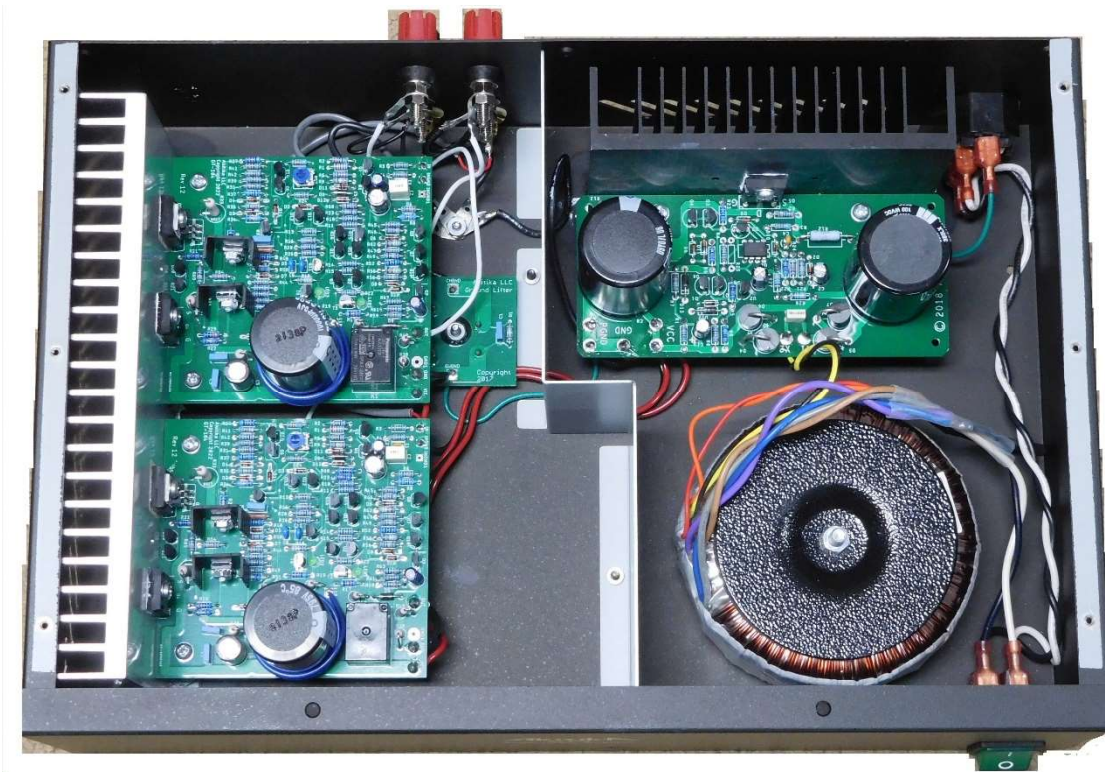


# Akitika

## ***GT-104 STEREO AUDIO POWER AMPLIFIER ASSEMBLY MANUAL***



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## **Section 1: About This Manual**

This manual gives the information you need to build Akitika LLC's GT-104 Stereo Power Amplifier. This manual applies to units shipped after June of 2023. The GT-104 delivers a total of 100 Watts in the form of 50 Watts per channel into 4-Ohm speakers. 3pXX revisions of the manual cover units shipped beginning in June 2023.

### ***Who Should Attempt this Project?***

You can build this kit if you can:

1. solder (using normal rosin core solder and a soldering iron).
2. use simple hand tools like screwdrivers, wire cutters, and pliers.
3. read and follow directions.

It helps if you:

1. know a bit about electronics, or
2. have a friend who knows a bit about electronics
3. can get to YouTube to watch a few helpful videos about the assembly process

### ***Tools You'll Need***

You'll need the following tools:

1. Phillips screwdriver (#1 and #2)
2. pliers or nut drivers suitable for #6 hardware (5/16" nut driver or hex wrench).  
Note that the 5/16" nut driver is also the correct size for the speaker binding post nuts.
3. needle nose pliers (helpful, but not strictly necessary)
4. pencil type soldering iron of 25 to 50 Watts (no soldering guns or blowtorches)
5. wire cutters and strippers
6. multi-meter (strongly recommended to check resistor values!)
7. magnifying glass, if you're over 42!

### ***Project Overview***

The project consists of the following steps:

1. Build the Power Supply Regulator Board
2. Build left and right channel amplifier circuit boards.

3. Install and wire the circuit boards, switches, and connectors into the chassis.

### **Important Safety Notes**

By purchasing, using, or assembling this kit, you have agreed to hold Akitika, LLC harmless for any injuries you may receive in its assembly and/or use. To prevent injuries:

- Wear safety glasses when soldering to prevent eye injuries.
- Always unplug the power before working on the amplifier.
- Large capacitors hold lots of energy for a long time. Before you put your hands into the amplifier:
  - Pull the AC plug!
  - Wait 2 full minutes for the capacitors to discharge!
- Remove jewelry and rings from your hands and wrists, or anything that might dangle into the amplifier.
- If working in the amplifier, keep one hand in your pocket, especially if you're near the power supply or power supply wires. This can prevent serious shocks.
- Build with a buddy nearby. If you've ignored all the previous advice, they can dial 911 or get you to the hospital.

### **About Components**

We reserve the right to make design and/or component changes at any time without prior notification.

### **Recommended Solder**

The kit must be assembled with 63/37 (tin/lead) Rosin Core solder<sup>1</sup>. The recommended diameter is 0.031 inches. Kester p/n 24-6337-8800 solder is a very good choice.

### **Warranty**

With the exception of fuses, Akitika will replace for free any parts of a correctly assembled kit that fail within one year of the date of purchase when the amplifier has been used in home stereo applications. It is the responsibility of the kit builder to install the replacement part(s). This warranty applies to the original purchaser only. It does not apply to units that have been physically or electrically abused, modified without prior factory authorization, or assembled with other than 63/37 Rosin Core solder. Akitika LLC's liability shall in no event exceed the cost paid to Akitika LLC for the kit.

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<sup>1</sup> [https://en.wikibooks.org/wiki/Practical\\_Electronics/Soldering](https://en.wikibooks.org/wiki/Practical_Electronics/Soldering) has entries for both 60/40 and 63/37 solder blends. This reference calls out a preference for 63/37 because it is a eutectic solder, which it says is less prone to cold solder joints.

## Section 2: Building the Power Supply PCB

This section details the process of building the power supply circuit board. We start with an overview on this page. The specifics you need to start building begin on the next page.

Figure 1 shows the bare power supply PCB. Your PCB will probably be Rev 5 or later.

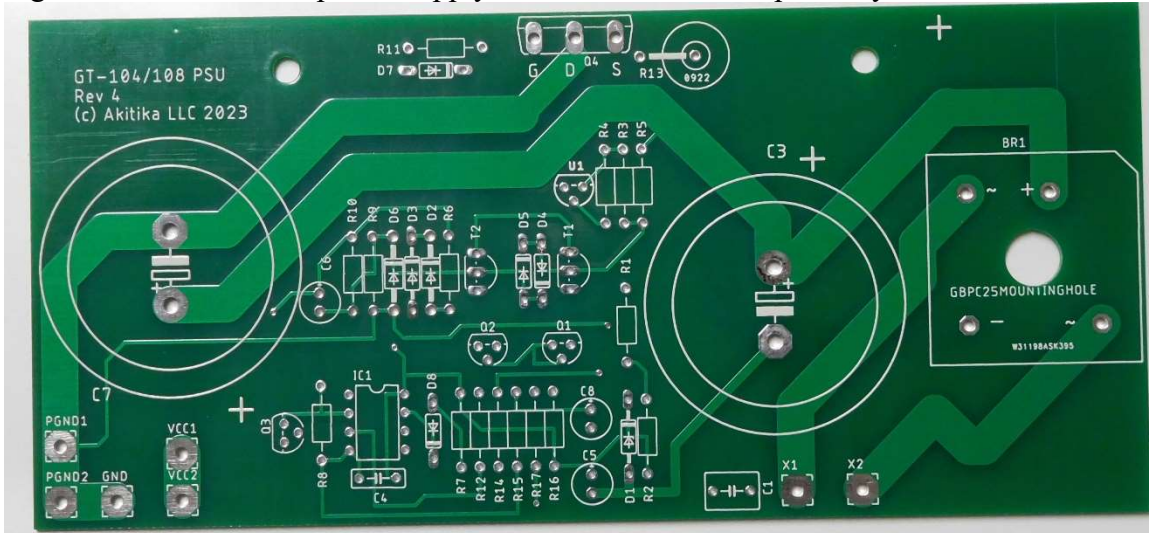


Figure 1-Component side of power supply PCB before loading

Begin by carefully emptying the contents of the envelope marked “GT-104 & 108 Power Supply” into a broad soup bowl, as shown below. You’ll start with the components that lay closest to the board, working your way towards the taller components. You will:

1. Install the resistors (all but one power resistor, left for later)
2. Install the diodes
3. Install the capacitors
4. Install the integrated circuits.
5. Install the transistors
6. Install the pass transistor Q4 as you mount the PCB to the heat sink.



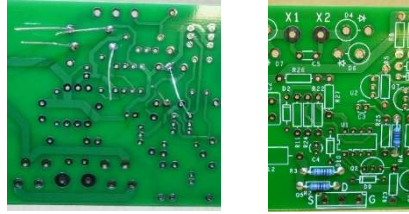
### Component Order

You’ll notice that the component designations in the directions don’t go exactly in order. We have grouped them so that all components with the same value appear together. This makes assembly easier. You’ll find in the parts kit that similar parts, e.g. 2 1K resistors, are typically (though not always) taped together.

### Install the Resistors

In general, you install the resistors by placing the body on the silk screen side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the resistors from falling out until you solder them in place. Try to bend the leads in a direction that won’t lead to solder bridges between traces that should remain disconnected.





**Figure 2-Installing resistors**

We recommend the following procedure:

1. Insert all the resistors of the same value, e.g. R1, R2, R5 and R6.
2. Bend the leads as described above.
3. Solder the leads on the back of the board.
4. Clip the leads just above the solder mound.

**Before installing any resistor, check its value with a meter**, and by reading the color code (See Appendix 1). Orient the resistor with the fat brown band on the right, then you can read both the Color Code column and the resistor from left to right. Track your progress by placing a check-mark in the done column as you install each resistor.

***The power supply envelope contains parts that would be used if you were building a GT-108 power supply. As a result, you will have a few parts left over when you've finished building the GT-104 power supply.***

¼ Watt, 1% resistors (if you use a lead-bending jig, use the 0.40" width)			
Designation	Value	Color code	Done? (✓)
R15		This location remains empty	
R8	1K	Brown, Black, Black, Brown, Brown	
R12	1K	Brown, Black, Black, Brown, Brown	
R17	4K99	Yellow, White, White, Brown, Brown	
R9	4K99	Yellow, White, White, Brown, Brown	
R14	6K81	Blue, Gray, Brown, Brown, Brown	
R1	8K45	Gray, Yellow, Green, Brown, Brown	
R2	8K45	Gray, Yellow, Green, Brown, Brown	
R4	20K	Red, Black, Black, Red, Brown	
R5	20K	Red, Black, Black, Red, Brown	
R6	10K	Brown, Black, Black, Red, Brown	
R10	15K0	Brown, Green, Black, Red, Brown	
R16	95K3	White, Green, Orange, Red, Brown	
R11	100	Brown, Black, Black, Black, Brown	
R7	120K	Brown, Red, Black, Orange, Brown	
R3	100K	Brown, Black, Black, Orange, Brown	

R13, a 0.1 Ohm power resistor, will be installed later in the assembly process.

### ***Install the Diodes***

Be careful to observe the polarity markings on the diodes. You'll notice that one end of the diodes has a band. That band indicates the cathode of the diode. Match the banded end of the diode with the banded end of the silk screen. The following information should help you identify the diodes.



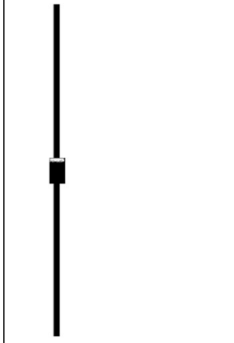
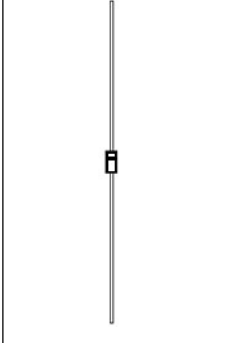
## Identifying the glass body diodes

The glass body diodes have the following identifying marks. If your vision is like mine, you may need good light and a magnifying glass.

- 1N4148 diodes have the number 48 visible.
- BZX55B20B, which are 20V Zener diodes, has the number 20 visible.
- BZX79-B10 has the number 10 visible.

Also, typically when these diodes are packed, you can preliminarily identify the types because:

- The 4 1N4148 diodes will typically be taped together.
- The BZX55B20B diode will be by itself.
- The BZX79-B10 diode will be by itself.

	
D2, D6 package type DO-41, opaque black plastic package	D1, D3, D4, D5, D7, D8, package type DO-35, glass package

Keep track of the diodes as you install them using the following table. Remember to watch the polarity of the diodes, matching the banded end of the diode to the banded end of the silk screen.

Designation	Type, Package	Description	Done? (✓)
D2	1N4004, DO-41	1A, 400 PIV, rectifier diode	
D6	1N4004, DO-41	1A, 400 PIV, rectifier diode	
D4	1N4148, DO-35	0.2 A, 100 PIV, switching diode	
D5	1N4148, DO-35	0.2 A, 100 PIV, switching diode	
D7	1N4148, DO-35	0.2 A, 100 PIV, switching diode	
D8	1N4148, DO-35	0.2 A, 100 PIV, switching diode	
D3	BZX55B20, DO-35	20 Volt 2% zener diode	
D1	BZX79-B10, DO-35	10 Volt 2% zener diode	

### Install the Bridge Rectifier

Install the bridge rectifier into the power supply PCB as shown on the right side of Figure 6. Make sure that the bridge sits flush to the PCB.

Designation	Value	Marking	Done? (✓)
BR1	25 Amp 600V	GBPC2506	

### Install the Last Resistor

R13 should be air-mounted, with the bottom of its body about 1/8" above the PCB.

2-Watt, 5% resistor			
Designation	Value	Marking	Done? (✓)
R13	0.1	0.1	

### Install the Small Capacitors

Now install the small capacitors:

<i>C5, C6, and C8 are polarized, showing a minus sign (-) on the negative end of the capacitor. Make sure that the minus sign faces away from the plus sign (+) marked on the silk screen for each of the capacitors.</i>			
Designation	Value	Description	Done? (✓)
C5	10 $\mu$ F	100V electrolytic (polarized), cylindrical shape	
C6	10 $\mu$ F	100V electrolytic (polarized), cylindrical shape	
C8	10 $\mu$ F	100V electrolytic (polarized), cylindrical shape	
C4	100 nF	50V, Z5U, +/- 20%, marked 104	
C1	10 nF	400V, film, 20%, box shaped, marked 10nk400	

### Install the Integrated Circuits

Install the integrated circuits.

<i>Orient IC1 so that pin 1 is nearest to the IC1 silk screen marking on the PCB.</i>			
<i>Orient U1 to match the silk screen outline.</i>			
Designation	Type	Description	Done? (✓)
IC1	LM258 or LM358	8 Pin DIP	
U1	TL431, TO-92	Programmable shunt regulator	
Be careful! Don't confuse U1 with the transistors. Make sure you see "431" on U1.			

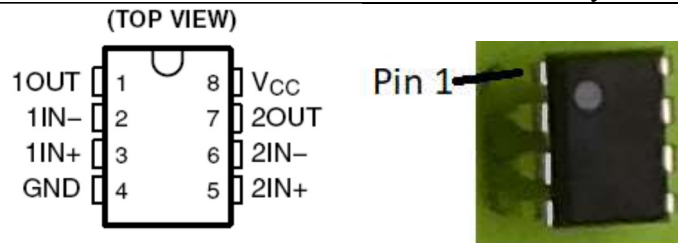


Figure 3-Pinout of U1, viewed from the top. Pin 1 is shown by either u-shaped mark or circle

### Install the Transistors

You may have to spread the outside leads a bit to make it easier to insert them into the board. Do not install Q4 now. It will be installed later.

*Orient the transistor so its body shape matches the silk-screen outline. Leave the top of the transistor about ½” off the board! The lead length prevents stress on the body and keeps the transistor safe from too much heat during the soldering operation.*

Designation	Type	Description	Done? (✓)
Q1	2N3904, TO-92	60 V NPN bipolar transistor	
Q2	2N3904, TO-92	60 V NPN bipolar transistor	
Q3	2N3904, TO-92	60 V NPN bipolar transistor	
T1	2N5401, TO-92	150 V PNP bipolar transistor	
T2	2N5401, TO-92	150 V PNP bipolar transistor	

*Don't use too much solder on the transistor leads. This is one place where the spacing is close enough that extra solder might cause short circuit between two leads on a given transistor. Note that Q1's collector and base are connected by the circuit board.*

## Install the Big Capacitors

Install C3 and C7.

*C3 and C7 are polarized. Be careful to get the polarity correct. Double check their polarity before you solder them in place. They have large terminals, so it will take a fair amount of heat and solder.*

Designation	Type	Description	Done? (✓)
C7	10,000 µF/80V	Electrolytic capacitor	
C3	6800 µF/100V	Electrolytic capacitor	

**Caution: C3 and C7 are not identical! Be sure to put each in its correct place!**

## Final Inspection of the Circuit Board

After you've taken a break, look over your completed circuit board one more time.

Looking on the component side, double check:

1. polarity (banded end) of diodes matching the banded end on the silk screen.
2. polarity of C3, C5, C7, and C8 (minus sign away from the indicated plus sign on the silk screen).

If you get one of these polarities wrong, there is a good chance that the power supply won't work, or there will be damage when you power it up.

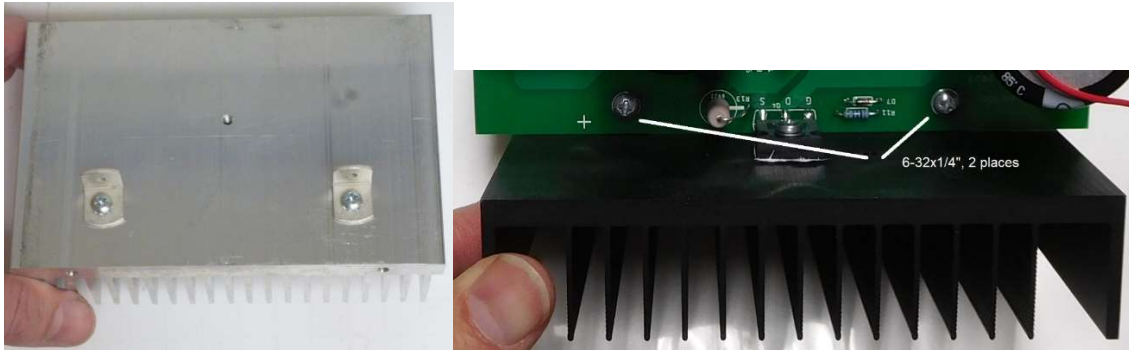
Look at the solder side of the board. Make sure that:

1. All component leads are soldered (it's easy to forget one or two, and that will cause either unreliable operation, or no operation at all!)
2. There are no solder bridges between pads which should be isolated. Solder bridges may stop the power supply from working correctly.

## Power Supply Final Assembly

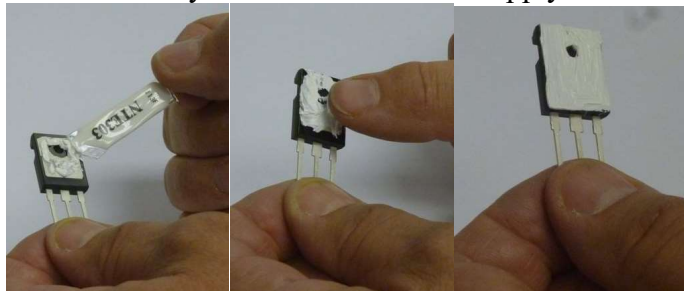
In this section, you'll install Q4 while you mount the power supply circuit board on its heatsink. Some kits have a silver colored finned heatsink. Other kits have a black-anodized heat sink. In either case, the power supply heatsink is about 5 3/8” wide. The kit

has one other silver colored double wide heatsink that that will be used for both amplifier modules<sup>2</sup>.



**Figure 4-Note the rounded brackets used for the power supply heatsink and PCB**

1. Use two 6-32x3/8" screws to fasten a pair of mounting brackets to the heat sink, placing the screw through the 9/64" clearance hole in the bracket. Note that one hole in the mounting bracket is a 9/64" clearance hole, the other hole is threaded to accept a 6/-32 screw. Don't tighten the screws yet. *Make sure you use the brackets with the rounded edges to mount the power supply PCB.*
2. Use two 6-32x1/4" screws to fasten the PCB to the mounting brackets and heat sink, Don't tighten the screws yet.
3. Place a thin film of thermal compound on the metal tab surface of Q5 as shown in Figure 5. Inset Q4 into the circuit board as shown in Figure 6. Secure it in place with a #6-32x1/2" screw, just finger tight for now. The side with the thermal compound must attach to the heat sink.
4. The previous step uses just a small amount of the thermal compound in the squeeze tube. Put the squeeze tube in a safe place, as you may choose to use the rest of its contents when you Fasten the Power Supply to the Chassis.



**Figure 5-Placing thermal compound on Q4**

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<sup>2</sup> Some kits may have instead been supplied with two separate black 4" wide heatsinks, one for each amplifier module.

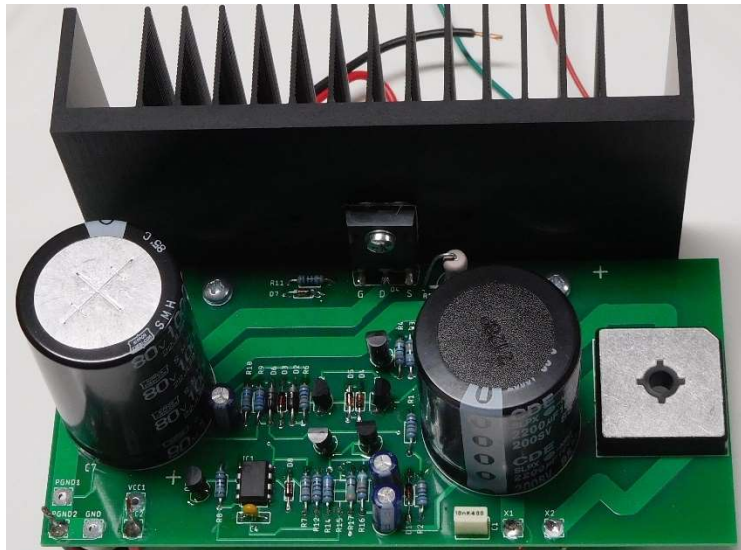


Figure 6-Installing Q4 on the heatsink and to the PCB

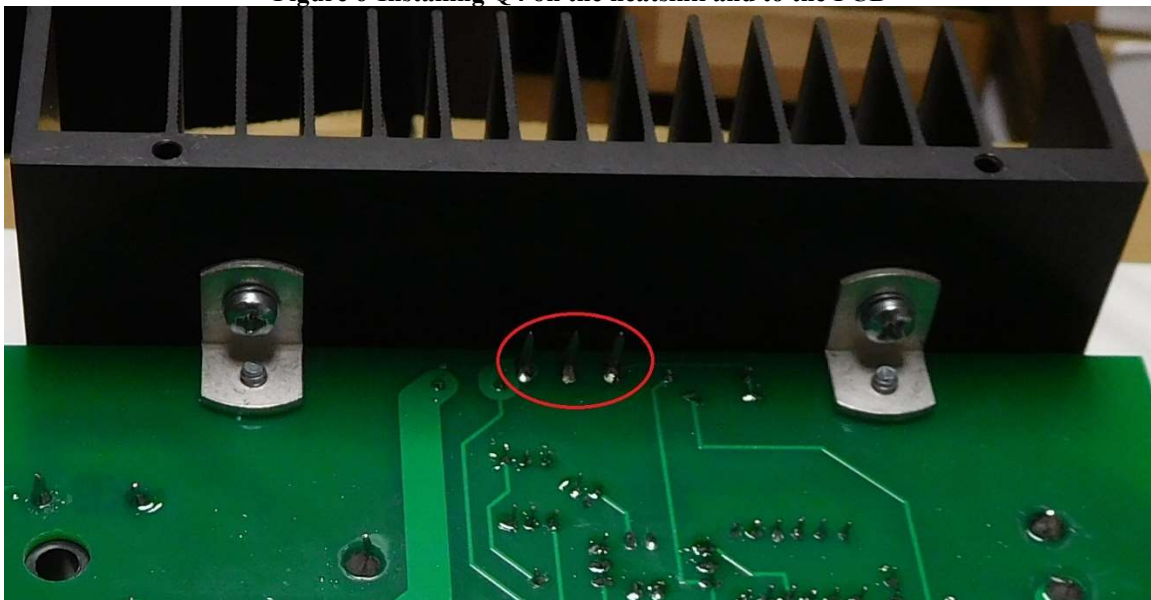


Figure 7-Remember to solder Q4's leads

5. Line up the PCB, brackets, and Q4 so everything is square and fits comfortably, then tighten the 5 screws:
  - a. 2 that hold the brackets to the PCB
  - b. 2 that hold the brackets to the heatsink
  - c. 1 that holds Q4 to the heatsink.
6. Solder the three leads of Q4 on the solder side of the board and clip the leads. Inspect your work from both the top and the bottom of the board to make sure there are no solder bridges between the leads.

Once the power supply/heat sink module is completed, set it aside and proceed to the next section, where you will build the amplifier modules.



## Section 3: Assembling the Amplifier Circuit Boards

This section details the process of building the amplifier module circuit boards. We start with an overview on this page. Begin by carefully emptying the contents of *one* of the envelopes marked “GT-104/GT-108 Amplifier Module Parts” into a broad soup bowl, as shown in Figure 8.

In general, you’ll start with the components that lay closest to the board, working your way toward the taller components. You will:

1. Install the resistors.
2. Install the small capacitors.
3. Install the diodes.
4. Install the LEDs (watch polarity)!
5. Install the medium size capacitors.
6. Install the transistors.
7. Install the big capacitor.
8. Wind and install the output inductor.
9. Install the relay.
10. Install the power transistors.



Figure 8-Empty the amplifier components into a soup bowl.

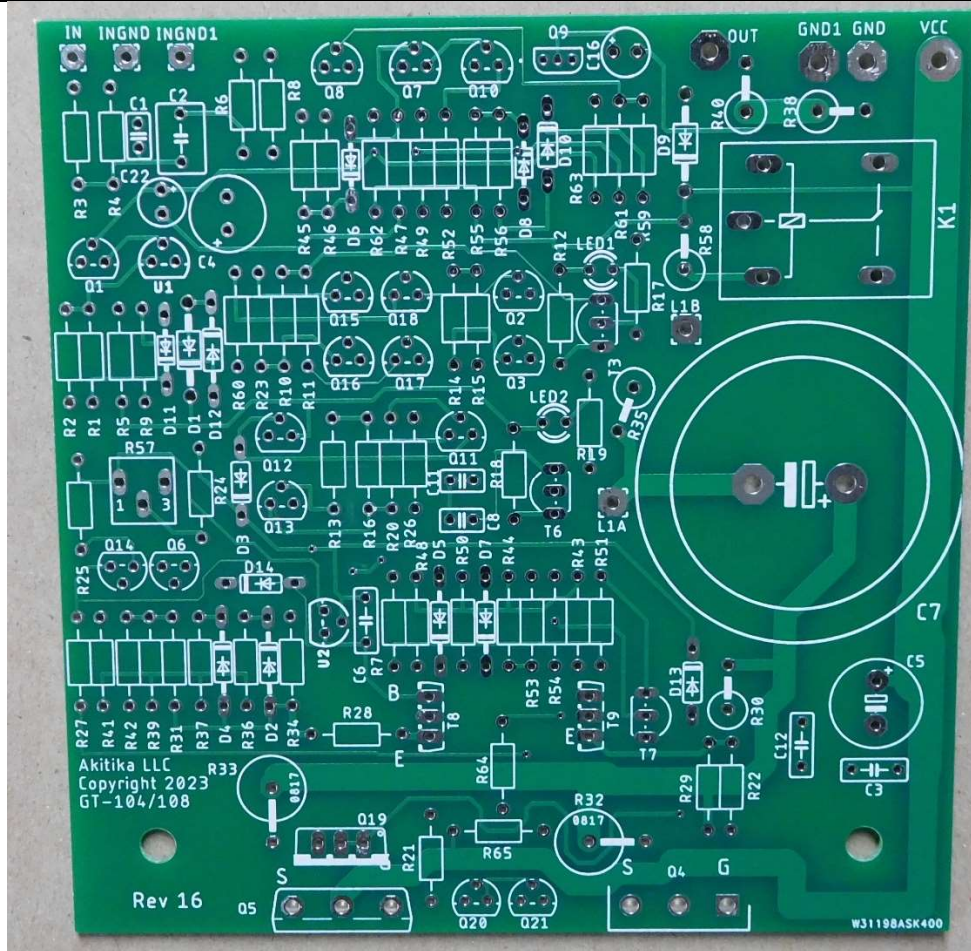


Figure 9-Close-up of bare Amplifier PCB

## Install the Resistors

In general, you install the resistors by placing the body on the silk screen side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the resistors from falling out until you solder them in place. Try to bend the leads in a direction that won't lead to solder bridges between traces that should remain disconnected.

We recommend the following procedure:

1. Insert all the resistors of the same value, bending the leads as described above.
2. Solder the leads on the back of the board.
3. Clip the leads just a bit beyond the end of the top of the solder joint.

To track your progress, place a checkmark in the done column as each resistor is installed. Check resistor values with a meter *and* by reading the color code. Orient the resistor with the fat brown band on the right, then you can read both the Color Code column and the resistor from left to right.

Assembly begins with installing the small (1/4 Watt) resistors and will progress to the larger (higher wattage) resistors.

<i>Important Notes:</i>				
<ol style="list-style-type: none"> <li>1. <i>The GT-104 is a dual channel amplifier. You will build two identical channels. We've provided two Done columns, Done1 for the first channel you build, and Done2 for the second channel. We recommend that you build the channels one at a time, completing the first channel, then returning to this point to build the second channel.</i></li> <li>2. <i>With the exception of two resistors, a 1K 0.1% and a 20K 0.1% resistor, all of the 1/4 W resistors have 1% tolerance. The two 0.1% resistors are listed at the end of the table.</i></li> <li>3. <i>Save time and make it neater if you use the 0.4" setting on a lead-bender.</i></li> </ol>				
Designation	Value	Color Code	Done 1	Done2
R22	24.9	Red, Yellow, White, Gold, Brown		
R34	49.9	Yellow, White, White, Gold, Brown		
R51	49.9	Yellow, White, White, Gold, Brown		
R16	88.7	Gray, Gray, Violet, Gold, Brown		
R10	100	Brown, Black, Black, Black, Brown		
R11	100	Brown, Black, Black, Black, Brown		
R14	100	Brown, Black, Black, Black, Brown		
R15	100	Brown, Black, Black, Black, Brown		
R52	100	Brown, Black, Black, Black, Brown		
R21	200	Red, Black, Black, Black, Brown		
R28	332	Orange, Orange, Red, Black, Brown		
R29	332	Orange, Orange, Red, Black, Brown		
R18	499	Yellow, White, White, Black, Brown		
R3	1K	Brown, Black, Black, Brown, Brown		



Designation	Value	Color Code	Done 1	Done2
R13	1K	Brown, Black, Black, Brown, Brown		
R12	1K	Brown, Black, Black, Brown, Brown		
R20	1K	Brown, Black, Black, Brown, Brown		
R31	1K	Brown, Black, Black, Brown, Brown		
R42	1K	Brown, Black, Black, Brown, Brown		
R53	1K	Brown, Black, Black, Brown, Brown		
R54	1K	Brown, Black, Black, Brown, Brown		
R37	1K5	Brown, Green, Black, Brown, Brown		
R48	1K5	Brown, Green, Black, Brown, Brown		
R36	8K06	Gray, Black, Blue, Brown, Brown		
R50	8K06	Gray, Black, Blue, Brown, Brown		
R2	10K	Brown, Black, Black, Red, Brown		
R5	10K	Brown, Black, Black, Red, Brown		
R26	10K	Brown, Black, Black, Red, Brown		
R45	10K	Brown, Black, Black, Red, Brown		
R61	10K	Brown, Black, Black, Red, Brown		
R63	10K	Brown, Black, Black, Red, Brown		
R64	12K7	Brown, Red, Violet, Red, Brown		
R24	15K	Brown, Green, Black, Red, Brown		
R39	15K	Brown, Green, Black, Red, Brown		
R41	15K	Brown, Green, Black, Red, Brown		
R43	15K	Brown, Green, Black, Red, Brown		
R44	15K	Brown, Green, Black, Red, Brown		
R23	20K	Red, Black, Black, Red, Brown		
R60	20K	Red, Black, Black, Red, Brown		
R9	24K9	Red, Yellow, White, Red, Brown		
R17	40K2	Yellow, Black, Red, Red, Brown		
R19	40K2	Yellow, Black, Red, Red, Brown		
R27	40K2	Yellow, Black, Red, Red, Brown		
R46	30K1 <sup>3</sup>	Orange, Black, Brown, Red, Brown		
R55	49K9	Yellow, White, White, Red, Brown		
R62	49K9	Yellow, White, White, Red, Brown		
R25	68K1	Blue, Gray, Brown, Red, Brown		
R4	100K	Brown, Black, Black, Orange, Brown		
R6	100K	Brown, Black, Black, Orange, Brown		
R47	100K	Brown, Black, Black, Orange, Brown		
R59	100K	Brown, Black, Black, Orange, Brown		
R1	110K <sup>4</sup>	Brown, Brown, Black, Orange, Brown		
R49	1MEG	Brown, Black, Black, Yellow, Brown		
R56	1MEG	Brown, Black, Black, Yellow, Brown		
R65	1MEG	Brown, Black, Black, Yellow, Brown		

<sup>3</sup> Sets relay pull-in voltage to 43 volts, appropriate for 60 Volt operation.

<sup>4</sup> Sets output quiescent voltage to 30 Volts DC, which is correct for nominal 60-volt rail.

## The following are 0.1% resistors

Designation	Value	Color Code	Done 1	Done2
R8	1K, 0.1%	Brown, Black, Black, Brown, Violet; In some kits, the resistor may have numbers: 1K 0.1% on a brown body		
R7	20K, 0.1%	Red, Black, Black, Red, Violet In some kits, the resistor may have numbers: 20K 0.1% on a brown body.		

## Install the Diodes

Now install the diodes. Here's what the 1N4004 diodes look like (not to scale):



And the rest of the diodes, with the exception of the LEDs, look like this:



*Be careful! Diodes have a polarity. Make sure the band on the diode aligns with the banded end of the silk screen!*

Designation	Value	Marking, type	Done1	Done2
D1	1N4004	4004, 1 amp 400 V diode		
D9	1N4004	4004, 1 amp 400 V diode		
D12	TZX6V2C	6V2, 6.2 V Zener diode		
D2	BZX79-10	B10, 10 V Zener diode		
D6	BZX79-10	B10, 10 V Zener diode		
D7	BZX79-10	B10, 10 V Zener diode		
D8	BZX79-10	B10, 10 V Zener diode		
D11	BZX79-10	B10, 10 V Zener diode		
D4	BZX79-C15	C15, 15 V Zener diode		
D5	BZX79-C15	C15, 15 V Zener diode		
D3	1N4148	4148, switching diode		
D10	1N4148	4148, switching diode		
D13	1N4148	4148, switching diode		
D14	1N4148	4148, switching diode		

Next, we install the LEDs (Light Emitting Diodes) – the green light from these LEDs will be of medium brightness, and thus visible in a normally lit room.

*Be careful! Light Emitting Diodes have a polarity, also! Read carefully to make sure you're putting the diodes in the right way!*

- For all LEDs, if the leads are uncut, the shorter of the two leads is the cathode.
- Viewed from the top, the circular outline has a flat side. That flat side is the cathode.
- Look at Figure 10. It shows that the flat side of the LED lines up with the number 1 or number 2 in LED1 and LED2.

Designation	Value	Package	Done1	Done2
LED1	LED, green	T1 LED package		
LED2	LED, green	T1 LED package		



Figure 10-Note flat side of LED package sits under number 1 and 2 in LED1 and LED2

### Small Capacitors

Designation	Value	Marking, Type	Done 1	Done 2
C3	0.1 $\mu$ F@100V	$\mu$ 1J100, small blue box shape, film		
C12	0.1 $\mu$ F@100V	$\mu$ 1J100, small blue box shape, film		
C6	0.1 $\mu$ F@100V	$\mu$ 1J100, small blue box shape, film		
C1	220pF COG	221, radial, COG, typically brown <sup>5</sup>		
C11	100p COG	101, radial, COG		
C8	100p COG	101, radial, COG		
C2	1 $\mu$ F@63V film	1J63, white box, film		



Figure 11-Capacitor Identification guide

### Power Resistors

The following resistors are power resistors, having a larger body than the ¼ Watt resistors installed in the previous section. These resistors are all mounted vertically as in the examples shown in Figure 12.

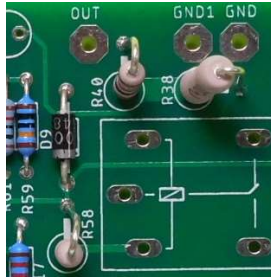


Figure 12-Vertical resistor mounting

R32	0.1@2W, 5%	Written on body		
R33	0.1@2W, 5%	Written on body		
R30	10@2W, 5%	10 Ω J		
R35	10@2W, 5%	10 Ω J		
R38	10@2W, 5%	10 Ω J		
R58	2K2@1W, 5%	Red, Red, Red, Gold		
R40	1K@2W, 5%	Brown, Black, Red, Gold		

## Transistors

Install the small signal transistors. Spread the leads a bit to make it easier to insert them into the board. **Double check their marking before you install them.**

*Orient the transistor so its body shape matches the silk-screen outline. Leave the **top** of the transistor about ½" off the board! The lead length prevents stress on the body and keeps the transistor safe from too much heat during the soldering operation.*

Q2	2N3904	NPN, 40 volts		
Q3	2N3904	NPN, 40 volts		
Q6	2N3904	NPN, 40 volts		
Q7	2N3904	NPN, 40 volts		
Q8	2N3904	NPN, 40 volts		
Q10	2N3904	NPN, 40 volts		
Q11	2N3904	NPN, 40 volts		
Q14	2N3904	NPN, 40 volts		
Q15	2N5401	PNP, 150 volts		
Q16	2N5401	PNP, 150 volts		
Q17	2N5401	PNP, 150 volts		
Q18	2N5401	PNP, 150 volts		
T3	2N5401	PNP, 150 volts		
T6	2N5401	PNP, 150 volts		
T7	2N3906	PNP, 40 volts		
Q12	2N5551	NPN, 150 volts		
Q13	2N5551	NPN, 150 volts		
Q20	2N5551	NPN, 150 volts		
Q21	2N5551	NPN, 150 volts		
Q1	J176	176, P channel JFET		

Q9 <sup>6</sup>	ZVN2110A or ZVN3310A	2110 or 3310, N Channel MOSFET 100 Volt		
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## Install the Voltage Regulators

Now install the voltage regulators. The two regulators have similar, but different part numbers. Make sure to get the right one in the right place. They are not interchangeable.

<i>Orient the regulators so their body shape matches the silk-screen outline. Leave the top of the regulator about 1/2" off the board! The lead length prevents stress on the body and keeps the regulator safe from too much heat during the soldering operation.</i>				
Designation	Value	Marking, type	Done 1	Done 2
U1	TL431	431, 2.5 V programmable regulator		
U2	TLV431	V431, 1.24 V programmable regulator		
<i>Don't confuse U1 and U2.</i>				

## Install the Speaker Coupling Capacitor

Now install the speaker coupling capacitor:

<i>Watch the polarity! Make sure the minus sign faces the place where K1 will be installed a few steps from now.</i>				
Designation	Value	Marking	Done 1	Done 2
C7	10000 $\mu$ F 63V	10000 $\mu$ F, 63 WVDC		

The speaker coupling capacitor will either snap or push into place. **Verify once more that you have polarity correct**, and then solder both terminals to the circuit board. This will probably take more heat, time, and solder than anything you have soldered up to now.

## Winding the Output Inductor

There...feel better? OK, let's go. Just follow these steps, **measuring the wire length carefully if you want to succeed on the first shot**.

1. Cut a 27.75" length of 18 AWG solid wire supplied with the kit. (The color may vary from the photo. The length will be about 30", so you'll have to carefully measure and cut the wire).
2. Strip back 3/8" of insulation from both ends of the wire. Be careful not to nick the conductors.
3. From the component side, place one stripped end of the wire into the L1A terminal. Bend it on the solder side to retain it, but don't solder it yet. Route it around the output capacitor as shown in Figure 13.

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<sup>6</sup>Viewed from the top of the package, be sure that the rounded edges of the package match the rounded edges on the silk screen.



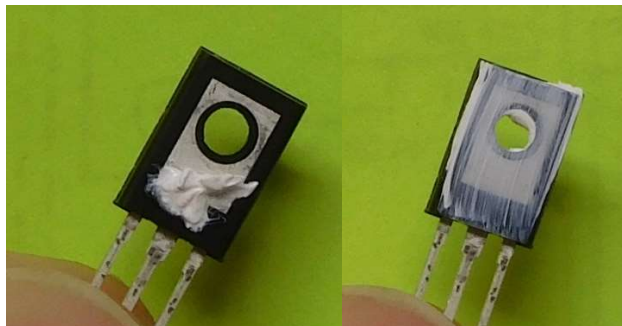
Figure 13-Winding the output inductor

4. Wind 6 turns of wire, closely spaced, so it looks like Figure 13. When you get to the end of the coil, fold the end across the existing turns, toward the L1B hole.
5. Pull the end of the wire through the L1B hole and solder it on the back of the board.
6. Solder the L1A side of the inductor to the PCB.

### Install T8 and T9

T8 and T9 are driver transistors, each with its own heatsink. Prepare the transistors with thermal compound before attaching them to a heatsink. Please refer to Figure 14.

- Place a small dab of thermal compound on the metal tab side of the transistor.
- Spread the dab into a thin film.



- **Figure 14-Spreading thermal compound on the metal tab side of the driver transistors**

*Please double check that the thermal compound is on the metal tab side of the transistor. Unsure if you have it right? There should be a zero-Ohm connection between the metal tab and the center lead of the driver transistors.*

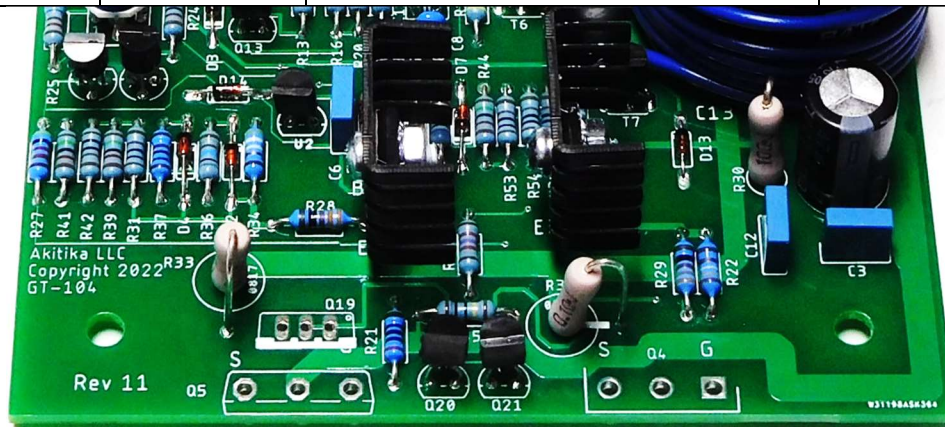




**Figure 15-mounting transistor (**

Mount the transistor as shown on in Figure 15. Attach the metal tab side of the transistor (the side that now has the thin film of thermal compound) to the heat sink. Use a 4-40 x 5/16” Phillips head screw and a 4-40 keps nut (keps nuts have captive lock-washers).

Designation	Value	Marking	Done 1	Done 2
T8	NPN Driver	MJE243 transistor marked JE243		
T9	PNP Driver	MJE253 transistor marked JE253		



**Figure 16-Installing T8 and T9 on the circuit board**

Leave about 0.1-0.2” between the bottom of the heatsink and the tops of the ¼ Watt metal film resistors. *Hint:* Start by soldering only the center leg. This makes it easy to adjust the transistor’s height. Once that’s correct, solder the two remaining legs.

### Install the Polarized Capacitors

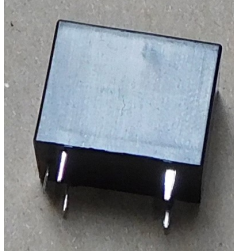
Designation	Value	Marking	Done 1	Done 2
C4	100 $\mu$ F, 50 V	100 $\mu$ F, 50 V, and minus sign for polarity		
C5	47 $\mu$ F, 100 V	47 $\mu$ F, 100 V, and minus sign for polarity		
C16	22 $\mu$ F, 50 V	22 $\mu$ F, 50 V, and minus sign for polarity		
C22	10 $\mu$ F, 50 V	10 $\mu$ F, 50 V, and minus sign for polarity		

### Install Relay K1

It’s important to get K1 installed flat onto the PCB. To do this:

1. Insert K1 through the PCB. It may be helpful to bend two corner pins to retain the relay until the pins are soldered.
2. Solder one corner pin. Make sure the relay sits flat on the board. If it doesn’t, push it in while you re-heat that pin.



Designation	Value	Marking	Done 1	Done 2
K1	SPST relay with 24 volt coil			

3. Solder the opposite corner pin and check again that all the pins have come through the PCB, and that the relay body rests flat on the PCB.
4. Finish soldering the rest of K1's pins.

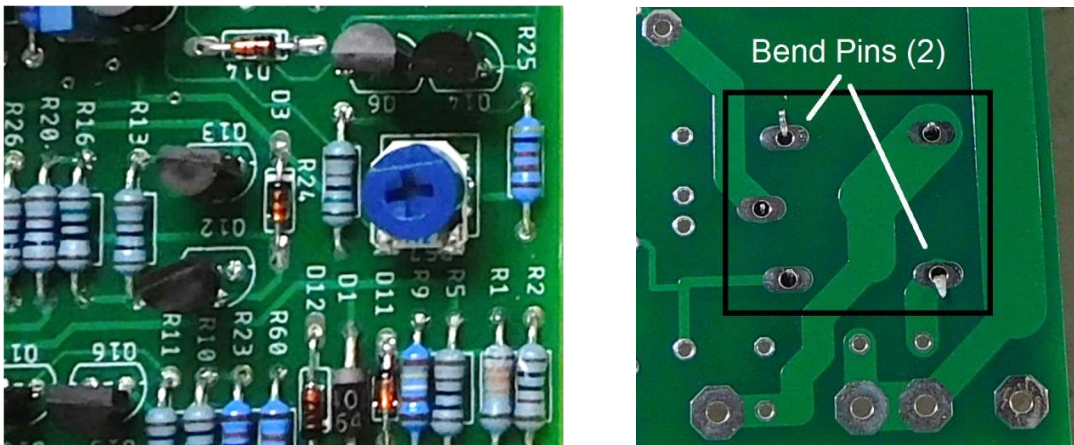



Figure 17-Bias pot and relay installation details

### ***Install Bias Pot***

Designation	Value	Marking	Done 1	Done 2
R57	Bias Pot			

Install bias potentiometer R57. Line up the leads carefully, then snap it into place. Solder the three leads on the solder side, as usual. Use a screwdriver to set the pot fully counterclockwise.

### ***Final Inspection of the Circuit Board***

After you've taken a break, look over your completed circuit board(s) one more time. Looking on the component side, double check:

1. polarity of diodes matching the banded end on the silk screen.
2. polarity (flat side of LEDs).
3. Polarity of the electrolytic capacitors.

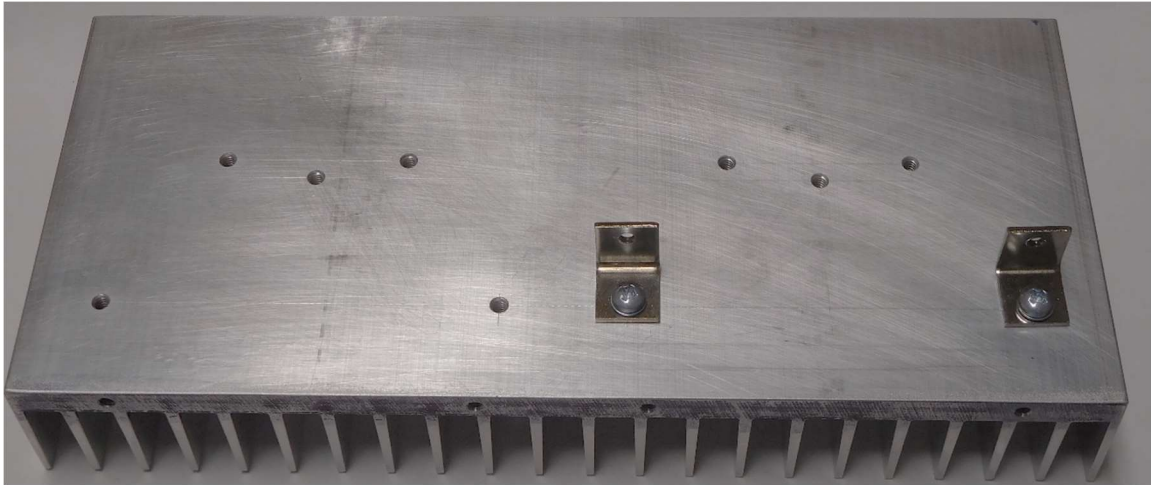
If you get one of these polarities wrong, there is a good chance that the amplifier won't work, or there will be damage when you power it up.

Look at the solder side of the board. Make sure that:

1. All component leads are soldered (it's easy to forget one or two, and that will cause either unreliable operation, or no operation at all!)
2. There are no solder bridges between pads which should be isolated. Solder bridges may stop the amplifier from working correctly.

### ***Install the Power MOSFETS and Mount the Amplifier Board to the Heatsink***

You'll repeat the process described in this section two times, once for each amplifier module. We'll show the details for the amplifier that mounts to the right-hand side of the heat sink<sup>7</sup>.



**Figure 18-Mounting assembled PCB to heat sink**

1. Use two 6-32x3/8" screws to fasten a pair of mounting brackets to the heat sink, placing the screw through the non-threaded hole in the bracket. Don't tighten the screws yet.
2. Use two 6-32x1/4" screws to fasten the PCB to the mounting brackets and heat sink. Don't tighten the screws yet.

### **Process Summary**

Following the details of this section, the result will be:

Designation	Marking	Comment
Q4	IRFP9140	Thermal compound
Q5	IRFP140	Thermal compound, insulator, and Q19
Q19	TIP32C	Mounts on top of Q5

<sup>7</sup> Paradoxically enough, this is connected to the LEFT channel ins and outs.

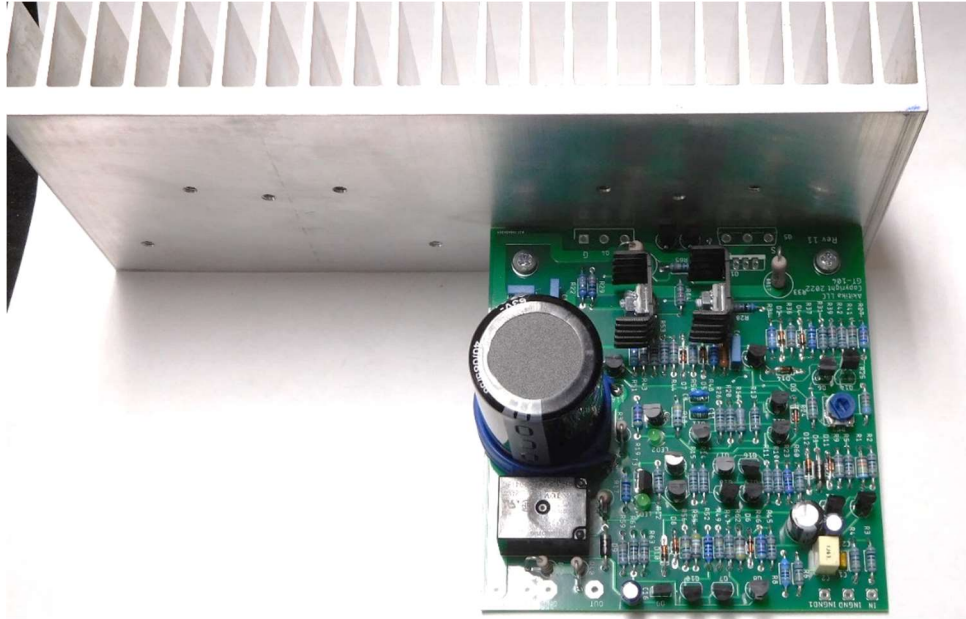


Figure 19-mounting the PCB to the heat sink

3. Place a dab of thermal compound on the back of the Q4, which is a **IRFP9140** power MOSFET and spread it into a thin film, being careful to keep the leads clean. This step uses just a small amount of the thermal compound in the squeeze tube. Put the squeeze tube in a safe place, as you may choose to use the rest of its contents when you fasten the amplifier heatsink to the chassis. **Note: Make sure you have the 9140, as swapping the two power mosfets will harm the amp.**

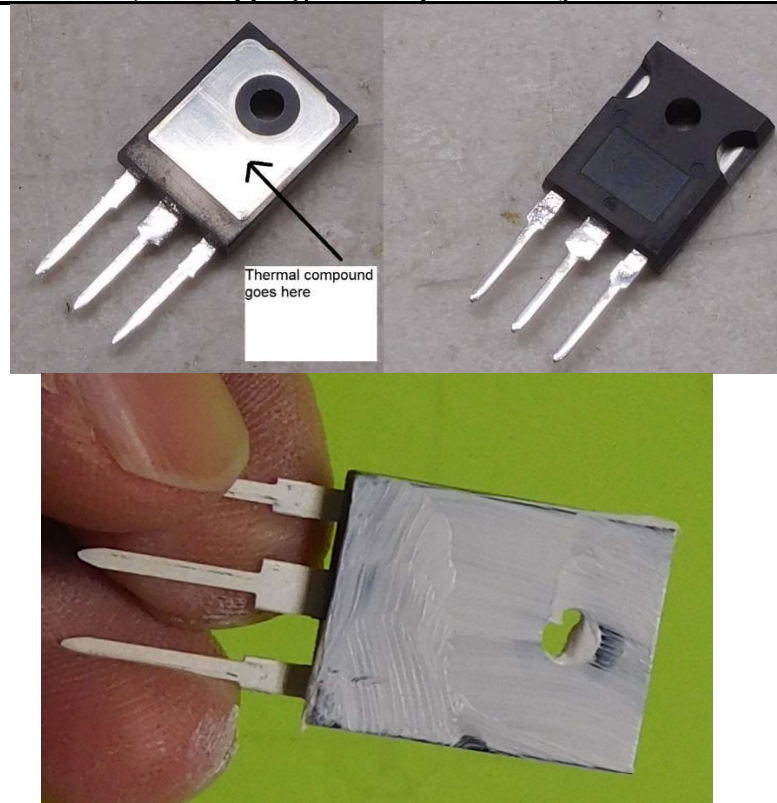
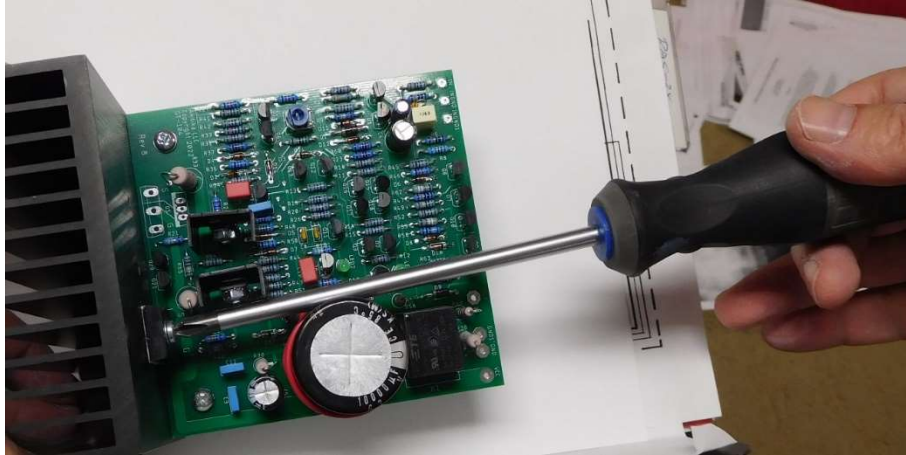


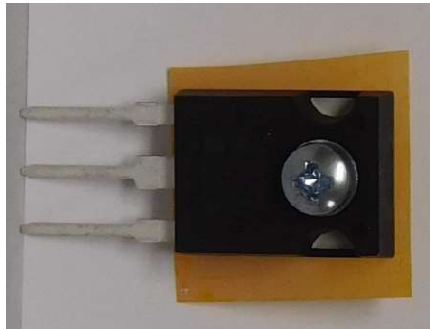
Figure 20-Spread a thin film of thermal compound on Q4 (IRFP9140), but keep it off the leads

4. Insert Q4 into the circuit board. Fasten Q4 to the heatsink using a 6-32x1/2" screw. You can thread a Phillips driver from the front to the back of the board to tighten this screw. Tighten all 5 mounting screws as you make sure that Q4 is perpendicular to the plane of the board.
5. Solder the 3 leads of Q4 on the solder side of the board.
6. If you previously moved T9's heatsink from vertical, return it to vertical so there is no chance for it to bump into T8's heatsink.



**Figure 21**-threading the screwdriver to Q4's mounting screw. Q4 is an IRFP9140. Check it!

7. Inspect your soldering from both sides, making sure that there are no solder bridges between the leads of Q4.
8. Locate Q5, an IRFP140, the insulator, and the 6-32x1/2" sems screw used to mount Q5 to the heat sink.
  - a. Insert the screw through Q5's mounting hole from the front side. Use that screw to locate the insulator onto Q5. For Q5, the insulator takes the place of thermal compound and it isolates the connection to the drain from the heatsink.
  - b. You'll notice that one side of the insulator is a bit tacky. I like to put that side toward Q5 as it keeps it in place while I'm assembling Q5 to the PCB and heatsink.
  - c. Assemble them as shown in Figure 22. Insert Q5 into the holes on the PCB and snug, but don't fully tighten the mounting screw. Solder Q5's leads into the PCB.



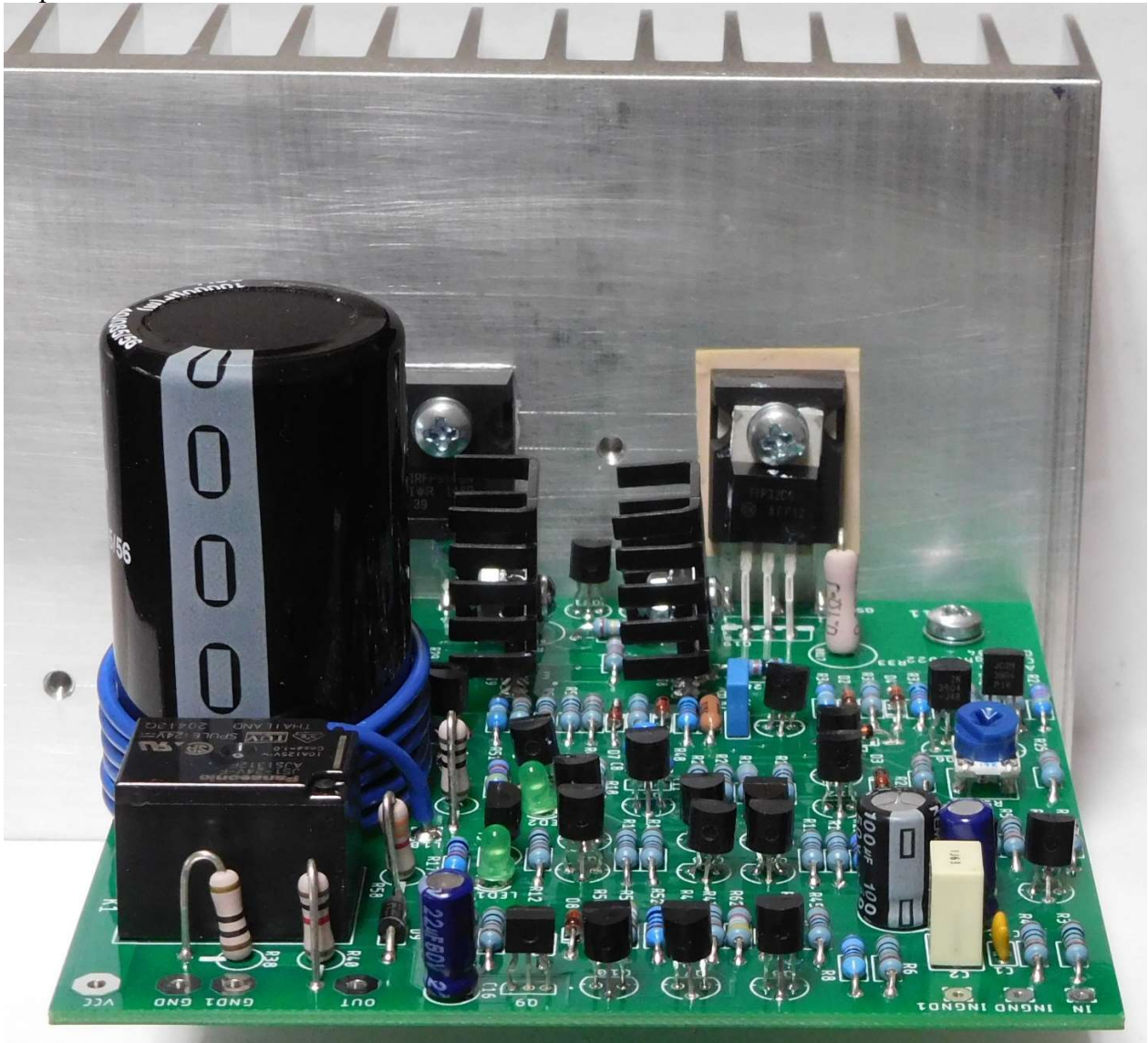
**Figure 22**-Q5 with 6-32x1/2" mounting screw and insulator

9. "Butter" the back of Q19, a TIP32C PNP power transistor with thermal compound.



10. Remove Q5's mounting screw carefully in order to keep its insulator in place. Place Q19's mounting leads into their PCB holes. Re-insert Q5's mounting screw thru Q19's tab, the body of Q5, and into the heatsink. Slowly tighten the screw as you push Q19's body to lay flat on Q5. The idea is that we want Q19 to be a good sensor of Q5's temperature. Tighten the mounting screw that holds Q19 and Q5 to the heatsink. Solder Q19's leads to the PCB.

You have just completed the first of two amplifier modules. Return to the beginning of Section 3: Assembling the Amplifier Circuit Boards to repeat the process to build the amplifier module for the second channel.



**Figure 23-first amplifier channel completed and installed**

Repeat the method as outlined above to attach the second amplifier circuit board and output devices to the large heatsink, beside the first amplifier. Figure 26 shows you how the result will look.

## Section 4: Wiring it All Together

Get out your trusty soup bowl and empty the contents of the “Top Level Hardware” envelope into it. The “GT-102 Wiring Kit<sup>8</sup>” is packed in the box, outside the chassis. It’s the source of all the wire used in this section.

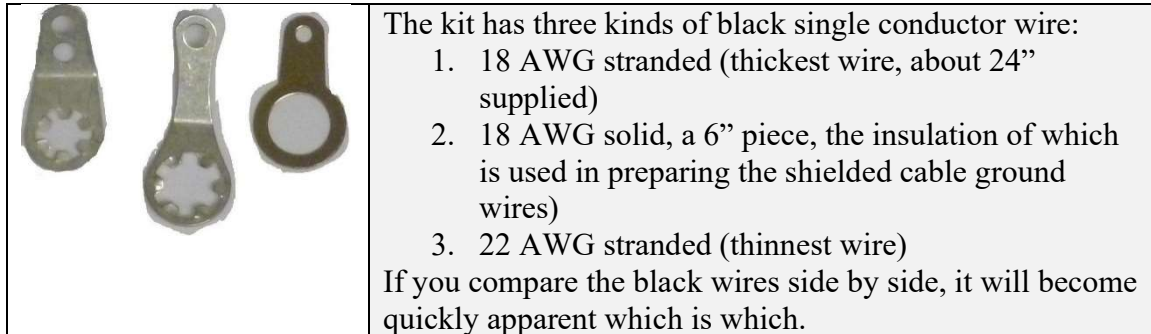


Figure 24—from left to right, #6 lug, #10 lug, RCA connector ground lug

### Attach the Power Supply Ground Wire

1. Cut a 7” length of black 18 AWG stranded wire. Strip 1/4” of insulation from both ends of the wire.
2. Insert one end of the wire into the GND eyelet (this is different from the PGND eyelets!) of the power supply PCB. Insert it from the solder side and solder it on the component side.
3. Tin the other end of the wire and insert it into the eyelet of a #6 lug. Crimp the wire and solder it to the lug.

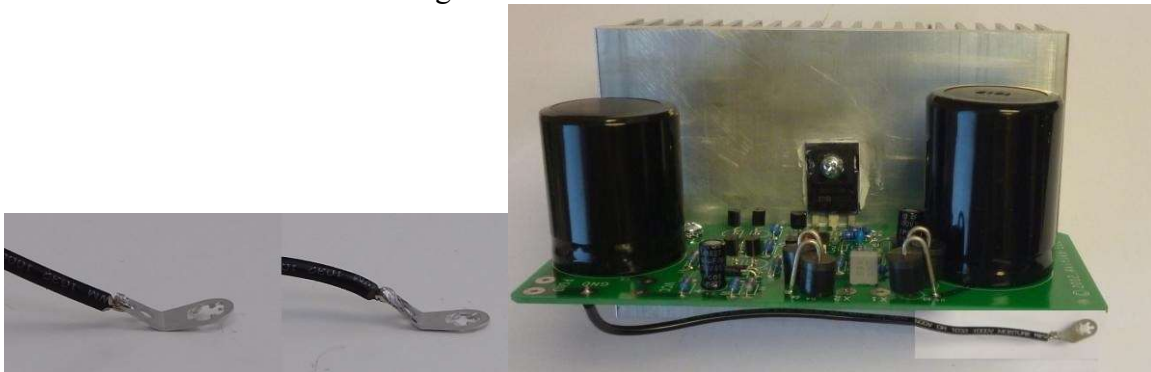
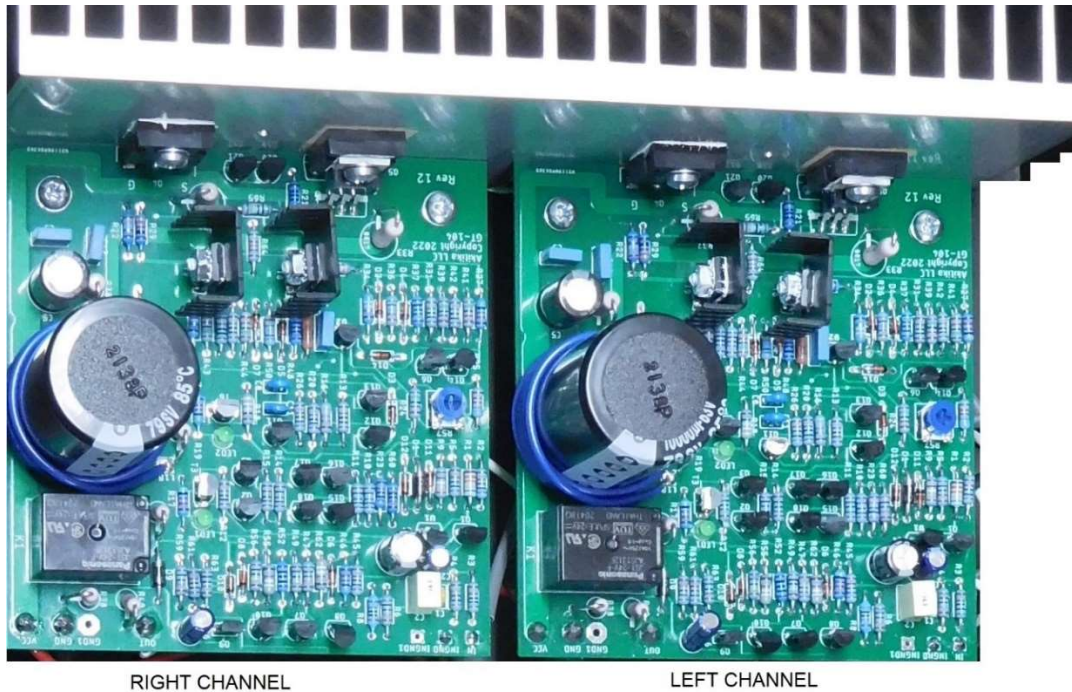


Figure 25—power supply with attached ground wire

Note: The X1, X2, VCC, and PGND eyelets will remain open until a later assembly step.

<sup>8</sup> The overall mechanical parts of the GT-102 and GT-104 are quite similar, so the wiring kit may say either GT-102 or GT-104, or even GT-108.

## **Attach the Amplifier Module Power Wires**



**Figure 26-Right and Left Channel Designations**

### **Attaching LEFT Module Power Wires**

1. For the module designated as LEFT (see Figure 26), cut a 9” overall length of Red/Black 18 AWG zip cord.
2. Separate the Red and Black wires about 1 inch at each end.
3. Remove about 1/4” of insulation from each of the four ends and tightly twist the copper strands together.
4. From one end of the Red/Black wire, insert the Red wire into the VCC eyelet, entering from the solder side. Solder the wire on the component side.
5. From that same end of the Red/Black wire, insert the Black wire into the GND eyelet, entering from the solder side. Solder the wire on the component side.

### **Attaching RIGHT Module Power Wires**

1. For the module designated as RIGHT (see Figure 26), cut an 11” overall length of Red/Black 18 AWG zip cord.
2. Separate the Red and Black wires about 1 inch at each end.
3. Remove about 1/4” of insulation from each of the four ends and tightly twist the copper strands together.
4. From one end of the Red/Black wire, insert the Red wire into the VCC eyelet, entering from the solder side. Solder the wire on the component side.
5. From that same end of the Red/Black wire, insert the Black wire into the GND eyelet, entering from the solder side. Solder the wire on the component side.

Set the amplifier modules and heat-sinks aside in a safe place for now, as we will install the RCA input jacks and speaker binding posts into the chassis.



## Prepare Input Shielded Cables

1. Prepare a 9 1/2" length of shielded cable for the LEFT channel input per the directions that begin on Page 57. Prepare both ends per those directions. Twist and tin the wires at one end of the cable. Leave the other end tightly twisted, but un-tinned.

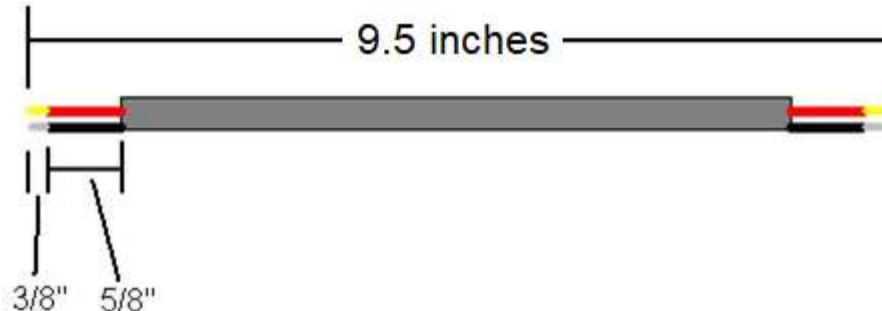


Figure 27-shielded cable for left channel. Right channel has overall length of 12 inches.

2. Prepare a 12" length of shielded cable for the RIGHT channel input per the directions that begin on Page 57. Prepare both ends per those directions. Twist and tin the wires at one end of the cable. Leave the other end tightly twisted, but un-tinned.

## Build the Ground Harnesses

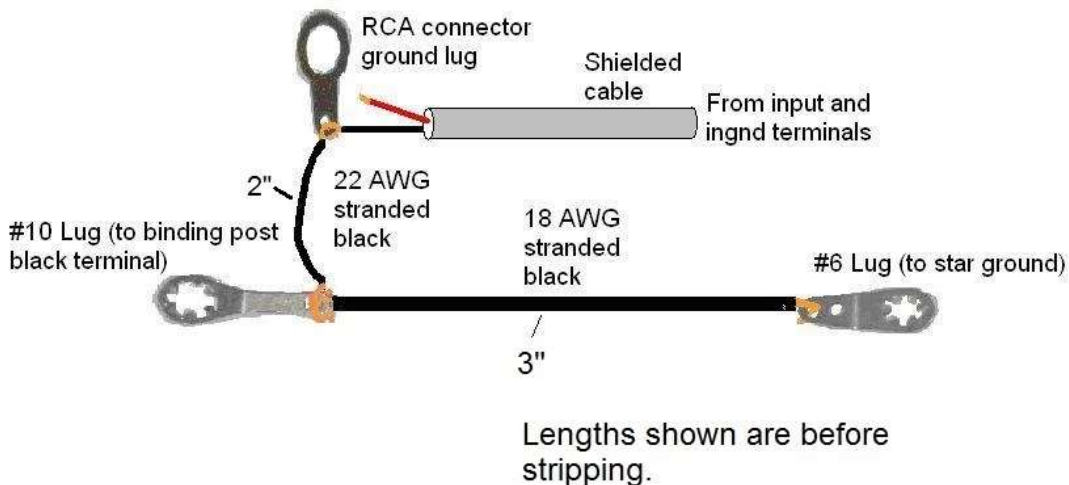


Figure 28-Channel Grounding Harness

The left and right channel ground harnesses are the same. However, they have different lengths of shielded cable attached. Figure 28 shows the construction details. The wire lengths called out on the figure specify the before-stripping lengths of the wires.

Unscrew the retaining nut from the RCA connectors to make the RCA connector ground lugs available for building the harnesses. Make sure to save the connector and nut.

Build two harnesses as shown:

1. Complete one harness using the left channel (9.5" long) shielded cable.
2. Complete the second harness using the right channel (12" long) shielded cable.

You'll get the best results if you've tinned the stripped ends of the wires before you crimp them into the solder lugs. Once all the connections are crimped in place on a given lug, solder the lugs using enough heat to make the solder flow. When you do this, the wires should be straight, as the heat will encourage the insulation to back off a bent wire.

### **Remove the Cover and the Shield Wall**

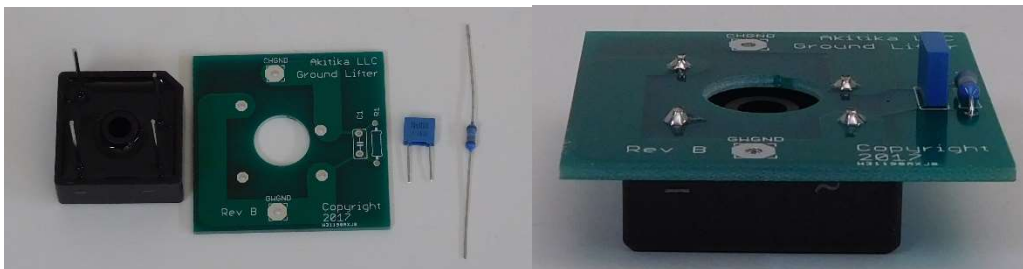
Remove the cover by removing the 11 small screws that hold it in place. Put them in a safe place as they are needed to complete final assembly.

Remove the shield wall by removing the two black 6-32 screws that hold it in place to the bottom of the chassis. Make sure to put the screws in a safe place, as you'll need them to complete final assembly.

### **Build the Ground Lifter**

There's one more small circuit board to build, the ground lifter circuit board. It supplies a robust diode-bridged connection between the AC mains ground (often called Green Wire Ground or GWG) and the Chassis Ground where all the signal and power connections come together. The ground lifter helps reject ground loop noise that sometimes occurs when connecting components together. It's particularly effective in minimizing the ground wire noise that some computers generate.

Figure 29 shows the bare ground-lifter PCB, both before and after assembly. Note that the resistor and capacitor install from the silk-screen side of the board in the normal manner. In contrast, the bridge rectifier installs from the bottom of the board, and gets soldered on the silk-screen side.



**Figure 29-Ground Lifter PC Board**

Designation	Value	Marking	Done
R1	24.9	Red, Yellow, White, Gold, Brown	
C1	10 nF	10nJ100	
BR1		GBPC3506W	

1. Locate the green 18 AWG stranded wire with a FASTON terminal installed on one end. Cut it to an overall length of 14", measured from the far-end of the FASTON. Remove 1/4" of insulation from the plain end of the green wire. Insert it into the GWGND eyelet on the Ground Lifter PCB. Insert it from the side with the bridge rectifier, and solder it on the silk-screen side of the PCB.
2. Cut a 2" length of black 18 AWG stranded wire. Remove 1/4" of insulation from both ends. Insert one end into the CHGND eyelet on the ground lifter PCB. Insert it from the side with the bridge rectifier, and solder it on the silk-screen side of the PCB.

- Twist and tin the other end of the wire. Insert it into a #6 lug. Crimp it and solder the wire to the lug.

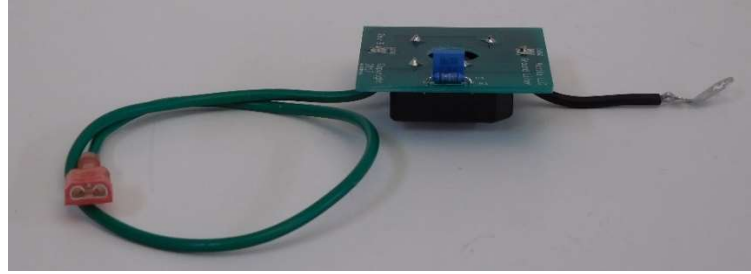


Figure 30-Ground Lifter PCB with ground wires connected

### ***Install the Feet***

Install the four feet into the corners of the bottom of the chassis using 6-32x 3/8" Phillips head screws (these are zinc-plated, so will look silver). Snug the screws, but don't over-tighten. Installing the screws will protect the bottom of the chassis from damage.

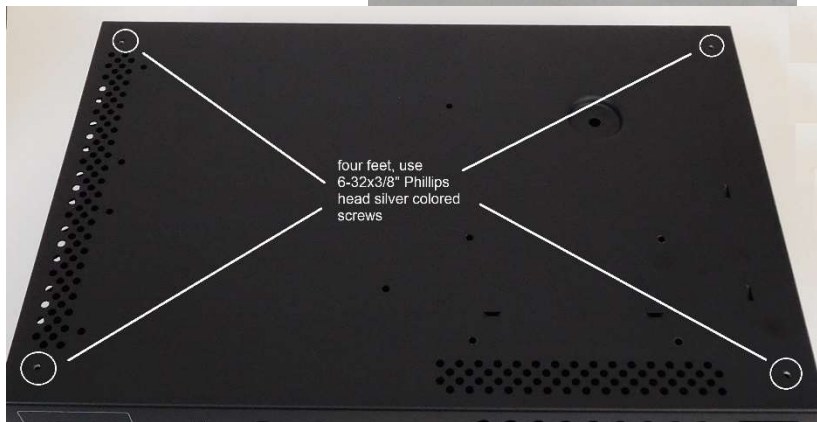


Figure 31-Install the feet here

### ***AC Power Wiring***

- Locate the 1 foot long white and black 18 AWG wires with FASTONS on both ends. Twist the wires together. This minimizes the radiated hum fields.

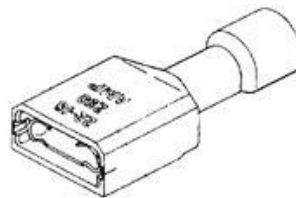


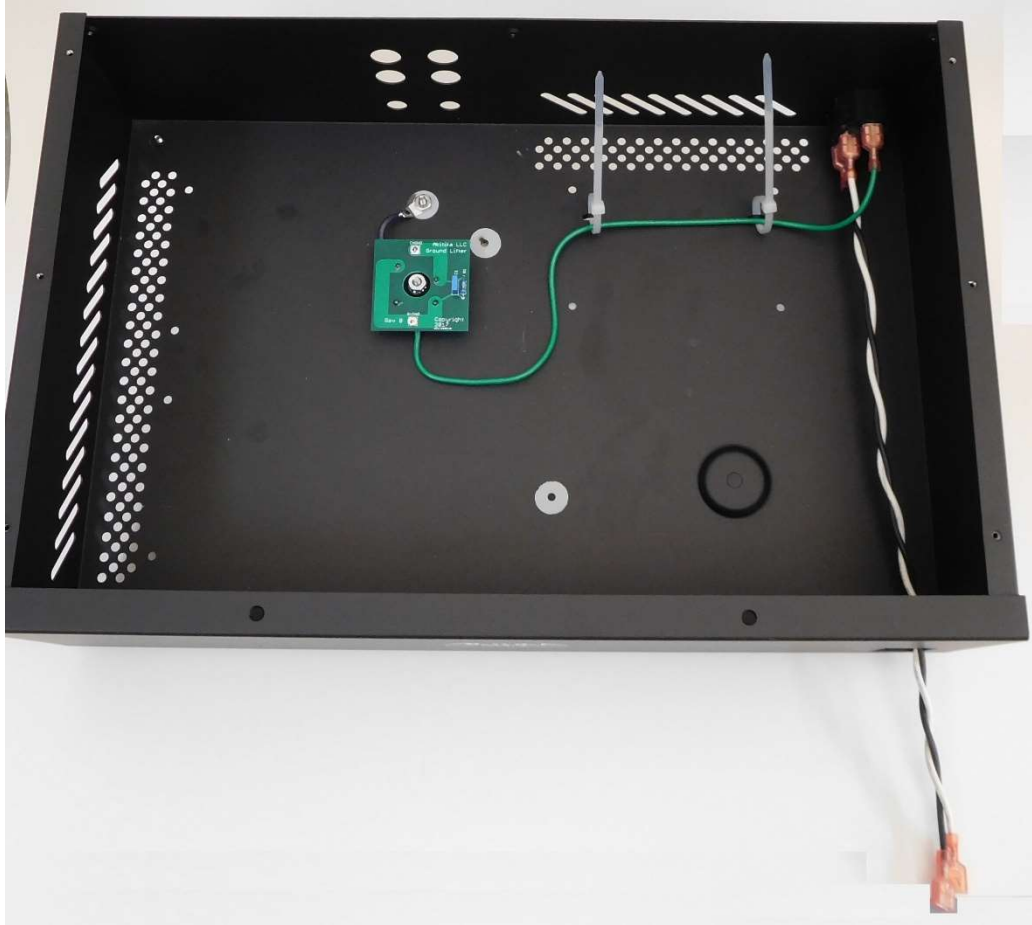
Figure 32-FASTON connector

- Slide the FASTON terminals onto the IEC power connector as shown in Figure 33.
  - Black wire to L (line) terminal.
  - White wire to N (neutral) terminal.
  - Don't connect the G  $\perp$  (ground terminal) yet.



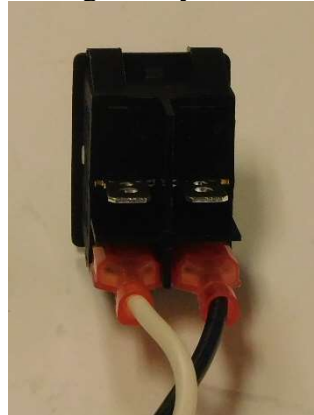
**Figure 33-Wiring IEC power connector line and neutral**

3. Starting outside the chassis, insert the black and white wires (already connected to the IEC power connector) into the hole in the back-right corner of the chassis as shown in Figure 34. **Make sure that the writing on the power connector is right side up!** Push until it clicks in place. It's easy to get it in, and tough to get it out, so double check the orientation before you install it.
4. Dress the black/white jacketed pair with FASTONs as shown in Figure 34. Insert the free end with the FASTONs through the rectangular switch hole in the front panel.
5. Connect the green wire from the ground lifter assembly to the ground terminal of the power entrance connector. It will be the top-most terminal, and the last open terminal on the connector.
6. Dress the green wire as shown in Figure 34 next to the tie down points. *Loosely loop cable ties as shown. We will tighten them later.*
7. Place the ground lifter assembly over the long threaded stud and secure it in place using a 6-32 keps nut (it has a built-in lock-washer). Tighten it snugly, but don't over-tighten.
8. Place the short black wire from the ground lifter assembly over the shorter threaded ground stud. Tighten down a plain #6-32 nut on the stud to hold the ground wire in place. Make sure it's secure.



**Figure 34-Power wiring with IEC connector installed into chassis**

9. Starting with the switch outside the chassis, push the FASTONS on the bottom switch terminals as indicated in Figure 35. The black or white wire may be on either side of the switch, so long as they both attach to the *bottom row* of contacts.

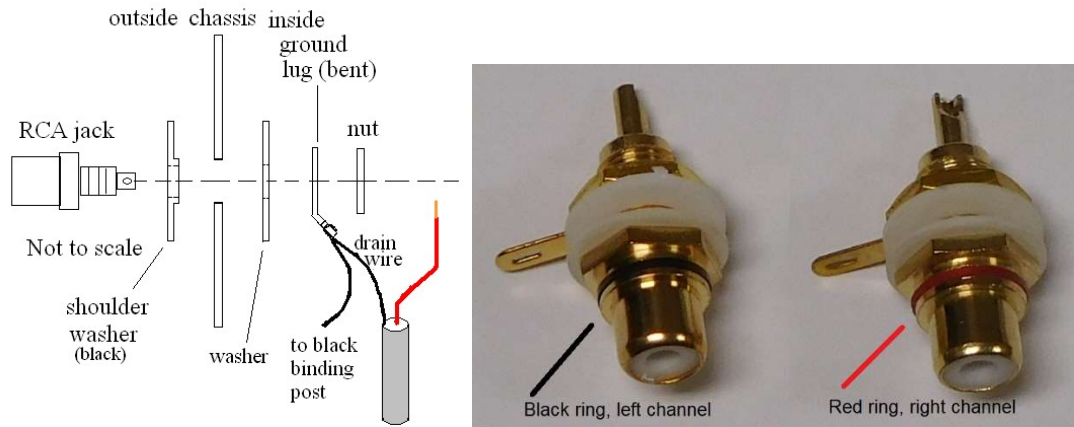


**Figure 35-Installing power wires on the switch**

10. *Leave the switch dangling outside the amp for now!!!*

### **Install the RCA Jacks and Speaker Binding Posts**

Locate the Left and Right channel shielded cable/ground harness assemblies. You will now connect them to the Left and Right RCA jacks.



**Figure 36-Installing RCA jacks. A half inch socket driver makes installation easier.**

#### Left Channel RCA Jack Installation

The left channel RCA jack has a black ring. Install it from the outside of the chassis into the left channel (marked) RCA jack hole. The mounting hardware arrangement is shown in Figure 36. Use the left channel shielded cable and ground harness that you previously built.

1. Insert the RCA jack and the *two insulating washers* and ground lug as shown in Figure 36. The ground lug already has two black wires attached. Tighten the mounting nut. Note that there are shoulders on the insulating washer that keep the RCA connector's body from touching the chassis.
2. Solder the (pre-tinned) red wire of the (9.5") shielded cable to the center terminal of the left channel RCA jack.

#### Right Channel RCA Jack Installation

The right channel RCA jack has a red ring. Install it from the outside of the chassis into the right channel (marked) RCA jack hole. The mounting hardware arrangement is shown in Figure 36. Use the right channel shielded cable and ground harness that you previously built.

1. Insert the RCA jack and the *two insulating washers* and ground lug as shown in Figure 36. The ground lug already has two black wires attached. Tighten the mounting nut. Note that there are shoulders on the insulating washer that keep the RCA connector's body from touching the chassis.
2. Solder the (pre-tinned) red wire of the (12") shielded cable to the center terminal of the right channel RCA jack.

### ***Install the Speaker Binding Posts***

The two speaker output connectors are heavy duty 5-way binding posts. Remove both nuts and the washer from each binding post. Install them into the chassis as shown in Figure 37. Make sure that the Red binding post is on the top. You'll use only one nut and washer to retain each binding post for now. Return the other nuts to the soup-bowl for safe-keeping. They will be used in a later step when they are re-installed to fasten a solder lug to the terminal.

The black plastic insulators have shoulders that fit inside the mounting holes. Make sure that the shoulders are centered in the mounting holes. They keep the binding post studs



from shorting to the chassis. The binding post wire-insertion holes should be horizontal, as shown in Figure 37.



Figure 37-Install both left and right binding posts

## **Connect the Speaker Binding Posts**

### Left Speaker Binding post

1. Slip the #10 lug from the left channel ground harness (black 18 AWG wire) over the black binding post stud. Position the lug as shown in Figure 38, then use a binding post nut (5/16" nut driver) from the soup bowl to hold the lug in place.
2. Place the #6 lug at the other side of the ground harness over the short ground stud on the chassis floor.
3. Cut an 8" length of white 18AWG stranded wire. Strip about 3/8" of insulation from both ends. Tin one end. Insert the tinned end into the small opening in a #10 lug. Crimp and solder the end as shown in Figure 38.
4. Place the #10 lug over the RED left channel binding post in the 8 o'clock position as viewed from the front of the chassis. Add one of the previously reserved binding post nuts and tighten it with a 5/16" nut-driver. The free end of the white wire will be connected to the left channel amplifier OUT in a later step.

### Right Speaker Binding Post

1. Slip the #10 lug from the right channel ground harness (black 18 AWG wire) over the black binding post stud. Position the lug as shown in Figure 38, then use a binding post nut (5/16" nut driver) from the soup bowl to hold the lug in place.
2. Place the #6 lug at the other side of the ground harness over the short ground stud on the chassis floor, along with the one already there from a previous step. Don't install a nut yet.
3. Cut an 11" length of white 18AWG stranded wire. Strip about 3/8" of insulation from both ends. Tin one end. Insert the tinned end into the small opening in a #10 lug. Crimp and solder the end as shown in Figure 38.
4. Place the #10 lug over the RED right channel binding post in the 8 o'clock position as viewed from the front of the chassis. Add one of the previously reserved binding post nuts and tighten it with a 5/16" nut-driver. The free end of the white wire will be connected to the right channel amplifier OUT in a later step.





Figure 38-I/O Connector wiring

### Amplifier Channels Final Wiring

Set the heatsink and amplifier PCB assembly into the chassis. Lay the fins of the heatsink on the floor of the chassis.

1. Identify the 18 AWG white wire that connects to the LEFT channel red binding post. Twist the conductor strands tightly, and insert the wire into the LEFT Channel OUT eyelet from the solder side of the board. Solder it on the component side of the board.
2. Identify the shielded cable that connects to the LEFT RCA jack. Tightly twist the conductors of both the drain wire and the center conductor.
  - a. Insert the drain wire from the solder side of the board into the LEFT Channel INGND eyelet. Solder it on the component side.
  - b. Insert the center conductor from the solder side of the board into the LEFT Channel IN eyelet. Solder it on the component side.
3. Identify the 18 AWG white wire that connects to the RIGHT channel red binding post. Twist the conductors tightly, and insert the wire into the RIGHT Channel OUT eyelet from the solder side of the board. Solder it on the component side of the board.
4. Identify the shielded cable that connects to the RIGHT RCA jack. Tightly twist the conductors of both the drain wire and the center conductor.
  - a. Insert the drain wire from the solder side of the board into the RIGHT Channel INGND eyelet. Solder it on the component side.

- b. Insert the center conductor from the solder side of the board into the RIGHT Channel IN eyelet. Solder it on the component side.

## Installing Amplifier Modules into the Chassis

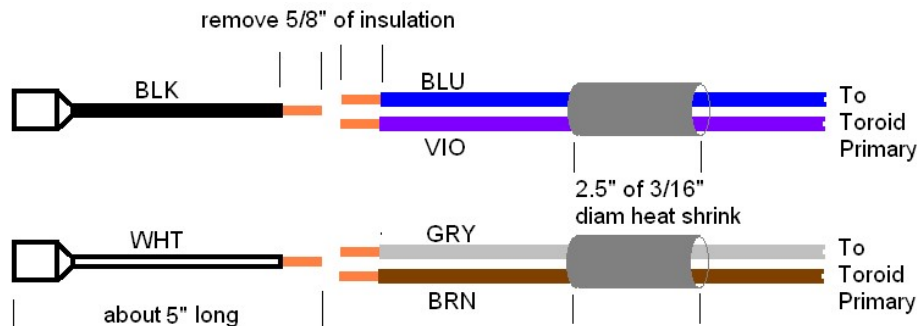
*Be careful not to flex the chassis. It's a bit "squishy" with the top off, but becomes quite stout once the top is installed and screwed in place. You may want to place a towel on your work surface to avoid scratching the paint as you complete this section.*

1. This step can be a bit messy, and is considered optional. Completing this step assures the maximum transfer of heat into the chassis. You're also likely to smear white thermal compound on the inside of the amplifier as you set it into place. We'll leave the choice up to you (a little more available output power versus a little prettier insides of the amp). Spread a thin film of thermal compound on the 1/4" wide ridge of the heatsink (the side with four 6/32 mounting holes).
2. Fit the amplifier/heatsink assembly in place and secure it using four black 6-32 3/8" screws inserted from the bottom of the chassis.

## Transformer Preparation

The directions in this section cover 120 Volt wiring. For 240 Volt wiring, you'll need the V240 kit. This kit has the parts and directions to wire the transformer for 240-volt power. The kit builder must supply a country-specific 240 Volt power cord.

Locate the 5" long black and white 18 AWG wires with FASTON connectors pre-installed on one end. Also locate the 3/16" diameter (clear) heat shrink tubing. For 120 Volt<sup>9</sup> wiring, the FASTON and toroidal primary wires will be connected as shown in Figure 39.

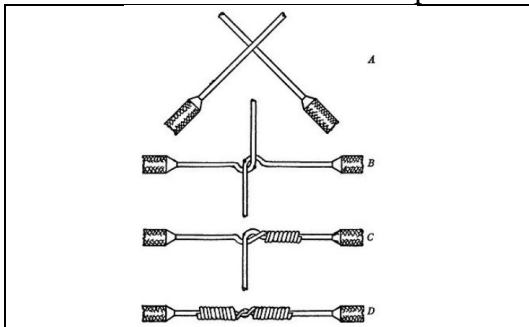


**Figure 39-Wiring toroidal transformer for 120 Volt operation**

1. Cut a 2.5" length of 3/16" diameter heat-shrink tubing. Slide it over the blue and violet leads of the power transformer. Slide it as far from the cut ends of the wire as possible.
2. Cut a second 2.5" length of 3/16" diameter heat-shrink tubing. Slide it over the gray and brown leads of the power transformer. Slide it as far from the cut ends of the wire as possible.
3. Cut 1/4" off the tips of the blue, violet, gray and brown transformer wires. This removes the portion of the wire that has solder from the manufacturing process. Doing so allows you to make a smooth Western Union splice, shown below.

<sup>9</sup> For 240 Volt wiring, see the directions that come with the V240 kit.

4. Remove 5/8" of insulation from the following 6 wires:
  - i. Black 4" FASTON wire
  - ii. White 4" FASTON wire
  - iii. Blue Transformer wire
  - iv. Violet Transformer wire
  - v. Gray Transformer wire
  - vi. Brown Transformer wire
5. Twist together the stripped ends of the brown and gray transformer wires
6. Twist together the stripped ends of the blue and violet transformer wires.
7. Make a Western Union splice between the brown-gray and the 4" white FASTON wire.
  - i. Solder the splice.
  - ii. Slide the heat shrink tubing evenly over the splice
  - iii. Use the tip or the barrel of the iron to shrink the heat shrink tubing.
8. Make a Western Union splice between the blue-violet and the 4" black FASTON wire.
  - i. Solder the splice.
  - ii. Slide the heat shrink tubing evenly over the splice
  - iii. Use the tip or barrel of the iron to shrink the heat shrink tubing.



*Important Note:*

- Check your Western Union splices for smoothness. Sharp wire points must not push into the heat shrink tubing.
- If you even suspect that to be the case, then you must wrap each piece of heat shrink tubing individually with a layer of electrical tape.

**Figure 40-Western Union splice has diameter less than the insulated wires and no sharp points**

9. Cut the red and orange transformer wires to a length of about 2".
10. Remove 3/8" of insulation from the red and orange transformer wires.
11. Twist the insulated parts of the orange and red wires together. Now twist the bare ends together and solder them to each other. Slide a 2" piece of 1/8" diameter (black)<sup>10</sup> heat shrink tubing over the pair of wires, about half on, and half off.
12. Use the tip or the barrel of the soldering iron to shrink the heat-shrink tubing all along its length.
13. Once the heat-shrink tubing has cooled, test your work by tugging on the heat shrink to assure that it will remain in place.
14. Cut the black and yellow transformer wires to a length of 3.5". Twist together the insulated portion of the black and yellow transformer wires. Twisting the pair reduces hum.
15. Strip 3/8" of insulation from the black and yellow wires of the transformer. Twist and tin each wire, preparing them for installation into the power supply in a later step.

<sup>10</sup> The transformer in some kits has thicker insulation for the orange and red wires. In that case, the black 1/8" heat-shrink won't easily fit over the wires. Instead, use a 2" piece of the white 3/16" heat-shrink.

## Transformer Installation

1. Set the transformer into the chassis, wire side up, over the raised circle in the chassis floor. You won't bolt it into the chassis until after the shield has been installed.
2. Twist the transformer primary leads (that's the transformer wires with the FASTON connectors) together to form a twisted pair. Slide the FASTON connectors from the toroidal power transformer thru the switch cut-out in the front panel. Connect them to the indicated switch terminals. Place black over black and white over white.

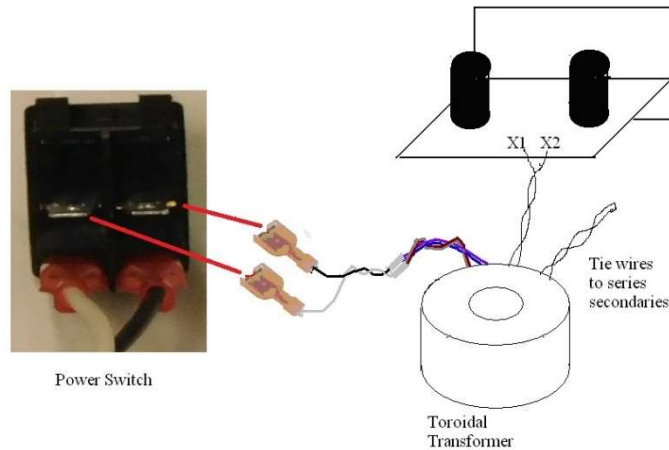


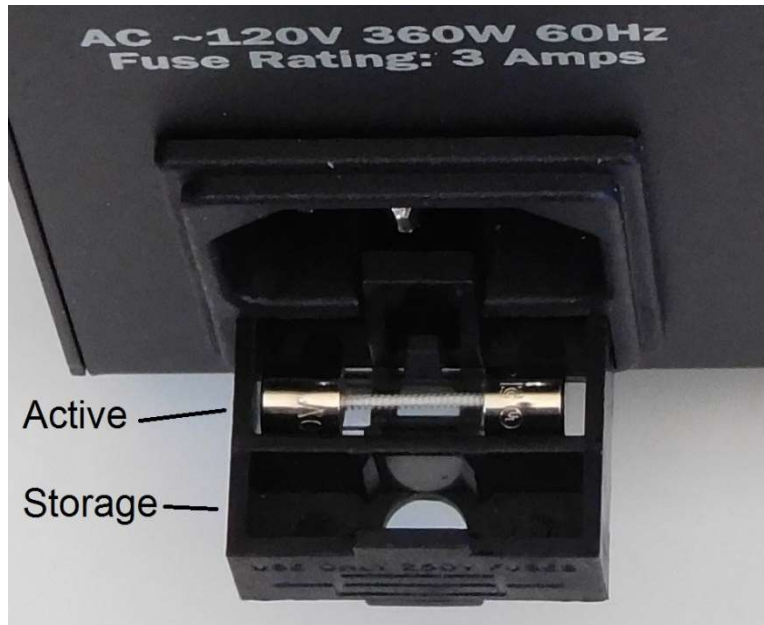
Figure 41-connecting up the power transformer

3. Insert the switch in from the front of the chassis. It may be a snug fit. **Make sure that the | is at the top of the opening** before you insert the rocker switch into the chassis. Push the rocker switch in the rectangular opening; it will click into place.
4. Dress the black-white twisted pair that goes from the switch to the power entrance connector into the crease along the right side of the chassis.
5. Dress the transformer primary leads as shown on the front cover of this manual.
6. Lay the power supply assembly into the case, fin side down, centered along the back of the chassis. The solder side of the circuit board should face the front of the chassis.
7. Insert the black and yellow transformer wires into the X1 and X2 terminals of the power supply PCB, inserting them from the solder side and soldering them on the component side. Connect black to X1 and yellow to X2, but it doesn't matter if they are reversed.

## Testing the Power Supply

1. Make sure that green ground wire from the IEC power entrance connector in the back-right corner of the chassis connects to the GWGND eyelet of the ground lifter PCB. Make sure that the wire from the CHGND eyelet of the ground lifter PCB connects to the grounding stud located between it and the back wall of the chassis, and that is secured by a tightened 6-32 nut.
2. Make sure that the power supply module PCB does not touch the chassis at any point.

3. Open the fuse drawer in the IEC power connector and make sure that the fuse is installed in the active slot of the drawer. It was placed there when the kit was packed to keep the glass fuse cartridge safe during transport. Close the fuse drawer. The fuse and fuse drawer is retained by the force of the contacts. If the fuse drawer flops open, you probably have placed the fuse in the spare location, as opposed to the active location.



**Figure 42-Showing active and storage locations in the fuse drawer**

4. Make sure that the power switch is in the off position (the bottom part of the rocker switch, labeled with a 0, is flush with the front panel).
5. Locate the supplied IEC power cord. Make sure it is NOT connected to the AC wall socket yet. Connect one end to the IEC power connector on the chassis.
6. Standing well away from the amplifier, connect the plug into the AC wall socket. Keeping one hand in your pocket, use the other hand to turn on the power switch.
7. The power switch should light up, but very little else observable should happen.
8. Observe the power supply, transformer, and wiring for any signs of heating or distress.
9. If everything seems cool (please pardon the pun), the probe the VCC and PGND eyelets on the power supply PCB with a DC volt meter. The voltage should be 60 volts (+/- 2 Volts) DC.
10. If the previous test is correct, then:
  - a. Turn off the power switch
  - b. Pull the power cord from the wall socket**
  - c. Remove the power cord from the power entrance connector on the chassis**
  - d. Go away from the amp for five minutes to celebrate and let the output capacitors discharge.

The raw power supply has only light bleeder resistors. It may take 5 minutes for the main filter capacitors to discharge.



## Final Amplifier Wiring

In this section, you'll wire the amplifier modules to the power supply. A quick look at the cover illustration will clarify anything not made clear by the following instructions.

### Wiring Amplifier Power

1. Identify the red/black zip cord that connects to the left amplifier module VCC and PGND pins. Route them along the chassis floor and toward the VCC and PGND pins of the power supply.
  - a. Insert the red wire into the VCC pin closest to the large capacitor, C6, from the solder side of the PCB and solder it on the component side. Don't let your soldering iron slide into C6.
  - b. Insert the black wire into PGND1 from the solder side of the PCB and solder it on the component side. Don't let your soldering iron slide into C6.
2. Identify the red/black zip cord that connects to the right amplifier module VCC and PGND pins. Route them along the chassis floor and toward the VCC and PGND pins of the power supply.
  - a. Insert the red wire into the VCC eyelet from the solder side of the PCB and solder it on the component side.
  - b. Insert the black wire into the PGND eyelet from the solder side of the PCB and solder it on the component side.

### Fasten the Power Supply to the Chassis

1. Tighten the cable ties that hold the green ground wire in place. Make sure that as positioned, it will not interfere with mounting the power supply heat sink. Cut the long tails of the cable ties.
2. This step is optional, but it is recommended if you listen for long periods at high levels. Spread a thin film of thermal compound on the 3/8" wide ridge of the heatsink (the side with two 6/32 mounting holes).

*Note: the transformer is not yet fastened in place. Leave the chassis flat to avoid a "gravitational accident" where the transformer goes rolling or sliding and leads rip loose.*

3. Place the power supply module onto the chassis and secure it in place using two black 6-32x3/8" pan-head Phillips screws inserted from the bottom of the chassis. I like to do this by sliding the edge of the chassis over the edge of the table, and inserting the screws from underneath the chassis.
4. Ground Stud
  - a. The ground stud already has a #6 lug, the black wire from the ground lifter PCB, and a #6-32 nut holding the lug in place. Make sure the nut is tight.
  - b. Above that nut, place these three #6 ground lugs:
    - i. From the ground eyelet of the power supply PCB
    - ii. From the ground (black) binding post of the left amplifier.
    - iii. From the ground (black) binding post of the right amplifier.
  - c. Place another #6-32 nut on top of the lugs, and tighten the nut to secure the grounding lugs in place.

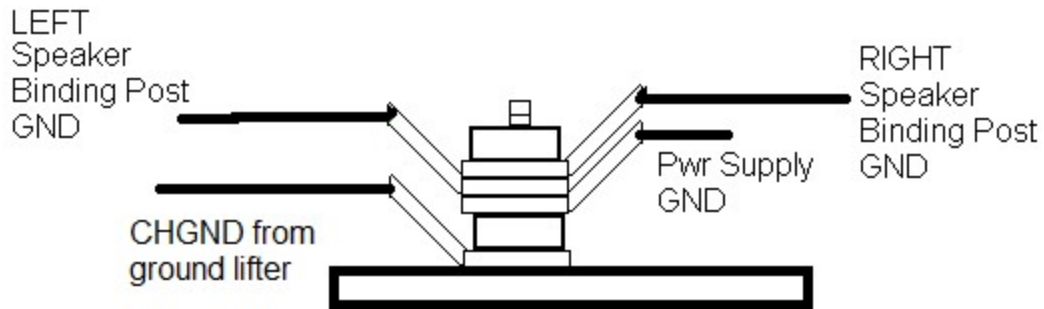


Figure 43-Grounding Stud Detail

### Install the Wall and Fasten the Transformer Down

If you've been following along, the transformer is not yet fastened in place. This will allow you to slide it toward the right chassis wall, making room to insert the divider-wall into the chassis. You may even decide to temporarily stand the transformer on its side to make extra room for this operation, but it really isn't necessary. Check the front cover to see which way the wall goes.

This is admittedly a bit of a Rubik's cube operation, but if you slide the front end of the wall right and the back end left, and get the wall under the front lip, it will fall into place.

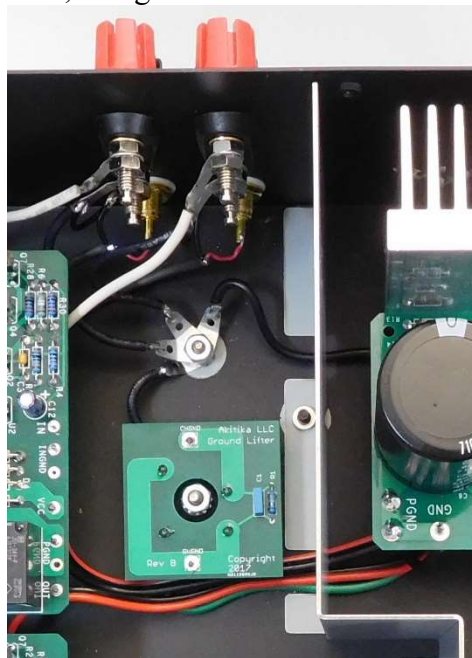
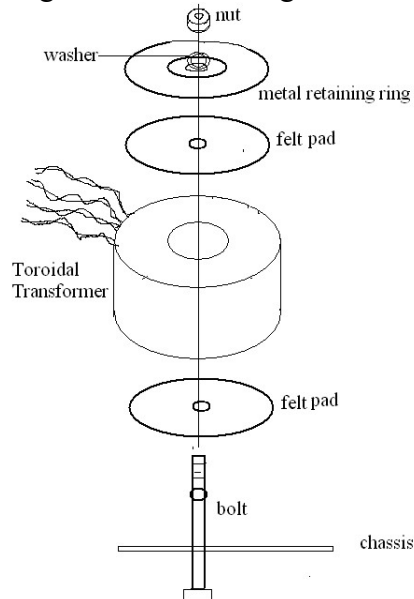


Figure 44-Routing the wires through the slots in the wall

Refer to Figure 44 to see how the power and ground wires route through the slots in the wall:

1. Route the power supply ground wire through the back hole in the wall.
2. Route both red/black power leads from the power supply and the Green Wire Ground lead from the power entrance connector through the front hole in the wall.
3. Make sure neither will be pinched when the wall is tightened in place. But first, we'll complete installation of the toroidal transformer.

4. Mount the toroidal transformer to the chassis using the hardware shown in Figure 45. Orient the toroid and power wiring as shown on the front cover of this manual. Make sure the mounting hardware and toroid are centered before tightening the mounting bolt. Make it snug, but do not over-tighten.



**Figure 45-Toroidal Transformer Mounting**

5. Fasten the wall to the bottom of the chassis using two 6-32x3/8" black screws installed from the bottom of the chassis and into the fasteners on the wall. Make sure that the wires pass easily through the slots in the wall, and aren't being pinched.

You have now completed all the wiring and 99% of the assembly of the amplifier.

## Visual Inspection

Check for the following items:

1. Power Supply wiring from the power supply to both amplifier modules is in place.
2. ***Double check the polarity of the power supply wiring!***

## Section 5: Testing It Out, Setting the Bias, and Installing the Top

*Be careful. The amplifier will be energized with the top off, and hazardous voltages will be present in the amplifier. Use appropriate precautions to avoid injury.*

Once the visual inspection looks ok and any shortcomings have been corrected, you can perform the following tests.

### Power-Off Tests

1. Connect an ohmmeter to the left channel red and black binding posts. The resistance should read between 900 and 1100 Ohms. The nominal value is 1000 Ohms.

2. Connect an ohmmeter to the right channel red and black binding posts. The resistance should read between 900 and 1100 Ohms. The nominal value is 1000 Ohms.
3. Disconnect the ohmmeter, and set it to DC volts, in preparation for the next tests.

### **Power-On Tests**

The only connections for these tests will be the AC mains power and/or the DC meter used to measure voltages. Make sure to keep clear of the high voltage. Plug in the amplifier and turn on the power. Watch it closely for one minute as you check for the lack of smoke. Turn the amplifier off quickly if you see any smoke!

Most typically:

1. The four green LED's (two on each amplifier board) should light up.
2. After about 7-10 seconds, you should hear the click of the speaker relays. If this is successful, then perform the following additional steps.

Measure the following DC voltages, repeating the test for both the left and right channel outputs.

1. Measure the DC voltage between the red and black speaker binding posts (with no speaker connected). You may see as much as 1 volt, which represents 1 mA of leakage current in the large output capacitor flowing through the 1K bleeder resistor on the output. The voltage will typically decline with time. When a speaker is present, the DC voltage will be less than 10 millivolts.
2. Turn the power off.

### **Set the Bias Current**

At this step, you will set the bias pots for the correct bias current. You'll repeat this for both the left and the right channels. You'll need a meter capable of measuring DC millivolts. The correct bias current is indicated by a voltage of 10 millivolts. A couple of small test clips will also be quite helpful, as well as a #1 Phillips head screwdriver. Here are the steps.

1. Power Off
2. Turn bias pot fully counterclockwise (it should have already been set that way).
3. Connect your DC millivolt meter to the wires that come out of the tops of R32 and R33 for the LEFT channel.
4. Disconnect inputs and speakers from the amplifier.
5. Power On. Wait 1 minute for the amp to stabilize. The DC voltage you read will typically be less than 1 milliVolt.
6. Use a small straight blade screwdriver to turn the bias pot clockwise. The action at first will be quite slow, with little apparent change in voltage. Take it slow and easy, continuing to turn the pot clockwise until you observe between 9 and 11 millivolts of DC voltage on the meter.
7. Turn the power off and wait 3 minutes
8. Go back to step 1, and repeat this process for the RIGHT channel:
  - a. Connect the meter to R32 and R33 of the RIGHT channel.
  - b. Adjust the RIGHT channel bias current for between 9 and 11 millivolts.

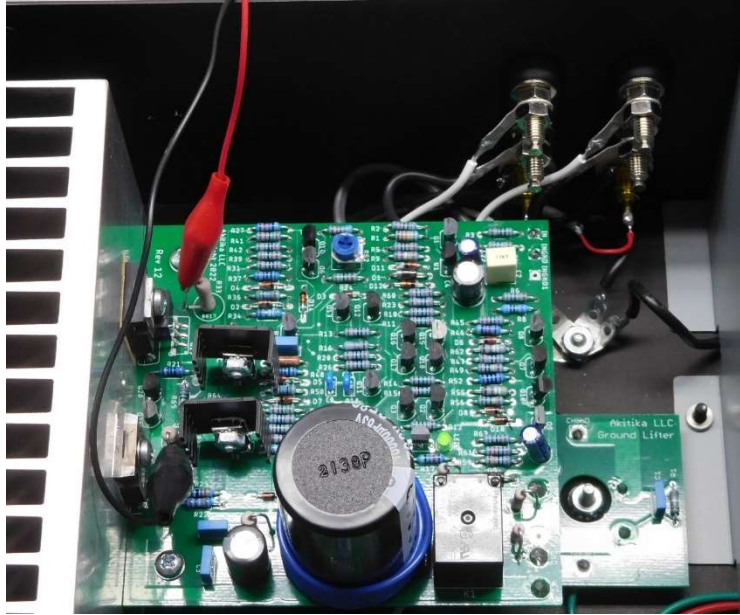


Figure 46-Measuring bias voltage, left channel shown

*Note: Make sure that your clip leads only touch the resistor leads.*

## Install the Top

Slide the top in place. Install the 11 #4-40x1/4" black flat-head Phillips head screws that keep the top in place.

1. Connect an input source to the RCA input jacks with the preamp volume down.
2. Connect a pair of speakers to the amplifier.
3. Turn the power on. There will be a 7-10 second delay while the amp powers up and its operating point stabilizes. The end of the delay time is marked by the soft click of the speaker relays (they will be slightly staggered in time).
4. Please note that with inputs disconnected, the speakers should be quite quiet.

## Place the Labels

We use the same chassis for a number of amplifiers. As your last assembly step, you'll place the two labels found in a 4"x6" pink plastic envelope on the front and back. Peel each label from its backing just before you apply it.

- The one-line GT-104 label goes on the front panel.
- The two line Model number label goes on the back panel.

The results should be as shown in Figure 47.



Figure 47-Installing labels on front and back



## Section 6: Using the GT-104

- Don't block the ventilation holes on the sides or the top of the amplifier.
- The amplifier has speaker relays that keep the speaker completely disconnected from the amplifiers until about 7-10 seconds after power up.
- Protection circuits shut the amplifier down in case of overload. If this happens:
  - Turn off the power and remove the overload condition
  - Turn down the input level
  - Turn on the amplifier, and in 7-10 seconds, you're ready to listen again.
- The amplifier is so quiet that with no input source connected, or with the input shorted, you will hear almost nothing from your speakers.
- The amplifier may have a tiny pop/thump at turn-off, determined by where in the cycle the musical signal was before the relay opened. This is normal.

## Section 7: Specifications and Schematics

Output Power:

- 50 Watts per channel into 4 Ohm loads

Small Signal Bandwidth: wider than 5 Hz to 100 kHz at -3 dB points

Damping Factor @ 1 kHz wrt 8 Ohms > 119, @ 20 kHz wrt 8 Ohms > 60

Signal to Noise Ratio: nearly 118 dB below 50 Watts into 8 Ohms, referred to a shorted input, 22 Hz - 22 kHz measurement bandwidth

Harmonic Distortion: typically 0.003% at 50 Watts into 8 Ohms at 1 kHz. Clipping (1% THD) occurs at a bit more than 60 Watts into 8 Ohms at 1 kHz.

Intermodulation Distortion (typ): 0.01%, SMPTE 60 Hz, 7 kHz, 4:1, into 4 Ohms

Separation: 73 dB @ 1 kHz, 60 dB @ 20 kHz, non-driven input shorted.

Input Impedance: 51 K Ohms

Sensitivity: 0.68 Volt RMS input produces 14.14 Volts RMS output

Input Power: IEC connector (North America style power cord supplied)

Input Power Fuse Rating and type:

- 120 Volt Operation - 3 Amp Slow Blow, 5x20 mm
- 240 Volt Operation - 1.5 Amps Slow Blow, 5x20 mm

Idle Power Drain (120 Volt Operation) - 22 Watts

Operating Temperature Range: 0 to 40 C Ambient

Dimensions: 15" Wide x 10" Deep x 4.5" Height (includes height of the feet)

Weight: 15.5 lbs

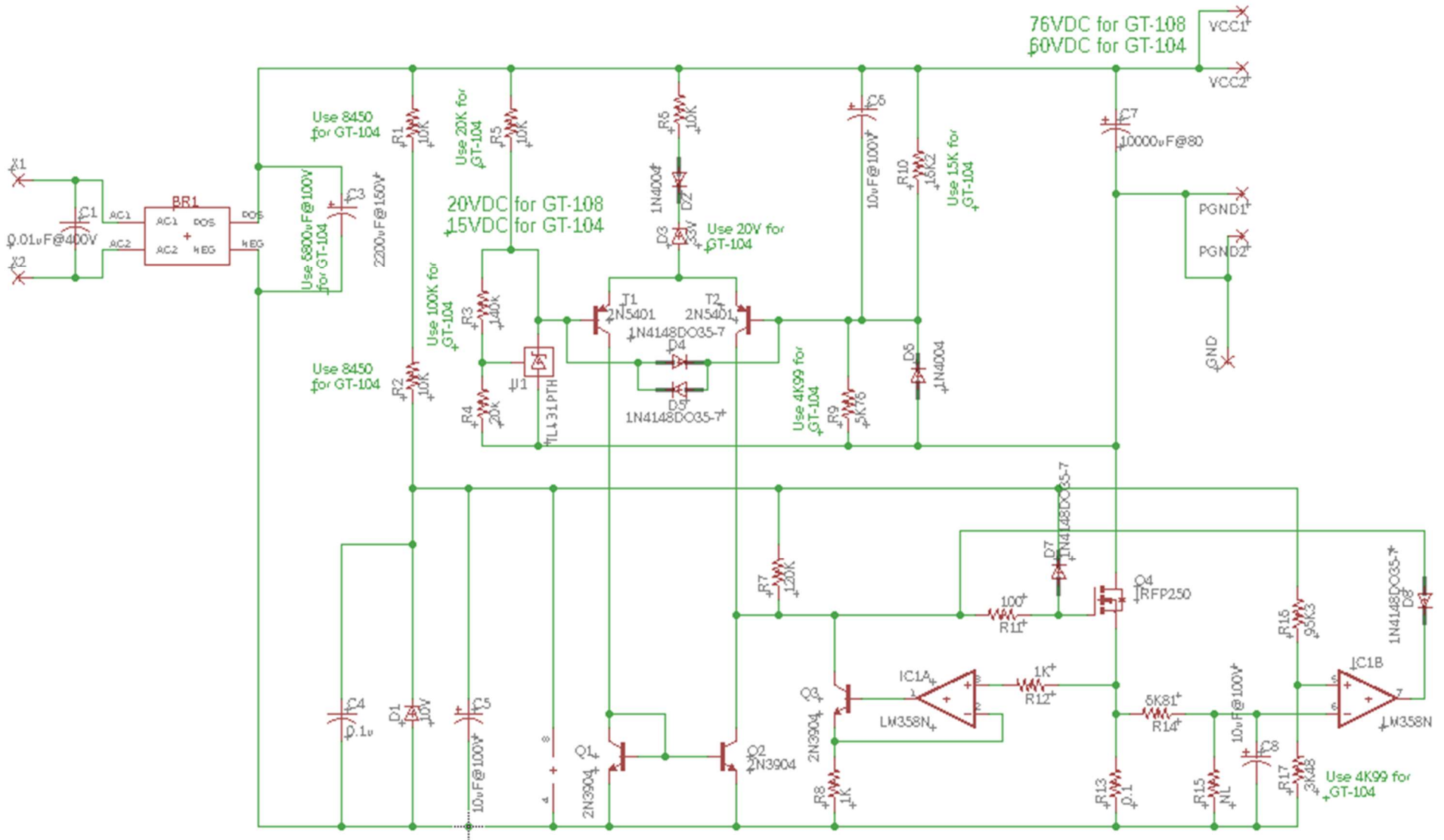


Figure 48-Power Supply Schematic

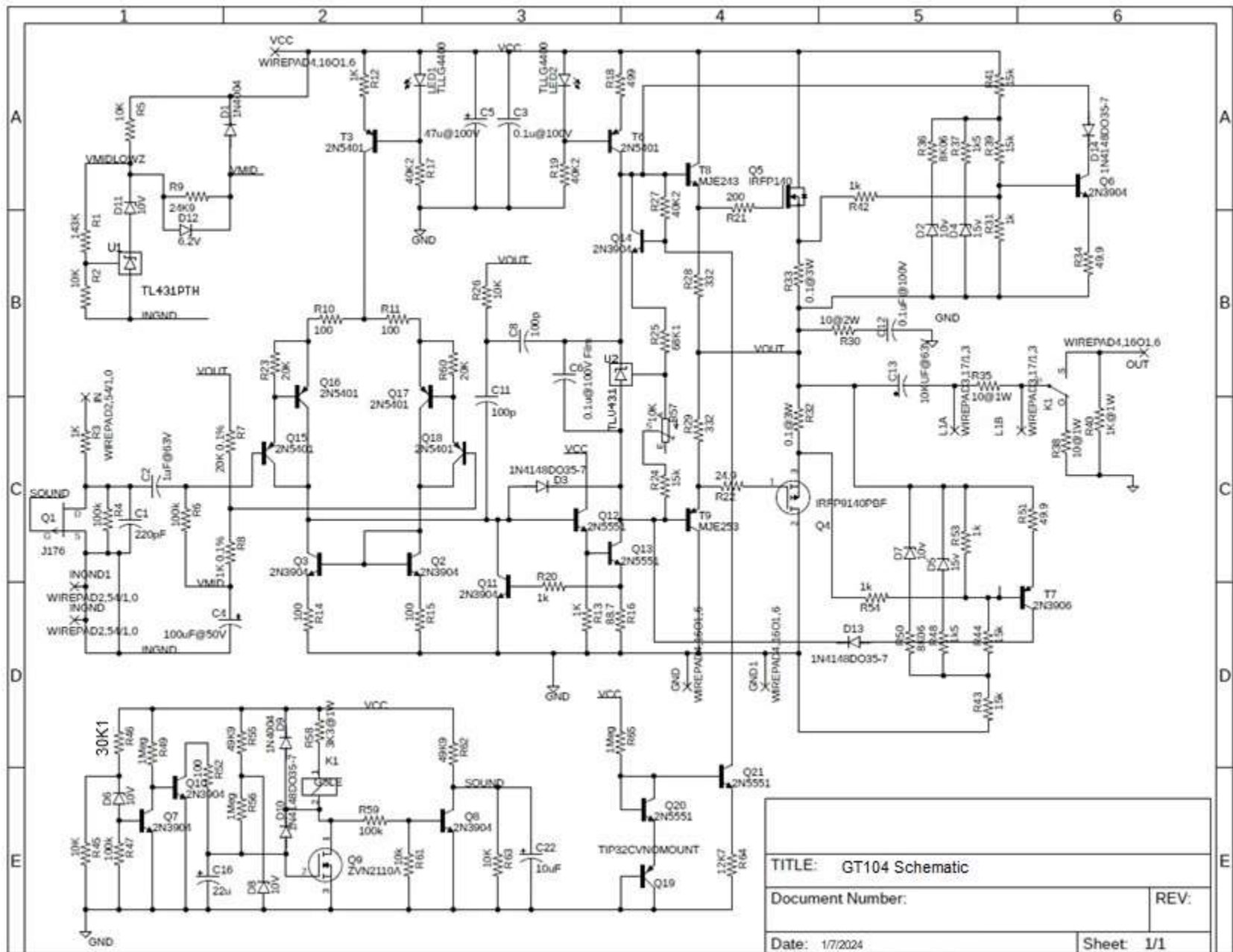


Figure 49-Amplifier Module Schematic

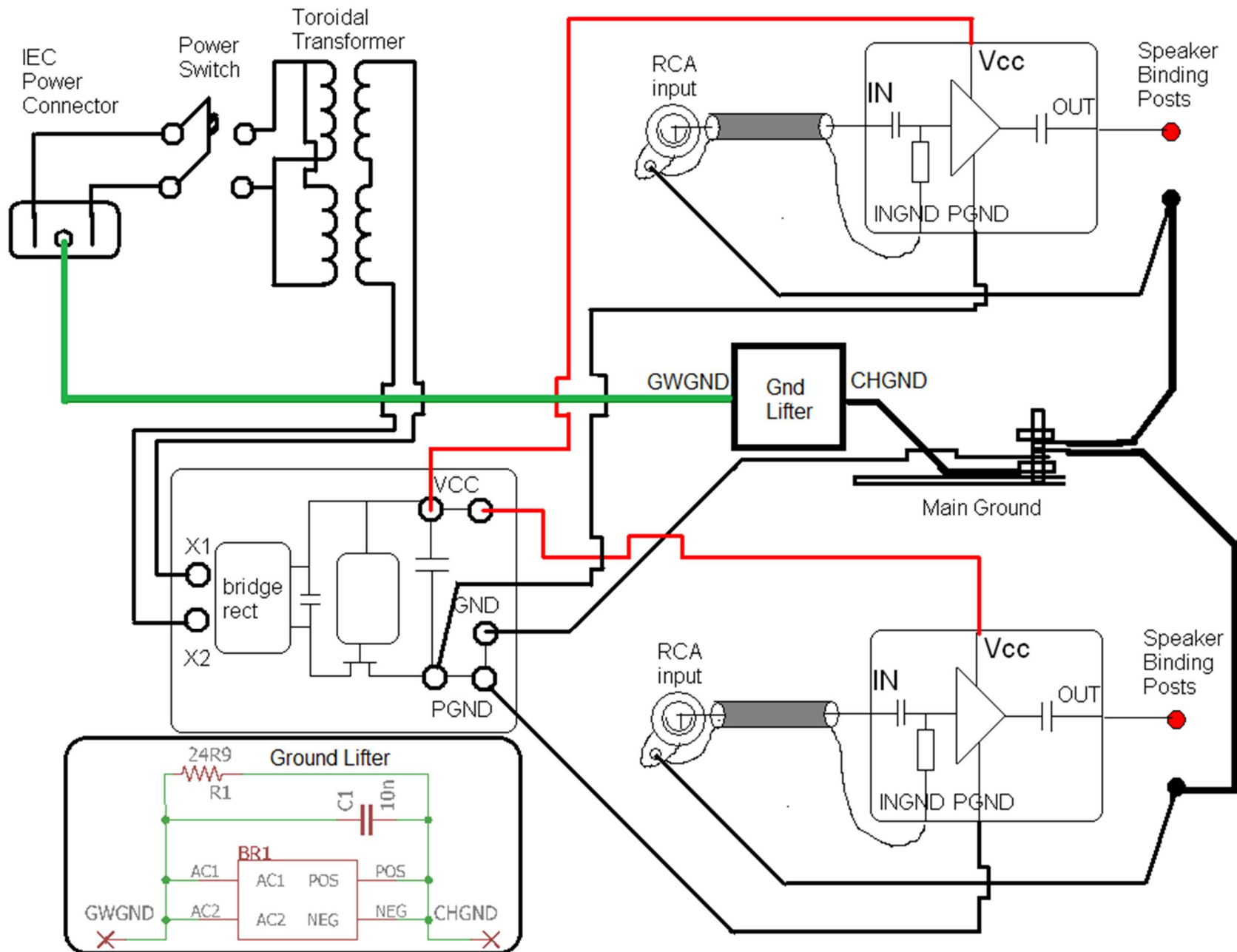


Figure 50-Overall Wiring (power transformer is wired for 120 VAC)

## Section 8: Theory of Operation

### ***Power Supply***

Please refer to Figure 48.

### **Bulk DC Supply**

We begin at the left side of the schematic. The toroidal power transformer steps the 120V or 240 V AC mains (selected as a wiring) option to about 63 Volts RMS. BR1 is a bridge rectifier that changes the input voltage to pulsating DC. C3 smooths that voltage. When lightly loaded (e.g. with the amps at idle or disconnected), there will be about 90 Volts DC across C3. C1 keeps switching noise from the diode bridge confined onto the power supply PCB, preventing it from radiating.

The rest of the circuit regulates the pulsating DC voltage across C3, turning it into a low-noise source of well-regulated 60 Volts DC that powers the amplifier modules. We'll now go over the operation of the regulator.

### **Pass Transistor**

Understanding this topology may make your head hurt. We will try to minimize the pain. Q4 is the pass transistor. Control circuits modulate its conductivity to stabilize the output voltage. The tricky thing? Q4 is in the negative rail. It would be much easier to think about if it were in the positive rail, but then we wouldn't be able to directly connect the drain to a grounded heatsink. That direct connection makes for the most effective heatsinking.

### **Regulator Control Circuits and their Power Supply**

R1, R2, and D1 set up a 10 Volt supply that runs the regulator control circuits. C4 and C5 provide power supply bypassing for the regulator control circuits. R3, R4, R5 and U1 set up a 15-volt reference voltage on the base of T1. T1 and T2 work together to make an error amplifier. The output voltage is sampled by R9 and R10. They provide a voltage on T2 that is compared against the 15-volt reference. Differences between the base of T1 and T2 produce a drive signal that changes the conductance of Q4 to stabilize the output voltage. D4 and D5 limit the drive at the bases of the error amplifier, protecting T1 and T2 during turn-on and turn-off.

Q1 and Q2 form a current mirror that makes use of the collector currents of both Q1 and Q2 to drive Q4. This maximizes the gain of the error amplifier, improving regulation and accuracy of the output voltage.

### **Current Limiting**

The components not discussed to this point are used during start-up or for protection. IC1B (pins 5, 6, and 7) limits the maximum DC (continuous) current that the power supply can deliver. R15 and R17 form a voltage divider that applies 0.5 volts to the positive input of IC1B. The negative input of IC1B (pin 6) is driven by a low pass filter

that senses the power supply output current. The DC current limit is set by  $500 \text{ mV}/0.1 \text{ Ohms}$  (R12) at 5 Amps. Thus the power supply can deliver  $5*60=300$  watts continuously. It delivers more than that for short periods of time, as determined by the R14-C8 time constant, and aided by the large size of C7, the  $10,000 \mu\text{F}$  output filter capacitor. When the DC current exceeds 5 Amps, pin 7 of IC1B goes low, robbing gate drive from Q4 by way of D8. This protects both the power supply and the amplifier in the event of fault conditions.

### **Start-up Circuits**

The power supply starts up in a constant current mode, delivering about 0.42 Amps. This can be calculated by solving  $(10-V_{th})/R7=I_{limit}*R13/R8$ . That yields:  
 $I_{limit}=(10-3)/120000*1000/0.1=0.583$  Amps. Thus the start up current is limited to about 0.58 Amps.

The power supply remains in constant current mode, supplying the amplifier modules and charging C7. This slows the rise of the output voltage. When the output voltage is more than about 36 volts, Zener D3 is conducting and D2 is forward biased. That turns on the T1-T2 error amplifier, which changes the power supply from constant current to constant voltage operation. From 37 volts to 60 volts, the output would rise quickly were it not for the effect of C1, which continues to give the output voltage a slowed rise-time. This limits the charging current in C6. Without a limit on the rise time, the charging current for C6 might be large enough to cause troubles.

R11, 100 Ohms, is used to stop high frequency oscillation in Q4. D7 prevents more than 10.7 volts from being applied to the gate of Q4, protecting it from damage.



# Amplifier Modules

This discussion refers to

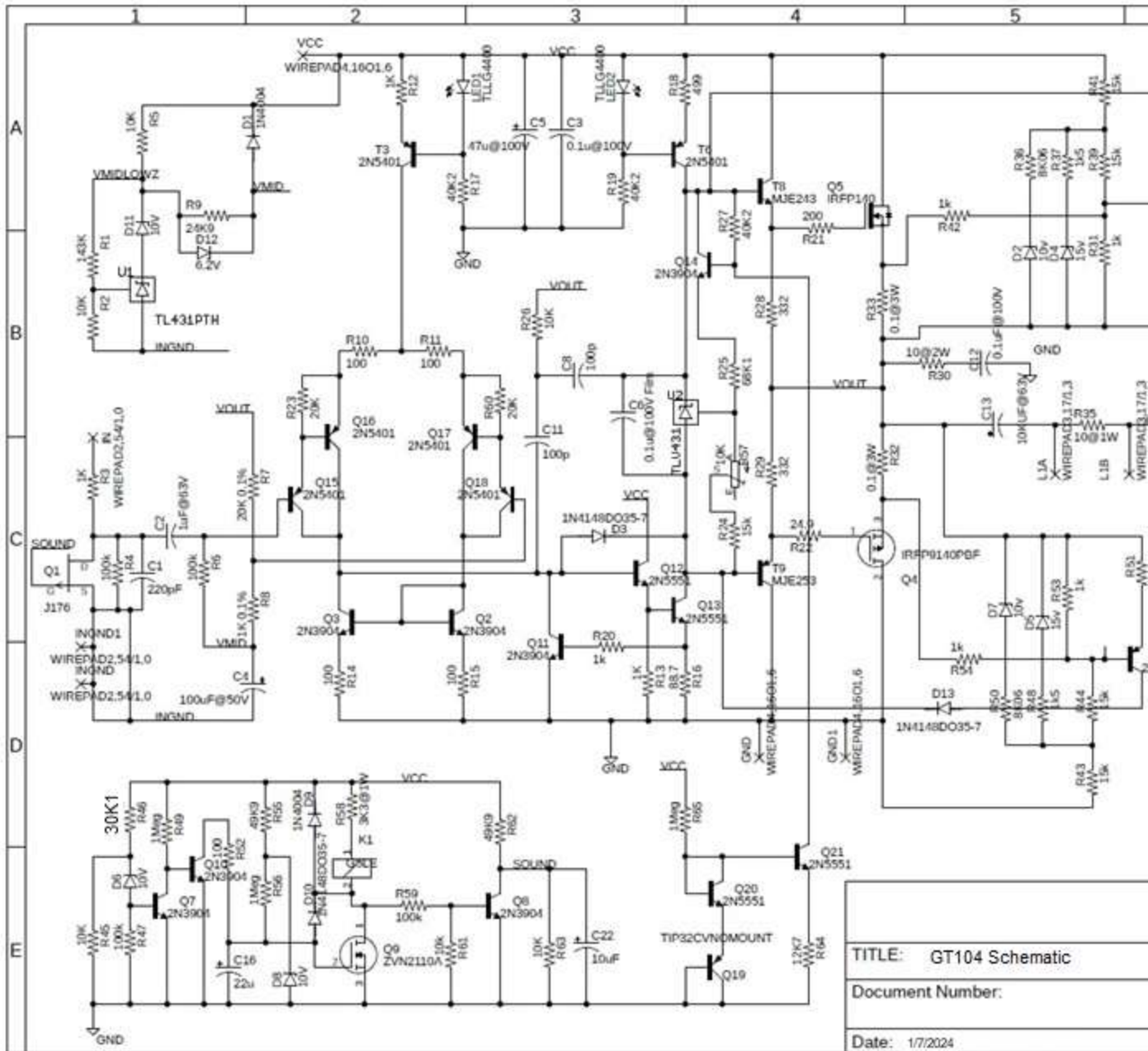


Figure 49.

The amplifier modules are based around discrete transistors with complementary MOSFET output devices.

R3 and C1 make a low-pass filter to eliminate radio stations that otherwise might be picked up on the inputs. Q15-Q18 form a Darlington differential input pair that keeps the input impedance high, making the GT-104 a friendly load for most tube preamps. C2 blocks the input stage bias voltage from appearing on the input RCA jack.

## Reference Voltage Generator

R1, R2, R5, D11, and U2 establish a 38-volt reference at node VMIDLOWZ. D11 assures that 20 volts appears across U2, keeping it well within its 36-volt rating. R9 isolates VMIDLOWZ. D12 helps charge C1 more quickly during turn-on, establishing the output voltage relatively quickly. VMIDLOWZ also sets the output voltage of the amplifier at 30 volts, half the supply rail. This is the optimum point to allow maximum linear output swing.

## Gain Setting Circuits

R7 and R8, 0.1% tolerance resistors, set the amplifier's gain so accurately that the amplifiers can be easily paralleled by paralleling the input pins and paralleling the output binding post. C6 and C11 help keep the amplifier stable under all conditions. C4 sets the low frequency -3 dB point at 1.59 Hz. This keeps the signal across C4 in the audio band miniscule, assuring high linearity. The input -3 dB point is dominated by C2 and R6, at about 1.59 Hz. R26 provides output inclusive Miller compensation.

C13, the output coupling capacitor, couples the amplifier's output to your speakers. L1, wound around C13, and R35 isolate capacitance in the speaker, also assuring stability for all load types. C13, at 10,000  $\mu\text{F}$ , makes a -3 dB point of 2 Hz when driving an 8 Ohm speaker (4 Hz when driving a 4 Ohm speaker).

## Relay Control Circuit

K1 mutes the output of the amplifier during power up and power down. That avoids any pops or clicks during those times. R45, R46, R47, Zener diode D6 keep transistor Q7 off until Vcc is more than 40 Volts. That allows R49 to Keep Q10 ON, which stops C16 from charging.

Once  $VCC > 40$  Volts, Q7 turns on, robbing base drive from Q10, turning Q10 off. C16 now charges through R56. The top of R56 is set at 10V by Zener diode D8 and R55, which makes for a very consistent time delay. D8 also keeps us from exceeding the allowed gate voltage on Q9. Eventually C16's voltage rises sufficiently to turn on Q9, closing relay K1, and connecting the speaker to the amplifier. By this time, the large output capacitor C13 has been charged, through R38, minimizing the transient when the speaker is connected.

R38 charges up C11 during the turn-on period. R40 keeps the negative end of C13 close to zero volts in the absence of a speaker load.

D8 limits the gate voltage on Q4, which protects Q4, and provides consistent operation of the delay function. Q10 resets C16, the delay capacitor, when the power supply voltage drops below 42 volts. R52 limits C1's discharge current.

R59, R61, R62, R63, and Q6 control Q1, a J176, a P-channel JFET that mutes the input whenever the power supply is less than 42 volts. C22 delays the muting function and allows it to smoothly be removed, making for a smooth transition from silence to sound.

R57 is used to set the idling current in the output stage. Q19-Q21, R64, R65 and R27 sense the temperature of the bias stage and adjust the bias voltage to minimize the variation in idling current with temperature.

## Appendix 1 - Resistor Color Code



**Figure 51-demonstrating the resistor color code**

Here's an extreme close-up of a  $\frac{1}{4}$  W metal film 20K (20,000) Ohm resistor, designated by the standard resistor color code.

The colors map to numbers:

Color	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

The color band positions have the following meaning:

Position	Meaning
1	Left-most Digit (e.g. most significant)
2	Next digit to the right
3	Next digit to the right.
4	Number of zeros that follow the three digits, unless: <ul style="list-style-type: none"> <li>• Band 4 is gold =&gt; multiply by 0.1</li> <li>• Band 4 is silver=&gt; multiply by 0.01</li> </ul>
5	Tolerance: <ul style="list-style-type: none"> <li>• Violet =&gt; 0.1%</li> <li>• Brown =&gt;1%</li> <li>• Red =&gt; 2%</li> <li>• Gold=&gt; 5%</li> <li>• Silver=&gt;10%</li> </ul>

## Appendix 2 - Preparing a Shielded Cable End

This section tells how to prepare the ends of the shielded cable. This process will be repeated four times, at both ends of both input cables (although the cables will have different overall lengths).

1. Cut the shielded cable to the overall required length.
2. Use a utility knife with a new, sharp blade to cut the plastic jacket of the shielded cable 1" back from the end. Hold the blade perpendicular to the cable, and draw it across the cable lightly as you rotate the cable along its long dimension. This creates a scored line through the plastic jacket. With a sharp blade, not much pressure is needed. You may need a bit of practice to get the feel.



3. If you've scored the jacket carefully, you can separate the jacket at the score line without using tools. Pull the insulating jacket off, exposing the cable, showing the foil shield, the drain wire, and the fuzzy string. The result is shown here, with the foil shield showing.



4. Cut off the fuzzy string



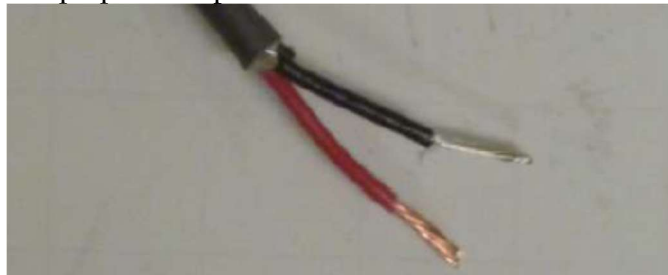
5. Separate and twist the drain wire.



6. Peel back and remove the foil. Remove the plastic wrap from the red and black wires. The drain (bare wire), red, and black wires are exposed now that gray insulating jacket, foil shield, and plastic over-wrap have been removed.
7. Pull the black wire out of the shielded cable.



8. Locate the #18 solid black wire in the wire kit. Remove 5/8" of the black insulation.
9. Slip the insulation from the previous step over the drain wire. This should leave 3/8" of bare drain wire exposed. It works best if you twist the insulation in the same direction as the drain strands are twisted. If it's difficult to get it started, then cut off a little bit of the end of the drain wire. That gives you a clean end, making it easier to start the insulation onto the drain wire.
10. Remove 3/8" of insulation from the red wire. Twist its strands tightly. Twist and tin the ends of the red wire and the drain wire.
11. Repeat the end preparation process for the other end of the shielded cable.



**Figure 52- Shield wire end prep completed**

Note – the “black wire” you see in Figure 52 is the really the drain wire covered by insulation taken from the 18 AWG solid black wire.