Firefly PCB Assembly Guide

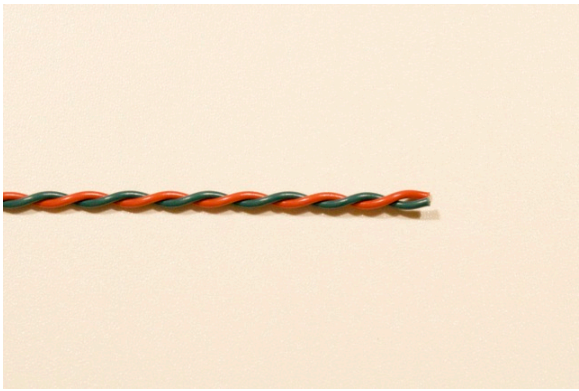
Contents

Note: Assembly guide is for Revision 8. Depending on the revision of your board, the photos of the PCB in this guide may not be identical to yours.

Document version **3** — John Calhoun, June, 2009

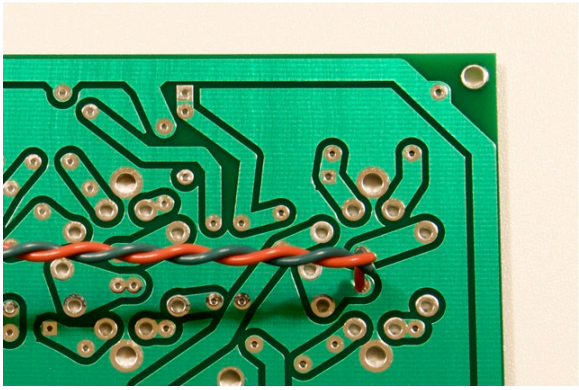
Firefly PCB Assembly

☐ 1 — The filaments of each tube are wired with a pair of twisted wires on the bottom side of the circuit board. Three twisted pairs of wires will make a sort of daisy chain connecting each of the vacuum tubes and finally ending at a pair of solder pads on the far edge of the circuit board.



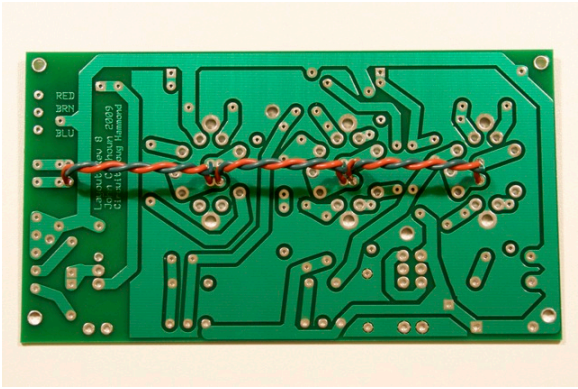
Take two 12 inch pieces of 20 or 22 gauge solid copper hook-up wire and twist together. A small drill makes this easy to do. The photo on the right shows a portion of the twisted wires. If you twist them too tightly you are in danger of breaking the wires, so don't get carried away with the drill.

We will be inserting these from the bottom side of the board and soldering them on the top side! See photos.



With your long twisted wire untwist 1/2" or so from one end and strip back about 1/4" of the insulation. Solder the two wires on this end to the two small holes in the center of the first tube (see photo to right and photo at bottom of page). Run the twisted wire across to the closest pair of holes in the center of the center tube.

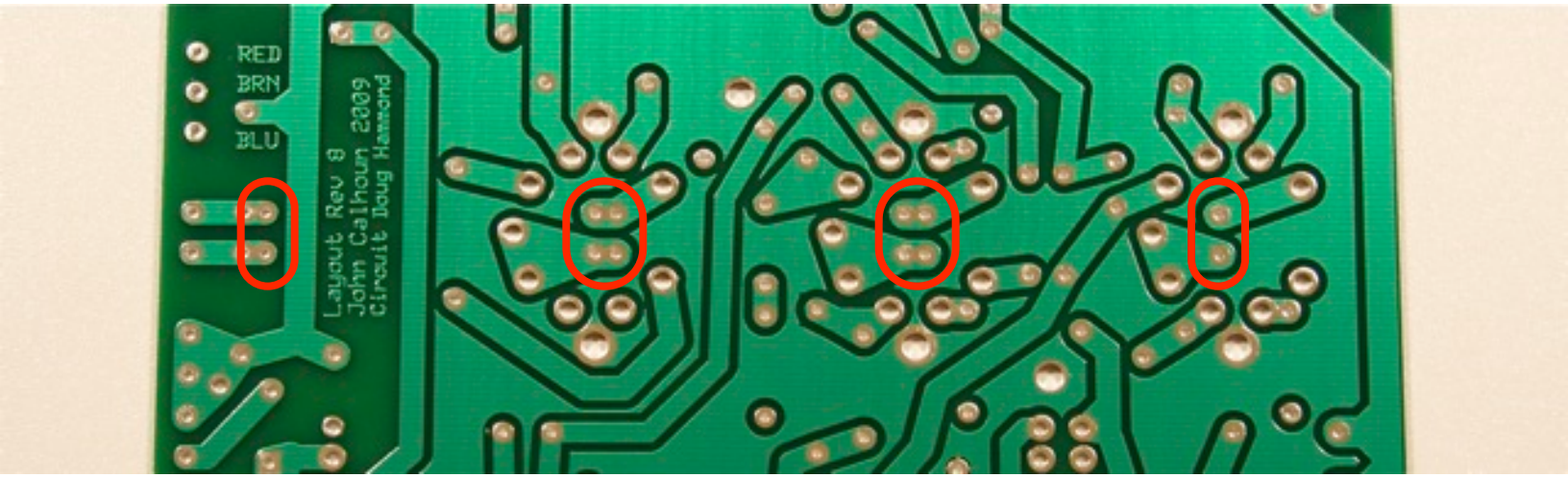
To reduce the introduction of AC hum into the amp, often builders will raise the twisted heater wires up off the board keeping them away from the PCB. The twisted wires should attach to the PCB at right angles and form sort of raised bridges (the photos show this somewhat).



Cut the twisted wires to an appropriate length, strip the ends and solder.

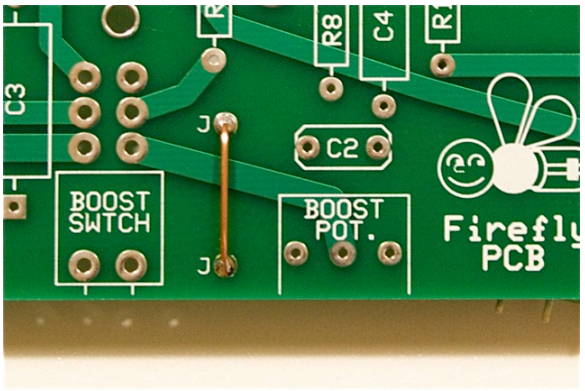
The second pair or wires start where the first pair ended. They go to a similar pair of holes underneath the last tube. Prepare the ends of your twisted wire as you did before and solder as before.

The last pair of wires runs from where the second pair ended to a pair of holes near the edge of the board (see photo below). Insert and solder the last twisted pair of wires as you did before. The photo to the right shows the completed filament wiring.



☐ 2 — Flip the board over — we're done for now with the bottom side of the board.

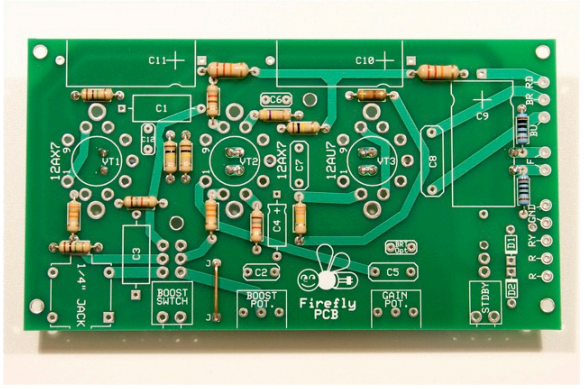
There is a single jumper wire that connects two portions of the ground plane (on the bottom side of the PCB). Make this jumper wire by stripping about 2 inches of insulation from the same 20 or 22 gauge solid copper wire you used for the filament wiring. Bend it to fit in the two holes labeled "J" and solder and trim excess.



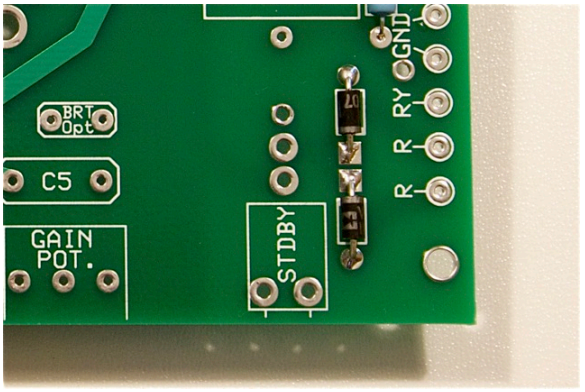
☐ 3 — Resistors R1 through R13 and R16, R17 are 1/2 Watt resistors. Insert, solder and trim R1 through R13 as well as R16 and R17 (R16 and R17 are 1% resistors).

☐ 4 — Resistors R14 and R15 are slightly larger 1 Watt resistors. Insert, solder and trim these next. You are done with the resistors (and frankly the most tedious portion of this build).

The photo to the right shows all resistors soldered in place.

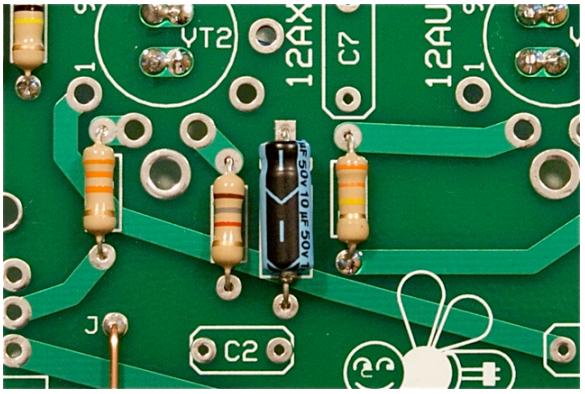


☐ 5 — Next carefully bend and insert diodes D1 and D2. **These are polarized so make very certain you place the diodes with the silver band oriented with the stripe in the silkscreen on the circuit board!** Solder and trim.



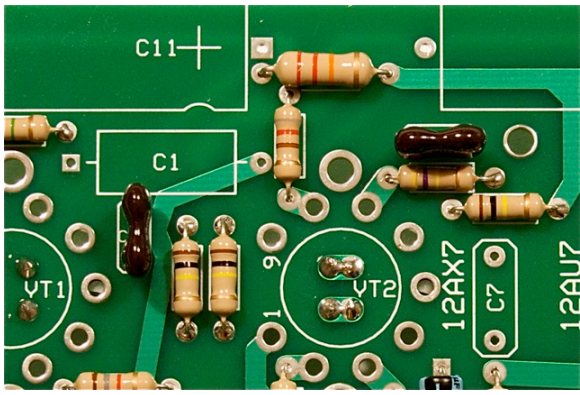
☐ 6 — Install the small electrolytic capacitor C4. **This component is also polarized.** The negative symbol on the capacitor should correspond with the round solder pad on the circuit board (the positive end goes into the hole with the square pad). The positive hole on the board is also marked with a small plus "+" symbol next to it.

Notice the electrolytic capacitor has an arrow labeled with a minus sign pointing to the negative lead (end) of the capacitor.

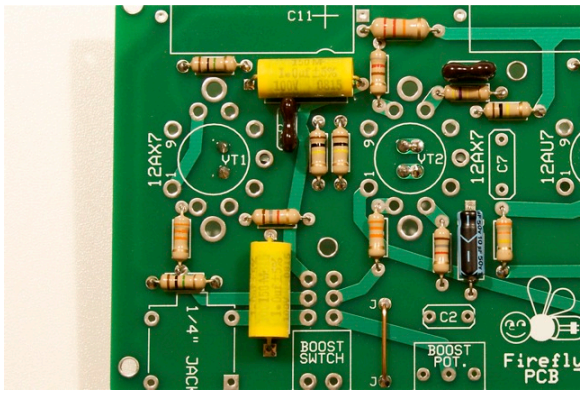


☐ 7 — Next insert and solder the brown mica capacitors C6 and C12. These are not polarized and so can be inserted in any orientation. Trim.

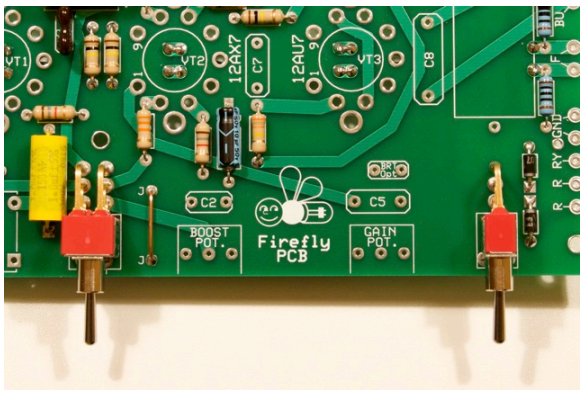
Note: There are holes for an additional, optional capacitor labeled **BRT Opt** on the PCB (near C5). This is for an optional “brightness capacitor”. If you wish to brighten the sound of the amp (especially at lower volumes) install a 220 picofarad (or so) mica capacitor. A larger value (say 440 picofarads) adds more brightness. A lower value (such as 120) adds less brightness.



☐ 8 — Insert and solder the yellow capacitors C1 and C3. These are not polarized and so also can be inserted in any orientation. Trim.

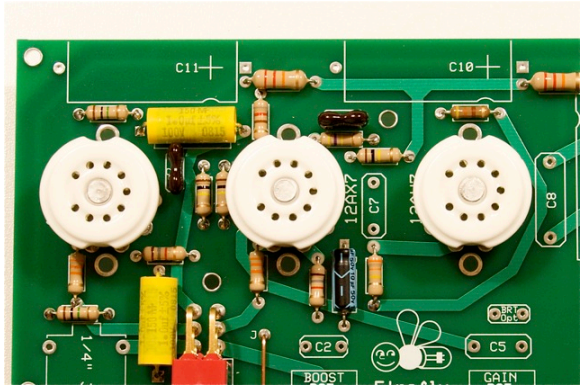


☐ 9 — Next install the two switches. These are the boost enable, and stand-by switches. Make sure they are flush before soldering. Be sure also to solder the two pins that ground the body of the switch and give it additional mechanical support.

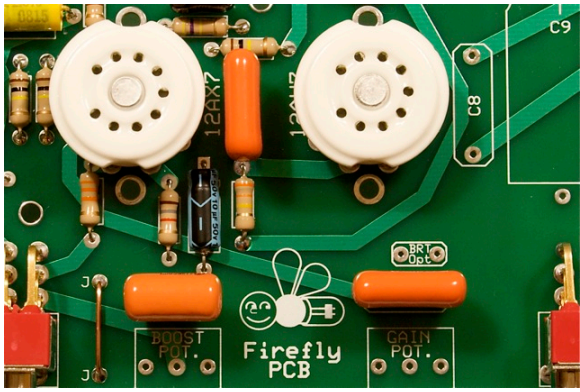


☐ 10 — Install the three ceramic tube sockets VT1, VT2, and VT3. Note the orientation (one place where a pin might be is missing). Be very certain that the sockets are pressed in firmly and are flush before soldering — otherwise your tubes won’t stick straight up.

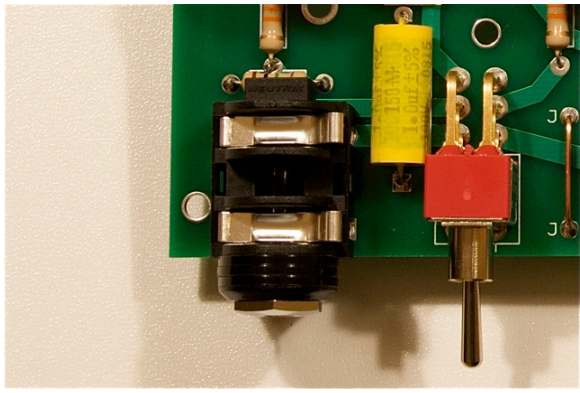
One trick I’ve tried with success is to install the tube-shield bases before soldering the sockets in (see step 16 where tube-shields are discussed). The shield bases help hold the sockets flush to the PCB wile you solder.



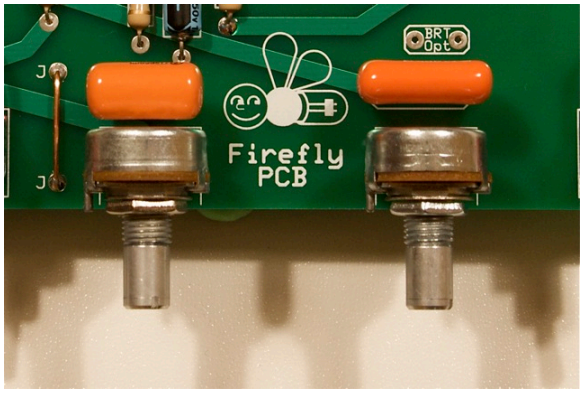
☐ 11 — Insert, solder and trim all of the “orange drop” capacitors: C2, C5, and C7. These are not polarized and so can be inserted in any orientation. Note that C8 is no longer required. Its original purpose was esoteric and found to be both unnecessary and in fact to dull the sound. It is no longer used.



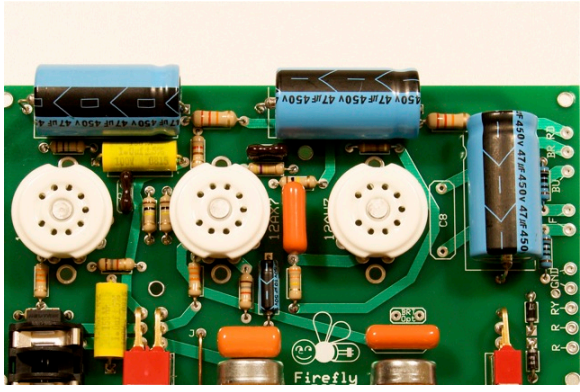
☐ 12 — Insert and solder the 1/4” phono jack. Make sure you install it such that a phono jack can be inserted (opening facing bottom edge of circuit board — see photo).



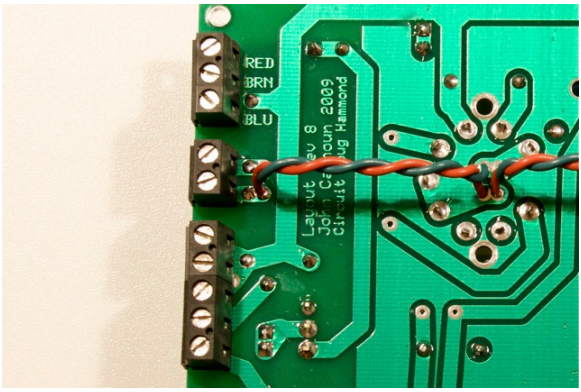
☐ 13 — Insert and solder the two potentiometers, VR1 (BOOST, 250K) and VR2 (GAIN, 1M). These are the boost and gain controls. When soldering them try to keep them straight up and down. Also, make sure the shafts of the potentiometers face outward across the edge of the board (again, see photo at right).



☐ 14 — Insert and solder the last of the capacitors — the large electrolytic capacitors C9, C10, and C11. **These too are polarized!** The positive lead must go into the hole with the square pad (with the plus “+” symbol next to it on the circuit board).



☐ 15 — Turn the board over and insert the screw terminals in the holes along the far edge of the board (see photo at right). The top position is for wiring the output transformer and gets a three-hole terminal. The next pair of holes get a two-hole terminal and are for the filament (heater) power supply. The last 5 holes consist of two ground and the power transformer hookups. The terminal connectors interlock with one another so you can take a three-hole terminal and a two-hole terminal and join them to one another before inserting into the board.



Make sure the openings on the side of the terminals are facing the outside of the board.

Attach all terminal blocks from the bottom and solder from the top side of the board.

☐ 16 — To finish off the PCB work, install the tube shield bases. The tube shields come in two pieces (see photo). We'll attach the lower section to the PCB using the shorter of the hex spacers and some of the metric screws. I start by screwing two hex spacers to the shield base as shown in the photo. Then carefully bend the hex spacers until they appear parallel to one another and square with the shield base. Then place the assembly over a tube socket and attach with screws from the bottom (see photo on page 1).

With the ground plane (large copper areas) on the bottom of the PCB, the tube shield base acts as part of that shielding system to reduce hum. The base electrically connects portions of the ground plane on the bottom of the PCB with other portions (that would otherwise be electrically isolated).

☐ 17 — The components on the board are complete. If you haven't already, **take a much deserved break!**

The last steps involve attaching wires to the board from the various "off board" components and connecting them to one another. You should go ahead and prepare your amplifier's chassis before proceeding with these final electrical hookups.

I have included in this document two chassis layouts you can use. One is intended for a standard 10" x 6" x 2" chassis (Hammond makes one for example). The other layout assumes you have a means to cut the metal of the chassis to a specific size and have access to a metal brake for bending the chassis. In either case however you will need a drill and a stepped drill bit or bits capable of drilling up to 1 1/8" or 1 1/4" holes (for the larger holes a punch can be used).

Drill all the holes required for mounting the circuit board, transformers, front panel controls, etc.

If you installed the screw terminals to the Firefly PCB then you can attach the wires from the off-board components at any time. With the terminals attached to the bottom of the board, it makes sense to go ahead and mount all components on the chassis including the Firefly circuit board itself.

When you are ready to wire the final components start by attaching the red, brown and blue wires from the small output transformer to the three-hole terminal block near the back of the board. Sadly I didn't label the bottom of the board, but on the silkscreen side these are labeled **RD**, **BR** and **BU**.

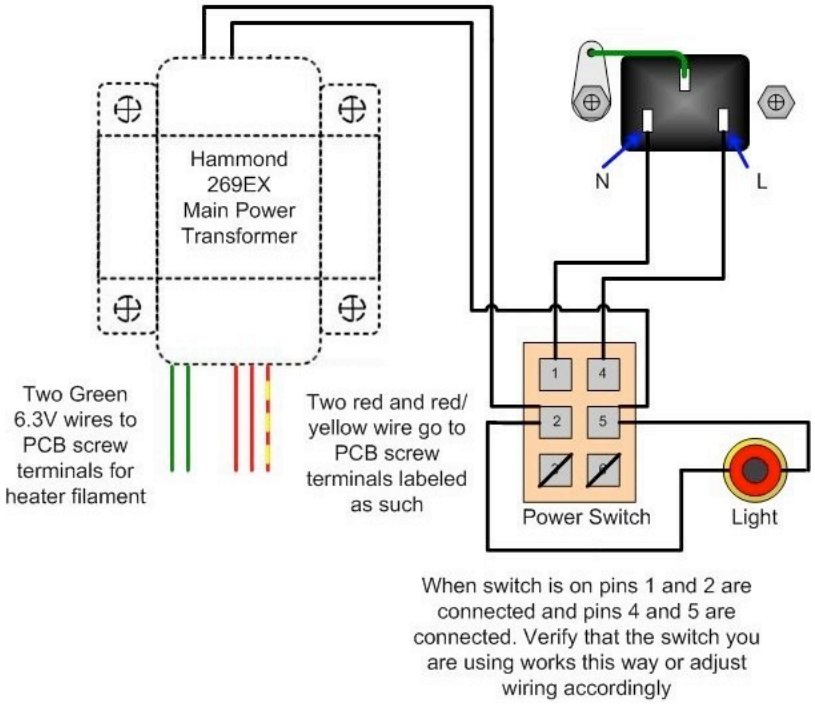
☐ 18 — Next we'll attach the wires from the large power transformer to the corresponding terminal blocks on the circuit board.

The green wires should be twisted together and attached to the two-hole terminal (labeled **F** for "filament" on the silkscreen side). It doesn't matter which green wire goes to which terminal hole.

And finally the three red wires should be braided and attached to the frontmost three holes of the five-hole terminal block. On the silkscreen side these are labeled **R**, **R**, **RY**. If you haven't guessed the red wire with the yellow stripe is the one that attaches to the **RY** hole, the other solid red wires attach to the holes labeled **R** (it doesn't matter which red wire goes to which hole).

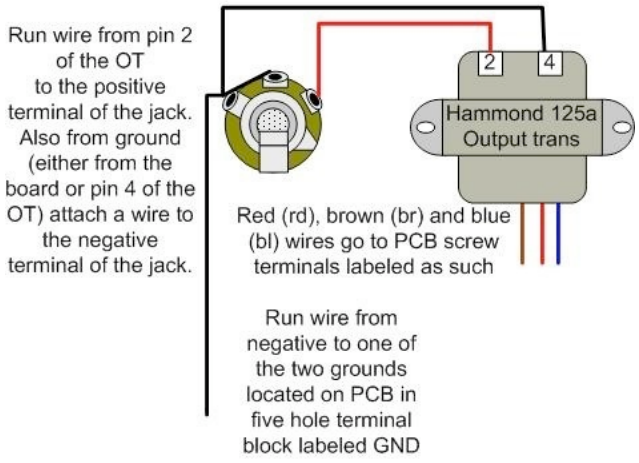
☐ 19 — The rest of the wiring will be primarily point to point between the various components on the chassis.

Start with the black wires from the power transformer and the neon indicator wires and attach these in parallel to the center of the power switch. (See illustration to right, pins shown labeled 2 and 5 on switch as viewed from bottom).



☐ 20 — One side of the power switch should be wired to the IEC connector and fuse assembly (AC mains). In this way, when the power switch is thrown, household current is supplied to both the neon lamp (to indicate the amplifier is on) and to the power transformer itself. Often a stranded wire of about 20 gauge is used for these connections. You should twist the AC mains wires together to minimize noise interference with the amplifier. *Note: two pins on switch have no connection.*

☐ 21 — If you are building a speaker into your cabinet (combo) you are ready now to wire that. If however you are building your amp as a separate "head unit", you will want to next wire up the 1/4" jack for the speaker output. In either case, you will be wiring from pin 2 of the Hammond 125A output transformer to the positive terminal of either the speaker or jack. You want then to run a wire from pin 4 of the Hammond 125A output transformer to one of the ground terminal holes on the circuit board (these are the two extra holes in the five-hole terminal block — labeled **GND** on the silkscreen side of the board).



Also from ground (either from the board or pin 4 of the output transformer) attach a wire then to the negative terminal of either the speaker or the jack.

☐ 22 — Carefully install the three vacuum tubes. Also make sure to install 1 Amp fuse.

Go take a break. Seriously. When you get back, double check that everything was installed correctly. Taking a break and coming back with “fresh eyes” is a great way to identify an obvious dumb mistake.

If everything looks good it is time for the “smoke test”. Attach an 8-ohm speaker (if not already attached). Do not attach a guitar at this time. Make sure power and stand-by switch are in their off (down) position — turn off boost switch as well and turn the main volume to zero. Plug in the amplifier.

First turn on the main power switch. If there is no flash or spark right away, that is good. The neon power indicator should have lit up. Observe the filaments in the tubes. Are they all glowing orange after 10 seconds or so? If so proceed, otherwise turn off the power and determine why no power is getting to the filaments.

If the filaments looks good go ahead and switch on the stand-by switch. Now high voltages are coursing through the amplifier. Hopefully you don’t hear any oscillation or suffer a blown fuse. If there is anything unusual shut off power and diagnose the problem.

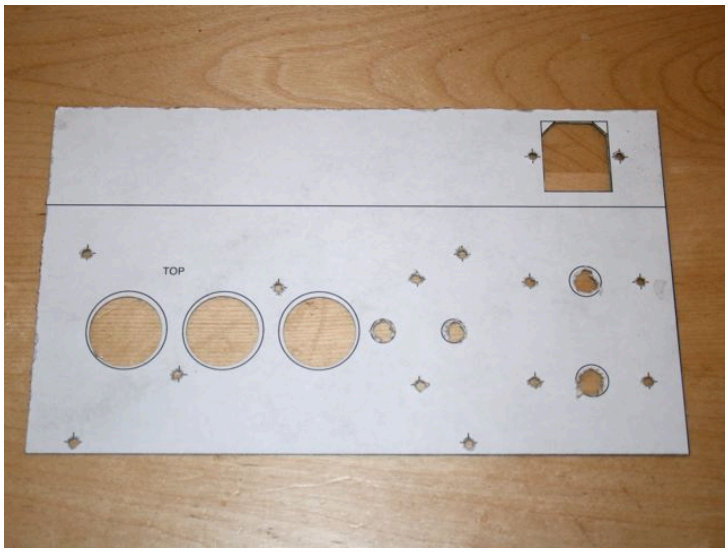
Finally if all is well to this point, turn up the main volume. You may hear a minute amount of hum especially at full volume, but in general it should be fairly minimal.

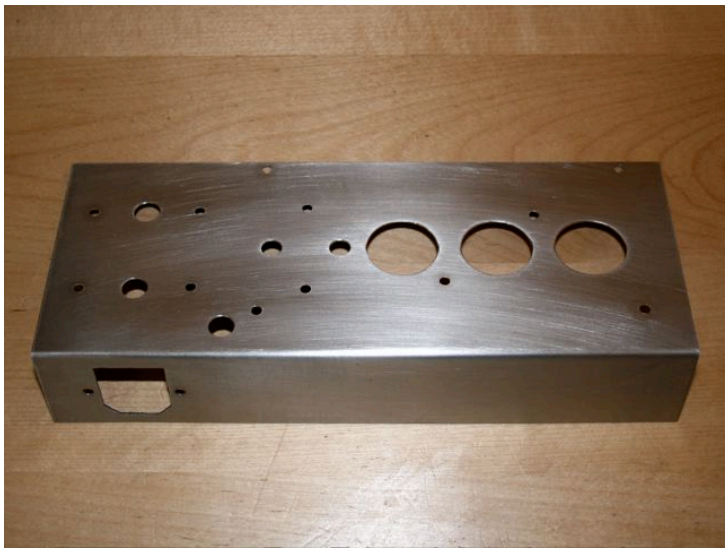
If everything has checked out to this point, go ahead and plug in a guitar and try plucking a string, You should be able to turn the volume up and down on the amplifier and hear it working without oscillation throughout the entire range. If everything has checked out up to this point then you are doing great. The last portion of the circuit to test is the boost stage.

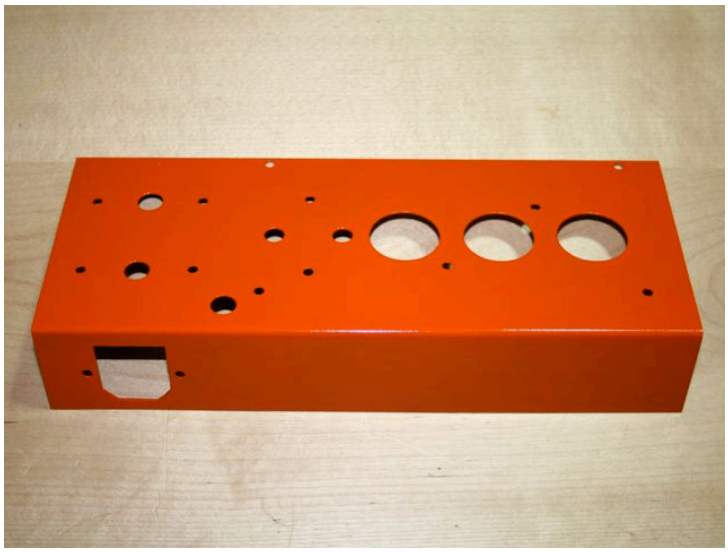
Drop the volume down to about 25% or so and set the boost gain down to zero. Switch on the Boost switch. Pluck a string on the guitar and slowly turn up the boost. If all is well, you will begin to hear the note, a little overdriven, coming through the amplifier. Play with the levels of the Boost and Volume to get the desired sound/level (you will hear some hum when the boost is engaged and turned up significantly).

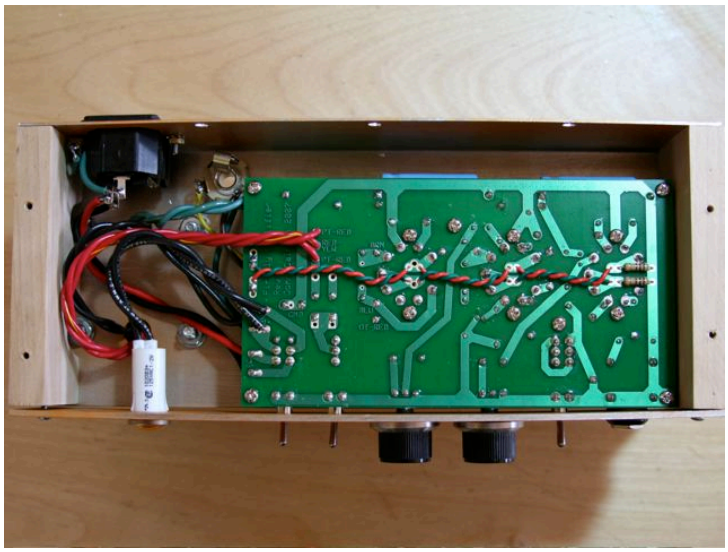
Enjoy your amplifier.

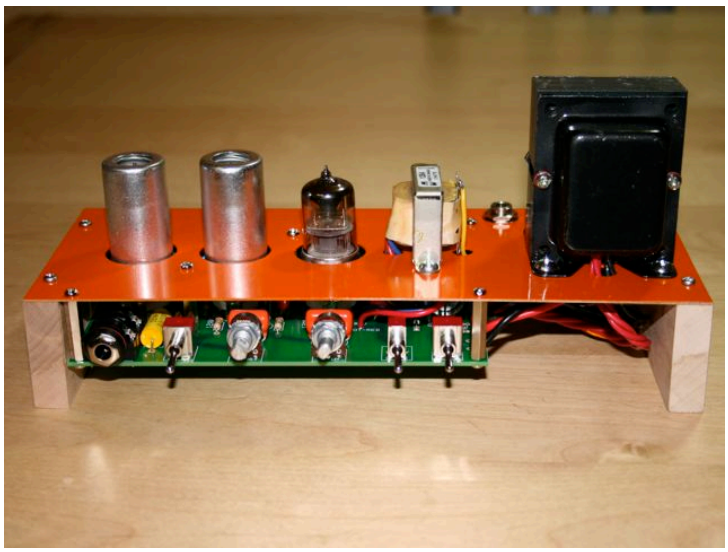
Here are some photos of a chassis I built. A pattern is included in this document. Pattern was glued to a sheet of aluminum. It was cut to size, drilled and painted. (Photos show an older Rev. 3 Firefly PCB.)



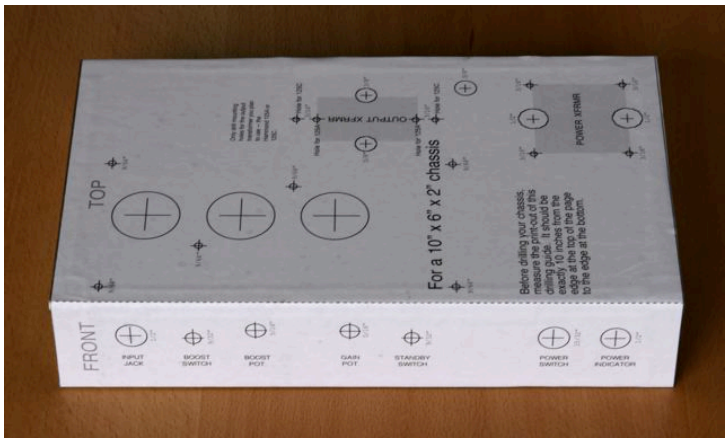


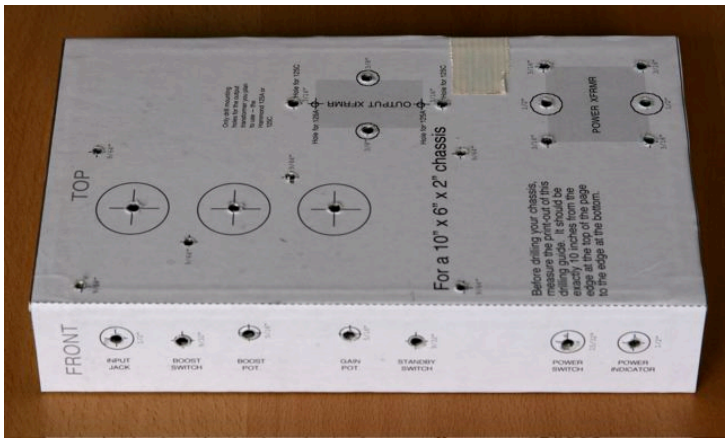


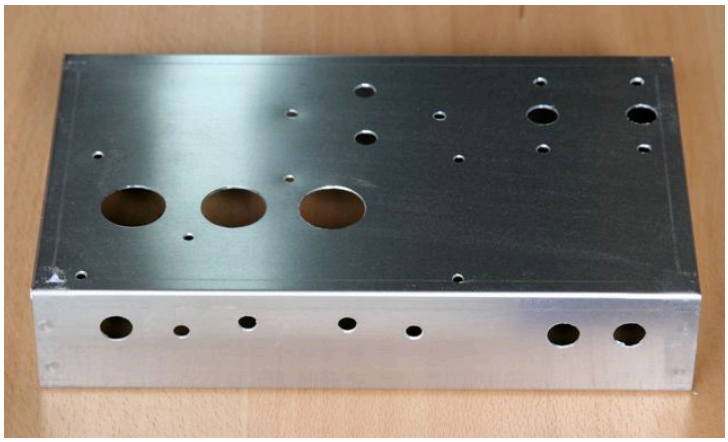




Here are some photos of another Firefly I built this time using the Hammond 2 x 6 x 12 inch aluminum chassis. A pattern is included in this document for the holes. As above, the pattern was glued to the chassis, it was drilled and painted.







Firefly PCB Bill of Materials

Part Number	Quant.	Description	Price	Total
Antique Electronics (www.tubesandmore.com)				
P-ST9-214	3	9-Pin Socket, Ceramic, PC-Mount	$ 1.75	$ 5.25
P-Q1N4007	2	1KV Diode	$0.25	$0.50
P-T125A	1	Output Transformer	$ 27.25	$ 27.25
P-T269EX	1	Power Transformer	$ 32.50	$ 32.50
T-12AU7-JJ	1	12AU7 Dual Triode JJ Electronics [1]	$ 8.75	$ 8.75
T-12AX7-S-JJ	2	12AX7 Dual Triode JJ Electronics [1]	$ 8.95	$ 17.90
P-SS9-325	3	9-Pin Shield, Aluminum	$ 0.95	$ 2.85
Mouser Electronics (www.mouser.com)				
313-1510F-1M	1	1MΩ Potentiometer PC-Mount	$2.16	$2.16
313-1510F-250K	1	250KΩ Potentiometer PC-Mount	$2.16	$2.16
550-12202	1	Phone Jack 1/4", PC-Mount	$1.00	$1.00
108-0020-EVX	1	SPDT Miniature Switch , PC-Mount	$2.98	$2.98
108-0024-EVX	1	DPDT Miniature Switch , PC-Mount	$3.62	$3.62
140-XAL450V47-RC	3	47 μF, 450V Axial Elec. Capacitor	$3.46	$10.38
140-XAL50V10-RC	1	10 μF, 50V Axial Elec. Capacitor	$0.25	$0.25
539-150105J100IC	2	1 μF, 100V Film Capacitor	$0.91	$1.82
75-225P400V0.022	2	0.022 μF, 400V Poly Capacitor	$0.60	$1.20
75-715P600V0.0022	1	0.0022 μF, 600V Poly Capacitor	$0.47	$0.47
5982-15-500V470	1	470 pF, 500V Mica Capacitor	$1.41	$1.41
5982-15-500V220	1	220 pF, 500V Mica Capacitor	$0.85	$1.70
294-22K-RC	10	22KΩ, 1 Watt Resistor [2]	$0.14	$1.40
293-1M-RC	10	1MΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-470K-RC	10	470KΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-330K-RC	10	330KΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-100K-RC	10	100KΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-33K-RC	10	33KΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-1.8K-RC	10	1.8KΩ, 1/2 Watt Resistor [2]	$0.05	$0.50
293-820-RC	10	820Ω, 1/2 Watt Resistor [2]	$0.05	$0.50
273-442-RC	10	442Ω, 1/2 Watt Resistor (1%) [2, 3]	$0.10	$1.00
273-100-RC	10	100Ω, 1/2 Watt Resistor (1%) [2]	$0.10	$1.00
103-0008-EVX	1	Toggle Switch, Panel Mount	$4.19	$4.19
607-1030D3	1	Neon Lamp Assembly	$2.22	$2.22
PF0001/28	1	AC Connector w/ Fuse	$2.33	$2.33
576-0215001.HXP	2	5 x 20mm, 1A Slo-Blo Fuse	$1.28	$2.56
48SM003	100	M3 x 6mm Screw	$0.012	$1.20
855-R30-1011002	6	M3 x 10mm Hex Spacer	$0.38	$2.28
855-R30-1012502	6	M3 x 25mm Hex Spacer	$0.60	$3.60
502-12A	1	1/4” Phone Jack (2 conductor)	$1.78	$1.78
538-39880-0302	2	Two-Hole Terminal Block	$0.46	$0.92
538-39880-0303	2	Three-Hole Terminal Block	$0.70	$1.40

Prices from December, 2007.

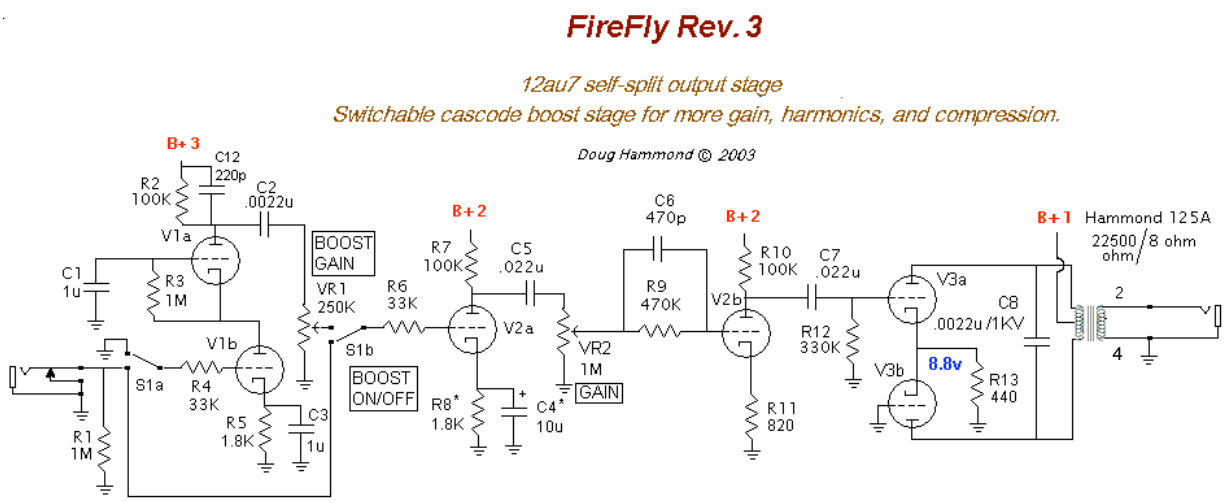
Notes:

1 — Pricier tubes may be substituted — the ones listed are the fairly inexpensive.

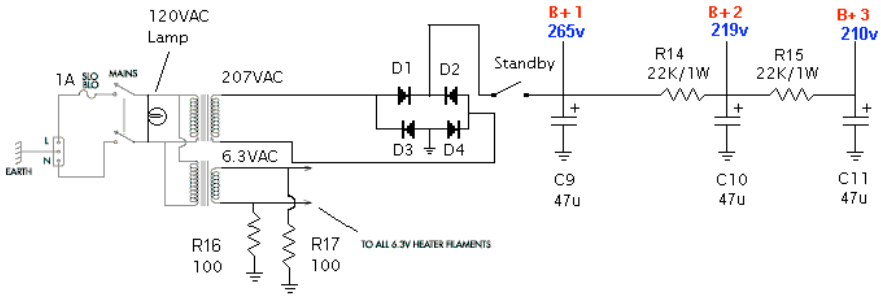
2 — Some parts have a minimum quantity when you order or cost less in bulk. You won't need all.

3 — This is to replace R13. R13 is listed as 440Ω but this is difficult to find.

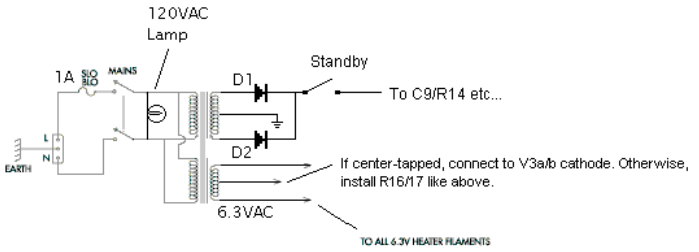
Firefly PCB Schematic



Power supply wiring using non center-tapped isolation transformer and separate filament transformer:



Power supply wiring using center-tapped 190-0-190 power/filament transformer such as Hammond 269EX:



Thanks to Niek for the inspiration!

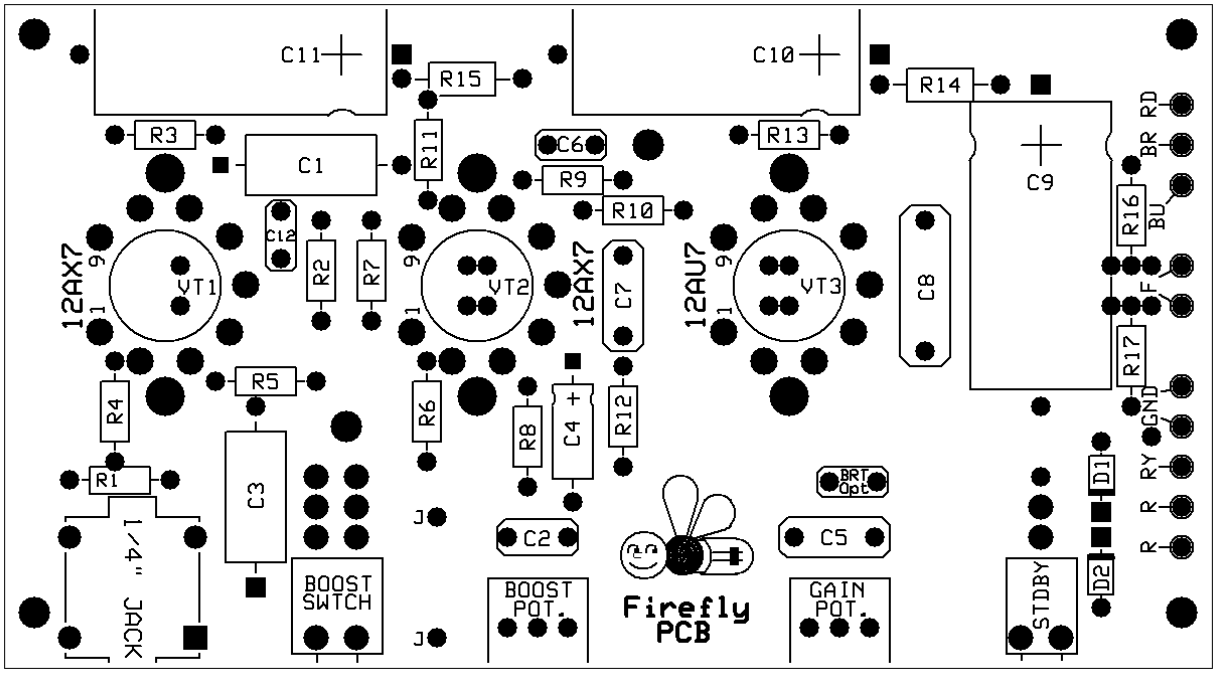
D1-D4: 1N4007
V1, V2: 12AX7
V3: 12AU7
All resistors 1/2 Watt unless otherwise noted.
Use 400V caps just to be safe.

* R8/C4 tweaked for fuller bass and smoother highs compared to Rev. 2.

Firefly PCB Parts List

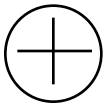
C1, C3	1 μF, 100V Capacitor
C2	0.0022 μF, 600V Poly Capacitor
C4	10 μF, 50V Electrolytic Capacitor
C5, C7	0.022 μF, 400V Poly Capacitor
C6	470 pF, 500V Mica Capacitor
C9, C10, C11	47 μF, 450V Electrolytic Capacitor
C12	220 pF, 500V Mica Capacitor
D1, D2	1N4007, 1KV Diode
R1, R3	1M Ω, 1/2 Watt Resistor
R2, R7, R10	100K Ω, 1/2 Watt Resistor
R4, R6	33K Ω, 1/2 Watt Resistor
R5, R8	1.8K Ω, 1/2 Watt Resistor
R9	470K Ω, 1/2 Watt Resistor
R11	820 Ω, 1/2 Watt Resistor
R12	330K Ω, 1/2 Watt Resistor
R13	430 Ω, 1/2 Watt Resistor (note, this is a 440 Ω resistor in schematic)
R14, R15	22K Ω, 1 Watt Resistor
R16, R17	100 Ω, 1/2 Watt Resistor (1%)
VR1	250K Ω Potentiometer
VR2	1M Ω Potentiometer
VT1, VT2	12AX7 Vacuum Tube
VT3	12AU7 Vacuum Tube

Firefly PCB Silkscreen



FRONT

INPUT JACK



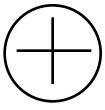
BOOST SWITCH

BOOST POT.

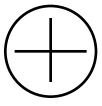
GAIN POT.

STANDBY SWITCH

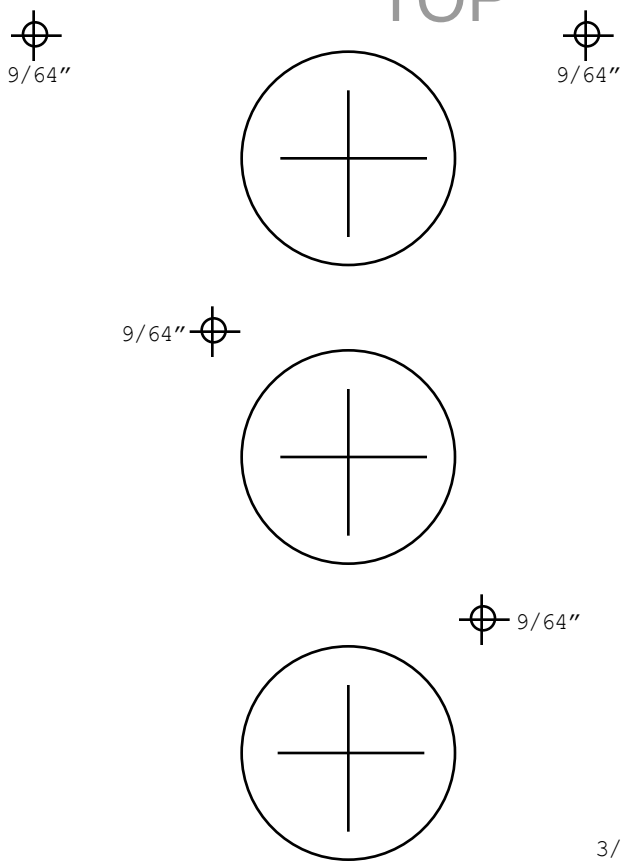
POWER SWITCH



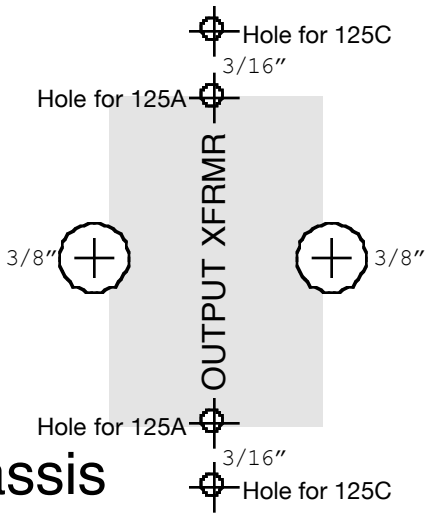
POWER INDICATOR



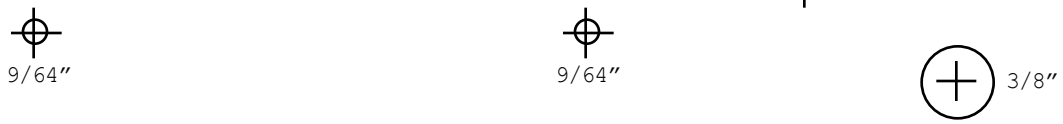
TOP



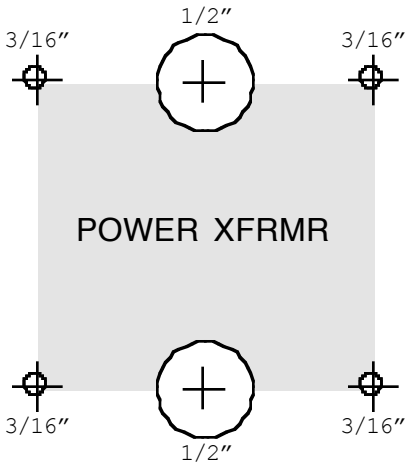
Only drill mounting holes for the output transformer you plan to use — the Hammond 125A or 125C.

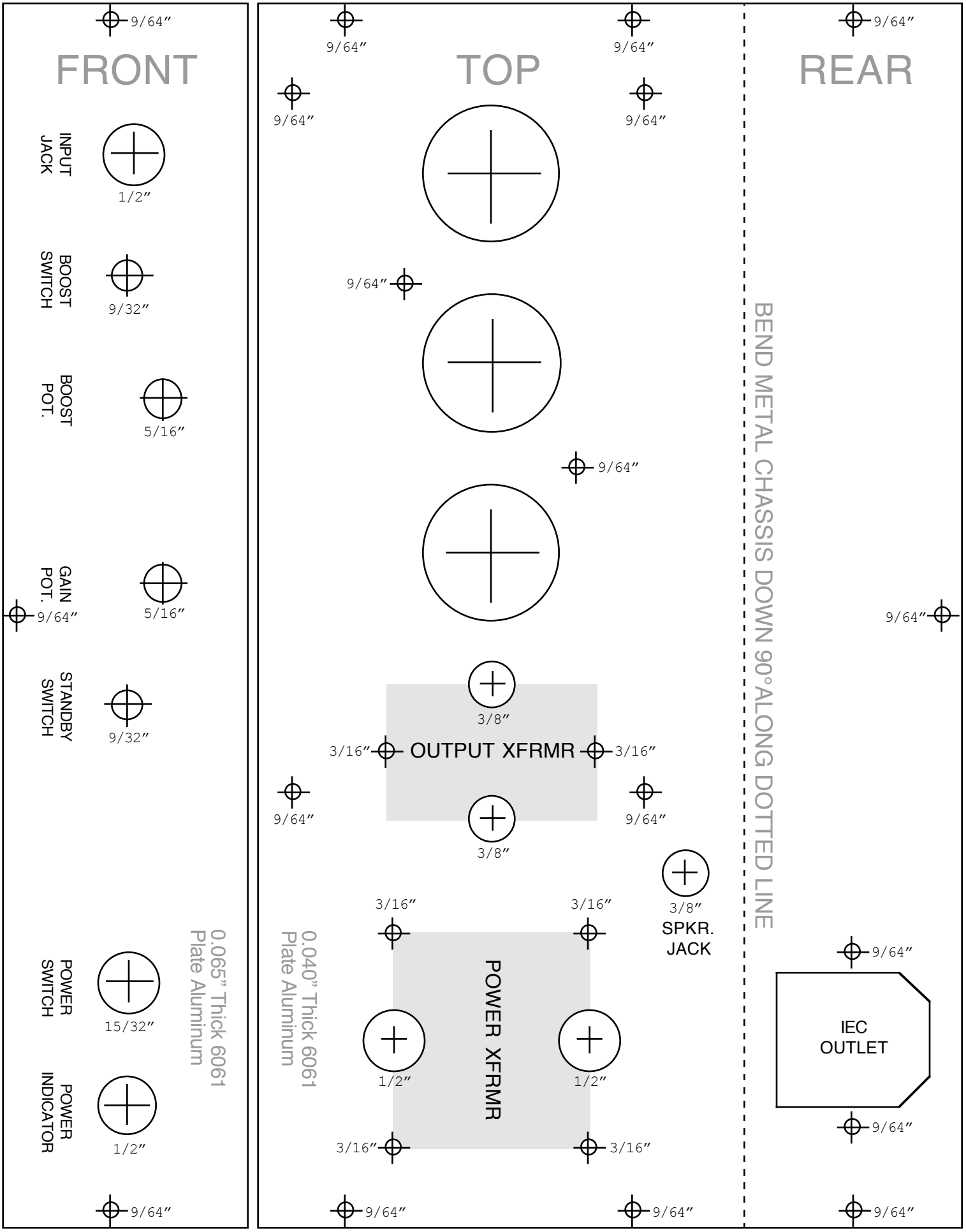


For a 10” x 6” x 2” chassis



Before drilling your chassis, measure the print-out of this drilling guide. It should be exactly 10 inches from the edge at the top of the page to the edge at the bottom.




FRONT
9/64″
INPUT JACK
1/2″
BOOST SWITCH
9/32″
BOOST POT.
5/16″
GAIN POT.
9/64″
5/16″
STANDBY SWITCH
9/32″
POWER SWITCH
15/32″
POWER INDICATOR
1/2″
9/64″
0.065” Thick 6061 Plate Aluminum
TOP
9/64″
9/64″
9/64″
9/64″
9/64″
9/64″
3/8″
3/16″
OUTPUT XFRMR
3/16″
3/8″
9/64″
9/64″
3/8″
SPKR. JACK
3/16″
3/16″
POWER XFRMR
1/2″
1/2″
3/16″
3/16″
9/64″
9/64″
0.040” Thick 6061 Plate Aluminum
REAR
9/64″
BEND METAL CHASSIS DOWN 90° ALONG DOTTED LINE
9/64″
IEC OUTLET
9/64″
9/64″
9/64″

Firefly PCB Assembly Guide End

John Calhoun, June, 2009