BLACK LION AUDIO
modify it.

ART Tube MP Modification

The ART Tube MP is inexpensive and widely available. This makes it a perfect candidate for mods and upgrades. While it's not the easiest candidate to modify, it has an unusual design (sweet holy Moses, I've never seen so many capacitors in a signal chain!) that will lend itself to a wide possibility of changes, and a unique sonic signature. *Because* the ART uses so many coupling capacitors (13 in all), I wanted to use Sanyo OS-CON caps, but I couldn't find a reliable supplier of this brand. I've taken the liberty of removing four of them entirely from the circuit. Since the ART uses a single sided supply, many of the coupling caps are biased, which helps reduce nonlinear response normally associated with electrolytic caps. Still, the fewer capacitors in a signal chain the better the audio signal is, so I've recommended that C22, C24, and C26 be removed entirely. This has a trade-off. C24 allows quiet mic/line gain switching since it helps isolate the switch from the circuit. There is more of a pop when activating the switch once the capacitor is removed. C26 serves to isolate the output level pot from the tube circuit, and without it the pot tends to have a swish when rotated. I suspect that this is because of a mismatch in stage to stage impedance. I theorize that lowering the value of R57 from 100k to 50k may solve this problem, but I haven't experimented with this. If anyone wishes to make a suggestion about these two aspects of the circuit, I would be most appreciative.

This is a *really* fast preamp—it'll blow the socks off the stock version, plus it'll compete with some of the higher-priced stuff you may currently be using in your studio. **This isn't something for beginners to tackle. You need good soldering skills and a good iron in order to avoid damaging the Tube MP circuit board.**

Tools you'll need for the job

- A good soldering iron. If you want a temperature-controlled workstation on a budget, try the Elenco SL540 soldering station. It's a fantastic deal for $30; I highly recommend it. DO NOT USE A SOLDERING GUN!
- Dikes or wire cutters
- Solder
- Desoldering braid or desoldering bulb.
- Solder flux
- Exacto knife

- A digital multimeter

Disassembly

Begin by disassembling the unit. Remove the input and output knobs and the associated nuts and washers. Remove the four fastening screws from the chassis. You'll find it's a little stubborn, but you can now remove the top from the unit. On the exposed PCB, locate the two mounting screws, one by the power supply jack (J5) and the other near C19 and C26. Remove both of these, and lift the PCB out of the chassis. Place all of the hardware in a plastic bag. Now you're ready to begin.

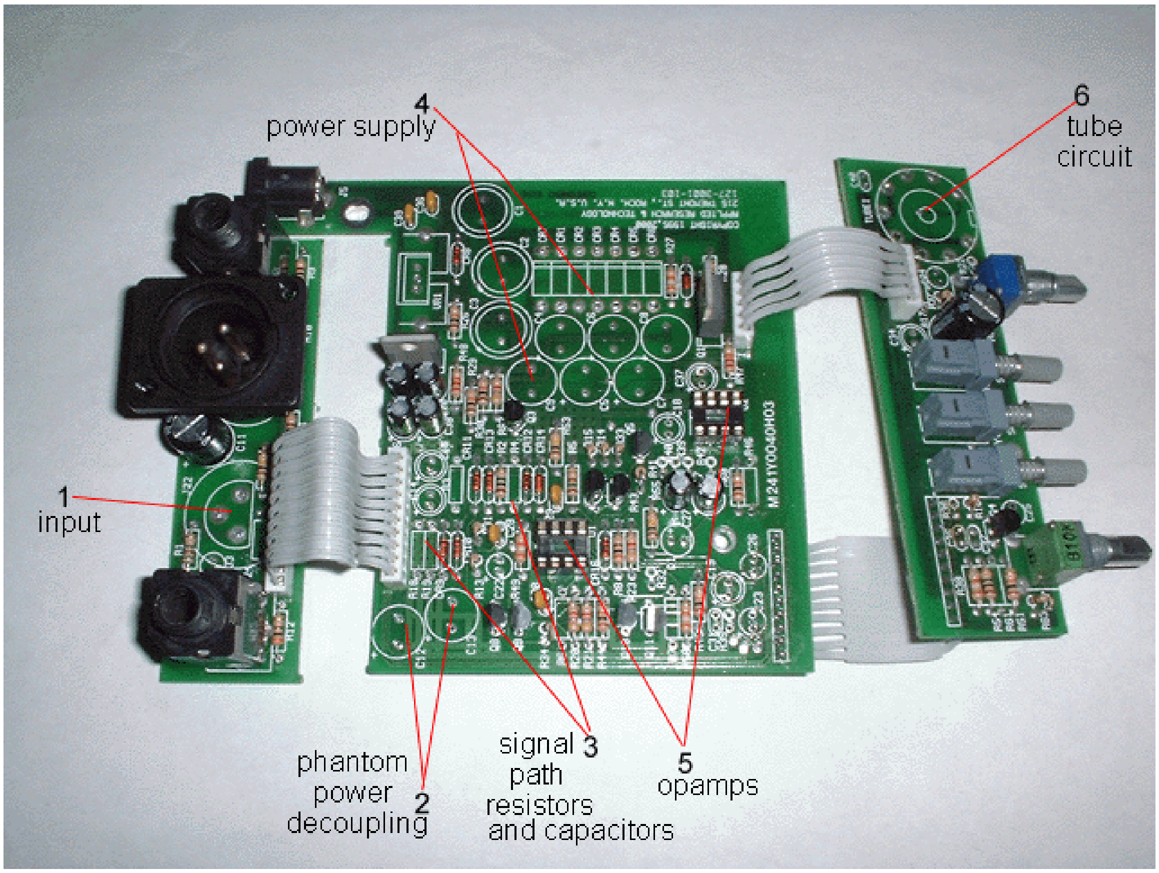
Component Removal

The ART uses a through-hole plated PCB, which is wonderful for conductivity, but lousy for desoldering. Because it can be difficult to remove solder, care must be exercised not to overheat and damage solder pads, many of which are very small. You must be very mindful of the amount of time your iron is left on the pad. This is where solder flux comes in. Solder flux improves the ability of the solder to flow, thereby assisting you in removing it from the joint.
I recommend using a pair of dikes or wire cutters to cut the leads on components such as resistors, diodes, and most semiconductors (except D1 and VR1!) before attempting to remove them. Apply a small amount of solder flux to the area before you heat it with the iron. Having said all of that, let's proceed.

Begin by removing all components listed below. This will probably take you 1-2 hours. Begin by removing D1, which is the indicator LED. It is easily damaged; it's best to remove it first. Even though it shows it in the picture, don't socket the IC footprints once you've removed U1 and U2.

Mic/Line input	**Tube Stage**	**Output stage**	**Pwr supply**
J2 (mic input jack)	Tube and Tube Socket	R9- R11	C1-C9
R2-R4	R61	R39-R42	CR1-CR7
R6-R7	R17	R46	VR1
R13	R22	R60	
R18-R19	R59	C17- C18	
R31	R56	C26	
R34-R36	R51	U2	
C12-C15	C24		
C19	C25		
C22	C34-C35		
C23	C40		
C31			
C33			
U1			

The tube socket and input jack must be removed in order to access some of these components. VR1 should be removed and saved for later section of the project. Once you remove these, put them aside with the chassis hardware and D1.

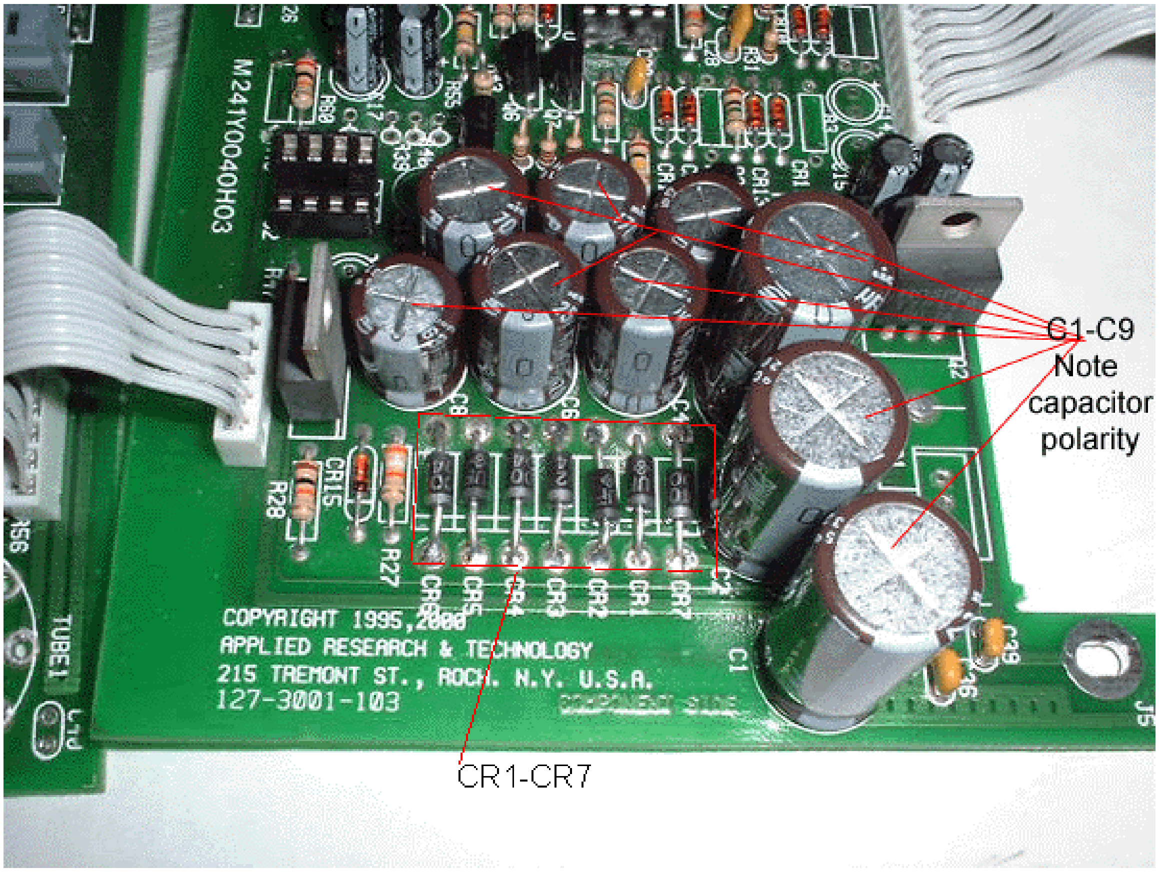


Power Supply

There's quite a bit going on under the hood of this little preamp, and the power supply is a good place to start working. The TMP's power supply generates six different supply rails: one for the tube plate and phantom power, one for the tube heaters, one for the opamps and the current-sourced input differentials, two for the opamp bias, and one for the LED driver. Since it uses both a voltage multiplier and two Darlington transistors to regulate the largest of the six rails (tube plate, phantom power, opamps and differential) I was initially concerned about lack of speed, diode noise, and output impedance. I'm pretty satisfied with the upgrades I've chosen for this circuit, though, and I think that they will help compensate for some of the problems inherent in this type of supply. This stage only involves component upgrades for CR1-CR-7 and C1-C9. Make sure that the diodes and capacitors are installed correctly.

- Upgrade CR1-CR7 with UF4002 diodes
- Upgrade C1-C2 with 2200uf 16v Nichicon

- Upgrade C3 with 1000uf 35v Nichicon
- Upgrade C4-C7 with 470uf 25v Nichicon
- Upgrade C8-C9 with 100uf 63v Nichicon



Input Stage

The microphone input of the Tube MP uses a transformerless input stage built around R24 and R25, and a pair of current-sourced differential amplifiers (Q6-Q11). Differential amplifiers have really good noise rejection ability, but phase response can be a problem. Current sourcing the differential amplifier helps to eliminate some of this. C12 and C13 are used to decouple the input from the phantom power voltage; C14 and C15 are used to decouple the input from CR9 and CR10, which are connected to a reference voltage. Like the last section, all we want to do here is upgrade signal path components. I briefly considered replacing the PNP 4403 transistors with FET's, but decided against it. Here's the list:

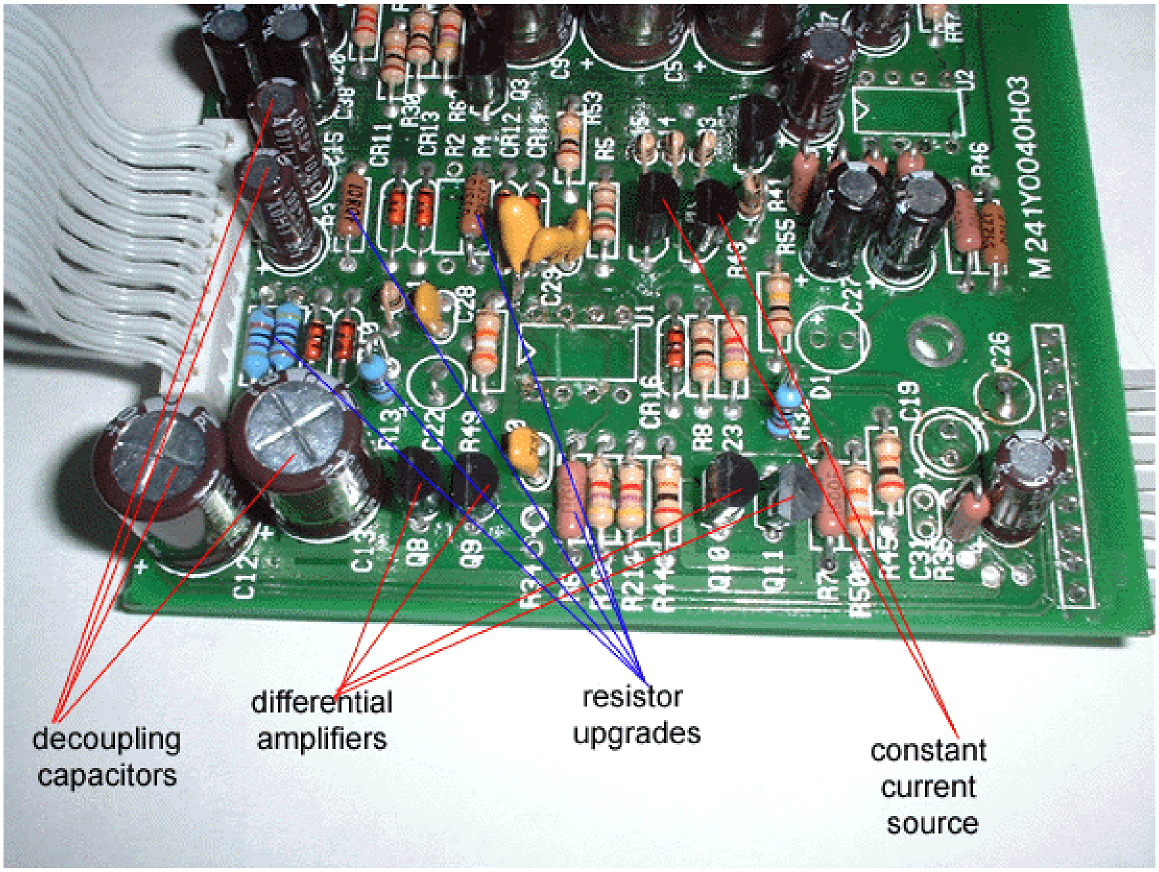
- Replace C12-C13 w/Nichicon UPW capacitors
- Replace C14-C15 w/ Nichicon UPW capacitors
- R24 and R25 w/ matched Vishay RN55D resistors (6.81k)
- R3 and R4 w/Vishay RN55D resistors

The instrument input is a non-inverting stage configured around ½ of U1, a TL072 opamp. R1 sets the input impedance of 5.1M, and C33 decouples the opamp. The opamp's output is then decoupled again via C22; R11 is there to discharge it. R13 most likely serves to tame noise. R18 and R19 tie the circuit to the differential pair, R19 most likely serves as a type of ground-compensation since the instrument input isn't truly balanced. At this point, we're not going to deal with a replacement for U1; we only want to upgrade the passives in the circuit.

- Use discarded resistor leads to jumper C22 and C33 (we need to rid ourselves of some of the signal chain caps!)
- R31 won't be replaced. Since there's no longer a decoupling cap, there's no longer a need for this resistor.
- Replace R13 with 1k Vishay RN55D
- Replace R18 and R19 with 4.7k Vishay RN55D

The other half of U1 is used as the gain stage following the differential pair. It's a simple inverting gain stage that converts the balanced signal to a single-ended one. It's configured for a gain of just over 67. Resistors 6 and 7 set input impedance, and R15 sets the gain. The output is decoupled via C23, and then tied to the mic/line gain switch where R36 can cut down some of the gain before the signal hits the tube. Again, no severe circuit changes yet, just simple passive upgrades.

- Upgrade R6-R7 with 150Ω with Vishay RN55D
- Upgrade R35 with 10k Vishay RN55D
- Upgrade C23 with 10uf 50v Nichicon UPW



Output Stage

We move on to the output stage, which is a TL072 configured as a non-inverting buffer in order to lower the output impedance of the tube and allow the Tube MP to be able to drive a balanced line (or maybe even a low-impedance load). The circuit begins at R58, which is the 100k volume pot. This is tied to yet another decoupling cap, C26. Input impedance is set by R46, R39 and R40 set the gain. C17 and C18 decouple the output; R41 and R42 are there to discharge them. Phase switching is handled at this point, and R9-R11 set output impedance. Once again, we want to upgrade the passive components in this stage.

- Jumper C26 with a discarded resistor lead
- Upgrade R46 with 39k Vishay RN55D
- Upgrade R39 with 10k Vishay RN55D
- Upgrade C17 with 47uf Nichicon UPW
- Upgrade R9-R11 with 300Ω Vishay RN55D
- Upgrade R40 with 10k Vishay RN55D

Switching Opamps

Upgrading the opamps isn't a plug and play kind of thing in the Tube MP. The single sided supply voltage of 30vdc (the schematic says 33vdc, but I measured 30vdc on the collector of Q2) makes things pretty difficult. For one thing, finding a replacement that can tolerate a supply voltage that high is a challenge in itself. Another thing that has to be addressed is the amount of input bias current needed for the new opamp. Opamps require input bias currents when powered from a single sided supply for reasons I won't attempt to discuss here. Suffice it to say each opamp has different bias current requirements, and the replacement will require us to re-bias the circuit before it can operate properly.

The opamp I chose as a replacement is the LM6172. This opamp can operate on a supply voltage as high as 36vdc. It has a slew rate of 3000v/μs and bandwidth of 100mhz—faster than most discrete audio circuits.

Let's make the necessary changes needed to implement it, starting with input bias. R2, R34, and R60 are the opamp bias resistors. Their old values were 1M, 10k, and 20k, respectively.

- Replace R2 with a ¼ watt 75k resistor
- Replace R34 with a ¼ watt 75k resistor
- Replace R60 with a ¼ watt 150k resistor

Since this opamp is so fast, its power supply pin (pin 8) needs to be bypassed. The data sheet recommends using a 2.2μF tantalum in parallel with a 0.1μF ceramic. Twist the leads together and solder them so the two capacitors are in parallel. Remember that tantalum capacitors are polarized. For U1, attach the positive side to pin 8, and the negative side to the anode (unbanded lead) of CR14, which is ground. For U2, attach the positive side to pin 8, and the negative side to the small ground pad between C7 and C18. Leads should trimmed be as short as possible, and pay attention to polarity!

In addition to this, the second half of U1 needs a 2ρf capacitor in the feedback loop to reduce overshoot and undershoot. The 2ρf cap replaces the 330ρf cap that was C31.

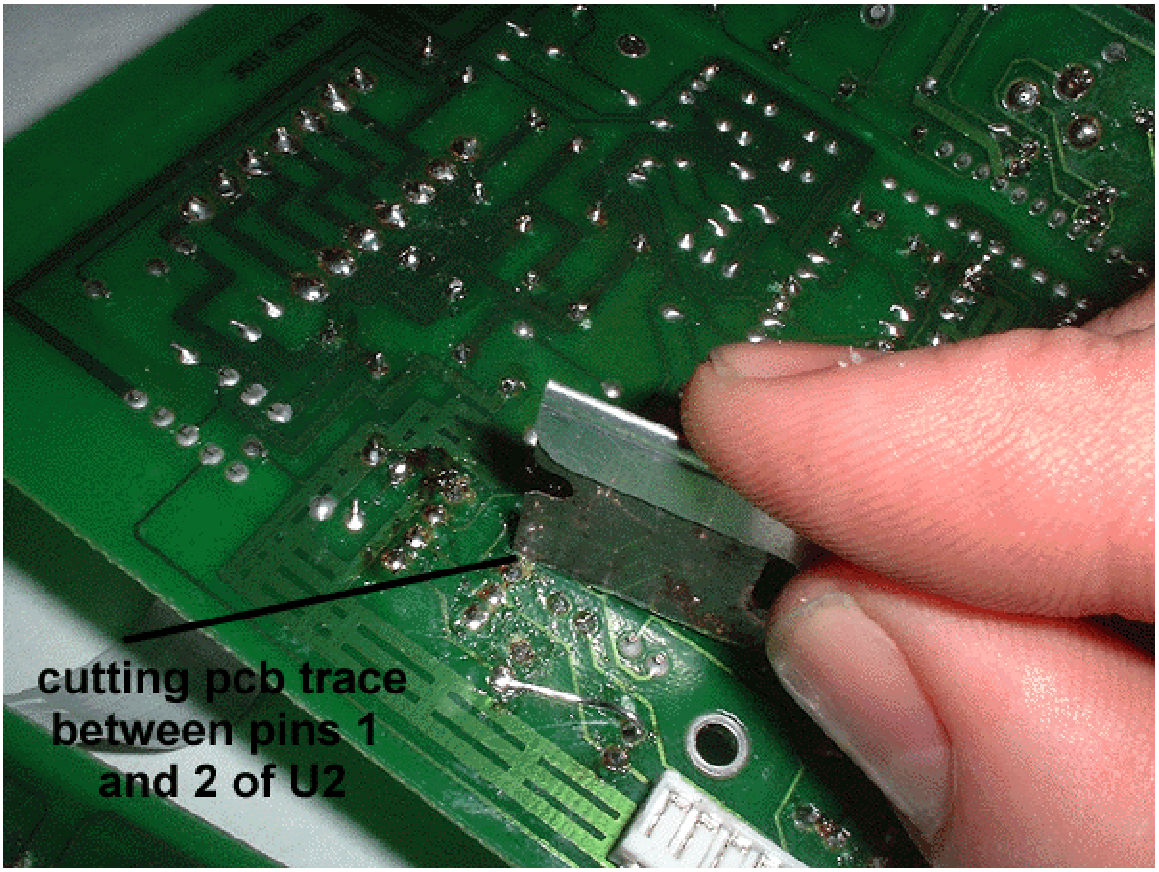
Since U2 is configured as a buffer, it requires a 1k RN55D resistor in parallel with a 2ρf capacitor in the first feedback loop. Treat the first buffer (pins 1, 2, and 3) just like the bypass capacitors. The leads of the 1k resistor and 2pf capacitor should be twisted together and soldered. Use the exacto knife to cut the trace between pin 1 and pin 2, on the underside of the board. It's very tiny, so be careful, and use your multimeter to test for continuity after you've made the cut to make sure the connection has been severed. Attach the resistor and capacitor network directly to the pin 1 and pin 2 of U2.

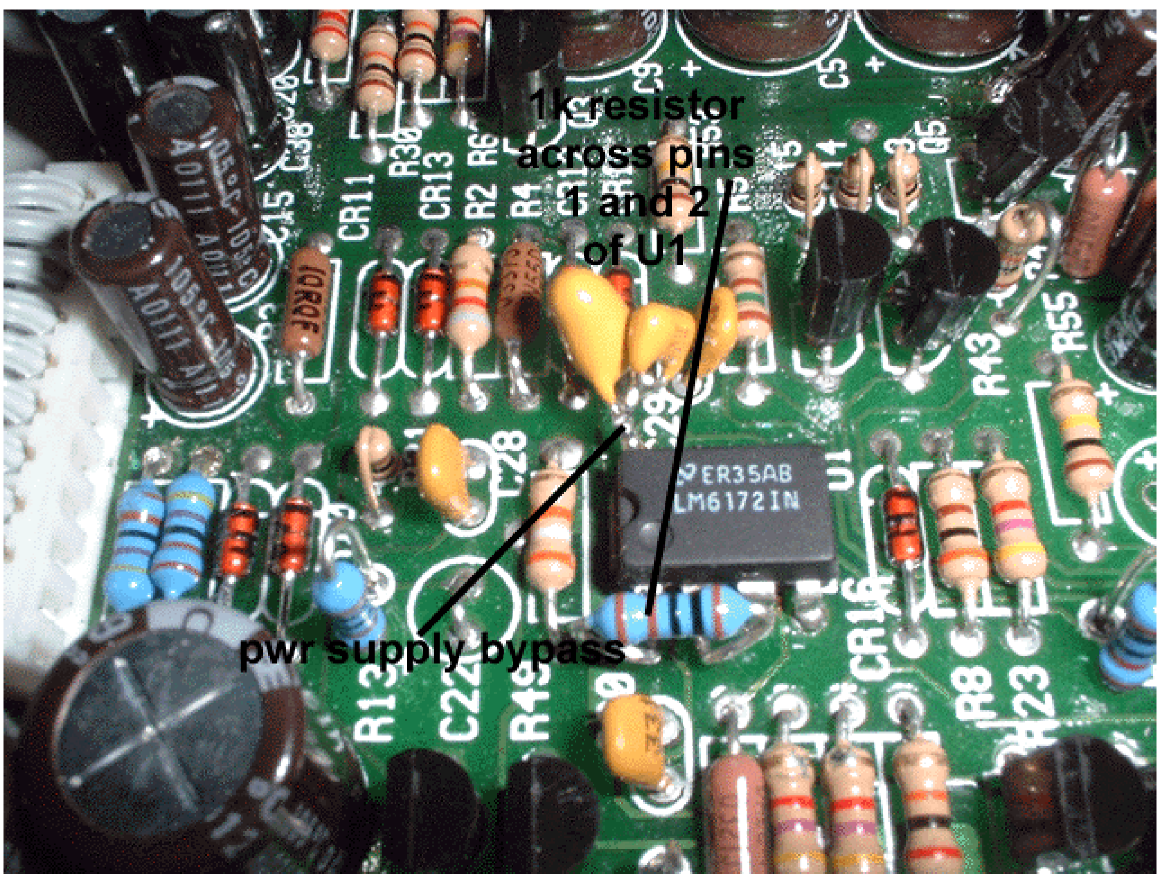
The first half of U1 (pins 1, 2, and 7) also needs the 1k RN55D resistor and 2ρf cap. Cut the trace between pins 1 and 2 on the underside of the PCB. Twist the leads of the 1k and the 2ρf together, like you did earlier, and solder them. Attach the RC assembly to pins 1 and 2 of U1 (see photos).

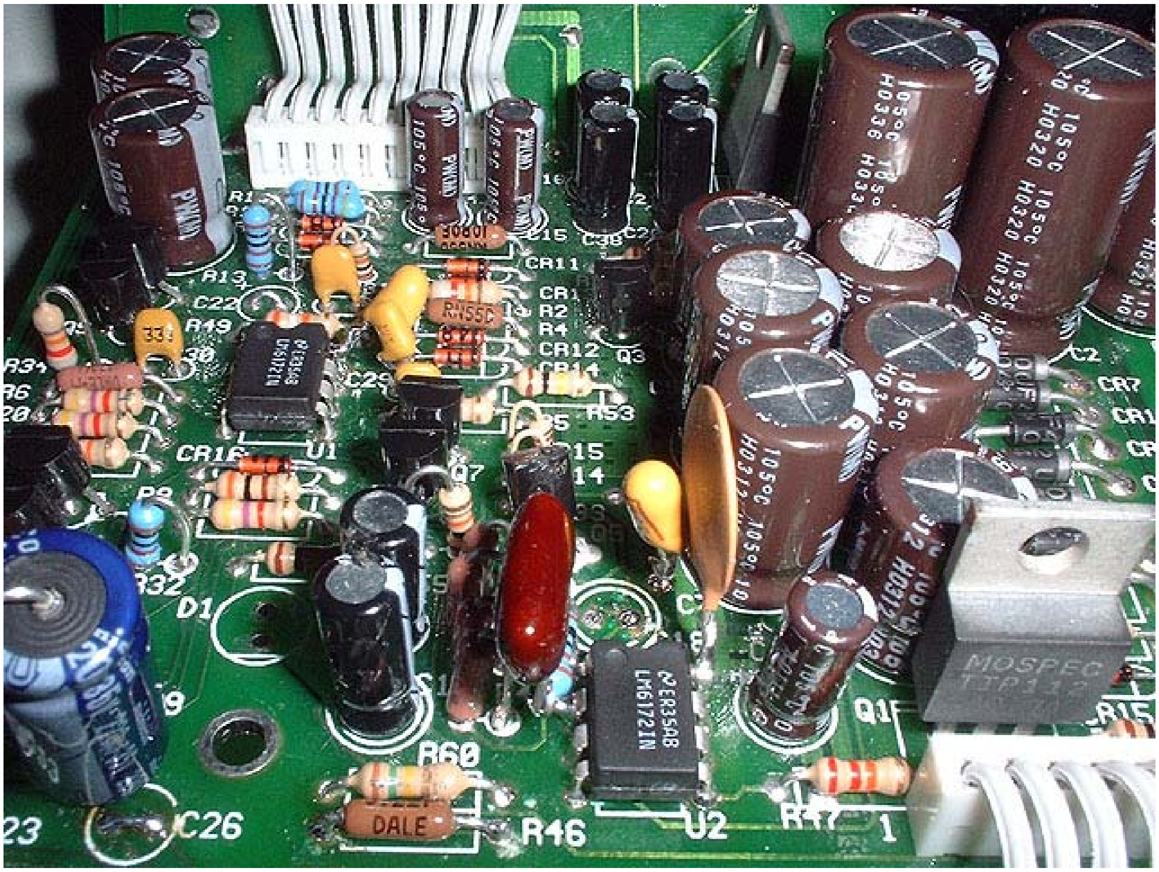
Here's what needs to be done, in order:

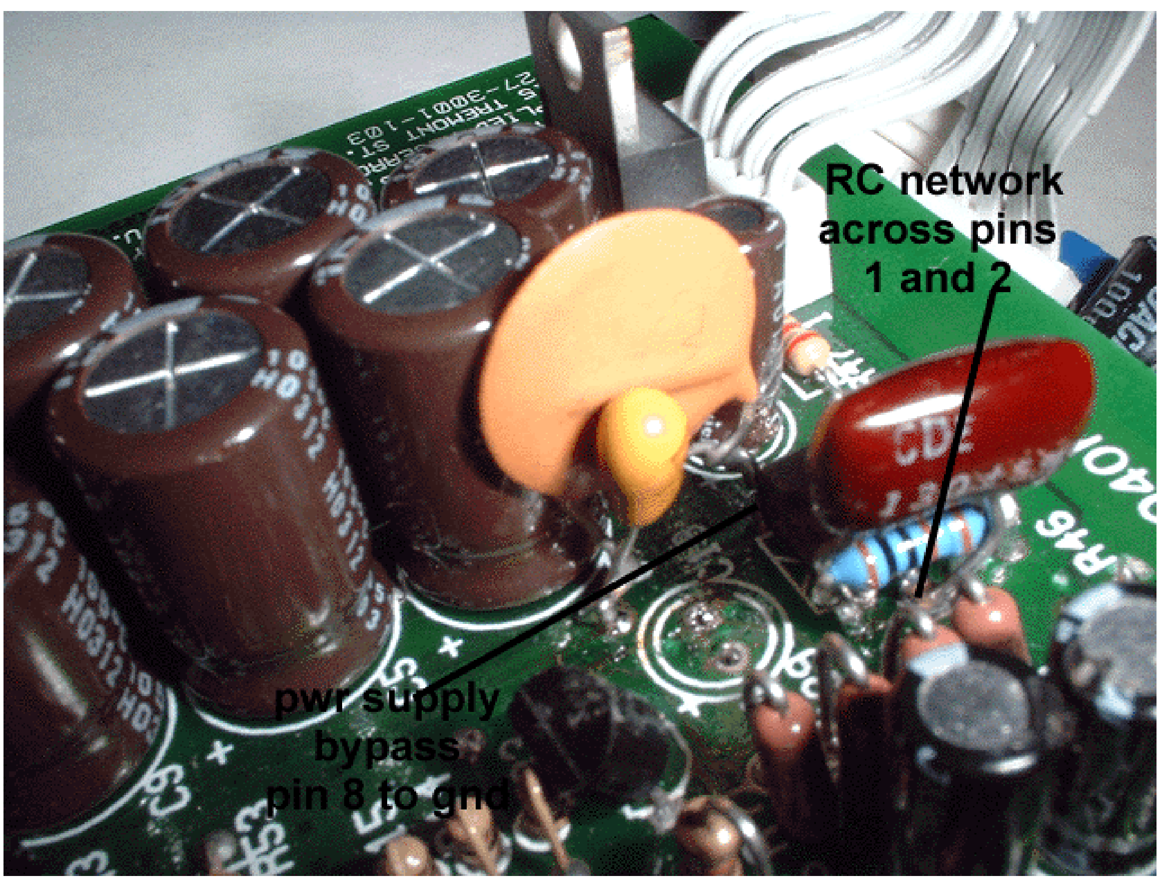
- Sever the trace between pin 1 and pin 2 of U1 and U2 using the exacto knife.
- Install the opamps. DO NOT SOCKET THEM! Sockets add extra capacitance, which may cause these opamps to become unstable.
- Solder the bypass capacitors to U1 and U2, make sure the polarity is correct

- Replace C31 with 2ρf polystyrene or silver mica
- Solder 1k-2ρf RC network to pins 1 and 2 of U2
- Install 1k resistor across pins 1 and 2 of U1
- Upgrade C18 with 47uf 25v Nichicon UPW


cutting pcb trace
between pins 1
and 2 of U2


1k resistor
across pins
1 and 2
of U1
pwr supply bypass


MOSPEC
LM6172IN
DALE
R60
R46
U2
C26
D1
R32
CR16
U1
Q7
Q1
R47


RC network
across pins
1 and 2
pwr supply
bypass
pin 8 to gnd

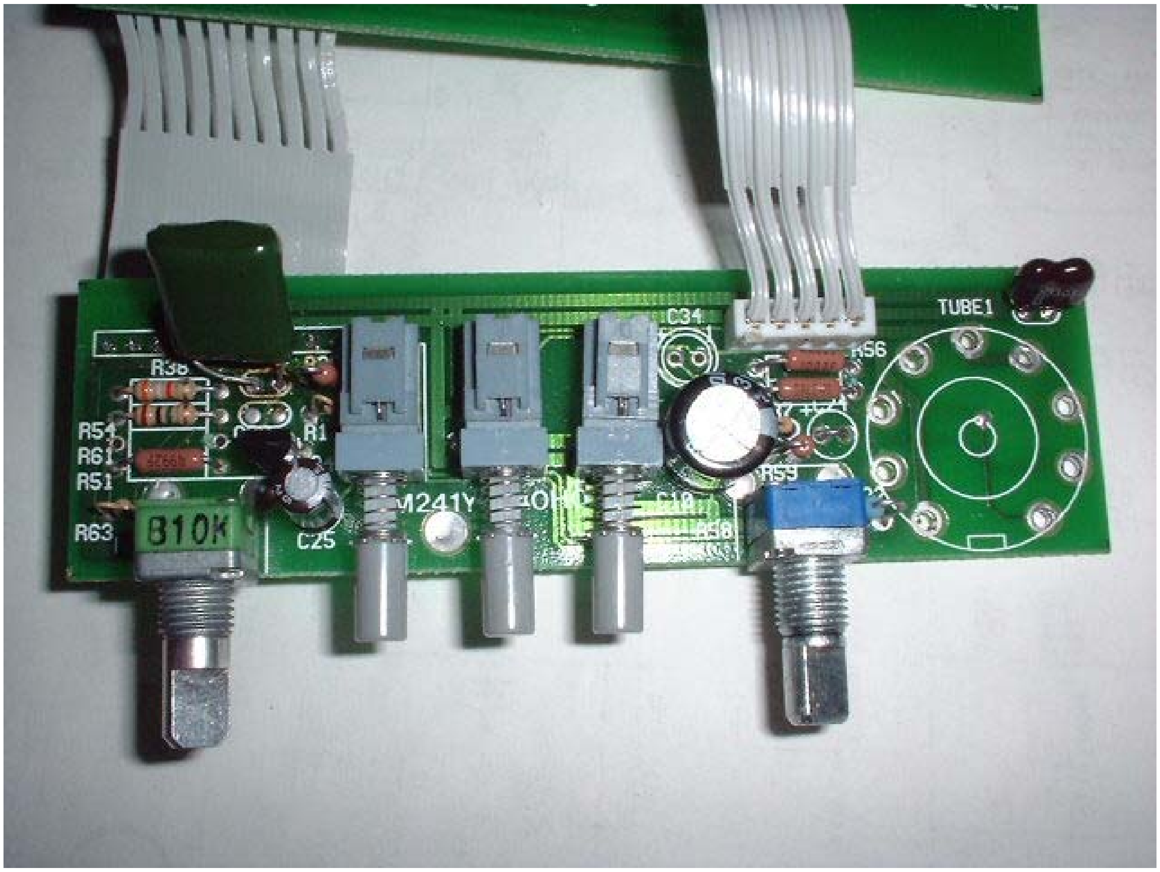
The Tube

The Tube MP uses a starved-plate, starved-filament constant-current draw grounded cathode design for its tube section. Made up of a grounded cathode amplifier cascading into a cathode follower, this circuit has a good amount of gain with low output impedance. In addition, this circuit's current draw remains constant regardless of its input signal.

The circuit starts at C24, which is (you guessed it), yet another decoupling capacitor. R17 sets input impedance, R56 sets plate bias and R59 is the cathode resistor, which is bypassed by C34. R61 and C35 form a feedback loop, and the tube output is coupled to Q4, a simple pass transistor stage. Starved plate designs aren't very linear circuits, but they're cheap to manufacture and they give an exaggerated tube sound. This one in particular is designed to break up pretty early. If you like that sort of thing, I would advise that you leave the circuit as is. The mod I've done to this circuit is designed specifically to make the tube more linear. Also, I advise that you use a different tube than the stock one. My Tube MP came with a 12AX7WA, which isn't the most musical thing in the world. The EH 12AX7 or the Ei ECC83 longplate are two excellent choices.

Post-modification, this circuit has 35db of gain, about 2.2dB less than the stock version, and less negative feedback. Whether or not you want to keep the starved filament design is up to you. If you do, just return VR1 to its original location. If not, stick a 12V (7812) regulator in its place. All other changes are listed below.

- Jumper C24
- Upgrade R17 to 3.3k Vishay RN55D
- Replace R22 with ¼ watt 1M resistor
- Replace R56 with ¼ watt 100k resistor
- Replace R59 with ¼ watt 1k resistor
- Replace R51 with ¼ watt 226k resistor
- Replace R61 with 100k Vishay RN55D
- Replace C35 with .1uf polystyrene
- Replace C34 with 22uf Nichicon UPW
- Replace C40 with 330pf polystyrene
- Replace VR1 with the regulator of your choice (5v or 12v)
- Reinstall the tube socket



Finish it

Once you've finished with the tube section, you need only to reinstall D1. Make sure the polarity is correct. Take a moment to carefully inspect your work. Look for solder bridges, cold joints, and components with reversed polarities. If everything looks good, you're all done, and it's time to test it out. Check your work, inspect your solder joints, and look for solder bridges.

Burn In

The LM6172 takes awhile to settle in, and my opinion is that it can sound a bit wild or pronounced at times during its settling period. If you've got the ability to run an audio signal into it for about 12-24 hours using a 1k square wave, I recommend doing so. It's not the end of the world if you don't do it, but it does force the opamp to settle in faster.

Personally, I've found that this really brings guitar and bass to life when used as a direct box and it sounds absolutely gorgeous on LD condensor microphones. It's so quick that I think you can actually hear a bit of diaphragm movement, and the coloration is nice and heavy without being overwhelming.

Parts List and Suppliers

Most of the parts for this project can be ordered from Mouser Electronics. The opamps are available from Arrow Electronics, and the tubes can be obtained from a variety of places; I recommend Triode Electronics or The Tube Store, but feel free to use a local supplier if you have one. Use Mouser's Quick Add or BOM tool; you can cut and paste the part numbers. I've listed Vishay RN55D's as replacement signal chain resistors because they are cheap and they sound great, but feel free to use Riken, Kiwame, or Allen-Bradley resistors if you want a grittier sound.

Semiconductors

- 7 Vishay fast-recovery diodes Mouser p/n 625-UF4002
- 2 LM6172 dual opamp Arrow p/n LM6172IN

Capacitors

- 2 16V 2200uF Nichicon UPW Mouser p/n 647-UPW1C222MHH
- 1 35V 1000uF Nichicon UPW Mouser p/n 647-UPW1V102MHH
- 4 25V 470uF Nichicon UPW Mouser p/n 647-UPW1E471MPH
- 4 63V 100uF Nichicon UPW Mouser p/n 647-UPW1J101MPH
- 6.3V 220uF Nichicon UPW Mouser p/n 647-UPW0J221MEH
- 1 10V 22uf Nichicon UPW Mouser p/n 647-UPW1A220MDH
- 330pf mica Mouser p/n 5982-10-500V330
- 2 2pf mica Mouser p/n 5982-5-300V1
- .1uF polyester Mouser p/n 5989-250V.1
- 4 25V 47uF Nichicon UPW Mouser p/n 647-UPW1E470MDH
- 4 50V 10uf Nichicon UPW Mouser p/n 647-UPW1H100MDH
- 2 50v 2.2uf tantalum Mouser p/n 80-T350E225K050
- 2 .01uf ceramic capacitors Mouser p/n 140-50Z5103M-TB

Resistors

- 5 6.98k metal film Mouser p/n 71-RN55D-F--6.98k
- 2 10Ω metal film Mouser p/n 71-RN55D-F-10
- 2 150Ω metal film Mouser p/n 71-RN55D-F-150
- 6 10k metal film Mouser p/n 71-RN55D-F-10k
- 1 3.32k metal film Mouser p/n 71-RN55D-F-3.32k
- 1 1.02k metal film Mouser p/n 71-RN55D-F-1.02k
- 1 1M metal film Mouser p/n 71-RN55D-F-1m
- 2 100k metal film Mouser p/n 71-RN55D-F-100k
- 1 39.2k metal film Mouser p/n 71-RN55D-F-39.2k
- 3 301Ω metal film Mouser p/n 71-RN55D-F-301
- 4 1k metal film Mouser p/n 71-RN55D-F-1.0k
- 2 4.75k metal film Mouser p/n 71-RN55D-F-4.75k
- 2 75k Mouser p/n 30BJ250-75k
- 1 150k Mouser p/n 30BJ250-150k

- 1 220k Mouser p/n 30BJ250-220k

Tube(s)
- Ei ECC83 or EH12AX7 can be purchased from the wonderful people at Triode Electronics

Solder Flux
- No-Clean Solder Flux pen Mouser p/n 533-0186

http://www.triodeelectronics.com
http://www.mouser.com
http://www.arrow.com

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