Printed Circuit Board
for dual rail linear power supply

Features:

Top side ground plane.

Flexible filter capacitor and transformer secondary options

FR4 double-sided, plated-thru holes, with conformal coating solder mask

For fast TO220 2 or 3-pin Schottky rectifiers

This PCB is intended for a variety of voltage/current possibilities, from +/-5V to +/-100V, depending on the power of the amplifier supplied.

Different voltages dictate different values for many of the components. The component values given are only a guide.

Pay extremely close attention to polarity of each electrolytic capacitor, since these are not forgiving of mistakes.

Note that double-sided PC boards require more heat and more solder then single-sided ones. Hold soldering iron motionless, in-place for longer periods to allow solder flow.

Part numbers on the schematic below match part numbers marked on the PCB. Not all parts need to be populated.

Fig 1. Schematic

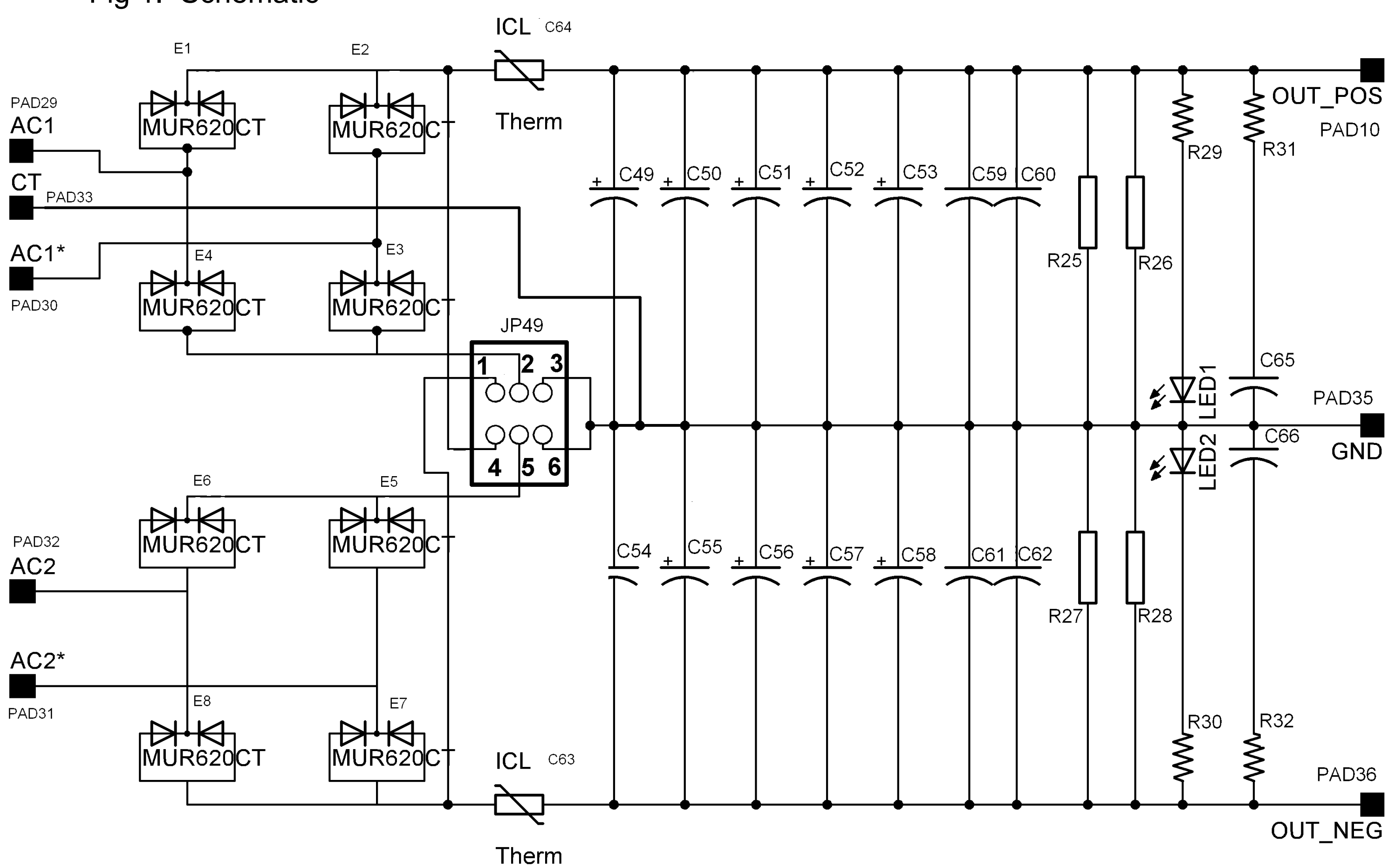
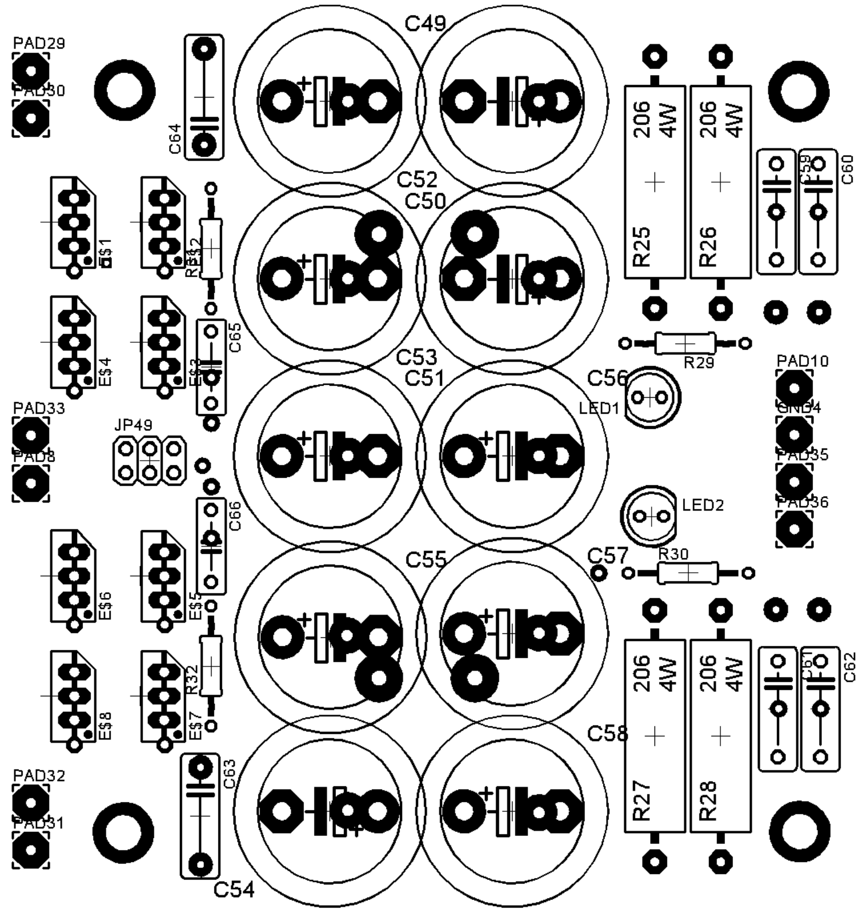


Fig 2. Component Placement



Rectifiers E1-E8:
TO-220 case Schottky of fast-recovery power rectifiers.
If using 3 pin rectifiers, anode (broad edge of triangle) must be at one (or both) outer pins and cathode (flat line) must be at center position. If using 2-pin rectifiers, anode must be at the smaller, round pad at the edge of each diode position (designated by a white dot). Cathode will go through the center pad of the diode pattern. This will be the same for all 8 rectifiers.

Capacitors C49-C58:
Electrolytic filter capacitors. Use a voltage about 10-15V higher than the peak voltage. Electrolytics are rated for “Working Voltage”, meaning that’s the voltage they are designed to work at. Overspecifying voltage by a wide margin only wastes money and space and does not improve any quality parameters. Capacitance value should be at least 1000uF for every 10 Watts of power drawn per channel. Class B amplifiers are 66% efficient , so a 50W amplifier actually draws about 75W at best efficiency point.. You may use as few or as many capacitors as you want or can afford.
You may use as few or as many capacitors as you can. You can populate as few or as many capacitors as you want or can afford (min 1 , max 5 per rail). Typically use the largest value that can fit on the board.
You can use up to 5 smaller capacitors in parallel, or a single large one, for each rail. For single capacitors, insert at the locations marked “CX” on the PCB. Carefully observe polarity.
The multiple smaller capacitor option exists for 2 reasons: to allow a lower profile solution, by using physically shorter parts. And to reduce ESR in a very effective way by paralleling capacitors. Low-ESR electrolytics often cost 3-4 times more than standard ones, and their ESR may be only 2-3 times lower than that of standard electrolytics. Paralleling 5 capacitors immediately reduces ESR and ESL by 80%, and does so economically.

Power resistors R25-R28 (optional)
Capacitor discharge resistors. Typically 5K - 50K total resistance, they allow the voltage rails to safely return to ground potential when the power is turned off.

Absence of these resistors causes dangerous voltages to remain on the rails after power off. Can also cause unexpected noises from the power amplifier after shutdown.

Lower sized resistors will discharge the electrolytics faster, but will run hotter during operation. Two positions are provided for using a parallel combination if necessary, which distributes the heat on a larger area.

ICL (labeled C63, C64):
Inrush Current Limiters
This component limits the high inrush current drawn at power-on, when filter capacitors are discharged, and have close to zero resistance. A large amount of capacitance can cause staggering currents to briefly flow, to charge them. This stresses the rectifiers, the transformer, the copper connections, and blows a fuse, if fuses are correctly rated for amplifier protection. This forces fuses to be over-rated, to accommodate the inrush, thereby no longer being optimally rated for load protection.

The ICL has a high initial resistance (when cold) often between 0.5 and 10 ohms. It's own dissipation quickly heats it up, and it then has a low resistance, when hot (often 10 to 100 times lower than its cold resistance). It thus takes itself out of the circuit after a couple of seconds or so of operation.

Correctly choosing and sizing an ICL depends entirely on the rail voltages used, the currents drawn by the load, the amount of filter capacitance used, and desired operating margins. It is beyond the scope of this text to discuss ICL selection, but resources can be found from their manufacturers.
As an example, Digi-Key part number KC006L-ND is a CL-60 ICL, made by GE Sensing, with a 10 ohm cold resistance, and a 0.18 ohm hot resistance at rated current of 5A steady-state.

Although these parts are optional, they provide a very important level of safety and reliability. If omitted, they should al least be replaced with a low value (1 ohm) power resistor, or one properly sized for safety. If omitted entirely, then replace with a jumper.

LED1, LED2, R29, R30 (optional)
These pilot light LEDs provide a visual cue of rail voltage operation. Led's are your choice of color, and resistors must be properly sized for the rail voltage used, and the LED brightness desired.
Resistor would be 3K-5K for a 40V rail, and they will dissipate about 0.5W so , must be sized accordingly. 1W metal oxide resistors are intended here.

R31-R32, C65-C66 (optional)
This is a snubber network.
A snubber may be required in some cases to dampen oscillations that may occur with some types of loads.
Typical values of R and C are 0.1uF and 1 ohm, 1W, but values can range from 0.5ohm to 5 ohm and from 0.03 uF to 3uF and should ideally be adapted to the specific load conditions.
A snubber is typically used to solve a problem. Otherwise there is no need to use it.
The component locations are provided on the PCB only for those individuals who know for a fact they need or want a snubber, because they have seen problematic oscillations with an oscilloscope.
More info about snubbers is here:
http://www.hagtech.com/pdf/snubber.pdf
http://us.st.com/stonline/products/literature/an/6785.pdf
Note that doing an internet search for snubbers returns mostly information referring to switching power supplies, in which the snubber is something completely different.
You can also check http://www.diyaudio.com/ you can do a keyword search for "snubber", or "snubberized" there.

Capacitors C59-C62
These are part of the filter capacitor bank. They are small value capacitors in parallel with the electrolytics. They provide fast transient response, to compensate for situations where the ESR of the large electrolytics would have limitations. Mylar or ceramics are required here. The highest value practical should be used. 0.47 uF , 1uF, or even higher. Voltage is any voltage higher than the rail voltage +20%\

SMD ceramic capacitors (optional)
Rectangular exposed solderable lands are provided on the bottom side of the PCB for SMD ceramic capacitors.

These capacitors occupy the same electrical position, and serve the same purpose as capacitors C59-C62.
SMD ceramics are even better at transient response compensation, than leaded parts, because they have the lowest possible ESR and ESL of any capacitor type. They are now found in fairly large values, like 4,7uF /50V and cost less then their leaded counterparts.

A 0.1uf in parallel with a 1uF would be appropriate, however you can parallel as many as will fit .

Jumper Block JP49 /J1 (optional)
If unused, then wire jumpers must be soldered to make the connections described below.

This is a 2x3 male header, which allows selection of transformer configurations. It requires 2 shorting blocks.

See Fig 1 for correct pin designations
In fig 1, starting at position “1”, this jumper block’s pin designation is:
Top row: 1, 2, 3 from left to right.
Bottom row: 4, 5, 6 from left to right
The top row of pins are also labeled on the PCB

Option 1,
Shorting pins 1 and 2 together
Shorting pins 4 and 5 together
This places the 2 bridge rectifiers in parallel, and feeds them from transformer inputs AC1, AC1*, with CT (center tap) becoming output ground

You would use this option if you have a transformer with a single, center-tapped secondary.

Option 2,
Shorting pins 2 and 3 together
Shorting pins 5 and 6 together
This lets each bridge rectify a different secondary , AC1, AC1* for the top bridge, AC2, AC2* for the lower bridge. It then ties the negative output of the top bridge to the positive output of the lower bridge to form the output ground.

You would use this option if you have a transformer with two secondaries, or two individual transformers each with its own secondary, to implement a split-rail supply.

Terminal Blocks (optional)
Screw-type terminal blocks should be used for inputs and outputs. (PCB requires 8 terminals): either standard terminal blocks, or pluggable terminals.
Pluggable type allows quick connect / disconnect after wire has been tightened by screw.

Note that is it proper practice to construct a PCB with no wires permanently dangling from it. All connections to a PCB should be removable for servicing, leaving the PCB free-standing.

Determining Transformer Secondary Phase

If you have a center tapped secondary, you connect it to AC1, AC1* and CT, leaving AC2 and AC2* unconnected. You short JP1 pins 1-2 and 4-5.
You can also connect the AC1 and AC2 terminals together, and the AC1* and AC2* terminals together on the PCB, to place the 2 rectifier bridges in parallel.

If you have 2 individual secondaries, you connect one secondary to AC1 and AC1*, the other to AC2 and AC2*, and short JP1 pins 2-3 and 5-6.

The asterisks indicate phase.
The transformer leads that go to the asterisks MUST be in the same phase. otherwise opposite phases will cancel out. and a short circuit will occur on the PCB.
(that means the secondary leads going to the asterisks must both be the "top" of their respective windings, or both be the "bottom" , but must be the same geometric orientation)

There is no way to know this information by looking at a transformer. This information must either be provided in a specification sheet, if you bought the transformer new. or marked on the transformer itself. Sometimes the secondary leads are color coded to indicate phase (secondary may be one blue lead and one blue lead striped with yellow, to indicate top phase for example. But a striped lead can also indicate a center tap).
If no information is available, you can determine phase experimentally.

Identify the 2 wires of each secondary.

Measure AC voltage individually on each secondary to confirm you have correctly identified all secondary pairs.

Label each wire with a small paper label (1,2,3,4) to differentiate them.

Now tie together one lead from one secondary, with one lead from another secondary (of same voltage). Pick any 2 leads.

Power the transformer and measure the voltage across the remaining free leads.
If it is approximately 2x the voltage of one secondary, then the leads you have tied together are DIFFERENT phase - one is asterisk, one is non-asterisk.

If you measure approximately 0 volts (or close to it), then the leads you have tied together are the SAME PHASE, asterisk or non-asterisk, doesn't matter, they are the same. The asterisk notation is arbitrary.

If you read 0 volts, it is a good idea to also read the voltage between a free extremity and the leads tied together, to confirm you get a correct voltage. You may get a zero volt reading because the transformer is not properly plugged into the outlet, or there is a faulty connection, so it is not safe to always trust zero readings without confirming.

Fig 3. Transformer Secondary Configurations