Bob Cordell's Super Gain Clone

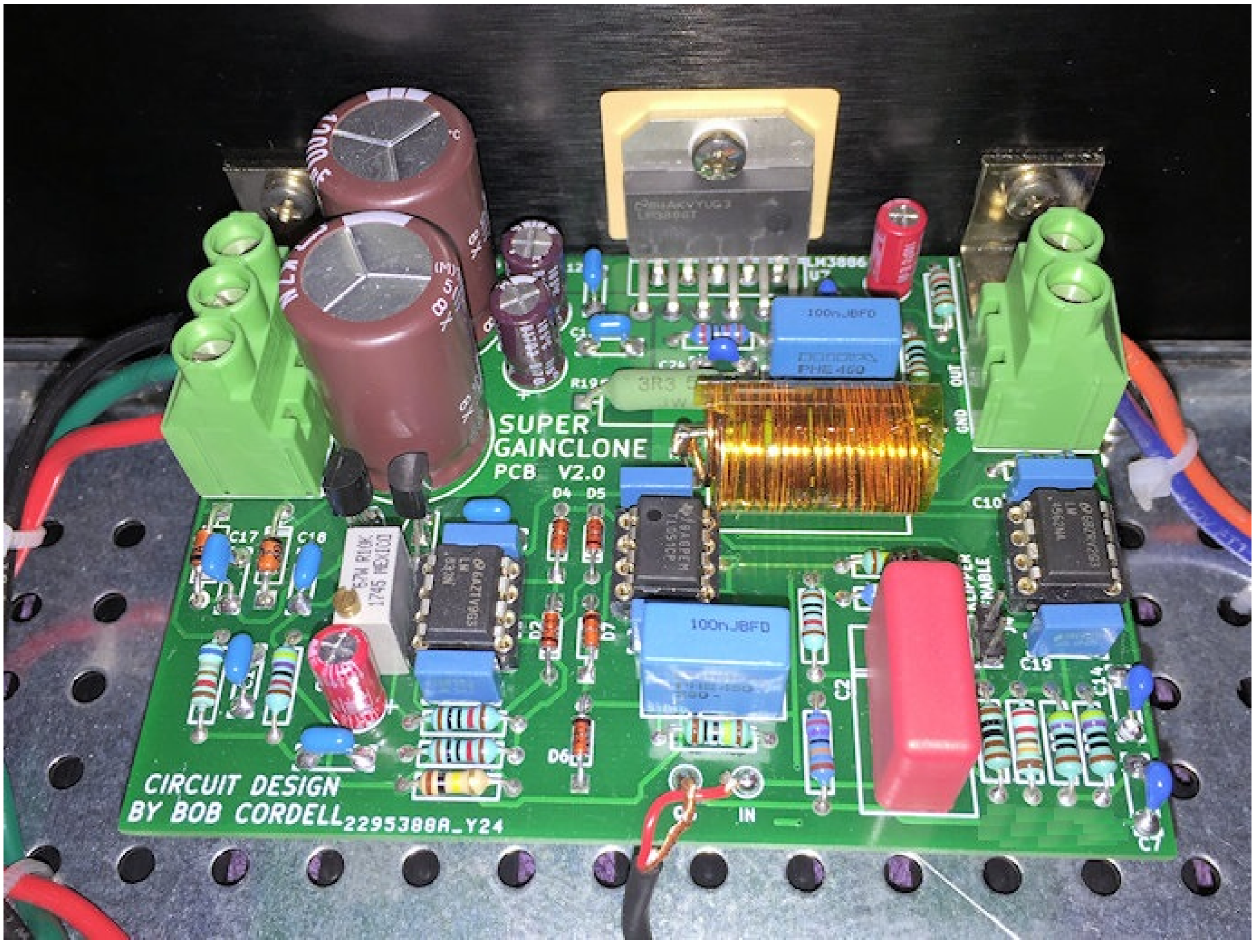


Table of Contents

Tools Needed

To assemble a Super Gain Clone amplifier, you will need

A Good Soldering Iron	Eutectic Solder
Flush-Cut Dikes	Wire Strippers
Long-Nose Pliers	Phillips Head Screwdriver
Wire Cutters	Digital Multi Meter
Third Hand Jig or Panavise	Small Adjustable Wrench
Blue Painters ("Masking") Tape	

Not absolutely required, but very VERY strongly recommended:

eBay "Mega328" Component Tester with Acrylic Case

This little device measures resistors, capacitors, and inductors. It tells you whether the tiny little capacitor in your hand, whose tiny printing is unreadably small, is 100 pF or 2200 pF or 2.2 uF. It prevents a huge number of stuffing and soldering errors. Every diyAudio builder should own one. Fortunately they are not expensive: about USD 17.00 including case and shipping to the US. Search eBay, you'll find many.

Misc. Fasteners Needed

To securely mount your Super Gain Clone board on its heatsink, you will need some metric "M3" sized fasteners:

1 piece: M3 bolt, 10mm long . . . . for LM3886
1 piece: M3 bolt, 8mm long . . . . for LM3886 (if shallow hole)
1 piece: M3 (or SAE #4 or 1/8") flat washer . . . . . . for LM3886 insulated tab
2 pieces: M3 bolt, 6mm long . . . . L-bracket to heatsink
2 pieces: M3 bolt, 8mm long . . . . L-bracket to PCB
2 pieces: M3 hex nut . . . . L-bracket to PCB
2 pieces: M3 star washer . . . . L-bracket to PCB

One convenient way to obtain these, is to purchase an assortment kit of M3 bolts and nuts from Amazon.com. Now you will have plenty of each, so won't be a major problem if you drop a part and can't find it. You'll also have more options; maybe you will discover that you prefer longer (or shorter) bolts than the ones listed here.

Parts List

The Super Gain Clone discussion thread on diyAudio.com, includes a spreadsheet containing a detailed Parts List. It is attached to post #1 of that thread. Download the Parts List spreadsheet to your computer and save it, you will refer to it many times when purchasing components and when building the PCB. Extra detail has been included to make it easy for you, the builder, to find parts whose electrical performance is acceptably good and whose physical size will fit the PCB. If one or more parts are out of stock or backordered, the Parts List is your savior. It will help you find a replacement that's just as good or better.

Also attached to post #1 is a .zip archive, that includes web links to Mouser.com preloaded Shopping Carts. These are so-called "one click" Shopping Carts. BEWARE: don't shut off your brain when using these! Check to be sure that every line item is in stock and not backordered. Check to be sure you're not accidentally ordering 1000 of something. Check to be sure you're not ordering parts for an option that you don't intend to actually build. (example: be sure you aren't ordering two LM3886 chips, one in the insulated tab package, and another in the metal tab non-insulated package).

Power Transformer Options

You'll need a power transformer rated at least 200 volt-amperes ("VA"), having two independent secondaries, and having primaries that are compatible with the AC mains in your country. Each secondary's output voltage (under full load) should be between 14.5VAC rms , and 31.5VAC rms.

The transformer secondary voltage (and VA rating!) determine the maximum available output power from each channel of the Super Gain Clone amplifier. This is plotted in Figure 1 below. (This figure appears in the LM3886 datasheet, which you should download; I simply overlaid red vertical lines for a few different transformer options).

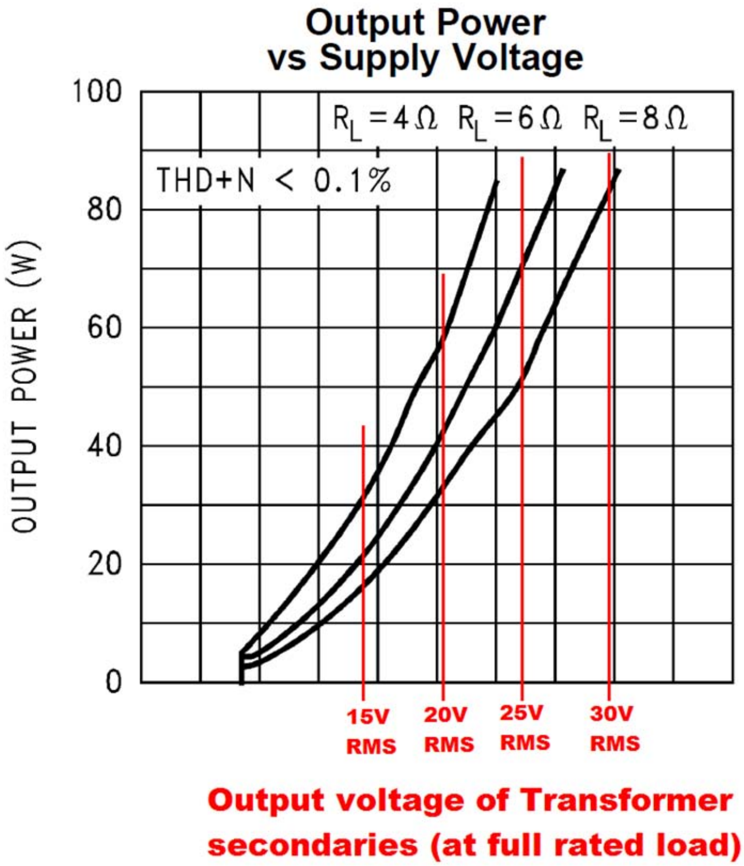


Figure 1: Super Gain Clone output power vs. Transformer secondary voltage

For example: a Super Gain Clone using a 200VA transformer with 2 x 20VAC secondaries (2nd red line), would deliver about 32 watts per channel into 8 ohms, or about 56 watts per channel into 4 ohms.

Power Supply Options

The "Universal Power Supply" PCB sold in the diyAudio Store, works well with a pair of Super Gain Clones and/or Compact3886s. Another option is a PCB called "PSU For Chipamps," sold as a Group Buy on diyAudio.com. It is smaller than the Universal Power Supply board, because it makes no attempt to be universal. It's just a simple PSU without any options or user configurable features, and it is specifically designed for stereo chipamps plus 200VA transformers. The idea is to allow builders to fit an entire stereo amplifier, including transformer and power supply, into a relatively small box.

Choosing a Heatsink

You will need to select a heatsink whose thermal resistance (measured in degrees Celsius per watt of power dissipation) is sufficient for your amplifier and your speakers. This varies with load impedance, and supply voltage (i.e. the amount of power the LM3886 can deliver). A simplified set of guidelines for heatsink selection are shown in Figure 2 below. These guidelines are chosen (a) to keep the heatsink temperature below 60 C; and (b) to keep the LM3886 junction temperature below 125 C.

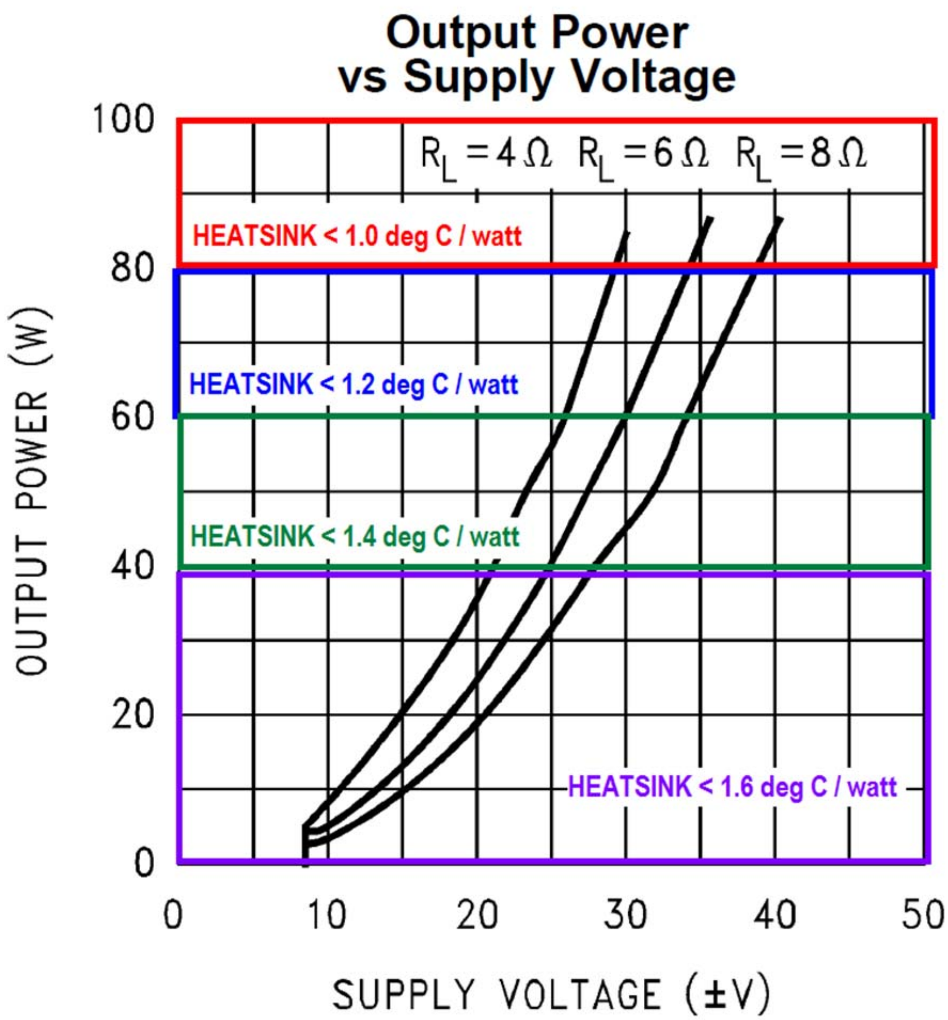


Figure 2: Guidelines for heatsink thermal resistance

Please note: the guidelines in Fig 2 were calculated assuming only a single LM3886 is mounted to the heatsink. If you plan to attach “N” Super Gain Clones to the same heatsink, you will need to divide the required thermal resistances in Figure 2, by “N”.

The HiFi2000 chassis sold by the diyAudio Store, with built-in 40mm heatsinks (model names “Deluxe” and “Dissipante”) all have thermal resistances below 0.5 degrees C per watt. Therefore, any of them will work beautifully with two (or four!) channels of Super Gain Clone PCBs. Builders who select a different chassis, should consult Fig. 2.

Drilling & Tapping the Heatsink

The final page of this document is a drilling template, showing the correct positions of the three holes you will need to drill and tap in your heatsink. The two outer holes are attachment points for the “Keystone 4336” L-brackets. The middle hole is an attachment point for the LM3886 itself.

Print the template onto copier paper, carefully selecting 100% zoom from the Print menu. Double check the distances with a ruler to be Absolutely Certain that your template has the correct dimensions.

Next, choose the exact position on the heatsink where you will mount the Super Gain Clone. This will depend on the position of the other components inside the chassis (power supply PCB, power transformer, chassis-mounted rectifiers, I/O jacks, switches, and so forth) so test your placements carefully, ideally with the actual boards and the actual transformer and the actual chassis itself including the attachment rails.

Some builders might decide to mount one or both PCBs “upside down”, i.e., with the solder side of the PCB facing the ceiling and the component side of the PCB facing the floor. Be sure to test your placements carefully, ideally with the actual boards and the actual heatsinks + rails.

Cut out the template and attach it to the heatsink at the position you’ve chosen. Use a center-punch to punch the positions of the centers of the three holes. Then remove the paper and drill those holes with a 2.5mm drill bit, then tap them with an M3 tap. Repeat for both heatsinks in a stereo amplifier.

Fabricating the Output Inductor

The output inductor consists of 20 turns of AWG-20 enameled wire (“magnet wire”), tightly wound on a 7/16-inch rod, called a “coil former”. 20 turns produces a coil whose length is slightly less than 20 mm wide. This is convenient because high temperature Kapton adhesive tape, 20 mm wide, is used to hold the tightly wrapped turns together, preventing them from unraveling.

A 7/16-inch diameter metal rod, approximately 12 inches long, is available at the hardware store, and/or a big box home improvement store. You can also use a 7/16-inch wooden dowel, as long as it is hardwood that won't "give" as you are winding the coil. If it's easier for you to buy a rod in metric units, 11 mm diameter will work just fine too.

Cut off a 3-foot long (1m) piece of AWG 20 wire. Use masking tape to attach the first 3-4 inches of the wire securely to the rod. Then tightly wind 20 turns on the rod, each turn securely snugged and touching the previous turn. After 20 turns, maintain tension on the wire, push the turns together into a tight bunch, and use masking tape to attach the remaining wire to the rod – so the turns can't come loose.

Again push the turns together into a tight bunch. Once they're tight and smooth, cut off a 3-inch long piece of 20mm wide Kapton tape, and securely wrap the coil with two complete wraps. Trim off and discard any excess Kapton tape. Now the coil is self supporting and you can trim off all but the last 2 inches of lead wire from either end of the coil. Remove the masking tape from the rod and slide the coil off the coil former.

You will need to scrape off the insulation from the ends of the coil's leads, so that you can solder the leads of the coil to the leads of its co-axial resistor (R20: 10 ohms, 3 watts). This resistor is inserted through the middle of the coil. Sandpaper, an X-acto knife blade, or a needle file can be used to remove the insulation. I prefer the needle file, in my experience it works the quickest.

Bend both leads of the 10 ohm 3 watt resistor R20, so they perfectly match the spacing of the holes on the PCB. It's now a "U" shape, with vertical legs and horizontal resistor body. Thread the coil over the resistor and arrange it so the resistor body is completely within and parallel to the coil. Then bend the coil leads around the resistor leads for a good electrical connection, and solder in place. Test-fit the coil+resistor assembly into the holes on the PCB. It should slide in easily, with the coil body snugly touching the board. Remove the coil assembly and don't solder it until all of the smaller parts have been stuffed and soldered.

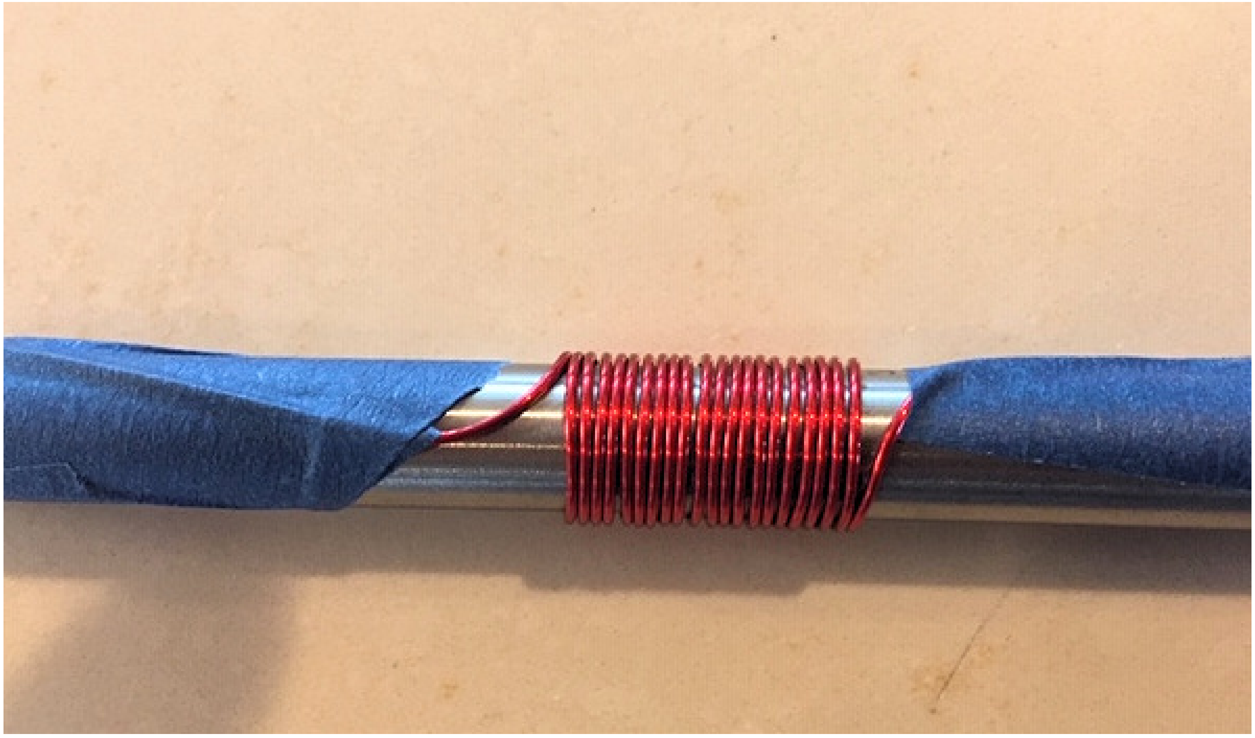


Figure 3: Winding the output inductor

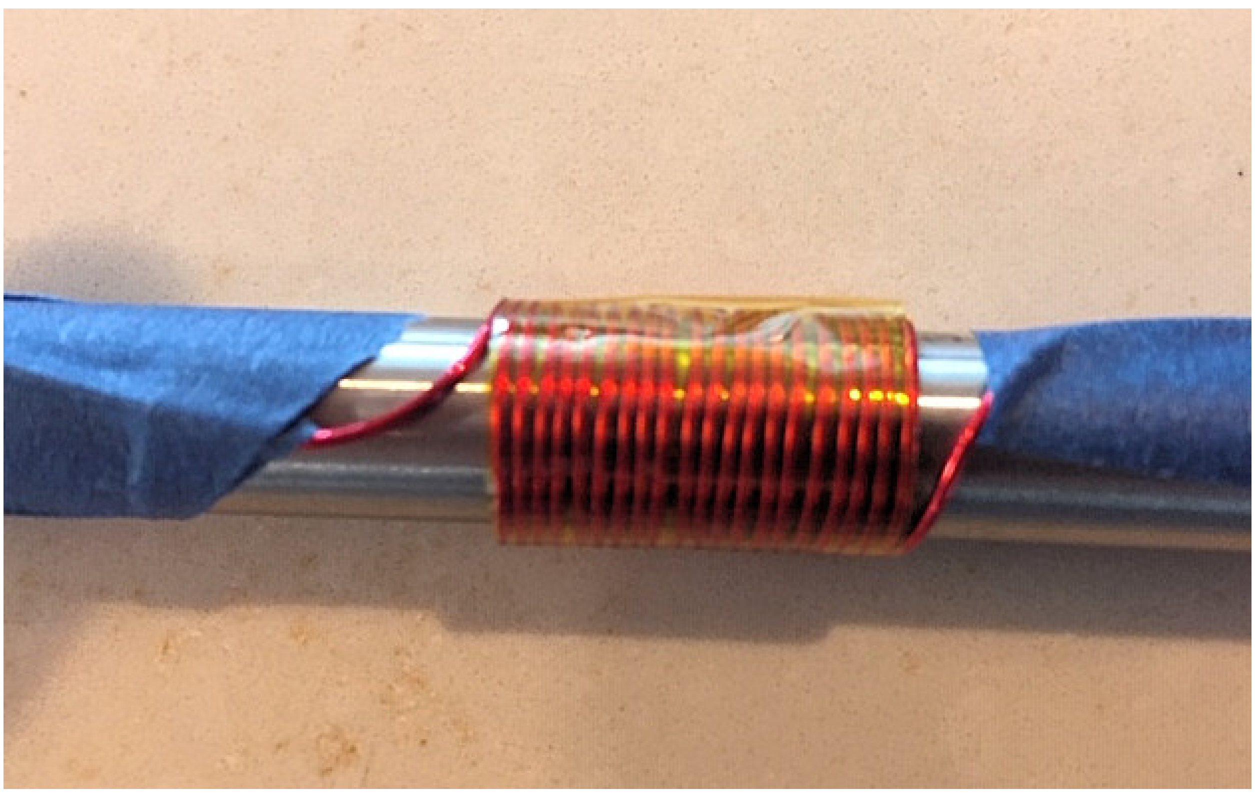


Figure 4: Kapton tape tightly wrapped around coil

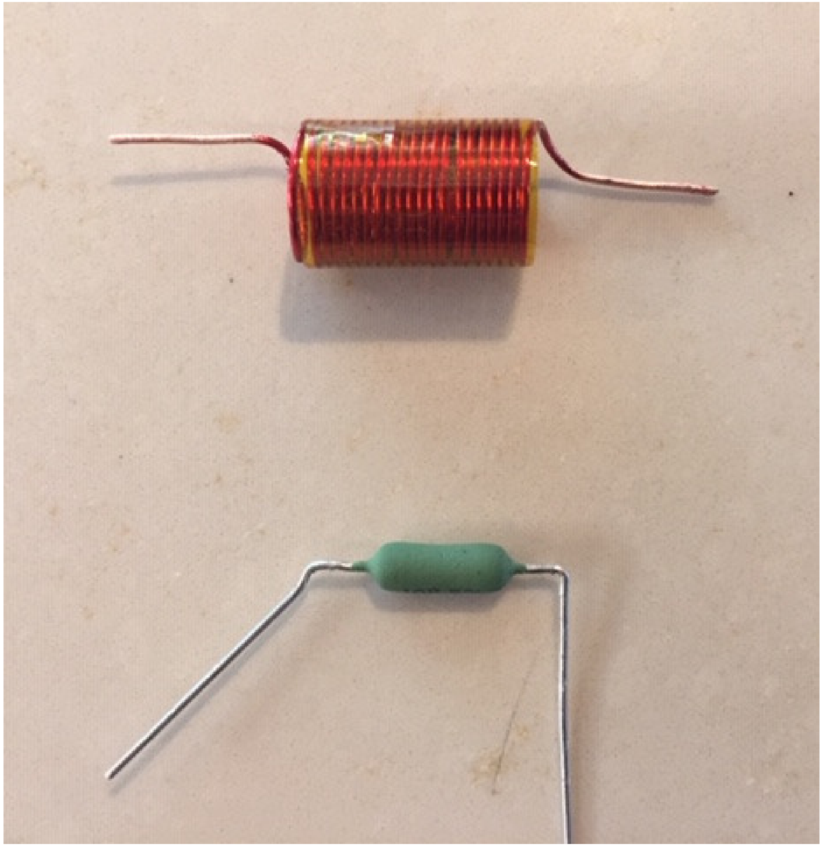


Figure 5: Inductor and resistor

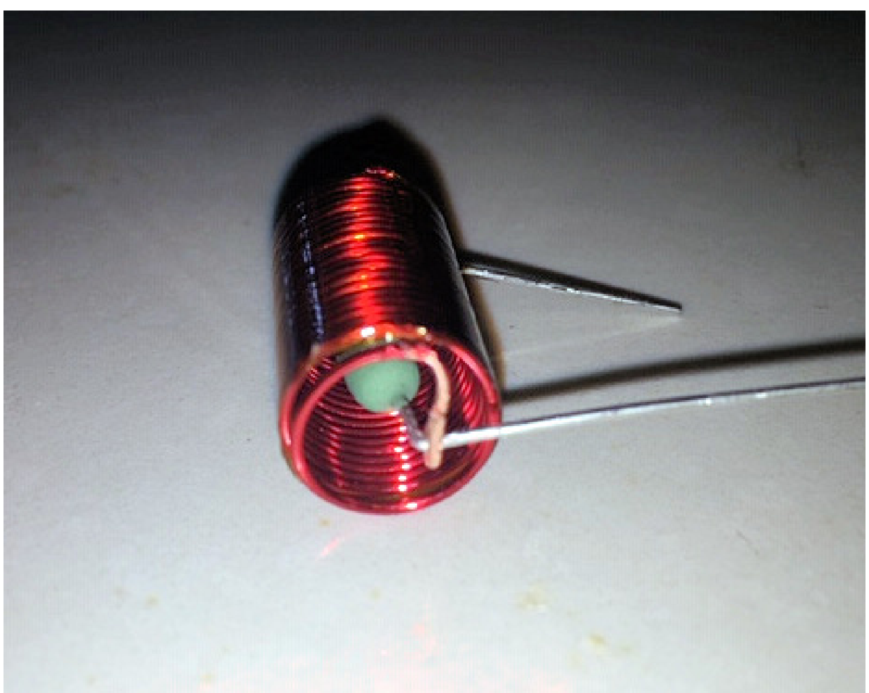


Figure 6: Inductor leads bent around resistor legs (then soldered)

Stuffing and Soldering the PCB

The first thing to do is print out a clean copy of the schematic. You'll refer to this again and again as you stuff and solder the board. Every time you stuff and solder a component, you will (a) measure it using the Mega328 component tester, to verify you have the correct part in-hand; and (b) once it is stuffed into the board, you will mark it on the schematic. Either a check mark, or a red circle, or a yellow highlighter can be used; just be sure you mark the schematic every time you stuff a component.

Part 1. Stuff and solder all seven diodes on the PCB. There are five standard PN diodes, and two Zener diodes. Trim the leads.

Part 2. Stuff and solder all non-3-watt resistors on the PCB. Trim the leads.

Part 3. Stuff and solder the 3 DIP-8 sockets.

Part 4. Stuff and solder all of the "small" (non-electrolytic, non-big-boxy-film) capacitors. Be SURE to check their values with the Mega328 component tester before stuffing and soldering. Trim the leads.

Part 5. Stuff and solder the two voltage regulator ICs in the TO-92 (transistor-like) 3 lead packages. Trim the leads.

Part 6. Stuff and solder all big boxy film capacitors and all electrolytic capacitors EXCEPT the two very large 1200 microfarad electrolytic caps. Trim the leads.

Part 7. Stuff and solder the two-pin header "J4" which accepts a jumper block.

Part 8. Stuff and solder the large Euroblox style wire-to-board screw connectors "J3" and "J5". Arrows on the PCB show the direction of the connecting wires. Seat these firmly and use masking tape to hold them down to the PCB before soldering; ensure they are snug against the board and not cockeyed. After everything is perfectly aligned, solder. Don't trim the leads, they are very fat.

Part 9. Stuff and solder the trimmer potentiometer VR1. Trim the leads.

Part 10. Stuff and solder the 3.3 ohm, 3 watt resistor (“R19” on the Super Gain Clone schematic).

Part 11. Stuff and solder the output inductor + co-axial resistor assembly into the PCB. Snug it to the board and hold it firmly in place with masking tape. Solder, and then trim the leads.

Aligning and Soldering the LM3886

The LM3886 is stuffed and soldered, after snugly mounting PCB to the heatsink. This ensures the entire assembly is perfectly aligned to *your* drilled and tapped holes in *your* heatsink, including the variability and imperfections that always occur when human hobbyists (not robots) operate machine tools.

Step 1: mount the L-brackets to the heatsink.

Step 2: starting below the L-brackets, slide the PCB upward until the top surface of the PCB contacts the bottom surface of the L-brackets. Bolt the PCB to the L-brackets using an M3 nut, an M3 screw, and a star washer at each bracket.

Step 3: insert the LM3886’s electrical legs into the holes on the PCB. At this point it is not necessary to apply heatsink grease (insulated package) or Keratherm washer (metal tab package). Thread the mounting bolt through the LM3886 and screw it into the tapped hole in the heatsink. Tighten finger-tight but not super extra snug.

Step 4: the LM3886 is now positioned exactly as it will be in the assembled power amplifier. Turn the heatsink upside down, and solder all eleven of the LM3886’s pins to the PCB. Don’t bother trimming the leads.

Step 5: remove the PCB from the heatsink by reversing steps 3, 2, 1. Clean the flux off the board and perform a careful visual inspection of all solder joints and all components, top and bottom side.

Step 6: apply heatsink grease, and/or Keratherm pad to the LM3886. Mount it in its permanent position on the heatsink. Tighten all 3 screws snugly but don’t over-torque!

Adjusting the Klever Klipper

To achieve the best possible performance from the Klever Klipper circuit, I recommend the following adjustment procedure. Notice that it requires (i) an oscilloscope; (ii) a signal generator; (iii) a pair of dummy load resistors, one for each amplifier channel (2 x 8 ohms, 75 watts or greater) or else (2 x 4 ohms, 150 watts or greater). If you don't own these, there exists an alternate adjustment procedure discussed below. You should beware: the no-scope adjustment procedure does sacrifice pre-clipping performance, since you are operating "blind". The alternate procedure also may reduce the amplifier's absolute maximum output power (i.e. during clipping), perhaps by several percent.

1: Connect a dummy load resistor to each amplifier channel's output terminals.

2. Adjust the LEFT channel's KK trimmer pot ("VR1") until U5 pin 3 equals -2.0 volts, or as close to -2.0V as you can get. Repeat for the RIGHT channel. This effectively disables the Klever Klippers.

3: Apply an 0.5V RMS 1kHz sinewave to both channels simultaneously, using a Y cable. You want each channel to draw its maximum possible current from the power supply. This produces the worst case voltage sag on the PSU.

4. Connect a scope probe to the LEFT amplifier channel and LEFT output ground.

5. Increase the amplitude of the 1 kHz input sinewave until the LEFT amplifier output has at least 30-40% of its sinewave clipped off. You want an input signal which positively, definitely forces the LM3886 into hard clipping.

6. Dial the LEFT channel's KK trimmer pot in both directions. Discover which direction smoothes the waveshape; dial in that direction until the sharp edged, flat topped clipping waveform transitions to smooth and rounded rather than sharp edged & spiky.

7. Turn the sinewave generator down to zero amplitude and let the dummy load resistors cool off for five or ten minutes.

8. Repeat the above steps on the RIGHT amplifier channel. Done!

After adjusting the Klever Klipper, the output waveforms in "clipping" should look like Figure 7 below. Sharp corners and flat tops have been smoothed and rounded.

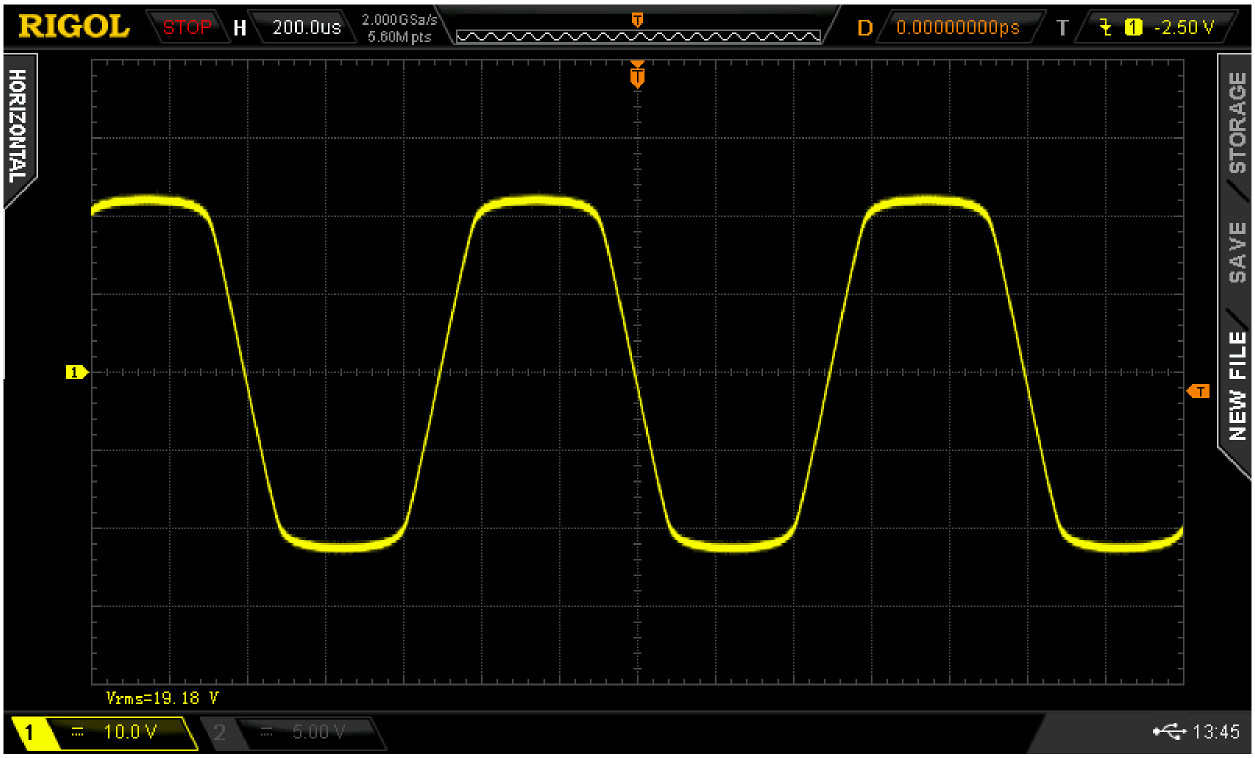


Figure 7: Super Gain Clone "clipped" output with Klever Klipper enabled

Alternate KK adjustment procedure (no oscilloscope)

Remember: this is an approximation at best. It's imprecise and so are the settings it produces. So don't obsess over minute details here. Remind yourself: it's imprecise.

1. Insert a shorting plug into each amplifier channel's input RCA jack

2. Measure the power supply voltage in this no-load condition. Write it down.

3. Find your measured power supply voltage on one of the plots in Figures 8-11. Read off the required voltage at the KK trimpot wiper node (which is U5 pin 3). Write it down.

4. Adjust the LEFT channel trimpot until the voltage at U5 pin 3 equals the value found in the previous step.

5. Adjust the RIGHT channel trimpot until the voltage at U5 pin 3 is as desired.

Figure 8 below shows the entire possible range of legal power supply voltages according to the LM3886 datasheet. Figures 9-11 are merely zoomed-in versions of the same information, showing it in greater detail.

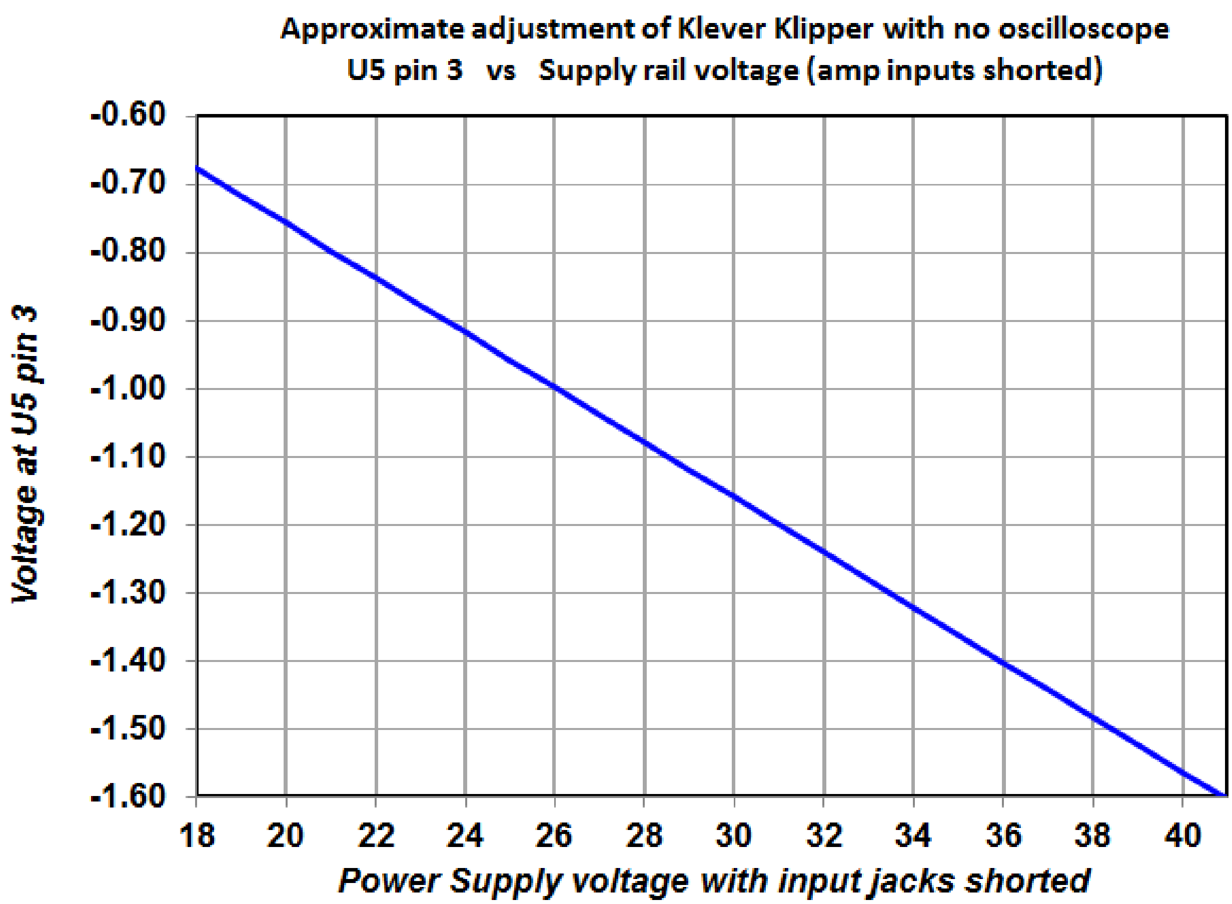


Figure 8: Required voltage on U5 pin 3 as a function of supply voltage

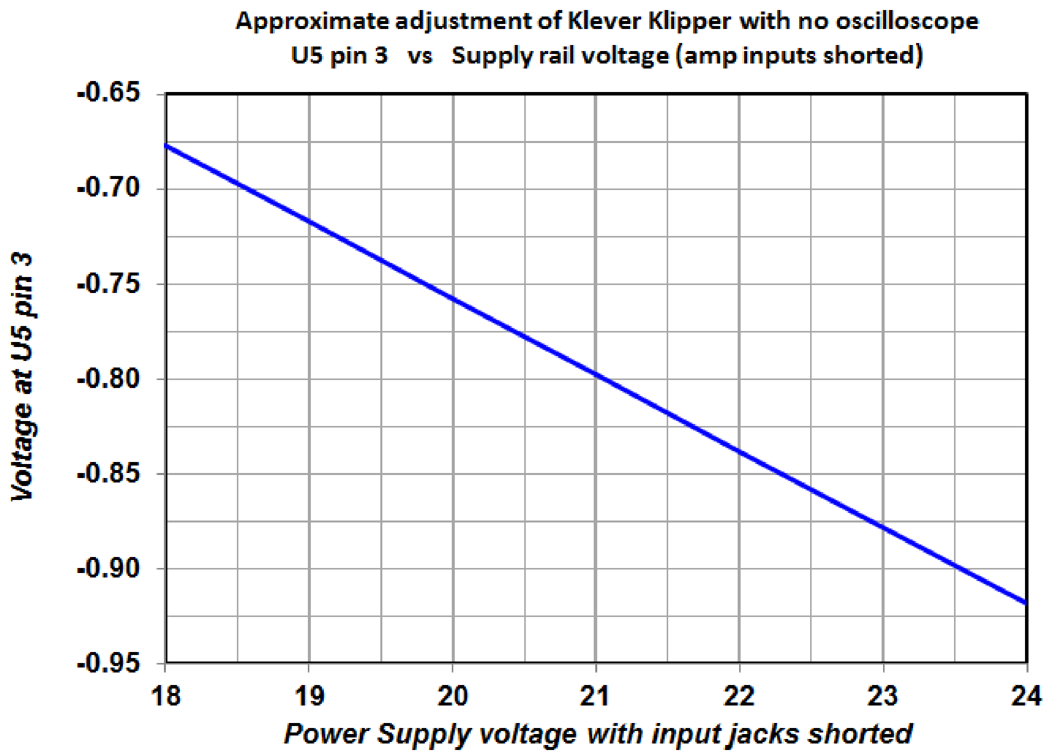


Figure 9: Left portion of Figure 8, magnified

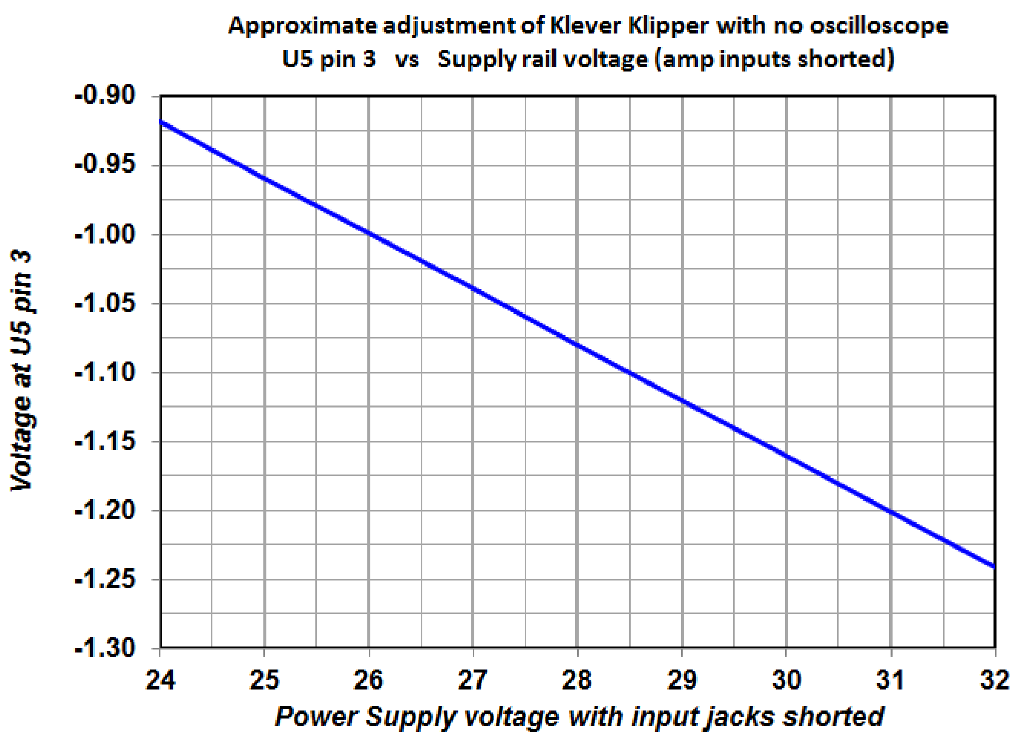


Figure 10: Middle portion of Figure 8, magnified

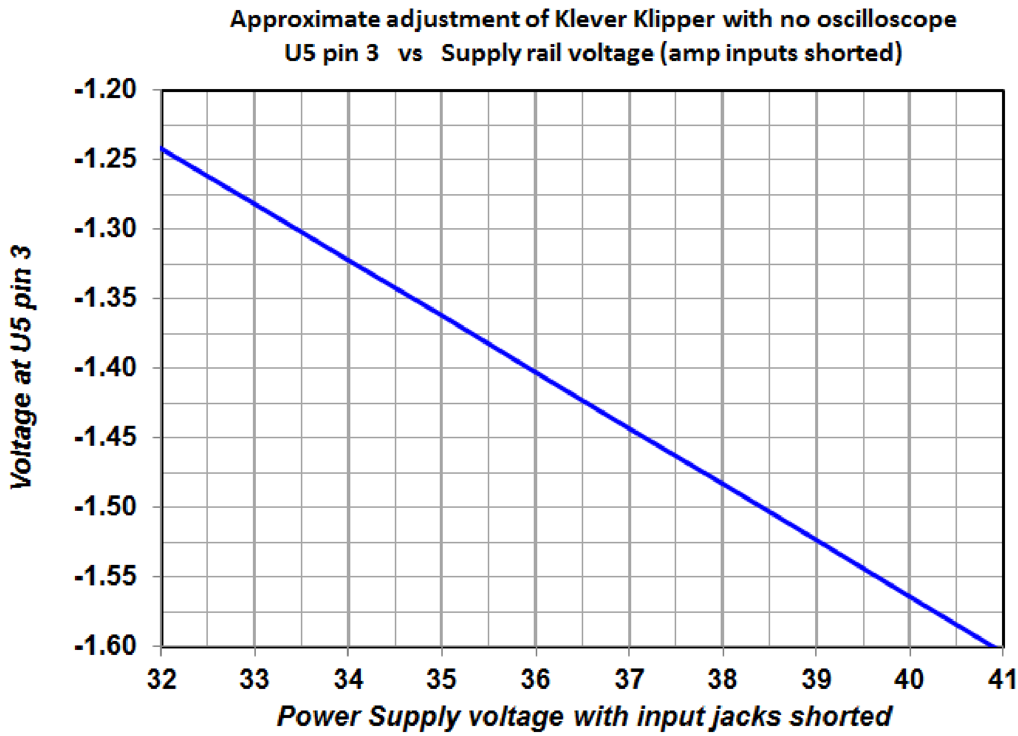


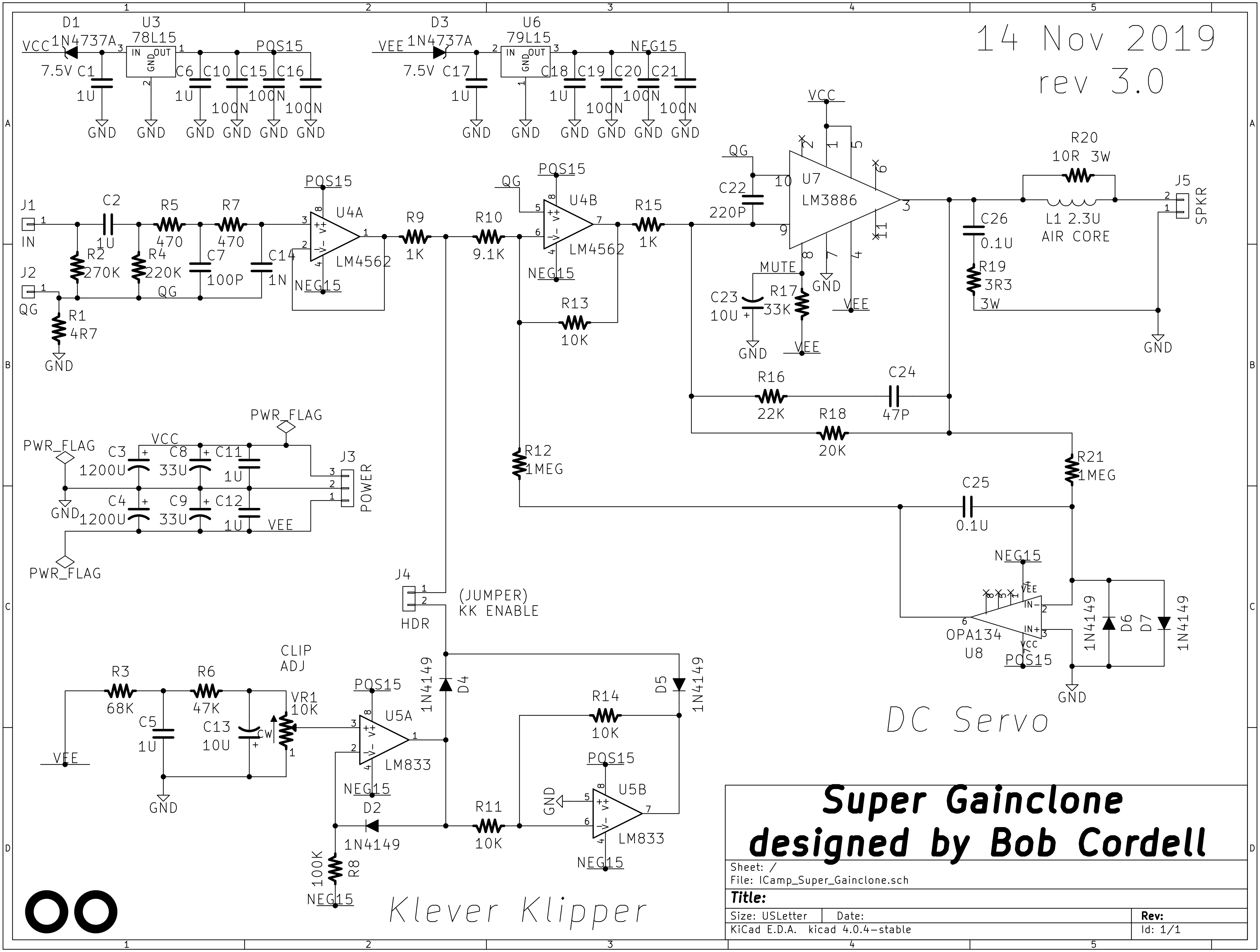
Figure 11: Right portion of Figure 8, magnified

Schematic Diagram

A full-page schematic is presented on p.18

Drilling Template

A full-page drilling template is presented on p.19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rev 3.0
D1
1N4737A
7.5V
VCC
U3
78L15
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OUT
GND
C1
1U
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1U
C10
100N
C15
100N
C16
100N
POS15
GND
D3
1N4737A
7.5V
VEE
U6
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C18
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C26
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3R3
3W
J5
SPKR
R16
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C24
47P
R18
20K
R12
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R21
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C25
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C3
1200U
C8
33U
C11
1U
C4
1200U
C9
33U
C12
1U
J3
POWER
J4
HDR
(JUMPER)
KK ENABLE
NEG15
OPA134
U8
D6
1N4149
D7
1N4149
DC Servo
CLIP
ADJ
R3
68K
R6
47K
C5
1U
C13
10U
VR1
10K
U5A
LM833
D4
1N4149
D5
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R14
10K
U5B
LM833
D2
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R11
10K
R8
100K
Klever Klipper
Super Gainclone
designed by Bob Cordell
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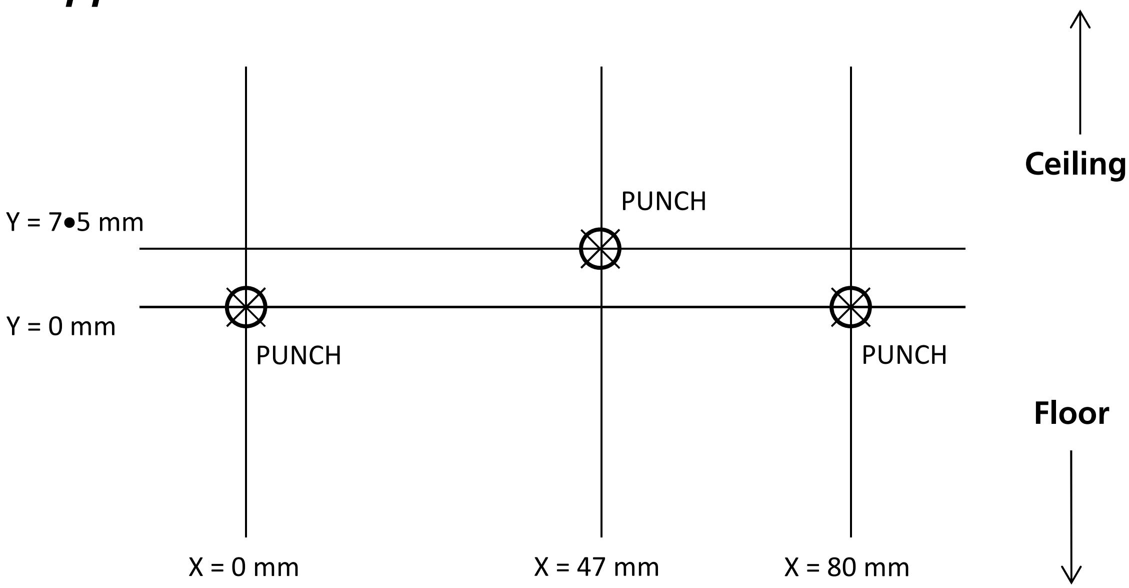
Date:
Rev:
KiCad E.D.A. kicad 4.0.4-stable
Id: 1/1

All holes 2.5mm diameter, then tapped for M3



Heatsink drilling guide for Super Gain Clone and Compact3886

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