

This document is extracted from the online DIY Audio Forums postings at: <u>http://www.diyaudio.com/forums/audio-sector/123003-commercial-gainclone-kit-building-instructions.html</u>

This thread idea started here: <u>http://www.diyaudio.com/forums/showt...69#post1500369</u> and is aimed to provide guidance in building a simple Gainclone amp.

While I'll be using as an example a commercial kit, there is nothing wrong with wiring the circuit point to point, without using printed board.

The basic kit contains printed board, 2 LM3875 chips, 8 resistors, 4 main filter capacitors and 16 diodes and is intended for dual mono application.

The boards have scoring lines separating amp and power supply sections, for now break them in half only, as it will simplify assembly.



The amp basic schematic shows only 4 resistors per channel.

R1 is optional and its value can be anything between 200R and 1k (or so). I usually don't install that resistor at all, placing piece of wire in its place. Alternatively, if you need coupling capacitor to protect the amp from DC that may be produced by a source component, a small electrolytic cap can be installed here: 4.7uF or bigger.



Identifying resistor values should not be a problem, as there are 4pcs that are 22k, 2 resistors are always longer, those would be 680R and the other two are 220R. You can also use a meter to check them out: it's good idea to choose out of four 22k, two that are close in value and use them for feedback (in place of Rf)

A resistor color band conversion table is attached.



The power supply section consists of 8 diodes per channel (we are discussing dual mono kit for now) and optional two small capacitors (10uF) which you may use, but they are not really required.



Since we covered the content of the kit, we can start soldering.

I usually use Kester rosing core solder, 0.020 (SN63PB37). For bigger jobs 0.031 is preferrable. I also use Wonder Solder for some specific projects.

If I can recommend one tool that is really helpful, it would be solder dispenser available from percyaudio.com . It is especially useful when both hands are busy and you need to use mouth to feed the solder.

As to soldering gun, a 40W would be maximum for such project and 25W more suitable.

I have 3 Hakko stations that simplify task, but for a beginner this is not needed.



I start with resistors, a set of tweezers is useful in forming leads and placing the parts, but not neccessary.

• D 0 00)• <u>•</u> • • d + 00 8-0-0 0

A close up, so you can't go wrong 😂



When soldering, place the tip of the iron on the pad and component pin and slowly feed the solder until a nice joint is formed.



Trim the leads after.



We do the chips and caps next.

The capacitors are polarized and their orientation is critical. Each electrolytic has one pin longer and this should be installed in a pad marked with + on the board. Also, the golden stripe marks the negative side and it installs opposite the +. When those caps are mounted the other way, after connecting power to the amp, they will explode.

Pin 1 and 4 on the chip are power pins and they connect to the planes in top layer. Please make sure that corresponding connection pads have enough solder in top layer as well.

That concludes the amp board. For Premium version of the kit, please check this link (currently, only blue mask boards are available, Black Gates are optional): http://www.diyaudio.com/forums/showt...425#post584425



If you are planning on dual mono power amp (separate transformer per channel) and simplified wiring, please install now 4 jumpers between amp board and power supply board on pads marked V+, PG+, PG- and V-.

I use bare copper 18ga wire.



The diodes are installed now and their orientation is critical as well. Make sure that metal tab is on a side of a white stripe marking the footprint.



This concludes the assembly and we have two separate amp channels with separate bridge rectifiers. All is needed now is to connect 2 transformers (one per channel) as per schematic posted here: http://www.diyaudio.com/forums/attac...amp=1210694958 , connect the input (SG for ground, IN for signal input) and output (OUT to positive binding post, OG to negative) and we have a working dual mono amplifier.

Pictured below, is one amp channel.



And this is how one complete amp channel looks when wiring is done. The transformer primaries are not connected yet, and I will explain it at later stages. I usually use 26ga solid core wire for input signal and I never found a need for shielded cable. I normally don't even twist them, but it's a good idea anyway. For speaker connections I use 19ga stranded wire.

See this table for American Wire Gauge Table:

http://cc.msnscache.com/cache.aspx?q...b17&FORM=CVRE2



These are some tools you may find useful for wire insulation stripping:



By stereo version I mean the use of a single transformer powering both channels. You could still use two separate rectifiers boards, but depending on wiring it may produce hum in some systems, so I always stick with a single rectifier board when using one transformer.

For demonstration purpose, I will install all the boards inside 3×1.5 " U-channel, 1.25" aluminum extrusion. For normal listening, this is enough to dissipate heat from the chips, and when things get hot, you can always attach it to larger aluminum panel.

I will show a version with a potentiometer, and without, so stay tuned.



The U channel is predrilled and components ready to install.



I like to use DeWalt pilot point drill bits, starting with a small hole and then increasing the size. Because of pilots, the hole locations can be wey accurate.

The other two tools are used for deburring.



I use 6-32 screws to mount the chips, which requires 7/64 tap drill. For tapping, I always use a cordless drill gun and presently, Tapmatic fluid. For more info on tapping see those posts: <u>http://www.diyaudio.com/forums/showt...9413#post69413</u>



I mount RCAs and binding posts first, and what you see is Cardas hardware. I use the cheapest RCAs: <u>http://www.cardas.com/content.php?ar...d=6&part_id=32</u> and to me they sound better than more expensive types.

As to binding posts, I prefer low mass ACBP S: <u>http://www.cardas.com/content.php?ar...=11&part_id=83</u>

When spade connectors are to be used, Patented Binding Posts are my first choice (CPBP CRS): <u>http://www.cardas.com/content.php?ar...=10&part_id=53</u>

Please note that isolation washers are used to separate connectors from a chassis. With RCAs, I don't use the ground tab; the wires are soldered directly to metal body.



It's time to install amp boards now.

There are two types of LM3875 chips: isolated package (LM3875TF) and non isolated

package (LM3875T). With the second one, isolation pad is required when mounting on grounded metal surface.

I use only isolated chips. Although pad is not required, one needs to apply heat transfer compound to improve heat dissipation from a chip to metal surface.

Don't use too much of that paste, only enough to fill the gaps. Also, the heatsink surface needs to be smooth and all burrs sanded out. I apply paste only to the chip, thighten pretty strongly; after half an hour realease the screw and this time tighten only moderately strong. Thick aluminum washer is used to improve contact.



Please note that in this particular assembly, the boards will be mounted only by attaching the chips. Further stability is obtained by applying double sided adhesive pads, which will secure caps against chassis wall.



and that how it's all done.



Here's wiring done for inputs and outputs. By proper internal layout we can minimize cables length. This is not critical, but won't hurt either 😂



Next, a version with potentiometer.

I've been using Noble pots for years; while they are not perfect, for the price they offer great value. Available from percyaudio and partsconnexion.

Most suitable value is either 25k or 50k (log taper, stereo). Picture below shows the connections, pin 1 & 5 are not being used in normal application (those are for loudness option)



And here how it's implemented in the amp.

I use SG (signal ground) on amp board as star ground for input signal. The ground wire from RCA and from ground pin on the pot (pin4) connect to SG. Signal wire from RCA goes to pin 2 on the pot, from pin 3 it goes to IN on amp board.

Those are the connections for one of the channels, the other channel is done exactly same way. Please note that so far the grounds are kept separately.



This is my test setup, where I'll show how to wire transformer and power supply. Please note that this is for demonstration purpose only, so you don't see a proper metal chassis.



Let's start with a transformer. I use Plitron 300VA, 2 x 22V AC in all my amps, both stereo and dual mono. It is is approx \$100 for a single unit. Getting similar Avel transformer from Partsexpress will cost you \$50/pc. If I order custom transformers, I prefer secondary at the core with wire diameter 1.8mm (for 300VA unit). I tested some amorphous core custom transformers and they sounded marginally better than standard core.



If your transformer comes with a standard mounting hardware, that's what you use.

Plitrons are epoxy filled and hardware is not included. I increase the hole to 3/8" size and install ancor nut with a matching screw, available from Home Depot. The screw hole size, in a bottom of a chassis, is 1/4".



You will also need power entry module and the two types I use most often are Q204 (on the left) and Q300, both available from digikey.com



I will start with connecting transformer primaries. In case of dual primaries, you can connect them either in parallel (to match 115V mains) or in series, to match 230V mains as per attached diagram (courtesy of Plitron).

The neutral wire from the mains connects to the transformer wire marked with dot, which is the start of the winding.

The wires are color coded, and may differ for other manufacturers.



My primaries are connected in parallel (the power module permanently attached to wooden board)



The Earth tab from power entry module is directly connected to metal part of the chassis. The mechanical connection may be required for safety reasons (no soldering), so check your local regulations.



Of course, don't forget about the fuse and use slow blow version. With 300VA transformer and no soft start, at least 4A rating is required (with 115V mains). In some instances even that blew occasionally so I normally use 5A SB fuses.

For 230V regions that would be half the fuse value.



This is how secondaries connect. For a given pair of wires (same secondary), it doesn't matter which wire connects to which pad, as long as the pads are marked the same (A1,A1 or A2, A2)



There is a spot for a LED on rectifier board and I like the small Panasonic LEDs available from DigiKey (part# P612). With those LEDs, 62K series resistor is required (R3 on rectifiers board, the long pin from the LED connect to square pad).

So the transformer is connected; before connecting rectifier board to the amp board we need to test voltages first.

If you didn't make any mistake, the simple test would be observing if LED lights up properly, but I will describe a more appropriate method tomorrow.



It's time to power up the circuit and test voltages.

With a new circuit, it's a good idea to increase mains voltage slowly, starting from 0V all way up to 120V and monitor current draw, voltages and components temperature. For that purpose I use Variac (Variable Auto Transformer). Alternatively you may consider "common 100 watt lightbulb wired in series with the mains supply" as described on Nuuk's site: http://myweb.tiscali.co.uk/nuukspot/...AQ.html#gcfaq1



We check the voltage between V+ and PG+





And between V- and PG- (black probe on PG)

If we measure approx. +/- 20V (positive will be lower because of LED) we are ready to connect amp boards.

Please note that voltages are much lower than expected beacuse of lack of smoothing caps.

If you have 10uF caps installed on rectifiers board both voltages would exceed 30V DC



The important aspect about sharing a single transformer and common rectifiers per two amp channels is power star ground.

While you could simply run PG+ and PG- (ground) wires from rectifier board to each amp board, in some setups hum problems were reported and presently I always use star (power) ground in all my amps.

I simply achieve it by connecting output grounds (OG, on the opposite side of speaker wire connection) with a 14ga solid core copper wire.

The center of that wire is my power star ground and both PG+ and PG- grounds from rectifier board connect here. In the picture below the connections are so short that I used single runs of wire, normally I use two wires for both PG+ and PG-.

Please note that power ground is also directly connected to the chassis.

I specifically refer to it as power star ground, as signal wires from RCAs are not connect directly here. They connect through separate traces on PCB to OG (output ground) pads.



More info on star and safety grounding was posted here: <u>http://www.diyaudio.com/forums/showt...92#post1509392</u>

If you need to implement ground break circuit between amp's power ground and chassis, you may consider the use of thermisor (CL60) as per F series of amps from Pass Labs.

I get my high gauge copper wires from electrical cables available at Home Depot.



We finish off by connecting power supply wires V+ (red) and V- (blue) from rectifier board to amp boards and this concludes the assembly.

Before we connect the amp to the speakers we need to test it.



Quote:

I specifically refer to it as power star ground, as signal wires from RCAs are not connect directly here. They connect through separate traces on PCB to OG (output ground) pads.

Should that read SG (signal ground) pads, Peter?

You are correct, wires from RCAs connect to SG (signal ground) pads. Signal star ground (on the board) connects with separate traces to OG pads, which are directly connected to the ground plane: <u>http://www.audiosector.com/images/Im3875_se_pcb.gif</u>

The first thing we do before connecting any speakers to the amp is measuring the DC offset. This can be done directly at the binding posts with no load connected. If the potentiometer is installed, the offset will vary depending on volume setting. This particular amp (right channel) measures 32mV offset when volume is completely down (input shunted to ground).



and 70mV when volume is at the maximum (15K combined input impedance of 50k pot and 22k input shunt resistor)

This is rather average chip when comes to offset, and for selected ones the offset is usually at 50mV or less at max setting.

The offset will be also lower when low impedance output preamp is connected.

When we switch the amp off and no speakers are connected, we can observe that for a moment or two the offset jumps pretty high to 4V or so. This is normal behaviour, and when load is connected (you may try it with 10R resistor across binding posts) the offset will stay low when turning the amp off.



We'll also measure the power into 80hm using dummy load connected to the amp's output $(4 \times 30R, 50w \text{ resistors})$ and feeding the amp with 100Hz sine wave. The measurement is taken before amp starts clipping.

At +/- 30.6V rails, the output voltage is approx 18V RMS with the input signal of 550mV. This translates into 40W output.

During such test, the heatsinks are way too small and the temperature rises substantially. At normal listening material and average levels though, the heatsinks are still fine.



We can also notice that with volume turned down, the rails are at 32.6V DC. So under full power they drop by 2V.



I do the same test for 40hm load (8 resistors in parallel) and initially we can see 56W power output with rails going down even further to 29.5V.



However, as the heatsinks warm up (and it happens really fast), the power collapses down to 10W or so. Those heatsinks are definitely not suitable for 40hm loads under full power.



The frequency response is approx 4Hz-240kHz (-3dB)

There is one other thing we can check tonight: lets disconnect one of the rails and see what happens with DC offset.

I disconnect the negative rail first.



Without any load connected, we measure 31.7V DC at the output.



After we connect the dummy load, the DC offset drops down to 75mV. In my test, it does not happen right away though, but takes approx a second or so for the voltage to drop.

I did try it with a test speaker and unfortunately the DC voltage was still present (at 24V or so)



With positive rail disconnected and no load the DC offset is approx 7V.



With test speaker connected, the voltage drops immediately down to 70mV and there is no danger whatsoever to the speaker.

The above findings are quite interesting and surprising. It was reported few times on a forum, that there is no danger to the speakers when one rail disappears, however, it seems like this is only the case with the positive rail. With a negative supply disconnected, I couldn't eliminate DC offset with my test speaker, although with a dummy load, the offset was going down indeed.

That Blaupunkt car speaker took 24V for at least 4 seconds many times over and still didn't suffer any damage 😂



Originally posted by Peter Daniel I do the same test for 40hm load (8 resistors in parallel) and initially we can see 56W power output with rails going down even further to 29.5V.

However, as the heatsinks warm up (and it happens really fast), the power colapses down to 10W or so. Those heatsinks are definitely not suitable for 40hm loads under full power.

I did the same test today with amp in a proper size chassis. A single channel was driven with 100Hz sine wave into 40hm dummy load. Just before clipping, I measured the output voltage.

Initially, the amp was producing 46W, after half an hour the power dropped to 37W (12.2 RMS voltage across the 4 ohm load). The sine wave was still reasonably clean and the chassis only moderately warm. The heatsink with power resistors (used as load) was close to 50deg in temp.

We can conclude that the amp with $2 \times 22V$ AC transformer will produce approx 40W into both 8 ohm and 4ohm loads (as measured).

The peak power should be much higher though.



Quote:

Originally posted by rfenergy What is your take on using/not using a Ci cap on your boards to control DC offset?

Would a potted resistor work to to decrease DC offset? and if yes , what would you use and where would it go in the signal chain?

In real life, the offset is quite low, especially with amp connected directly to preamp stage with low impedance buffered output.

I often measure chips for offset and it's quite possible to select them for less than 5mV offset in a given configuration.

Ci cap is in a signal path, and it will influence the sound basically same way as input coupling cap. That's why I prefer not to use it.

In a minimized GC circuit, I don't see a way to adjust offset with a trimpot. Lowering the input resistance will decrease the offset, but you might not want go too low with it.

Here're the DC offset values measured in a batch of 40 chips: top number at 0R, bottom at 15K input impedance



Re: parts

Originally posted by CFT

1) Noticed your suggestion on the value of snubber is 0.10hm/ 3.3nF. Could I use it on the 22,000 uF Panasonic TS that I already have on hand? (There is another set out there with value of 10hm/ 100nF, do they both yield similar results?)

2) The 22,000 uF caps will be shared by three chips. Since I have some extra 1,000 uF FC, is there any merit if I also use them right near each chip?

3) For I/P cap, I wondered if **4.7 uF BG NP** would be a better choice than for instance, Panasonic polypropelene or Auricap, etc.?

1 The use of snubber with chipamps was introduced by CarlosFM and he changed suggested values few times, I'm not sure what would be the difference between those two sets of values. I expressed my views on snubbers here: http://www.diyaudio.com/forums/showt...981#post838981

2 You may try adding small caps directly at the chips and the overall effect can be only assessed when listening to both setups (with small caps and without).

3 BG N 4.7/50 (or 10/50) is my first choice for coupling applications. The only other cap that I prefer is teflon V-Cap.

BG N is sensitive to orientation; I chose long pin for output.

Originally posted by rfenergy I have some caddock MK132 22k resistors, would these be ok for feedback resistors? Or do I need the 22.1k resistor?

Also I am thinking of ordered Antek brand 300VA 22+22 toroid transformers are these any good?

Or should I get the 400VA 22+22 version?

Caddock 22k would be the same as 22.1k. You may even use 24k and it won't make any substantial difference.

I'm not familiar with Anteks, but they look good on pictures. If there is not much difference in price, 400VA is proabably a better choice.

All PCBs are blue now. If I'm out of stock in tin plated, gold plated is supplied instead.

Originally posted by rfenergy

I have some 330pf 50V polystyrene caps for RF blocking if needed, they are big(5mm X 12MM). How do you mount the between pins 7 and 8? If needed will the big size cause other problems?

I don't think the big size will cause any problems, just mount them hanging in the air trying to reduce leads length.

The attached graph shows powers output vs supply voltage for different loads. Based on that, for 8 ohm speakers 2 x 22V AC transformer is recommended, and for 4 ohm speakers 2 x 18V AC transformer. In practice, I didn't find any drawbacks with using 2 x 22V AC secondaries with 4 ohms either, so that value can be a good overall choice. The amp will clip with 4ohm speakers when pushed hard, but you will soon learn not to push it on certain recordings (I had 2 or 3 such disks that I had to be careful about)

