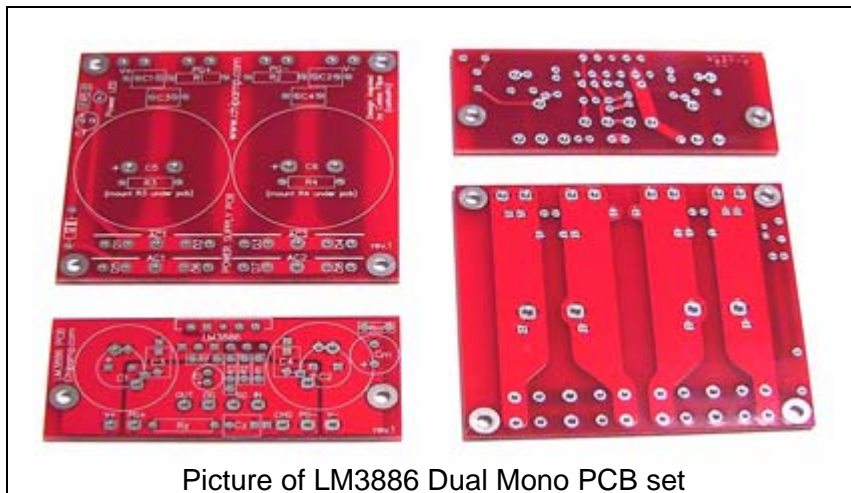


Users Guide for the Non-Inverted LM3886 Kit

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Picture of LM3886 Dual Mono PCB set

1 Introduction

Thanks you for purchasing the Non-inverted LM3886 kit/PCB. This kit has already been completed by several people with great results. This guide should offer an easy path for building a finished amplifier.

The power supply for the LM3886 is based off Carlos Filipe's Snubberized design, and works quite well with the LM3886. The supply will also work with all of the other gainclone designs.

Note: Please be extremely careful when dealing with power supply voltages. Use common sense, and follow proper procedure. It is highly recommended to assemble the power supply first, then test the voltage levels, before connecting the amplifier boards.

1.1 Terminology used in this document

Non-Inverting – Operational Amplifier (opamp) topology used in this kit. An opamp has 2 input terminals. If the input goes into the +input, then it is generally non-inverting, meaning that the output is in phase with the input.

Negative Feedback (NFB) – A technique used in most power amplifiers to set the voltage gain. The output is fed back into the negative input on the amplifier. The effect of negative feedback is to cancel out distortion and negate the effect from non-ideal characteristics. The NFB loop should be as short as possible. This leads to the NFB resistor not being placed on the PCB, and soldered directly to the device pins. On the Rev B board, the option of including the NFB resistor is included, but not required and the builder is encouraged to still solder the NFB directly as described in the following instructions.

LM3886 – Amplifier IC used in this kit. It is available in 2 different packages, insulated LM3886TE, and un-insulated LM3886I. The insulated package is usually preferred, due to the ease of use. Some people say that the insulated package also sounds better.

PCB – abbreviation for printed circuit board

Gain – Ratio of output divided by Input, expressed by: $A_v = \frac{v_{out}}{v_{in}}$

Gainclone – Amplifier using a chip amplifier, such as the LM3886 or LM3875.

PS – short for Power Supply.

LED – Light Emitting Diode

IC – Integrated Circuit (sometimes used to refer to chips)

IN – Input RCA connection to PCB

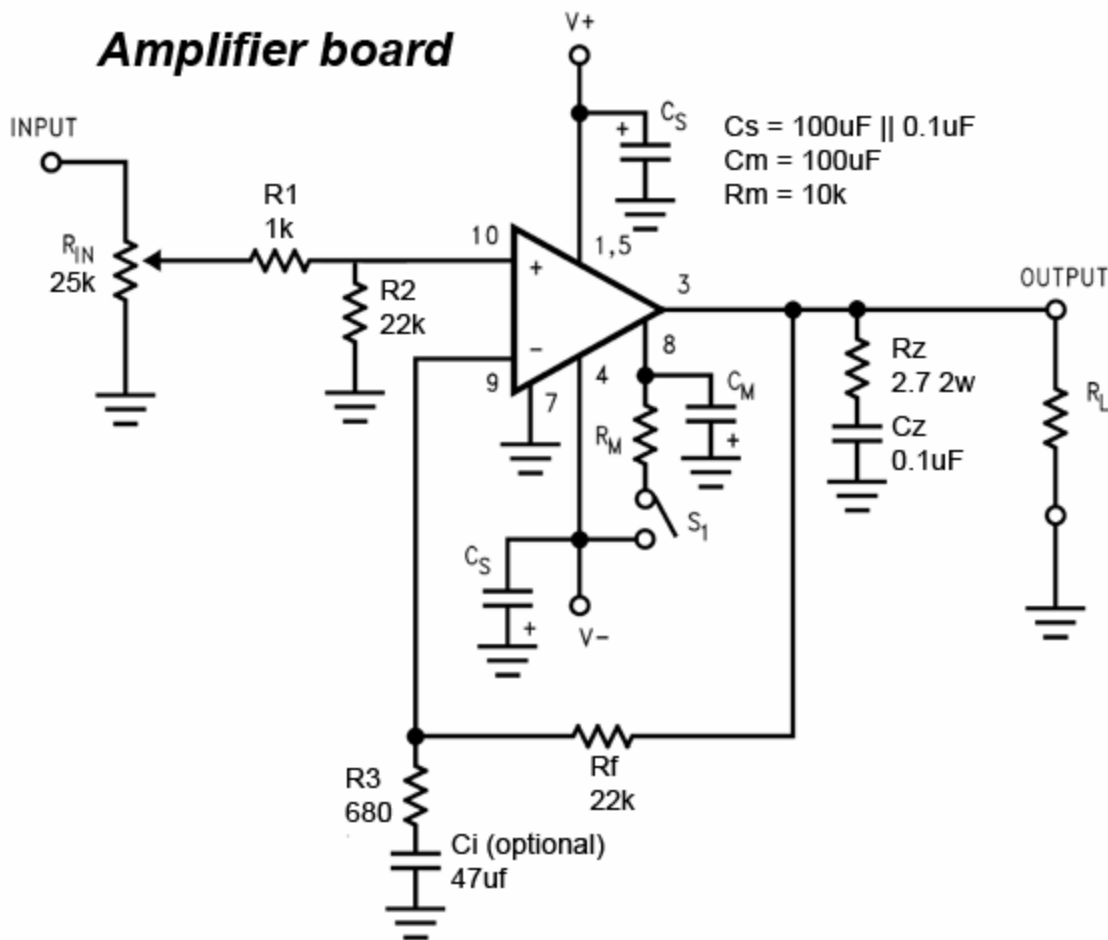
SG – Signal ground connection from RCA jack

OUT – output connection to output terminal +

OG – output ground connection to output terminal –

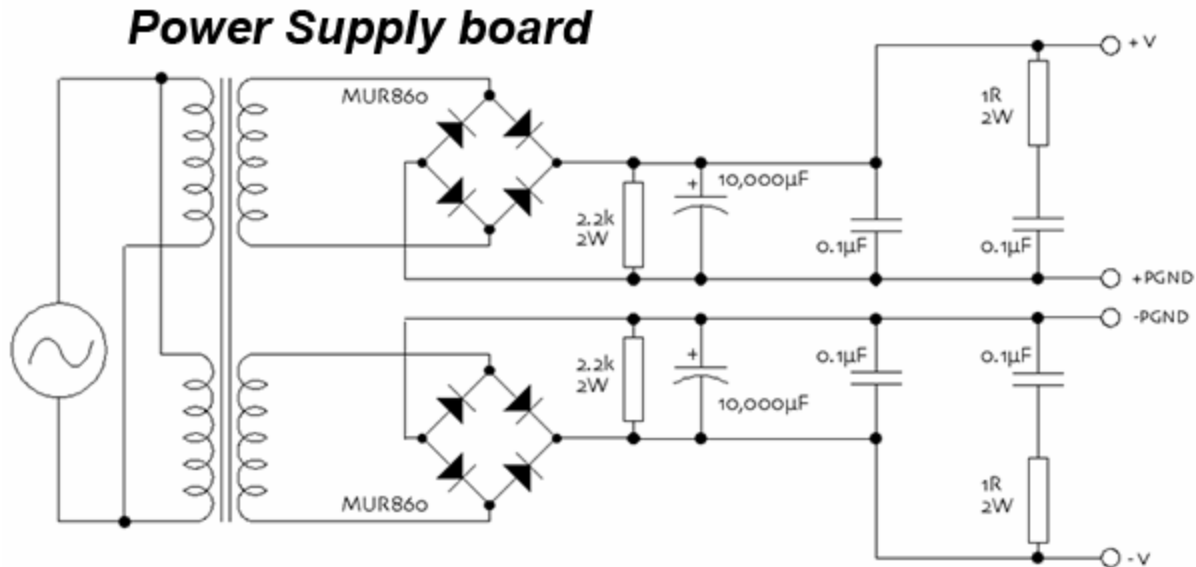
CHG – chassis ground connection to central chassis ground

1.2 Amplifier board schematic



R_{IN} = optional potentiometer in series with the input, for use as a volume control.

1.3 Power supply board schematic



Power supply board schematic based off of a design by Carlos Filipe (CarlosFM)

AC line fuse not shown in picture. Recommended AC line fuse: 3A slow blow for US and 2A slow blow for International use. The fuse should be placed in series with the AC primary hot wire between the AC jack and the transformer.

Building Instructions for the Kit

1.4 LM3886 Dual Mono Kit Contents (Snubber PS version)

Description	Quantity
LM3886 Amplifier boards	2
LM3886TF - National Semiconductor chip amplifiers	2
<u>Amplifier Part bag:</u>	1
22k ohm – Phoenix SFR16S resistors (R_2 and R_F)	4
1k ohm – Phoenix SFR16S resistors (R_1) – band colored black	2
680 ohm – Phoenix SFR16S resistors (R_3) – band colored blue	2
10k ohm – Phoenix SFR16S resistors (R_M) – band colored red	2
2.7 ohm 2w – Phoenix PR02 resistors (R_Z)	2
100uF 50v – Panasonic FC capacitors (C_1, C_2, C_M)	6
47uF 50v - Panasonic FC capacitors (C_i) [optional component]	2
0.1uf 63v – BC polypropylene capacitors (C_3, C_4, C_z) – small blue caps	6
<u>Power Supply parts bags:</u>	2
Power Supply boards (snubberized CarlosFM version)	2
10k ohm – Phoenix SFR16S resistors (R_5) – band colored red	2
1 ohm 2w – Phoenix PR02 resistors (R_1, R_2)	4
2.2k ohm 2w – Phoenix PR02 resistors (R_3, R_4)	4
MUR860 – On Semiconductor fast diodes (D1 – D8)	16
1N4004 diodes – On Semiconductor standard diodes (D9)	2
0.1uf 63v – BC polypropylene capacitors ($C_1 - C_4$) – small blue caps	8
10uF 50v - Panasonic FC capacitor (C_7)	2
Blue LED – Lite-on LEDs (Power LED)	2
Terminal blocks – 2 pin (for AC input)	4
10,000uF 50v – Panasonic TS-U 35mm x 30mm capacitors (C_5, C_6)	4

1.5 LM3886 Stereo Kit Contents (Snubber PS version)

Description	Quantity
LM3886 Amplifier boards	2
LM3886TF - National Semiconductor chip amplifiers	2
Power Supply boards (snubberized CarlosFM version)	2
<u>Amplifier Part bag:</u>	1
22k ohm – Phoenix SFR16S resistors (R_2 and R_F)	4
1k ohm – Phoenix SFR16S resistors (R_1) – band colored black	2
680 ohm – Phoenix SFR16S resistors (R_3) – band colored blue	2
10k ohm – Phoenix SFR16S resistors (R_M) – band colored red	2
2.7 ohm 2w – Phoenix PR02 resistors (R_Z)	2
100uF 50v – Panasonic FC capacitors (C_1, C_2, C_M)	6
47uF 50v - Panasonic FC capacitors (C_i) [optional component]	2
0.1uf 63v – BC polypropylene capacitors (C_3, C_4, C_Z)	6
<u>Power Supply parts bags:</u>	1
Power Supply board (snubberized CarlosFM version)	1
10k ohm – Phoenix SFR16S resistor (R_5) – band colored red	1
1 ohm 2w – Phoenix PR02 resistors (R_1, R_2)	2
2.2k ohm 2w – Phoenix PR02 resistors (R_3, R_4)	2
MUR860 – On Semiconductor fast diodes (D1 – D8)	8
1N4004 diode – On Semiconductor standard diode (D9)	1
0.1uf 63v – BC polypropylene capacitors ($C_1 - C_4$)	4
10uF 50v - Panasonic FC capacitor (C_7) (2 extras provided)*	1
Blue LED – Lite-on LED (Power LED)	1
Terminal blocks – 2 pin (for AC input)	2

1.6 Soldering Tips

(You are welcome to skip this section if you know how to solder)

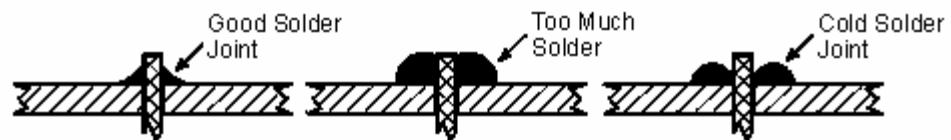
If you haven't soldered before, my recommendation is to find a friend to teach you. The best way to learn is to watch someone else solder and experience it first hand. It is important to have a decent soldering iron, as you don't want one that gets too hot or not hot enough. If your soldering iron is too hot, it can ruin the components on the boards, so if you are using an unregulated iron, I would not exceed 30 watts. Also make sure that your iron gets hot enough, as cold solder joints cause bad connections.

I like to use a temperature regulated soldering station, like the Weller WPTCT. It is a rather expensive iron (should be able to find it online for around \$100), but it should last a lifetime if you plan on doing more than just this project.

Recommended soldering procedure:

1. Simultaneously apply the tip of the iron and the solder to the circuit board so that they touch both each other and the wire being soldered to the solder pad. (working on the bottom side of the board)
2. When the solder begins to flow, remove the solder and hold the iron on the joint until the solder flows and bonds to the wire and the pad.
3. Pull the tip of the iron up so that it slides up the wire, leaving a nice smooth soldering joint.
4. Next, you will want to cut the excess wire off. Be sure to trim the wire just above the solder joint. You do not want to cut into the solder joint.

Here is a picture that I found on the web of a good soldering joint, and 2 bad ones:



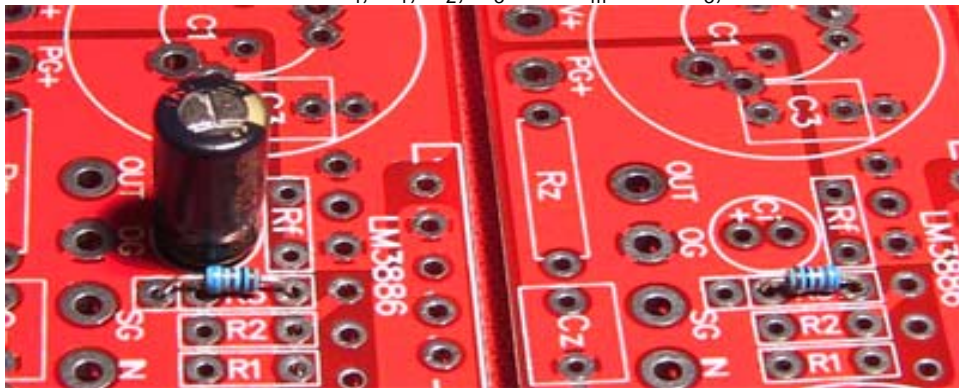
Additional tips:

- Liquid rosin flux might also work well. For anything that didn't come out nicely, you can touch with a brush wetted in flux and touch with the soldering iron. This will make it look nicer and remove any solder excess.
- If mistakes are made, or too much solder is used, desoldering braid is a very helpful tool. Simply hold the desoldering braid up to the soldered joint, and apply heat with the iron for removing unwanted solder. I prefer to use flux along with this to make the process go more smoothly.

1.7 Assembling the Amplifier PCB

As far as assembling the amplifier boards, it is best to start with the lowest profile components first. This allows for easy soldering.

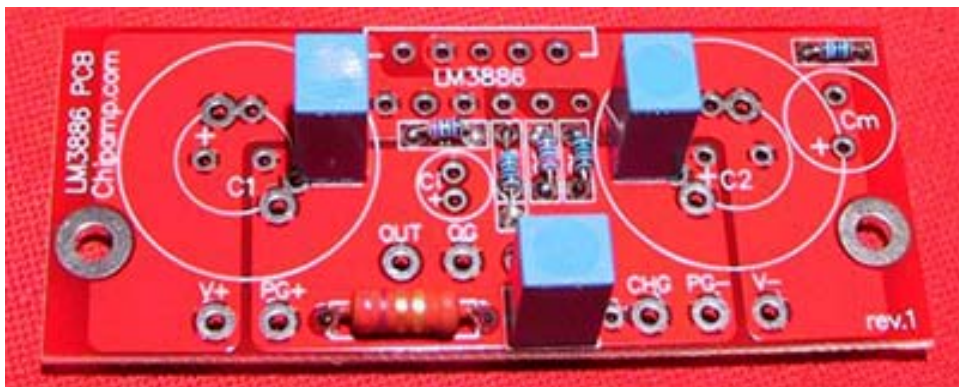
1. Install the small resistors R_f , R_1 , R_2 , R_3 and R_m . For R_3 , there are 2 choices:



- For using the standard configuration, R_3 is installed as shown on the right.
- For using the feedback capacitor, R_3 is installed as shown on the left.

As for the preferred configuration, the standard configuration has been said to sound better, but lower DC offset can be obtained through using the feedback capacitor.

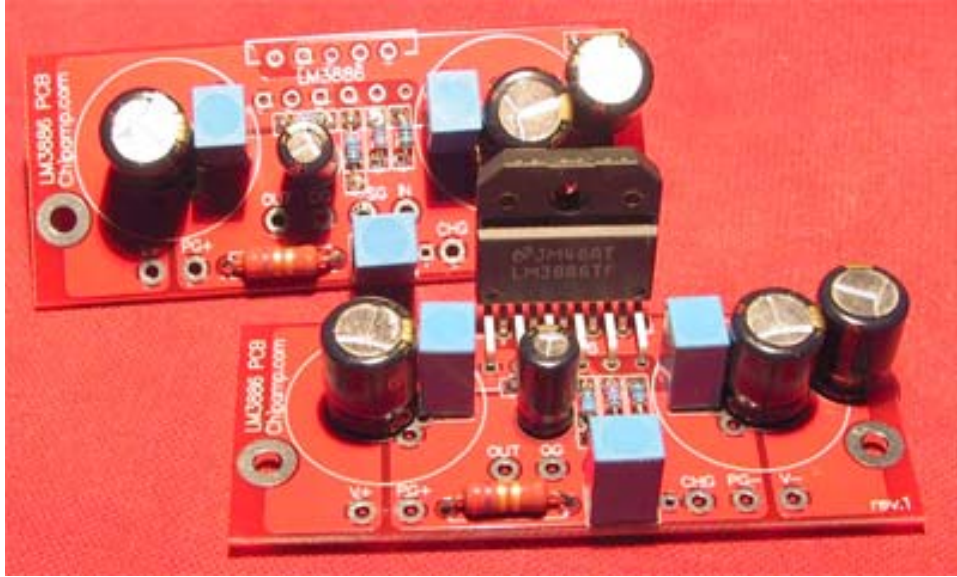
2. Install the larger 2w resistor R_z .
3. Install the 0.1uF capacitors C_3 , C_4 and C_z



The pcb should look like this once you have completed step 3.

4. Install the 100uF capacitors C_1 , C_2 and C_m . Be sure to observe the polarity of these capacitors. The - side of the cap is labelled. Make sure to install the longer lead in the + pad on the pcb.
5. (optional) Install the feedback capacitor, C_i (observe polarity)

6. Install the LM3886 IC.



PCB during the process of assembling the LM3886 ICs

7. You should now have the boards assembled and ready to move to the next step.

1.8 Assembling the Snubberized Power Supply PCB

1. Install R_5 and D_9 for the LED power supply circuit. (observe polarity for D_9)
2. Install larger 2w resistors $R_1 - R_4$
3. Install the 0.1uF capacitors, $C_1 - C_4$
4. Install the Blue LED (observe polarity, there is an arrow ">" this points towards where the long leg is soldered in.)
5. Install the LED capacitor, C_7 (observe polarity, longer lead = +)
6. Install the MUR860 diodes $D_1 - D_8$ (observe polarity, bar = metal side orientation)
7. Install the large power supply caps, C_1, C_2 (observe polarity, - side labelled on capacitor, + side labelled on pcb)
8. Install the terminal blocks on the bottom of the pcb

For pictures of the assembled Power supply pcb, see:

<http://www.briangt.com/gallery/snubber>

1.9 Picture of finished PCBs

You should now have all your boards finished for your amplifier and now be ready to assemble them in to a working amplifier. Here is a picture of a set of finished PCBs, ready for assembly:



Assembled PCBs (stereo configuration)

Once the soldering process is complete, I like to clean them up with some rubbing alcohol and a plastic brush. This will remove the rosin flux from the solder, and make the board look better. For older solders, the flux may be slightly conductive, so removing the flux will avoid any possible problems.

2 How to Turn the Assembled Kit into a Working Amplifier

2.1 Choosing a transformer

For the transformer, a transformer with dual secondaries producing between 18vac and 25vac is recommended. One DIYer has used a 2x30vac transformer without issues, but 2x25vac should work best for a wide variety of loads.

One can choose a variety of VA ratings and rail voltages. Keep in mind that after rectification, the rail voltages are somewhat higher than the non-rectified AC secondary rating of the transformer. The secondary voltage averages to $1.4 \times$ the AC voltage, minus diode losses. The transformer regulation is also a factor, dependent on the size and regulation characteristic of the transformer in question. Suffice it to say that a commonly used 18V transformer results in approximately 25V rectified, while a common 22V supply produces around 34V rectified.

Referencing the National datasheet LM3886.pdf, you can find the practical maximum rail voltage rating for the average impedance of your speaker. The Output Power vs. Supply Voltage chart is a good indication of the maximum rail voltages for a given speaker that you will design to. When looking over the curves a speaker with a nominal impedance of 4 ohms tend toward 25V rails with a reasonable margin of safety, while voltages above 35V are still well within the range for 8 ohm speakers. This shows that transformers with 18-22V secondaries are well within reason for many common commercial and DIY speakers. A transformer with 25V transformer secondaries can also be successfully with less of a safety factor.

The VA ratings on transformers is also a consideration. Within reason, a larger transformer has more constant regulation under load, but this chip operates very successfully without extremely large transformers. Many have successfully used 160VA transformers, while the 220VA range seems to be adequate for almost all stereo implementations, not straining the transformer. The price point between 220VA and 330VA, however might lead one to purchase the larger of the two. Anything above this could be considered frivolous for a stereo pair, unless one happens to be on the shelf or in a surplus vendors stock. Don't be tempted to buy an extremely large transformer such as used for Class-A applications as it is simply not required. The fuse required will be dictated by the size of the transformer, due to the inrush current when power is first applied. A 2 amp slo-blo typically works fine for transformers around 220VA or less, while a 3 amp slo-blo fuse might be required if using a larger transformer.

Using an EI transformer or a toroidal transformer is up to the end user. Both have their advantages, but the common availability of toroids and their successful use in many designs makes them a common choice. If you have access to a good quality EI, don't be afraid to use it.

2.2 Wiring the power supply and installing into the chassis

1. Connect the Transformer primaries to the AC jack, with a fuse in series with the AC hot wire. The AC gnd connection should connect to the chassis ground location.
2. Power up the transformer and verify that the expected AC output is coming out of the transformer secondaries.
3. Connect the transformer secondaries to the power supply board and check the DC output voltage from the board. The blue LED should light up. If it doesn't light up, and DC voltages are measured from the V+, PGND+ output pads, then it is possible that the LED is installed backwards. In this case, remove the LED and reinstall.
4. Make the necessary Amplifier PCB connections:
 - IN (Input) -> RCA + input connection
 - SG (Signal Ground) -> RCA – (gnd) input connection
 - V+ -> V+ on power supply board
 - PGND+ -> PGND+ on power supply board
 - V- -> V- on power supply board
 - PGND- -> PGND- on power supply board
 - CHG -> chassis central ground point
5. Power the amplifier up without any load connected. Measure the output DC voltage between the + and – output terminals to verify that a low DC offset is obtained (usually < 100mV)
6. Connect source to amp and test speaker to test amp.
7. If all goes well, the amp is now finished!

2.3 Chassis Considerations

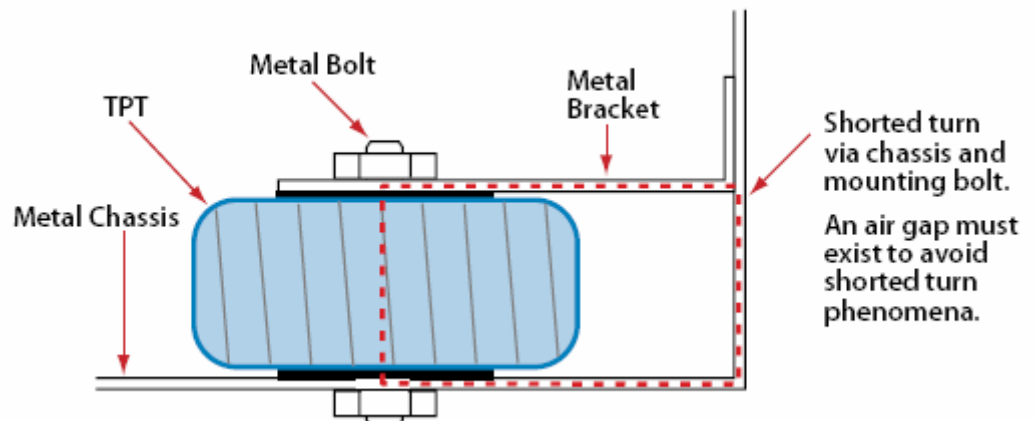
There are many options on chassis design. Much of this us up to the builder's taste, tools, budget and time. One fundamental issue which is the same, regardless of final design, is safety. The chassis keeps dangerous voltages from harming anyone or anything that is in the area of the amplifier.

The chassis must be properly grounded to the mains ground to prevent possibly lethal voltages from being seen on the chassis in the event of failure. Ground loops, which commonly are a source of hum in situations may still be alleviated by proper chassis layout, shielding and the use of a star ground. Stopping the source of hum is the only option, instead of disconnecting the chassis ground. At times, when connected to a complex system, hum can be caused by interfacing to coax cable used for video. Try disconnecting this cable from the system entirely and if this solves the problem, consider an isolation transformer for cable systems. Chassis layout also can affect hum. Keeping signal level wiring away from the transformer is a good place to start.

Just about anything which can safely isolate the user from the amplifier could be a viable chassis. Some great and creative examples can be found on www.briangt.com as well as other sites on the Internet. Some designs focus on aesthetics, while others offer simplicity and others focus on optimising various materials to provide a stable platform for the amp to subjectively sound its best.

The last consideration for chassis construction is heatsinking. This amplifier does not require huge heatsinks. Successful implementations have used computer heatsinks without fans, solid pieces of bar stock or aluminum angle and others rely on standard large heatsinks. An aluminum plate around 3" x 3" x 1/2" should be plenty for most applications if allowed to circulate in free air.

When attaching a torrodal transformer to the chassis, care must be taken to not create a shorted turn. This occurs when a ferrous (metal) object creates a loop through the center of the transformer. In the following example, eliminating the top metal bracket and using only the washer supplied with the transformer would eliminate the shorted turn.



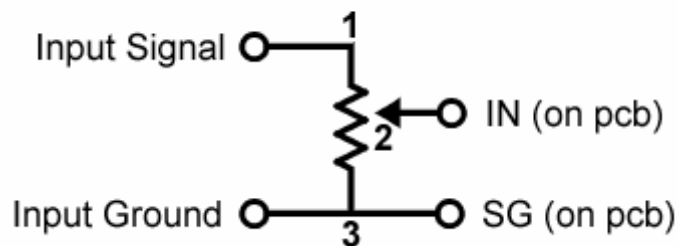
2.4 Volume Control

Volume control can be achieved by use of a receiver or pre-amp or via signal attenuation. An attenuator can be made using a potentiometer with a shunt resistor or a multi-position switch with various combinations of resistors to attenuate the signal to appropriate levels. If a switch is used, a make before break switch should be used to eliminate the possibility of popping when switching from one setting to another.

If a receiver or pre-amp is used and has sufficient gain, the amplifier could be overpowered and clipping could occur. If the volume control on the pre-amp gets extremely loud with small variation, lowering the gain of the amplifier is in order. Lower the gain of the amplifier by varying R3 per the equation $\text{Gain} = 1 + R_f/R_3$. The standard supplied gain set by R3 is 33dB. Gain should remain above 10dB to reduce the chance of the amplifier going into oscillation. To lower the gain, increase the value of R3.

The following diagram shows the wiring scheme for a typical three-leg potentiometer:

Potentiometer wiring diagram



Here is an example of a Noble stereo potentiometer:

