3-INput Pre-Amp

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Acknowledgements

We would like to thank everyone that supported our ideas and help facilitate a greater understanding of electrical engineering and life. To our professors at Cal Poly San Luis Obispo, families, friends and distinctively our senior project advisor Vladimir Prodanov, thank you. There's no free lunch, we now know.

Abstract

There is no commercial available pre-amplifier that takes 3 individual input signals and synthesizes them for an acoustic guitar. The acoustic pre-amplifier takes three separate small signal inputs and combines or isolates to endure amplification depending with user setting. The user deciphers which signal or signal combination is desired. The device features coil pick-up, microphone pick-up, and piezo disc pick-up for variety of tone quality and control.

I. Introduction

In the world of music, a musician explores his instrument contained by creative bounds, grasping for refreshing new perspectives. The 3-INput Pre-Amp meets costumer needs by offering a creative door to be opened by the musician. This door allows the musician to embrace the full embodiment of the acoustic guitar. With renewed perspectives come innovative styles, new cultural uprisings, which all hold constructive value in a progressive society. The 3-INput Pre-Amp provides variation of tones with synthesis adding a further extension and control of the natural acoustic sound.

II. Requirements and Specifications

TABLE I
3-INPUT PRE-AMP REQUIREMENTS AND SPECIFICATIONS

Table 1: Requirements and Specifications

Marketing Requirements	Engineering Specifications	Justification
1	Signal Distortion: 1% of input/output signal	Based on similar commercial available products. Also test equipment limitations.
1	Frequency Response: 20Hz to 20KHz(-3dB)	Human audible sound range.
1	SNR: Greater than -70dB	Based on similar commercial available products. Also test equipment limitations.
1,5	Voltage Gain ~ 16 dB (Per Individual Input)	Based on similar commercial available products.
1,2,3	Input Impedance ~ 50Mohms	Prevent loading transducers.
1,2,3	Output Impedance ~ 3kohms	Prevent loading pre-amp.
2,3,4,5	Power Supply : 4.5V (3 AAA Battery) , Less than 10mA consumption	Commercially available power source, Extend battery life and efficiency.
2,3,4,5	Weight: < 5 Lbs	Easy to use, install and maneuver.
2,3,4,5	Dimensions: 5"L x 3"W x 2" H	Comparable to guitar pedals.

Marketing Requirements

1. The system should have great sound quality.
2. The system should be easy to install.
3. The system should have low cost.
4. The system should have long battery life.
5. The system should have switches for choosing input arrangement.

For competitive purposes, product suitability and commercial standards, the goal is to meet specifications and compete commercially. Our amplifier should have great tone quality with low sound distortion, be low cost in comparison to market value products, have just as long battery life, portable or easy to fit next to other guitar pedals, durable and have the ability to give the user the choice of synthesis for their specific choice of tone.

III. Functional Decomposition (Level 0 and Level 1)

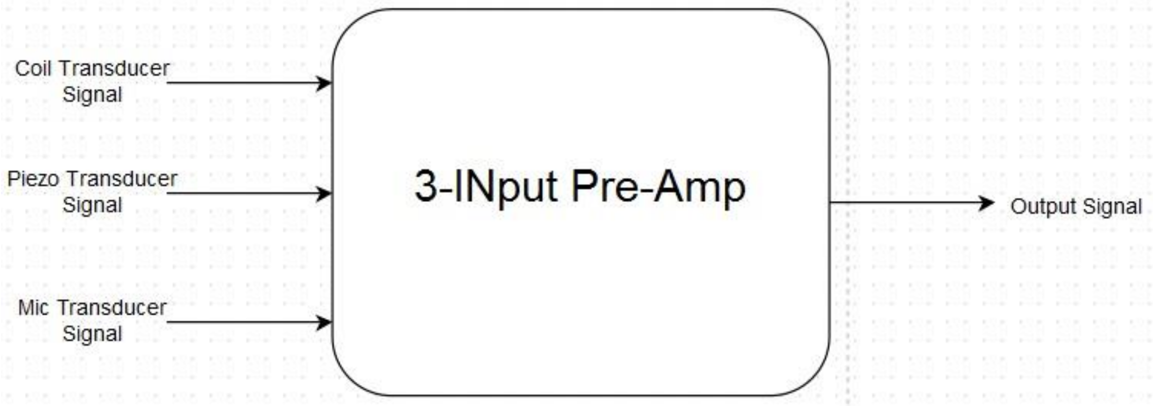


Figure 1: 3-INput PRE-AMP Level Zero Block Diagram.

Figure 1 above shows the main inputs and outputs of the 3-Input Pre-Amp. The system allows three different pick-up inputs: coil, microphone and piezo-disc, which can be selected individually or whatever combination choice by the user.

Figure 2: AAA Battery Holder, Coil Transducer, Piezo Transducer and Electret Microphone

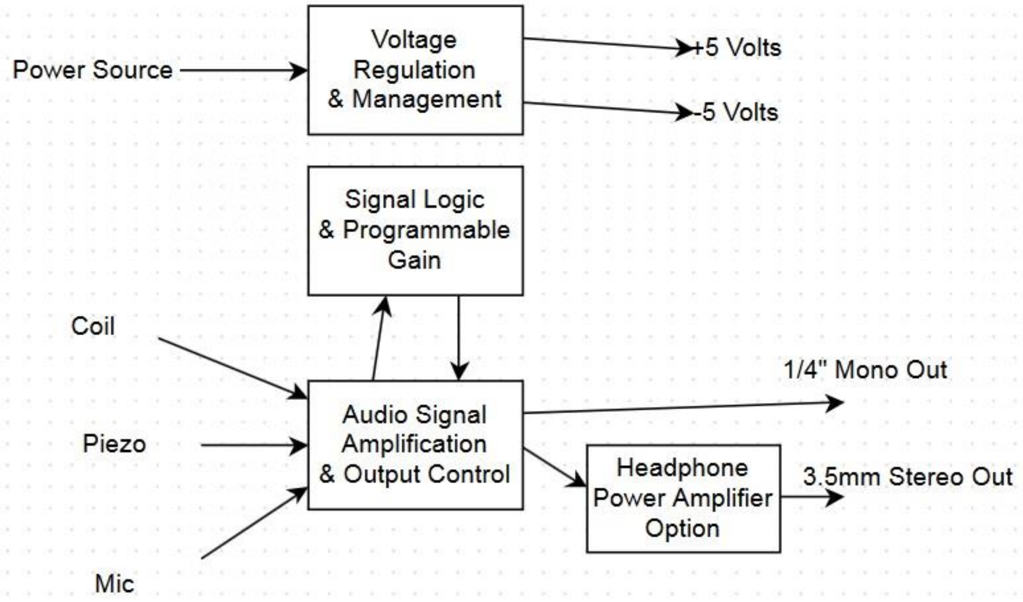


Figure 3: 3-INput PRE-AMP Level 1 Block Diagram.

Figure 3 elaborates on the main internal functions of the pre-amplifier which require the Voltage regulation and Management, Signal Logic and Programmable Gain, Audio Signal Amplification and Output Control, and Headphone Power Amplifier Option.

TABLE II
LEVEL ONE BLOCK DIAGRAM DESCRIPTION

Table 2: Level One Block Diagram Description

Modules	**3-Input Signal Amplifier**
Inputs	3 Small Signals: Magnetic Coil pick-up Signal, Microphone Transducer pick-up, and Piezo disc vibration pick-up. Power Source consist of two inputs one is optional. Primary Source is Battery with auto switch Auxiliary (USB) capability available.
Outputs	Amplified, synthesized output signal to either ¼” mono jack or 3.5mm Stereo headphone option.
Functionality	The system takes in three small input signals. Conditions and Synthesizes accordingly to create a large clean output signal.

IV. 3-INput Pre-Amplifier Design, Test and Implementation

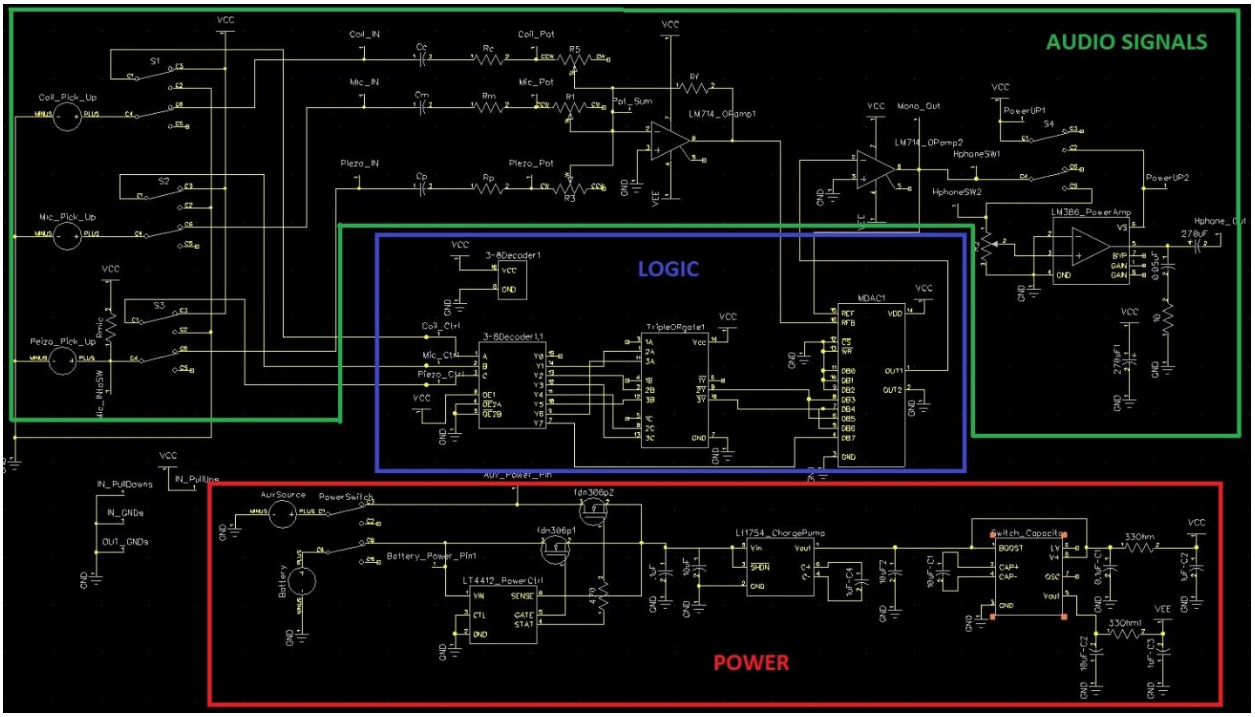


Figure 4: 3-INput Pre-Amplifier Schematic

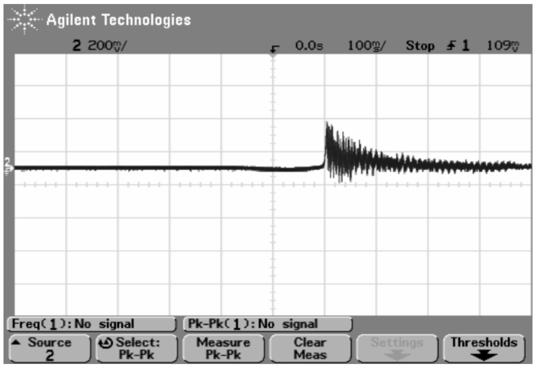
The 3-INput Pre-Amplifier can be divided into three different stages: the power stage, the logic stage and the audio signals stage. The power stage contains a power source controller, voltage regulator and a switch capacitor which sets the appropriate rails for the operation of the system and allows the user to power the pre-amp with either a battery or auxiliary source. The logic stage is composed of a 3-8 line decoder, OR Gate and MDAC. This stage controls the gains of the input signals according to the number of pick-ups that are set on manually by the switches. The audio signals stage equalizes all inputs signals so that the output of the pre-amp is approximately 1V-2V, which is standard for the input of power amps. The system also contains a headphone boost option which amplifies the signal to 2-4 V with internal adjustment for headphone use.

i. Input Signal Ranges

The three different pick-ups were tested in order to obtain the voltage ranges of the input signals to the pre-amplifier system. Each pick-up was observed with different styles of playing to gather the setting values for the designing of the pre-amp. The average or common values were then considered for the selection of the components in the design to avoid distortion of the signal by clipping. The following figures and tables summarize the data gathered:

Piezo Pick-Up

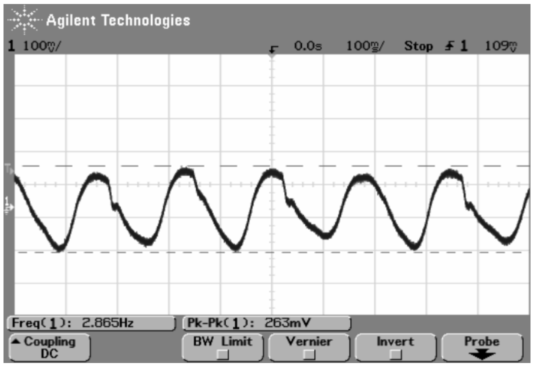
E6 String – (82Hz):


2 200mV/ 0.0s 100ms/ Stop 1 109mV

Freq(1): No signal

Pk-Pk(1): No signal

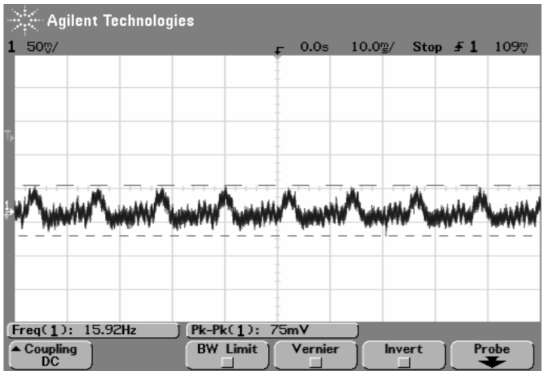
Figure 5: Pluck Style Test


1 100mV/ 0.0s 100ms/ Stop 1 109mV

Freq(1): 2.865Hz

Pk-Pk(1): 263mV

Figure 6: Manual Pulling Test


1 50mV/ 0.0s 10.0ms/ Stop 1 109mV

Freq(1): 15.92Hz

Pk-Pk(1): 75mV

Figure 7: Guitar Pick Test

E1 String – (330Hz):

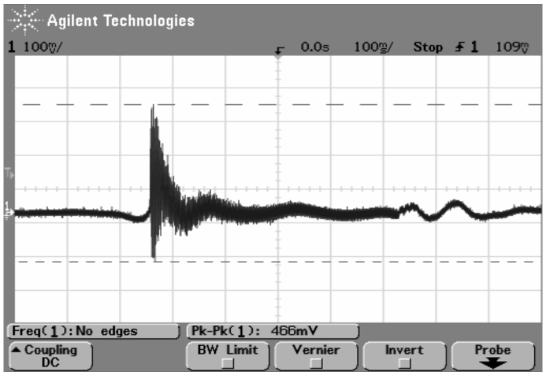


Figure 8: Pluck Style Test

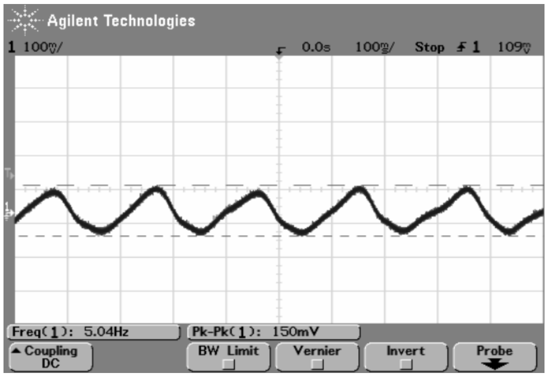


Figure 9: Manual Pulling Test

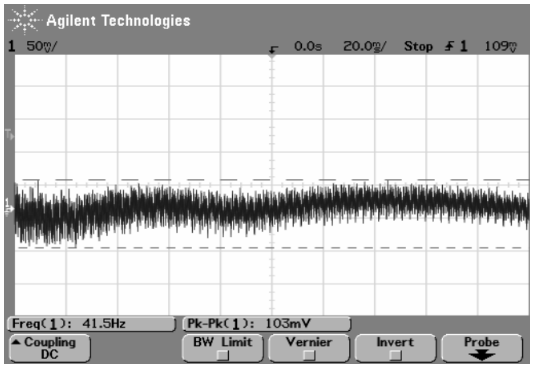


Figure 10: Guitar Pick Test

Other Testing Styles:

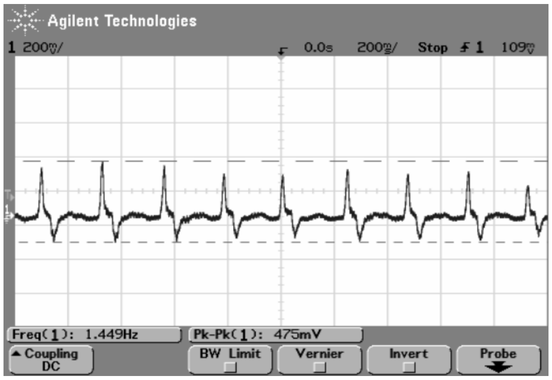


Figure 11: Moderate Banging Test

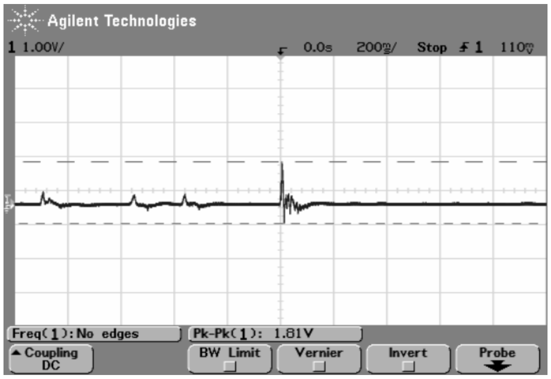


Figure 12: Extreme Banging Test

Coil Pick-Up

E6 String – (82Hz):

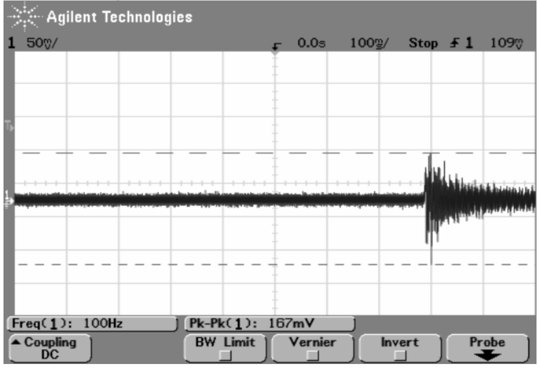


Figure 13: Pluck Style Test

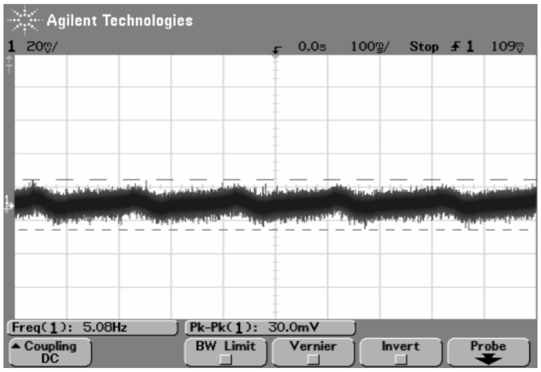


Figure 14: Manual Pulling Test

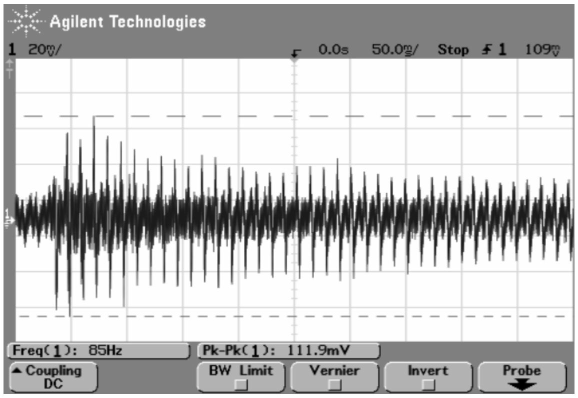


Figure 18: Guitar Pick Test

E1 String – (330Hz):

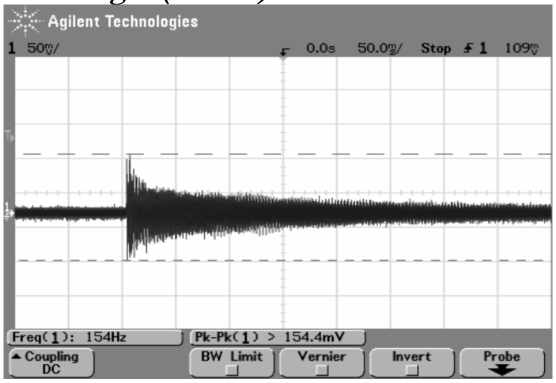


Figure 21: Pluck Style Test

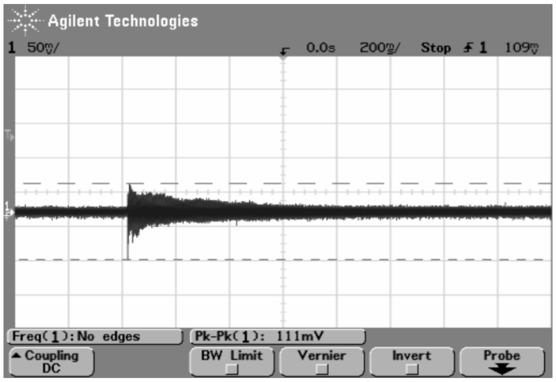


Figure 22: Guitar Pick Test

Other Testing Styles:

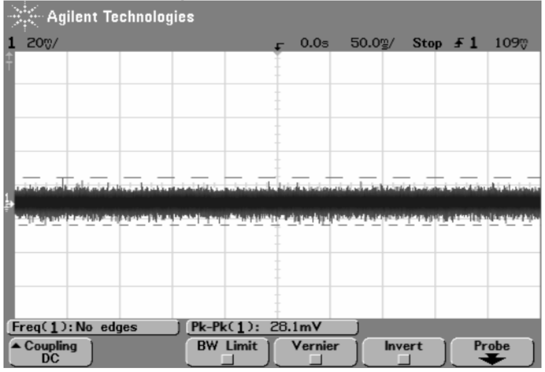


Figure 16: Nothing Test

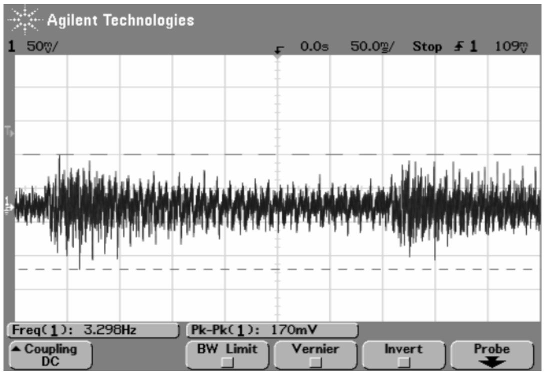


Figure 17: Open Strum Test

Electret Microphone Pick-Up

E6 String – (82Hz):

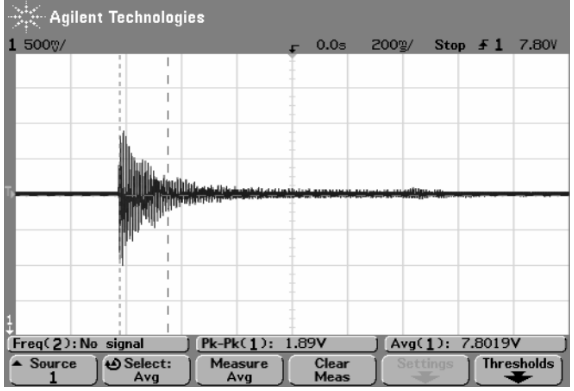


Figure 19: Pluck Test

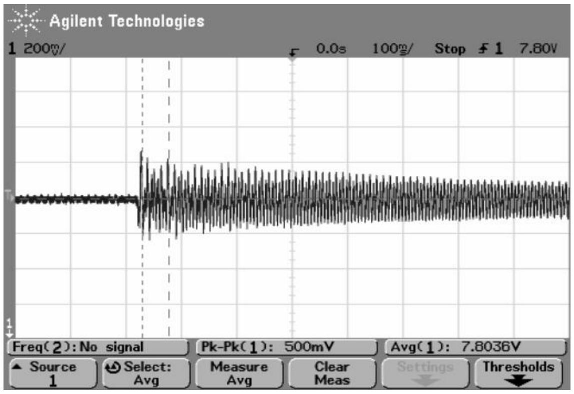


Figure 20: Guitar Pick Test

E1 String – (330Hz):

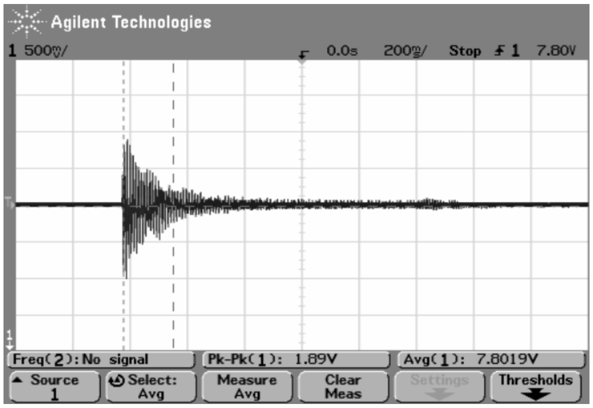


Figure 23: Pluck Test

Other Testing Styles:

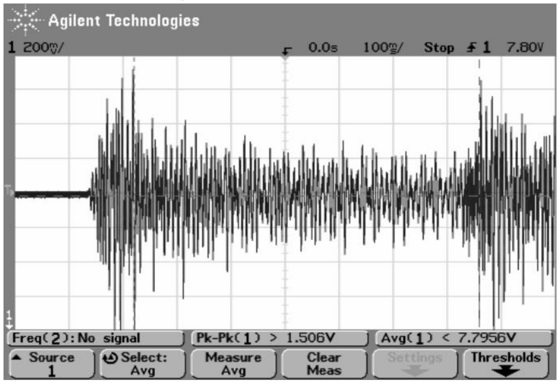


Figure24: Open Strum Test

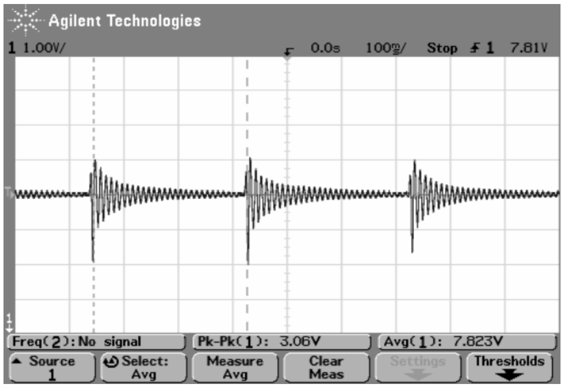


Figure 25: Moderate Banging Test

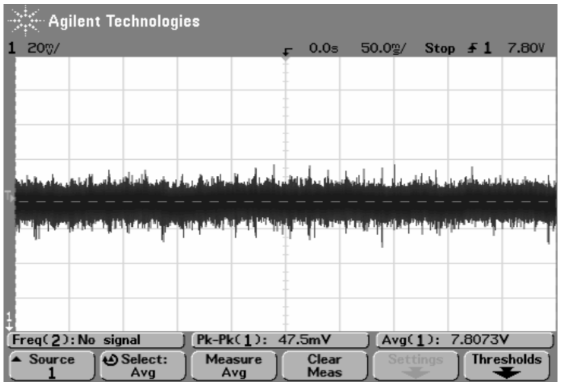


Figure 26: Nothing Test

Table 3: Peak-Peak Voltages for Piezo, Coil, and Microphone Pick-Ups

Guitar Test Style	Nothing	Manual Pulling	Open Strum	Extreme Slap	Moderate Slap	Guitar Pick(E6/1)	Hard Finger Pluck(E6)	Hard Finger Pluck(E1)	Approx.
Coil Pick-Up	20	30	170	N/A	N/A	112	167	154	~mVpp
Piezo Pick-Up	N/A	263	200	1800	475	87.5	400	2.09V	~mVpp
Electret Mic	47.5	N/A	400	4.19V	3.06V	500	1.89V	980	~mVpp

The data obtained from the waveforms in the figures above is summarized in Table 1. The highlighted values are the common values for each input signal. These values are the ones considered for setting appropriate component values for the design of the pre-amp gain stages in order to maintain an output signal free of distortion.

ii. Power

Power Source Switching and Voltage Regulator

The low-loss power path controller with current charge pump regulator provides automatic switching between two power sources, auxiliary and battery. The first stage of the low-loss power path controller controls a P-channel MOSFET which acts as a power switch. The sense pin of the LTC4412 outputs the highest voltage between the two power sources. Therefore, when the aux input is ON, the battery input would be disconnected saving power dissipation from it unless required. The LTC1754 current pump regulates output voltage of the controller and sets it at a steady 5V which is the operating voltage for the pre-amplifier. The regulator allows an input voltage in the range of 2.7 to 5.5 V in order to allow a 5V output. This particular stage enhances battery life.

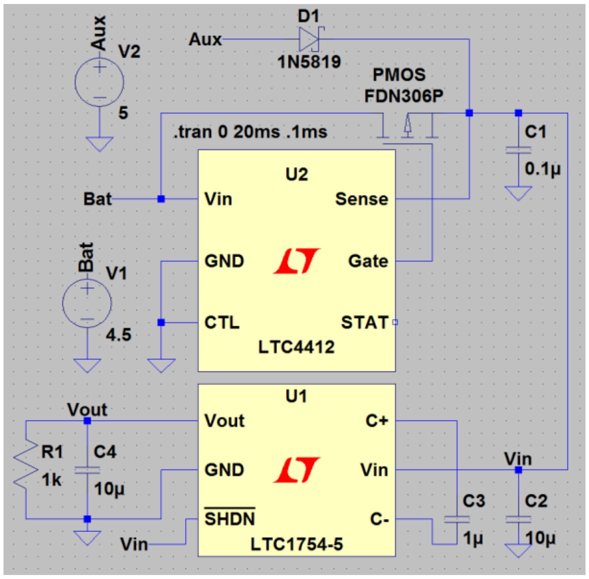
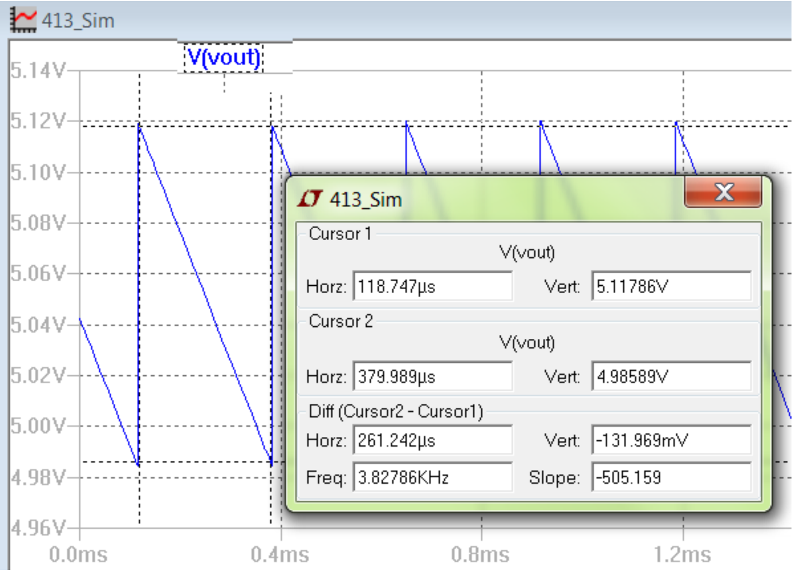


Figure 27: Schematic for Power Source Switching and Current Charge Pump

Below are the results for various tests done to verify that the output power to the system holds at 5V regardless of being powered by a battery or USB source and is able to output 5V with even a low input voltage of 2.7V. As seen from Figure 28, the output voltage contains some ripple but through testing, the operation of the pre-amp didn't seem to be affected by it.

Table 4: Test Cases for Power Source Switching and Voltage Regulator Stage

$V_{BATTERY}$ (V)	V_{AUX} (V)	V_{OUT} (V)	V_{RIPPLE} (mV)
4.5	0.0	5.04	108
4.5	5.0	5.04	106
2.7	0.0	4.99	52
4.5	5.5	5.05	131



Cursor 1
V(vout)
Horz: 118.747µs Vert: 5.11786V
Cursor 2
V(vout)
Horz: 379.989µs Vert: 4.98589V
Diff (Cursor2 - Cursor1)
Horz: 261.242µs Vert: -131.969mV
Freq: 3.82786KHz Slope: -505.159

Figure28: Power Controller and Regulator Voltage Output Simulation

The Figure below shows the implementation of the power controller and regulator. It has two inputs, one for an auxiliary source and another for a battery source. The 5V output is then connected directly to the input of the switch capacitor.

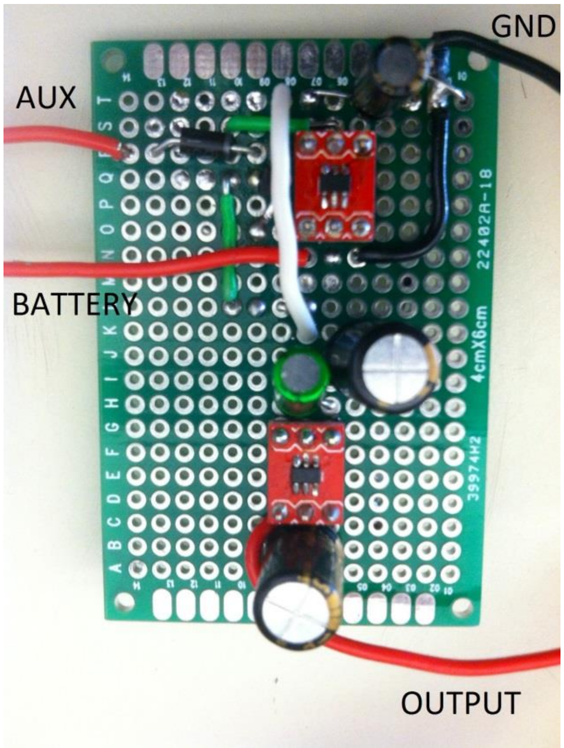


Figure 29: Power Controller and Current Charge Pump Regulator

Switched Capacitor

In order to simplify the design of the pre-amplifier and provide headroom (voltage range) to prevent distortion, the system is sustained using a dual-supply of 5V to –5V making the reference voltage at GND level. The power stage will produce a 5V output and therefore, a switched capacitor is used to produce the negative voltage of –5V. The figure below shows the configuration of the MAX1044 Switch Capacitor.

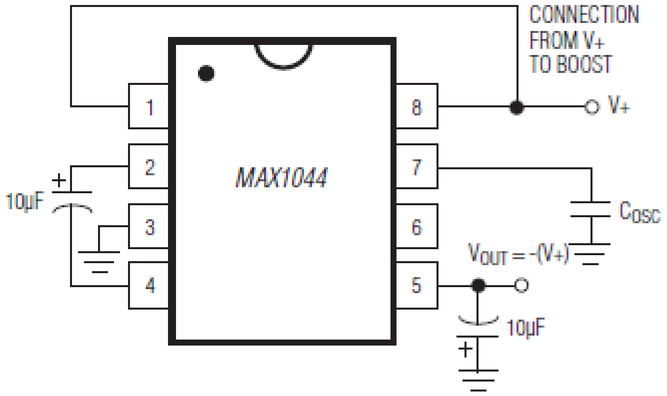


Figure 30: Switching Capacitor Configuration

The Switched Capacitor effectively produced the -5V for the dual supply of the op-amps but introduced noise to the system. As seen in the waveform below, the positive rail or channel 2 waveform produced a noise voltage of approximately 560mVpp and the negative rail or channel 1 waveform produced 890mVpp noise.

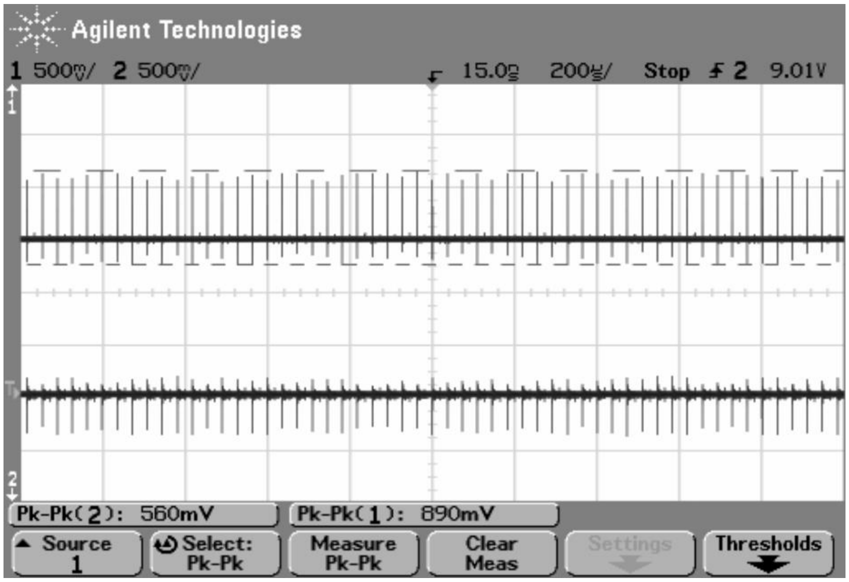


Figure 31: Switched Capacitor Rail Noise

The noise was also present in the output of the pre-amplifier, for which filtering was required in order to reduce the corruption in the signal. The values for the filter design were found according to the calculations shown below considering that the total system pulls

7mA. The cutoff frequency was chosen at 5.3kHz to eliminate all high frequency noise while retaining the bandwidth required for the range of frequencies of the input signals of a guitar (~ 20 Hz – 1.5 kHz). The calculations and values chosen for the filter components were made for an initial 9V to -9V design but still applied to the final 5V to -5V design, therefore were kept unchanged.

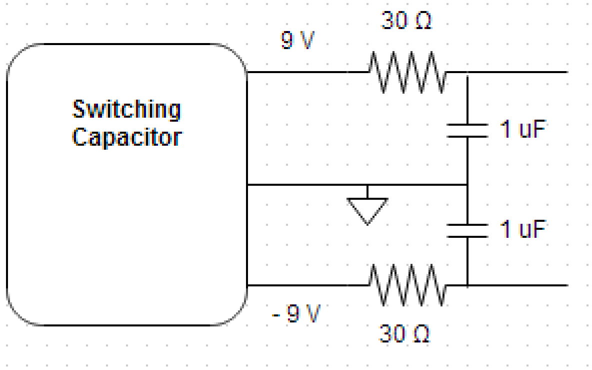


Figure 32: Switched Capacitor biasing Circuitry

$$5\%\ of\ 9V = 480mV \approx 390\ mV$$
$$V = I * R$$
$$390\ mV = 13mA * R$$
$$R = \mathbf{30}\ \Omega$$
$$C = \frac{1}{2\pi * 5300 * 30} = \mathbf{1\ uF}$$

After filtering, the noise at the output reduced by a factor of 5 yielding peaks of 162.5Vpp at the same frequency of 27kHz as shown in the figure below.

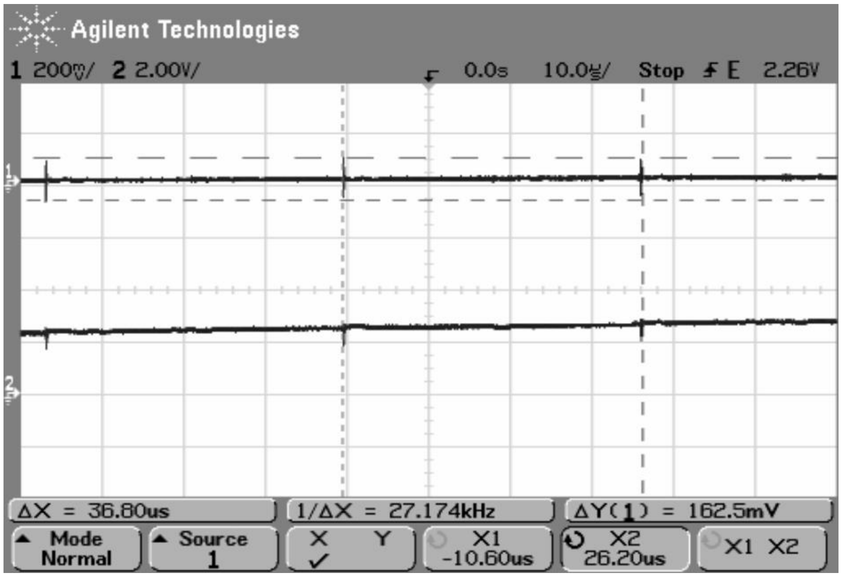


Figure 33: Input and Output Signals with Switch Capacitor Filter

The final design is operated with a 5V dual supply. The rails of the system are shown in the picture below for the final prototype.

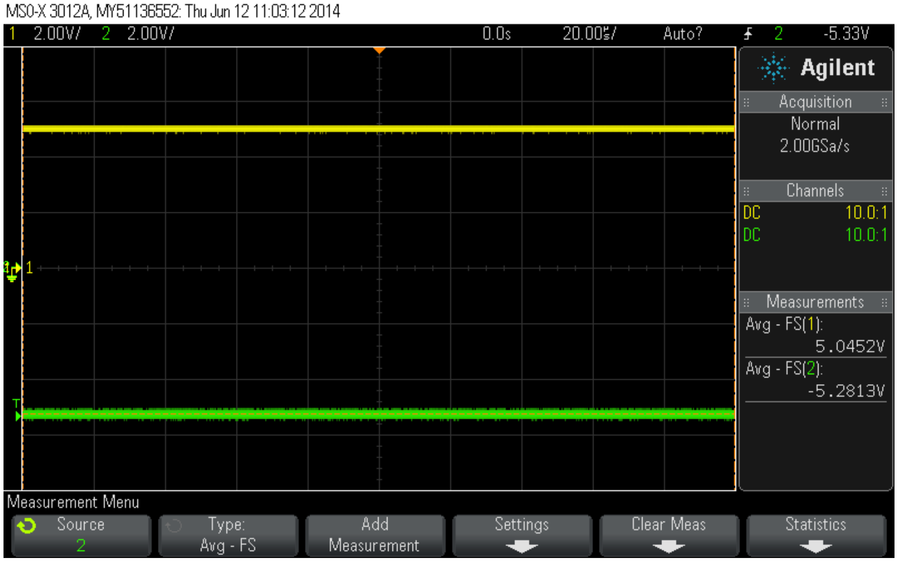


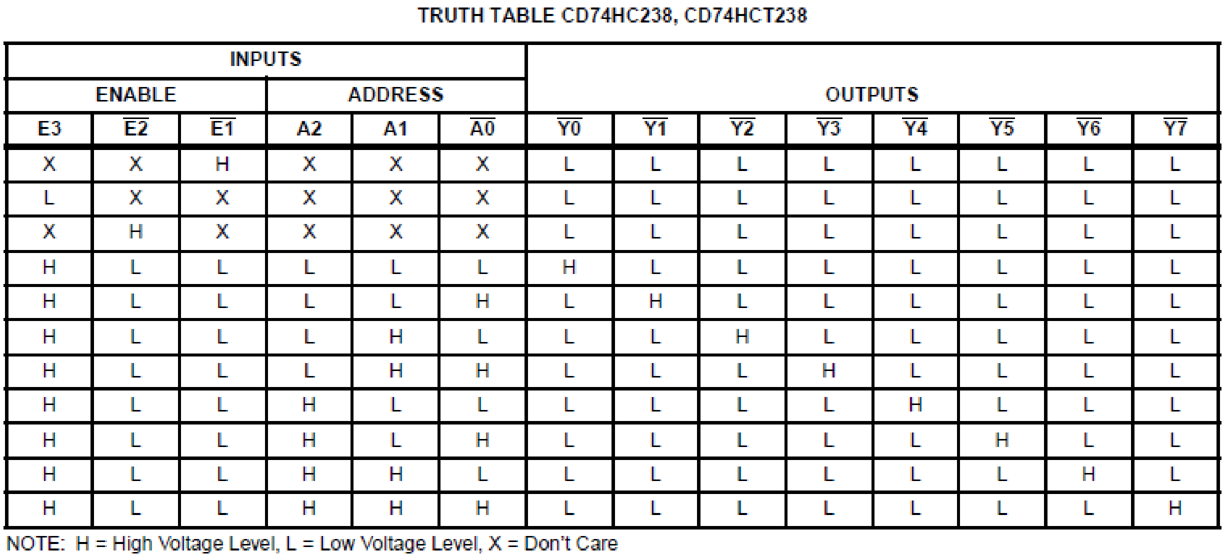
Figure 32: Voltage Rails for Final Prototype

iii. Logic

3-8 Decoder and OR Gate

The switches required for turning ON/OFF the input signals and setting the appropriate values for the programmable gain are going to be controlled by a CD74HC238 3-8 line decoder and a CD74HC4075 OR Gate. Three external switches will allow the user to control the inputs signals to be used (coil, piezo, mic or a combination of these). The state of the switches will also dictate the appropriate digital values set for the MDAC in order to provide the corresponding gain for the various cases. The programmable gain is set to amplify the signal depending on the number of inputs that are going into the system. The gain is set differently when only one input is on, two inputs are on or all input signals are going through. The 3-8 decoder determines how many switches are on and the OR gate combines the different possibilities for a single signals or for two signals being on. The case were the three switches are on does not require any ORing. As seen from the tables below, Y1, Y2 and Y4 are inputted into one OR gate and Y3, Y5 and Y6 are inputs to a second OR Gate.

Table 5: Truth Table for Inputs and Outputs of the 3-8 Line Decoder



TRUTH TABLE CD74HC238, CD74HCT238

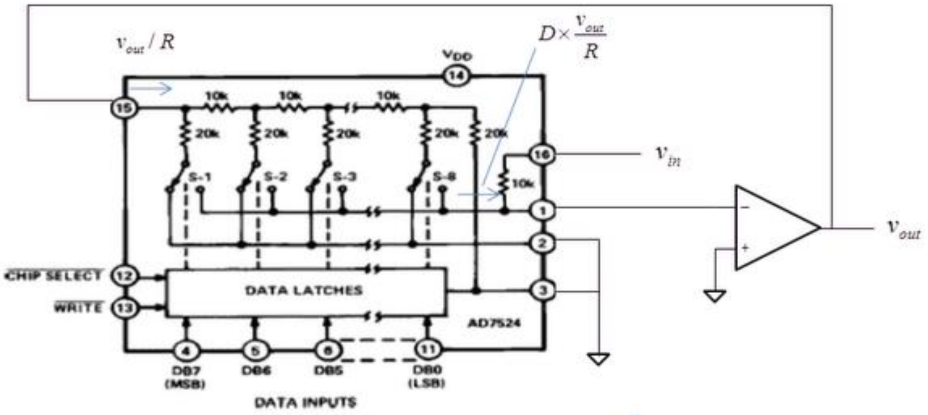
INPUTS						OUTPUTS							
ENABLE			ADDRESS										
E3	$\overline{E2}$	$\overline{E1}$	A2	A1	$\overline{A0}$	$\overline{Y0}$	$\overline{Y1}$	$\overline{Y2}$	$\overline{Y3}$	$\overline{Y4}$	$\overline{Y5}$	$\overline{Y6}$	$\overline{Y7}$
X	X	H	X	X	X	L	L	L	L	L	L	L	L
L	X	X	X	X	X	L	L	L	L	L	L	L	L
X	H	X	X	X	X	L	L	L	L	L	L	L	L
H	L	L	L	L	L	H	L	L	L	L	L	L	L
H	L	L	L	L	H	L	H	L	L	L	L	L	L
H	L	L	L	H	L	L	L	H	L	L	L	L	L
H	L	L	L	H	H	L	L	L	H	L	L	L	L
H	L	L	H	L	L	L	L	L	L	H	L	L	L
H	L	L	H	L	H	L	L	L	L	L	H	L	L
H	L	L	H	H	L	L	L	L	L	L	L	H	L
H	L	L	H	H	H	L	L	L	L	L	L	L	H

NOTE: H = High Voltage Level, L = Low Voltage Level, X = Don't Care

Table 6: Inputs and Outputs of the 3-8 Decoder and OR Gate according to number of inputs ON

# of Inputs	Gain	3-8 Decoder Outputs (OR Gate Inputs)
1	6	Y1,Y2,Y4
2	3	Y3,Y5,Y6
3	2	Y7

Programmable Gain



KCL @ Op-Amp "-" Terminal: $$D\frac{V_{out}}{R}+\frac{V_{in}}{R}=0 \quad \Rightarrow \frac{V_{out}}{V_{in}}=-\overset{>1}{\boxed{\frac{1}{D}}}$$

Figure 35: MDAC Programmable Gain Schematic

The TLC7524 MDAC was set at three different programmable gains depending on how many pick-up signals are inputted. The minimum programmable gain is 2, therefore when the three pick-up signals are simultaneously ON, the MDAC was set to have a gain of 2. The table below summarizes the other cases together with the formula used for the calculations made.

$$GAIN = \frac{Vo}{Vin} = \frac{256}{D}$$

Table 7: Programmable Gain Values

Programmable Gain			
# Inputs	**Gain (1/D)**	**D7-D0**	**D**
3-input	2	1000 0000	128
2-input	3	0101 0000	80
1-input	6	0010 1000	40

The following figures show the output of the MDAC driving by the switched capacitor dual supply. The waveforms were observed before filtering was applied to the switched capacitor stage and therefore noise in the signals is very noticeable.

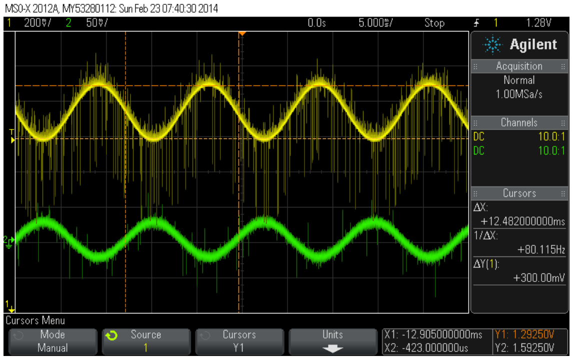


Figure 36: Programmable Gain of 2

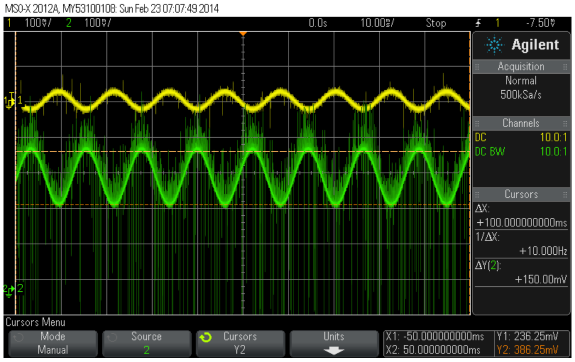


Figure 37: Programmable Gain of 3

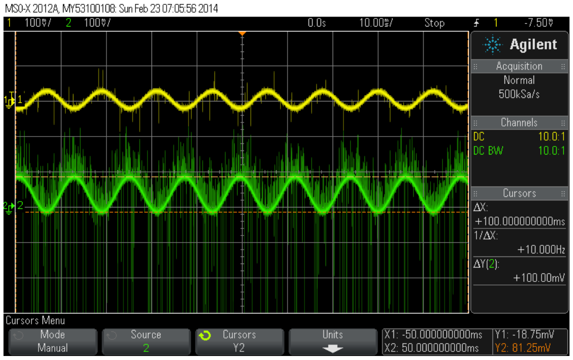


Figure 38: Programmable Gain of 6

iv. Audio Signals

Summing Amplifier Stage

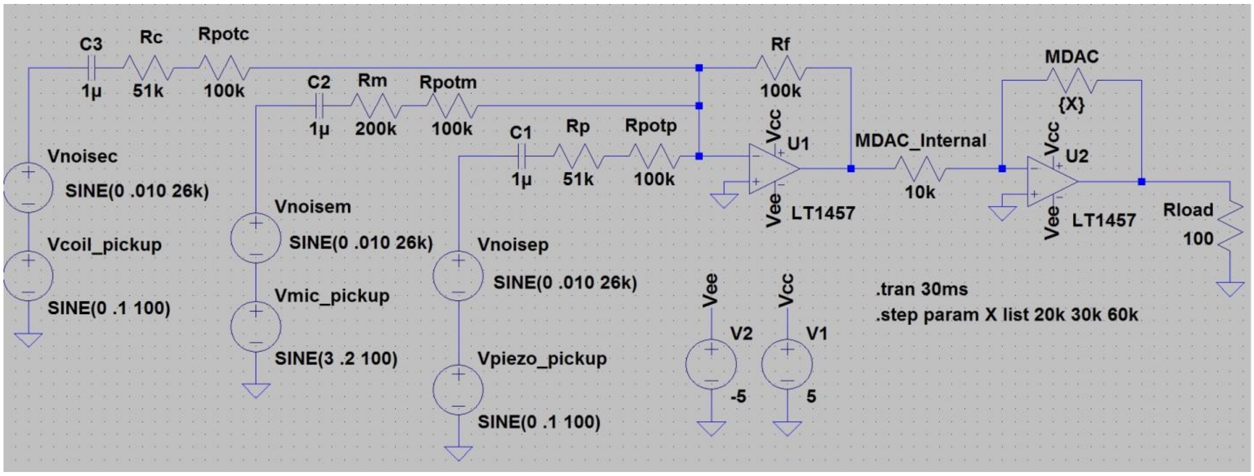


Figure 39: Pre-Amp Design Schematic Prototype I

Figure 39 shows the schematic for the audio signal stage of the 3-Input pre-amplifier system. The first amplifier stage is a LM741 summing amplifier that inputs all three signals with their respective gains. The 1µF capacitors are dc coupling capacitors to eliminate any offset present in the incoming signals. The resistor values were chosen considering the peak-to-peak voltages that each pick-up produced in order to equalize the three signals and achieve the desired 1V-2V output signal. The three 100k potentiometers were chosen equally for the three inputs to allow approximately the same range of volume control. The final portion of the schematic represents the programmable gain stage of the system, the MDAC, which is simply represented by an op-amp with the varying gains of 2, 3 and 6. The simulations below were done with 200 mVpp input signals for the Coil and Piezo pick-ups and 400mVpp for the Mic with all inputs set at 100Hz.

Figure 40 shows the case when all switches are ON, allowing all three signals to go through. It demonstrates the minimum output voltage since the potentiometers were all set at 100kΩ. The minimum output signal is ~ 800mV.

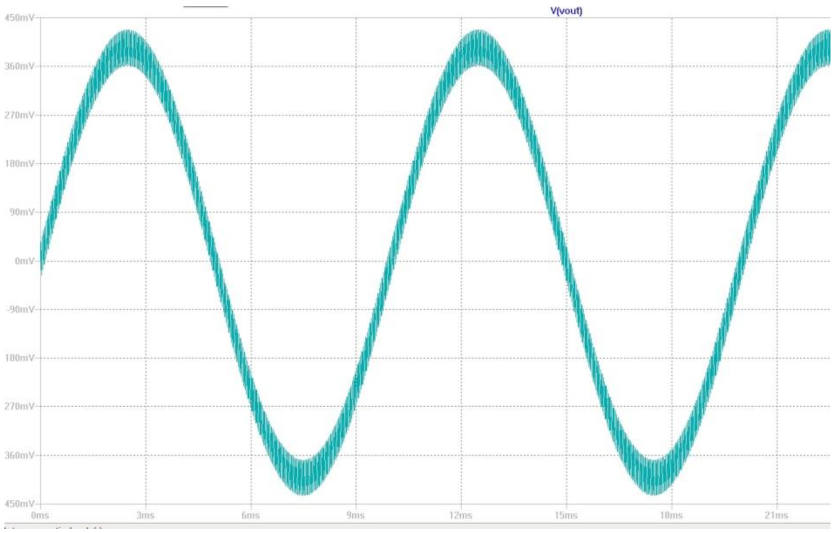


Figure 40: Minimum Output Voltage (All Signals ON and all Potentiometers at 100kΩ)

Figure 41shows the same configuration than above but demonstrating the maximum output voltage when all potentiometers are set at 0kΩ. The maximum output signal is ~ 2.1V.

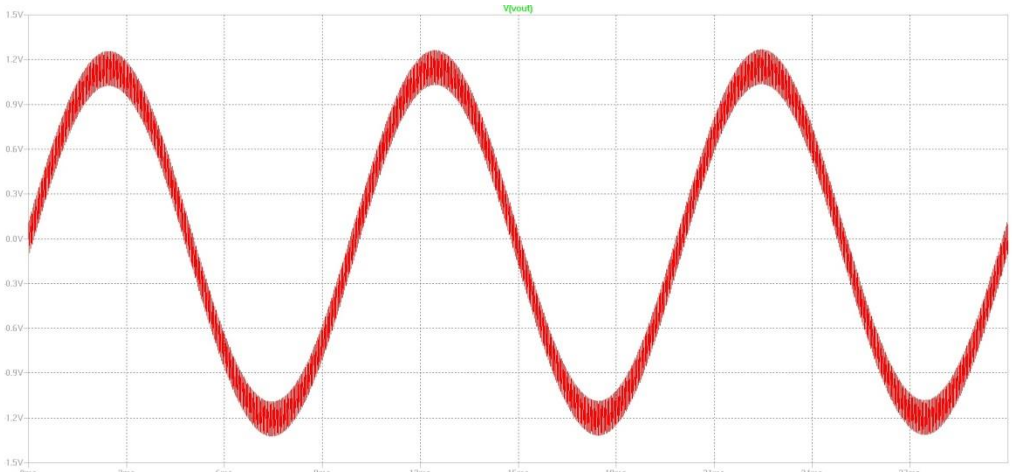


Figure 41: Maximum Output Voltage (All Signals ON and all Potentiometers at 0kΩ)

The simulation below was done in order to verify the operation of the MDAC programmable gain. All the waveforms demonstrate when only one input signal is coming in but what is varying is the number of switches that are ON or OFF. The MDAC sets a gain of 2, 3 or 6 depending on the number of switches that are On or OFF regardless of whether the input signals are coming through or not.

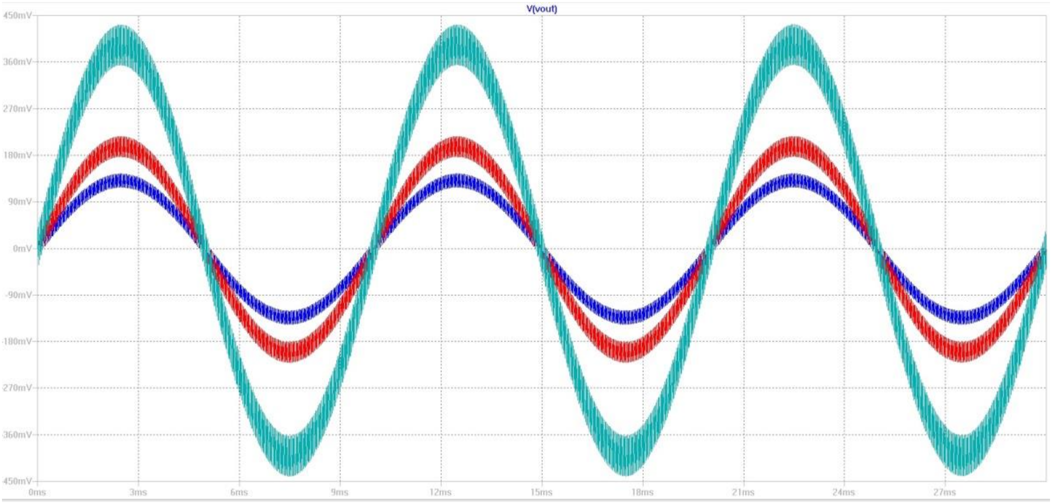


Figure 42: Coil Signal in with 1, 2 or 3 Switches ON

The table below summarizes the results of the three cases to test the MDAC functionality.

Table 8: MDAC Simulation Test Cases

ONLY Coil Signal ON	
# of Switches	Output Signal (mV)
1	800
2	400
3	130

The same test was done to the actual circuit to verify the results obtain in the simulation. The waveforms below are all for when only the coil signal is being inputted. The number of switches is then changed to see the MDAC programmable gain changing. Table summarizes the results obtained.

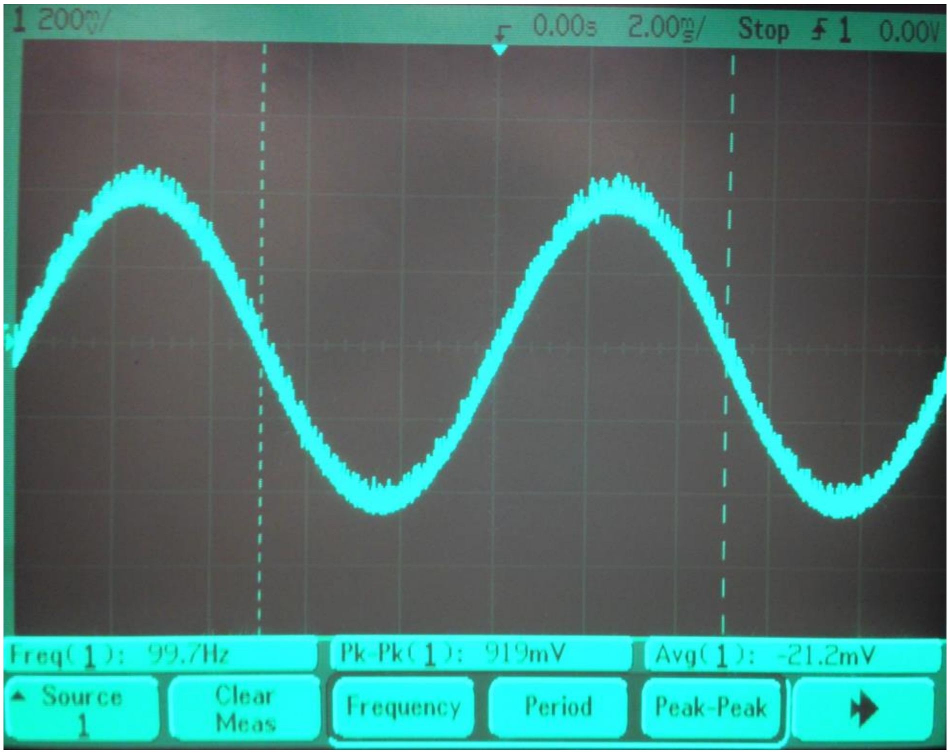


Figure 43: Coil Input Only with 1 Switch ON

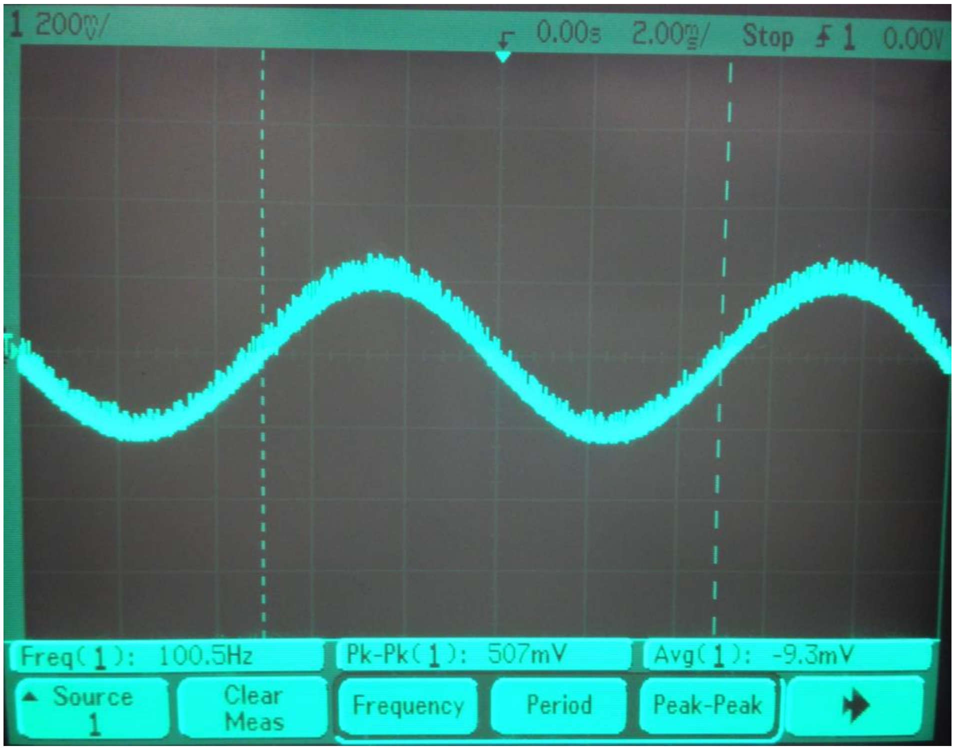


Figure 44: Coil Input Only with 2 Switches ON

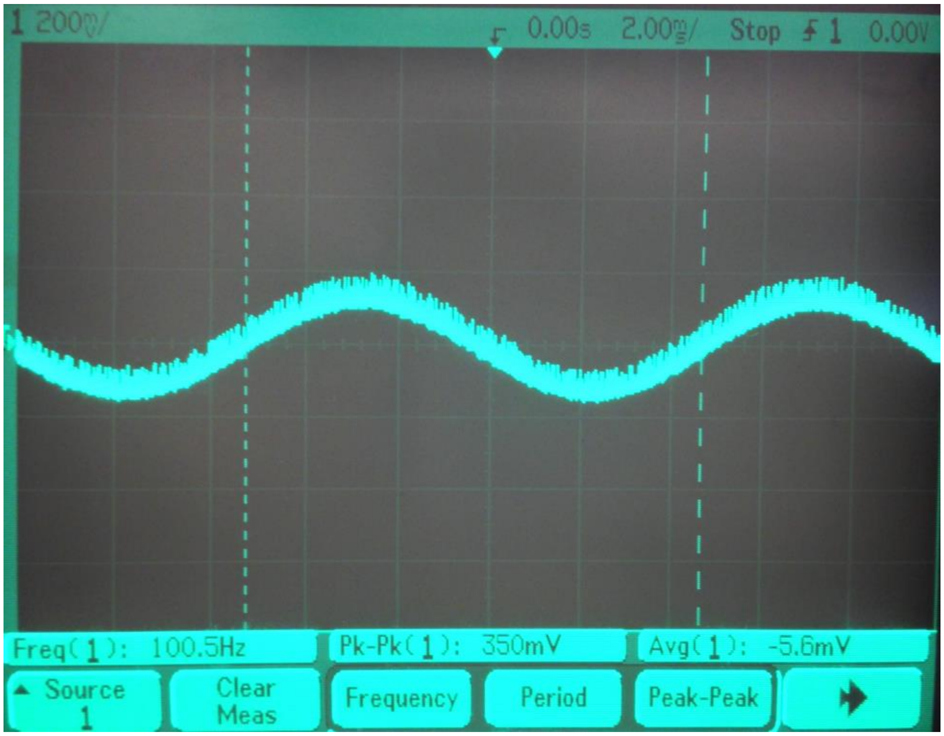


Figure 45: Coil Input Only with 3 Switches ON

Table 9: MDAC Experimental Test Cases

ONLY Coil Signal ON	
# of Switches	Output Signal (mV)
1	919
2	507
3	350

Power Boost HeadPhone Option

In addition to the 1V-2V mono output to a power amplifier, the design allows a headphone option. The user can switch ON the boost selection with a double pull double throw switch which enables the signal to be heard through a 3.5mm stereo output. The LM386 low voltage power amplifier IC was used for this application. This stage takes the input signal and amplifies it to ~2V – 4V output and the internal 10k potentiometer allows for volume regulation. When the DPDT switch is turned on, the LM386 gets powered and the current through the system increases from 7 mA to 12mA. The DPDT switch efficiently prevents the circuit from drawing extra current without being needed. Only when the headphone option switch is enabled, the system draws the extra 5mA needed for this selection.

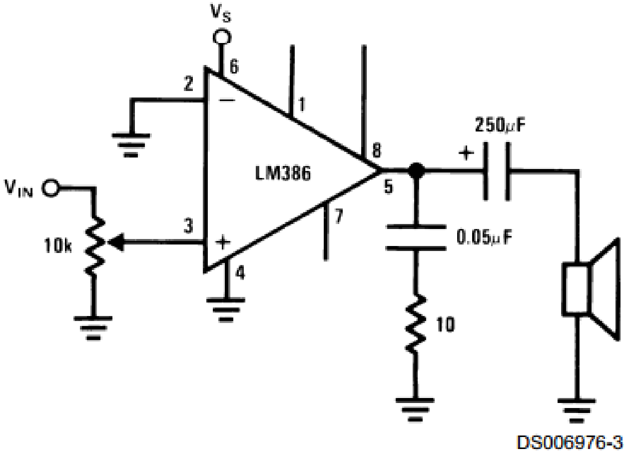


Figure 46: Power Amplifier Circuitry for Headphone Option

The schematic in Figure 46 provided by TI fails to illustrate the need of a bypass capacitor from the voltage source to GND. Without this capacitor the lower frequency bass sounds would sound static like and drastically decreased the quality of sound.

v. 3-Input Pre-Amplifier Overview

The Figure below shows the final schematic for the 3-INput Pre-Amplifier. The pickup signals are inputted into three corresponding double pull double throw switches. One side of each switch is inputted to the logic stage of the system. This sets highs or lows (Vcc or GND) to the 3-8 decoder to determine the number of switches that are ON. The different combinations of a single input or two inputs need to be passed through and OR Gate which controls the digital inputs of the MDAC setting the appropriate gains of 2, 3 or 6 in the second op-amp stage. The other side of the input switches allows the pick-up signals to go through the first amplifying stage. The gains are chosen to produce a 1V-2V voltage for a ¼” mono output. Each pick-up signal has a fixed input resistor and a 100k potentiometer. The potentiometer enables the user to adjust the volume of each individual signal producing a huge variety of tone qualities at the output. A power boost stage is also available for the user to listen to the signals through a 3.5mm stereo output. The headphone option is also controlled by a DPDT switch which powers the LM386 power amplifier only when the switch is ON, therefore consuming more current when it is only required. Without the boost option, the system consumes only ~7mA and when it is ON it draws ~12mA.

The power management of the whole system starts with a DPDT switch which enables the auxiliary source and the battery source to provide power. The LT4412 controls which source the power is acquired from, the Aux input or the Battery input. The charge pump regulator acts as a voltage regulator setting the voltage at 5V with a ranging input voltage of 2.7V to 5.5 V. The 5V dc output is then passed to the switch capacitor which generates a dual supply voltage of 5V to -5V to operate the pre-amplifier.

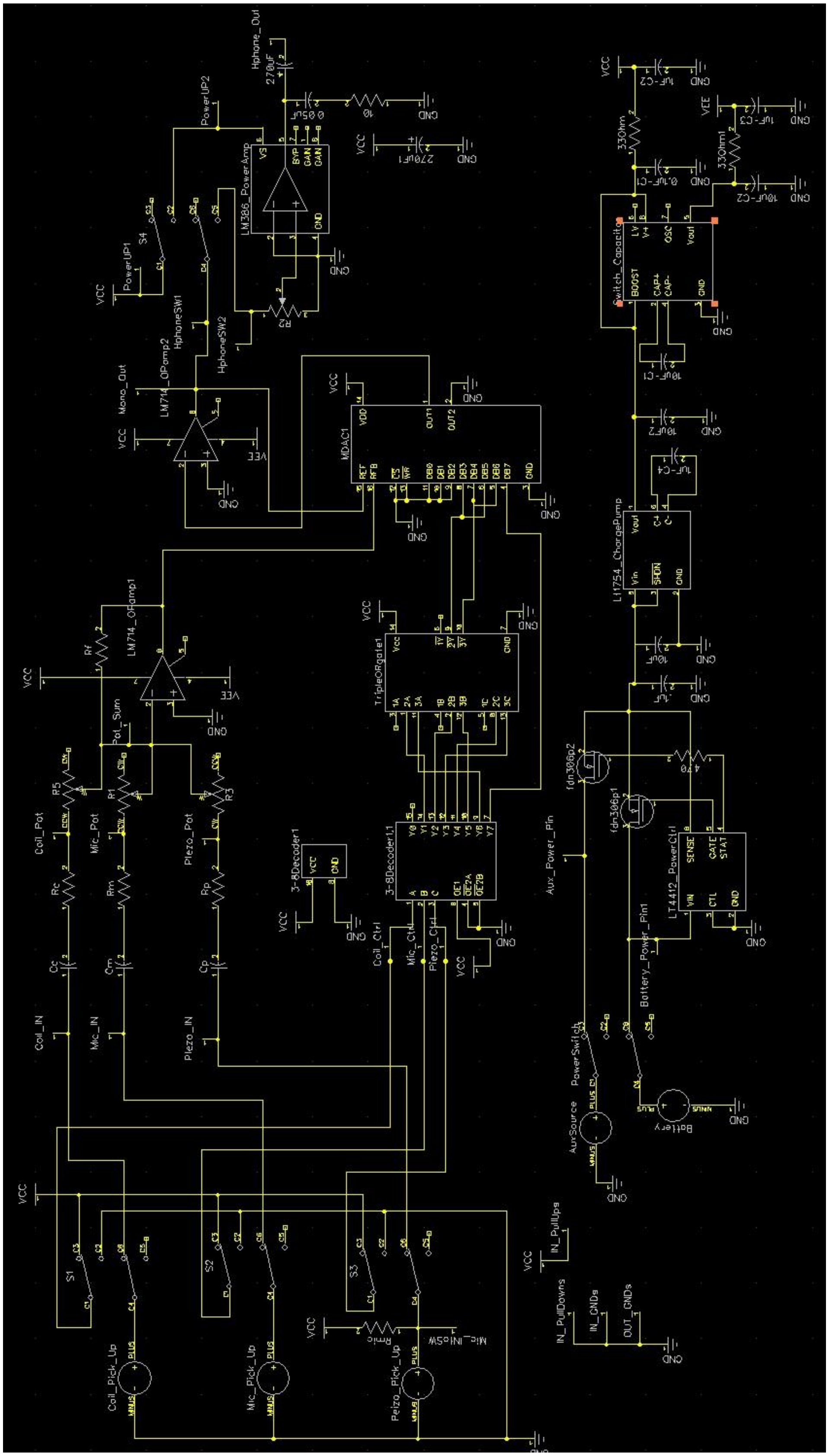


Figure 473: 3-INput Pre-Amplifier Schematic

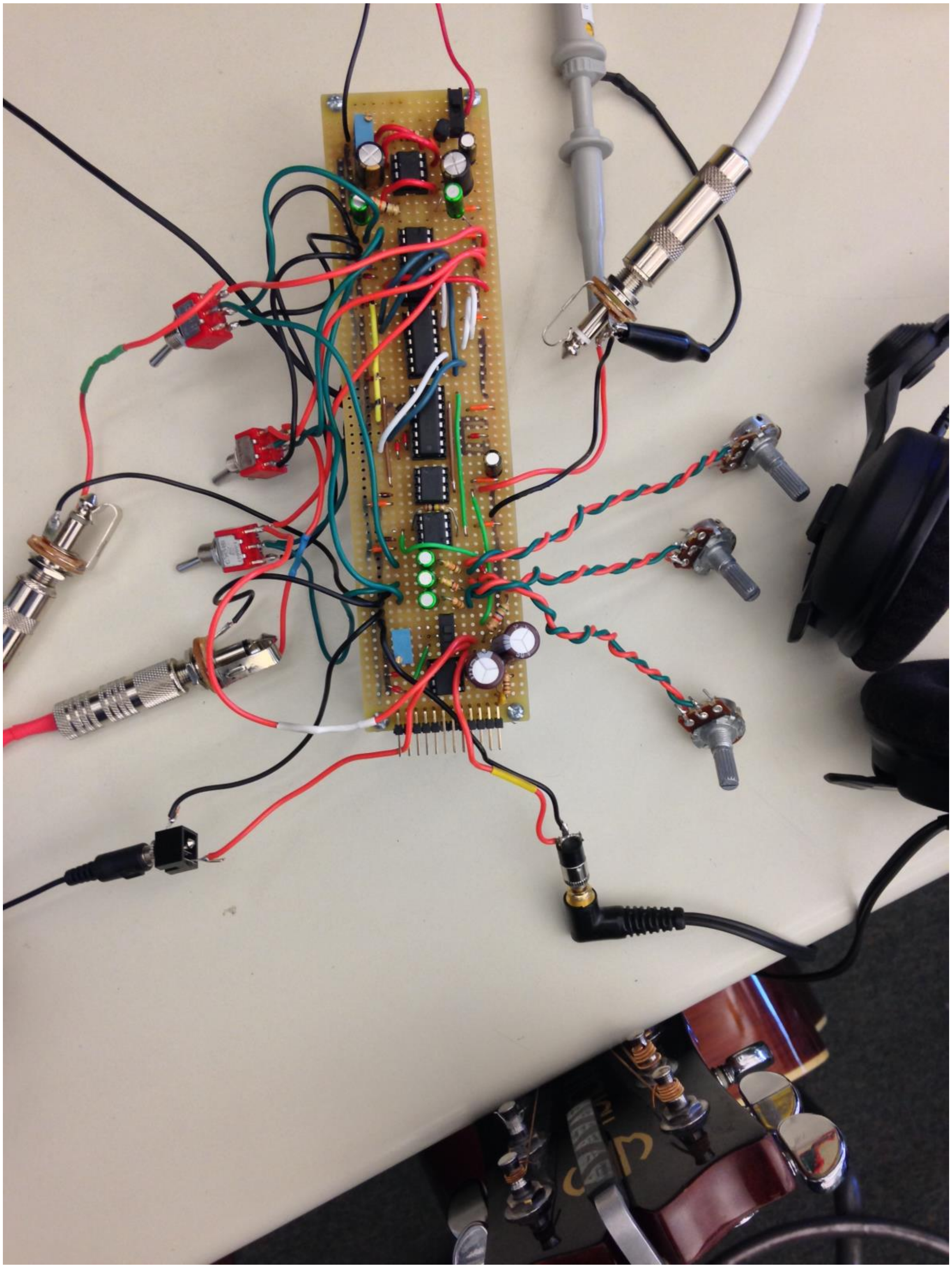


Figure 484: Implementation of the 3-INput Pre-Amplifier Prototype

V.

VI. Conclusion

This project started with a simple idea, to make a preamplifier that fuses three different signals to create a user defined unique sound. Then the project built a road for product development and design experience. The project entailed a variety of different tasks: understanding similar commercial products and research, understanding audio standards, design research ideas, make our design, circuit simulations, parts research, part compatibility, part ordering, logistics, cost analysis, environmental impact analysis, task management, prototyping on breadboard to proto-board to designing a PCB, testing, troubleshooting, final build, and finally presenting it to customers. The 3 INput Pre-Amp project provided a deeper understanding how an idea develops into a full-fledged product.

VII. Future Improvements

The following pictures show the 3-D design for the box of the 3-INput Pre-Amplifier. The design will emulate the shape of a guitar to esthetically illustrate its use. The input and output connectors would be placed on the sides of the box while all controls and switches will be easily access through the top of the box.

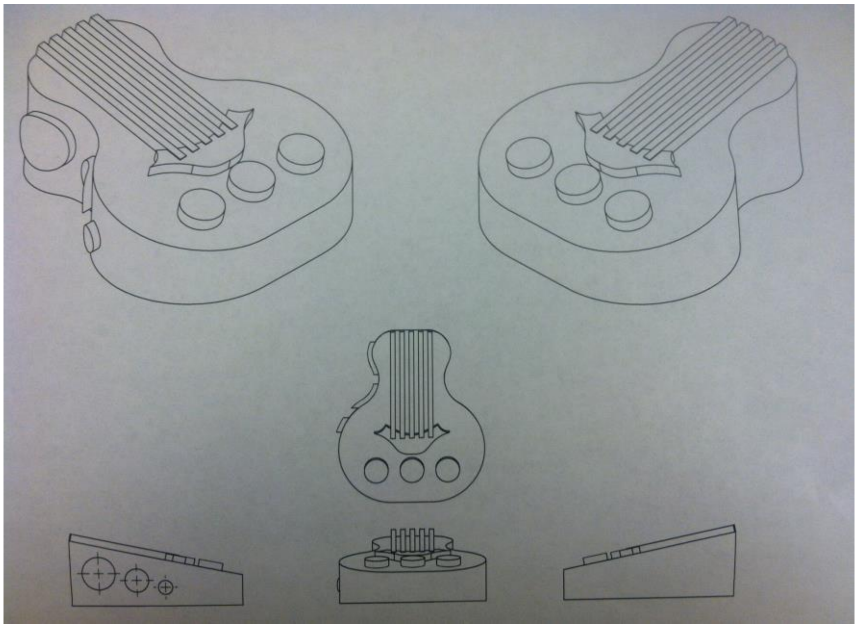


Figure 49: Box Design for 3-INput Pre-Amplifier [11]

Figure 50: 3-D Box Design for the 3-INput Pre-Amplifier [11]

Appendix A – Analysis of Sr. Project

Project Title: 3-INput Pre-Amp

Student's Name: Daniel Pico & Salomé Ramirez

Advisor's Name: Vladimir Prodanov

1. Summary of Functional Requirements

The acoustic pre-amplifier takes three separate small signal inputs and combines or isolates to endure amplification depending with user setting. The user switches between a signal or signal combination. The device features coil pick-up, microphone pick-up, and piezo disc pick-up for variety of tone quality.

2. Primary Constraints

Our equipment for testing is not as good as commercial companies so specifications have to be within reasonable bounds. Money is also limited for sensor purchasing therefore affecting the quality of our end product. The final product will be on a solderable breadboard opposed to a PCB, therefore affecting the visual appeal of our final product. Time would also always be a constraint, iterations of the design implementation and testing's will be limited.

3. Economics

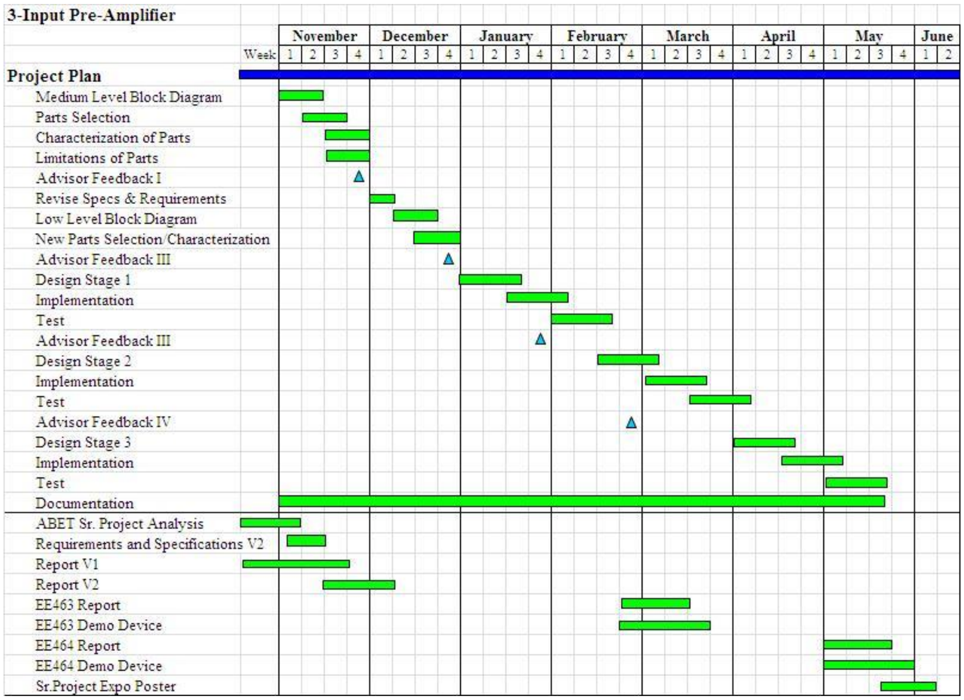
a. Economic Impact
    i. Human Capitol - The project would increase technical aspects of product design and build. The designer and builder and even user of the product all increase in value. Designer and builder increase in experience, while the user would increase through creative vision enable by the product.
    ii. Financial Capitol - will come initially from the project designers and visionaries and hopefully sponsors of the product.
    iii. Real Capitol - Soldering station with related products: solder, solder wick, helping hands, solderable pcb boards, electronic components. Also assembly material such as mounting assembly, wiring system.
    iv. Natural Capitol - Relatively none.
b. When and where do cost and benefits accrue thought out the project's lifecycle?
    i. The majority of the cost happens during the initial design and testing man hours of the product. Also component and testing equipment cost. The benefits will occur after the finish product is marketed and

distributed, but relatively speaking for us the finish product is the reward.

c. What inputs does the experiment require? How much does the project cost?
    i. The experiment requires 3 different types of input sensors: coil pick up, microphone pick-up, and piezo pick up.
    ii. The project cost approximately $2500 including labor. All labor will be free, because the initial design team is us.
    iii. Estimated Cost: $147.63 (paid by us the designers)
    iv. Equipment needed for testing.
        1. Agilent Oscilloscope DSOX2012A $1,572.00
        2. Agilent Function Generator 33210A $1,279.00
        3. Agilent Power Supply E3630A $794.00
        4. Agilent Multimeter 34401A $1,123.00
        5. Test Leads(Bananas-Grabbers) $50.00
        6. Scope Probes(3) $60.00
        7. Bnc-Grabbers $50.00

d. How much does the project team earn? Who profits?
    i. We earn only the satisfaction of a complete product.

e. Timing
    i. Gant chart



    ii. Products exist as long as the market allows it to exist and or also component lifespan. No relative maintenance costs although a 9V battery needed for operation. After projects ends, customer feedback and improvements are required for product optimization.

4. If manufactured on a commercial basis:

   a. Estimated number of devices sold per year: 100
   b. Estimated manufacturing cost for each device: ~$100
   c. Estimated purchase price for each device: ~$150
   d. Estimated profit per year: 5,000
   e. Estimated cost for user to operate device, per unit time: 1 (9V battery-500mAh) @ 10mA power consumption would last approximately 50 hours.

5. Environmental

   a. Environmental Impact - Solder waste may impact the environment without proper disposal. Plastic waste from wiring may also need to be disposed of correctly. Along with any electrical components used for the pcb manufacturing process and the actual pcb itself.
   b. What natural resources and ecosystem services does the project use directly or indirectly?
      i. The project requires electrical energy provided by the utility companies. So any effect on the environment by the utility company is cause of our consumption. Postal service environmental impact is also inherited along with any environmental impact of the electronic component part manufacturing.
   c. What natural resources and ecosystem services does the project improve or harm?
      i. Harms the ecosystems in terms of electronic waste and material production waste.
   d. How does the project impact other species?
      i. The butterfly effect could effectively be active.

6. Manufacturability

This process could be partly out of control due to third party involvement. When the pcb design is sent out to be manufactured, aspects of the product rely on them. Any component bought may have manufacture defects or not be within specification.

7. Sustainability

Majority of issues would become apparent with wear and tear over time of the product. The product material has a major effect on the duration of the time. Depending on design upgrade many aspect of initial could be recycled or constant reducing environmental impact. Improved circuitry could reduce electronic components and less pcb space therefore diminishing environmental waste.

8. Ethical

Components used for the design will be selected to cause the minimal endangerment to the environment such as lead-free solder instead of regular solder. Component parts will be supplied from a manufacturer that follows the same ethical values, such as environmental sustainability and equal rights principles.

The design of the 3-input pre-amplifier tries to improve the technology of similar existing products, which creates new features. The design will be tested numerous times to assure that user's property will not be affected. Previous design implementations will be deeply investigated as a base for the project. in order to avoid conflicts with the designers of these products, all sources of information used throughout the project will be recorded and shown in the final report.

Throughout the course of the project, co-workers should be able to offer honest criticism to each other and create a professional environment in order to maximize the efficiency of team work. Tasks will be clearly divided between group members so each person has to accept the responsibility in the decision making process.

9. Health and Safety

The design of the project would not create any relevant health or safety concerns since most of the designing will be using simulations in programs such as LTSpice. During the implementation of the design, inaccurate design parameters could cause the damage of the system's components. The final product would need to have the necessary preventions to protect all other systems connected to the pre-amplifier (i.e. guitar, power amplifier).

10. Social and Political

Political and social issues could arise with users of the pre-amplifier and individuals/companies that have similar products on the market. Direct stakeholders would be musicians or general users of the design, which would benefit from the variety of different input pick-ups. Companies or individuals that produce guitar pre-amplifiers might be harmed by the addition of a new design as it can be seen as competition.

The project does not create any direct inequities in the community. The project would affect the stakeholders equally throughout the community.

11. Development

A new tool used for the planning of the project was a new organization technique. An overall project planning was constructed to indicate various milestones throughout the course of the project.

New tools were taken from literature research which indicates similar products on the market. Using previous, already made products gives useful information for project design.

References:

[1] R. Ford and C. Coulston, *Design for Electrical and Computer Engineers*, McGraw-Hill, 2007, p. 37

[2] Richard Kuehnel, *Guitar Amplifier Preamps*, Amp Books LLC, 2009
An in-depth understanding of preamp circuits is essential to creating a guitar amplifier design that stands out from the crowd. It is here that the designer gets a first crack at setting the amp's gain, frequency response, and distortion limits. Written for electronic engineers and professional amp builders, Guitar Amplifier Preamps moves beyond simplistic advice to present a complete guide to the theory and operation of triode and pentode voltage amplification. from the guitar pickup to the second stage grid, every aspect of circuit design is rigorously explained and thoroughly explored using real-world examples from Ampeg, Fender, Gibson, Laney, Marshall, Matchless, Orange, and Vox.

Richard Kuehnel is a member of the Circuits and Systems Society of the Institute of Electrical and Electronic Engineers. He has been a presenter at the International Conference on Signal Processing, the International Conference on Acoustics, Signals, and Signal Processing (ICASSP), and the Asilomar Conference on Signals, Systems, and Computers. He has written for the IEEE Transactions on Circuits and Systems and is the inventor of five US patents: an oscilloscope display, an analog integrated circuit, two digital integrated circuits, and a Class D power amplifier.

[3] Piezo Electric Sound Components, *Murata Manufacturing Co, Ltd.,* 2012
This datasheet will be usefull because it explains how the size of the piezo disc determines it characteristics for our application use. Murata is a international company that has been around since 1950.

[4] Audio Operational Amplifiers, *Texas Instruments*, Aug. 2010
The is the datasheet for the op-amp that will be used in the pre-amp. TI is an reputable company that has been around for more than 80 years internationally.

[5]Aleksander Dec, Hiroshi Akima, Russell Mohn, and Ken Suyama, *Audio Pre-Amplifiers for Digital Electret Microphonesin 0.18um CMOS Process*, IEEE, 2009

This article develops on the design of CMOS audio pre-amplifiers for microphones. The designs presented achieve high input impedance, high signal to noise ratio and low noise distortion.
It is credible it was developed by Epoch Microelectronics, Inc. and published in IEEEXplore.

[6]John Linsley-Hood, *Audio Electronic,* Oxford, 1998
The book describes the principles of audio analog design. It has a section solely on the design of preamplifiers where it describes the methods of noise reduction and distortion. It also develops on the characteristics of input signals and how these would affect the design of your preamplifier.
It is a credible source, since the author has many publications audio design and is well known for his simple Class A amplifier designs which are commonly used in sound systems.

[7]Walt Jung, *Op Amp Applications Handbook* , Newnes 2005

This book develops in new audio op-amp applications and how what improvements have been developed compared to past designs. It will be a good source to maximize the quality of our pre-amplifier.

This book is developed by Analog Devices Incorporation and describes many applications of op-amps that are being used in the real world.

[8]Fred Floru, *An Improved Microphone PreAmplifier Integrated Circuit*, AES 16th UK Conference, 2001

This article was published in the American Education Services UK Conference. The article focuses on the improvement of the performance of a microphone amplifier. It develops on the electrical design of preamplifiers and their complexity.

[9]Andrea Baschirotto, Marcello De Matteis, Stefano D'Amico, towards *Minimum Power Analog Filters*, ICICDT, 2013

This paper investigates the improvement margins of analog filters in terms of energy efficiency. This is a useful research source since it provides methods of improving power efficiency of our system. It has been published by the University of Milano-Bicocca and University of Salento faculty.

[10]Thomas Joseph Krustick, *Musical instrument preamplifier*, United States Patent, 2013

The present invention provides embodiments of a musical instrument preamplifier. It is especially suited to acoustic and electric guitars and basses. All components, including the power source, are contained within or on the body of the instrument. The preamplifier dubbed BPTD (for Battery Powered Tube Driver) contains a vacuum tube input stage and may utilize a second stage consisting of either a vacuum tube or semiconductor device, such as a JFET. Circuitry is included to bias the cathode heater and the preamplifier circuit with no dangerous high voltages present. The tube may be mounted on the instrument body to provide for a pleasing display.

[11]Edlín Garcia, Solid Works Draft, May 2014

Appendix B – List of Materials

Power Management Stage

Capacitors: 0.1µF, 1µF, 10µF
Resistors: 470kΩ, 33Ω
P-Channel MOSFET
Schottky Diode 1N5819
LTC4412 Low Loss PowerPath Controller ThinSOT
LTC1754-5 Micropower, Regulated 5V Charge Pump with Shutdown in SOT-23
MAX1044 Switched Capacitor

Logic Control Stage

CD74HC238 3-8 Line Decoder
CD74HC4075 Triple OR Gate
TLC7524 MDAC

Audio Signals Stage

Capacitors: 1µF
Resistors: 51kΩ, 200kΩ, 100kΩ
Potentiometers: 100kΩ
LM741 Op-Amps

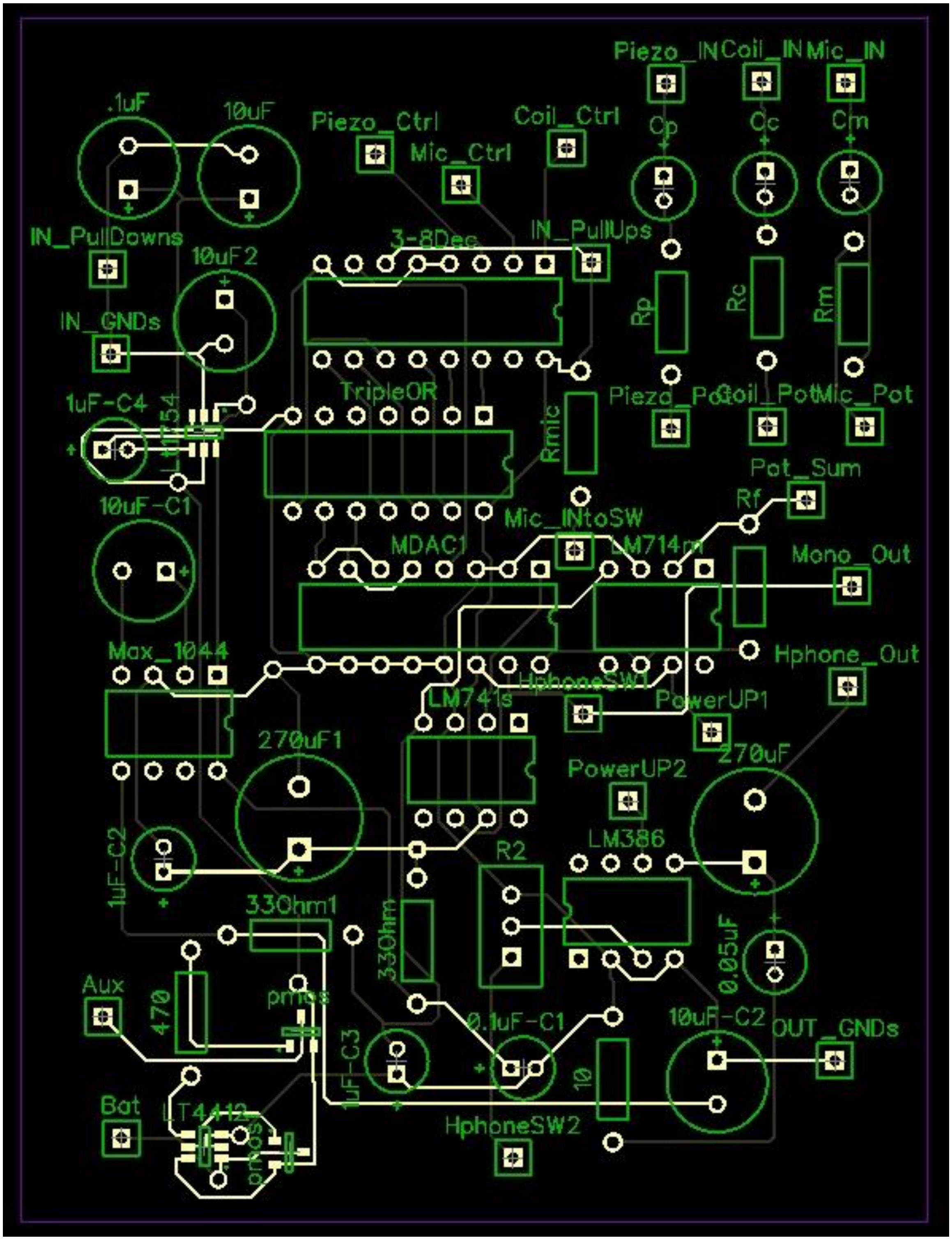
HeadPhone Boost Stage

Capacitors: 270µF, 0.05µF
Resistor: 10Ω
Potentiometer: 10kΩ
LM386 Power Amplifier

Others

Switches
DPDT Switches
1/4" Mono Connectors
3.5mm Stereo Connectors
Battery Holder
USB Connector

Appendix C – PCB Layout



Appendix C – Piezo Pick-Up Construction