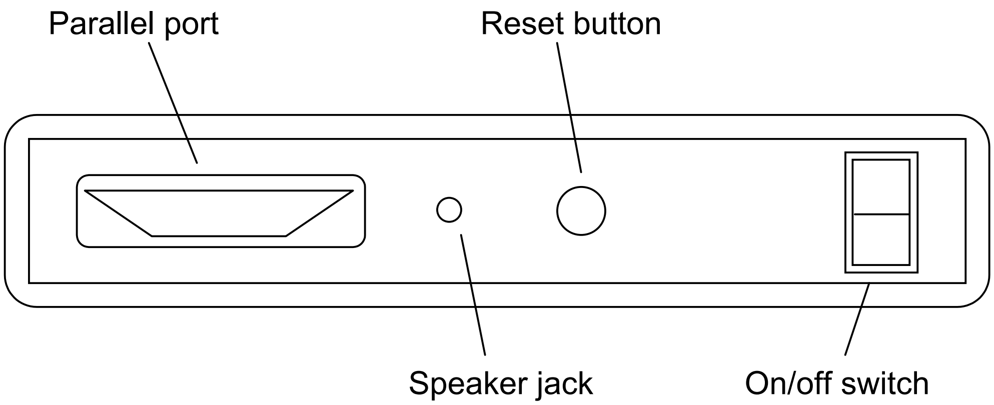


Figure 2: Sound Generator

The front panel of the sound generator contains a power switch, a reset button, a speaker jack, and a parallel port for interfacing with a computer.

The device is capable of generating all 7 musical notes and their flats and sharps throughout octave 0 to 6. In addition, a C bass tone that repeats every 1.5 seconds could be played in the background.

User inputs of the sound generator are captured from either the 11 sensor gears or the computer graphical user interface[1] (GUI). Sensor gear control signals are received using 2 AM receivers and displayed in the GUI.

Pressing the reset button configures the sound generator with the default settings. A note that is being played will be stopped, and subsequent notes will be played at octave 3.

[1] Refer to section 2.2.1 – QNX Graphical User Interface – for details on the GUI.

2.2.1 QNX Graphical User Interface

A QNX GUI has been developed for the sound generator, as shown in Figure 3.

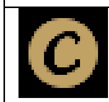
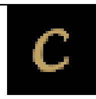
Figure 3: Sound Generator GUI

The GUI can both display the status of the sound generator as well as writing control signals to it.

When the sound generator receives a signal from the sensor gears, it would simultaneously propagate the data to the GUI. As a result, the icon that corresponds to that signal will be substituted with another one that indicates the signal has been activated. Moreover, the picture of the user or his hands would be changed to reflect the motion that has taken place. For example, Table 2 shows the images associated with the C note[2].

[2] Refer to Appendix A for the complete list of GUI note images.

Table 2: C Note Images

On Icon	Off Icon	On User Position	Off User position
			

The GUI offers a user-friendly environment for controlling the sound generator. Tones and configures signals are activated by clicking on the corresponding icon with the mouse pointer. Once a signal has been activated, the icon as well as the user's picture will also be modified following the same conventions described above.

3 Deviation of the Device

3.1 Sensor Gear and Signal Transmission

3.1.1 Change of Angular Motion Detect method

In our original proposal, the motion detection method for our sensors was designed with pulley. The pulley design was not very practical since the elastic behavior of gear was not very stable for our frequency generator circuit and was not suitable for our angular motion. To use our original design, the sensors require a stable and constant force to give reliable switch action, however, because the recoiling mechanism of the pulley was elastic band or spring, the recoiling suspected to defect our circuit stability. Hence, we have changed the detect method to lever action to push the button switches. Therefore, whenever we have angular motion with certain degree, our lever pushes button and our frequency generator circuit are energized.

3.1.2 Change of Position of Hip Sensor

Since we realized that the hip sensor is not giving us enough angles to push the button, we changed the position of the sensor. The new position was located right under the chin so, the button could be pressed with angular motion of a user's chin.

3.2 Signal Processing Unit and Sound Generation

Figure 4 shows the block diagram of the sound generator.

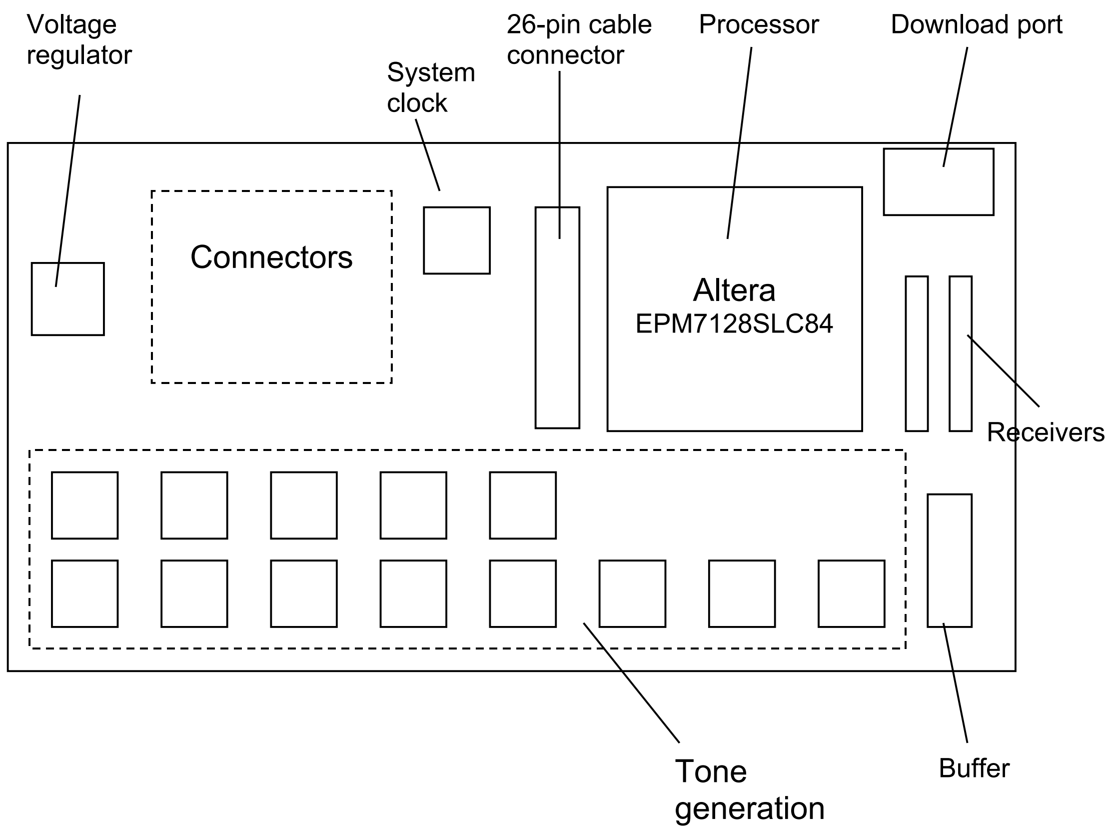


Figure 4: Sound Generator Block Diagram

The final design of the sound generator differs greatly from what was previously discussed in the Design Specifications due to the unavailability of resources, unexpected component performances and change of designs.

Initially, we intended to use the Altera EPF10K10LC84 as the processor. However, since we could not get this device we have switched to the Altera EPM7128SLC84 instead. Unfortunately, the 7128 does not have the sufficient resources required for the tone generation algorithm, we had to use external 555 analog timer circuits to generate the tone frequencies.

In addition, the slew rate of the receiver output is far worst than we have anticipated, therefore, a CMOS buffer has been added to the circuit to speed up the data transition before the outputs of the receivers are fed into the FPGA processor, as shown below in Figure 5.

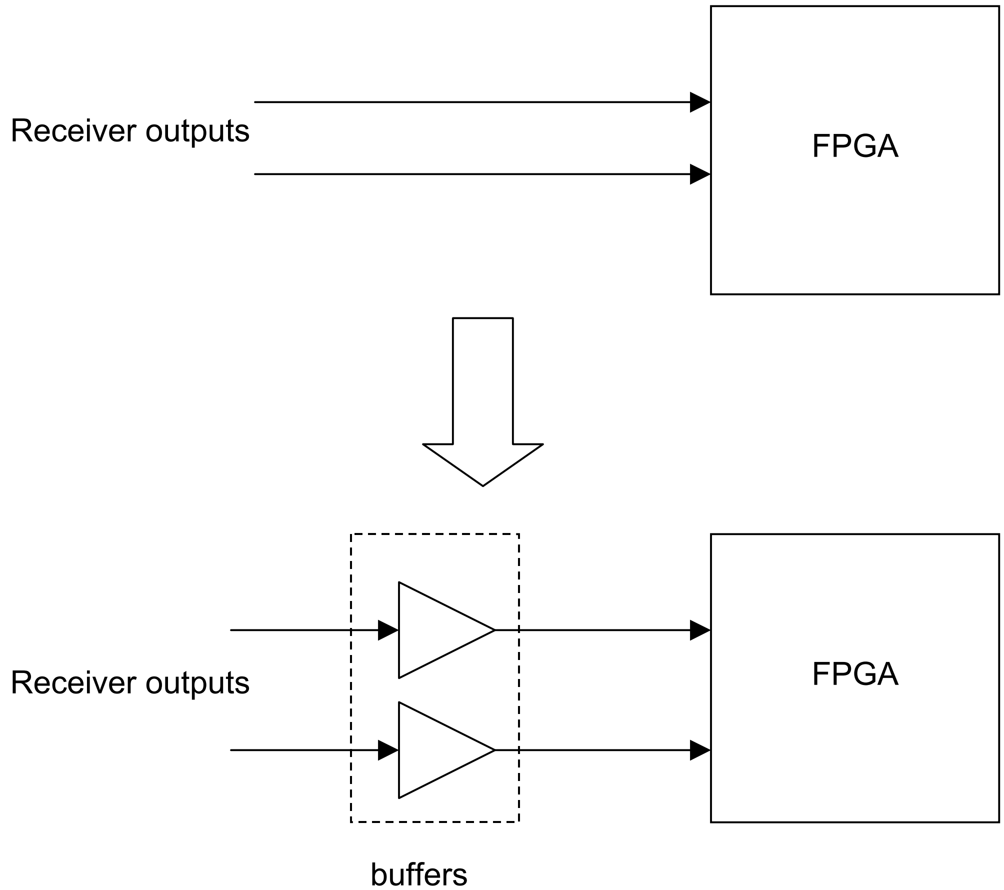


Figure 5: Buffers for Receiver Data

Finally, we managed to spend the time to develop a computer interface for the sound generator. This design change involves modifying the FPGA configuration program and the addition of a 26-pin cable connector.

4 Future Plans

4.1 Changing of Host Computer Operating System

The GUI implementation is to be implemented on a Microsoft Windows Operating System instead of QNX. Additional features such as a short interactive tutorial would also be implemented.

4.2 More Reliable Sound Generation Circuitry

With better knowledge on digital and analog circuits, more reliable circuits for tone generation are possible, which will improve the sound quality as well as processing speeds.

4.3 Better Packaging

Since the motion detection unit is portable, we plan to design a more reliable packaging with a better case such that the circuitry inside has better protection. We also plan to mount the detection unit on a suit so it will require less training for the user to put the detectors on.

4.4 More Reliable Gear

The sensitivity level of the gear is to be increased without transmitting an increasing amount of noise. It is also desirable to construct a gear that has a variable sensitivity level depending on user preference in addition to a smaller physical size. A smaller physical gear allows a dancer to move more freely.

4.5 Alternative Power Supply

The receiver and sound generation module are powered by eight AA cells. Each of the sensors uses two 3V button batteries. We wish to optimize the power consumption of the circuits such that the fewest number of batteries can be used to supply the product with the maximum working period, while reducing the product size and weight.

4.6 Sound Effects

It is possible to implement more sound effects such as drums and to add circuitry that convert the sound output to replicate other musical instruments.

5 Budgetary and Time Constraints

5.1 Budget

Table 3 lists the predicted expense as described in the proposal. Table 4 lists the actual expense of the project.

Table 3: Estimated Budget

Required Materials	**Estimated Cost ($)**
Field Programmable Gate Array	$150
Speakers	Accessible from team members
Prototyping Circuit Board Materials	$50
Switches	$50
Transmitter/ Receiver Pair	$20 * 11 = $180
Miscellaneous (tools, cables, etc.)	$80
Estimated Total	**$500**

Table 4: Actual Expense

Required Materials	**Cost**
Field Programmable Gate Array	Accessible from SFU Engineering Lab
Speakers	Accessible from team members
Prototyping Circuit Boards	$75
Electronic Components (Resistors, capacitors, chips, switches, buttons, cases, etc.)	$240
Batteries and Battery Holders	$100
Transmitters and Receivers	$345
Total Expense	**$760**

The difference between the estimated total cost and the actual total cost can be explained by the following reasons:

- Numerous important design changes made during different stages of the project result in different materials required.
- Actual costs of many required components were higher than expected.
- Some suppliers charged expensive costs for shipment.
- The team has not been able to obtain funding for the project yet.

As various future improvements can be implemented to the *Dancing Orpheus*, the total expense may continue to vary.

5.2 Time

During the course of planning, we failed to take into account the effect of assignment deadlines as well as midterms and final exams of other courses we were taking. As a result, our project was finished two weeks behind schedule. As well, technical difficulties associated with debugging our design directly contributed to the delay of our product completion.

6 Inter-Personal and Technical Experiences

6.1 Sharon Chang

When this group first formed, I knew we would make a good team. After 13 weeks of working closely together, we have proved that we indeed make a good team.

During these 16 weeks, we had weekly meetings to discuss about the project. I found it interesting that we always managed to have someone to act as the contradicting role. Although sometimes it is not as easy to take different opinions as to have someone agreeing, it turns out that this is very helpful to improve our ways of thinking. We make quite a few good modifications to our project because of these different opinions. I also find it a great advantage to discuss with other members about my part of the project, because often they offer good ideas and inspirations to my work.

From technical prospective, I think the best part is to apply what we have learned about semiconductor devices and make use of them to achieve our desired functionality. I also learned about different approaches to circuit designs and how to apply the use of different devices to simplify the circuit. Because of the particular part I am responsible for, I was also exposed to some mechanical aspect of the project. I experimented with different designs of gear-connected switches to meet our needs, and in the end I was able to create a design that is both functional and simple.

6.2 Eddy Chiu

This project has proved a quote I heard as a child,

"Dreams are beautiful, but reality is harsh."

-Anonymous

admittedly, we experienced a great deal of difficulties.

My responsibilities[3] in the project include the design and development of the sound generator and its graphical user interface. Each of these tasks was accompanied by complicated debugging processes, which have allowed me to gain important technical and interpersonal experiences.

[3] Refer to company website www.sfu.ca/~sschang/mint/team.htm for details on the contribution of Eddy Chiu in the project.

The sound generator, as described previously in section 3.2, contains both digital (FPGA) and analog components. From previous co-op experience as a digital designer, frankly, I developed and tested the VHDL configuration program within a very short period of time. However, our prototype failed to operate once it has been integrated with the analog timers. The debugging process carried for over a week, but we never made any progress. In addition, while we were trying to eliminate existing “bugs”, we accidentally caused damages to the board including blowing up 2 precious FPGA. At the end, we managed to solve our problems after receiving precious advice from the lab instructors and fellow students.

On the other hand, problems occurred when I tried to establish communication between the GUI host computer and the sound generator. For over a week, I attempted to search for errors in both the sound generator board and the computer software source code, but failed. When I eventually found the cause of the problem, it turns out the connection cable I was using was improperly soldered and broken, whereas the system was, in fact, operating correctly from the start.

From the two scenarios described above, I would like to emphasize that the process of the project has enabled me to understand the advantage to seek for suggestions whenever we have problems, as well as the importance of paying attention to details – such as cables and soldering skills.

Finally, I sincerely appreciate my fellow group members for having tolerated my aggressiveness. Although we never officially chose a leader among ourselves, I have served the position as a coordinator. I tried my best to listen to their comments as much as possible, but I believe the group dynamics would have improved if I had been more objective.

6.3 Tony Leung

In the past four months, I had learned a very important experience that it could not be found in any pervious courses I had taken before. Actually, by taking ENSC 340, it gives me a great opportunity to work and perform some ideas I had learned in class.

Start from planning about the project, ordering the necessary components, integrating the system and testing the complete system is the remarkable development cycle in the past 13 weeks. It allows me to understand and experience how the real functional product can be created on the paper and release it to the user. I realized that how to use some simple circuits to provide a good and reliable output base on the knowledge I had learned in class. Especially for sound generating and frequency of transmission, I leaned how to design a circuit with different approach. Moreover, I also had a chance to improve and chance the existing circuit in order to meet our product requirement. It gives me a valuable designing technique and technical debugging skill through out the whole development cycle.

It is no doubt that a group project will create certain disagreements and arguments because of the different point of view. Fortunately, we had made a very good positive attitude and respect in our group whenever we got a problem. I am glad that we achieved to complete the project with many positive ideas and opinions from each of the group member. We communicated and discussed about the problems faithfully. I had also learned a very crucial interpersonal experience and communication skill.

At last, I really enjoyed in this project and gain a lot of knowledge and friendship in this summer. This project really gives me a significant team project working skill, valuable experience of circuit designing and testing skills.

6.4 Robert Sin

For me, ENSC 340 gave me a lot of confidence. Before ENSC 340, we did not actually build a hardware system. In addition, I could see what all the related previous courses really meant. Through this course, I have learned that a technical design and an actual design were really different from each other. Hence, I enhanced hardware debugging and trouble shooting skills. To find a stable frequency generator was real fun and to design the gear for human body was an excellent experience, too. Also, I realized that the physical human body behavior was not as simple as I thought. Most importantly, for the hardware design, the power efficiency is critical. Moreover, I have learned that the prototype is never as aesthetic as we expected ☺.

As a group project, I have learned that the communication within the group was crucial for progress. I learned how to listen to other people's opinion and how to disagree to other's view. At the end, we compromised the all the details with good communication. I really enjoyed working with my group members, Eddy, Lydia, Tony and Sharon. Without group effort, I do not think we could accomplish our project.

Lastly, I have experienced how the rough idea becomes a complete product with all the debugging and alterations.

6.5 Lydia Tse

Valuable technical and interpersonal experience is obtained during the development of our product. It has been extremely remarkable to be involved in the development of a functional product from an idea on paper.

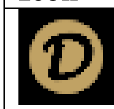
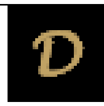
Throughout the past four months, my technical knowledge has certainly been improved by a lot, especially in soldering skills due to the nature of my responsibilities throughout the project. As well, I have had the opportunity to learn about the functions and characteristics of different electronic components, and interfacing between different chip sets and environments. Numerous hardware debugging skills and approaches to problem solving are also picked up. This project has been a very important learning experience because it provides me with the chance to deal with real problems in circuit design that are not discussed in textbooks and allows me to apply many theories that I have learned from numerous courses.

Most importantly, I have acquired crucial interpersonal skills necessary for teamwork in the future. I have learned how to accept constructive criticism, disagree with others appropriately, and express my ideas and viewpoints clearly towards achieving our project goal. In particular, I have noticed the significance of careful team planning and task distribution beforehand in order to avoid team dynamics problems and to maximize teamwork efficiency.

I am glad to have worked closely with the members on the team over the past four months. Our friendship as well as understanding among one another has definitely grown throughout the entire project experience.

7 Appendix A

D Note Images

On Icon	Off Icon	On User Position	Off User position
			

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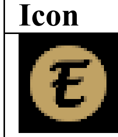	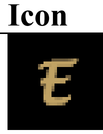		

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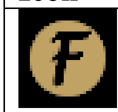	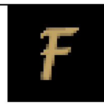		

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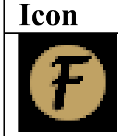	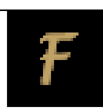		

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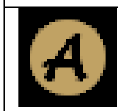	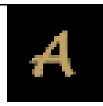		

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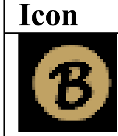	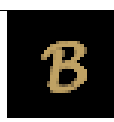		

Octave Up Images

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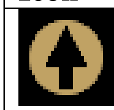	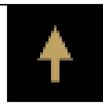	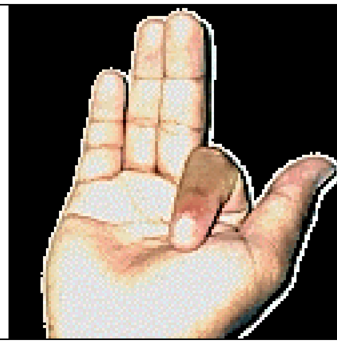	

Octave Down Images

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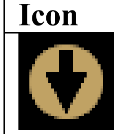	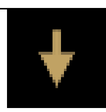	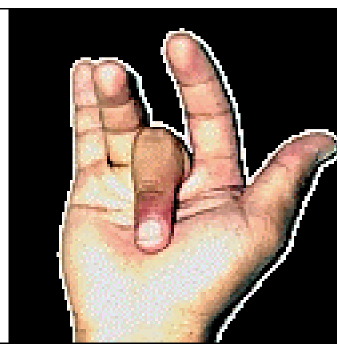	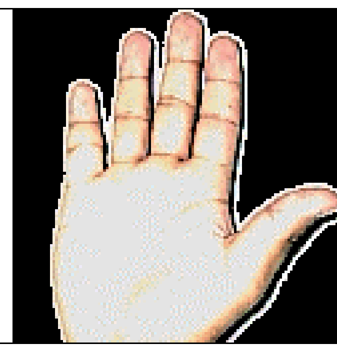

Flat Images

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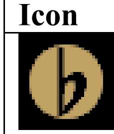			

Sharp Images

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