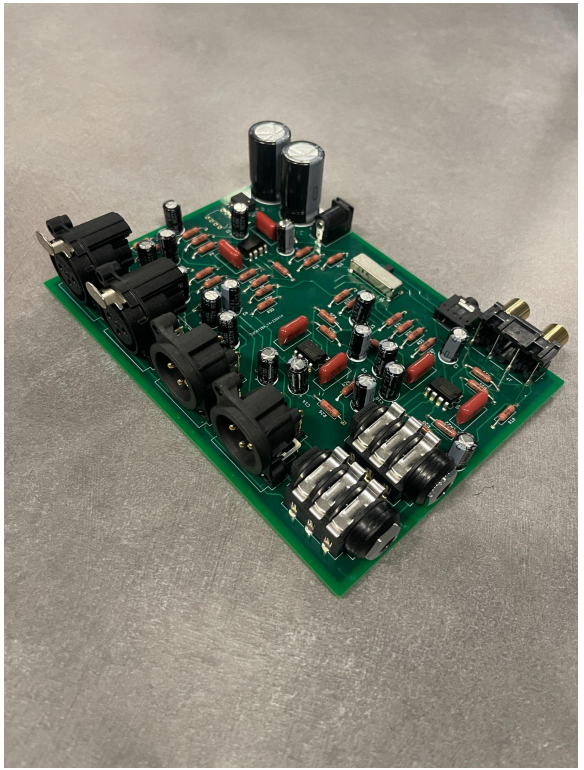
The Unifier

All-in-one stereo line level converter

By Baker Audio

The Unifier: Overview

- **All-in-one solution** for all things line level
- Converts between different line level specifications
- Intended use for PA systems
- Great for lower budget gigs
- **Plug any connector in, plug any connector out!**



01. **Scope**

What exactly should the device to do?

02. **Research and Planning**

Figure out how to make it happen

03. **Simulations and Schematic**

Make sure things make sense theoretically

04. **Breadboarding**

Make sure things actually work!

05. **PCB Layout**

Design the physical layout of the product

06. **Assembly**

Put it all together!

01

Scope

What exactly should the device do?

Line Level Specifications

Consumer

- RCA, 3.5mm headphone jack
- Unbalanced
- -10 dBv

Professional

- XLR, 1/4 Inch TRS
- Balanced
- +4dBu

(About an 11.78dB difference)

A Little Backstory…

- DJ, Lots of lower budget gigs where I have to travel by myself
- **Don’t know what equipment is available** until you show up
    - Always uncertainty when using someone else’s gear
- **Everything has different inputs and outputs!**
- Have to carry a bunch of different cables to accommodate
    - Only one backpack

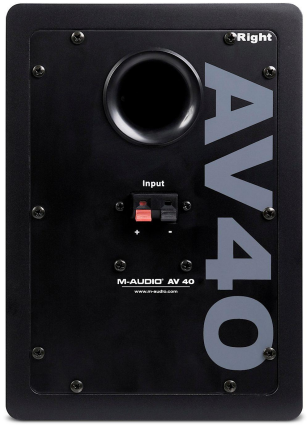
Why Is This Better?

- **Get all the benefits of balanced cables** even with an unbalanced input
  - Interference, noise floor, run longer lines
- **Turn unbalanced to balanced!**
  - You can now get all the benefits of a balanced signal in this case as well
- **Don’t have to carry a bunch of converter cables with you**
  - Only use common cables

Some Examples:


ANALOG
IN
ww.genelec.com


Left
Input
L
TRS
R
L
Line
R
Output
to Right Speaker
M-AUDIO AV 40
CAUTION
Power
On
Off
AV40


Right
Input
M-AUDIO AV 40
AV40


Pioneer Dj


Marshall
Bluetooth


LINE OUTPUTS
RIGHT
LEFT
Focusrite


Focusrite
Focusrite Audio Engineering Ltd
www.focusrite.com
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la NMB-003 du Canada
Focusrite Scarlett Solo 2nd Gen
MSIP-REM-FAE-MOSC0019
LINE OUTPUTS
RIGHT
LEFT
Designed in England
Made in China

Project Specifications

- **Carry The following:**
  - 2 XLR Cables
  - 2 TRS Cables
  - 2 RCA Cables
  - 3.5mm Aux Cable
- You can connect basically **anything to everything**
  - With the best possible audio quality in every configuration

Competing Product: ARTscessories CLEANBoxPro

Things we can improve...

Project Specifications

- Convert line level **consumer to/from professional** (bi-directional)
  - **Using same connectors!** (form factor, simplicity)
  - Change directionality using a switch
- **Fixed gain and attenuation** - no user control
  - Ensure device compatibility
- **Use every cable type!**
  - XLR Male, XLR Female, TRS
  - RCA, 3.5mm Headphone Jack
- Ability to **use box as cable adapter** to/from any cable type
  - Support balanced to balanced, unbalanced to unbalanced
    - This part works without power

We just saved a lot of weight and backpack space!

No more converter cables :)

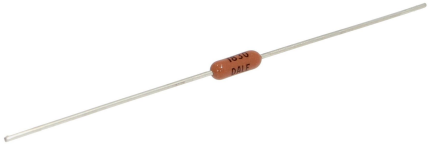
02

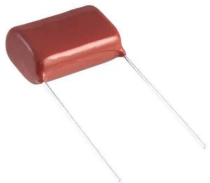
Research

Figure out how to make it happen

Parts Research

- Integrated circuits - **Texas Instruments OPA2134**
  - Dual op-Amp, dip 8
  - Best audio op-amp for the price! (like 6-7 bucks)
- Resistors - **Vishay Dale CMF55 Series**
  - Very high-quality metal film resistors
  - Great for audio applications
- Coupling capacitors - **Rubycon YXJ Series**
  - Regarded as one of the best aluminum electrolytic capacitors
  - Higher capacitance values
- Power Capacitors - **Rubycon ZLJ Series**
  - Good for power stuff?
- Op-Amp Bypass Capacitors - **Panasonic ECW Series**
  - Very high-quality film capacitors
  - Great for audio applications





Parts Research

- Common wall power supplies **only have positive voltage values**
  - Commonly referred to as “single supply power sources”
  - For example, **12-volt** center pin, and **0-volt** “ground” sleeve

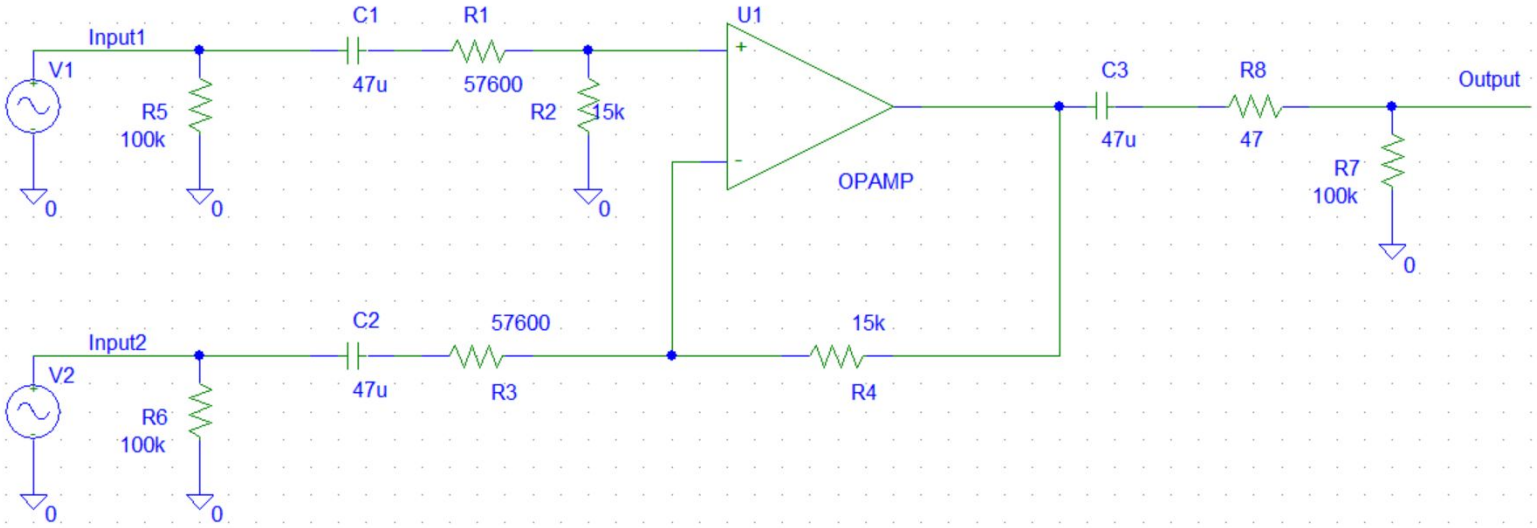
- Op-amp needs to have voltage supply in range of audio signal
- But audio signal **has both positive and negative voltages**!
  - How do you accommodate for this?
  - Many audio circuits DC bias the signal before going into the op-amp using a resistor divider (signal centered around 6 volts)
- “Rail Splitter” - **Texas Instruments TLE2426**
  - Provides very stable virtual ground at half of supplied voltage
  - **6 volts becomes 0 volts, or “ground”** for entire circuit
  - Voilà! We now have negative voltage

03

Simulations and Schematic

Make sure things make sense theoretically

PSPICE Simulations Part 1: Balanced to Unbalanced



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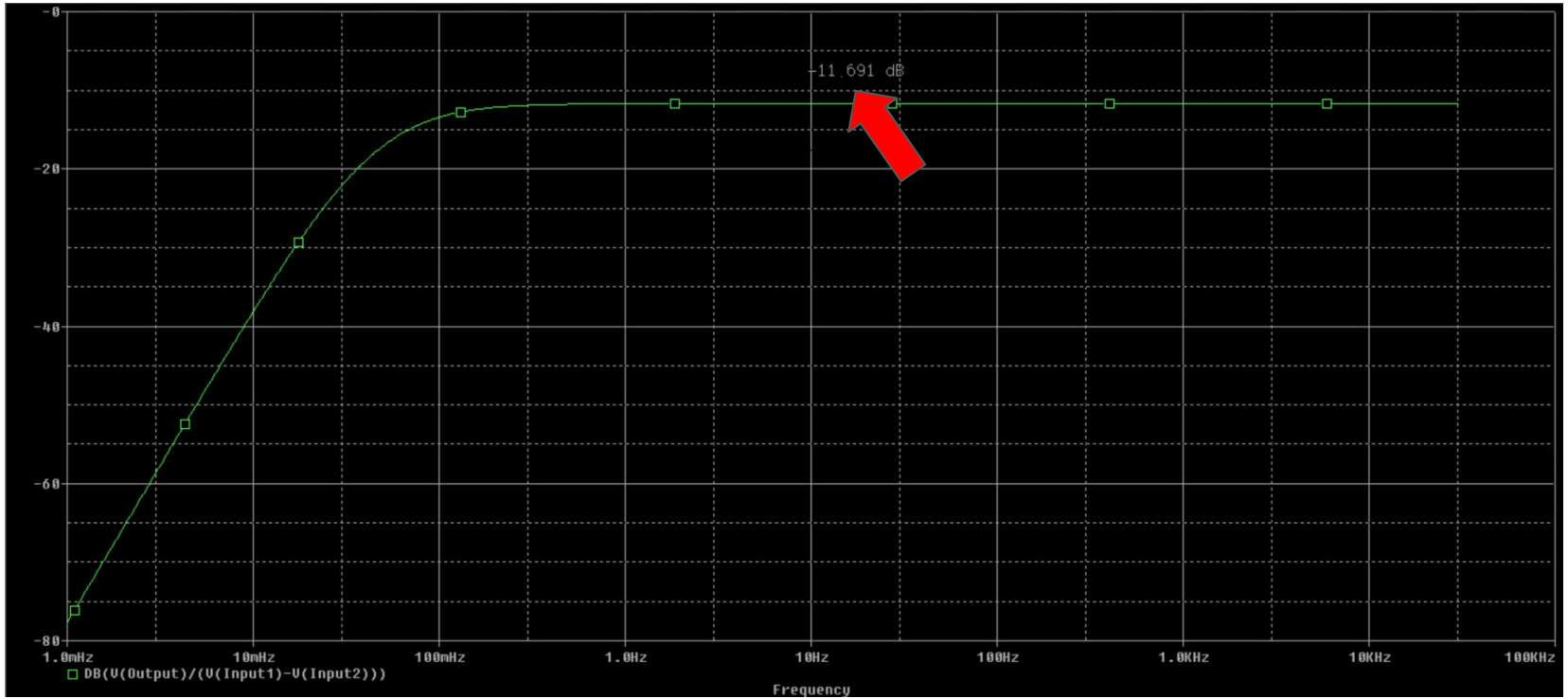
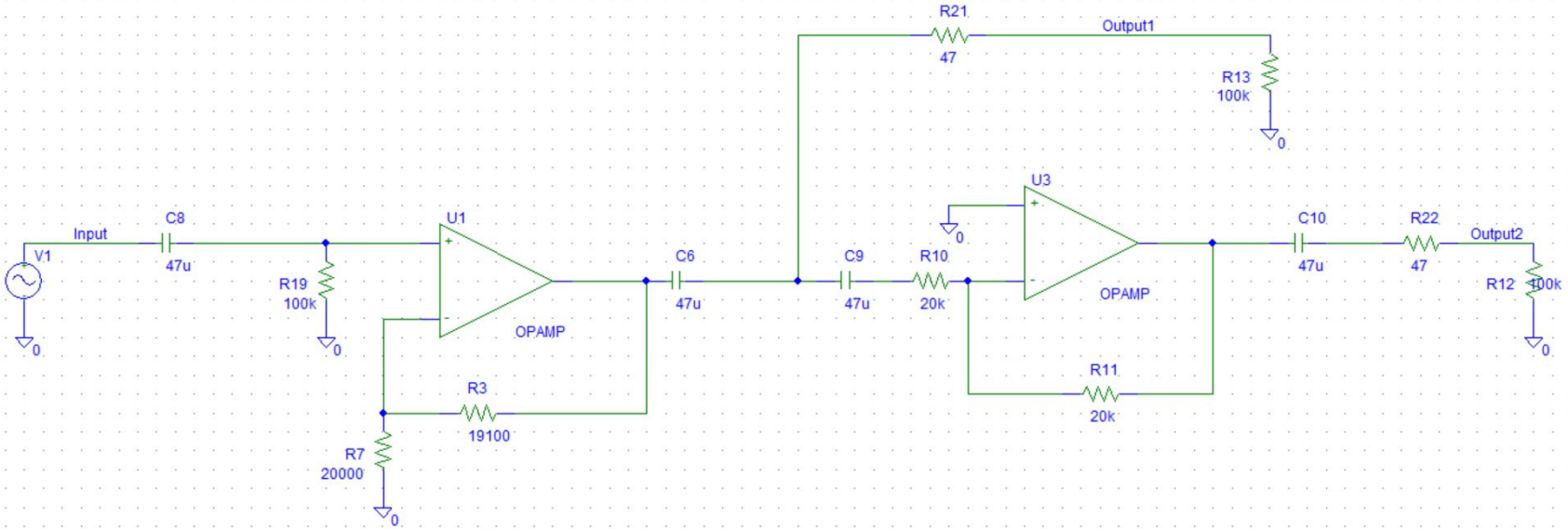


PSPICE Simulations Part 2: Unbalanced to Balanced



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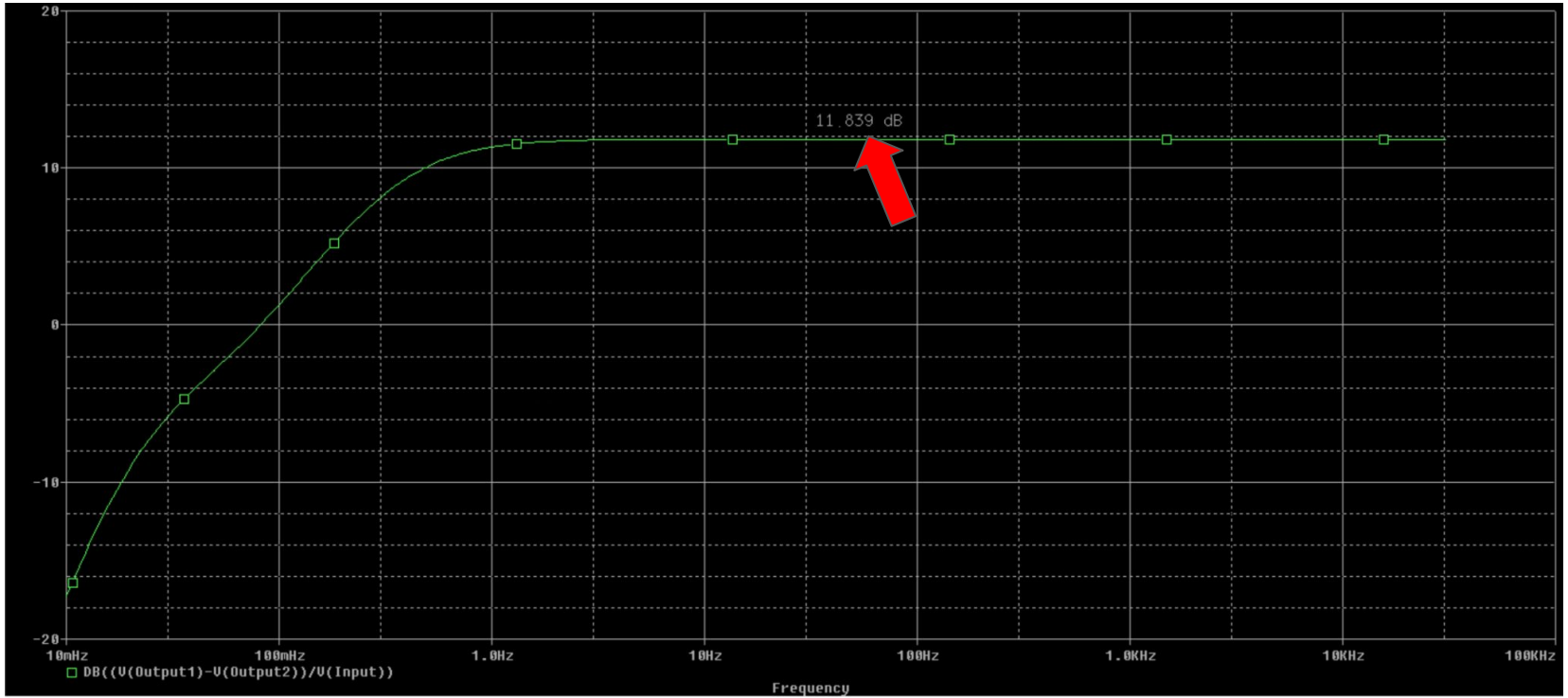
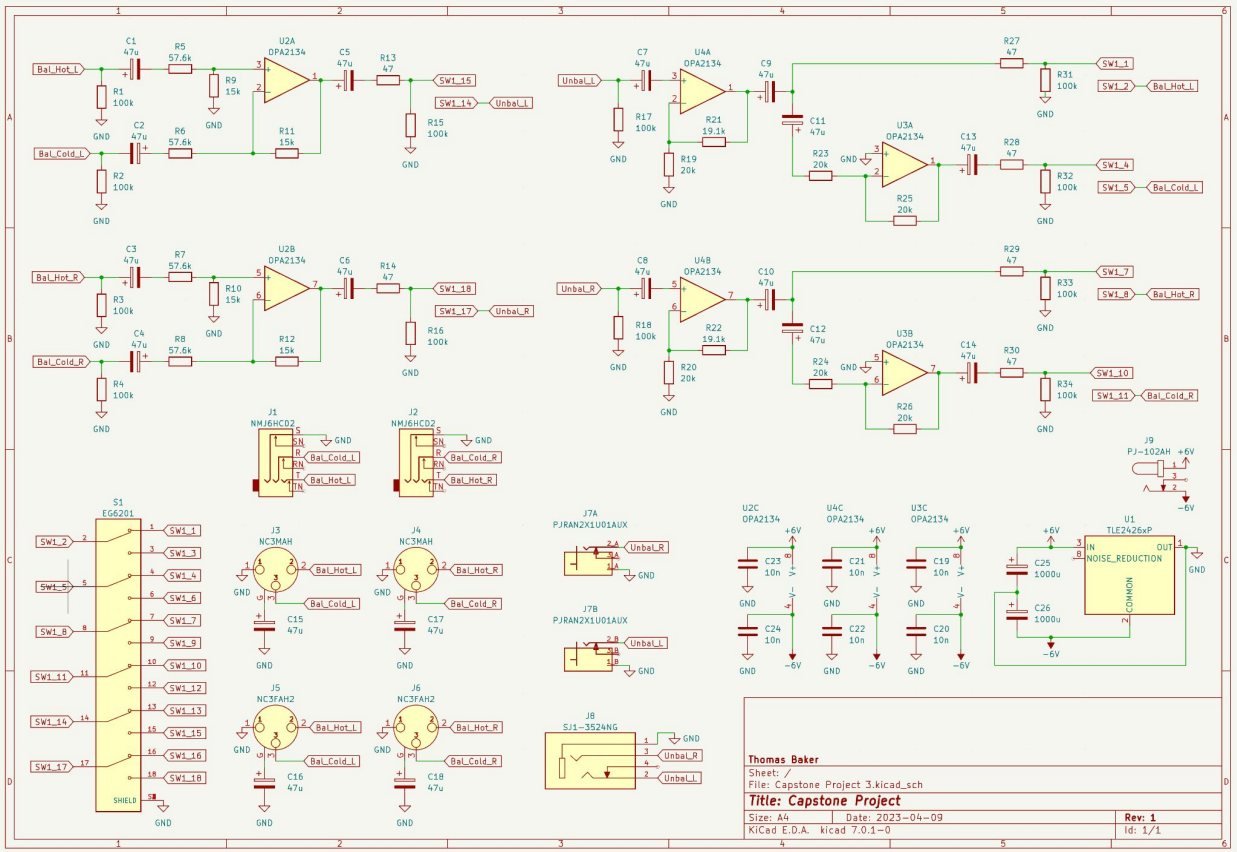


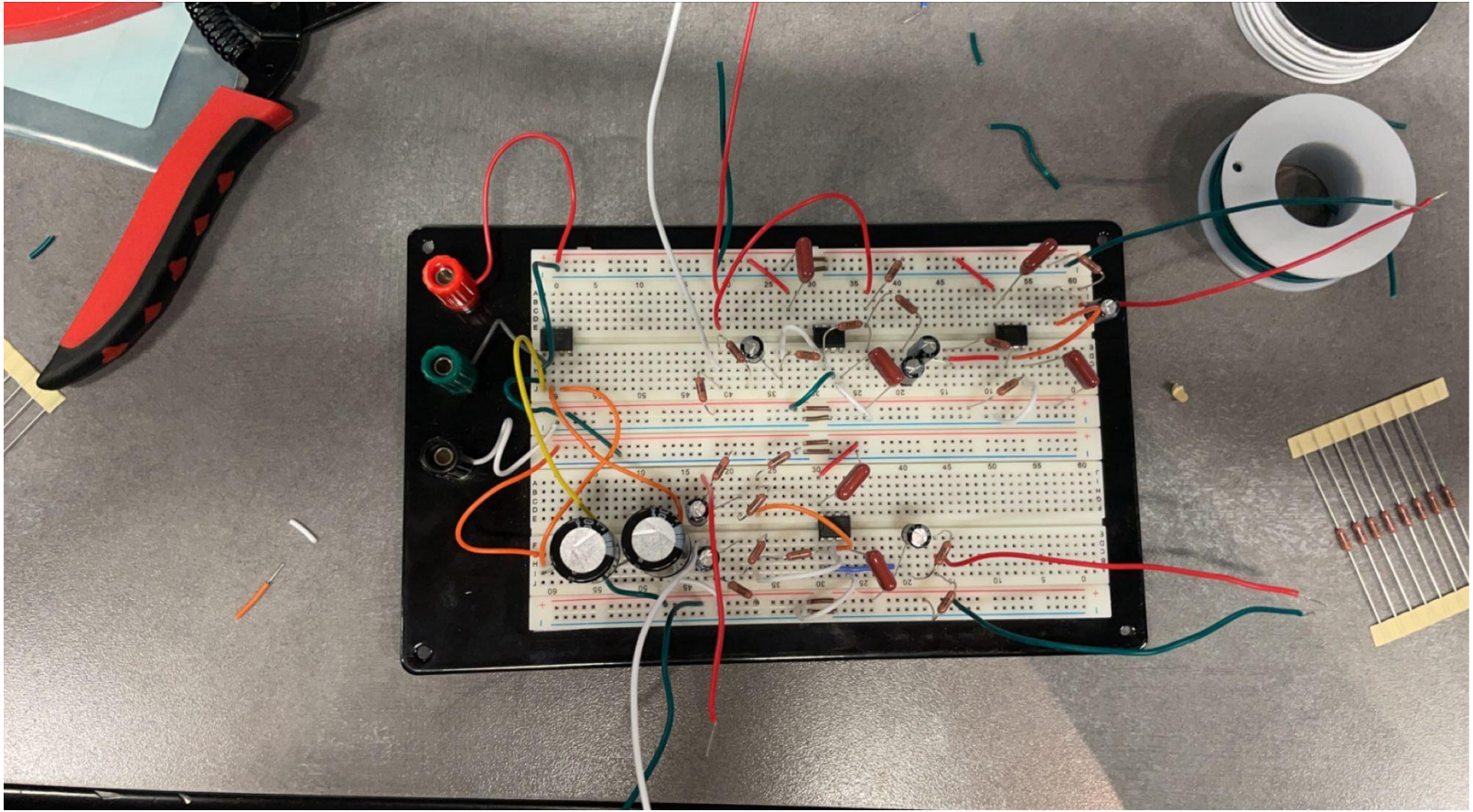
Final Schematic



04

Breadboarding

Testing phase, make sure
things actually work!



Oscilloscope: Balanced to Unbalanced

Input: Balanced Hot - **1V Peak**

(Hot - Cold = 2V Peak)

Output: Unbalanced - **526mV Peak**

Measured Gain: **-11.60 dB**

Theoretical: -11.69 dB

Oscilloscope: Unbalanced to Balanced

Input: Unbalanced - **1V Peak**

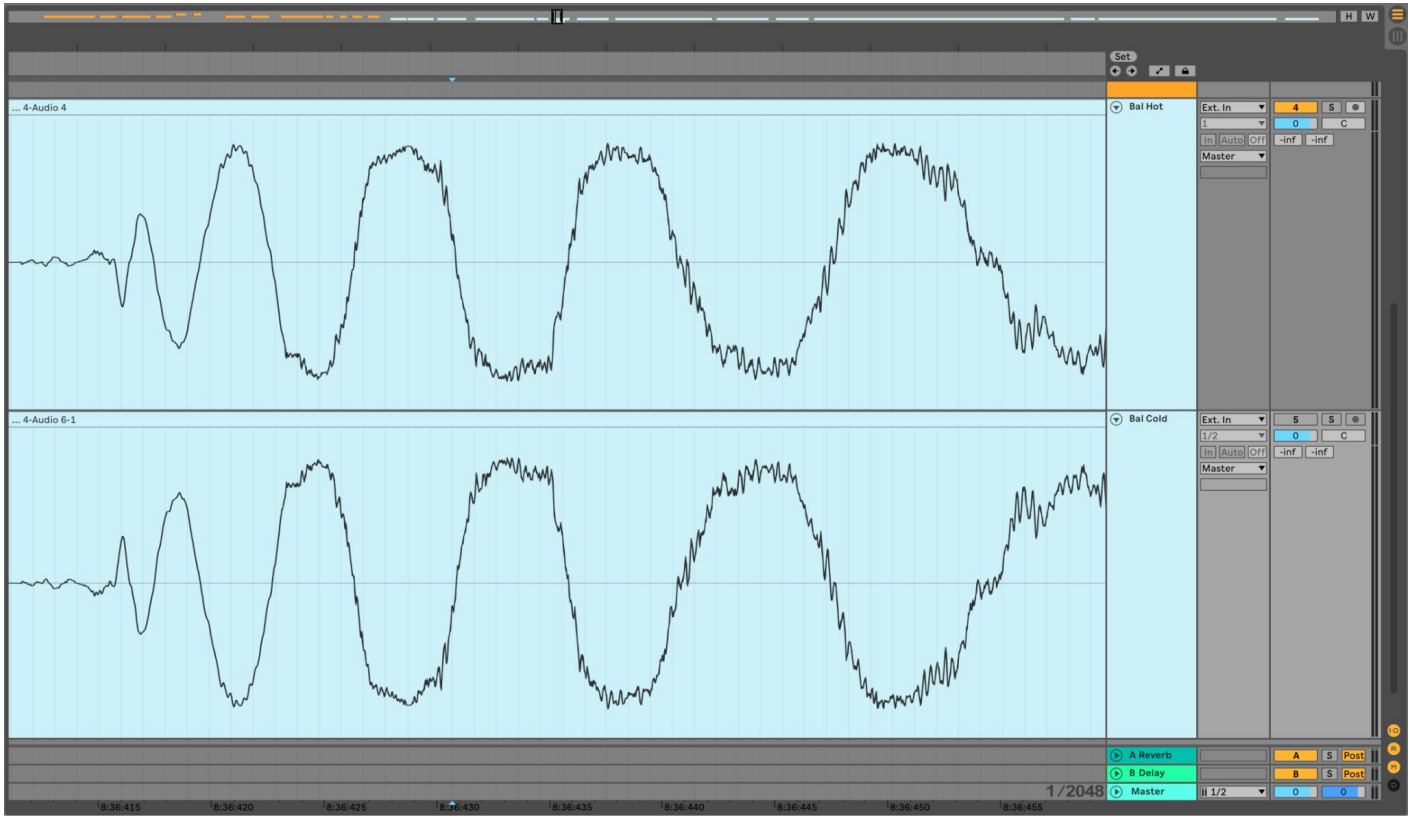
Output: Balanced Hot - **1.94V Peak**

(Hot - Cold = 3.88V Peak)

Measured Gain: **11.78 dB**

Theoretical: 11.84 dB

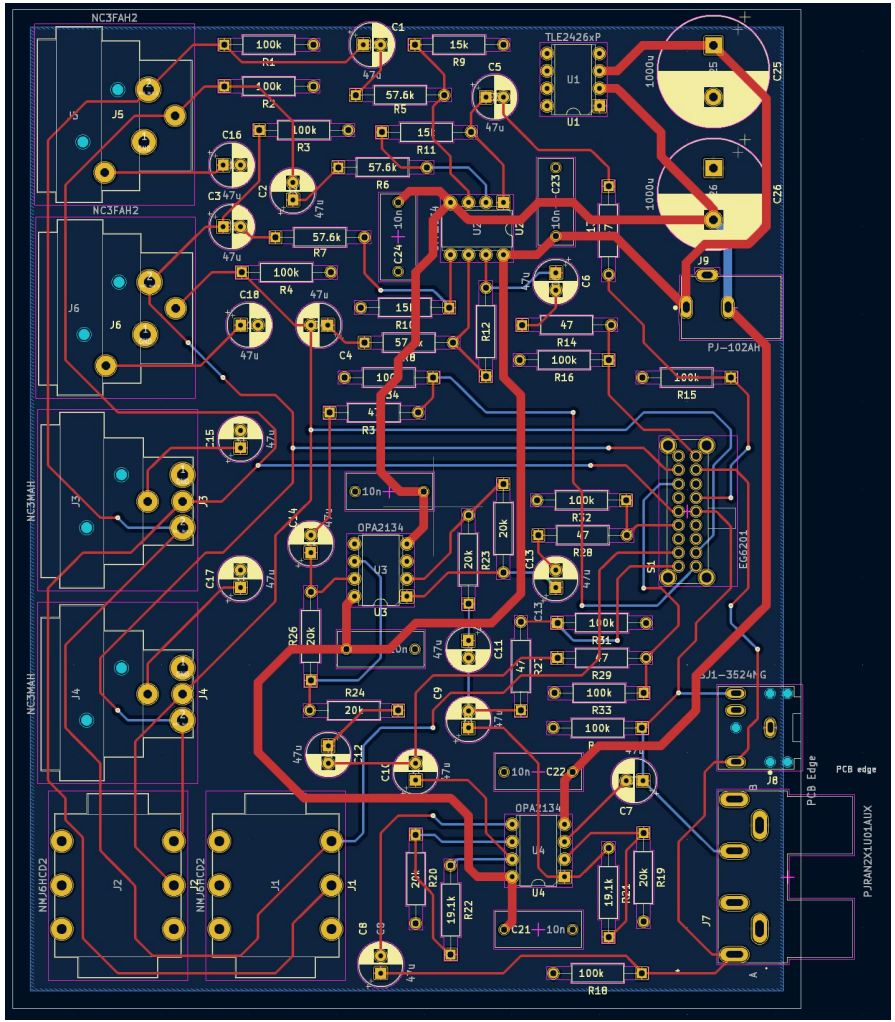
Balancing Audio



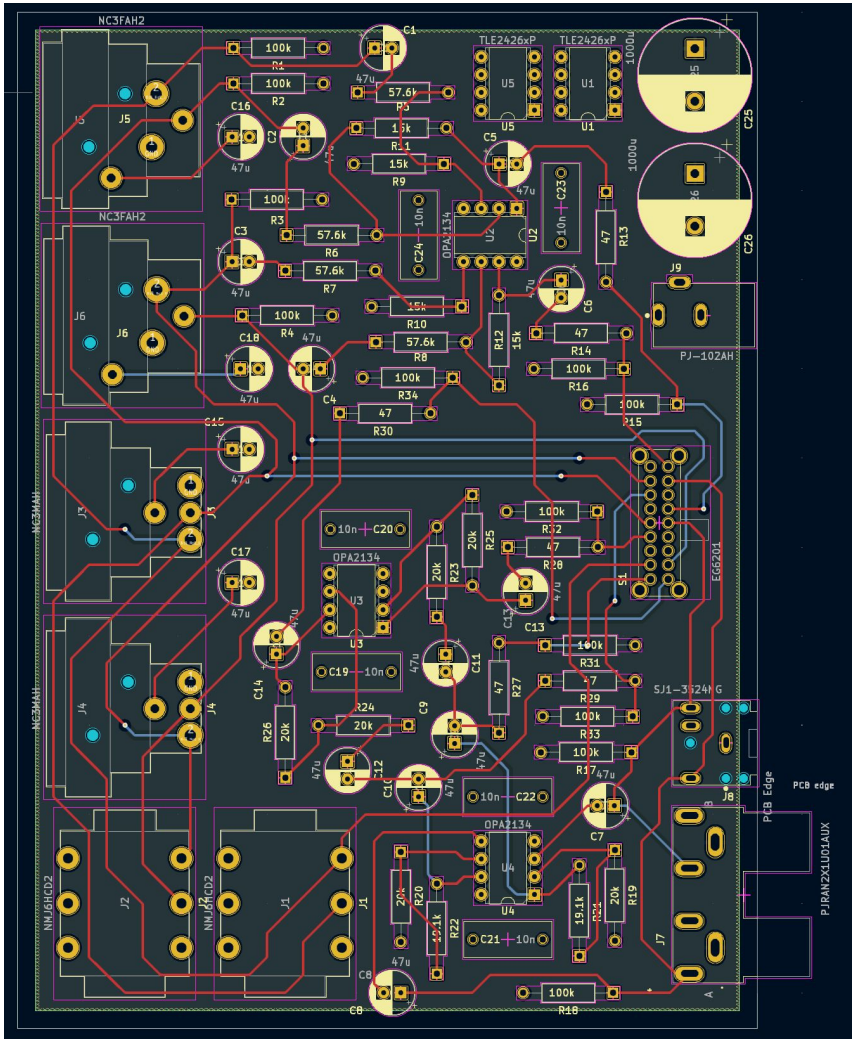
05

PCB Layout

The fun part!



- 2-Layer PCB
- Designed using KiCad



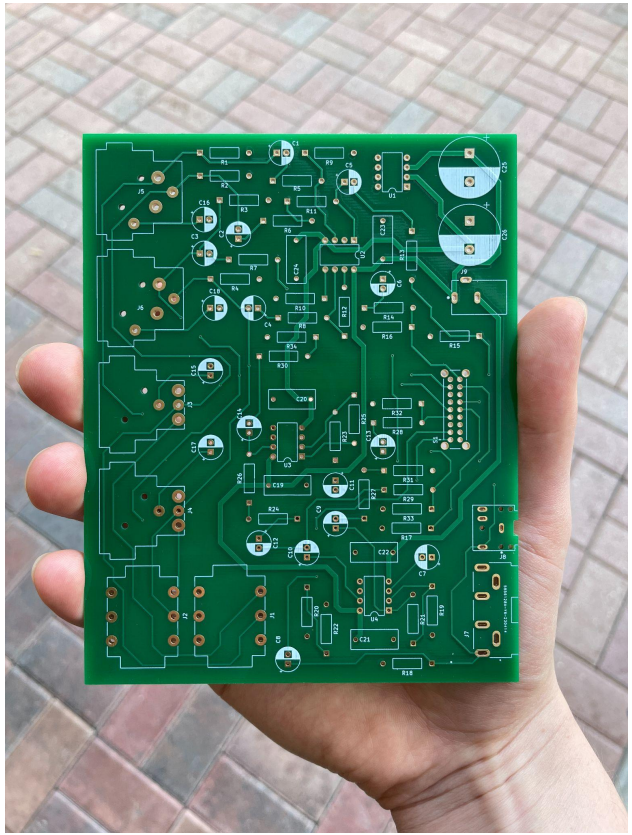
- 4-Layer PCB
- Planes (from top to bottom)
  - Signal
  - V+
  - V-
  - Ground

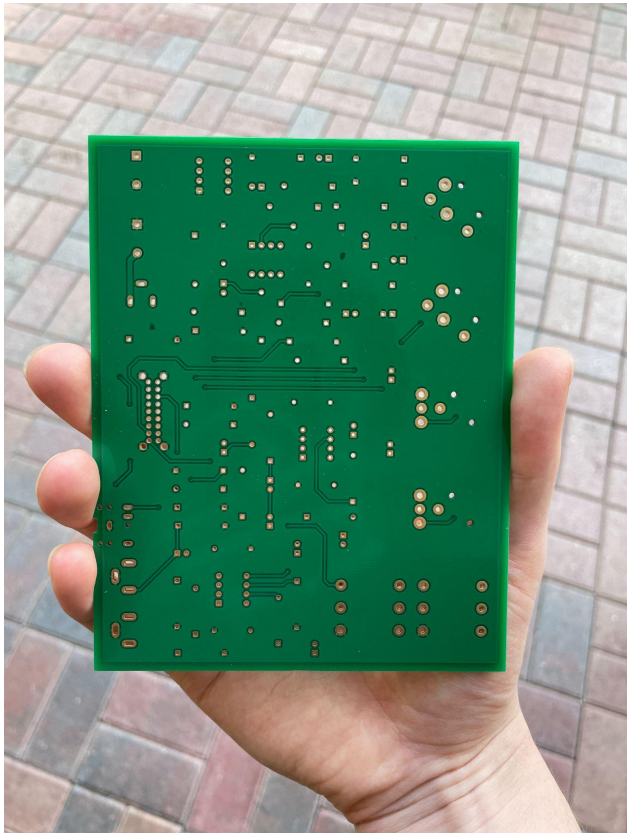
06

Assembly

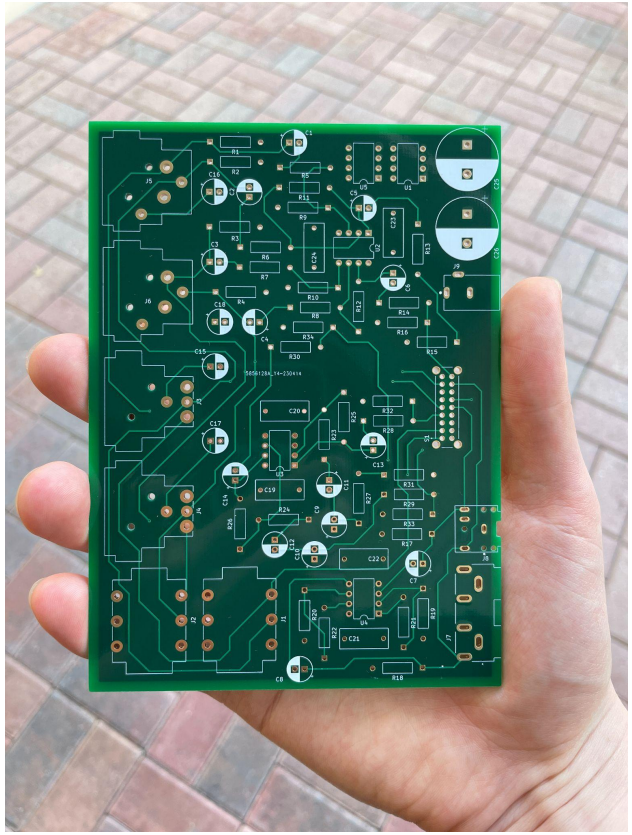
Putting it all together

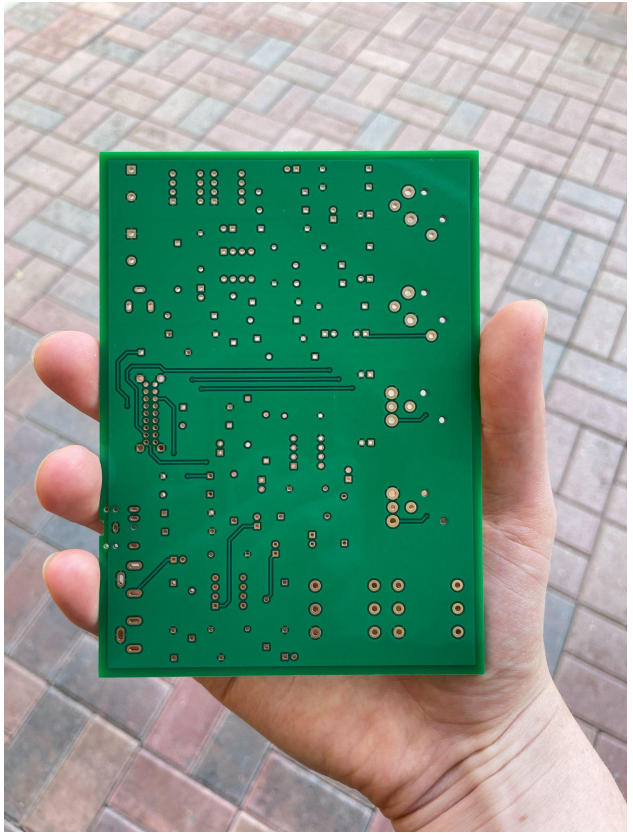
2 layer board: 5.7 x 4.5 inches

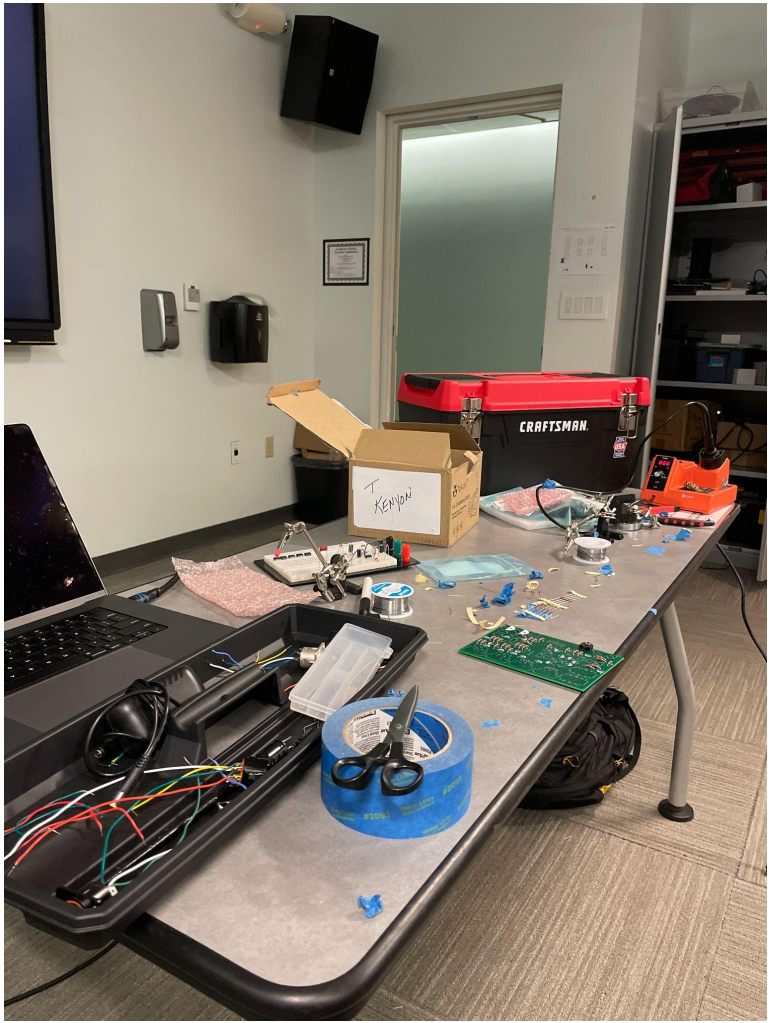




4 layer board: 5.7 x 4.15 inches



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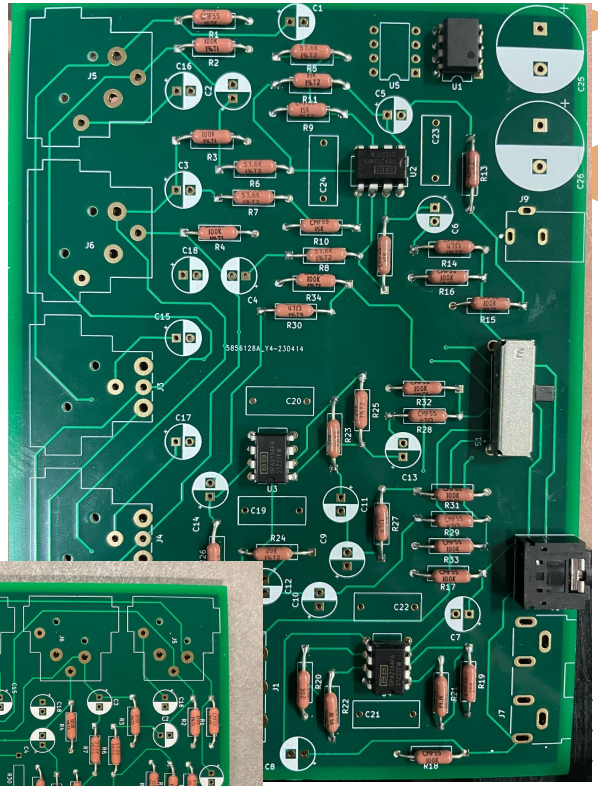

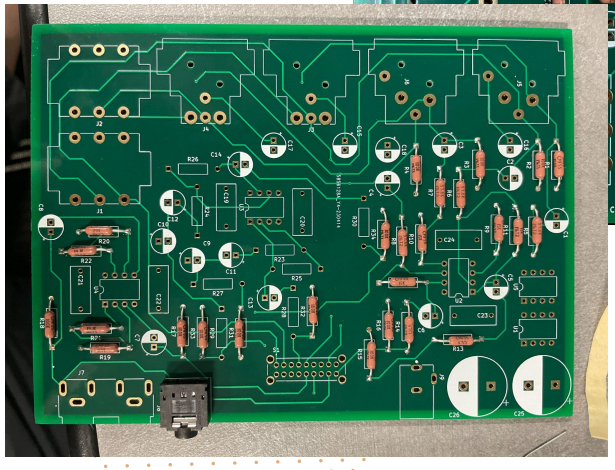

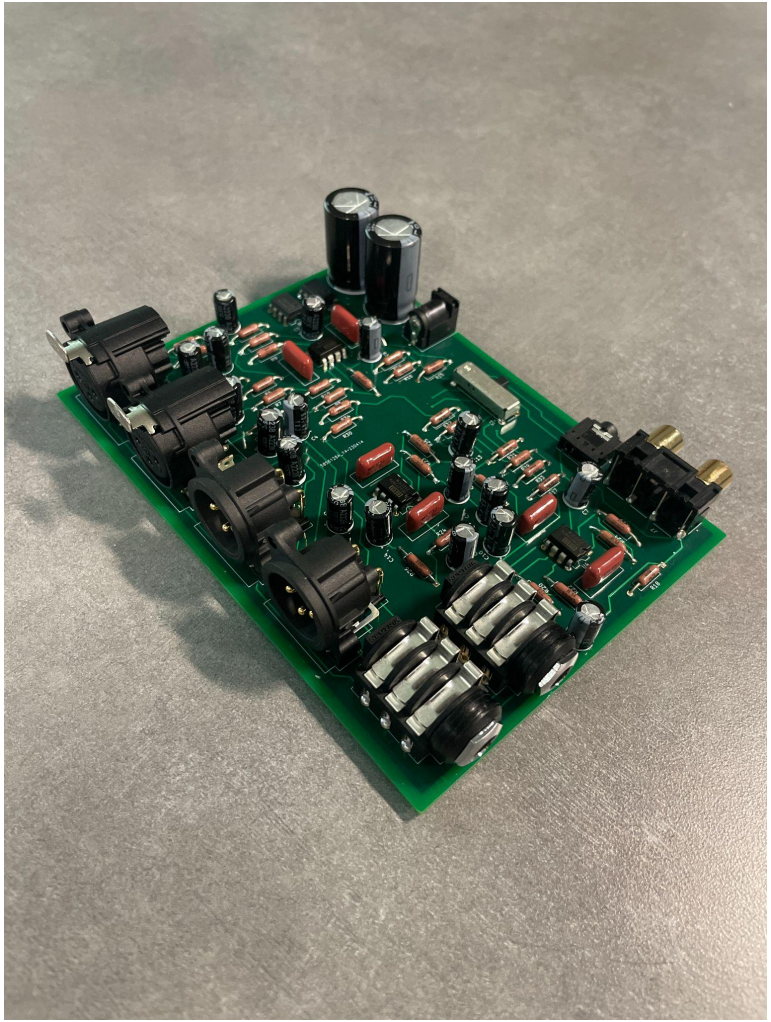

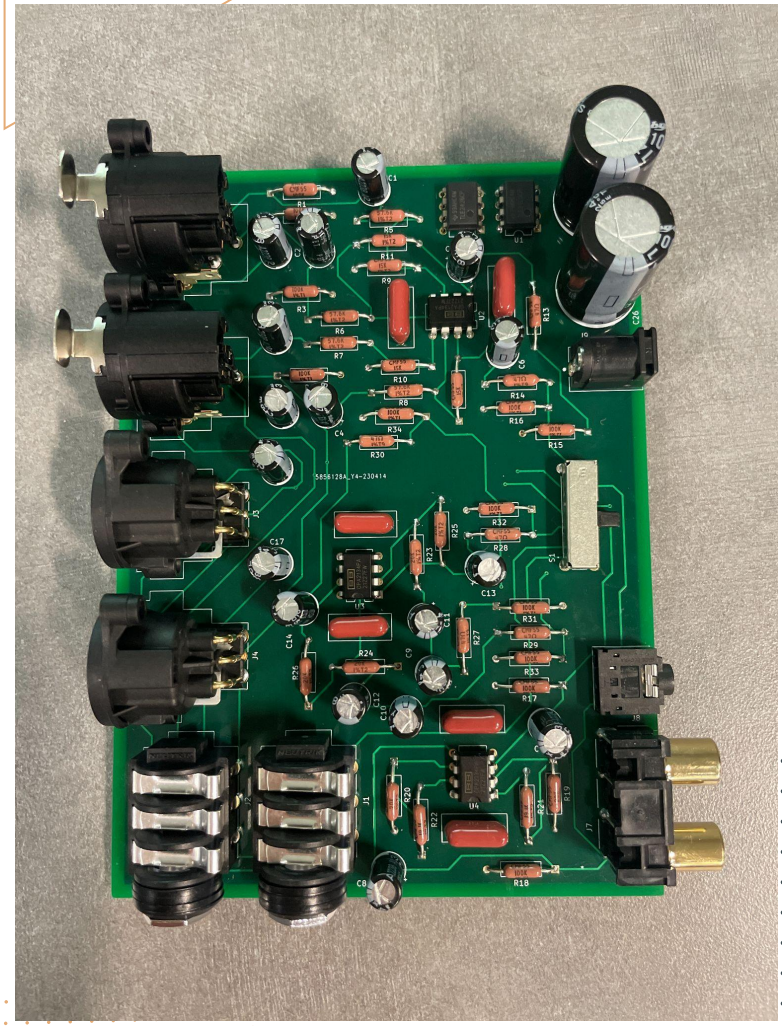

Does it work?

Yes!!!

(not perfect, but a great first prototype)

Some Future Improvements...

- **Fix distortion issues**
  - Impedance mismatch - output impedance too high?
  - Less distortion with higher impedance inputs
- 12 dB gain difference too drastic
- Even smaller form factor - very flat right now
- Better PCB layout, Create housing for PCB to make it practical

Analysis

Is this a viable product?

Cost and Production Analysis

- For a **2-layer** PCB
  - Cost to build 1 unit: **$128.79**
  - Cost to build 500 units (bulk prices): **$22740.56**
    - Cost per unit: **$45.48**
- JLCPCB has 5 board minimum quantity, why it's so expensive for 1 unit alone
  - have to pay for the 4 extra
- For **4-layer** PCB (higher quality, basically)
  - **+ $25.39** for 5 boards, or **+ $5.08 per unit** (not worth it!)
  - **+ $0.44** per unit for 500 boards (worth it! I think)

Bill of Materials

	Part ID	Component Value	Manufacturer #	Quantity	Unit Cost (for Quantity)	**Total Cost (for 1 device alone)**	Quantity for 500 devices	Unit Cost (for quantity for 500 devices)	**Total Cost (for 1 device of 500)**	Additional Notes
	R1-4, R15-18, R31-34	100kΩ	CMF55100K00FKEA	12	0.481	5.77	6000	0.09698	1.16376	Digi-Key
	R5-8	57.6kΩ	CMF5557K600FHEB	4	0.73	2.92	2000	0.16918	0.67672	Digi-Key
	R9-12	15kΩ	CMF5515K000FHEB	4	0.73	2.92	2000	0.16918	0.16918	Digi-Key
	R13, R14, R27-30	47Ω	CMF5547R000FEEK	6	0.95	5.7	3000	0.33815	2.0289	Digi-Key
	R19, R20, R23-26	20kΩ	CMF5520K000FHEB	6	0.73	4.38	3000	0.16918	1.01508	Digi-Key
	R21, R22	19.1kΩ	CMF5519K100FHEB	2	0.73	1.46	1000	0.17524	0.35048	Digi-Key
	C1-18	47uF	63YXJ47M6.3X11	18	0.242	4.36	9000	0.07468	1.34424	Digi-Key
	C19-23	10nF	ECW-F6103JL	6	1.43	8.58	3000	0.52743	3.16458	Digi-Key
	C25, C26	1000uF	63ZLJ1000M16X25	2	2.17	4.34	1000	0.895	1.79	Digi-Key
	U1	Rail Splitter	TLE2426CP	1	2.45	2.45	500	1.4506	1.4506	Digi-Key
	U2-4	Dual Op-Amp	OPA2134PA	3	5.49	16.47	1500	3.285	9.855	Jameco, Digi-Key for Bulk
	J1, J2	TRS Jack	NMJ6HCD2	2	2.4	4.8	1000	1.76	3.52	Mouser
	J3, J4	XLR Male	NC3MAH	2	2.37	4.74	1000	1.31	2.62	Mouser
	J5, J6	XLR Female	NC3FAH2	2	2.85	5.7	1000	1.65	3.3	Mouser
	J7	RCA Stereo Jack	PJRAN2X1U01AUX	1	3.36	3.36	500	2.2848	2.2848	Digi-Key
	J8	3.5mm Stereo Headphone Jack	SJ1-3524NG	1	1.15	1.15	500	0.71629	0.71629	Digi-Key
	J9	Power Barrel Connector Jack	PJ-102AH	1	0.82	0.82	500	0.5656	0.5656	Digi-Key
	SW1	6PDT	EG6201	1	1.64	1.64	500	1.08228	1.08228	Digi-Key
	SW2 (Not included in this prototype)	SPST	C5503ATNAB	1	1.22	1.22	500	1.22	1.22	Digi-Key, for turning power on/off
		12V Power Supply	VEL05US120-US-JA	1	6.5	6.5	500	5.46	5.46	Digi-Key
		PCB Manufacturing		**5 (JLCPCB minimum)**	7.902	39.51	500	1.70362	1.70362	JLC PCB, 2-layer board, 5.7x4.5 inches, ENIG. Minimum quantity 5 boards. Final prices, includes shipping from China to Florida in cost
Total						**128.79**			**45.48113**	

Need to Take Into Account...

- **Not a final product!**
  - Still needs a housing, a box to put the PCB in
  - Probably a couple extra dollars per unit
- Plus labor, component shipping cost, packaging, branding costs, etc...
- **Viable product?**
  - **Yes**, but need to cut down on cost + other improvements
  - Using highest quality materials in this prototype, can easily cut down cost

Thank You!

Questions?