diyAudio™ "diyAB" Class AB Power Amplifier Build Guide

Prepared, written and compiled by JojoD818
Build Guide revision 1.0 for use with diyAB PCB revision 2.0

Introduction:

This illustrative build guide has been written to aid anyone in building diyAudio's "diyAB" Class AB Power Amplifier, available from the diyAudio Store. This guide includes a step by step process that should be as applicable to a newbie as it would be to a more experienced weekend warrior. It is urged that the builder, novice or not, read the entire build guide for useful information before starting construction.

So how did this amplifier come to be? It all started when diyAudio approached Pete (aka Ostripper), one of diyAudio's most accomplished amplifier designers, to design and lay out a best of breed Class AB amplifier to be featured in the diyAudio Store. Starting with the premise that the amplifier would combine many of the best characteristics of class AB amplifiers, and further refined using the comments and suggestions of other diyAudio members, the design took shape.

The diyAudio "diyAB" Class AB Power Amplifier (or "Honey Badger" as we call it at diyAudio HQ) was designed to fill the needs of members that require a high power amplifier with similar capabilities and characteristics to those found most in modern, expensive high end commercial amplifiers. Driving low impedance loads is not a problem with this amp and with an estimated output power of about 150W on an 8 ohms load, this amp has plenty to give and the headroom you've always wished for. The circuit is very stable and well behaved, and the circuit design is both innovative and formidable.

Basic design goals were:

- An output power of about 150W @ 8 ohms (~250W @ 4 ohms)
- 3 pairs of easily obtained BJT output devices in TO-3P or TO-247 packages
- An "all in one" construction approach whereby the builder need only apply a clean power supply and the amp is ready to go

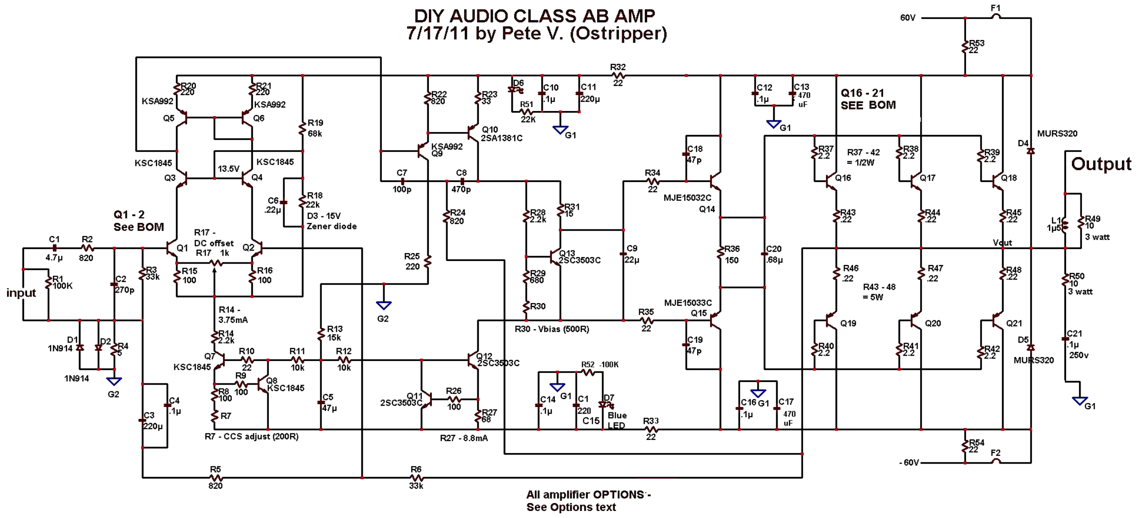
The finished design features:

- A fully starred grounding scheme with the voltage stage and input stage "lifted" and brought back to the star ground
- Output feedback point and speaker output tapped dead center
- Driver and output devices thermally coupled for increased thermal tracking and reliability.

Different choices for the transistors used in the amp were also considered not only for their performance but also for their availability making this amp immune from any "hard to find" parts and so it can be built by anyone, anywhere in the world you may be.

About the circuit:

Below is the schematic of the DA Class AB Power Amplifier and a brief description of the important sections of this wonderful amp.



The Input Section (aka LTP)

The input section of this amp is comprised of Q1 and Q2, C1 - C4, R1 - R6, and D1 - D2. This stage is the "first in line", it sees both your music input signal and a attenuated version of the final amplified signal (feedback).

It is more technically knows as a differential input pair but is more popularly known as a "Long Tailed Pair" (LTP).

The Cascode/Current Mirror

The Cascode is consisted of Q3 - Q4 R18/D3-19 + D3, while the Current Mirror consists of Q5 - Q6 R20-21

These stages are what "transmits" and refines your LTP signal so it is usable to the next stage. The Cascode is a "level shifter" and allows for low voltage LTP devices as well as increasing the impedance going to the current mirrors (CM).

The current mirror keeps the current between the "front and rear" (Q1/3 and Q2/4) LTP and cascode devices equal to improve performance.

The VAS *(Voltage Amplification Stage)* and CCS *(Constant Current Source)*

The VAS is comprised of Q9, Q10, Q11, Q12 R12-13 R22-27 C5, C7-C8 (VAS - "big" CCS) and Q7, Q8, R7-R11, C5 ("small" CCS).

The "small CCS" is next to the "big CCS" on the PCB. "CCS" refers to "constant current source", both CCS's share the same voltage source (the V- rail) and reference to ground through R11, R12, R13, and is filtered by C5. This common reference makes them "turn on" simultaneously, reducing "thump" for a smooth turn-on experience.

The VAS, (Voltage Amplification stage) is what takes the small signal from the Cascode/Current Mirrors and creates a wide, rail to rail "swing". With 60V supplies, this can be a large as 110V peak to peak. This signal is also what you will "hear"... after the big devices of the output stage increase the current a 1000 times or more.

The VBE (aka Bias Servo)

The VBE multiplier is comprised of R28 - R31, C9, and Q13 (mounted on the main heatsink). This section keeps the output stage biased correctly and sets a negative temperature compensation (coefficient) to keep the output transistors from overheating and ultimate destruction.

The Driver Stage and Output Stage

The driver stage Q14 and Q15, a complimentary pair, takes the signal from the VAS and buffers it so it can drive a number of output devices. The output devices Q16 to Q21 on the other hand multiply the current and make the signal ready for your speakers.

Bill of Materials:

Following is the recommended Parts List for constructing **ONE CHANNEL** of the DA Class AB Power Amplifier project.

Please refer to **Ideas and Alternatives** section for help with alternate parts, substitutions, and other combinations.

Transistors:

Q1	MPSA18/SS9014	bipolar transistor
Q2	MPSA18/SS9014	bipolar transistor
Q3	KSC1845	bipolar transistor
Q4	KSC1845	bipolar transistor
Q5	KSA992	bipolar transistor
Q6	KSA992	bipolar transistor
Q7	KSC1845	bipolar transistor
Q8	KSC1845	bipolar transistor
Q9	KSA992	bipolar transistor
Q10	2SA1381	bipolar transistor
Q11	2SC3503	bipolar transistor

Q12	2SC3503	bipolar transistor
Q13	2SC3503	bipolar transistor
Q14	MJE15032	bipolar transistor
Q15	MJE15033	bipolar transistor
Q16	NJW0281	bipolar transistor
Q17	NJW0281	bipolar transistor
Q18	NJW0281	bipolar transistor
Q19	NJW0302	bipolar transistor
Q20	NJW0302	bipolar transistor
Q21	NJW0302	bipolar transistor

Diodes:

D1	1N914	diode (any 1A diode)
D2	1N914	diode (any 1A diode)
D4	MURS320	diode 3A (Any 3A diode)
D5	MURS320	diode 3A (Any 3A diode)
D6	Red LED	3mm diameter
D7	Blue LED	3mm diameter
D8	MURS320	diode 3A (these are optional)
D9	MURS320	diode 3A (these are optional)

Resistors: (All are 1/4W unless otherwise specified)

R1	--	100K
R2	--	820R
R3	--	33K
R4	--	4.7R
R5	--	820R
R6	--	33K
R7	--	200R trimmer (5mm total LS or staggered 2.5 + 2.5mm 10-20 turn)
R8	--	100R 1%
R9	--	100R 1%
R10	--	22R
R11	--	10K
R12	--	10K
R13	--	15K
R14	--	2.2K
R15	--	100R
R16	--	100R
R17	--	1K trimmer (5mm total LS or staggered 2.5 + 2.5mm 10-20 turn)
R18	--	22K
R19	--	68K
R20	--	220R 1%
R21	--	220R 1%
R22	--	820R
R23	--	33R 1/2W
R24	--	820R

R25 -- 220R
R26 -- 100R
R27 -- 68R 1/2W
R28 -- 2.2K
R29 -- 680R
R30 -- 500R trimmer (5mm total LS or staggered 2.5 + 2.5mm 10-20 turn)
R31 -- 15R
R32 -- 22R 1/2W
R33 -- 22R 1/2W
R34 -- 22R
R35 -- 22R
R36 -- 150R 1W
R37 -- 2.2R 1/2W or 1W
R38 -- 2.2R 1/2W or 1W
R39 -- 2.2R 1/2W or 1W
R40 -- 2.2R 1/2W or 1W
R41 -- 2.2R 1/2W or 1W
R42 -- 2.2R 1/2W or 1W
R43 -- 0.22R 5W
R44 -- 0.22R 5W
R45 -- 0.22R 5W
R46 -- 0.22R 5W
R47 -- 0.22R 5W
R48 -- 0.22R 5W
R49 -- 10R 3W
R50 -- 10R 3W
R51 -- 22K
R52 -- 100K
R53 -- 22R 1/2W
R54 -- 22R 1/2W

Capacitors: (LS = Lead Spacing, D = Diameter)

C1 -- 4.7µF WIMA 5, 10, 12.5,15 22.5, 25mm LS 35-50v poly
C2 -- 270pF 7.5mm LS 50-100v poly
C3 -- 100nF (.1uF) 7.5 OR 10mm LS 35-50V
C4 -- 220µF NON-POLAR 12.5mm D 5mm LS
C5 -- 22-47µF (63v -100V) 6mm D 3.5mm LS
C6 -- 220nF (0.22uF) (could be .1uf 7.5-10mm) LS 35-50v
C7 -- 100pF SILVER MICA 3-500v
C8 -- 470pF SILVER MICA 3-500v
C9 -- 22µF (could be 25-35v , 63-100v if small enough) 6mm D 3.5mm LS
C10 -- 100nF (0.1uF) 7.5 OR 10mm LS 100v
C11 -- 220µF 80-100v (63v for low voltage supplies) 12.5mm D 5mm LS
C12 -- 100nF (0.1uF) 7.5 or 10mm LS
C13 -- 470uf -1,000uf 80-100v (63v for low voltage supplies) 16-18mm D 7,5mm LS (5mm for 220uF-470uf)
C14 -- 100nF 100v (0.1uF) 7.5 OR 10mm LS
C15 -- 220µF 80-100v (63v for low voltage supplies) 12.5mm D 5mm LS

C16 -- 100nF 100v (0.1uF) 7.5 OR 10mm LS
C17 -- 470uF-1,000uf 80-100v (63v for low voltage supplies) 16m-18mm D 7.5mm LS (5mm for 220uF-470uf)
C18 -- 47pF SILVER MICA 3-500v or multilayer ceramic 100v+
C19 -- 47pF SILVER MICA 3-500v or multilayer ceramic 100v+
C20 -- 680nF (0.68uf to 2.2uf) 100v (form leads for 7.5-10mm LS)
C21 -- 100nF (0.1UF) 250v 10mm LS -up to 5mm width

LC Cap -- Lead Compensation Cap. 2pf-10pf SILVER MICA 3-500v (see **Ideas and Alternatives** for further details)

Others:

L1 -- 1.5μH inductor - 14-16 turns 18gauge enameled copper wound around a 12.5 -15mm diameter coil form

Mica Insulators, M3 Bolts, Thermal grease, FastOn Connectors, 2-pin Euroblock

Different colored wires

10 ohm 1W sacrificial / test resistors – 2 pieces

PCB:

Shown here is a picture of the printed circuit board prototype for the DA Class AB Power Amplifier. Note that two (2) circuit boards are required to make a 2-channel stereo power amplifier.

These boards are available in the diyAudio Store.

Tools Required:

Screwdrivers - Phillips and Flat

Miniature Screwdrivers - Phillips and Flat

Small Diagonal Cutters

Insulation Strippers

Needle-nose Pliers

Solder 60/40 Rosin cored or better

Soldering iron about 30 - 40 Watts

Digital Multi Meter

Miscellaneous Tools
:
Electric Hand Drill
Assorted Files
Solder Sucker
Solder Remover Braid (Solder Wick)
Extra Flux
Lacquer Thinner

You might like to use http://www.diyaudio.com/recommended as a starting point for tool research or purchase.

Ideas and Alternatives:

This section of the build guide describes the different types of devices that can be used with the amplifier as well as setting up the Cascode/Current Mirror.

The “Honey Badger” was designed to accept different brands and types of transistors making sure that it can be built by anyone anywhere in the world. Certain types of transistors are not readily available some countries which could pose a problem to the builder if they were among those being used in a design. Hence, most of the parts were chosen not only for their performance but also for their availability worldwide.

Input Stage (Q1 and Q2)

You can choose many devices for Q1 and Q2, as long as they are E-B-C in lead orientation and have low noise and high gain (200Hfe+ - 3-500 preferred). 40 - 65V (Vce), NPN TO-92 BJT.

Some of the choices for Q1 and Q2 are: (but not limited to)

2N4401 - GP
SS9014 - LN
MPSA18 - LN/HG
MPSA05 - GP
MPSA06 – GP
MPSA42 – GP
PN100 - GP
KSC815 - HG
KSC1008 - GP
KSD1616 - GP
ZTX1051a - LN/HG
ZTX690b - HG

Legend:
LN = Low Noise
HG = High Gain
GP = General Purpose

Cascode / Current Mirror

The cascode (Q3-4) can be setup in 2 (or more) ways.

- The first is a zener referenced design. Omit R18, replace it with a 1/2W – 1W, 12V -15V zener diode and set jumper pad "C" to "Z" with a jumper wire. The "CRZ" jumper pads are located above D1-D2, near "OFFSET". You will have a cascode reference of either 12 or 15V, depending on your zener diode choice.

- The second way is to use the "Luxman" way, a crude resistive design. R18 is left as is (NO D3), jumper "C" will bridge to "R". This will set the cascode reference to roughly 1/3 of the supply voltage, whatever that is.

Either of these 2 Options can use the "C to R" or "C to Z" jumpers in any combination, all will work.

VAS and “Big” CCS (Q10, Q11, Q12)

2SC3503 / 2SA1381 (TO-126)
MJE340 / MJE350 (TO-126)

<u>VAS compensation modes:</u>

1. Conventional Miller Compensation (CMC) - Omit R24 (the feedback 820R 1/4w resistor), omit EITHER C7 or C8 replace one with a wire jumper and the remaining one with a 68pF 300-500v silver mica capacitor. So, C8 = jumper, R24 = nothing, C7 = 68pF (as an example).

2. Transitional Miller Compensation (TMC) - This will reduce distortion further, R24 - 820 feeds output back to junction of C7 and 8. Schematic shows correct values. The board is (as it is) setup for TMC, just include R24, C7 and C8.

The "Big" CCS is also a part of the VAS. With R27 having a value of 68R, the VAS will have a current of about 9mA. Other values for R27 are 100R for a current of about 6mA or 56R for a current of around 10.5mA.

Bear in mind that any change in R27 will also affect the overall Bias of the amplifier, so if you change R27, please make sure that the bias pot R30 is set at maximum 500R before powering up the amplifier again!!!

VBE (Bias Servo Q13)

2SC3503 (TO-126)
MJE340 (TO-126)

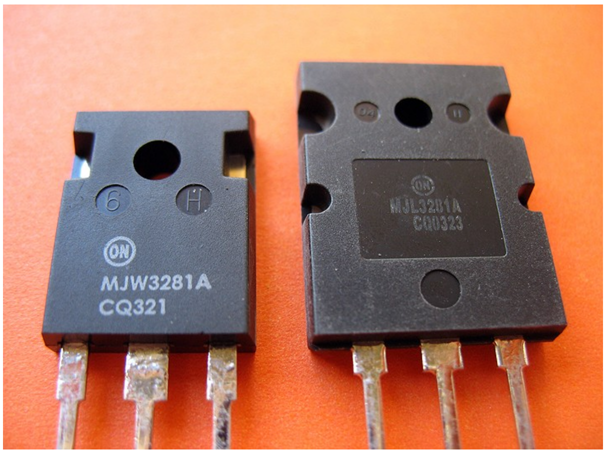
Driver Stage (Q14 and Q15)

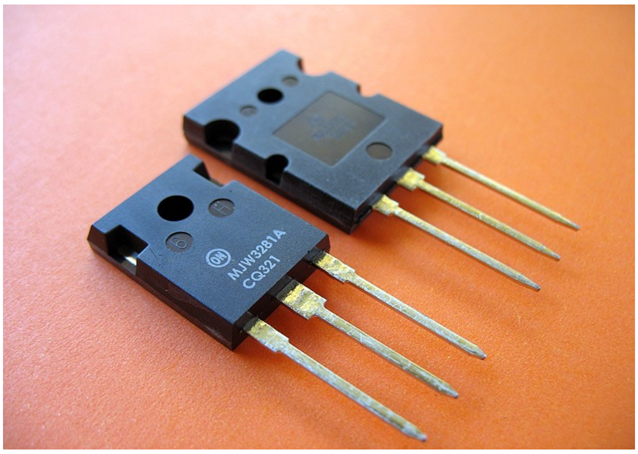
MJE15032 / MJE15033
MJE15030 / MJE15031
2SC4793 / 2SA1837

Output Stage (NPN Q16 – Q18 and PNP Q19 – Q21)

Note: The board is designed to accept TO-3P, TO-247 and other similarly oriented and same lead spacing device packages.

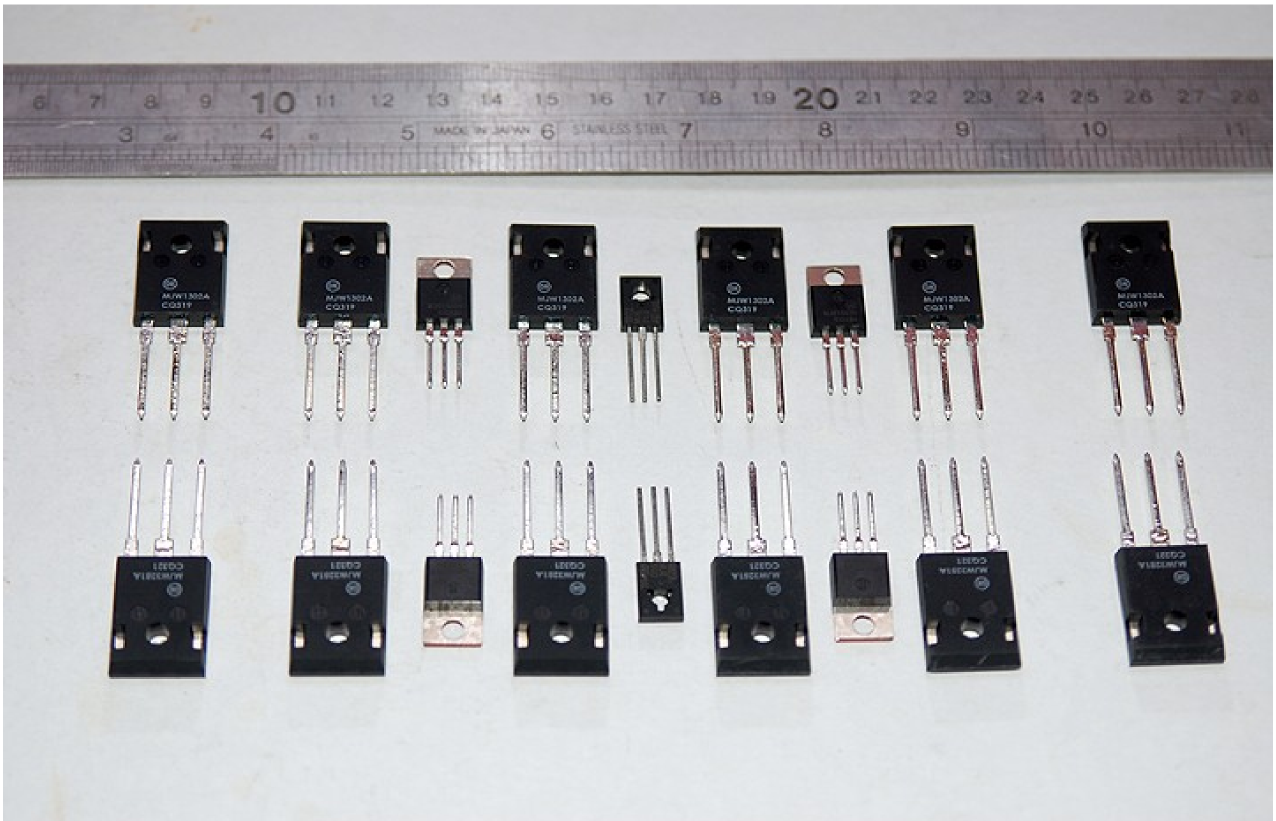
NJW0281 / NJW0302 (TO-3P)
MJL4281A / MJL4302A (TO-3PBL / TO-264)
MJW3281A / MJW1302A (TO-247)
MJL3281A / MJL1302A (TO-3PBL / TO-264)
MJL21194 / MJL21193 (TO-3PBL / TO-264)
2SC5200 / 2SA1943 (TO-3PBL / TO-264)
FJL4315 / FJL4215 (TO-3PBL / TO-264)





The photos above shows comparison between a TO-247 (left) and a TO-264 (right) output transistor device packages. Either type of device packages can be used by the constructor. Some of the important parameters to take into consideration in choosing the output device would be the power supply used, output power, intended load impedance and costs.

The photo below shows the Vbe transistor (TO-126), Driver transistors (TO-220) and Output transistors (TO-247) that were used in building this amp’s prototype.



Lead Compensation Capacitor (LC Cap)

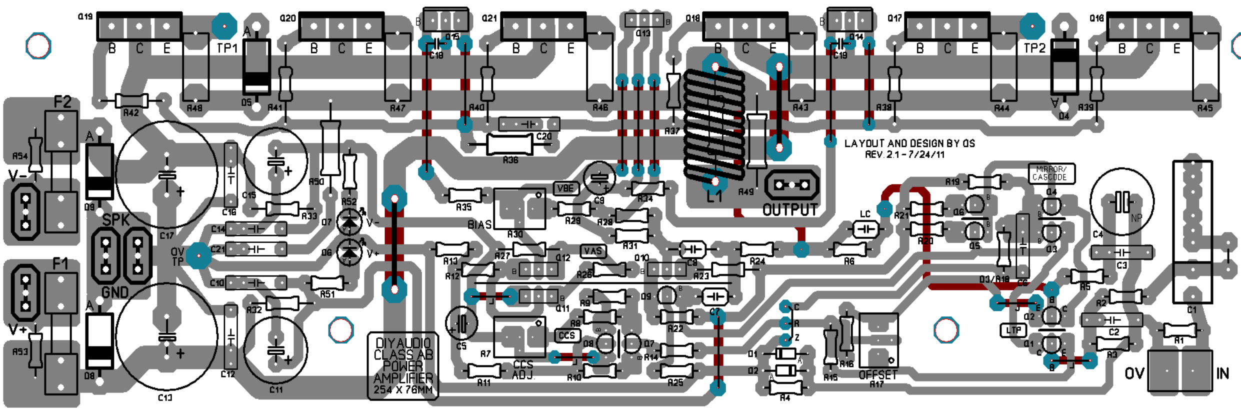
Located above R6 and labeled as "LC" is the option Lead Compensation capacitor. Its value is usually 2-10pF (silver mica 3-500V). It can change the sound to flatten the overall response and increase stability. With 2 pF and a single 68pF CMC (VAS SECTION), this could make driving pure capacitive loads easier on this amp. In this CMC mode, the phase margin is increased at the unity gain point. Don't overdo it. A 2-5pf will really change the high frequency phase drastically.

Power Supply Recommendations:

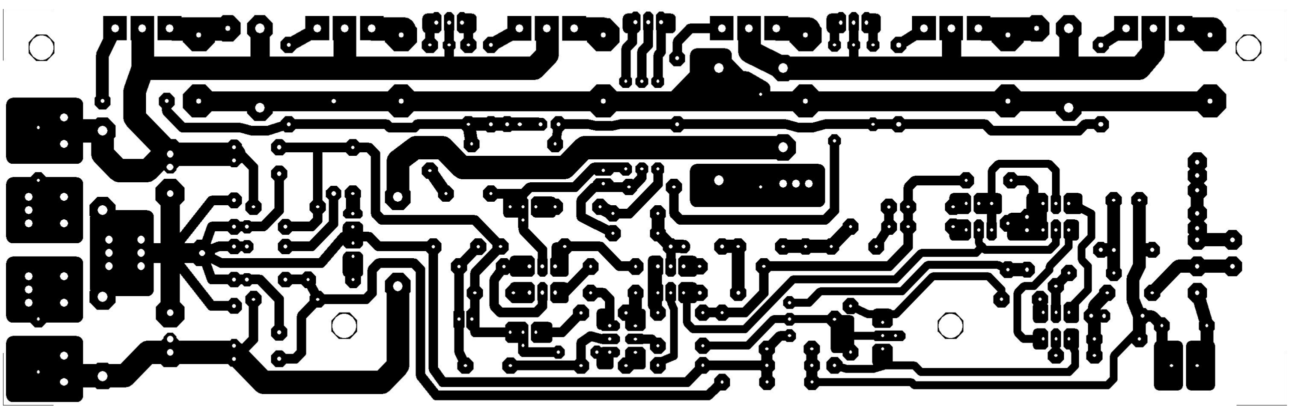
- The amplifier was tested with a power supply of +/-63V (from a 45-0-45 transformer).
- The transformer used was an AnTek AN-8445, 0-45V x2 @800VA.
- The PSU board used were a pair of diyAudio P-PSU-1V20 boards, one for each channel.
- Recommended capacitance is a total of 40,000uf per rail. If you are using the diyAudio PSU board, that would be 4 X 10,000uf caps per rail for a total of 8 caps.
- If the recommended AnTek AN-8445 transformer is used, a minimum of 75V working voltage is recommended.

Construction:

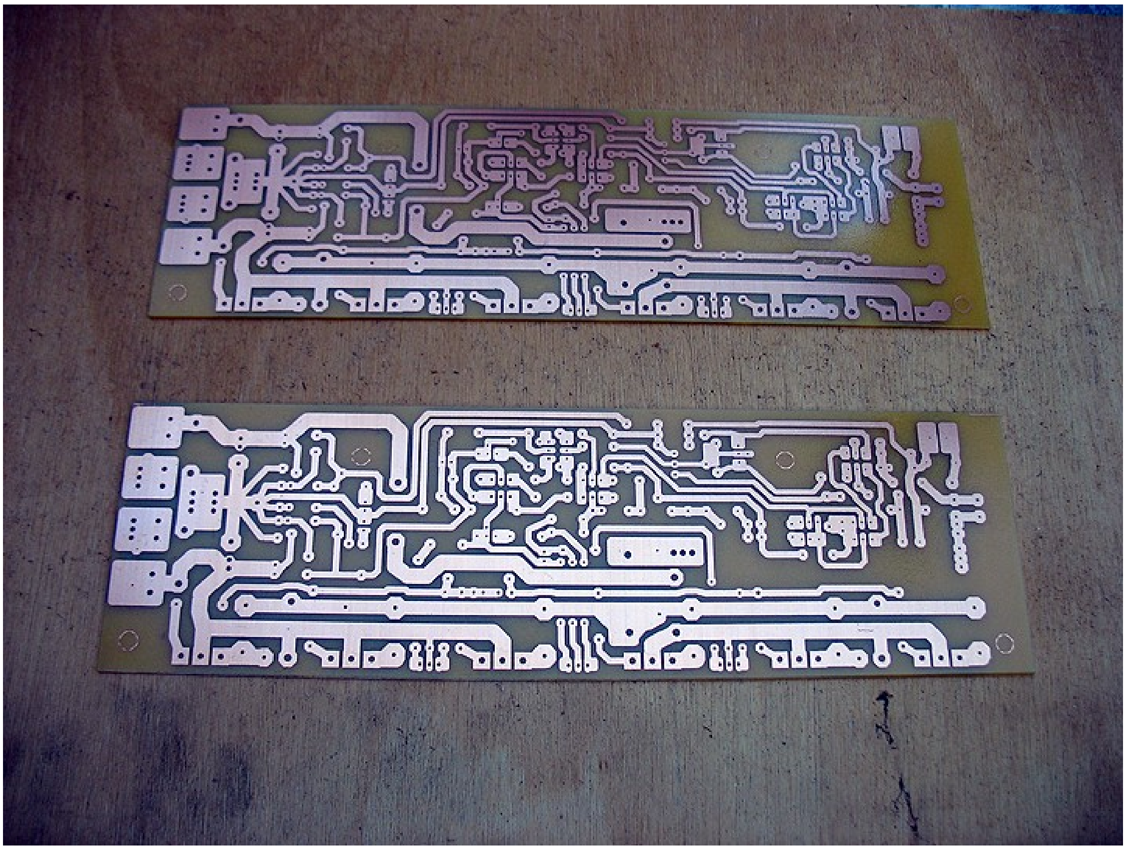
Parts Placement Guide for the DA Class AB Power Amplifier PCB.

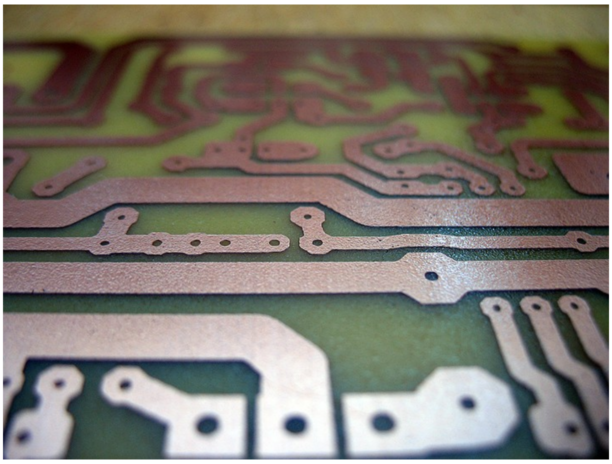


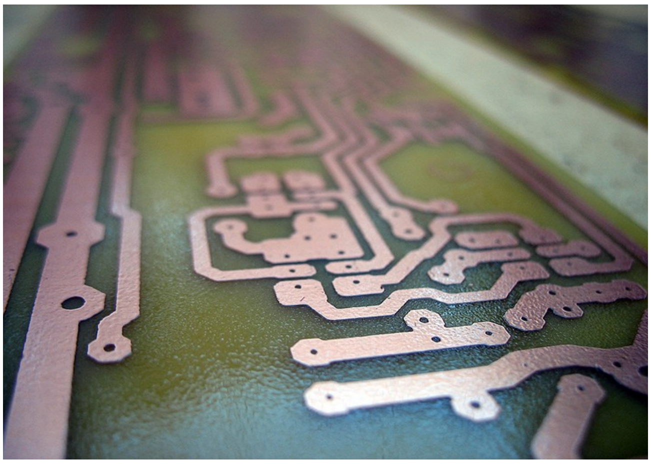
Foil pattern layout for the DA Class AB Power Amplifier PCB. (Top view)



It is always good practice to inspect for cracks, hairline shorts or other errors in your PCB before doing any major construction with it. Check the actual PCB against the Parts Placement Guide and the bottom Foil Pattern Layout and make sure all vias and holes are in place and properly drilled.



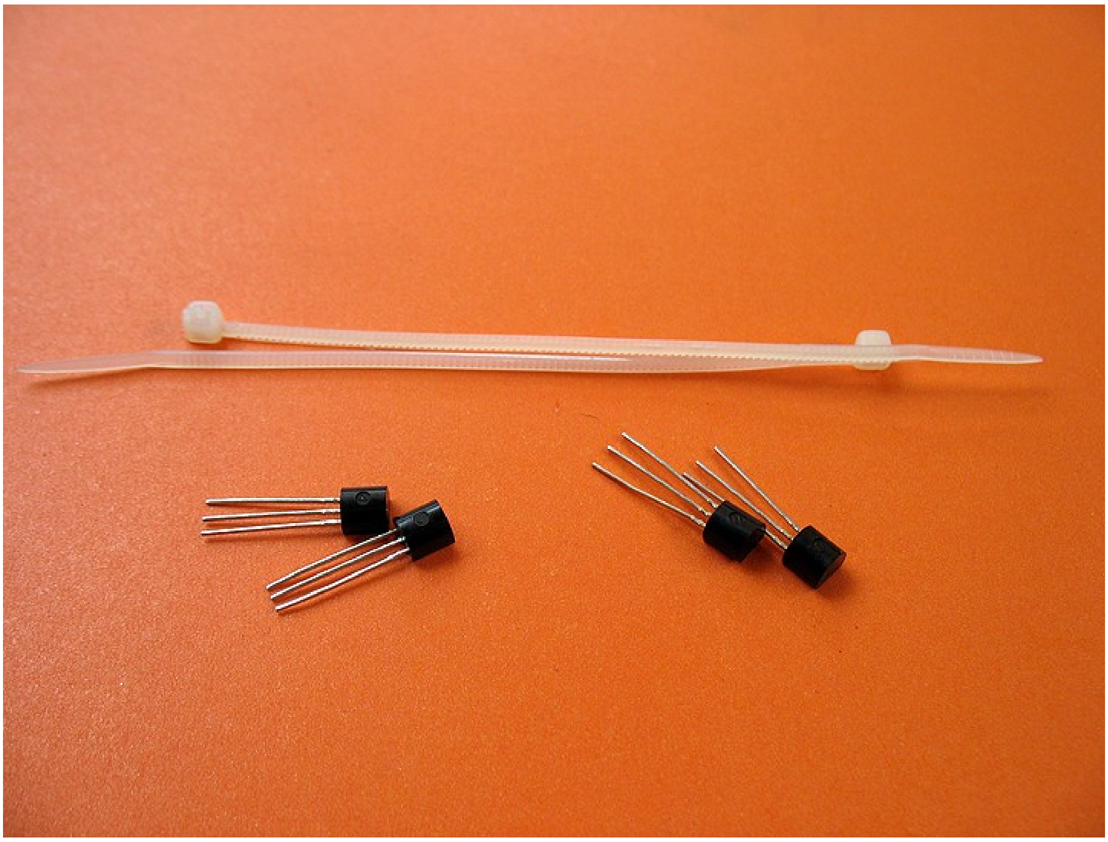




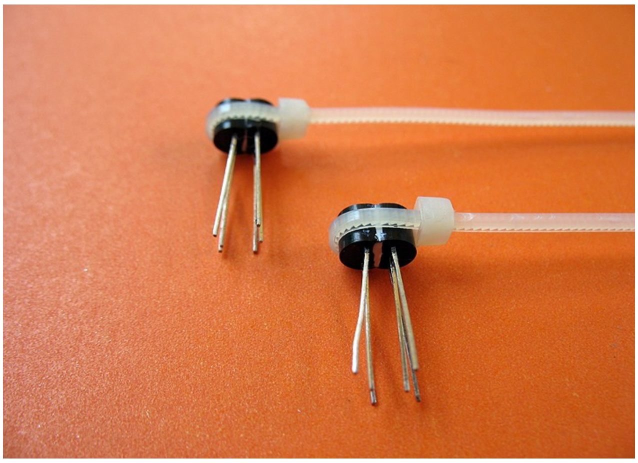
Start populating your board with the resistors first, a quick verification of their resistance using a DMM could save you a lot of time later on when a problem occurs because of a wrong value resistor! This is also a good time to install and solder all the jumpers in the board.

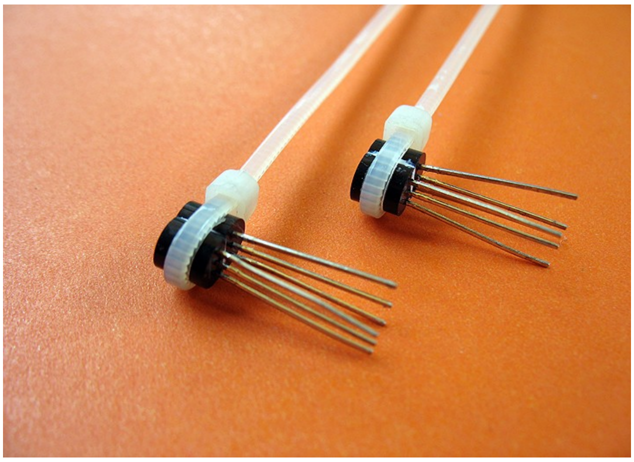
Then install the diodes and small capacitors next. Pay particular attention to the polarity of electrolytic capacitors and pin orientation of the diodes. Install the red and blue LEDs, pay close attention to the polarity and orientation of their leads.

Prepare the LTP (Q1 and Q2) and the “small” CCS (Q7 and Q8) transistor pairs by applying a small amount of thermal compound on the flat side of the transistor and secure the pairs with cable tie or a small piece of ¼” polyolefin heat shrink tube. Bonding these pairs ensures excellent thermal tracking which helps in the performance of the power amplifier.

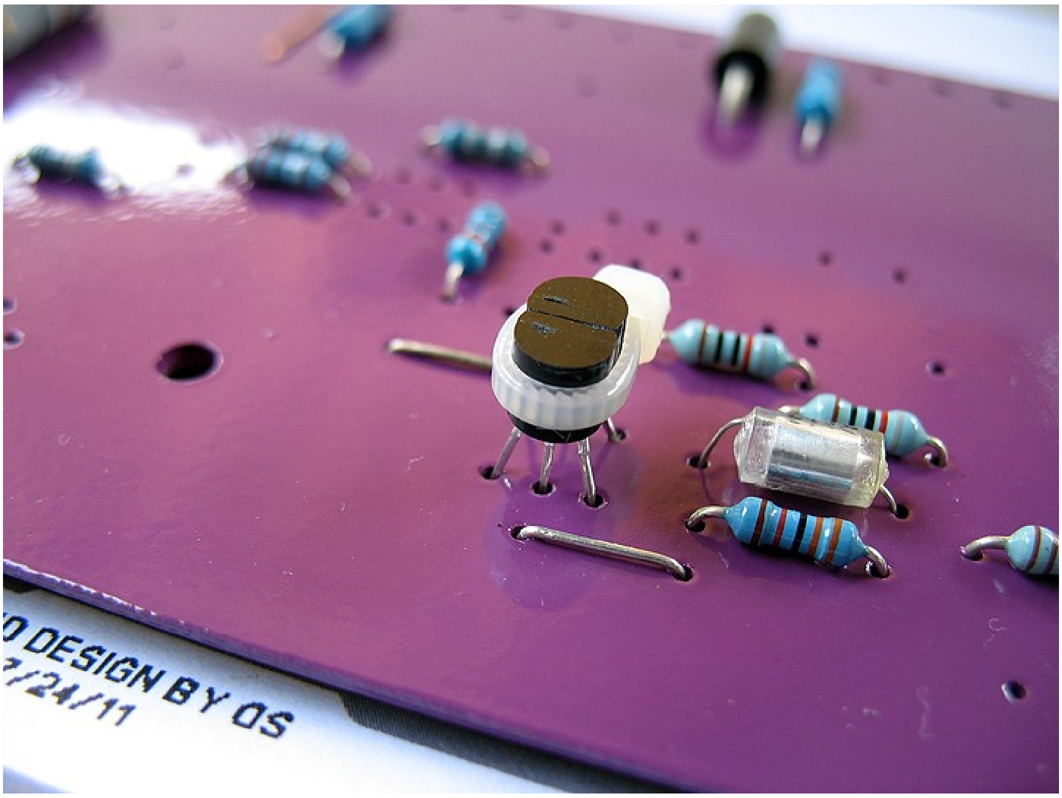


LTP (Q1 and Q2) and the “small” CCS (Q7 and Q8) transistor pairs with thermal compound and secured with cable ties.





Continue populating the board by inserting and soldering the small signal transistors followed by the 3 trimmer resistors. Make sure to pay special attention to those parts with polarity and pin orientation. The TO-92 small signal transistors have an E-B-C lead orientation facing you, make sure to align those leads properly when inserting to the PCB.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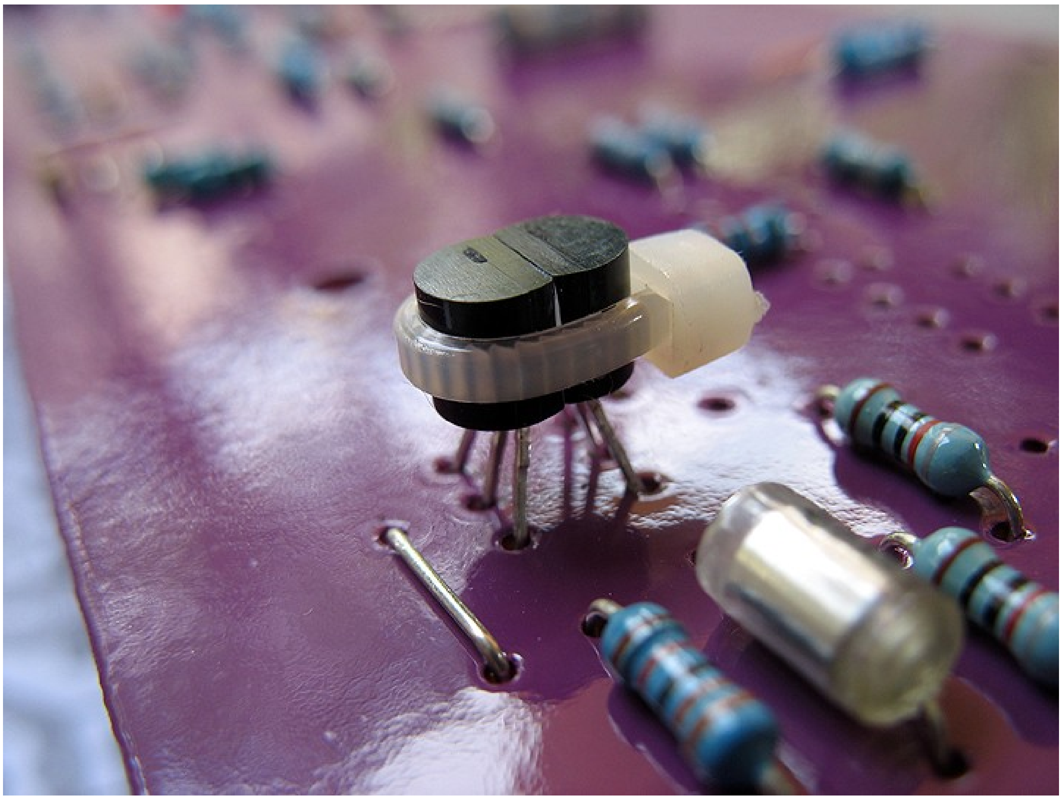
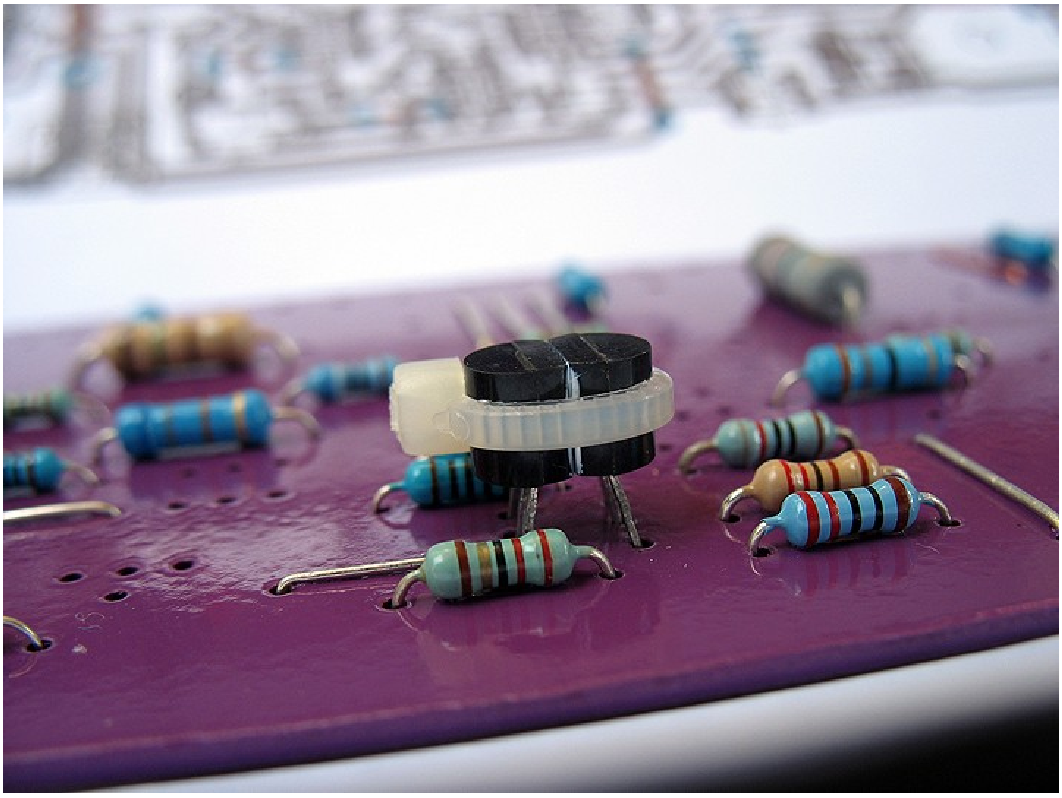
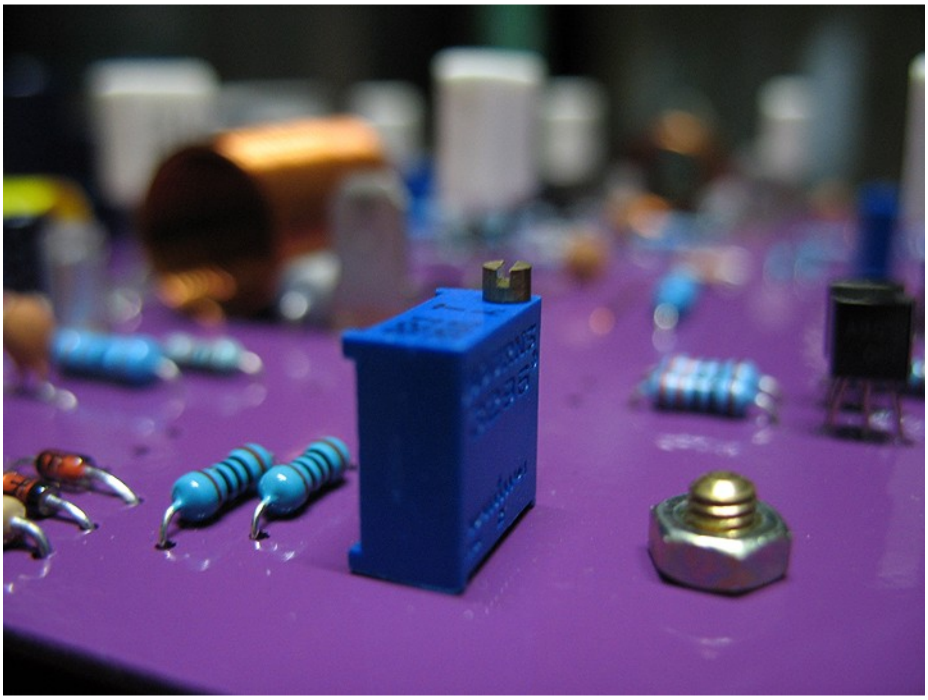
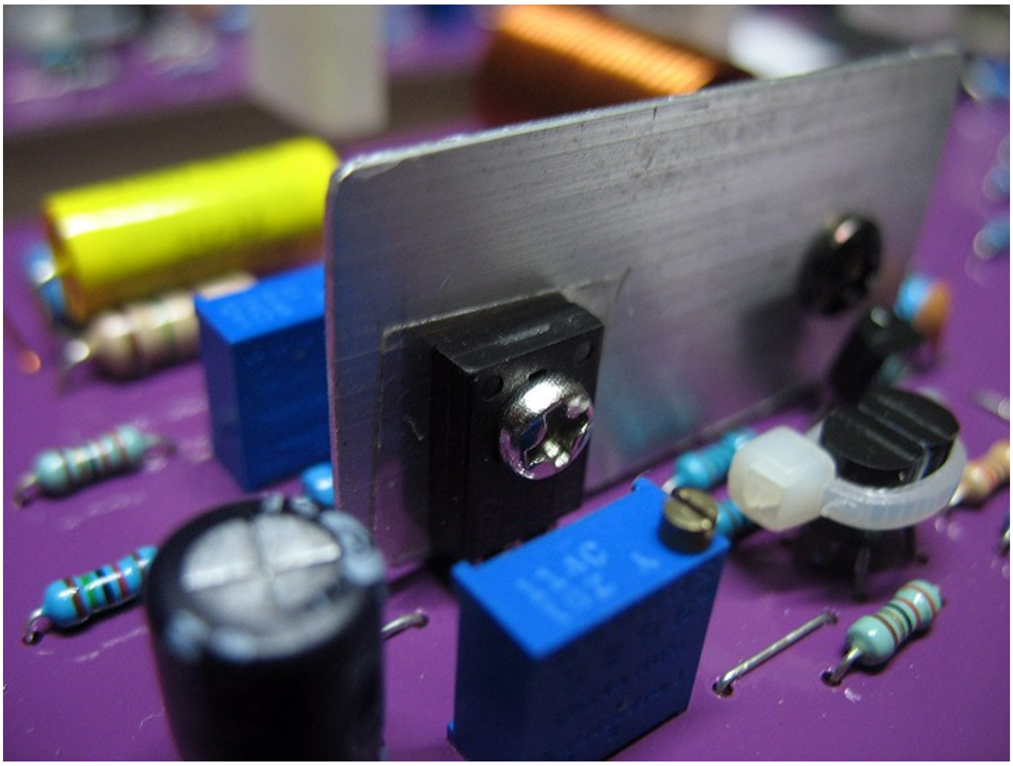


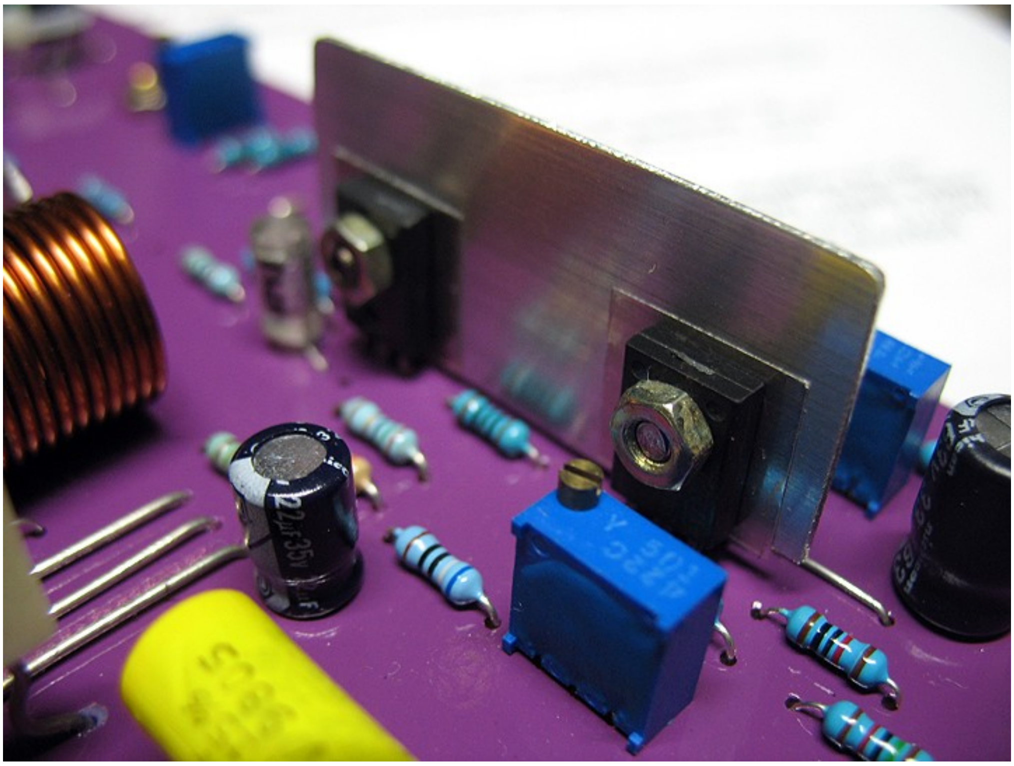


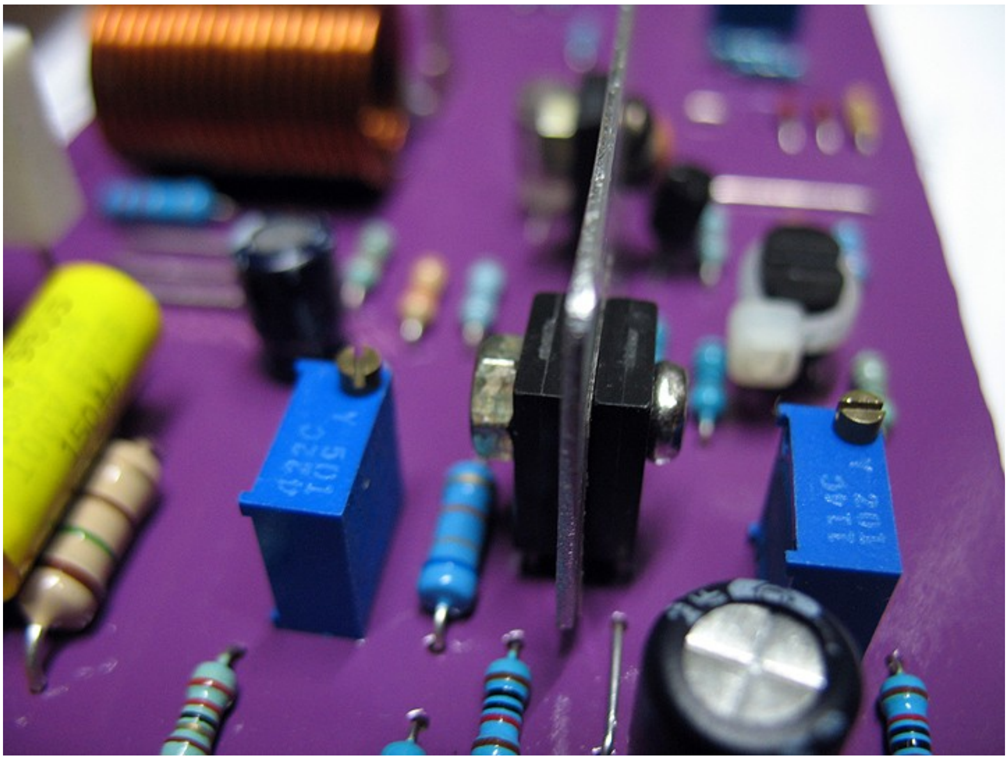
There are 3 trimmer resistors in each of the boards, here's a close up of one of the trimmers.



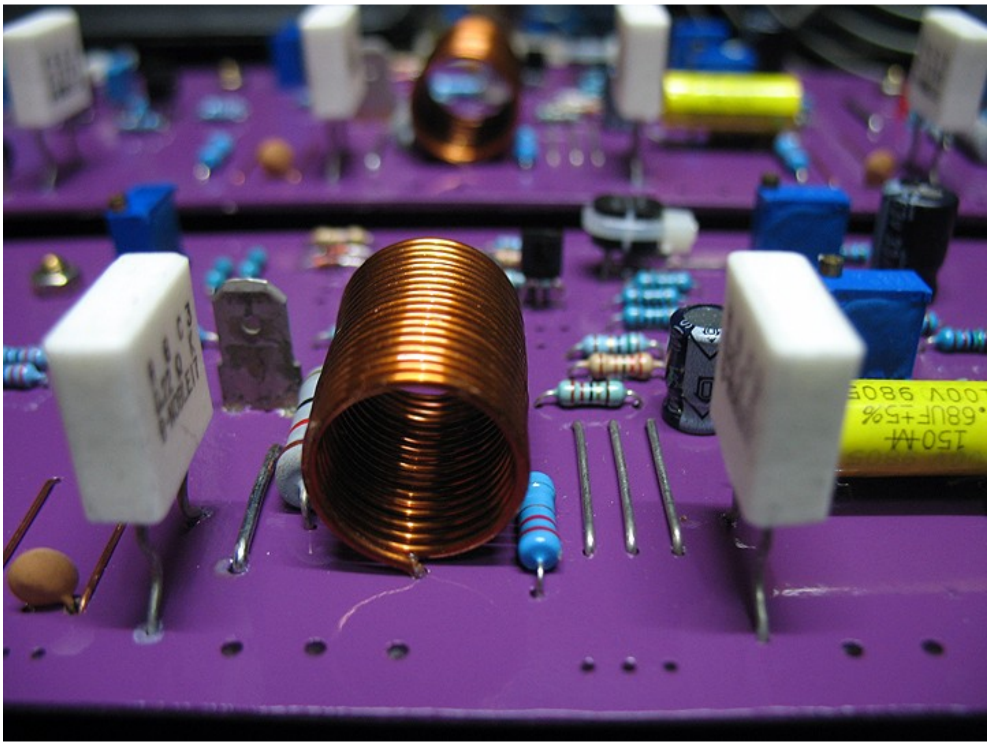
Prepare a 25mm X 75-80mm piece of thin aluminum for use as VAS heatsink, line up with Q10, Q11, and Q12, mark holes, use M3 bolt and nut with thermal compound to complete coupling. Don't forget to use mica insulators for all 3 transistors!

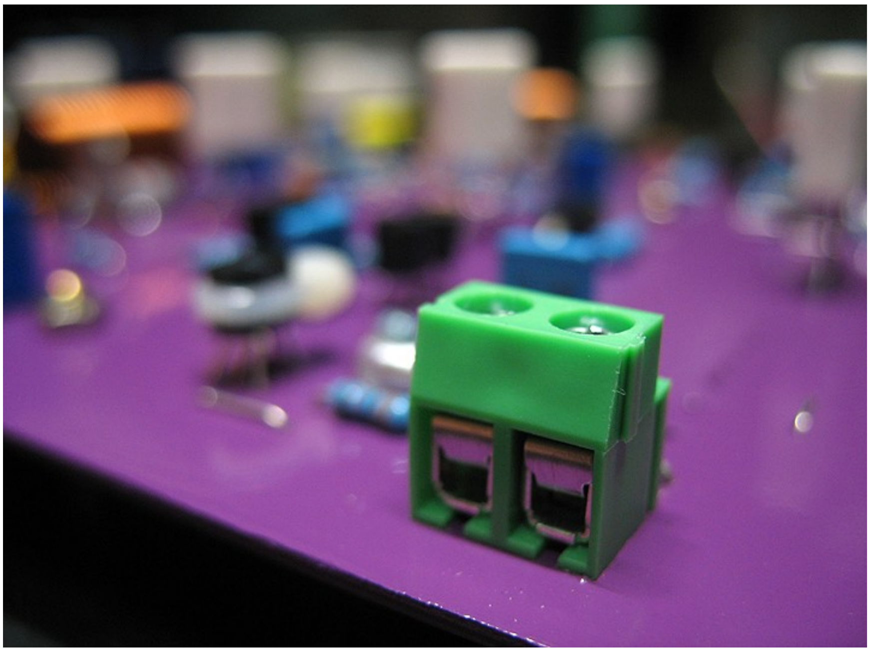






Prepare L1 by neatly winding 14-16 turns 18gauge enameled copper wound around a 12.5 -15mm diameter coil form. The coil form used can be anything from a marker pen, to a piece of small tubing. Strip the ends of the copper wire to remove the insulation then insert and solder securely on the board.



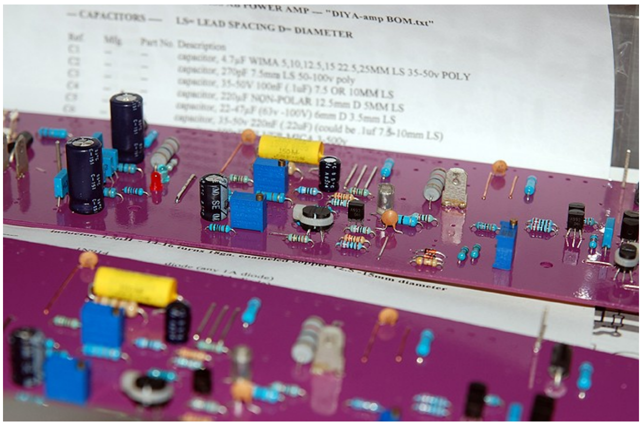


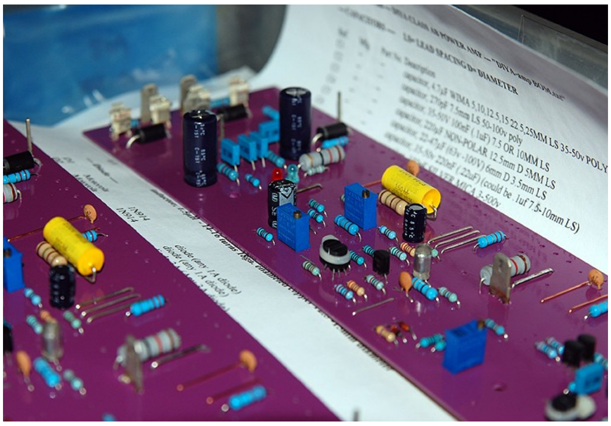
The photo on the left shows the Euro-block connector used for the input connection of the amp.

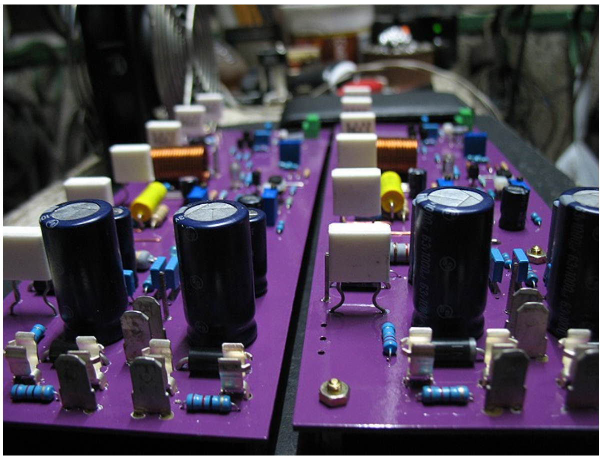
The photo on the right shows the “Power Good” Red and Blue LEDs that lights up to indicate V+ and V- power is applied to the power amp.

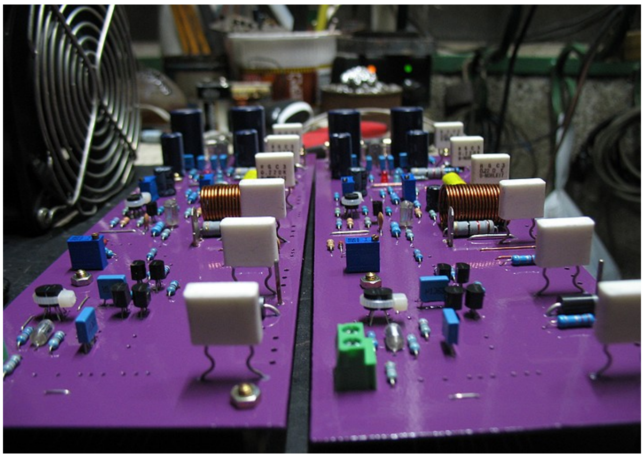
As you continue to populate your board, always check and recheck polarities and pin orientation of polarized parts such as diodes, capacitors, LEDs, etc. Take it slow, investing time now to inspect and check your parts can save you a lot of trouble later on. ;)

After some time, your board should slowly look like these…

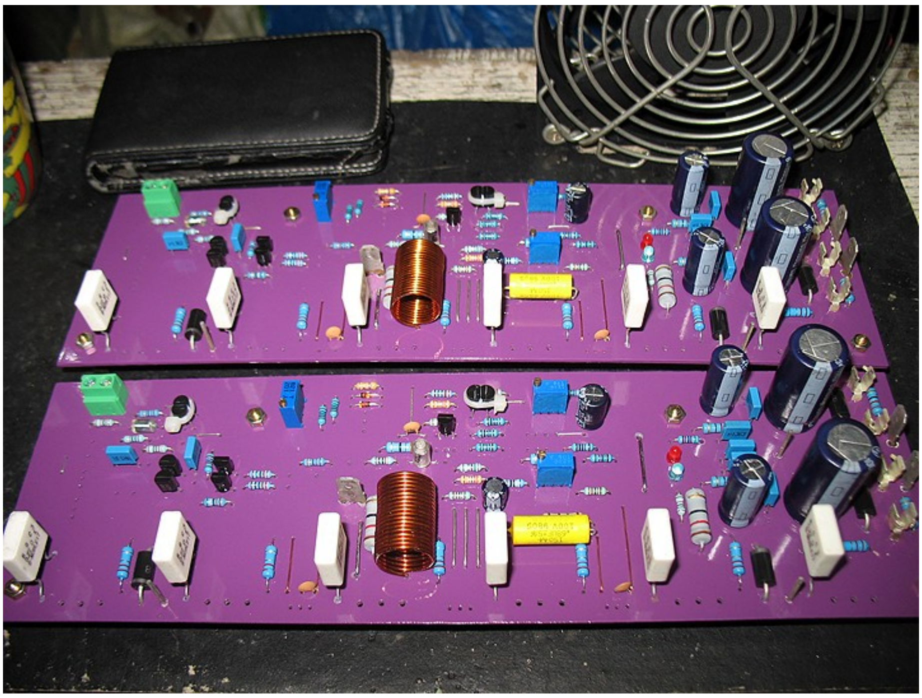








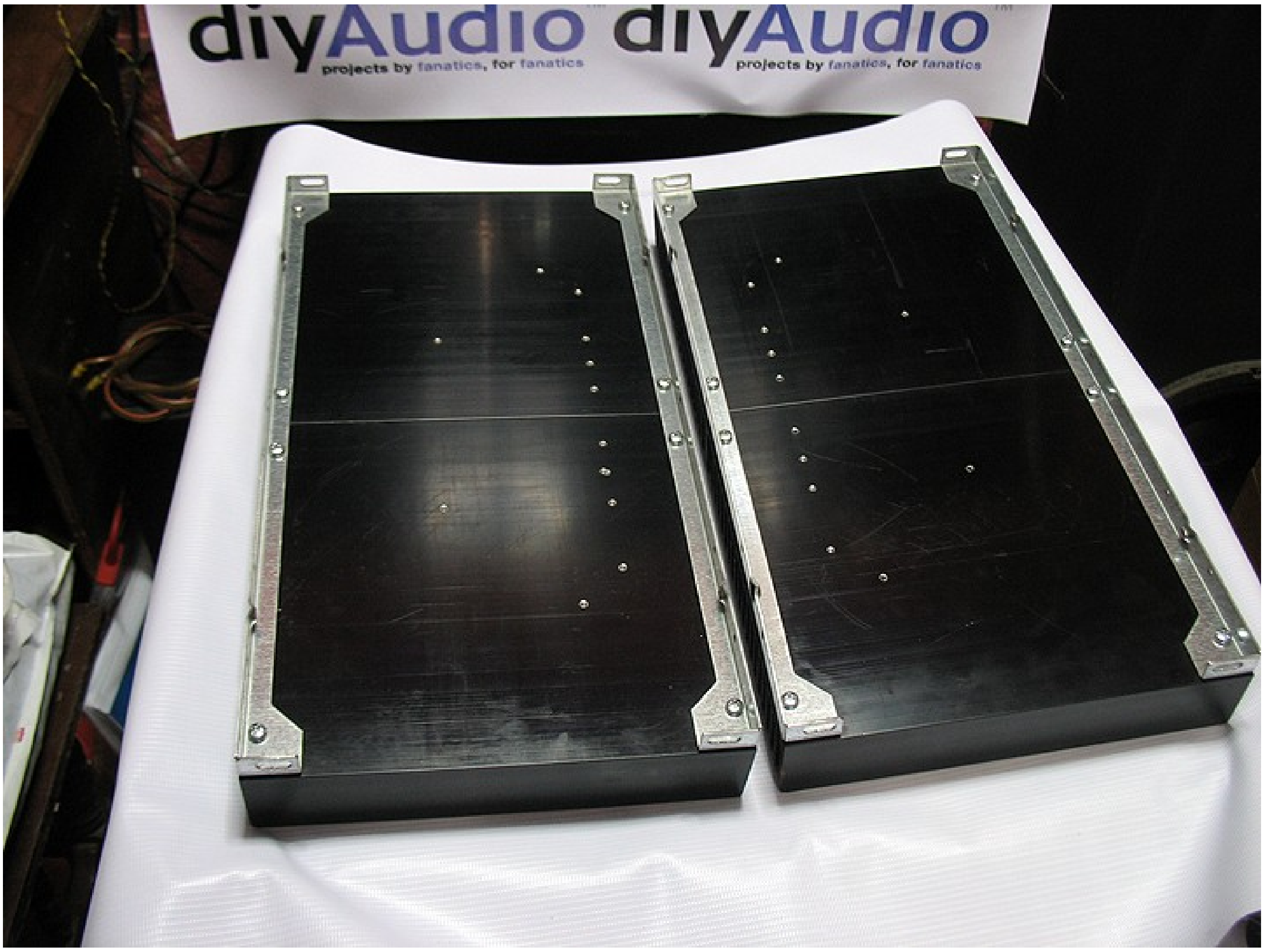
And finally, with the exception of the VBE, Driver, and Output transistor, the board with all the parts installed and soldered should look similar to this photo:

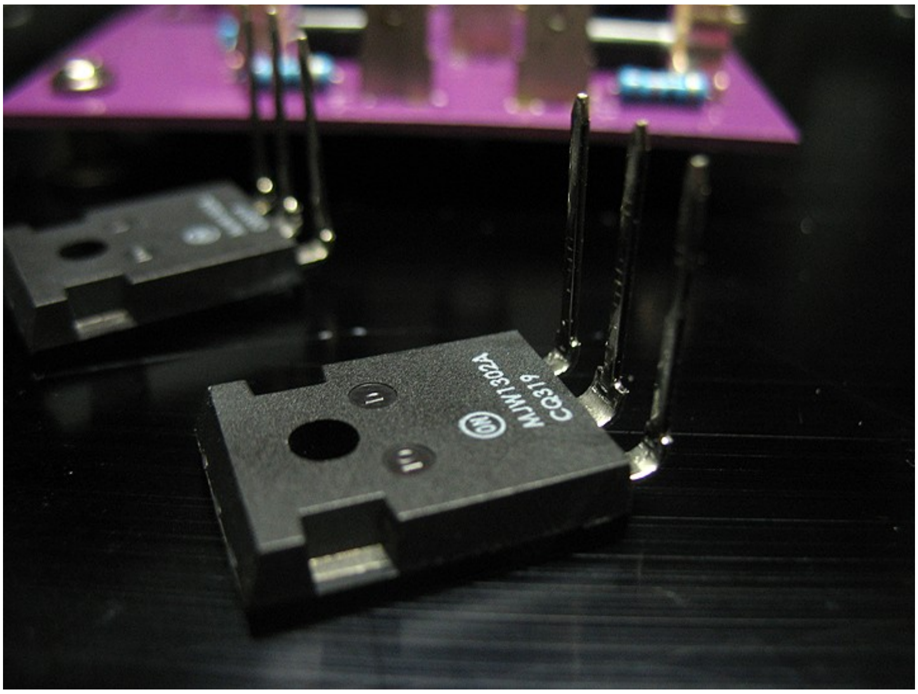


There are several alternate ways of installing the board and output transistors but we won't cover those in this build guide and instead leave them to the builder’s imagination and experience level instead. The prototype power amplifier build had the board’s orientation lying flat and parallel with the heatsink face. This way the boards can be secured via M3 bolts to standoffs which are in turn bolted down on the heatsink. The driver and output transistors are soldered directly to the boards which eliminate additional wiring or what we call flying leads.

The first thing you would want to do is to get your heatsinks ready. It will be a big help if you consult diyAudio Universal PCB & Semiconductor Mounting Specification (UMS) for the proper tapped hole intervals for the driver, output transistor and the board mounting itself.

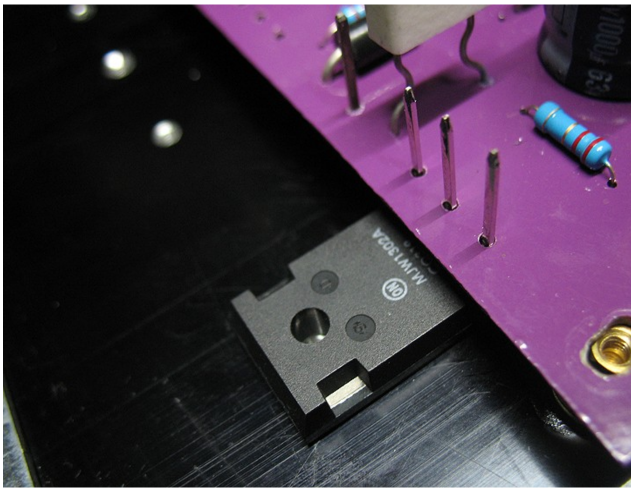
Your heatsinks should now look like these, holes tapped and clean.

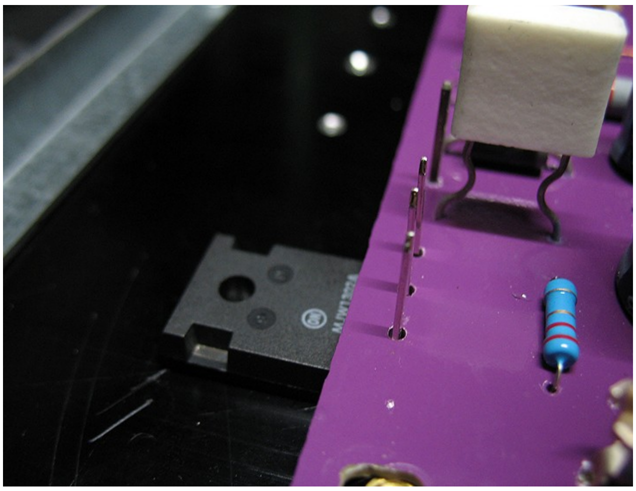




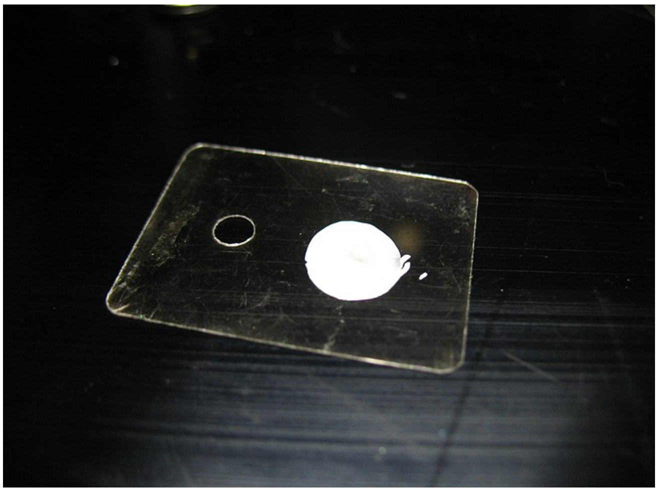
Next is to get those boards and transistor leads aligned. The transistor leads have to be bent 90 degrees so their leads face upwards (see photo on the left).

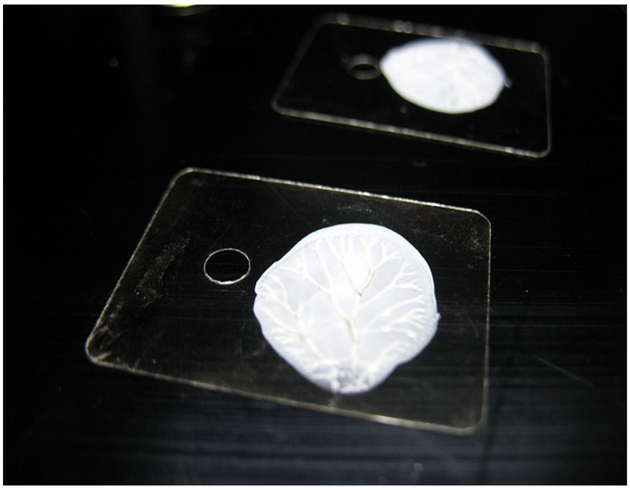
It is a good idea to “dry fit” the transistors and board installation if they align with each other. Be careful not to put too much strain or pressure on the transistor leads or they will get damaged.



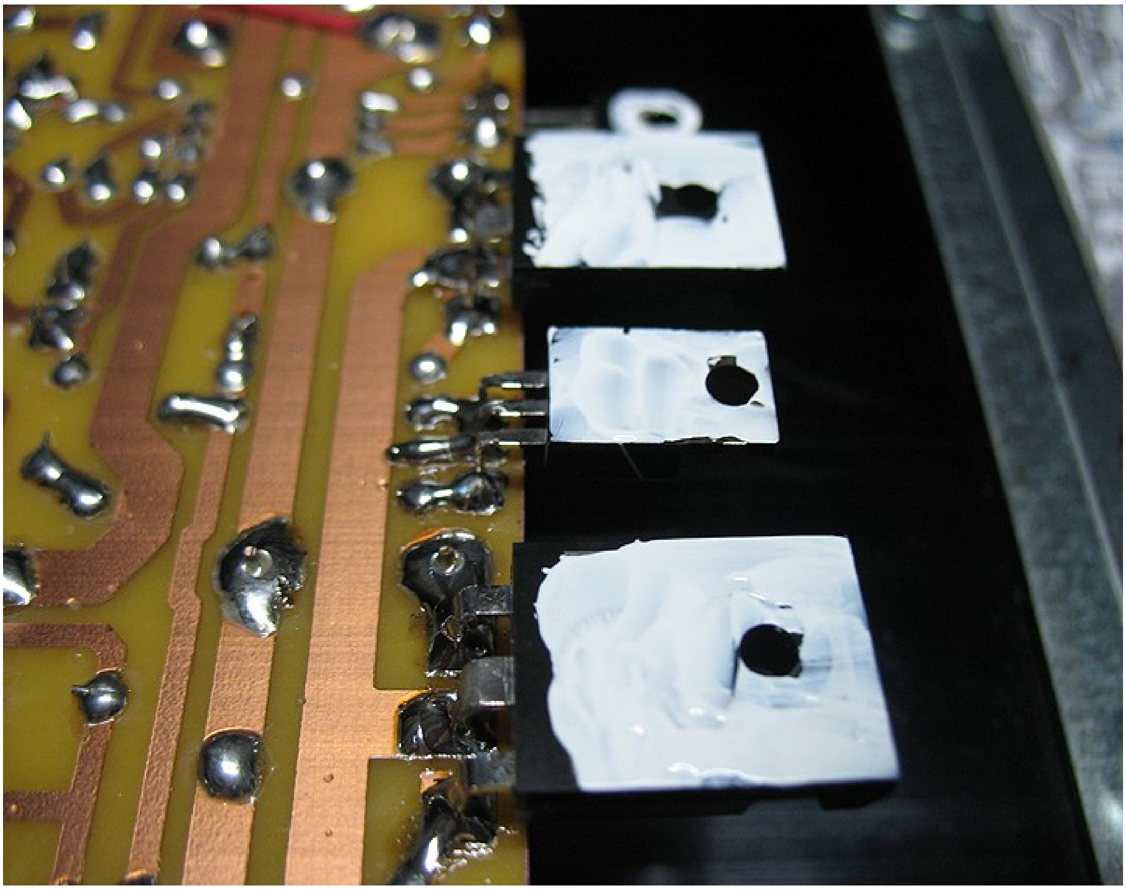


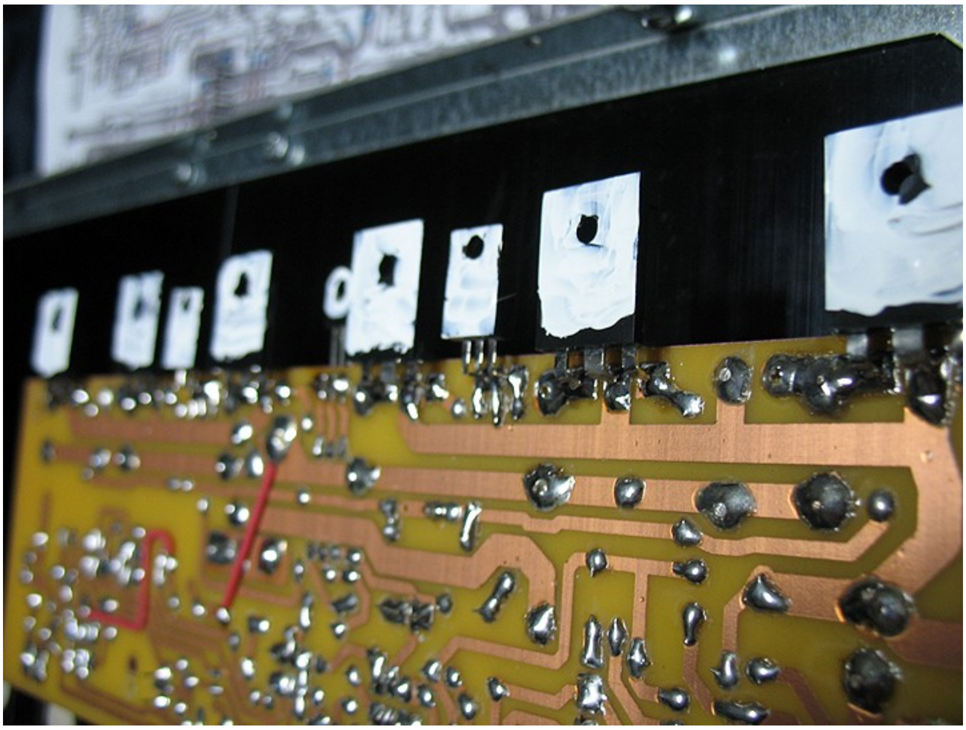
If all goes well with you alignment of the transistor leads then next thing to do is ready your mica insulators and apply thin amounts of silicon thermal grease on each side.



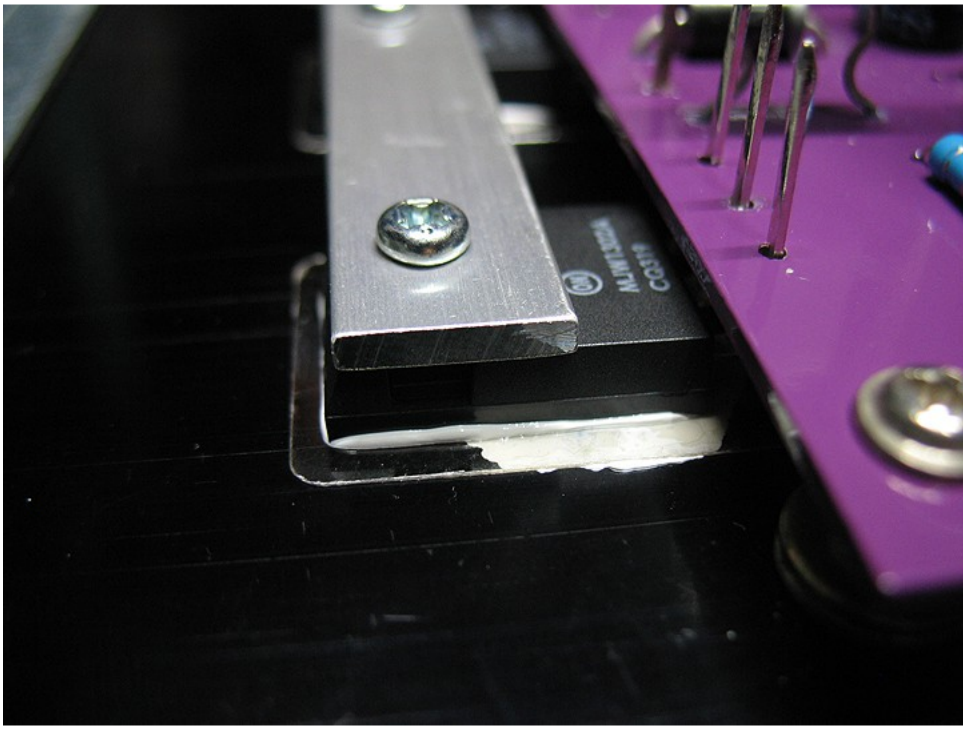


I won't pretend to be the authority on using thermal grease but you can also put some on the transistors themselves. :)

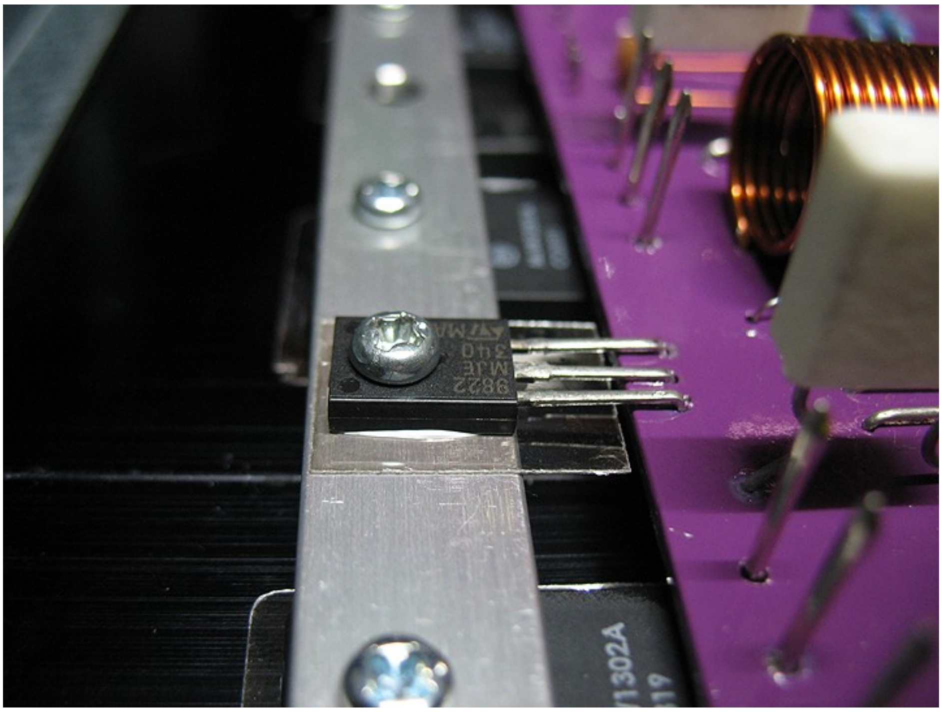


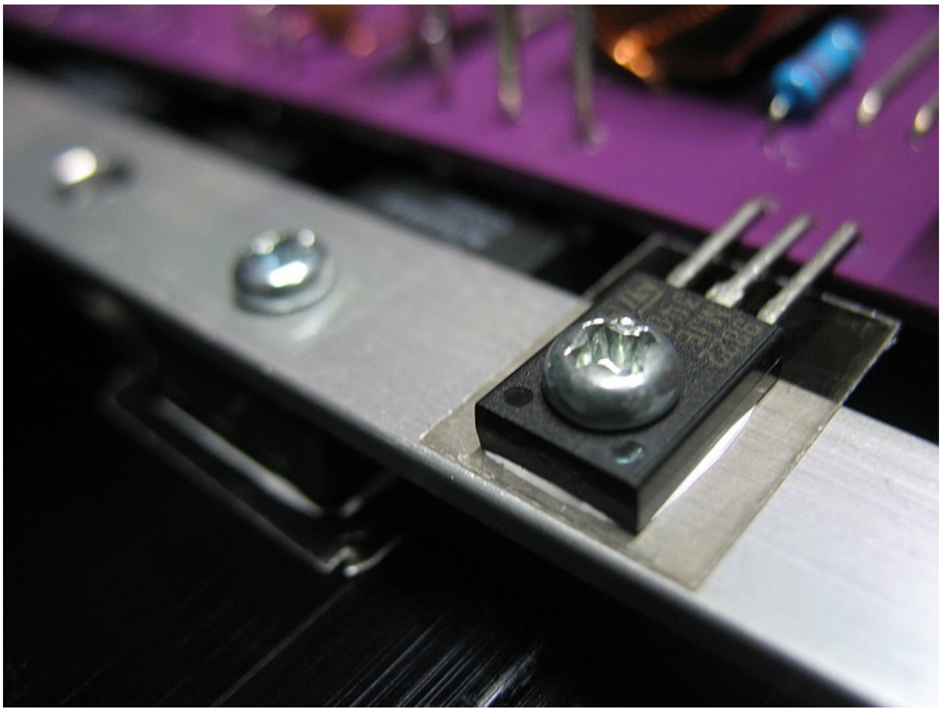


When all is set, start assembling the board/heatsink assemblies. Don't forget to also use mica and plastic insulators on the bolts holding down the TO-220 driver transistors.

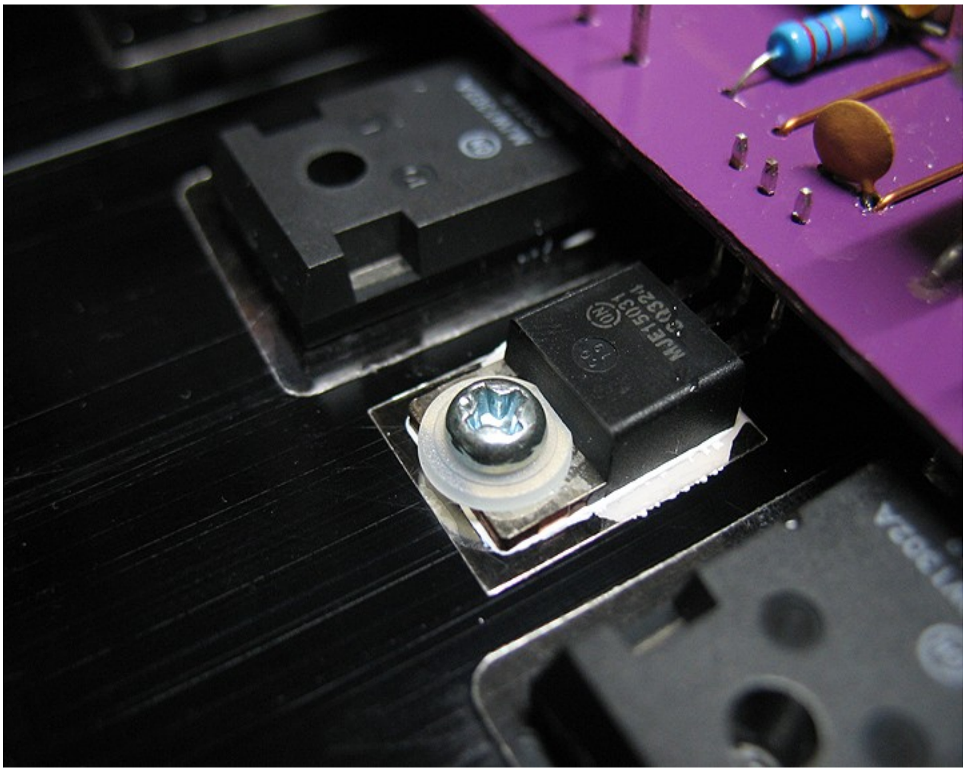


Notice in the prototype that I used a thermal bus bar made out of a strip of aluminum where the Vbe multiplier is also bolted down using an M3 bolt.



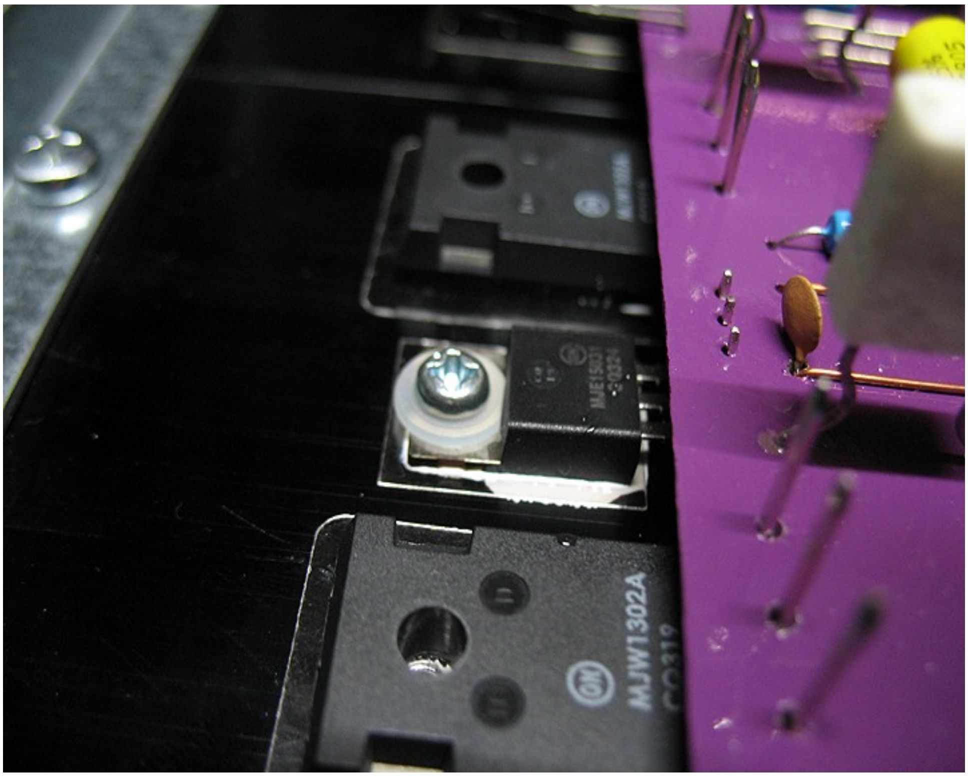


This next picture shows the driver transistor (TO-220 device package), notice the white plastic insulator used to isolate the bolt from the transistor.



Securely tighten the bolts for the transistors, but do not over tighten or you'll mess up the threads.

Use a DMM to test for continuity between the heatsink and the leads of the transistors. Make sure there is no short between the metal tab of the transistor and the heatsink!!!



Checking Your Work:

Building electronic stuff is fun and enjoyable, up to the point when you are about to power it on for the first time! To help in reducing the risk of failures and boost a builder's confidence, these are my usual procedures when checking a finished board.

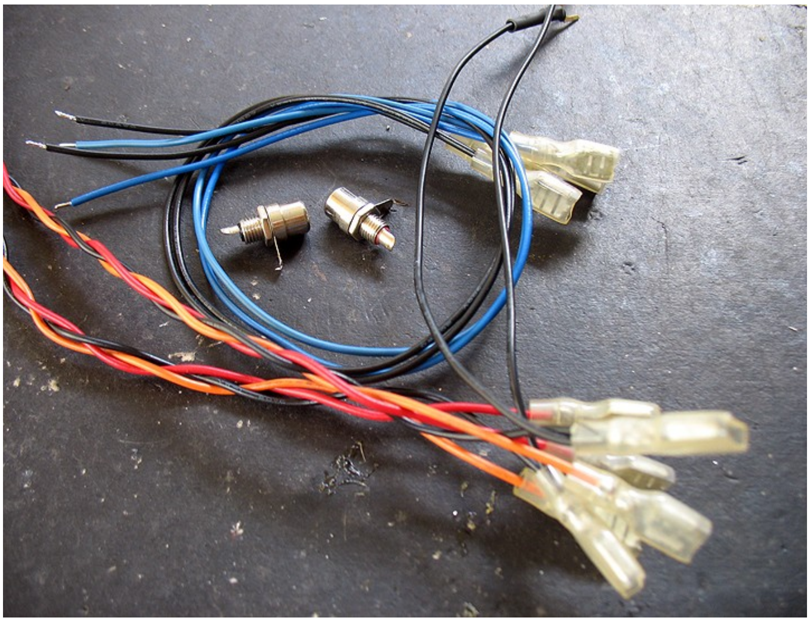
Resistors – Visually check each resistor, cross reference it with the BOM and make sure that you placed the right value in the right spot. It is also good practice to do a quick resistance test of a resistor using a DMM before soldering it in place. It is very easy to mistake a 5-band 68K resistor with a 68R resistor!

Capacitors – Electrolytic capacitors are polarized so check and pay careful attention to their pin orientation. Make sure the markings on the capacitor matches the polarity marked on the board.

Diodes – It is so easy to overlook the lead orientation of diodes especially those small signal types and zener types. Check and make sure that their polarity matches the assigned polarity markings on the board.

Transistors – These devices have markings on their bodies that may require the use of a magnifying glass. Read and make sure that every transistor is properly oriented on the board and that the particular transistor installed is indeed the type of transistor that is required to be installed in that position. Catastrophic failure may occur if you misplace or install a transistor the wrong way so take your time to check and recheck.

Wiring – it helps if the wires you use are of different colors. For example, all V+ wires are Red, Ground wires are Black, and V- wires are Orange. That way, there won't be any confusion when doing tests and assembly of your amp. Also, make use of suitable thickness wires, but do not overdo it. Remember too that it's harder to dress a thick wire. Use at least AWG#16 stranded hookup wires. Of course no one's stopping you from using those ultra high end cables for wiring the amp. Use shielded wires for all small signal carrying wires.



Testing and Calibration:

Things you'll need:

1. Digital Multi-Meter (DMM). Two of these would come in handy. Three would be great.
2. Suitable Power Supply in the range of +/-50VDC
3. Trimmer adjustment tool. Those plastic ones will do.

First things first:

There are 3 trimmer resistors in the board that need to be adjusted for optimum performance. These trimmer resistors are:

- R17 – Output DC Offset Adjustment
- R7 – LTP CCS Adjustment
- R30 – Bias Adjustment

Familiarize yourself and know the positions of these trimmers on the board. The initial resistance settings for these trimmers before powering up the amp for the first time must be:

- R17 – Set to midway position
- R7 – Set between 70R to 100R
- R30 – Maximum resistance (500R)

These things must be checked / understood before powering up the amp!!!

1. The "DC Output Offset" Adjustment (R17) will be set after powering up the amplifier for the first time and usually just needs between 1/4 and 1/2 a turn to bring the output voltage within 1-2mv of 0V. This all depends on how closely these 2 devices (Q1-2) are "matched". A DMM Hfe test within a few digits will usually produce the 1/4-1/2 turn scenario described above.

2. The small CCS just has a 20 turn 200R trimmer (R7). This CCS controls the LTP current. The small CSS can be adjusted between 1.8ma to almost 6ma, and this is achieved by adjusting R7 to between 70 and 100 ohms, which will result the desired output of 3.5ma at the "tail" of the LTP. 3.75mA gives roughly 8.25V across R14. Before powering on the amp, set R7 to 85ohms.

3. Output bias R30. Adjusting this is simple, R30 (BIAS) should be set to 500R (read it with your DMM). This will forward bias Q13 to the max and make the voltages across C9 their smallest, biasing the output stage to class B levels.

4. Temporarily install 10 ohm 1W resistors in place of the two fuses.

Powering the Amplifier for the first time:

- Connect a DMM across one of the temporary 10 ohm 1W resistors placed in lieu of the fuses. Set to read DC Volts.

- If you have another DMM, connect this to TP1 and TP2. Set to read DC millivolts.

- Connect your power supply to the board's V+, Ground, and V- faston connectors.

- Turn on the amplifier. With nothing connected to the amp's input and output, watch your DMM connected across the 10 ohm 1W resistor and apply power (tap the power on for a moment only). The DMM reading should be close to 0V. Also, the two LEDs (Red and Blue) in the board should light up immediately. Check your work if you see anything higher than 0.5V.

- Connect a DMM at the output to measure DC offset. Connect the positive terminal of your DMM to the speaker output and the negative terminal to ground. Reading should be around 1mV to 2mV. Adjust R17 for the smallest possible reading.

- Slowly turn R30 until you see your first few millivolts across TP1 and TP2. Continue until the test points show 15-20mv, allow a few minutes for the output transistors to thermally stabilize and then adjust further

- Power down and remove the temporary 10 ohm 1W resistors and install fuses. Recheck Bias and let the amp run for a while and then adjust further if needed.

Notes on biasing: Some may like it biased "hot" at around 30mV - 40mV (100mA per device), while some may like it running "cool" at 20mV - 25mV (50mA per device) between TP1 and TP2. Crossover distortion is usually minimizes, if not eliminated at >50mA and up bias.

Bias calculations:

For 100mA bias per pair, measure about 44mV between TP1 and TP2.

I = 44mV (measured between TP1 and TP2) / 0.44

I = 0.1A = 100mA

Listening Tests and Reviews:

After all the tests and adjustments, it is time for some listening tests. I started with a 12SN7 Aikido Tube Preamp and an Apple iPod Touch connected via LOD (line out dock) and loaded with some nice lossless files. I used my Wharfdale 9.1 bookshelf speakers for my initial testing of the amp.

Initially, the amp showed a very open presentation with lots of air and low end punch. Applying the LC Cap really changed the sound and overall presentation making it sound warmer but still has that transparent sound to it. Some may or may not like the use of this lead compensation capacitor but it sure is a welcome addition to have that option.

I used a dual mono style arrangement for the rectifier and filter of the prototype amp and boy it was really worth it. Channel separation was awesome and imaging was easy to achieve. This power supply arrangement also provided enough “mojo” for those demanding passages where other amps would already start to clip.

Power is never an issue with this power amplifier. A friend of mine who is also into audio gear said and I quote, “I have never heard those Wharfdale 9.1s sing like that, and frankly, I thought they never could”. This amplifier has a great authority over my speakers.

I also tried a simple passive preamp in front of this beast and it was a wonderful experience. The amp behaved well, even without any gain upfront. The sound was even cleaner and more natural.

Lastly, in the past few years I’ve had the honor of opening up, repairing, modding and tweaking several revered commercial power amplifiers. It was a great privilege because if not for their owner leaving them to me for whatever reasons, I wouldn't have had the chance to hear those amps for myself, moreover, in my own humble system. I've built a lot of amps; clones, new designs, solid state, vacuum tubes and mixtures of both. I thought I'd heard them all, but I’m thankful that I also got the chance to build the Honey Badger Power Amp. It’s a fantastic amp that I’m sure you’ll enjoy from building to listening. A highly rewarding DIY project.

Feedback and Final Notes:

The constructor has the option to run things (the output section) cool or hot. Biasing the output section high ensures no or minimal crossover distortion which will be evident in the highs especially at low listening levels. With the driver and output devices used in the prototype, I was able to run them as low as 15mA per pair without any significant distortion coming from the amp.

This can be optimally verified by using an oscilloscope and a function generator. However, these test equipments are expensive and not usually within reach of every constructor or hobbyist. Setting the bias to between 35mA and 50mA should remove any crossover distortion, but you can also up this to 100mA IF you have enough heatsink surface area to spare. It is also important to note that different brands and models of output transistors require different bias values; some will exhibit no crossover distortion even at low bias values while others will need more.

Enjoy!

JD