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Physics 498 (Physics of Music)

Valve Junior Modification

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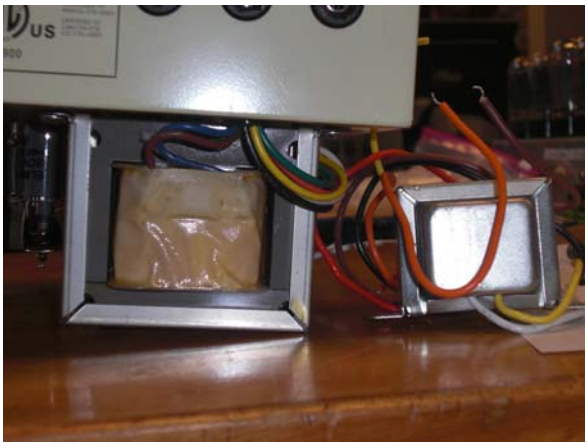
Introduction

My original idea for a class project was to build a tube guitar amplifier. I have wanted a tube amp for some time, but I was always hesitant because of the large price tag. After beginning to learn about how tube amps are designed and built, I was quickly overwhelmed by the amount of knowledge needed. A student in the class, Jeremy, suggested I modify a tube amp as a starter project and suggested the Epiphone Valve Junior. This paper will serve as documentation of the modifications I made to the Valve Junior and as a 'how to' guide for others that would like to turn their Valve Juniors into Valve Seniors. My goal is to make this paper easy enough to understand so that someone with limited knowledge of circuits would be able to perform these modifications by themselves.

Modifications

Output Transformer. The easiest modification to make to these tiny amps is to replace the output transformer. The stock transformer is very small and it can be clearly heard that the iron is saturating when the amp is driven at maximum volume. This gives the amp a strained sound. I replaced it with a Hammond output transformer. It is physically bigger so that there is more cross sectional area so that it will not saturate. It also has better laminations in it to prevent eddy current losses in the iron.



Tone Stack. The tone stack allows the user of the amplifier to have more control over the frequency content of signal. It consists of three separate knobs that control potentiometers. A potentiometer is basically a variable resister. It has three terminals. The leftmost and rightmost terminals are just like each end of a normal resister. The middle terminal is a conducting wiper that slides across the resister allowing it to conduct at difference spots effectively changing the resistance from either side to the middle.

In this tone stack circuit, the potentiometers are used in what is effectively three different filters.

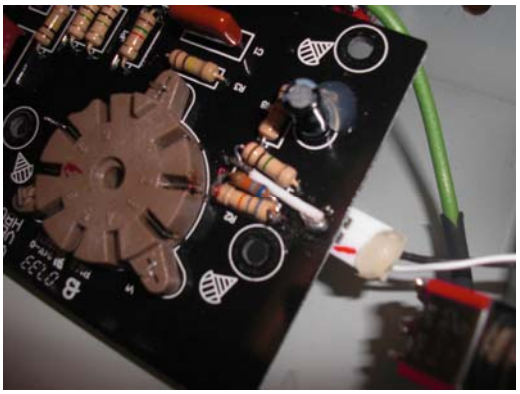
It consists of a lowpass, bandpass, and high pass filters that are controlled by the treble, mid, and bass, respectively. The change in resistance from turning the potentiometers changes the time constant of the RC circuits that are acting as filters and they allow different frequencies through while throwing others away.

Deep/Bright Switch. The deep/bright switch can add more much more variety to the sound the amplifier can produce. This is especially true when used in combination with the tone stack. When activated, the bright switch gives the signal more treble. This is accomplished by connecting a portion of the circuit that allows high frequencies to pass around the volume control pot. A 120 pF capacitor is used to accomplish this since it has an impedance of

$$Z = 1/(j*w*c) \text{ Ohms}$$

It can be seen that as frequency, w, increases, the impedance decreases. A similar idea is used to accomplish the deep switch. When the deep switch is closed, it creates a path to ground which is also guarded by a capacitor so that only high frequencies will go to ground. This makes the signal have relatively more bass frequencies.

Input Voltage Divider. R2 and R1 on the schematic are wired incorrectly. In the stock setup, they are acting as a voltage divider and attenuating the signal. The left side of R1 is connected to ground and the right side is connected after R2. This should be changed so that the right side of R1 is connected before R2. This will cause the signal to be less attenuated and give the amp more drive.



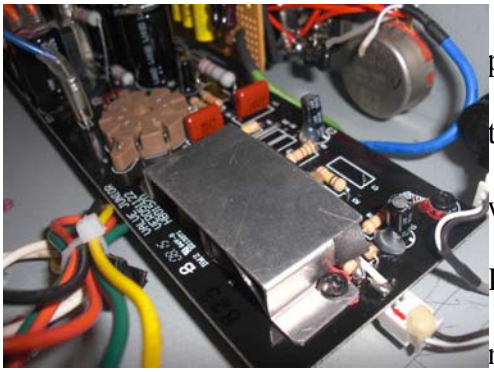
Halving the Input Resistance. If more drive from the amplifier is desired for more distortion, the input resister, R2 can be halved. Either it can be removed and replaced with a 34 K Ohm resistor, or another 68 K Ohm resistor can be soldered in parallel with R2.

$$1/Rtot = 1/Ra + 1/Rb \text{ (for resistors in parallel)}$$

$$1/Rtot = 2/Ra \text{ (if the resistance values are equal)}$$

$$\Rightarrow Rtot = Ra/2$$

Interference Blocking Metal Plate. Another student in the class was doing a similar modification to the same amp and they ran into some problems with interference. It was discovered that the interference stopped when a hand was placed above the pre-amp tube socket and input to the main printed circuit board. To prevent any other interference problems a thin sheet of metal was fashioned in order to cover the tube socket and input. It is grounded by screwing it down with the same screws that hold the printed circuit board in place. I put it in my amp as an extra precaution. It may not be necessary in all cases.



To prevent any additional interference, shielded coax cable should be used whenever possible. This is especially true for any longer wires in the signal path.

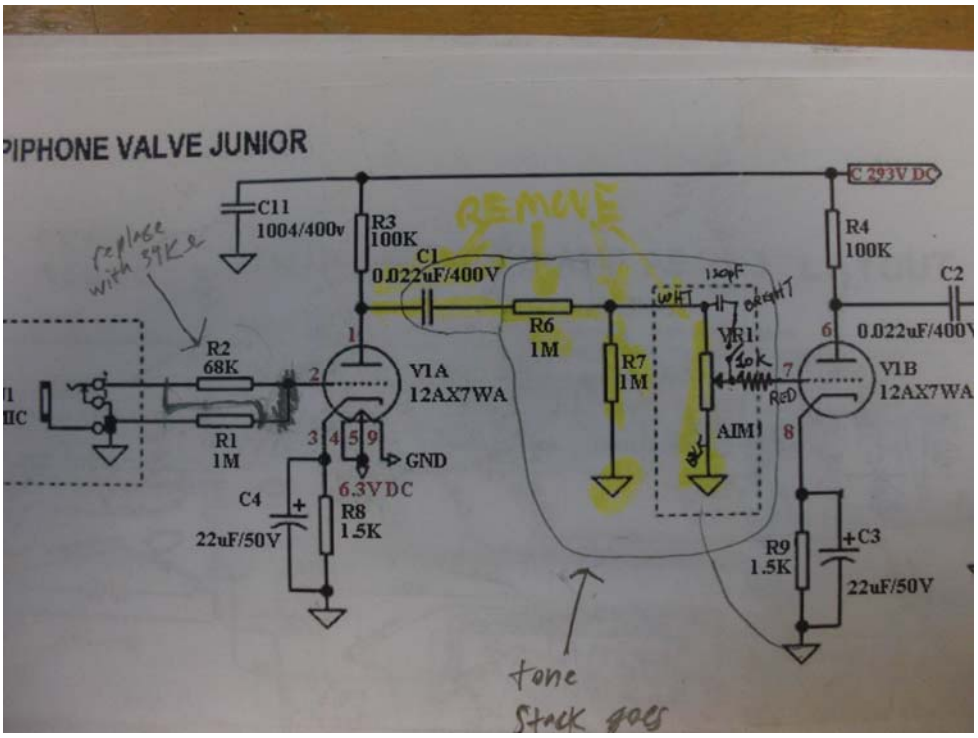
Parts

Most parts were purchased from tubesandmore.com. Prices listed are prices from this website. Make sure all capacitors, potentiometers, and resistors used in the tone stack and switch portions are rated at a high enough voltage. Anything greater than 300 V should be fine.

Part	Price	Comments
Valve Junior	≈$90 (after shipping)	Easy to find on eBay
Hammond Output Transformer	≈$50	-
Potentiometers (x4)	≈$10 x 4 = $40	Precision brand is the best. Avoid Alpha pots.
Knobs (x4)	≈	
PC Board	≈$1.50	You need a relatively small one. I had to cut mine to be smaller.
3 Position Switch	≈$5	On – Off – On switching
68 K Ohm Resistor	≈$1	Carbon film (sold in multiples of five)
100 K Ohm Resistor	≈$2	Carbon composition
10 K Ohm Resistor	≈$1	Carbon film
10 M Ohm Resistor	≈$2	Carbon composition
27 K Ohm Resistor	≈$2	Carbon composition
330 pF Capacitor	≈$2	Silver mica
120 pF Capacitor	≈$0.40	Silver mica
0.022 uF Capacitor x 2	≈$1.50	One of these can be reused from the parts you take out of the amp.
0.047 uF Capacitor	≈$1.50	
Wire		
Coaxial Cable		
Sheet Metal		For the interference blocking plate
Total	**≈$200**	

Process

The process section will be a step by step guide on how to perform each modification. I will try to provide as detailed instructions as possible and tailor it for someone who doesn't have much circuit experience. Before doing any work on the amplifier, make sure it is unplugged and remove the tubes so that they are not damaged while working.

Input 

Section of the Amplifier. In the input section of the amp, I fixed the voltage divider problem and halved the input resistance. The first step is unscrew the printed circuit board. Locate resistor R1. Always test with a multimeter to make sure you are locating the right component or pin. The lead that is farthest from the end of the board must be desoldered and pulled out of the hole in the board. A short piece of wire will be needed to make the new connection. Solder the short piece of wire to the newly broken lead of R1 and solder the other of the wire to the small metal pin sticking up from the input jack wires. There should be two small pins sticking up. Us the pin that comes from the white wire. This fixes the voltage divider problem. If you want to halve the input resistance, simply solder a 68 K Ohm resistor in parallel with R2. You can simply have it be sitting on top of R2 and solder the new resistors leads to the leads of R2 as shown in the picture.

Hammond Output Transformer. The output transformer is the smaller of the two transformers on the underside of the amp. Start by finding the four colored wires coming out of the output transformer. Remove the glue holding them in place. (I used wire cutters.) Do not remove the glue around green wire with two shades of green on it. It is connected to a screw elsewhere in on the

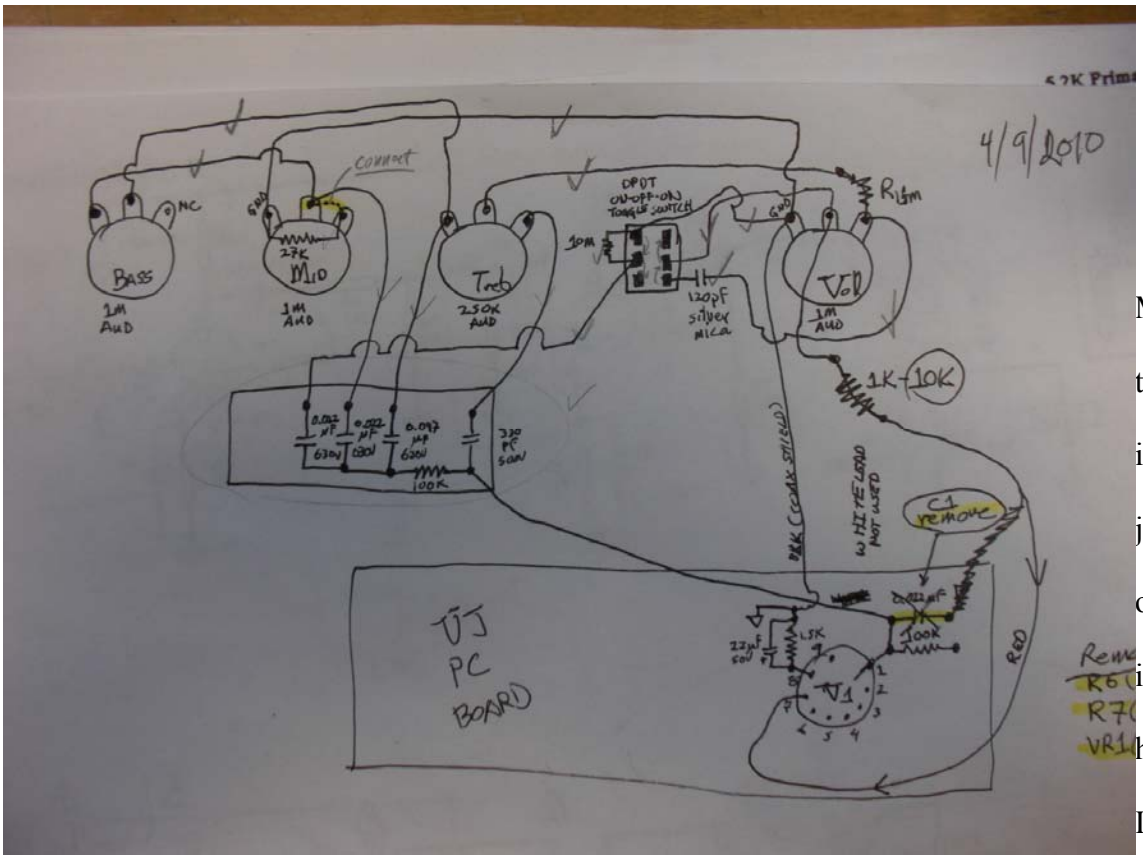
chassis. This is the ground wire and needs to stay there. Disconnect the speaker jacks from the chassis of the amp with a wrench so that you can get to the bottom of the board. Desolder the four wires coming from the output transformer and pull them out.

There should also be two wires going from the output transformer to the main printed circuit board attached with metal slide on connectors. Pull these off and cut the slide on connectors off so that you can get to the clear rubber insulators. You will want to reuse the insulators. Unscrew and remove the old transformer. The new transformer is much bigger and a new hole will need to be drilled in order to mount it. Reuse the hole closest to the side of the amp from the old transformer and carefully measure the new transformer to see where to drill the new screw hole. After the new hole is drilled, you can mount the new transformer.

Check the wiring diagram and solder the proper wires back onto the output jacks. The yellow wire should go to the farthest side from the two shade green ground wire, followed by the solid green wire, and the orange wire. The orange wire should end up next to the two shade green ground wire. The white wire will not be used and the conducting part should be covered with a heat shrink. You will need two new slide on connectors for the brown and blue wires going to the PC board. Make sure you put the insulator on each wire before putting the connector on. Solder the wire to the connector and then crimp it on the end of the wire. Brown should go to connection T4 and blue should go to connection T3.

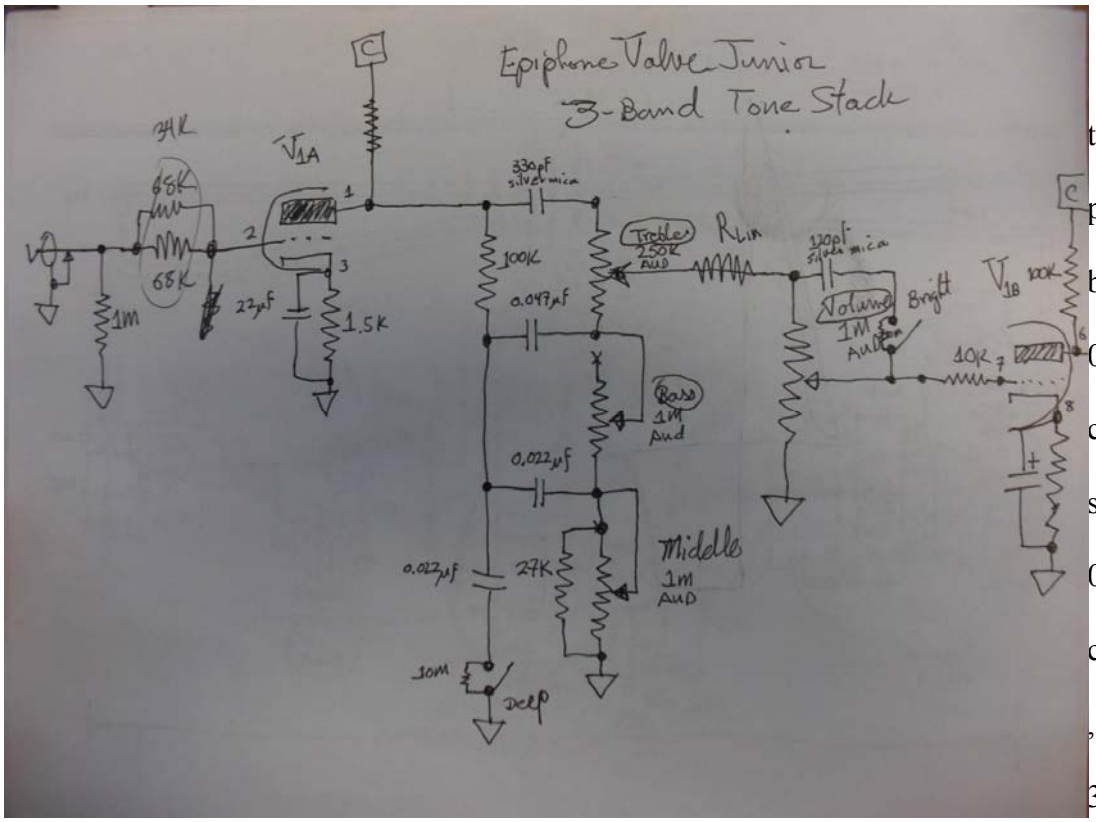
Tone Stack and Bright/Deep Switch. The first thing that must be done is to lay out the front of the amp. For mine, I moved the input jack over, reused the input hole for the volume pot, drilled a new hole for the switch, reused the volume pot hole for the treble pot, and drilled two new holes for the mid and bass pots. Space everything out evenly and mark where to drill the holes with pencil. You will want to put all of the pots in the same place to make the wiring easier later and have the input jack off to the side. When drilling the holes, brace the chassis with a block of wide so that it will not bend. Also place a block of wood behind where you are drilling the whole so that you do not accidently hit

circuit board. Standard spacing for the pots is 1.5 inches. I used 1.25 inches between the tone pots because of the limited space. This will limit the types of knobs you can use, but there are several styles that are small enough. Remove the input jack and original volume pot from the chassis before drilling the holes.



Move the input jack over to its new home. It will have to be mounted sideways to fit. The old volume pot can be removed and allow the three wires from the blue coax cable to be exposed. Mount the pots with the leads pointing up for easier soldering.

Parts of the old pre-amp need to be removed. You will need to desolder and remove C1, R6, and R7 in addition to the old volume pot. Keep the blue coax cable that goes to the volume along with the black, white, and red leads coming out of it.



At this point both 0.022uF capacitors, the 0.047uF capacitor, the 330pF capacitor, and the 100 K Ohm resistor can be soldered on to the extra PC board as shown in the diagram and picture in the modifications section. Bend the leads from each component and solder them together to avoid using extra wire. Do not clip all of the leads off as they may be used to connect to pots instead of extra wire in some places. If the leads are used, make sure to cover them in heat shrink to prevent them from shorting out. Shielded coax cable was used to send the signal from the main PC board to the new PC board. Ground the outer braided conductor. The inner conductor of the coax cable should be connected to old pin of C1 that is connected to pin 1 of the pre-amp tube. Scratch the paint off of a ground trace on the bottom of the PC board so that the metal trace is exposed. Solder the braided conductor to this to ground it.

Connect the red and black leads from the blue coax to the appropriate parts of the tone circuit. Make sure to put a heat shrink on the end of the unused white lead in the blue coax. At this point it is your decision whether or not to add a grid stop resistor. This will be added right before the second gain stage. A 10 K Ohm resistor can be used and added as physically close to the input of the tube as

possible. This resistor will roll off high frequency noise from cell phone and radio interference, but will also cut down on signal. If you choose to put it in, flit over the PC board and find pin 7 of the pre-amp tube. Cut two slashes in the trace to pin 7 with a razor blade and gouge out the trace. Solder the grid stop resistor to connect the gouge you just made. Make sure you do this as close to the pin as possible.

Specs

Voltage Measurements. All measurements were taken with the Deep/Bright switch in the off position and all knobs at 12 o'clock.

AC Line Voltage = 118.5 V RMS

Main Secondary Voltage = 276.9 V AC to CT

6.3 V AC Voltage = 7.113 V AC RMS to CT (GND)

6.3 V AC DC Voltage = 6.53 V DC

A = 338.7 V DC

B = 308.2 V DC

C = 287.0 V DC

	Grid	Cathode	Plate	Screen
V1a	0.000	1.575 V DC	181.9 V DC	-
V1b	0.000	1.514 V DC	185.9 V DC	-
V2	0.016	9.77 V DC	338.7 V DC	308.2 V DC

Voltage Gain.

V1a: Vin = 20mVpp, Vout = 840mVpp

G1 = Vout/Vin = 840/20 = 42

V1b: Vin = 15mVpp, Vout = 732mVpp

G2 = 732/15.0 = 48.8

V2: Vin = 732mVpp, Vout = 61.8V

G3 = 61.8V/(732*10^-3)V = 84.4

Summary

In conclusion, this is a great beginner project for learning about amplifiers. It is an easy project for a beginner to tackle when it comes to modifying amplifiers. It is also cheap and gets you a great sounding finished product. I learned much about how amplifiers work and I would like to thank Professor Errede and Adam Watts for all of their help during the semester.