



**Fig.6:** use these overlay diagrams and the photograph below as a guide when building the *Soft Starter*. Just one component, the 0.01Ω SMD resistor, goes on the underside. The diodes, electrolytic capacitors and IC1 must be installed with the orientations shown here. Multiple pads are provided to suit differently sized X2 capacitors. Secure CON1 with a machine screw at each end before soldering its pins.

The relay gets close to the full 24V across its coil initially to turn it on, but the 220µF capacitors then partially discharge. The reduced coil voltage is sufficient to keep it energised and the rest of the circuit will run happily with ±6V or less. When the relay turns off, the 220µF capacitors charge back up to their original level.

### PCB layout

While various components in the circuit are shown connected to ground, the main reference point is the 'Nin' (Neutral In) terminal of CON1. This is the potential which the shunt sense voltage is relative to. Because this is very low (just a few mV), it's critical

that the ±3.3mV references track this ground potential accurately or the unit won't work properly.

Therefore, the connection between the cathode of D3, the anode of D4 and pin 3 of CON1 is separate from other ground paths.

This way, current flowing through ZD1, ZD2, the 220µF capacitors and other components to ground does not interfere with the comparator's operation.

As is typical with a circuit which runs directly from mains, the PCB has a high voltage section at 230V AC and a low voltage section of ±12V (relative to the neutral potential).

Since the only components connected to live are the 10MΩ 1W resistor

and 330nF X2 capacitor, all other tracks are clear of those pins. There can also be a fairly high voltage across TH1 and TH2 when they are conducting, so their terminals are kept clear of other tracks.

### Construction

The *Soft Starter for Power Tools* is built on a 59mm × 80.5mm PCB, coded 10107121. This board is available from the *EPE PCB Service*. It is a double-sided PCB with tracks on the top side, paralleling the high-current paths on the bottom to improve its current-handling capability. All components are through-hole types, which mount on the top with the exception of the 10mΩ resistor, which is an SMD.



Here's a view inside the box, fairly close to life-size. You can clearly see the way the wiring is connected to the terminal block on the left end of the PCB – follow this along with the diagram above when wiring it up. If placed inside a metal box, the earth wires must instead be firmly anchored to the box – see text for more details.