ENGR 301 Final Project Report: Low Noise Amplifier

ENGR 301
Section 1
Spring 2019

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Objective:

To practice and apply my knowledge of microelectronics and design to realize a low noise amplifier. Using EagleCad to create a schematic and board design, soldering components to the board, and verifying the functions of the board. I first created the schematic in Eagle, doing this I had some issues with the program and some confusion that always comes with learning anything new. During the project I also got to work with many different types of components that I learned about in lecture such as diodes and binary junction transistors. After creating the schematic it was time to place all the components on the board, it took me a couple of tries to get a layout I was satisfied with. Knowing what components and parts of the circuit had to be far away from each other was a crucial part of this project. The goal was to gain a better understanding of how these different parts worked in the circuit and interacted with different elements of the circuit.

Design:

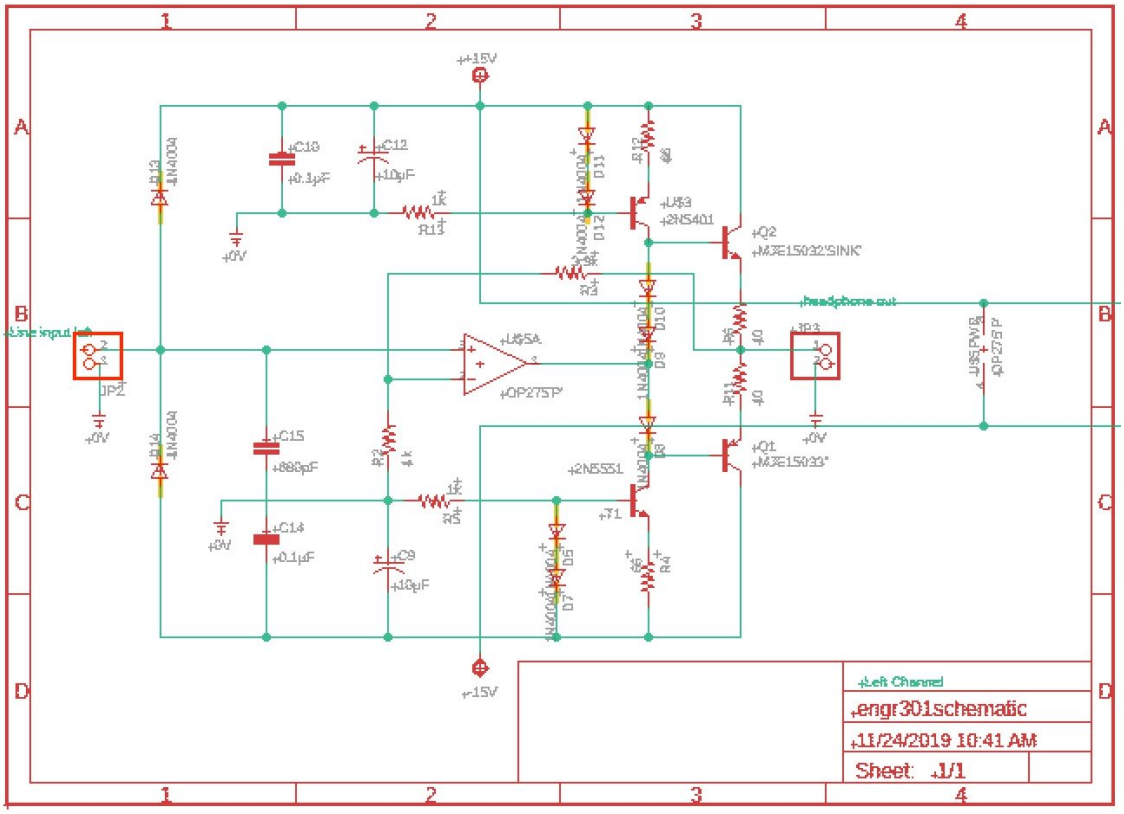

Figure 1: Left channel audio amplification

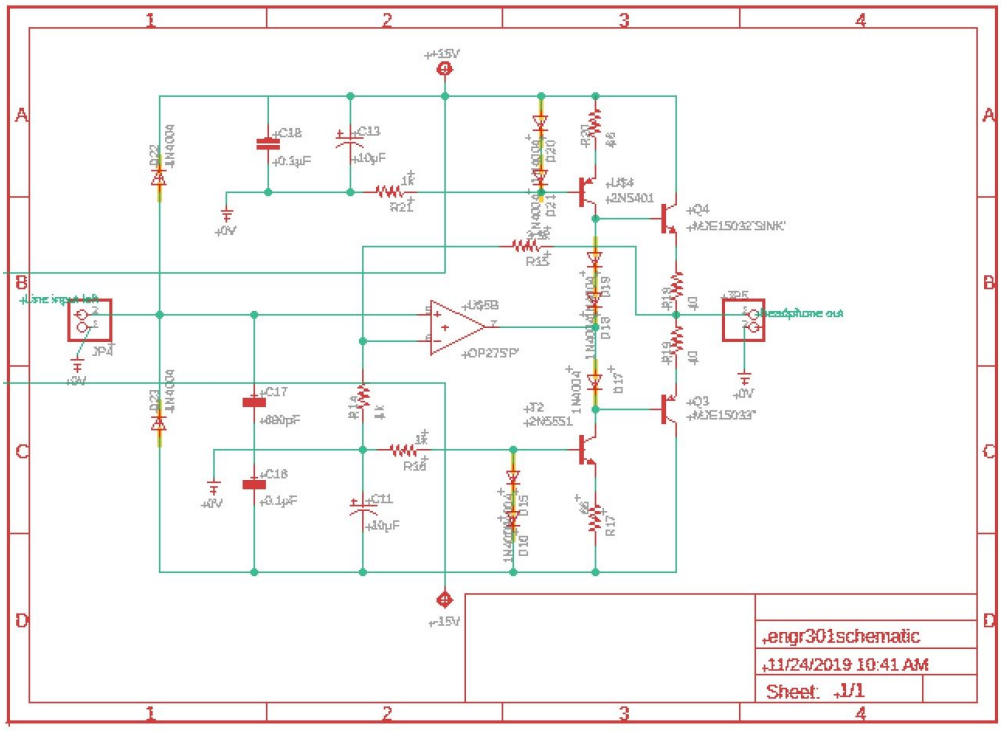

Figure 2: Right channel audio amplification

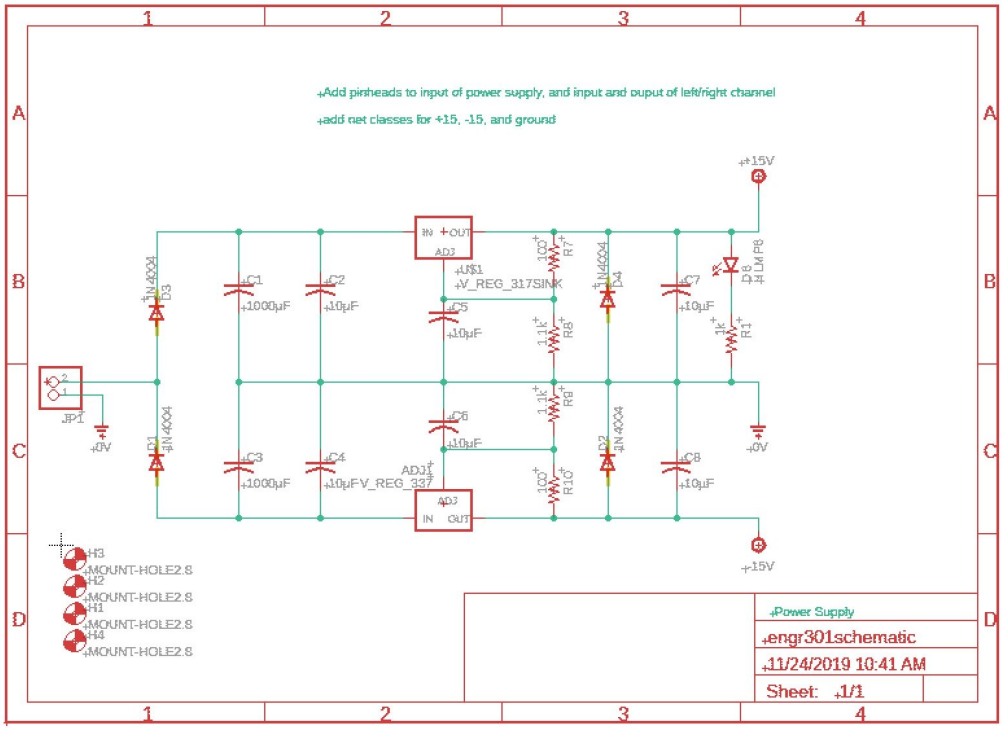

Figure 3: 15V AC Power Supply

As we can see from Figure 1 and 2, we have right and left channel audio that takes an input signal and amplifies it by sending the signal through a OP275 chip housing two operational amplifiers. Essentially increasing the amplitude of the input waveform, this input is first controlled by a potentiometer to raise or drop the voltage of the circuit to create a volume knob. There are 8 polarized capacitors in the power supply, on each side, positive and negative, there are 4 polarized capacitors each. These are used as signal smoothing capacitors. The 1N4004 diodes in the power supply are used as rectifier diodes. One side of the circuit is converted to +15 V and the other to -15 V in the power supply which are then used to feed power to the operational amplifiers.

I had a relatively easy time connecting up the schematic from the reference that was provided in the lab manual, though I did read the wrong value for the 56 Ohm resistors, and instead modeled the circuit with 66 Ohm resistors. Since this was only the model, I was able to get my hands on the proper value resistors in time to get the board working. Though it would still theoretically work with 66 Ohm resistors albeit quieter it was better to use the recommended value. I also modeled the circuit with two negative voltage regulators, though I was able to bend the legs of a positive voltage regulator and fit it in all the same. Another mistake that I made during my schematic creation was to use the right silkscreen for the proper size components. The best example of this is the 1000uF capacitors that had to be placed on the bottom side of the board because I failed to realize the size of my components.

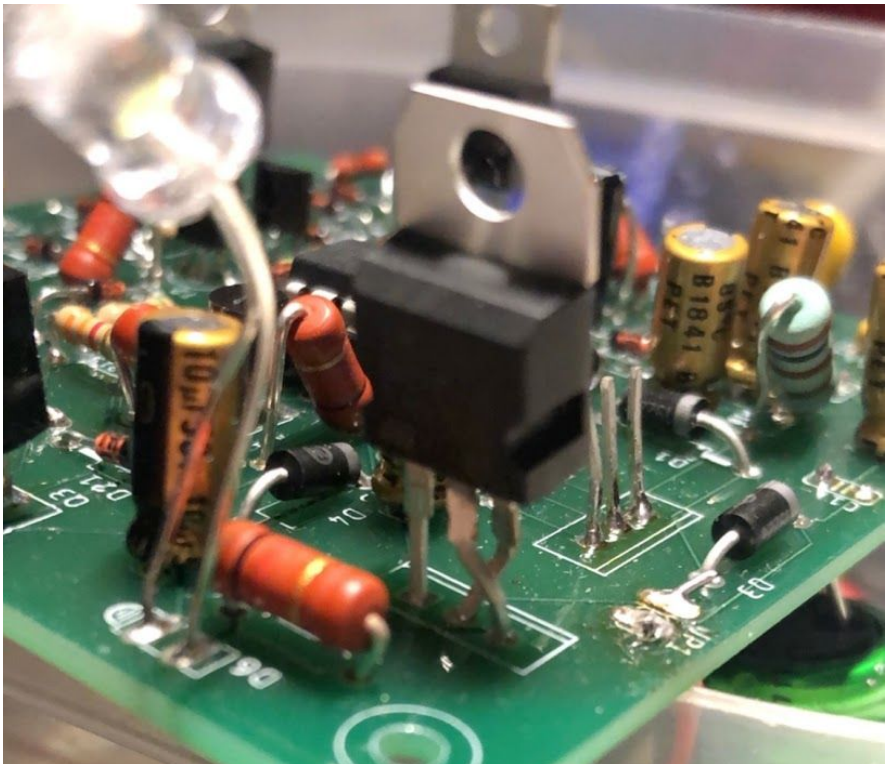

Figure 4: Positive voltage regulator with bent leg to fit negative voltage regulator soldering points.

When laying out the components I started by finding all the components that needed to be close to each other, such as the power supply, left channel and right channel. After separating those out, I knew that a good place for the amplifiers would be close to the middle of the board. After that, I knew that I wanted the voltage regulators and the transistors as far away from the amplifier as possible so I placed them towards the edge of the board, next it was up to me to place all of the components with as short leads as possible. I noticed that a lot of students laid out their components neatly and in rows, I decided not to take this approach because I felt that the leads between the components became too long and I would be sacrificing lead length for looks. After placing all the crucial parts on the board, I went backwards from them and put the leads that were closest to them and fit them in where I found the space. In hindsight, I should have gone with a more structured approach, with more time and patience, I'm confident that I could create a board that has close to no vias in it. I tried my best to keep the power leads that carry the high voltage far away from the signal wires so that there would be the minimum amount of noise. I used two pin headers for input and output of the signal wires, though in hindsight it would have been smarter to combine the output and input to its own three pin header so that they would be next to each other and would create an easy time soldering, however I used two, two pin connectors as separated headers for the input and output.

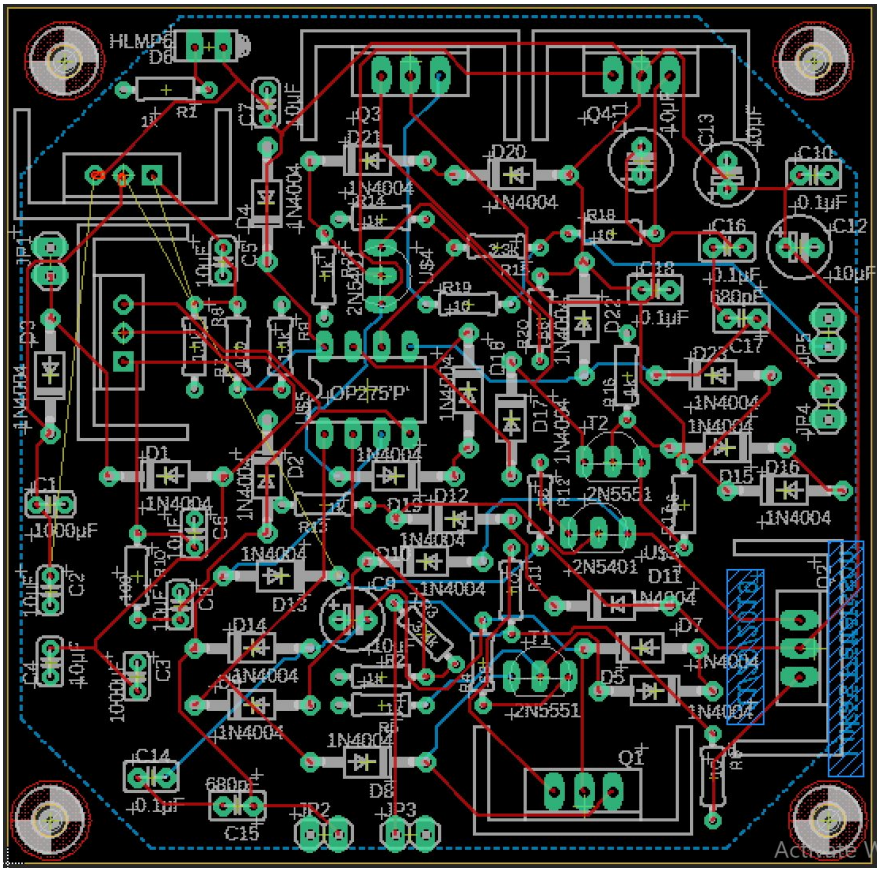

Figure 5: Eagle board with components laid out. (voltage regulator swapped after design was fabricated.)

Component List:

Line Item	Ordered	Cancelled	Shipped	Item Number/ Description	Unit Price USD $	Amount USD $
1	1	0	1	**PART:** 497-19621-ND **MFG** : STMicroelectronics / LM317BT **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8542.39.0001 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff **DESC:** IC REG LINEAR POS ADJ 1.5A TO220	0.53000	0.53 T 0.05
2	1	0	1	**PART:** LM337TGOS-ND **MFG** : ON Semiconductor / LM337TG **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8542.39.0001 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff **DESC:** IC REG LIN NEG ADJ 1.5A TO220AB	0.75000	0.75 T 0.08
3	2	0	2	**PART:** 493-10826-ND **MFG** : Nichicon / UES1E102MHM **COO** : JAPAN **ECCN:** EAR99 **HTSUS:** 8532.22.0040 ROHS3 COMP REACH UNAFFECTED Jan-2017 **DESC:** CAP ALUM 1000UF 20% 25V RADIAL	1.57000	3.14 T
4	6	0	6	**PART:** 493-11003-1-ND **MFG** : Nichicon (VA) / UFW1H100MDD1TD **COO** : MALAYSIA **ECCN:** EAR99 **HTSUS:** 8532.22.0020 ROHS3 COMP REACH UNAFFECTED Jan-2017 **DESC:** CAP ALUM 10UF 20% 50V RADIAL	0.24000	1.44 T
5	4	0	4	**PART:** 399-9859-1-ND **MFG** : KEMET (VA) / C315C104M5U5TA7303 **COO** : MEXICO **ECCN:** EAR99 **HTSUS:** 8532.24.0060 ROHS3 COMP REACH UNAFFECTED Jan-2019 **DESC:** CAP CER 0.1UF 50V Z5U RADIAL	0.24000	0.96 T

Line Item	Ordered	Cancelled	Shipped	Item Number/ Description	Unit Price USD $	Amount USD $
6	2	0	2	**PART:** 1293PH-ND **MFG** : Vishay BC Components / S681K29Y5PN63J5R **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8532.23.0060 ROHS3 COMP **DESC:** CAP CER 680PF 1KV Y5P RADIAL	0.24000	0.48 T
7	4	0	4	**PART:** 1N4004RLGOSCT-ND **MFG** : ON Semiconductor (VA) / 1N4004RLG **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8541.10.0080 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff **DESC:** DIODE GEN PURP 400V 1A DO41	0.20000	0.80 T 0.08
8	18	0	18	**PART:** 1N4148FSCT-ND **MFG** : ON Semiconductor (VA) / 1N4148TR **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8541.10.0070 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff **DESC:** DIODE GEN PURP 100V 200MA DO35	0.05800	1.04 T 0.10
9	5	0	5	**PART:** 277-1645-ND **MFG** : Phoenix Contact / 1933189 **COO** : GERMANY **ECCN:** EAR99 **HTSUS:** 8536.69.4040 ROHS COMP **DESC:** TERM BLOCK HDR 2POS VERT 5MM	0.15000	0.75 T
10	10	0	10	**PART:** PPC1.0KW-2CT-ND **MFG** : Vishay BC Components (VA) / PR02000201001JR500 **COO** : INDIA **ECCN:** EAR99 **HTSUS:** 8533.21.0090 ROHS3 COMP **DESC:** RES 1K OHM 2W 5% AXIAL	0.32300	3.23 T
11	2	0	2	**PART:** CF14JT3K30CT-ND **MFG** : Stackpole Electronics Inc. (VA) / CF14JT3K30 **COO** : CHINA **ECCN:** EAR99 **HTSUS:** 8533.10.0065 ROHS3 COMP REACH UNAFFECTED Jan-2019 **Mercury:** Cert on File. For more information contact Environmental@DigiKey.com Section 301 Tariff **DESC:** RES 3.3K OHM 1/4W 5% AXIAL	0.10000	0.20 T 0.02
12	2	0	2	**PART:** 66.5XBK-ND **MFG** : Yageo / MFR-25FBF52-66R5 **COO** : TAIWAN **ECCN:** EAR99 **HTSUS:** 8533.21.0090 ROHS3 COMP REACH UNAFFECTED Jul-2017 **DESC:** RES 66.5 OHM 1/4W 1% AXIAL	0.10000	0.20 T
13	4	0	4	**PART:** PPC10W-1CT-ND **MFG** : Vishay BC Components (VA) / PR01000101009JR500 **COO** : INDIA **ECCN:** EAR99 **HTSUS:** 8533.21.0090 ROHS3 COMP **DESC:** RES 10 OHM 1W 5% AXIAL	0.24000	0.96 T

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Line Item	Ordered	Cancelled	Shipped	Item Number/ Description	Unit Price USD $	Amount USD $
14	2	0	2	**PART:** 100DYCT-ND **DESC:** RES 100 OHM 2W 5% AXIAL **MFG :** Yageo (VA) / FKN2WSJR-73-100R **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8533.21.0080 ROHS3 COMP REACH UNAFFECTED Jul-2017 Section 301 Tariff	0.52000	1.04 T 0.10
15	2	0	2	**PART:** 100DYCT-ND **DESC:** RES 100 OHM 2W 5% AXIAL **MFG :** Yageo (VA) / FKN2WSJR-73-100R **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8533.21.0080 ROHS3 COMP REACH UNAFFECTED Jul-2017 Section 301 Tariff	0.52000	1.04 T 0.10
16	2	0	2	**PART:** 100DYCT-ND **DESC:** RES 100 OHM 2W 5% AXIAL **MFG :** Yageo (VA) / FKN2WSJR-73-100R **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8533.21.0080 ROHS3 COMP REACH UNAFFECTED Jul-2017 Section 301 Tariff	0.52000	1.04 T 0.10
17	2	0	2	**PART:** PPC1.10KXCT-ND **DESC:** RES 1.1K OHM 1/2W 1% AXIAL **MFG :** Vishay BC Components (VA) / SFR16S0001101FR500 **COO :** SOUTH KOREA **ECCN:** EAR99 **HTSUS:** 8533.21.0090 ROHS3 COMP	0.20000	0.40 T
18	2	0	2	**PART:** MJE15033GOS-ND **DESC:** TRANS PNP 250V 8A TO220AB **MFG :** ON Semiconductor / MJE15033G **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8541.29.0095 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff	1.50000	3.00 T 0.30
19	2	0	2	**PART:** MJE15032GOS-ND **DESC:** TRANS NPN 250V 8A TO220AB **MFG :** ON Semiconductor / MJE15032G **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8541.29.0095 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff	1.50000	3.00 T 0.30
20	2	0	2	**PART:** 2N5551TFCT-ND **DESC:** TRANS NPN 160V 0.6A TO-92 **MFG :** ON Semiconductor (VA) / 2N5551TF **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8541.21.0095 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff	0.27000	0.54 T 0.05

Line Item	Ordered	Cancelled	Shipped	Item Number/ Description	Unit Price USD $	Amount USD $
21	2	0	2	**PART:** 2N5401YBUOS-ND **DESC:** TRANS PNP 150V 0.6A TO-92 **MFG :** ON Semiconductor / 2N5401YBU **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8541.21.0095 ROHS3 COMP REACH UNAFFECTED Jan-2019 Section 301 Tariff	0.26000	0.52 T 0.05
22	1	0	1	**PART:** OP275GPZ-ND **DESC:** IC AUDIO 2 CIRCUIT 8DIP **MFG :** Analog Devices Inc. / OP275GPZ **COO :** PHILIPPINES **ECCN:** EAR99 **HTSUS:** 8542.33.0001 ROHS3 COMP REACH UNAFFECTED Jan-2019	4.58000	4.58 T
23	1	0	1	**PART:** AE9986-ND **DESC:** CONN IC DIP SOCKET 8POS TIN **MFG :** Assmann WSW Components / A 08-LC-TT **COO :** TAIWAN **ECCN:** EAR99 **HTSUS:** 8536.69.4040 ROHS3 COMP REACH UNAFFECTED Jan-2019 **Mercury:** Cert on File. For more information contact Environmental@DigiKey.com	0.18000	0.18 T
24	1	0	1	**PART:** EG5619-ND **DESC:** SWITCH ROCKER SPST 10A 125V **MFG :** E-Switch / RA1113112R **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8536.50.9065 ROHS3 COMP REACH UNAFFECTED Jan-2017 **Mercury:** Cert on File. For more information contact Environmental@DigiKey.com Section 301 Tariff	0.54000	0.54 T 0.05
25	1	0	1	**PART:** PDB182-K220K-103B-ND **DESC:** POT 10K OHM 1/8W CARBON LINEAR **MFG :** Bourns Inc. / PDB182-K220K-103B **COO :** CHINA **ECCN:** EAR99 **HTSUS:** 8533.40.8070 ROHS3 COMP REACH UNAFFECTED Jan-2017 Section 301 Tariff	2.08000	2.08 T 0.21
26	1	0	1	**PART:** F1902-ND **DESC:** FUSE HLDR CART 600V 20A PNL MNT **MFG :** Littelfuse Inc. / 03450613H **COO :** MEXICO **ECCN:** EAR99 **HTSUS:** 8538.90.8180 ROHS3 COMP	4.41000	4.41 T

In addition I also purchased a female to male audio jack extension cable that I used to facilitate my input and output signal. I also used 10uF capacitors scavenged from other electronics and microelectronics kits that I had laying around.

Board Testing:

The initial test that I tried on my board was to make sure that the power supply was working correctly. With only the power supply soldered to my board, I probed pin 4 and pin 8 of the IC chip socket to find that there was a stable 30 volt potential difference between the two. This makes sense since one side is the input of -15 V and the other is the input of the +15 volts. I also probed those two pins with respect to ground to find -15 and +15 volt potential difference. After testing that the power supply was safe, I connected the left and right channel components to the board and soldered two 56 ohm resistors to the output signal wires to better match the impedance of the load. I found after testing the final board that I had a loose transistor, which I promptly soldered down. After soldering down the transistor the board worked and I was able to amplify a signal that was played from my computer. There ended up being very little noise in the circuit to the point that it was impossible to make out any noise when the volume was turned up even a quarter of the way.

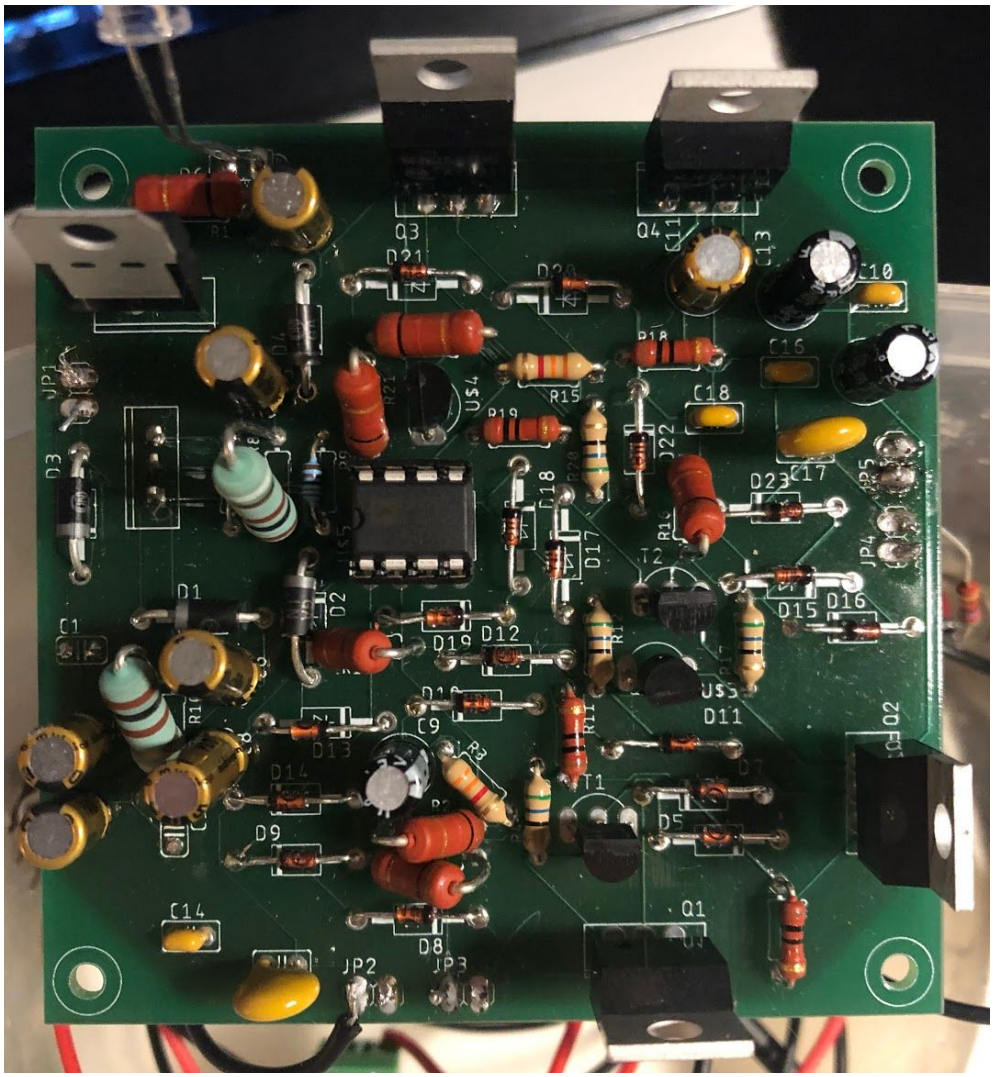

Figure 6: Front of board

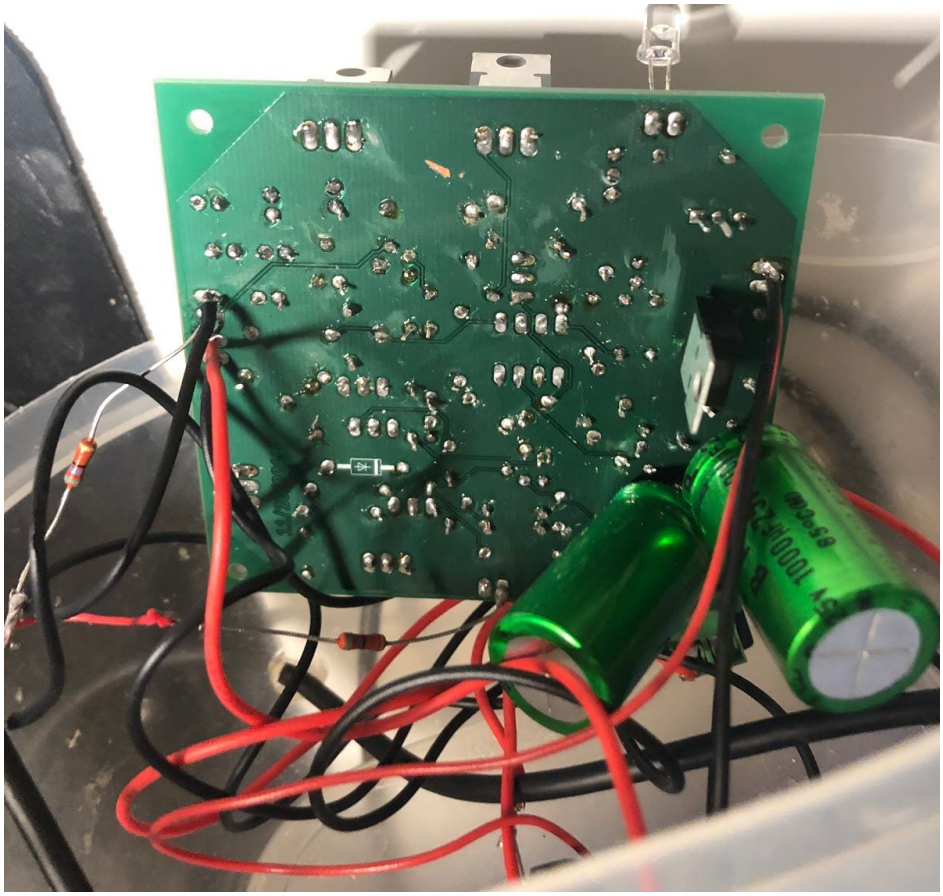

Figure 7: Back of board

Conclusion:

In conclusion, I learned a lot about microelectronics by doing this project, I was able to learn how to solder and appreciated how much planning played a part from start to finish in a larger scale project. Though my board ended up working great, and it does the job, the executing was sloppy, and had I planned out my project better I would have got a cleaner result. I learned that I have to pay attention to the size of my components and what size silk screen that I use when creating boards in the future. As mentioned earlier in the report, I had forgotten to order some of the diodes that I needed, though I was able to find them laying around in my spare parts bins, and on other electronics. Everything from the 56 ohm resistors hanging off the board and the giant capacitors and voltage regulator hanging on the underside of the board could have been prevented had I taken the extra time to think the project through before ordering my parts and sending the board to manufacturing. I would like to get proper sized 1000uF capacitors and fit this into a proper enclosure because I would like to use it for my electric guitar to have a mini amplifier that I can take and plug in a pair of headphones to when I don't want to bring a full amplifier to carry around.