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Parametric Equalizer for Audio Applications

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Presentation Outline

- Abstract
- Introduction
  - Background
  - Problem Statement
- System Requirements
- System Overview
- Status of Device
- Signal Processing
- Microphone Preamplifier
- Power Supply
- Conclusions & Lessons Learned
- Questions
- Demonstration

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Abstract

- What is a Parametric Equalizer?
- In what situations would a Parametric Equalizer be used?
- Who would be interested in Parametric Equalizers?
- How is a Parametric Equalizer different from other types of audio equalization?

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Background

- Worked with audio and audio electronics for nearly 15 years
  - Rewiring Electric Guitars
  - Civic Theatre
  - University of Saint Francis
  - Make, Modify or Repair Guitar Pedals

Problem Statement

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- Objectionable Audible Attributes
  - Hum
  - Feedback
  - Frequency Band too High or Low in Level
- Allows for Audio Engineer to fine tune spectral response of a frequency band

System Overview

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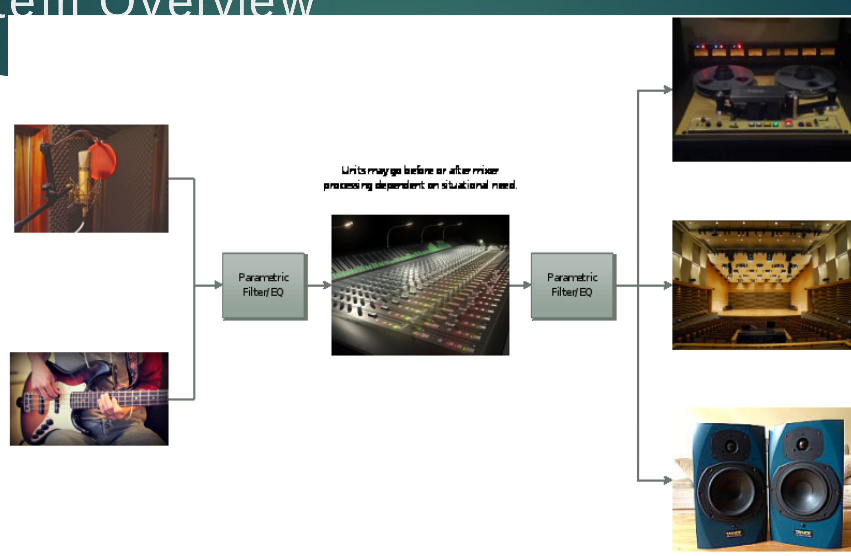

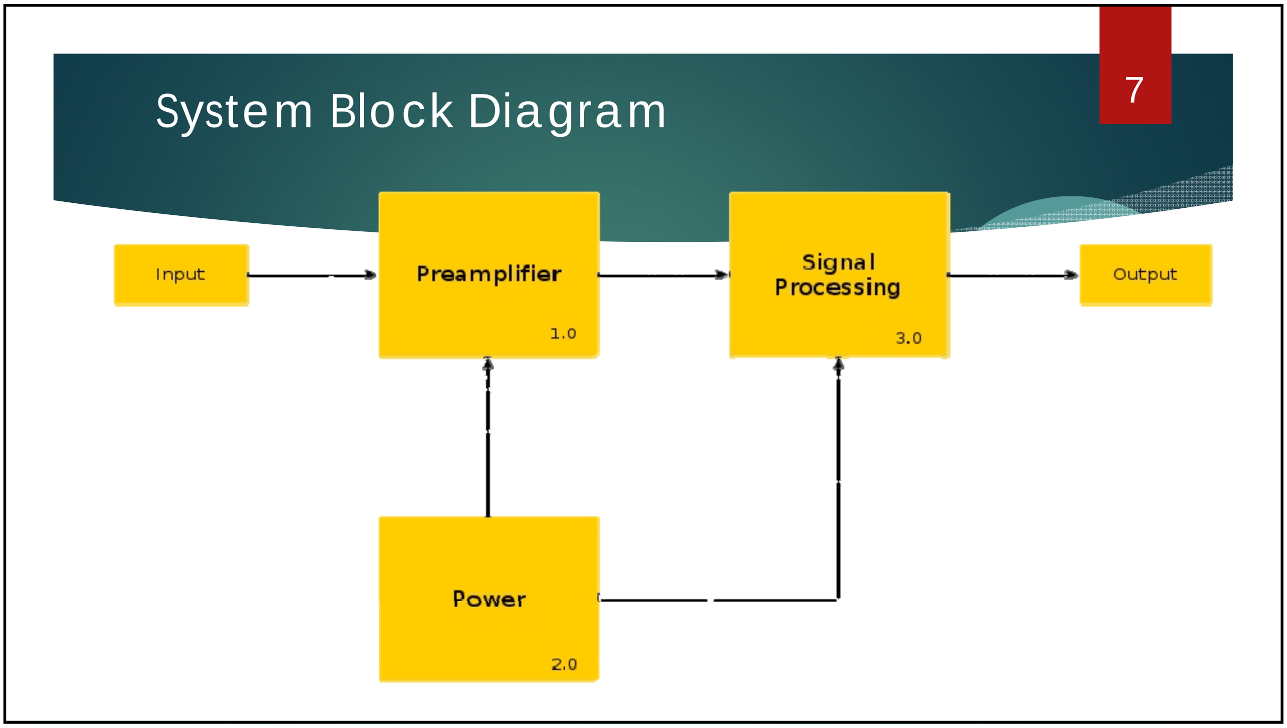
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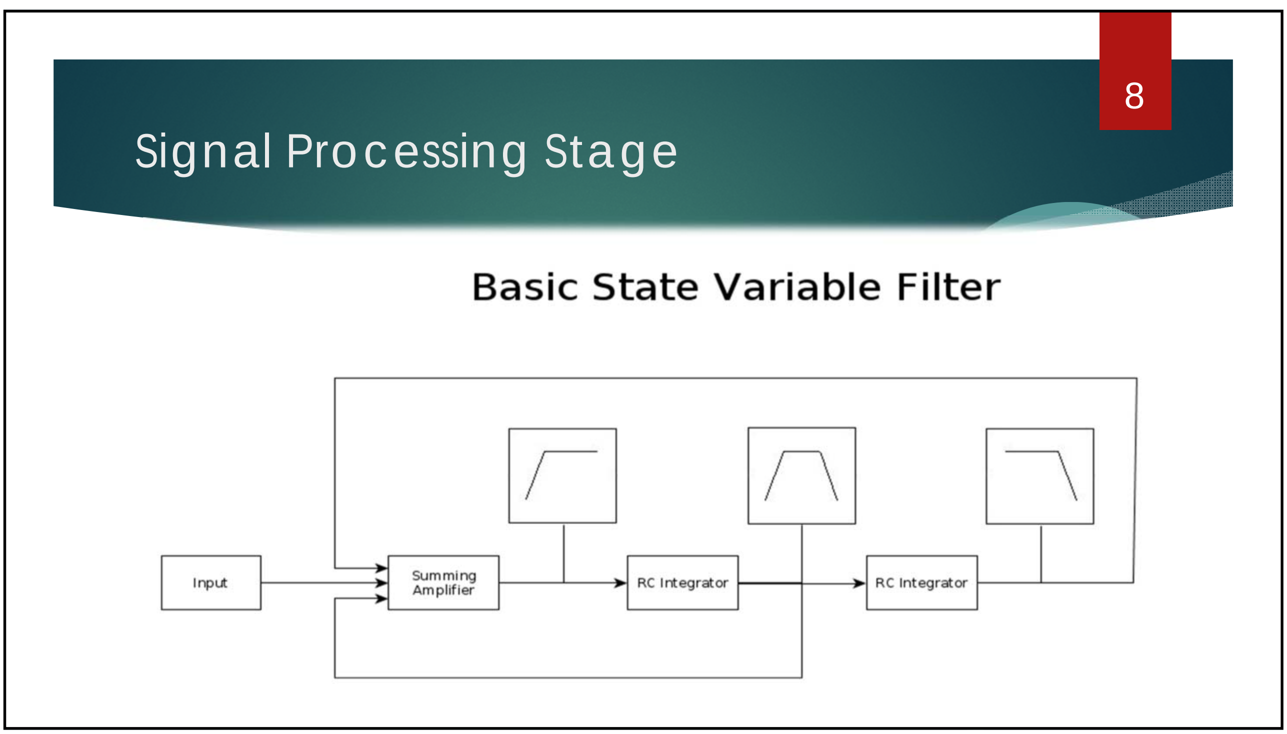
System Block Diagram
Input
Preamplifier
1.0
Signal Processing
3.0
Output
Power
2.0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Signal Processing Stage
Basic State Variable Filter
Input
Summing Amplifier
RC Integrator
RC Integrator

Basic State Variable Filter Schematic

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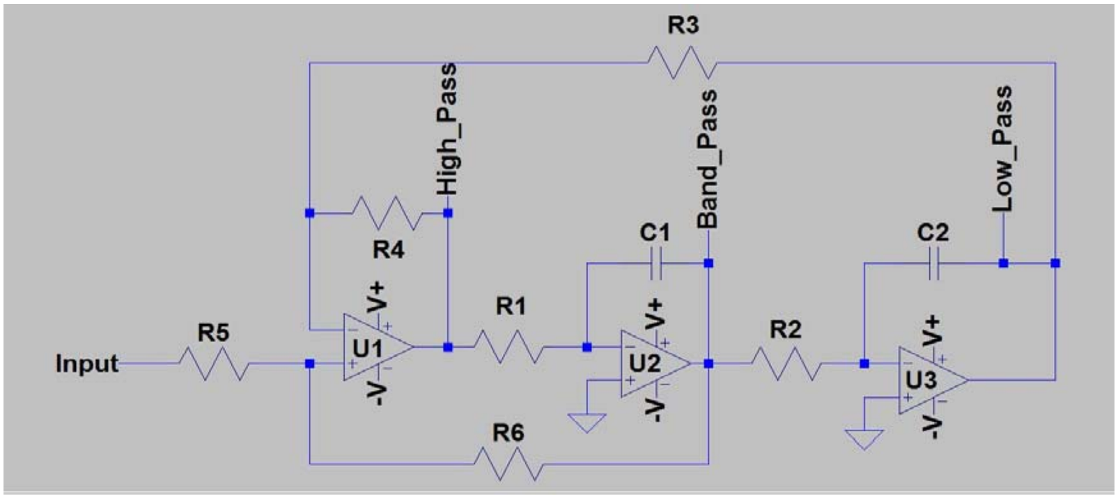

Transfer Function for BP SVF

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$$H_{bp}(s) = \frac{V_{out}}{V_{in}} = -s \cdot R_1 \cdot C_1 \cdot H_{lp}\,(s) = \frac{-\frac{R_6}{R_5}\left(\frac{1+\frac{R_4}{R_3}}{1+\frac{R_6}{R_5}}\right)\frac{1}{R_1 \cdot C_1}s}{s^2 + \left(\frac{1+\frac{R_4}{R_3}}{1+\frac{R_6}{R_5}}\right)\frac{1}{R_1 \cdot C_1}s + \left(\frac{R_4}{R_3}\right)\frac{1}{(R_1 \cdot C_1)(R_2 \cdot C_2)}}$$

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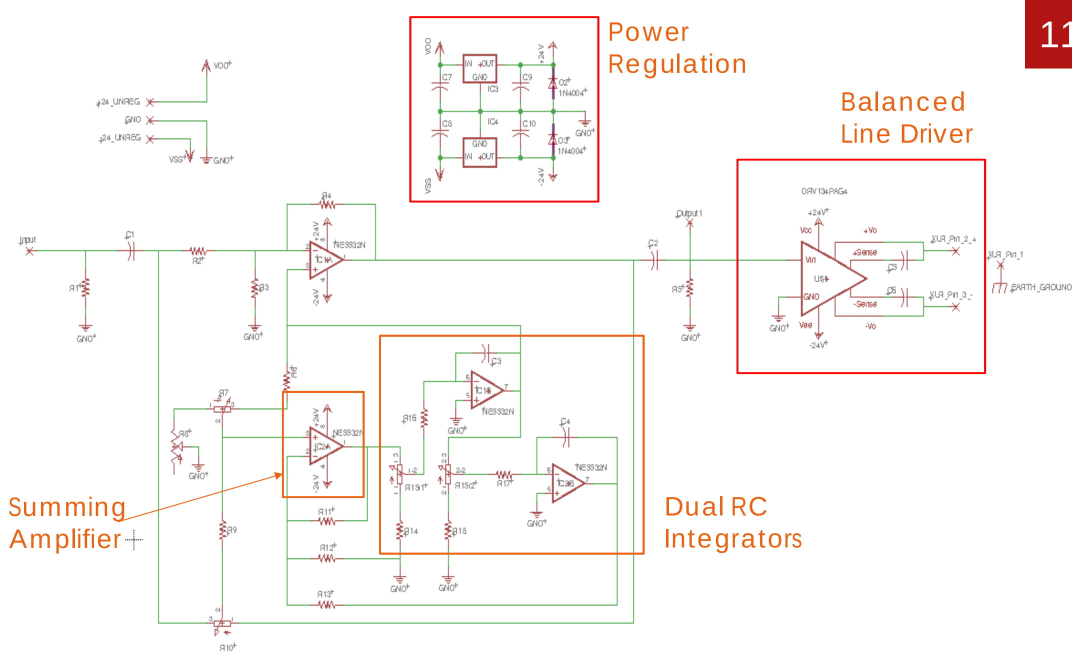

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Frequency Band Calculations

$$F_c = \frac{1}{2\pi(R_{20} + R_{23})C_4} = \frac{1}{2\pi(R_{24} + R_{27})C_5}$$

	Minimum Center Frequency	Maximum Center Frequency	Value of C4 and C5
Low	15 Hz	318 Hz	0.1µF
Low-Mid	69 Hz	1447 Hz	0.022µF
Mid	270 Hz	5684 Hz	5.6nF
High-Mid	561 Hz	10610 Hz	2.7nF
High	1010 Hz	21221 Hz	1.5nF

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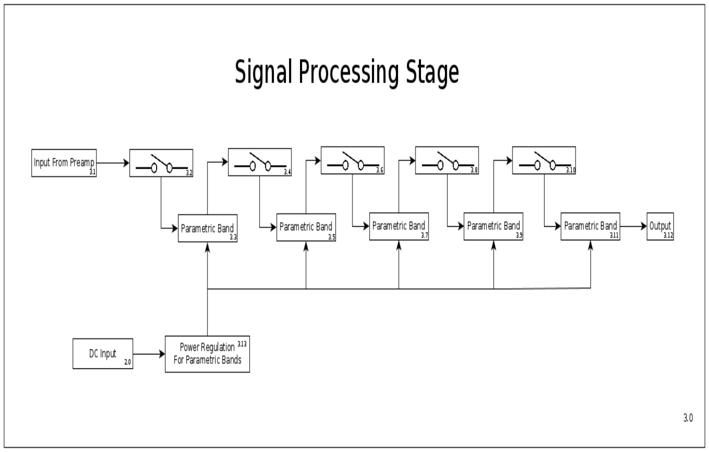
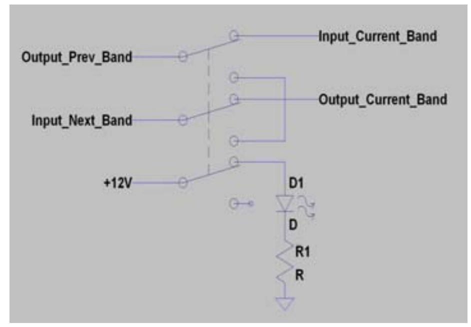
Switching Between Bands





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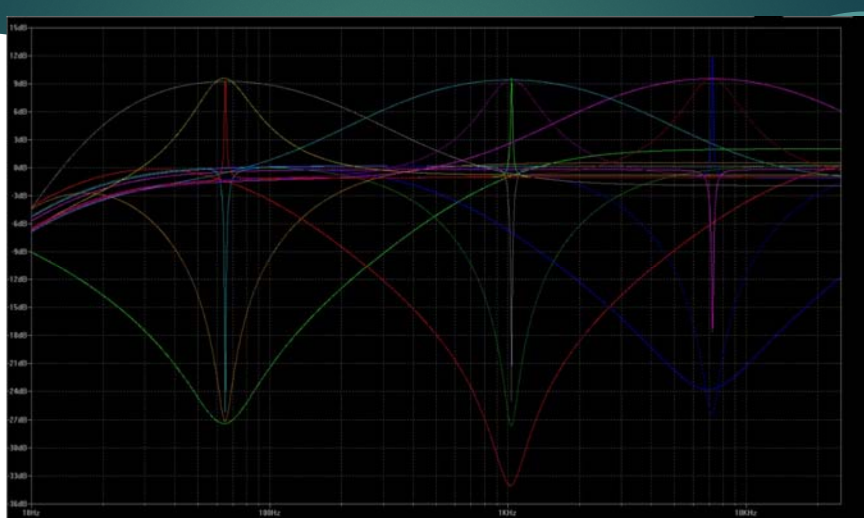
Signal Processing Simulations



Signal Processing Bench Test

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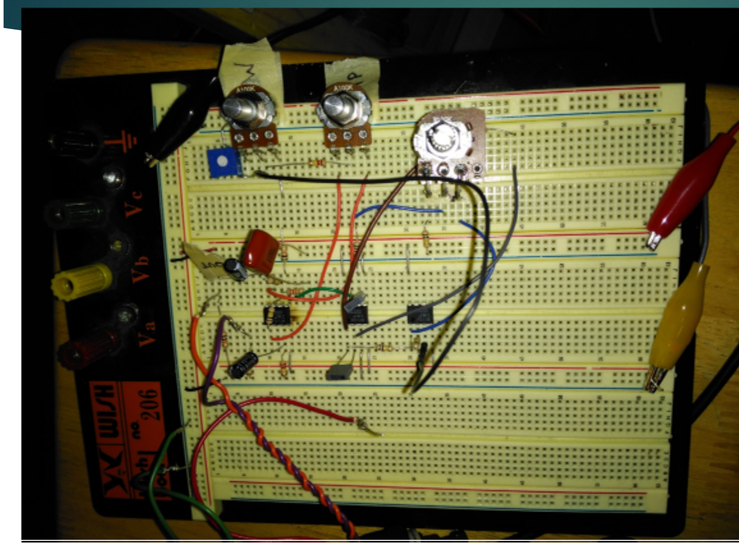

- Used Incorrect Tapers
- Approximate Component Values

Signal Processing PCB Layout

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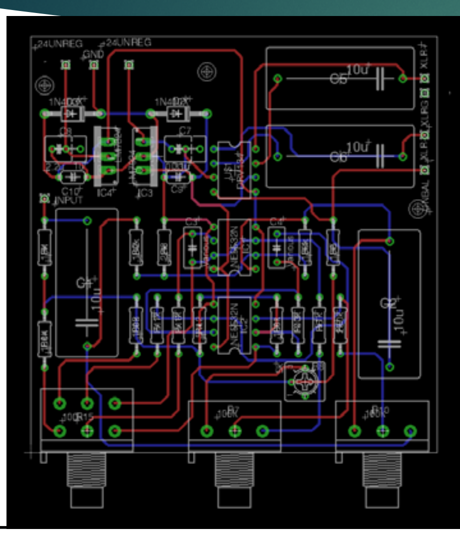

- Designed in Eagle CAD
- Dual Line Driver On-Board
- Designed to be Modular
- Next Revision
  - Move Center(Q) Pot To Solder Side

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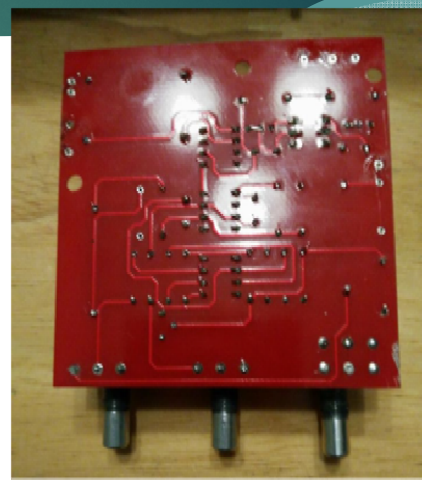
Signal Processing PCBs



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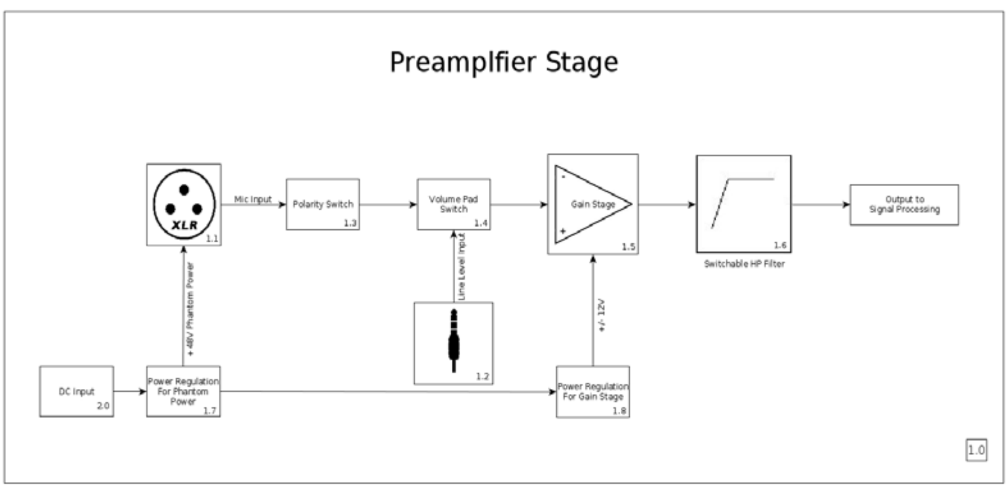
Microphone Preamplifier Stage



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Added Features

- Phantom Power
- Polarity Switch
- -20 dB Pad
- Switchable High-Pass Filter

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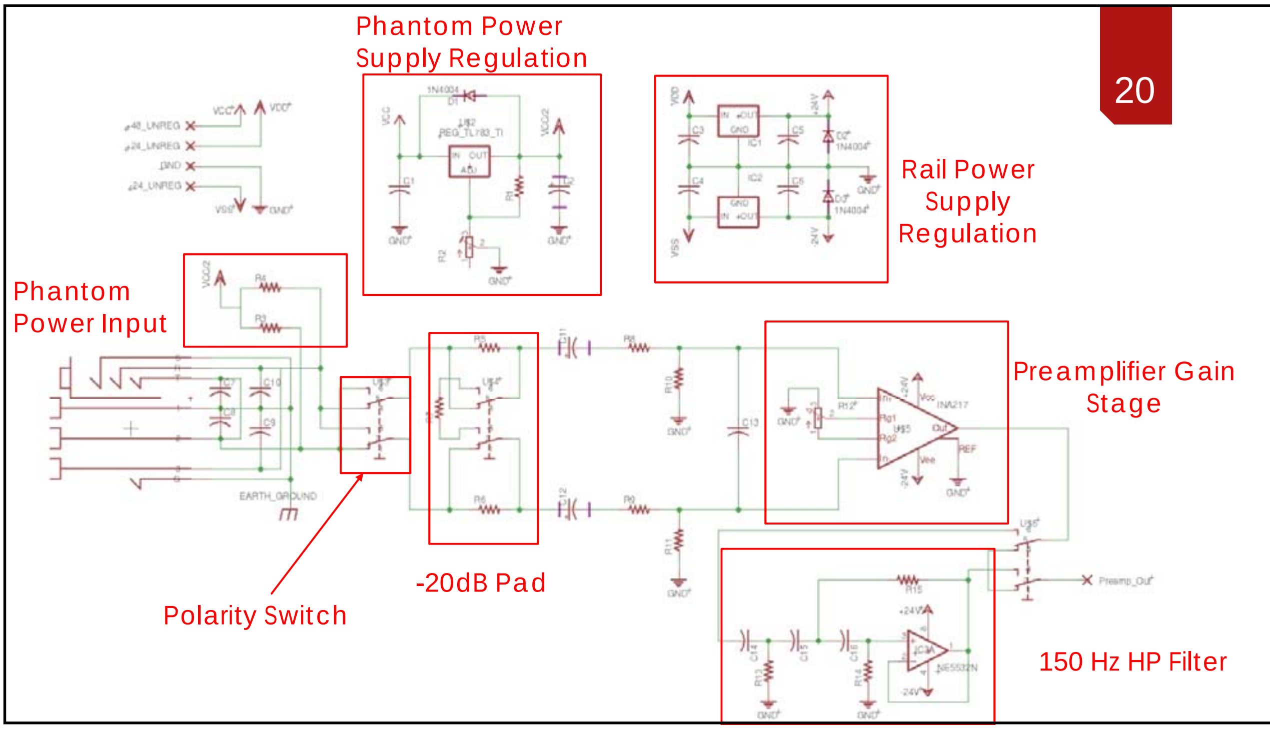

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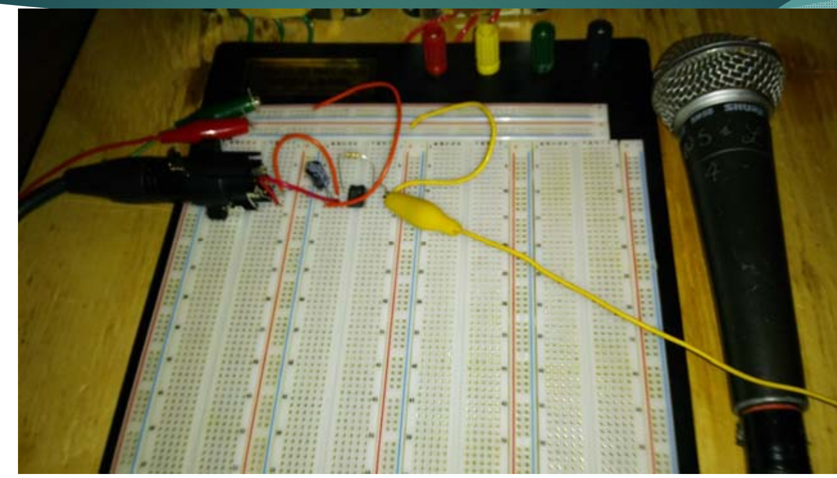
Microphone Preamplifier Bench Test



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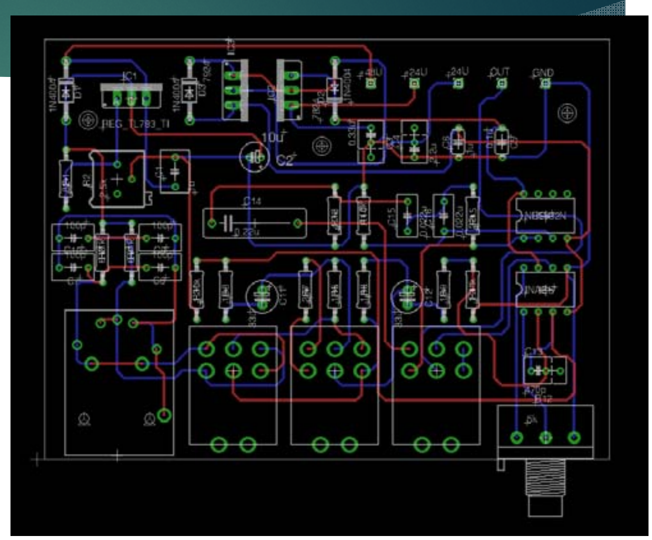
Microphone Preamplifier PCB

- Designed in Eagle CAD
- Next Revision
  - Move Microphone Jack Off-Board



Power Supply Stage

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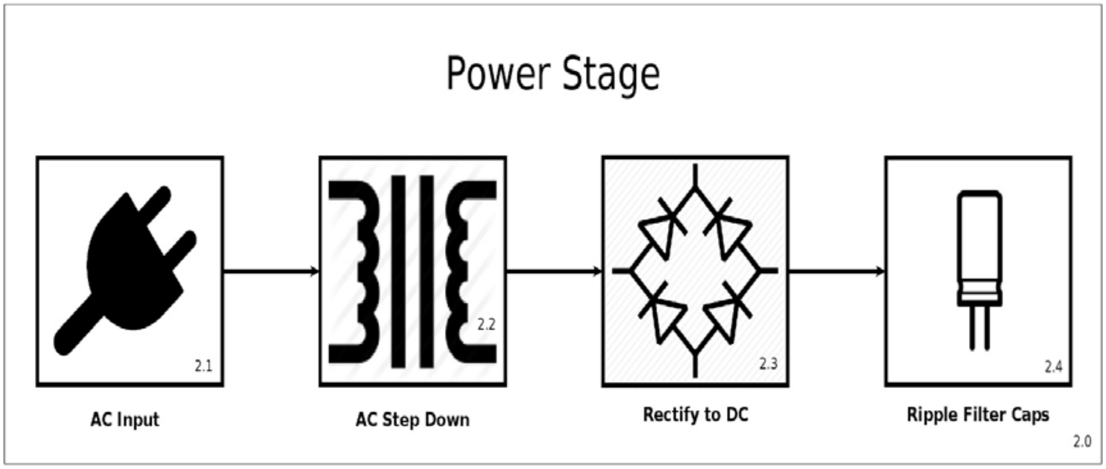

48V Phantom Power

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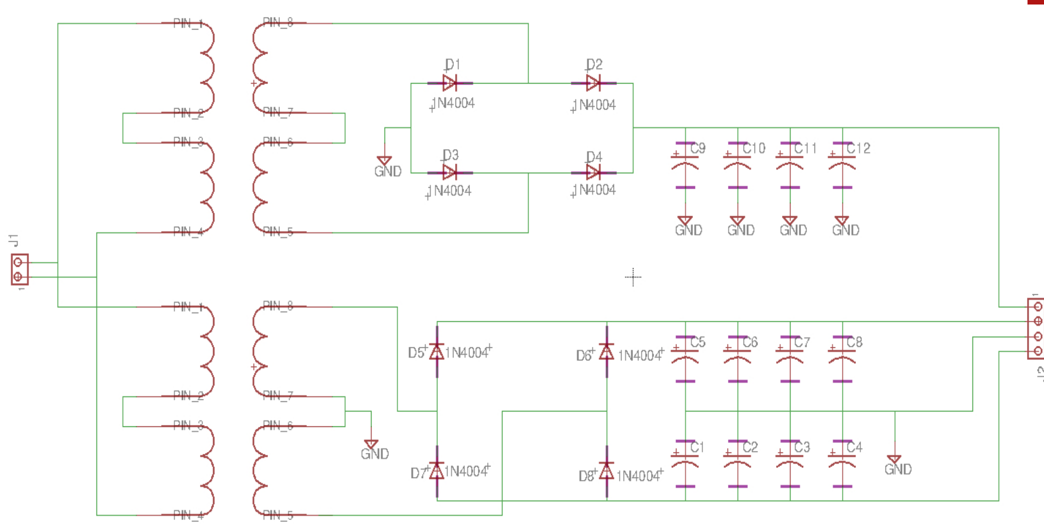

Positive/ Negative Supply Rail

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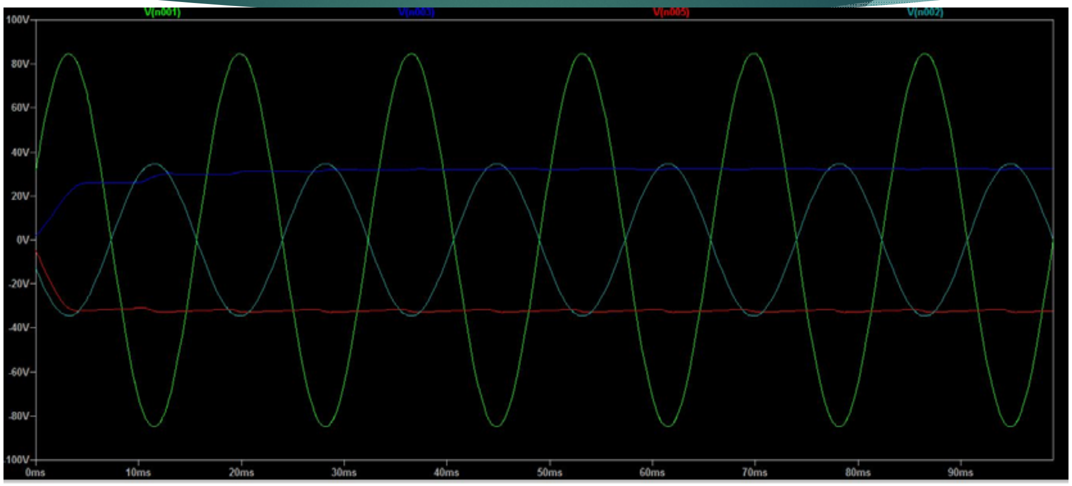
Simulation for Power Supply Rail Voltages



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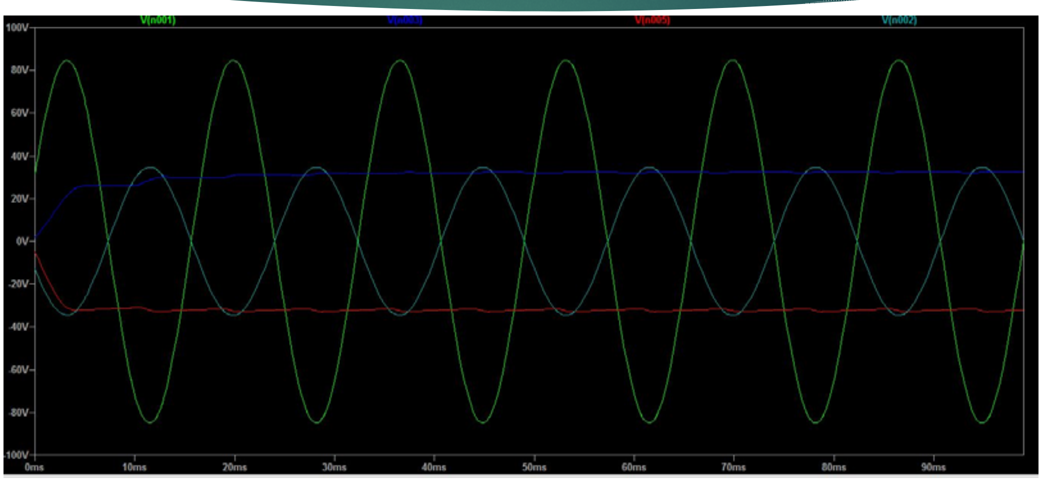
Simulation for Phantom Power Supply



Power Supply Bench Test

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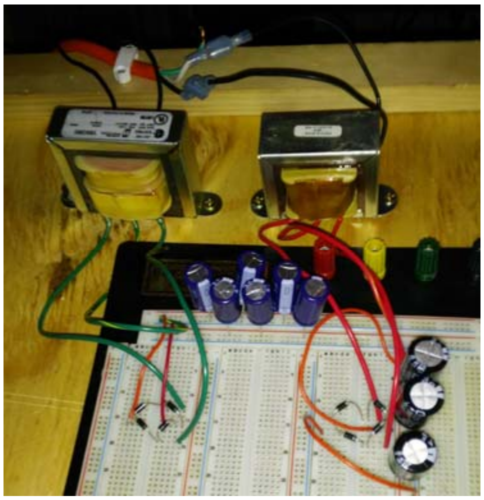

Power Supply PCB

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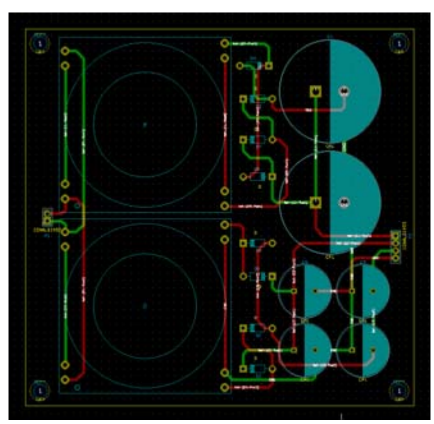
- Designed in KiCAD
- Next Revision
  - Create Power Buses



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Project Management

- Cost Risk - 1
  - Chosen Op-Amps Have an Unusable THD Level
- Schedule Risk - 4
  - Unable to Obtain Test Equipment
- Technical Risk - 5
  - Microphone Preamplifier Stage Too Difficult to Design

			Risk Ranking				
			1 Insignificant: minor problem easily handled by day to day processes	2 Minor: some disruption possible	3 Moderate: significant time / resources required	4 Major: operations severely damaged	5 Catastrophic: project survival is at risk
5 Almost Certain: >90% chance	Likelihood	5					
4 High: 50 - 90% chance		4					
3 Moderate: 10 - 50% chance		3			6		5
2 Unlikely: 3 - 10% chance		2		2	1, 3	4	
1 Rare: <3% chance		1					
			1	2	3	4	5
			Severity				

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Major System Requirements

- The system shall operate from 20 Hz to 20 kHz with no more than 3dB variation
- The system shall have multiple equalization bands
- The system shall be able to provide +/- 12dB of gain per band
- The system shall have the ability to adjust the Q of each equalization band
- The system shall have the ability to adjust the center frequency(Fc) of each equalization band
- The system shall have independently adjustable Fc, Q, and amplitude

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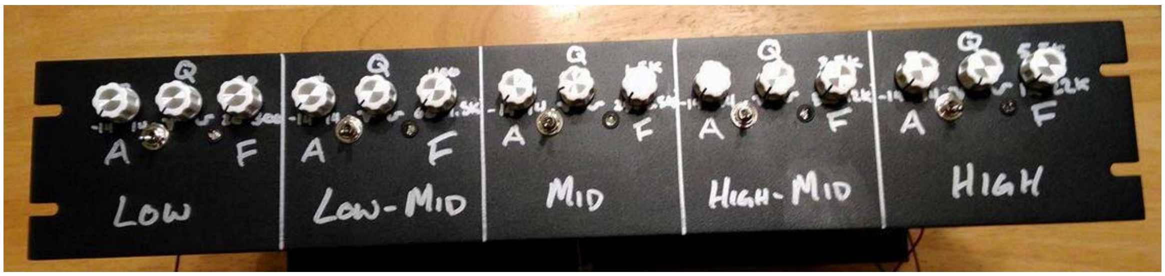
Status of the Device



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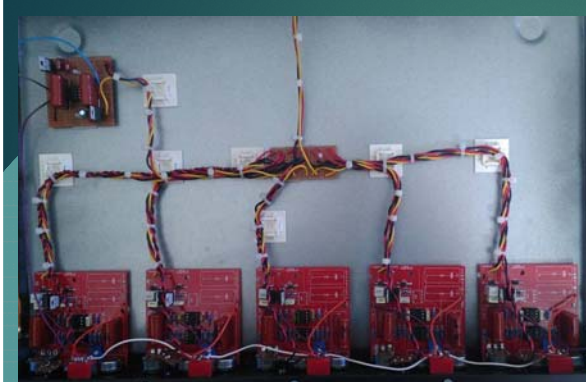
Inside Assembly



UPPER LEFT – DUAL LINE DRIVER BOARD

CENTER – POWER BUS

BOTTOM – EQUALIZATION BANDS

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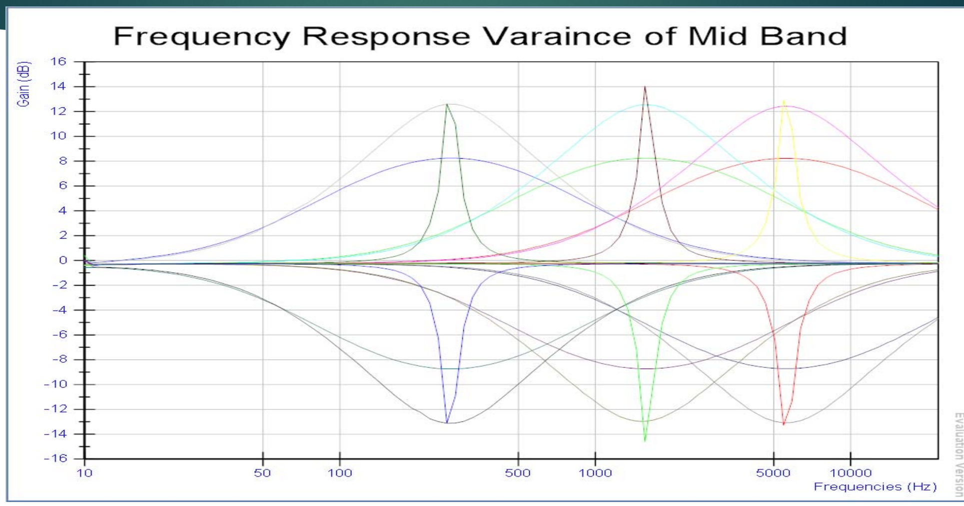
Testing



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Testing

Parametric Band	Minimum Frequency of Band	Center Frequency of Band	Maximum Frequency of Band
Low	15 Hz	88 Hz	306 Hz
Low-Mid	64 Hz	385 Hz	1450 Hz
Mid	262 Hz	1566 Hz	5455 Hz
High-Mid	571 Hz	3410 Hz	11900 Hz
High	979 Hz	5545 Hz	22000 Hz

Parametric Band	Magnitude at Minimum Frequency	Magnitude at Center Frequency	Magnitude at Maximum Frequency
Low	14.63 dB	14.49 dB	13.92 dB
Low-Mid	13.90 dB	14.00 dB	13.92 dB
Mid	12.61 dB	14.04 dB	12.90 dB
High-Mid	12.97 dB	13.69 dB	13.25 dB
High	14.43 dB	13.72 dB	13.30 dB

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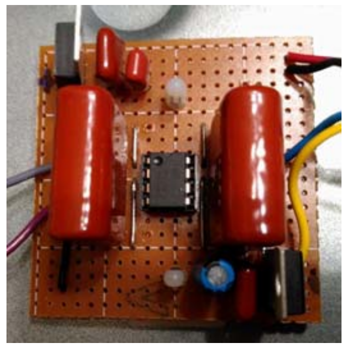
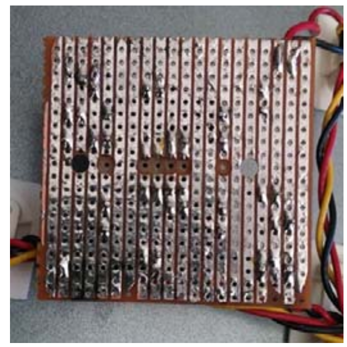
Future Recommendations

- Rotary Switch to Change Filter Types
- Switchable High Q Notch
- LED Connections on Signal Processing Board
- Dual Line Driver Board





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Conclusions and Lessons Learned

- Don't take time for granted
- There is always more to learn from a circuit
- Op-Amps sound different


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Questions?


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Demonstration