EEL 4914 - Senior Design 1 Project - Group C

Analog and Digital Effects Processing Technology (ADEPT)

Department of Electrical Engineering and Computer Science

University of Central Florida

Dr. Lei Wei

Group C

Diego Conterno - CpE

Tyler Michaud - EE

Alejandro Porcar - CpE

Dylan Walter - EE

Project Narrative Description

As engineering students, as well as musicians, we find that a senior design project based around audio engineering, music technology, and sound design would be very rewarding and informative. It would be the perfect opportunity to apply the engineering fundamentals we have learned into something we are passionate about. Closing the gap between technology and music, we aim to provide new alternatives for musicians who want to stand out and shape their sound in a unique way. We are attempting to provide a digital multi-effects solution that will have a creative impact on musicians with an interest in electrical and computer engineering.

Therefore, we are proposing the idea of designing a musical instrument effects processing unit. This simple-to-use effects pedal would be able to take the analog input from a guitar or other musical instrument (via a ¼" instrument cable), convert that analog signal into a digital signal that can be manipulated within a processing unit, and then be converted back into an analog signal that can be heard by human ears.

The digital signal processing (DSP) will be done by a microcontroller or microprocessor. This processor will have a minimum requirement of a 16-bit resolution, and a sample rate of 44.1kHz. This will guarantee a high-fidelity stereo sound output. The DSP chip can be either integrated into the main processing unit or it can be external. In this way we are not limited on the type of processing unit we will use for our effects. We plan to have a variety of modulation and time-based effects (delay, reverb, chorus, phaser, and tremolo), as well as some effects that implement a manipulation of gain or bit depth (distortion/overdrive, bitcrusher, etc).

Since we are attempting to manipulate analog signals digitally, an ADC/DAC (Analog-to-Digital/Digital-to-Analog Converter) will have to be implemented into the design. Since most guitar pedals that are commercially available run off of 9V – 12V (DC), the power requirements would be very simple to integrate. Due to the nature of this project, and its integration between software and hardware elements, the workload will be very balanced between the EE and CpE students on the team.

Requirements Specifications

Features/Requirements

- Use of microcontroller/microprocessor for DSP
- Stereo output
- Able to run on 9V – 12V (DC)
- Minimal added noise no greater than -14dB
- At least 7 different digital effects to choose from
- Ability to control various programmed effect parameters
- Reprogrammability via USB
- Minimum of 4 simultaneous memory presets
- At least 16 bits (or higher quality)
- Sample rate of 44.1kHz

Tentative Features:

- MIDI/sampling compatibility
- Animations/visuals/oscilloscope screen
- Touch screen user interface
- Expression Pedal control

House of Quality

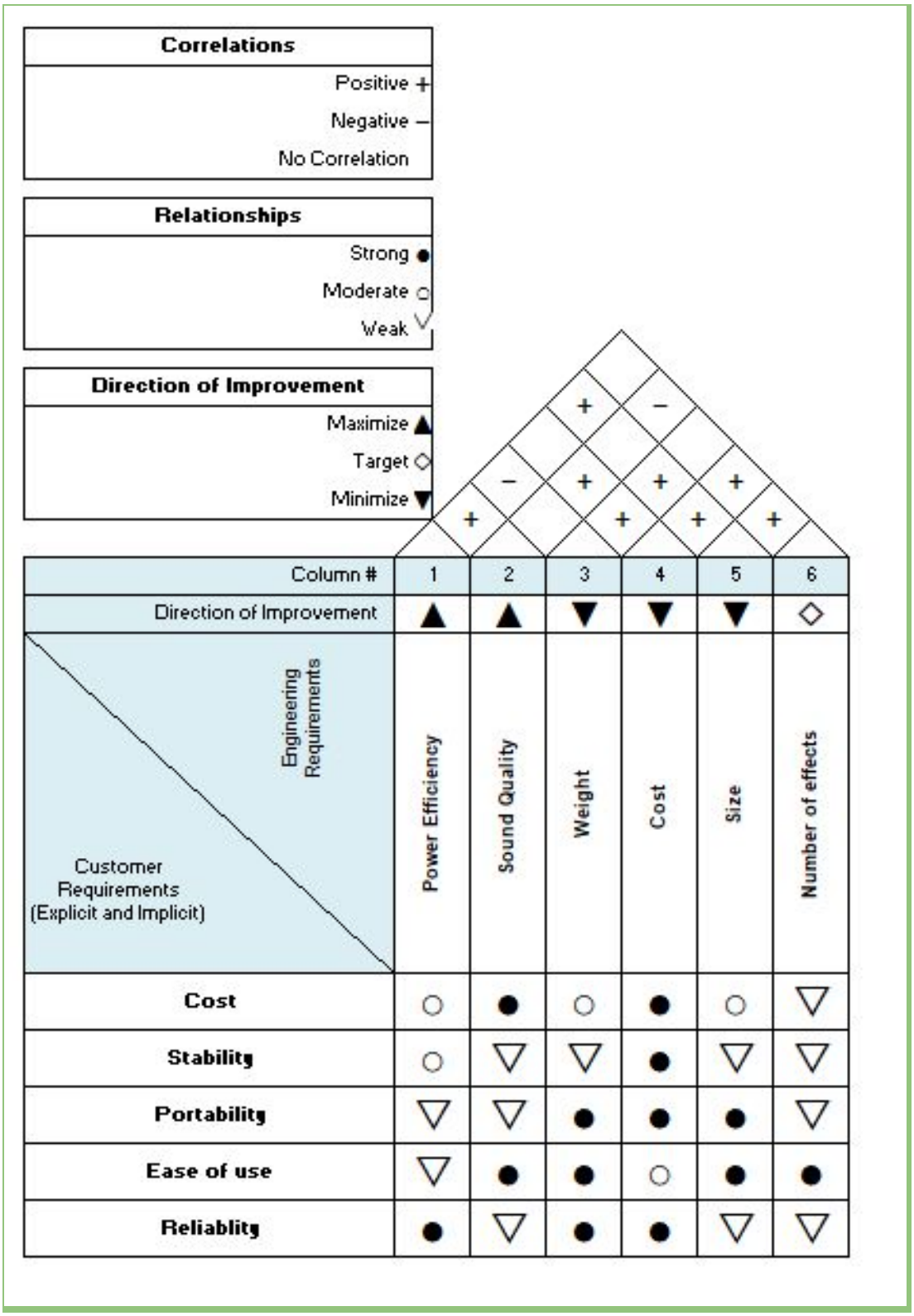

Figure 1: House of Quality

Block Diagram

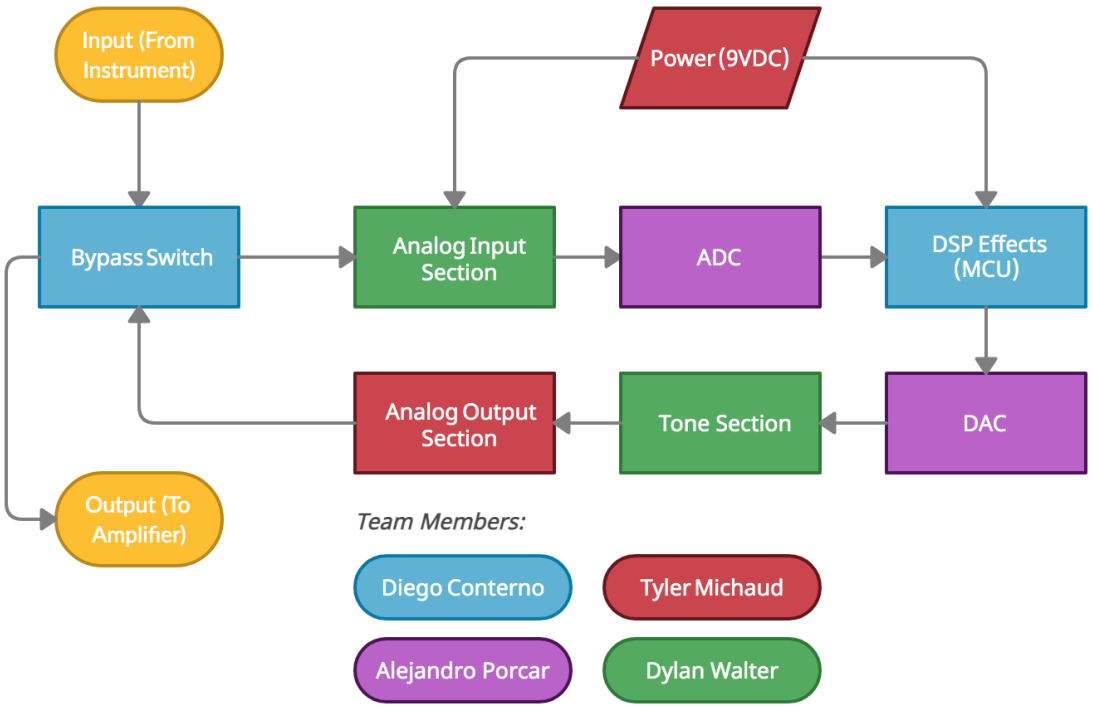

Figure 2: Block Diagram

Block Title	**Block Status**	**Responsible Member**
Bypass Switch	Researching	Diego
Analog Input Section	Researching	Dylan
ADC	Researching	Alejandro
DSP Effects (MCU)	Researching	Diego
DAC	Researching	Alejandro
Tone Section	Researching	Dylan
Analog Output Section	Researching	Tyler
Power (9VDC)	Researching	Tyler

Table 1: Block Diagram Responsibility Chart

Budget

Since the cost of these parts is relatively minimal, our team will not require a sponsorship for our project. The total estimated cost of all the parts necessary in order to build the working ADEPT prototype will be approximately $150.

Parts	**Cost**
PCB	$50-100
ADC/DAC/CODEC	$10-20
Resistors (various values)	Already purchased
Capacitors (various values)	Already purchased
Diodes (1N4148 and 1N4001)	Already purchased
Operational Amplifiers	Already purchased
Transistors (2N2222A)	Already purchased
Logarithmic (Audio, B type) Potentiometers	$0.55/ea
4-Position Encoder Rotary Switch (for preset selection)	$2.00
MCU (for DSP)	TBD
Memory chip (for preset selection)	TBD
Interface chip (for programming)	TBD
Mini oscilloscope screen/LCD	$15-20
9V DC Power Jack (Center Negative)	$0.65/ea
Metal Enclosure (likely Hammond 1590BB)	$6.00
Knobs	$0.65/ea
3PDT true bypass switch OR soft-click momentary switch w/relay switching system	$2-10
¼” mono input/output jacks	$2.00/ea
USB connector (for programming)	$2.00
Indicator LEDs	Already purchased

Table 2: Budget and Parts List

Milestones

TASK	ASSIGNED TO	PROGRESS	START	END
Project Report				
Divide and Conquer Document	Alejandro, Dylan, Tyler, Diego	100%	1/28/21	1/29/21
Table of Content	Alejandro, Dylan, Tyler, Diego	0%	1/29/21	4/16/21
60 page draft report	Alejandro, Dylan, Tyler, Diego	0%	1/29/21	4/2/21
100 page draft report	Alejandro, Dylan, Tyler, Diego	0%	1/29/21	4/16/21
100 page final report	Alejandro, Dylan, Tyler, Diego	0%	1/29/21	4/27/21
Research, Documentation & Design				
Block Diagram	Dylan	100%	1/25/21	1/29/21
Components and parts list	Alejandro, Dylan, Tyler, Diego	25%	1/27/21	2/1/21
Microcontroller/Microprocessor	Alejandro & Diego	0%	1/27/21	2/2/21
ADC/DAC	Alejandro & Diego	0%	1/27/21	2/2/21
Network & connections schema	Diego & Dylan	0%	1/27/21	2/2/21
Effects	Diego & Alejandro	0%	1/27/21	2/2/21
Power supply	Tyler & Dylan	0%	1/27/21	2/2/21
PCB layout	Tyler & Dylan	0%	1/27/21	2/2/21

Figure 3: Semester Milestones Gantt Chart

Products Under Consideration

1. Instrument Amplifier
2. Instrument Effects Pedal
3. Effects Processing Design
4. Electronic Instrument/Synthesizer
5. Recording Software (DAW)
6. Virtual Software Instrument
7. Standalone Audio Workstation
8. MIDI to Audio Converter
9. Music Notation Software
10. Preamplifier
11. Video Synthesizer
12. Music for the Deaf
13. Guitar Fretboard Learning Device
14. Acoustically Responsive Speaker
15. High Fidelity Audio Interface
16. Sound Sampling Capabilities

References / Research

Dissecting a Distortion / Overdrive Guitar Pedal
https://www.neatcircuits.com/doctor_pedal.htm

Digital Signal Processing using a Raspberry Pi
https://www.electrosmash.com/forum/pedal-pi/207-basics-of-audio-dsp-in-c-for-rapsberry-pi-zero

DSP chip Alternatives:
https://cdn-shop.adafruit.com/datasheets/vs1000.pdf
http://www.vlsi.fi/en/products/vs1103.html
https://ww1.microchip.com/downloads/en/DeviceDoc/70292G.pdf
https://www.ti.com/product/TMS320C6711D

Solid State Relay 24-V AC Switch With Galvanic Isolation
https://www.ti.com/lit/ug/tidub92b/tidub92b.pdf?ts=1612840577475&ref_url=https%253A%252F%252Fwww.google.com%252F

OPAx134 SoundPlus™ High Performance Audio Operational Amplifiers
https://www.ti.com/lit/ds/sbos058a/sbos058a.pdf?ts=1612821803447&ref_url=https%253A%252F%252Fwww.google.com%252F

Similar projects

TI Digital Guitar Pedal
https://www.ti.com/lit/ml/sprp499/sprp499.pdf

FV1 Bit Crusher
https://www.youtube.com/watch?v=VuZOQ0T5Y0w

Arduino Mega Guitar Pedal
https://hackaday.com/2018/05/08/stomping-microcontrollers-arduino-mega-guitar-effects-pedal/

FV1 8FX Pedal
https://www.youtube.com/watch?v=5byraXi2TQg

Arduino Vocal Effects Box
https://www.instructables.com/Arduino-Vocal-Effects-Box/