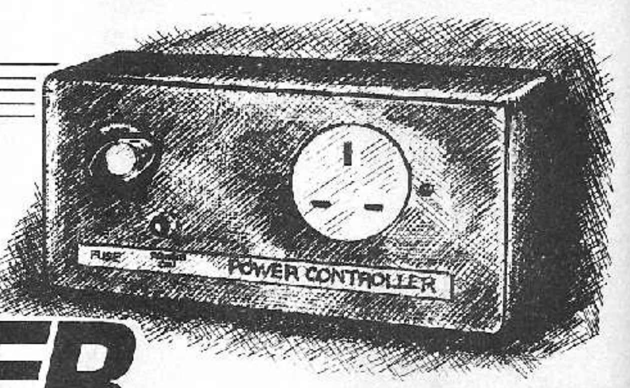
Constructional Project

POWER CONTROLLER



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A multi-purpose mains power controller based on phase control. Maximum output 1200W at 250V. Incorporates full RFI suppression. Robust and simple design makes for easy construction.

ANY READER who will be familiar with the operation of a light dimmer switch will no doubt be aware of the principle of mains power control by chopping the a.c. sinewave, in order to vary the total power applied to the load. A dimmer switch incorporates a triac and a triggering circuit, and the triac can be made to conduct at differing points in the a.c. cycle. The effect is that the sinewave can be curtailed by cutting off the triac part way through a mains cycle (see "How It Works").

The effect is that the power output can be reduced, and in this example the light level emitted by the lamp can be reduced in accordance with one's requirements. Of course, the light level cannot be increased beyond the brilliance which would be observed if there were no dimmer switch at all.

In practice, this *phase control method* is probably the simplest method of power control, although technically it is perhaps a little crude. It is still a major improvement on its rheostat predecessor! One drawback is that there is a considerable amount of radio frequency interference (R.F.I.), because of the sharp "edges" which result in the waveforms when the a.c. cycle is suddenly interrupted. This necessitates r.f.i. suppression components to combat this.

In the interests of simplicity the Power Controller to be described here employs a phase-control circuit to vary the power applied to the load. To further simplify matters, the Power Controller is based upon a thick-film CSR device which incorporates its own firing circuit within the same package. This reduces the number of mains connections we have to make, easing construction and generally improving reliability.

The Power Controller can be used for light-dimming (except fluorescent tubes), heater control or motor speed control, and further application notes are given at the end. The design also includes a complete r.f.i. suppressor circuit to substantially reduce interference.

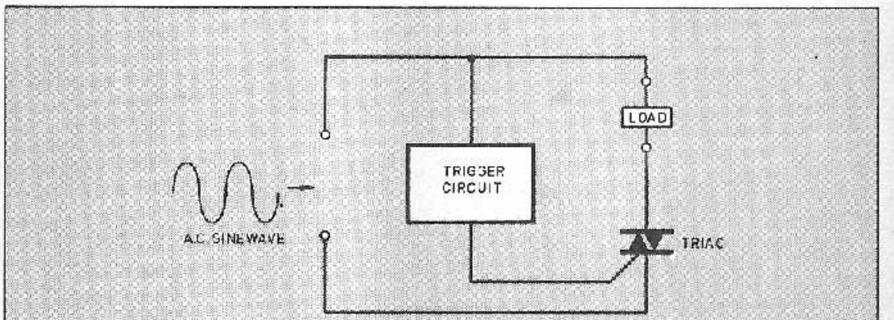


Fig. 1. Block diagram for the Power Controller. The controller employs a special i.c. incorporating both the trigger circuit and triac in a three pin package.

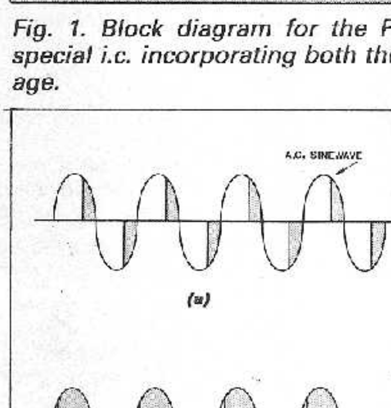


Fig. 2 (left). Output waveforms of the controller under (a) low power and (b) high power. This is depicted by the shaded areas.

HOW IT WORKS

The mains a.c. waveform is applied as shown in Fig. 1, and a trigger circuit causes the triac to conduct at a certain point in the sinewave cycle.

When the triac is triggered at the start of each sinewave, it passes full power to the load. The trigger circuit can be made to interrupt the sinewave part way through its cycle, so that the "chopped" waveform is applied to the load, resulting in an overall reduction in power output.

The waveforms as seen by the load under low power and higher power output levels is shown in Fig. 2. In Fig. 2a the shaded area under the sinewave represents the portion of the a.c. sinewave when the triac is conducting, i.e. it is the power applied to the load.

In this case, the load operates at a low power. The unshaded area is lost completely, so that all the load sees is a series of "spikes".

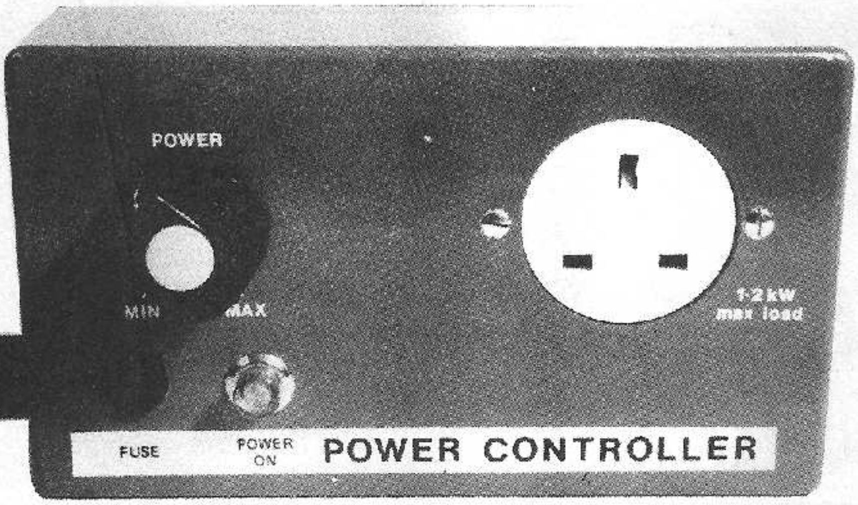
In Fig. 2b, with the triac conducting more fully, the power applied to the load is increased, as the shaded area depicts more power is driving the load.

CIRCUIT DESCRIPTION

The full circuit diagram of the Power Controller appears in Fig. 3. IC1 is a power controller i.c. around which the design is based. It has three terminals, those designated A (Anode) and K (Cathode) are in effect connected in series with the load to be controlled.

The S terminal (pin 1) is connected via a 220k potentiometer (VR1) to the mains sinewave, and by adjusting VR1, the triggering point of the internal triac is advanced or retarded. This chops the a.c. sinewave applied to the load, thereby varying the power across the load.

Whilst it is customary to include r.f.i. suppressors to reduce interference, sometimes the suppression is in the form of a small



COMPONENTS

Potentiometer
VR1 220k linear

Semiconductor
IC1 UAL1004B power controller, 10A 240V

Miscellaneous
SP1 mains suppression filter Roxburgh SDC 051, 5A

SK1 Panel mounting 13A mains socket
FS1 20mm panel mounting, 5A fuse
LP1 240V a.c. panel mounting neon indicator

Case, diecast box BIM5006-16, 192×113×61mm: knob to suit VR1: aluminium for SP1 mounting bracket; 13A 3-core mains cable, 1.5 metres approx; 13A plug, fused 5A; cable gland, large, to suit 3-core cable; nuts; bolts; solder; etc.

Shop Talk
See page 527

Approx. cost Guidance only **£25**

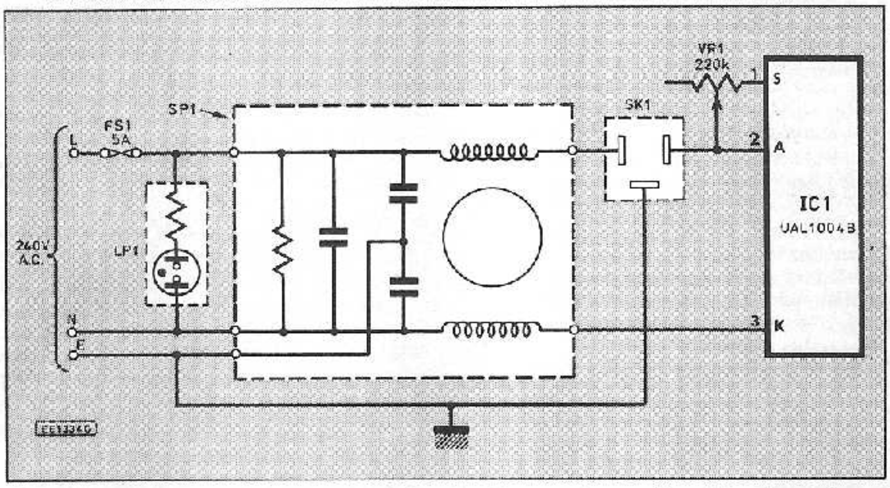


Fig. 3. Complete circuit diagram for the Power Controller. The dotted area marked SP1 is the mains suppressor unit, which prevent interference reaching the mains supply.

choke and these may only be partially effective. The Power Controller includes a complete r.f.i. mains filter unit which takes care of r.f.i. generated in the triac component.

As can be seen from the circuit diagram, the mains filter unit SP1 incorporates several devices, namely a delta capacitor which shunts noise away, and a 2mH 5A choke which further reduces r.f.i. There is also a "bleeder" resistor which discharges the capacitor network when the mains supply is switched off—*important to prevent electric shocks when handling the mains plug.*

The mains supply itself is connected through a 5A fuse FS1, and LP1 is a neon indicator which illuminates when the mains is on. The load itself is plugged into SK1, a panel mounted 13A square pin mains socket.

Although the specified power controller i.c. is rated at 10A r.m.s., the power output of the complete design is determined by the current rating of the suppressor (5A maximum) and also the thermal resistance of the heatsink used to cool IC1. Obviously other factors such as the rating of the interwiring etc., determined the maximum current, too.

CONSTRUCTION

It is recommended that the Power Controller is built into a diecast aluminium box. This provides a very rugged housing, which is especially important if the unit is to be used on a workbench, for example. The box also acts as a heatsink for IC1, though normally you can expect it to barely rise in temperature in normal use.

The box used for the prototype was BIMBOX No. 5006-16 measuring 192×113×61mm and this comfortably housed all components with some room to spare. The main criterion when selecting the box is to ensure that there is adequate depth for the mains filter, which measures 38mm diameter.

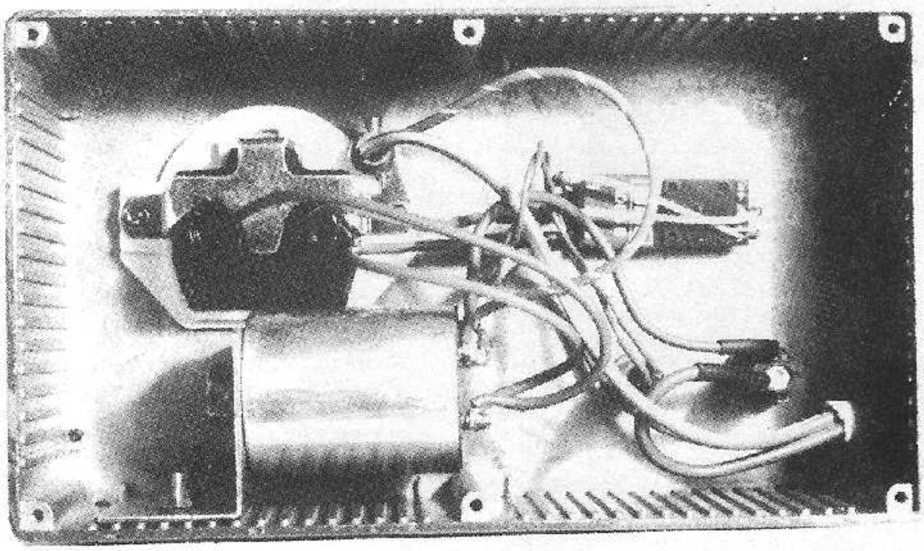
The front panel of the case must be prepared to take the potentiometer, fuseholder, neon lamp and socket. If the specified socket is used, then a 50mm round cutout is required; on the prototype this was achieved with a Q-Max chassis cutter, using a smaller Q-Max to punch the pilot hole.

The alternative is to drill out a ring of holes and/or saw out the centre with a hacksaw-type Abrafile blade, then file the edge with a half-round file until a smooth finish is achieved.

Two countersunk holes will also be required for the 3.5mm socket mounting screws, and these holes are 30.5mm from the centre of the large 50mm cutout. It is quite essential that these holes align correctly with the socket, of course: to make marking out easier, the socket itself can be used like a template to mark the mounting holes, once the main 50mm cutout has been punched.

Further drilling is required for a cable entry gland. As usual, it is necessary to provide some support around the cable at the point where the cable passes through the box. Normally a grommet would be used, but because the walls of the diecast box are comparatively thick—3mm or so, including the moulded p.c.b. guides—then a grommet will not fit in this application. Instead, it is best to utilise a cable gland, since this will accommodate the thickness of the wall; it will also firmly clamp the cable, so it dispenses with the need to use a "P" clip to prevent the cable from pulling out.

The completed Power Controller showing the layout of components inside the diecast metal box.



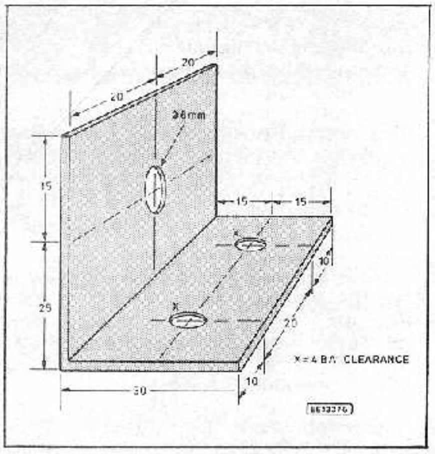


Fig. 4. Dimensions of the aluminium mounting bracket for the mains suppressor SP1.

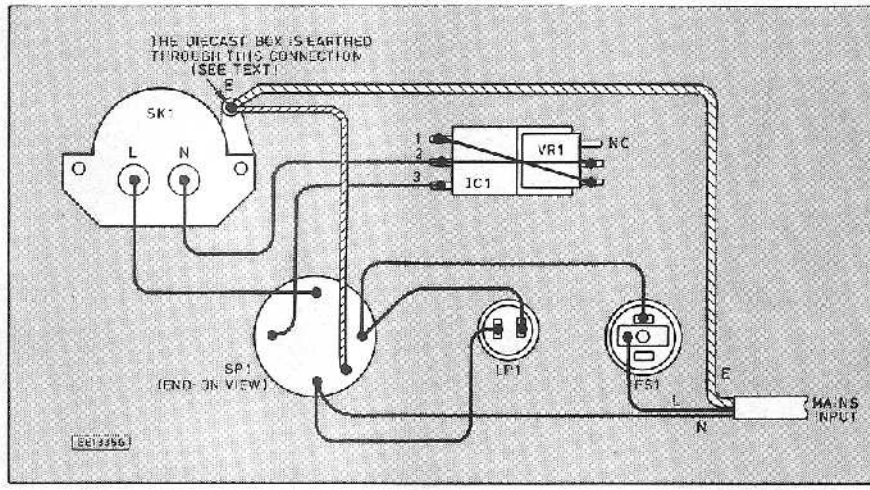


Fig. 5. Interwiring details to the "load" socket SK1, mains suppressor SP1, IC1/VR1, power on lamp and fuse FS1. Use cable rated at 6A minimum and cover all soldered joints with insulated sleeving.

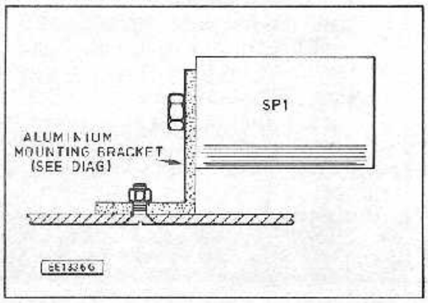


Fig. 6. Method of mounting the suppressor inside the case.

Two 4BA clearance holes are drilled along the bottom side of the case to carry the mains filter bracket. This bracket can be fabricated from a small piece of scrap aluminium, and the dimensions are summarised in Fig. 4.

After all drilling and metalwork has been completed, the diecast box can be painted as required; the prototype box was in its raw unfinished state and so it was given a coat of spray-on primer. Several coats of a car touch-up aerosol paint were applied afterwards. You may also wish to embellish the case by adding labelling etc. according to taste, and rub-down lettering can be used in the normal manner.

The next stage of construction is the interwiring and it is recommended to start with the potentiometer and power controller i.c. sub-assembly, see Fig. 5. The bush of the potentiometer passes through the large hole in the tab of IC1: using the mounting nut of VR1, loosely bolt the two components together while you complete the interwiring between IC1 and VR1. Next solder two flying leads to terminals two and three of IC1 as shown, taking care to insulate with heatshrink tubing or p.v.c. sleeving as necessary.

The power controller i.c. and potentiometer can now be bolted finally into place in the mounting hole on the front panel. The rest of the interwiring is very straightforward and is completed in accordance with Fig. 5.

It is preferable to wire the connections to the mains filter SP1 and mains socket SK1 prior to bolting these components into their intended positions. When soldering wires to SP1, a larger tip or iron may be needed to bring the joints up to the correct temperature.

Since all wiring is at mains voltage it is essential that the soldered joints are of a good quality and they should be properly insulated as necessary. Cable of 6A rating should be used, i.e. 32/0.2mm, though the neon lamp can be hooked up with general-purpose interconnecting wire.

The mains input cable is rated 13A, chosen more for its mechanical strength rather than its electrical rating. It is fitted with a square pin plug fused at 5A.

EARTHING

The Earth input lead is wired straight to the earth terminal of SK1 as shown in Fig. 5 and a further Earth wire then runs to the appropriate terminal of the mains filter SP1. It will be seen that the Earth terminal of SK1 is electrically connected to the socket mounting screws, and it is through these two screws that the diecast box is earthed. To ensure that the screws are in sound contact with the diecast box, remove any excessive paint from around the screw holes to make certain of a good connection.

When you are satisfied that all construction is complete, you can test the assembled Power Controller in conjunction with a table lamp or desk light, since this will suffice as a low power load to check for correct operation of the device. If the lamp can be dimmed by rotating the control knob of the Power Controller, then go on to test the unit with, say, an electric drill just to confirm that it functions correctly.

APPLICATION NOTES

The Power Controller will find several uses in the home and workshop, but there are some appliances that the device CANNOT control. We have already mentioned fluorescent lamps, and brushless motors such as shaded-pole "gram" motors or other induction motors, should not be connected to the controller; such motors respond more to a change in frequency than the applied voltage, and the Power Controller therefore cannot provide effective control.

In general terms, any mains motor up to 1000 Watts (1kW) which is fitted with brushes can be used, and the prototype has been used with motors up to 800W with success. When used with electric drills, when the load on the drill is increased, the torque output will decrease. At the extreme, when the drill is running at very low speeds under a high load, the motor may stall completely.

In these circumstances the power applied to the drill is very low and it is improbable that the motor will be damaged. However, since the Power Controller does not of course include any feedback elements, it cannot compensate for the decreased torque when a slow-running motor is under load. This implies that it cannot operate an electric drill with a view to power-screwdriving or machining.

You will still find the design of benefit when starting off drilling centres, wire brushing, or other applications where it is undesirable to run a drill at full speed.

The prototype has been pronounced a success when powering electric fires up to 1kW (one bar)—though you ***MUST NOT*** use the controller on electric Fan Heaters, because they incorporate a shaded-pole motor to drive the fan. No doubt readers will find other applications for this simple and robust design. □