Post Mortem Report for

Electric Guitar Effects Combiner

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Submitted To: Dr. Andrew Rawicz
Dr. Steve Whitmore

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March 11, 2010

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

Re: ENSC 440 Post Mortem for an Electric Guitar Effects Combiner

Dear Dr. Rawicz,

Musictronics are a commited engineering company that is commited to create music related engineering product. For capstone project we design a device that can combine multiple analog stompbox effect for guitars. The device uses digital switching mechanism and blends the signal using analog method.

The attached document, *Post Mortem Report for an Electric Guitar Effects Combiner*, describes the state of our current projects, the deviation of our current project, updated timeline, and the future plan for our product.

Musictronics team is established by three innovative and passionate engineers: Kianoush Nesvaderani, Amanueal Heilegio, and myself, Gondang Prabowo Yudo. If you have any questions or concerns about our proposal, please feel free to contact me by e-mail at gpy1@sfu.ca.

Sincerely,

Gondang Prabowo Yudo
President and CEO
Musictronics

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1.0 INTRODUCTION

Musictronics members, Gondang Yudo, Kianoush Nesvaderani, and Amanueal have devoted the past 13 weeks designing and constructing the Combinator. This document outlines the design process for this device which includes the current state, deviation from the design and future plans. Also, budgetary and time constraints are discussed as well as each member's individual experience recapping the highs and lows during the Combinator development.

2.0 CURRENT STATE OF DEVICE

Musictronics team was able to create the Combinator system which was described in the project proposal. The Combinator is a music box that can combine the analogue effects of an electric guitar and gives the option to the player to combine 4 active effect boxes at the time with 4 different combinations. Figure 1 shows a basis system overview of the device.

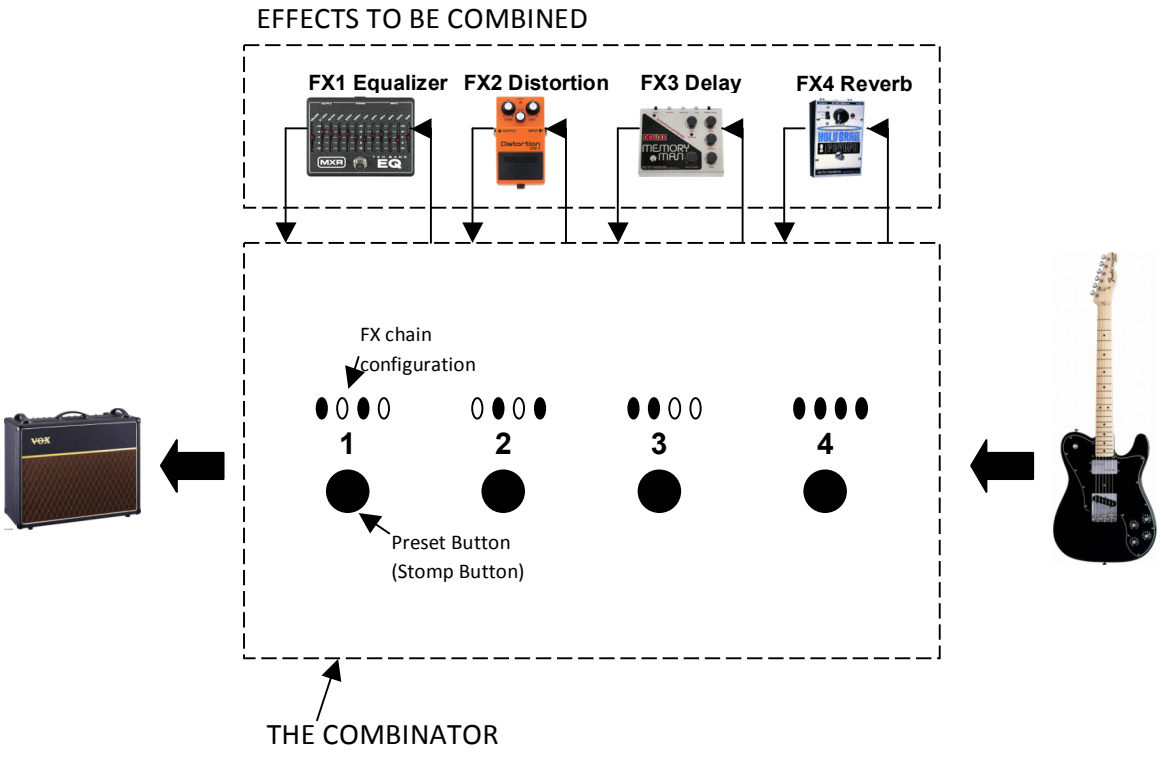

Figure 1

The device includes a controller unit, a mixer unit, and a power unit. The user is able to set up four different combinations of effects and choose a set by only pressing a simple button while playing.

Figure 2 shows the high level system design:

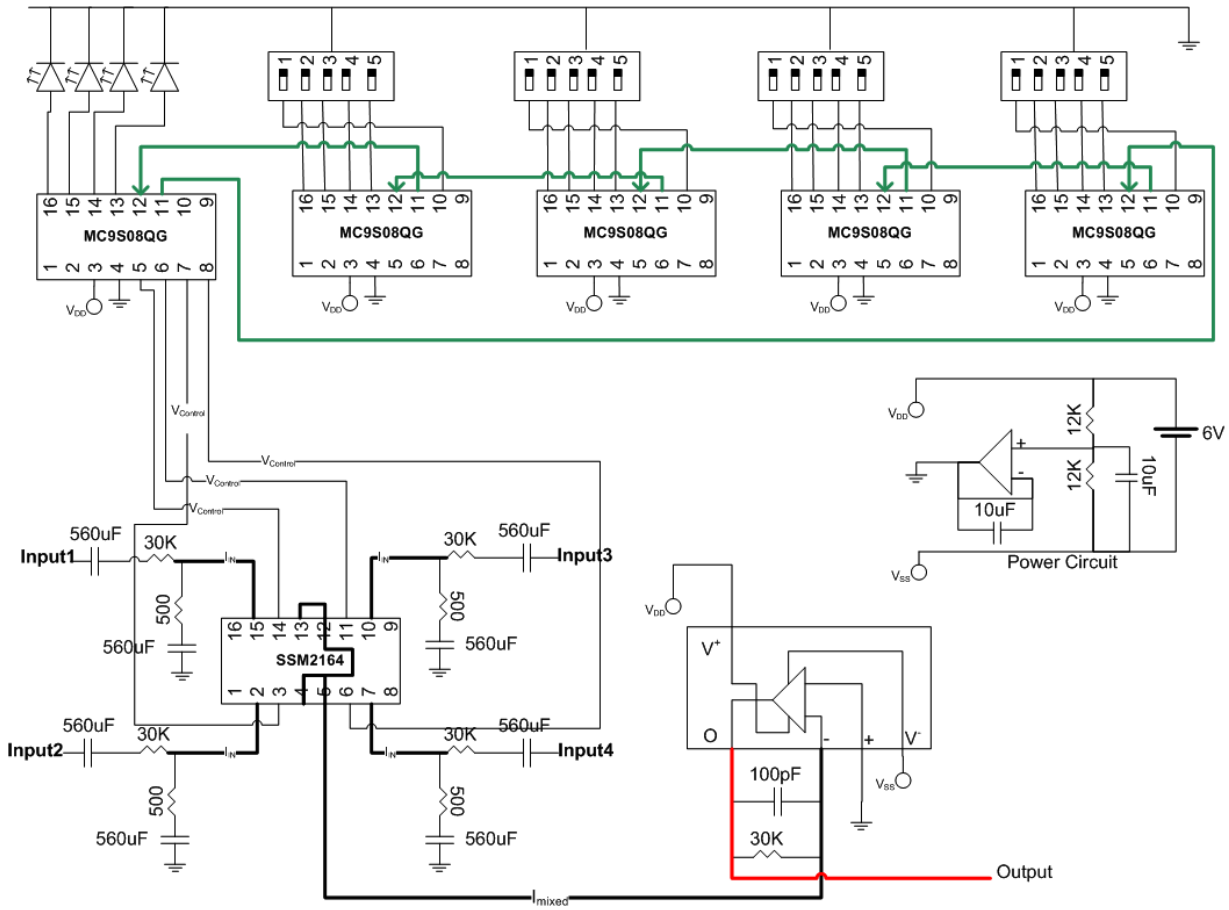

Figure 2

Each switch combination with 5 selection lines is connected to one microcontroller. The microcontrollers have been programmed to let the user select between the 4 combinations. On each combination, switch number 5 has been assigned as the master switch. For each combination to be able to be selected, switch number 5 must be on beforehand. A fifth microcontroller has been used to turn on and off 4 LEDs, each of which related to one combination. Finally, a voltage control current amplifier is used to mix the receiving signals from the fifth controller and send the output voltage to the speakers.

3.0 DEVIATION OF DEVICE

3.1 Overall System

Overall, we were able to construct the Combinator without much deviation from our initial design specs. However, due to budget constraints and the unexpected results we received from our testing phase, we decided to apply two major changes in the whole system.

3.2 Controller

Initially, the controller unit, formerly called as the configuration circuit, was designed on a separate circuit connected to the FPGA board. We basically started from scratch and coded the circuit in VHDL to be able to send signals to the FPGA board. However, after completing the whole system, the output sound that we received from the FPGA output was so low and undetectable that we saw the need for a major change in order to get the best quality of sound possible. In the original system design, the analogue inputs used to first get converted into digital signals. Then, the digital signal was to get mixed in the FPGA before going through the DAC built in the FPGA and getting played on the speakers. After trying a lot of ways to improve the quality and even trying a separate DAC, we came to the conclusion to get rid of the FPGA and work on analogue signals only without using any converters. As a result, the new controller unit is composed of five microcontrollers that only control the selecting of different combinations of analogue signals.

3.3 Mixer

This part was initially a set of VHDL codes programmed on the FPGA board. The codes used to take the converted digital signals and multiply the digital values together in order to get a mixed value before having the value converted into an analogue output. However, now the part is consisted of a voltage control current amplifier that takes 4 inputs from 4 different stompboxes. The unit is connected to one of the microcontrollers that tells the unit which combinations should be on in order to be sent to the output.

3.4 Power

This unit is basically a new addition to our device. Before, we were planning to power up our device using the FPGA board adaptor. However, with the board out of the picture, we designed a new component that includes a voltage divider to divide 6 volts into two +3 and -3 volts and an operational amplifier to amplify the whole circuit.

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4.0 FUTURE PLANS

4.1 Overall System

In future designs, the combinatorics will be able to support additional inputs, Independent volume control for each effect for a more flexible and balanced output mix. Implement the circuit on PCB board to reduce interference noise from surrounding electrical equipment. Other than those key points mentioned above, we have fully met our specification for the proposed design.

4.2 Controller

Implementing the MCU in a Star network to make it more robust, currently in our system the MCU is arranged in a ring network.

5.0 BUDGETS AND TIMELINE

5.1 BUDGET

Due to the fact that our group was formed later on the second week of classes, we were unable to apply for ESSS funding. The group members were left to share the cost equally. Since we changed our implementation drastically the cost reduction was significant. The cost for the two ways of implementation is given below.

Equipment List	Estimated Unit Cost
FPGA Board	$270 x 2 = $540
3.5 mm Mono Plug (10 per Package)	$13
Prototyping Breadboard	$40
Latching Stomp Switch	$10 x 4 = $40
σΔ ADC	$6 x 10 = $60
σΔ DAC	$6 x 10 = $60
Casing	$50
Miscellaneous	$100
Total Cost	$903

Table 5.1 Cost of final product using FPGA

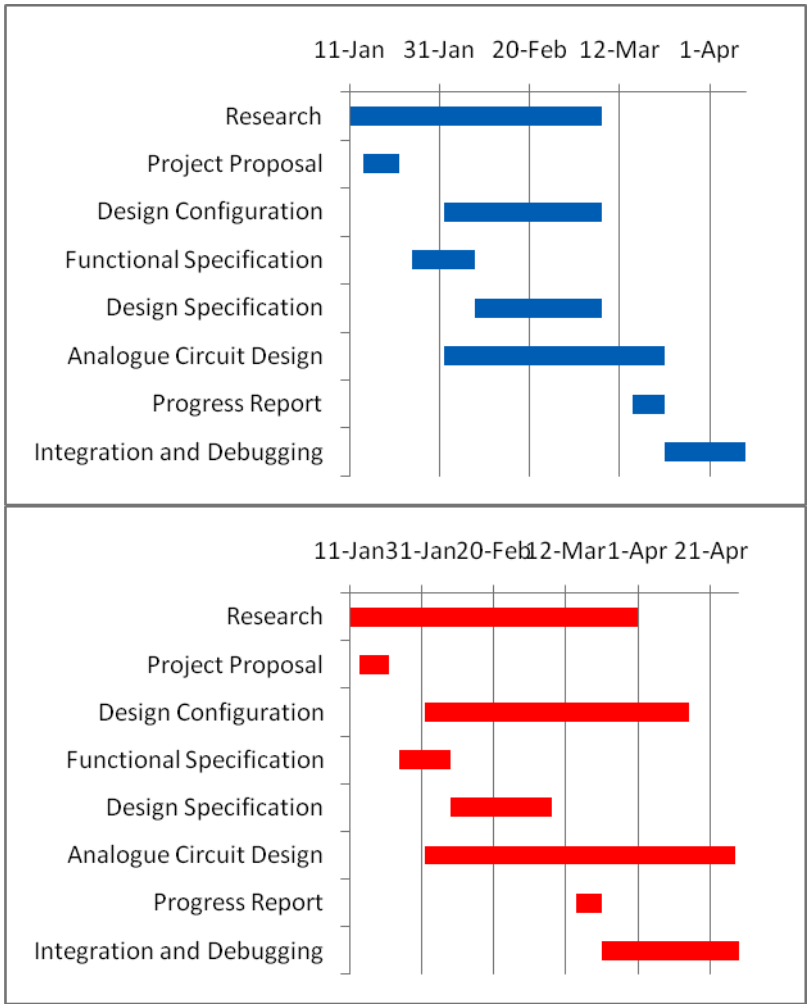
Equipment List	Cost
Microcontroller(MC9S08QG8)	$8.50
Mixer (SSM216PZ and LME49720NA)	$18.50
PSU IC(LM324AN)	$1.75
Breadboard	$0
Stomp cables	$20.95
Switches	$20
Capacitors	$6
Resistors	$4
Casing	$10
Total Cost	$89.7

Table 5.2 Cost of final product using analog mixing

Overall, musictronics spent less than the expected cost due to the switch from digital mixing to analog mixing. Moreover, we ordered parts in excess in order to prevent additional shipping expenses incase parts malfunctioned in middle of implementations.

5.2 Timeline

April 9, 2010 was the estimated completion date of the Combinator. The following Gantt charts illustrate the proposed timeline for the various developmental stages as they compare to our actual amount of time spent. The proposed time for each stage is in blue and the actual amount of time spent is in red.



First of all, due to the lack of our funding, we had to wait to be able to rent the FPGA board from school. Unfortunately, we were unable to get the board before the Olympics break, and that held us back for two weeks. When we got the board after the break, we had to work extensive schedule to just simulate with the board with our already design configuration circuit. We were able to finish the simulation and make the board get corrects responses from our switching unit. After that, we basically worked everyday till the end of the March to finish the project. However, when we started testing our last part, we were unable to get a good quality sound out of the board's DAC. That was the crucial time we had to decide on some other way, and that was when we came to the conclusion that the FPGA board is actually holding our project back. At the time, we started brainstorming again and designed a new circuit, all in analogue. Then, we spent the last 2 weeks of April making the new circuit. We only had two days for testing before we prepare for our demonstration.

6.0 PERSONAL EXPERIENCES

Gondang Prabowo Yudo

ENSC 440 has given me an insight on how projects are being researched, developed, and delivered in real life. The course can be a nightmare at times but the end result is rewarding. I know beforehand that for my ENSC 440 I wanted to do something with a guitar since guitar is my passion. And I am glad that I found people that appreciates my idea and agreed on taking it as our ENSC 440 projects. This course teaches me a lot, not only technically but also mentally.

An important lesson I learned from this course is how to be an independent learner, especially during researching on our project. The knowledge on how one interprets datasheet of a component into something that is useful or applicable in our project does not come from studying but from repetitive action or habit in reading technical papers.

This project has increased my knowledge on analog designing especially audio signal processing. Designing audio circuit is a more delicate process due to the fact that noise is so much more apparent on Audio signal in compare to other. I also learned the process of programming a microcontroller unit using CodeWarrior since I never really use or program a microcontroller before.

ENSC 440 also taught me on how to work in a team and how to be a leader which is really useful in future. I learnt that each person has different way of problem solving and way of undergoing certain tasks and this open my eyes to see thing in different perspectives. I also learned on how to be supportive to a team member as a leader when they are having difficulties.

Kianoush Nesvaderani

It was quite a pleasure for me retaking the capstone project course and successfully completing it after a harsh and unpleasant time I went through for the past six months. I was enrolled to this course last semester, but things got out of my hand in my personal life I had to withdraw from the whole semester. What really bothered me at the time was the completely childish way my former group was trying to treat me. First of all, they tried reporting me before giving me any warning. I used to send my parts to them, and they never mentioned they were not happy with them, and when I was planning to tell them in a formal way that I was withdrawing, they gave me an ultimatum to do some unreasonable amount of work in 3 days or they expel me. Due to this unprofessional behavior, I just decided to not tell them anything and let the natural process of my withdrawal go through. However, when they did not get anything back from me in 3 days, they tried to change the password of a server I had rented and that caused the server company to find the fraud and suspend the server. Worst of all, they wrote bunch of lies about me deleting the stuff from the server. Why would I have ever wanted anything deleted while I was already withdrawn from the course?

On the other hand, this semester I had the chance to find two new friends who were cooperative and understanding in so many ways. We managed everything and even when we went out of time in April, we never lost the track and with cooperation and time managing, we came up with the new design. Besides, trying to be friends instead of partners helped us a lot in understanding our time schedule and behavior.

We never went hard on us and were always flexible towards each other, which made us survive in my opinion.

On the technical side, I had the chance to learn a new programming language. I never had the chance to use VHDL in my previous courses and exposing myself to a hard challenge made me learn a lot about how to use this language in integrating circuits. Besides, I learned a lot about programming microcontrollers and how I can use them for selecting inputs on a circuit. Last but not least, I learned how time management is crucial to an engineering project and how the design on a paper can differ from actual physical experience on a circuit. In general, I am happy I retook this course despite all the issues I am still struggling with in life.

Amanueal Hailegiorgis

First and foremost I would like to express my gratitude to my teammates as they have worked very hard during the term to make our vision a reality. It was a pleasure working with them throughout the term. In addition to gaining numerous technical skills, I have learned, from this experience, how to better function as a member of a team, as well as how to design and implement the product. Moreover, I learned how to plan ahead, which is an essential skill to acquire for an engineer.

Throughout the past few months, my teammates and I have had regular meetings to plan and execute our project. Through good communication, we were able to successfully resolve all the issues we encountered with professionalism as we had a great group dynamic. Since we tackled the project in phases, we were able to leave an ample amount of time to integrate and test the complete system.

In this project, my tasks encompassed that of a Chief Technical Officer. Mainly, I was responsible for quality assurance as well as proper implementation. While working on this project, I had to apply the theoretical knowledge I learned in the courses I have taken in my undergraduate career and used it directly in the design process. I ran into complications midway through working on the project, but I was able to act quickly and we the combined effort of my teammates we were able to stir our project into the right direction.

All in all, I enjoyed working on this project. I believe that I have gain many transferable skills that will aid me in my future endeavors. My teammates were professional and co-operative, and it was a pleasure working with a group of people with different sets of skills and know how.