



High Power Linear Bench Supply

Last month, we introduced our new Linear Bench Supply, capable of delivering 8A at 45V or 2A at 50V. It's based around a 500VA toroidal transformer, a PCB control module fitted to a finned heatsink and two thermally controlled fans to keep it cool. These all mount in a metal instrument case. This month we cover the assembly and testing details of the PCB module.

There are quite a few steps involved in building this Supply, but none are terribly complicated. So if you follow our instructions, you shouldn't have any trouble getting it to work and ensuring that it's safe.

You'll need most or all of the parts in the list at the end of this article, so the first job is to gather those.

There's a bit of screwing, drilling, tapping and cutting needed to complete the hardware side of this project. Ideally, you should have a drill press, although you can get away with a decent hand drill.

You'll also need assorted drill bits, an M3 tap set, files and a hacksaw on hand.

Around half the assembly time is in building the control module, with the other half preparing the case and putting it all together. We'll have the case assembly and wiring details next

month. This month's article concentrates on building that control module.

We've made it as easy as possible by using almost entirely through-hole parts and mounting them all on a single PCB. So let's get started building it.

Construction

Before mounting any parts on the control board, use the blank PCB and some of the other parts to mark out where holes will need to be drilled on the heatsink. The hole locations are shown in Fig.5, but it's better to use the actual PCB and devices to determine where to drill.

Start by fitting the PCB with the 9mm tapped spacers at each corner. Then temporarily place transistors Q3, Q4, Q5, Q6, Q7 and REG3 into their

respective mounting holes, but don't solder them yet.

Place the acrylic spacer under the heatsink to lift it up by 3mm, then centre the PCB on the face of the heatsink.

Making sure that each component is sitting up straight and at the same height, mark where the centre of each mounting hole sits on the heatsink (eg, using a felt tip pen).

Hold the bridge rectifier in place above the main devices, centred on the heatsink (see photos) and mark its mounting hole too.

While you're at it, use the acrylic insulating plate to mark out the positions of the four mounting holes on the underside of the heatsink, two on each side.

Now take the heatsink away and carefully drill all the marked holes with a 2.5mm bit to a depth of at least 6mm (or deeper if you don't have an

by Tim Blythman

M3 finishing/bottoming tap), making sure they are drilled perpendicular to the face of the heatsink. Use kerosene or light machine oil to lubricate the drill bit and regularly clean out swarf.

Once all the holes have been drilled, tap them for an M3 thread to a depth of at least 6mm, again using plenty of lubricant and regularly clearing swarf from the tap.

Be careful not to use too much force to turn the tap, or you could break it, ruining both it and the heatsink.

As long as you regularly remove the swarf and re-lubricate the tap and hole, a consistently moderate amount of torque should be required.

If you do encounter increased resistance, unwind the tap a little bit and then try winding it clockwise again. If the resistance is still there, take it out and clean and re-lubricate the hole, then try again.

You can use a finishing tap to get the tapped holes to the required depth, or drill them a bit deeper and use the intermediate tap to cut threads at least 6mm into each hole. When finished, deburr all the holes and clean out all the swarf.

You may like to wash the heatsink with soapy water and let it dry off to get rid of some of the lubricating oil and the remaining swarf.

Before proceeding, it's also a good idea to use the bare PCB to mark out where its mounting holes will go in the bottom of the case.

Use the heatsink acrylic spacer to do the same for the four heatsink mounting holes, and position the mains transformer as shown in the photos, to mark out its central mounting hole.

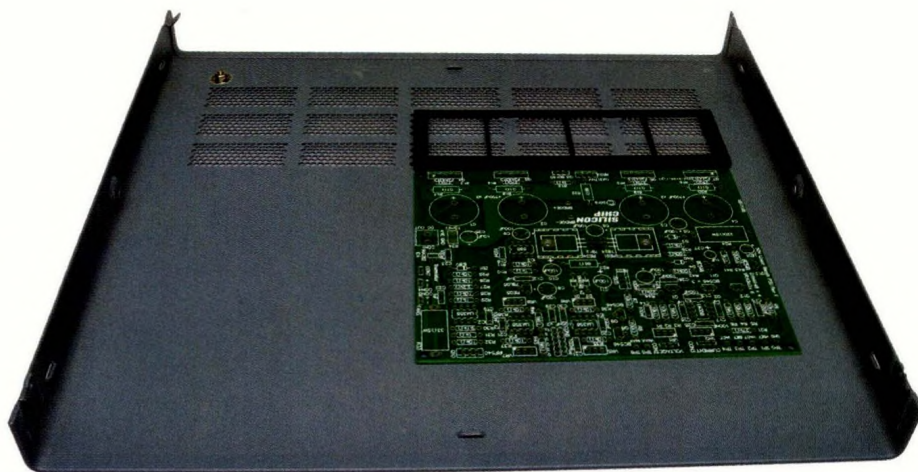
Make sure you leave enough space behind the heatsink fins for the fans. The fins should be around 45mm from the inside rear of the case.

PCB assembly

With that out of the way, we can now proceed to assemble the PCB using the overlay diagram, Fig.6, as a guide.

The Bench Supply is built on a double-sided PCB coded 18111181, measuring 150 x 120mm. The following description assumes the PCB is orientated as shown in Fig.6, with the heatsink mounted devices at the bottom edge.

There are two surface-mounted parts on this PCB, which should be fitted first. These are the 15mΩ shunt resistor and shunt monitor IC4, in an



It's a good idea to use an unassembled PCB and the acrylic heatsink spacer as a template to mark the mounting hole positions inside the case bottom. It's easier to do this now, rather than later!

8-pin SOIC package, which is mounted near the shunt.

Start with IC4. Apply flux paste to its pads, then locate IC4 over them. Make sure that its pin 1 is orientated so that it's closest to the shunt pads. Pin 1 is typically marked with a dot or divot on top of the IC package and a bevelled edge on that side.

Once it is in the correct location, solder one of its pins. Check that all of its pins are lined up with their pads. If not, re-heat the solder joint and gently nudge the part into place with tweezers.

Once you are happy that the part is aligned and flat against the PCB, solder the remaining pins by applying some solder to the iron tip and carefully touching each pin in turn. The solder should flow from the iron to the pin. Once the other pins are soldered, go back and re-touch the first pin.

If you are having trouble, apply some more flux. Excess solder can be removed with solder wick and a bit of extra flux paste. If a bridge occurs, don't remove it right away, but solder any unsoldered pins first. Then use the

wick on one side at a time to remove any bridges.

The shunt is the next part to be fitted. It is relatively easy to solder but is connected to a wide power trace, so it may need a bit more heat. It is not polarised.

Apply solder to one pad, then rest the part on top and apply heat again to allow the part to sink into the solder and down onto the pad (pressing down on the part with tweezers helps with this process).

When the first solder joint is good, solder the other side, then go back and re-touch the first joint.

With these two parts in place, it's a good idea to clean up any excess flux on the PCB using isopropyl alcohol or a specialised flux remover.

Through-hole parts

You can now fit all the smaller axial parts, ie, resistors under 1W, zener diode ZD1 and small signal diodes D1-D4. Make sure that the diodes are orientated as shown in the overlay diagram.

While the resistors have colour-

Fig.5: a half-size drilling template for the heatsink. All holes are drilled and tapped for an M3 thread, to a depth of at least 6mm. While this should give you an idea of what to expect, as mentioned in the text, it's better to temporarily insert the actual devices and mark where their mounting holes sit if possible.

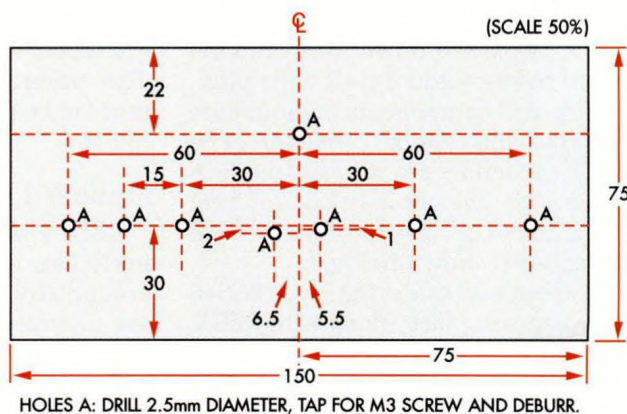
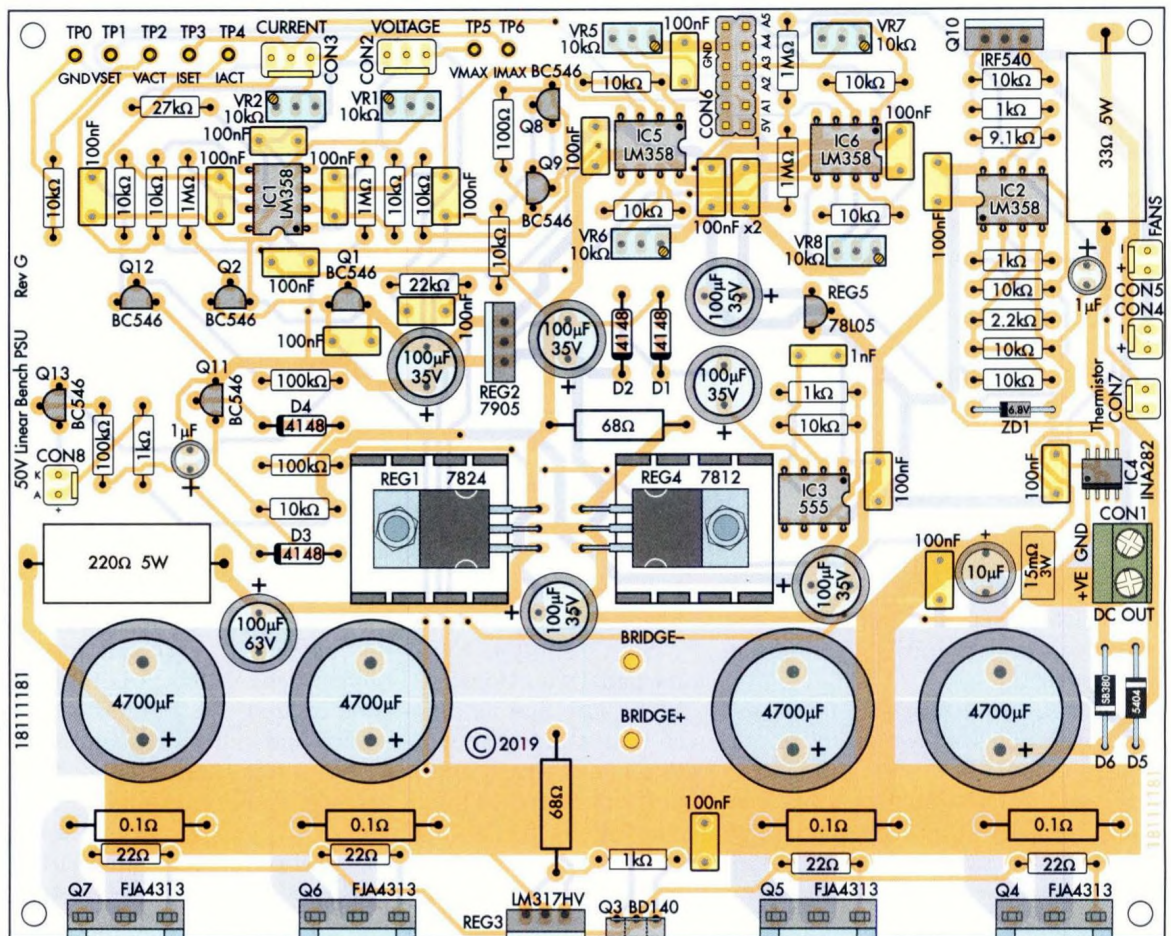


Fig.6: most of the Bench Supply components mount on this control board. Ensure that the diodes, transistors, ICs and electrolytic capacitors are fitted with the correct orientations as shown. It's also a good idea to check carefully that the different value resistors and capacitors go in the right places. Note that one of the 100µF electros is rated at 63V (below and to the right of the 220Ω 5W resistor) where all others are 35V. Fit the four 4700µF capacitors last, after the power devices (that mount on the heatsink along with the bridge rectifier) have been soldered in place.



coded bands, these can be hard to distinguish, so it's best to check each with a multimeter set to measure ohms before soldering them in place.

Next, fit the six 1W resistors and the two larger diodes (D5 & D6), again ensuring their cathode stripes are facing in the directions shown in Fig.6. Watch out as they are orientated differently.

The next job is to fit DIP ICs IC1-IC3, IC5 and IC6. These are all LM358 op amps except for IC3, which is a 555 timer.

You don't need to use sockets; in fact, it's better to solder these all directly to the PCB. But make sure that in each case, the pin 1 dot/notch is facing as shown in the overlay diagram and the IC is pushed down fully onto the board before soldering all of its pins.

The next components to mount are the MKT and ceramic capacitors. The MKT capacitors are mostly 100nF in value, although one is 1nF so don't get them mixed up. The location for each capacitor is shown in Fig.6.

You can now solder the seven BC546 transistors in place, along with REG5. The transistors and regulator look similar so don't get them mixed up. You may need to bend their leads out with

small pliers to fit the PCB pad patterns.

Next, mount DIL pin header CON6, followed by the trimpots. Orientate them so that the adjustment screws are positioned as shown in the overlay diagram. They are all the same value.

Follow with the two 5W resistors, which can be installed slightly above the PCB surface to improve convective cooling, although this is not critical.

Note that, as explained last month, you may need to change the value of the 33Ω 5W resistor if you're using different fans from the ones specified (which we don't recommend!).

Now fit the terminal block (CON1), with its wire entry holes facing the edge of the board, and polarised headers CON2-CON5, CON7 and CON8. The polarised headers should be mounted with the orientations shown in Fig.6.

Onboard regulators

REG1 (7824) and REG4 (7812) both need flag heatsinks as REG1 drops around 20V and REG2 drops 8V. Both are mounted identically but rotated 180° relative to each other.

Start by lining up the component with its footprint to determine where

the leads need to be bent down by 90°. Having bent the leads, check that the tab mounting hole lines up with them inserted. If not, adjust the bend.

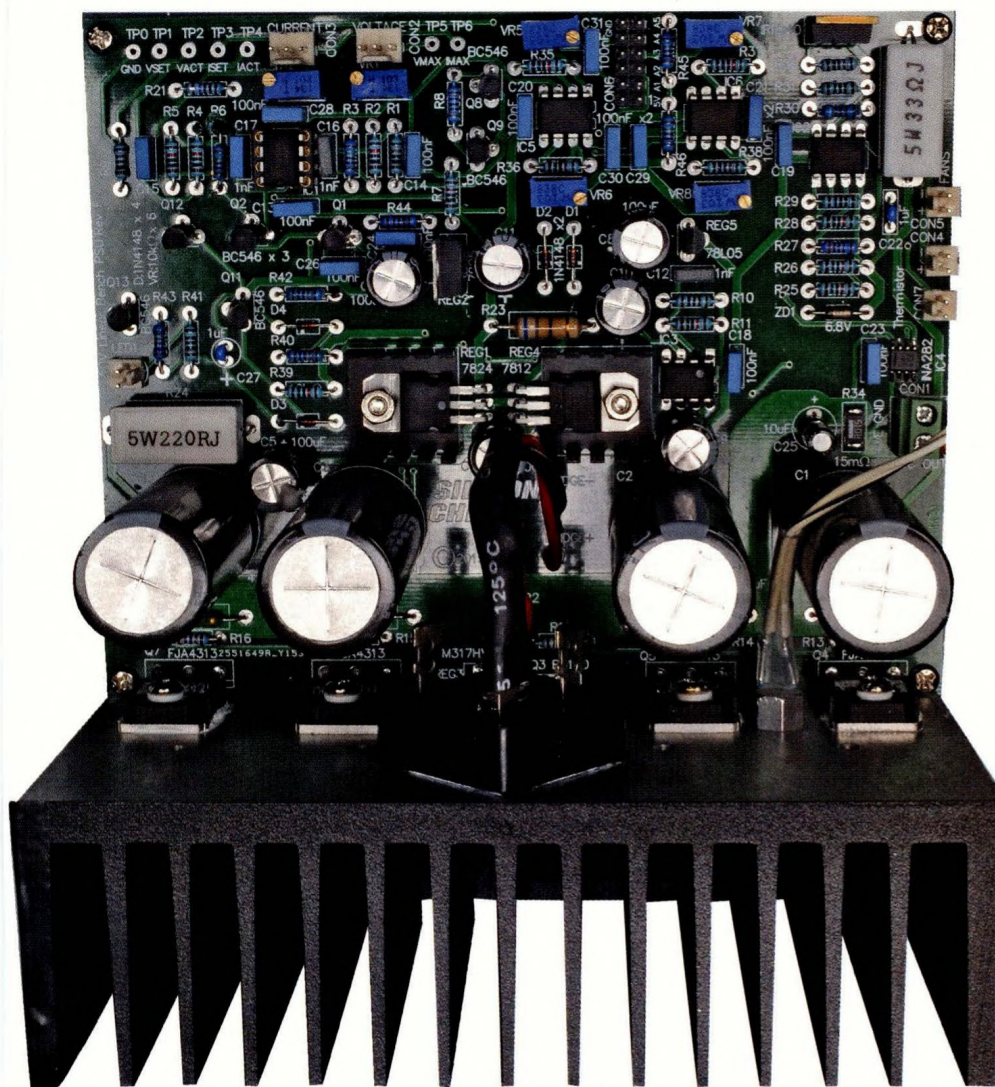
When you are happy with this, smear a small amount of thermal compound on the back of the regulator and mount it by sandwiching the flag heatsink between the regulator and the PCB.

Fasten with a 6mm machine screw from the bottom and a nut on the top of the tab. Ensure the nut is tight but be careful not to twist the regulator and its leads.

Ensure the regulator and heatsink are square within their footprints and not touching any other components before soldering and trimming their leads.

You can fit most of the electrolytic capacitors next; all but the four large 4700µF units. They are polarised; in each case, the longer (positive) lead must be soldered to the pad marked with a "+" on the PCB. The cans have stripes on the opposite (negative) side.

Follow with the two remaining on-board TO-220 components, REG2 and Q10. These do not need heatsinks as their dissipation is quite low. They can be fitted vertically, but make sure that



Compare the PCB layout opposite with this shot of the completed board, albeit with its transistors (and bridge) already fixed to the heatsink

their tabs are facing as shown in Fig.6.

Connecting the off-board components

Presuming that you are using the Five-way Panel Meter module for display, you will need to build that separately (see the article starting on page 90). If you're using individual panel meters, we'll leave that part of the construction up to you. Most of the work is in cutting holes for them in the front panel and wiring them up.

Voltage and current adjustment potentiometers VR3 and VR4 mount on the front panel and connect to the PCB using flying leads and polarised plugs. This prevents them from being accidentally connected backwards if the unit is later disassembled.

Separate a 150mm length of 10-way ribbon cable into two three-way pieces and three two-way pieces. Trim the two three-way pieces to around 10cm

each, separate the wires at each end, strip them and solder one end of each to the leads of VR3 and VR4. You may wish to protect the solder joins with short pieces of small diameter heatshrink tubing.

Now crimp the polarised plug pins onto the other ends of the wire. If you don't have the correct tool, it may be easier to solder the wires, although the tabs of the pins will still need to be bent over to fit into the housing.

You can crimp them using small pliers in a pinch (no pun intended), but it's a bit tricky. These will plug into CON2 and CON3.

The square pads of CON2 and CON3 are connected to ground, so should go to the ends of the potentiometer tracks which have a low resistance to the wipers with the pots fully anti-clockwise. The middle connections of CON2 and CON3 go to the wipers, and the third pin goes to the other end of the tracks.

You can check this by verifying that, with the pot cables plugged into the board, the middle pins have a low resistance to ground (TP0) when the relevant knob is wound fully anti-clockwise. If this is not the case, you may have the outside leads reversed.

LED1 is also attached using flying leads and mounted off the PCB, via CON8. Solder a length of the two-way ribbon cable to the pins for a matching polarised plug, then solder the other ends of the wire to the LED. The longer lead of the LED must be soldered to the wire that goes to the pad on CON8 marked with a plus sign.

If using a pre-wired panel mount LED, simply crimp or solder the wires to the plug pins and push them into the housing. If you have a bare LED, you should heatshrink the wires to insulate and protect them, and use a bezel for mounting.

If your fans are not already terminated with 2.54mm-pitch headers, attach a keyed plug as for the LED. Note that the positive lead for both fans (ordinarily red) goes to the pin closest to output connector CON1.

A similar header is used to connect the NTC thermistor for monitoring the heatsink temperature. It is not polarised like the other components, but you can still fit the same style plug to connect to the locking header on the PCB, so do that now.

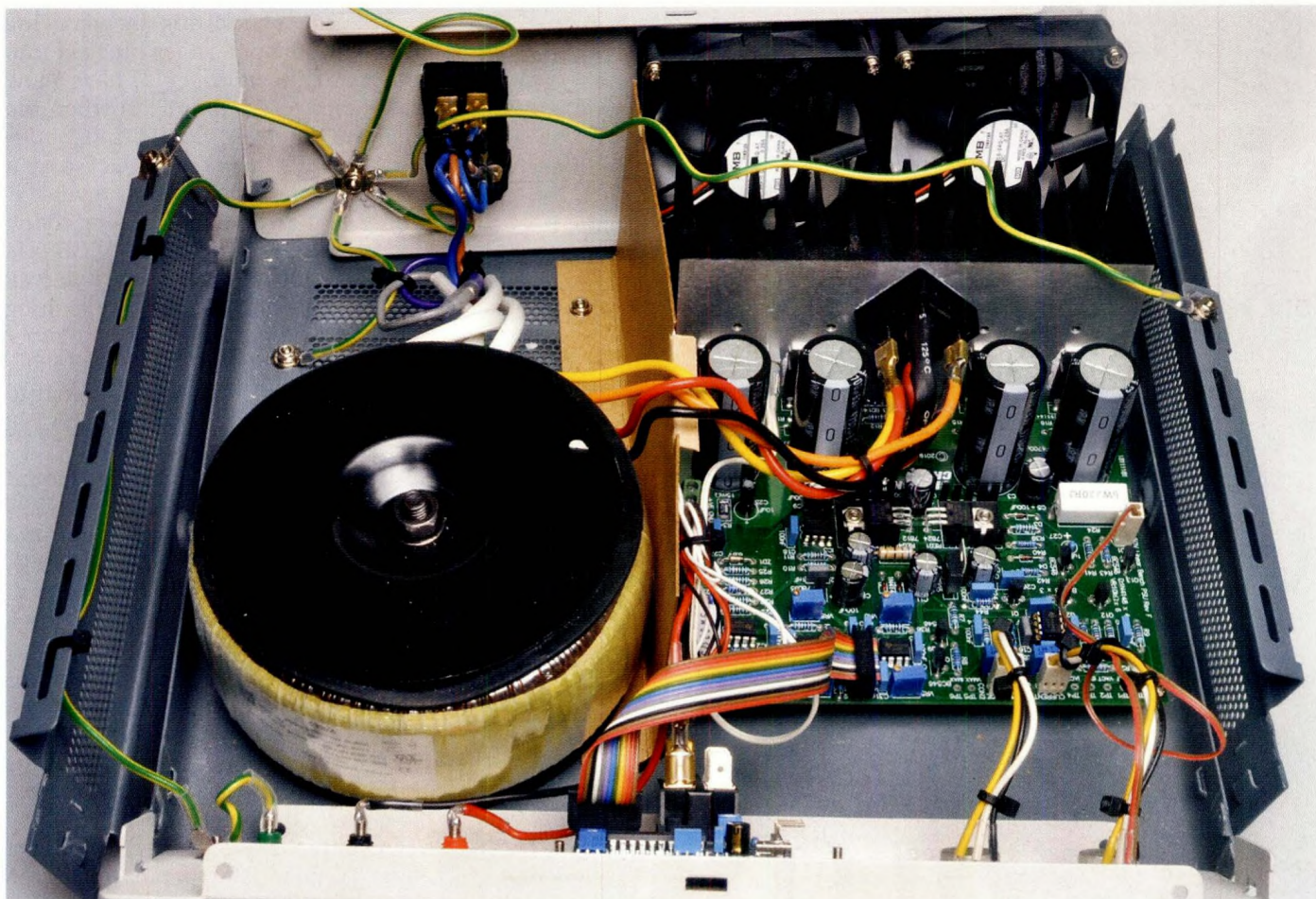
The bridge rectifier (BR1) is mounted on the heatsink and connected to the transformer and PCB via four stout (10A-rated) wires. Cut two wires around 7cm long and crimp or solder spade terminals to one end of each. Protect the outside of the spade using heatshrink tubing insulation.

Solder the other end of the wires to the PCB. The red wire should go to the terminal marked BRIDGE+ (and the bridge rectifier terminal with a plus) and the black wire to the terminal marked BRIDGE- (and the diagonally opposite bridge rectifier terminal).

Initial testing

Now detach all the external components except for the two potentiometers, VR3 and VR4, and the NTC thermistor. This will allow you to do some basic checks.

Before powering the board up, double-check the construction so far, making sure that all the onboard components have been fitted, with the correct polarity. Check also that



We've "opened out" this otherwise completed Supply to give you a better idea of what goes where and with what. Note the Presspahn insulation (fawn colour) which isolates the bitey bits from the rest of the circuitry – just in case..

the solder joints all have good fillets, do not look dry and that there are no shorts between solder joints on the underside of the board.

The initial tests are only made at low power, but there is still enough energy present to damage components if something has been installed incorrectly. There is the possibility of components becoming very hot if a fault occurs, hence the initial low-power tests which should hopefully find any problems before delivering enough energy to do any damage.

Note that there can be 70V differential voltage between various parts of the circuit when it is powered on. This is enough to give a shock. Make sure the PCB is mounted on insulated tapped spacers and there is nothing underneath the board which might cause a short circuit (eg, do not place it on a metal surface!).

Before powering up the unit, wind all the trimpots and variable resistors to their minimum positions. This includes the six trimpots on the PCB and the two externally mounted ad-

justment potentiometers.

The best way to do the initial tests is with a variable DC supply fed into the BRIDGE+ and BRIDGE- leads with the appropriate polarity. You will need around 40V to ensure that REG1 is delivering the full 24V at its output.

If you don't have a 40V DC supply, you can feed 27-39V DC directly into REG1's input (with the positive lead clipped to the right-hand lead of the 220Ω 5W resistor). Or you can feed 24V into REG1's output, via the left-hand lead of the 68Ω 1W resistor. But in the latter case, any faults in REG1 itself may not show up.

It would be ideal if you can monitor the current drawn by the circuit; if your supply lacks an ammeter, you can monitor the voltage across the 220Ω 5W resistor, assuming that you are not bypassing this due to a lower test supply voltage.

Power up the circuit and check the current draw. It should be around 60mA, which corresponds to 13.2V across the 220Ω resistor. If there is a severe fault, then you will see a much

higher voltage across this resistor and it could get very hot. In that case, shut off power as soon as possible and check for faults. Any more than 20V across this resistor means that something is wrong.

Assuming the current draw is OK, you can now check the various voltage rails for correctness. Connect the negative multimeter probe to ground via TP0 and check the voltages with the positive probe. The 24V rail can be measured at the left end of the 68Ω resistor (assuming you aren't feeding power in there, as there would be little point in checking it then).

You should get a reading close to 24V, although it may be lower if your test supply does not have a high enough output. As long as it is above 18V, the remaining voltage rails should still be correct.

But you will not be able to complete the calibration until 24V is available from REG1, nor can you accurately calibrate the device if feeding power into the 24V rail.

The 12V rail can be measured at pin

PARTS LIST – LINEAR 45V 8A BENCH POWER SUPPLY

- 1 double-sided PCB coded 18111181, 150 x 120mm
- 1 vented metal instrument case [Jaycar HB5556]
- 1 Five-way Panel Meter module (see article starting on page 90)
- WITH** 1 acrylic bezel [SILICON CHIP ONLINE SHOP Cat SC5167]
- OR** 1 set of separate 5V panel meters and suitable mounting hardware
- 1 acrylic spacer for heatsink [SILICON CHIP ONLINE SHOP Cat SC5168]
- 1 40V 500VA toroidal transformer [element14 2817710]
- 1 35A 400V bridge rectifier (BR1) [Jaycar ZR1324, Altronics Z0091]
- 1 IEC mains input socket with fuse and switch [Jaycar PP4003, Altronics P8340A]
- 1 150 x 75 x 46mm diecast finned heatsink [Jaycar HH8555]
- 2 24V DC 80mm high-flow fans [Digi-key P122256]
- 2 80mm fan filter/guard [Jaycar YX2552]
- 2 TO-220 flag heatsinks, 6073B type (for REG1 & REG4) [Jaycar HH8502, Altronics H0630]
- 1 16V DC/230V AC 16A SPST or DPDT panel-mount toggle switch [Jaycar ST0581/ST0585]
- 1 208 x 225mm sheet of Presspahn or Elephantide [Jaycar HG9985]
- 2 TO-220 insulated mounting kits (for Q3 & REG3) [Jaycar HP1176]
- 1 2-way terminal block, 5mm pitch (CON1) [Jaycar HM3172, Altronics P2032B]
- 2 3-way polarised headers (CON2, CON3) [Jaycar HM3413, Altronics P5493]
- 2 3-way polarised plugs (for VR3 & VR4) [Jaycar HM3403, Altronics P5473 + P5470A]
- 4 2-way polarised headers (CON4, CON5, CON7, CON8) [Jaycar HM3412, Altronics P5492]
- 4 2-way polarised plugs (for LED1, thermistor & fans) [Jaycar HM3402, Altronics P5472 + P5470A]
- 1 6x2-pin header (CON6) [Jaycar HM3250, Altronics P5410]
- 2 12-pin IDC headers (to connect CON6 to Panel Meter) [Digi-Key 2057-FCS-12-SG-ND]
- 1 10k Ω stud-mount or lug-mount NTC thermistor [Digi-key 495-2138, Altronics R4112]
- 11 6.3mm spade crimp connectors (for BR1 and mains socket)
- 1 red chassis-mount banana socket/binding post
- 1 black chassis-mount banana socket/binding post
- 1 green chassis-mount banana socket/binding post
- 1 6A fast-blow M205 fuse (F1)
- 2 knobs (to suit VR3 and VR4)
- 4 instrument case feet and associated mounting hardware

Wire, cable etc

- 1 1m length of 3-core 10A mains flex
- 1 1m length of 12-way ribbon cable (to connect CON6 to the Panel Meter module and to connect VR2, VR3, LED1 and the thermistor)
- 1 1m length of 10A-rated red wire (for BR1 and output terminals)
- 1 1m length of 10A-rated black wire (for BR1 and output terminals)
- 1 small tube of thermal paste
- various lengths of 3mm and 6mm diameter heatshrink tubing
- pack of small (2mm) cable ties
- pack of self-adhesive wire clips

Fasteners

- 8 M3 x 32mm machine screws (for mounting fans)
- 1 M3 x 15-16mm machine screw and flat washer (for mounting BR1)
- 5 M3 x 12mm machine screws (for rear panel Earth and mounting Panel Meter)
- 13 M3 x 9-10mm machine screws (for mounting fans and Q3-Q7)
- 18 M3 x 6mm machine screws (for panel Earths, PCB mounting, REG1, REG3 & REG4)
- 4 M3 x 10mm Nylon machine screws (for mounting heatsink)
- 8 M3 x 15mm tapped Nylon spacers (for mounting fans)
- 4 M3 x 9mm tapped Nylon spacers (for mounting PCB)
- 13 6.3mm spade crimp connectors (for BR1, the mains socket and output switch)
- 6 M3 crinkle or star washers (for panel Earths)
- 16 M3 hex nuts (for panel Earths, REG3, REG4 and mounting Panel Meter)
- 12 crimp eyelet lugs, 3mm inner diameter (for panel and output Earths)

Semiconductors

- 4 LM358 op amp ICs, DIP-8 (IC1, IC2, IC5, IC6)
- 1 555 timer IC, DIP-8 (IC3)
- 1 INA282 shunt monitor IC, SOIC-8 (IC4) [Digikey 296-27820-1]
- 1 7824 24V linear regulator, TO-220 (REG1)
- 1 7905 5V linear regulator, TO-220 (REG2)
- 1 LM317HV high-voltage adjustable regulator, TO-220 (REG3) [Digikey LM317HVT/NOPB]
- 1 7812 12V linear regulator, TO-220 (REG4)
- 1 78L05 5V linear regulator, TO-92 (REG5)
- 7 BC546 NPN transistors, TO-92 (Q1, Q2, Q8, Q9, Q11-Q13)
- 1 BD140 PNP transistor, TO-126 (Q3)
- 4 FJA4314 NPN power transistors, TO-3P (Q4-Q7) [SILICON CHIP ONLINE SHOP Cat SC4096]
- 1 IRF540N N-channel Mosfet, TO-220 (Q10)
- 1 5mm red LED with bezel (LED1) [Jaycar SL2610, Altronics Z0220]
- 1 6.8V 1W zener diode (1N4736 or equivalent; ZD1)
- 4 1N4148 signal diodes (D1-D4)
- 1 1N5404 400V 3A diode (D5)
- 1 SB380 80V 3A schottky diode (D6)

Capacitors

- 4 4700 μ F 63V electrolytic [Altronics R5228]
- 1 100 μ F 63V electrolytic
- 6 100 μ F 35V electrolytic
- 1 10 μ F 63V electrolytic
- 2 1 μ F 50V multi-layer ceramic
- 18 100nF MKT
- 1 1nF MKT

Resistors (all 1/2W 1% metal film unless otherwise stated)

- 4 1M Ω 3 100k Ω 1 27k Ω 1 22k Ω 16 10k Ω
- 1 9.1k Ω 1 2.2k Ω 5 1k Ω 1 220 Ω @ 1 100 Ω
- 2 68 Ω # 1 33 Ω @ 4 22 Ω
- 4 0.1 Ω # [Digi-Key 0.1GCCT-ND, Mouser 603-KNP1WSJR-52-0R1]
- 1 0.015 Ω 2W or 3W, SMD 6432/2512 size [Digikey YAG2165CT, Mouser 603-PE25FKE7W0R015L]
- 6 10k Ω vertical multi-turn trimpots (VR1, VR2, VR5-VR8)
- 2 10k Ω linear 24mm potentiometers (VR3, VR4)

1W 5% @ 5W 10%

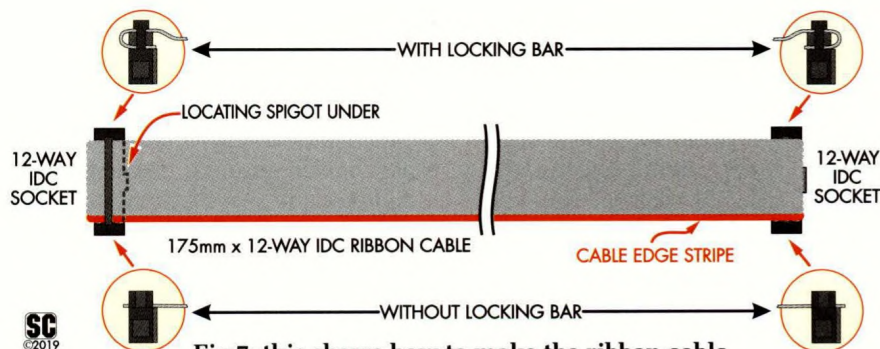


Fig.7: this shows how to make the ribbon cable which connects the Five-way Panel Meter to the Bench Supply main PCB. Whether your cable looks like the pictures inside the upper or lower circles depends on the style of IDC connector that you are using.

4 or 8 of IC3. If the 12V rail is correct, then the negative rail generator should be working, and the tab of REG2 should have around -9V on it. The output of REG2 is connected to pin 4 on IC1, IC5 and IC6 and these should all be close to -5V.

Finally, the output of the +5V rail can be found at pin 1 of CON6 (marked "5V"). The outputs on CON6 marked A1-A4 correspond to the signals for the external panel meters. They should all read 0V if trimpots VR3 & VR4 are fully clockwise.

Pin A5 on CON6 should read around 3-4V if the thermistor is working correctly, but it may be a bit lower at high ambient temperatures.

If this is correct and you have built the Five-way Panel Meter, it can now be connected to CON6 to allow it to be calibrated (see the section on making the ribbon cable below, if you haven't already done so).

All the readings, apart from the temperature, will be incorrect until calibration is complete.

If you are using individual panel meters, they can be connected now. Due to the limited current available from REG5, separate digital panel meters may need a separate 5V supply.

Initial calibration

Now check the voltages TP5 and TP6. TP5 should be at around 12V if VR1 has been wound to its minimum. Once you've verified that, adjust VR1 until TP5 measures 15.6V.

This sets up VR3 to provide 50V at the output when fully clockwise. This depends a little on the exact properties of trimpot VR3 itself, but this setting can be fine-tuned when construction is complete and you can measure the actual output voltage to full scale.

Similarly, adjust VR2 to get 6V at

TP6, corresponding to approximately 8A at the output. This too can be fine-tuned later. If you wish to set a more conservative maximum current limit, you can adjust VR2 for a lower voltage at TP6.

At this stage, TP1 and TP3 should all be showing very close to 0V. If not, adjust VR3 and VR4 respectively so that this is the case. This ensures a minimum output voltage when the unit is fully powered up later.

TP2 and TP4 should also be near (or even below) 0V. This shows that the output voltage and current are both zero. You should not proceed unless this is the case, as there should be no output with REG3 absent. If you get positive readings here, check around IC1 and IC4 for circuit problems before proceeding with any high-power tests.

We will need to adjust VR4-VR7 later; this is not possible until the Supply is fully assembled.

Other checks

If you have a frequency meter or oscilloscope, you can check the two oscillators. Their exact frequency is not critical, but significant variations can indicate other problems.

The oscillator for the negative rail generator is at pin 3 of IC3 and should measure around 60kHz. You should also check the duty cycle if possible; it should be close to 50% for maximum efficiency. If the duty cycle is wrong, and the negative rail is not reaching -5V, the values of the components around IC3 may be incorrect.

The frequency of the fan PWM circuit can be measured at pin 1 of IC2. This should be around 280Hz, with a 50% duty cycle. Pin 1 delivers a square wave while pin 2 can be probed to check the 'triangular' waveform if you have a 'scope. With the thermistor near

25°C, the fan PWM output at pin 7 of IC2 should be off, so a voltmeter will read 0V.

If the thermistor is warmed up (such as by being held in a warm hand), the average voltage at pin 7 should rise to at least 3V, representing a 12V PWM signal with a duty cycle of around 25%. This indicates that the thermistor circuit is working as expected.

Mounting the power devices

Once you are happy with the results of the tests outlined above, the power components can be added to the board. Disconnect the power and allow the capacitors to discharge, which may take a minute or so.

The components in this area connect via thick tracks and may need more heat than the earlier components to solder.

Re-check now that the heatsink is free of swarf and metal dust, as these can puncture the transistor insulating pads and cause a short circuit. The face of the heatsink should be smooth. A light sanding with fine sandpaper will help to flatten any raised areas.

First, mount transistors Q3-Q7 and REG3 loosely to the heatsink. Use a 6mm M3 machine screw, insulating bush and insulating washer for REG3. The mounting for Q3 is the same as REG3 except that you'll need a longer, 10mm screw. Mount the four large transistors using 10mm-long M3 machine screws, with a thin smear of thermal paste over the side of the devices which touch the heatsink.

While Q3 is in a TO-126 package, a TO-220 insulating mounting kit will work fine with some careful trimming. Note that Q3 has its plastic face mounted against the heatsink, so the washer is more to ensure good contact than it is for insulation.

Check for continuity between the heatsink and leads of Q3 and REG3; there should be no continuity on any of the leads. You will need to probe the non-anodised face of the heatsink. If there is, remove that part, check the insulation and reattach. You must do this before soldering or fitting the PCB, as Q3's emitter is effectively connected to the heatsink via the collectors of Q4-Q7.

Now position the 3mm acrylic spacer next to the PCB, with the latter sitting on its 9mm tapped spacers. Line up the power device leads with the PCB pads and drop them into place, with the heatsink resting on the acrylic spacer.

Check the device mounting heights

and adjust if necessary. Then solder one lead at each end of each device. You can then carefully flip the whole assembly over and solder all the pins thoroughly, with the PCB resting on something to prevent it sagging under its own weight. When finished, trim the leads short.

Tighten up all the screws holding the devices to the heatsink and check that they are firmly attached, as once the large electrolytic capacitors are fitted, access will be limited. You might also like to re-check that REG3 and Q3 are still insulated from the heatsink.

Next, smear the face of BR1 with thermal paste and attach it to the heatsink using a 16mm-long M3 machine screw and flat washer. Install it with the positive terminal at the bottom. This means that the wires do not need to cross over to reach the PCB terminals. The bridge has a bevel to identify the positive terminal, and will typically also be printed with a "+" symbol on the side.

Connect the BRIDGE+ and BRIDGE- terminals to the bridge rectifier by pushing the spade connectors onto its tabs.

The final components to fit are the four 4700µF 63V capacitors mounted directly in front of the output transistors. Their negative stripes must face towards the front edge of the PCB. Solder them in place and trim the leads to complete the component assembly.

Now is a good time to attach the thermistor to the heatsink. If using the stud-mount type, thread it into its hole on the heatsink. If using the lug type, attach it with a machine screw and shakeproof washer. Mount it on the flat side of the heatsink so that it is not directly cooled by airflow from the fans.

Check the thermistor leads for continuity against the heatsink; there should be none. If there is, check the mounting and re-insulate as necessary.

IDC ribbon cable assembly

Now is a good time to make up the IDC cable that will connect the Five-way Panel Meter to the control board (assuming you're using that meter and not some other arrangement). Cut a 175mm length of 12-way ribbon cable and attach the IDC sockets at each end with the same orientation. So with the cable stretched out flat, the two polarising tabs on the IDC connectors should face the same way.

If you can't get 12-way ribbon cable,

take some wider ribbon cable, cut between the 12th and 13th wires and then gently pull the two sections apart. They should separate cleanly.

See Fig.7 for details on how to make this cable. Usually, IDC connectors are supplied as three pieces: the main part of the connector, with holes to mate with the pin header on the bottom and blades to slice through the cable insulation on the top; a plastic clamp which is pressed down on the top of the cable to force it into the blades, and a locking bar which provides strain relief and holds it all together.

The way the cable is fed through these three-piece IDC connectors is shown at the top of Fig.7. But the 12-way IDC sockets we purchased only consisted of two pieces, with the clamp and locking bar integrated and no provision for cable strain relief. This arrangement is shown in the lower two circles. Make your cables to match one or the other, depending on the style of IDC sockets that you have.

It's essential to use sufficient clamping force to ensure that the blades properly pierce the cable insulation and make contact with the copper strands within, without pressing so hard that you break the plastic.

You can do this in a vice; however, a proper IDC crimping tool generally makes the job easier (eg, Altronics Cat T1540).

More testing

Now that you've finished assembling the control board, assuming you have a suitably safe source of AC or DC power, you can do some more testing.

Plug in the Five-way Panel Meter, VR3, VR4, thermistor and LED and then apply power to the two unconnected terminals

of BR1. You can use 24-40V AC or 30-58V DC.

If you can limit the current to a few hundred milliamps, that's a good idea, but note that this will mean that it takes some time for the main capacitor bank to charge, and it will draw the maximum current as it does so.

Once the Supply is powered up, check that the Panel Meter powers up too. You may need to tweak the brightness and contrast if these have not been set.

The voltages and currents should all read zero as VR5, VR6, VR7 and VR8 should have all been set to their minimum and have not been calibrated. The temperature shown on the Panel Meter should be around ambient if the thermistor is wired up correctly.

Assuming that it checks out OK, power it off; it's time to start preparing the case.

We'll have the full details on the final assembly and testing in part 3, next month.

SC



We'll cover the final assembly of the supply in the third and final part of this project next month.