Build this for your hifi system

Power Up: ends the multiswitch fiddle

How would you like to turn your entire hi-fi system on or off using just the one switch on the amplifier — and get rid of that ugly mess of piggy-backed power plugs at the same time? It's easy with our Power Up device, which should also prove useful in many other similar situations.

by JEFF SKEEN

The Power Up is basically a current operated switch which senses whether a controlling appliance, eg an amplifier, is drawing current, and turns on all the other components in the system if it is.

This should have applications for any combination of appliances, such as a computer or audio system, where mains power has to be applied to many devices at once. Rather than turn on and off maybe three or four switches, the Power Up allows you to control the system with just one switch.

A further benefit is that no warranty voiding modifications have to be made to any system component. The Power Up is a completely self contained unit, designed to be placed out of sight behind the system. It plugs into the wall socket and provides four outlets into which the devices to be controlled can be plugged. A fifth socket, mounted on the end face of the unit, powers the controlling appliance.

Another application for the Power Up is in providing an auto turn-off facility at the end of a record. This presupposes that you have an automatic or semi-automatic turntable.

In this case, power supplied to the turntable is used to control power to the rest of the system. When the start switch of the turntable is pressed, the system is automatically turned on. After the record is finished, the turntable automatically turns itself off, thus turning off the rest of the system.

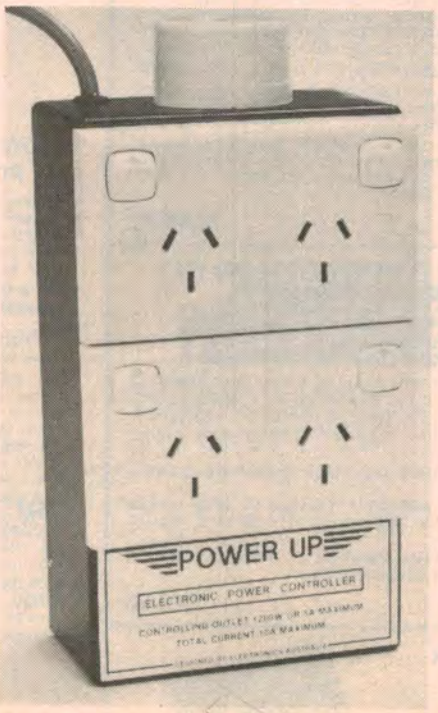
This can be a useful feature if you listen to records in bed at night, or if, like the author, you forget to turn off the rest of the system after the record has finished. In this case the amplifier usually sits for several hours doing nothing but wasting power.

A cassette player with automatic shut-off may also be used in the same manner as the turntable.

As the Power Up is permanently connected to the mains, it should consume as little power as possible. With this in mind we have designed the circuit so that standby consumption is under 0.75 watt. This increases to around 3.75 watts when the relay is activated, mainly due to dissipation in the 10 watt resistor and the relay coil.

How it works

To best understand the circuit it is necessary to split the operation into several parts. To begin with, assume that the unit has just been plugged into a wall socket and there are no appliances connected to any sockets.



Power Up automatically controls up to four separate mains appliances.

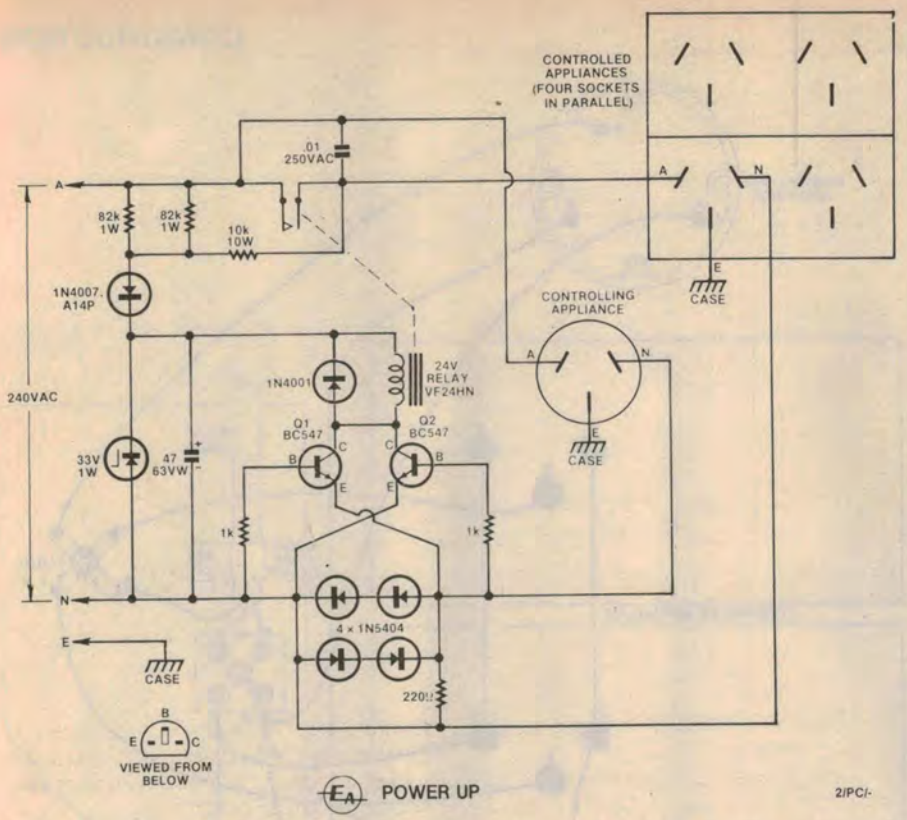
When the voltage on the active lead goes positive, current flows through the two 82kΩ resistors in parallel, through the 1N4007 diode, and charges the 47μF capacitor to the zener value, approximately 33V. When the active lead goes below the capacitor voltage the 1N4007 diode is reverse biased and prevents the capacitor discharging. The capacitor takes several seconds to charge.

If an appliance is now plugged into the controlling socket, and the appliance turned on, a voltage will appear across the 1N5404 diodes. This voltage is used to turn on the relay in the following manner. When the voltage on the active lead goes positive, current through the controlling device and through the diodes, makes the base of transistor Q2 about 1.2V positive with respect to its emitter.

This turns Q2 on, which discharges the 47μF capacitor through the relay coil. The current supplied by the capacitor pulls in the relay, closing its contact. This switches in the 10kΩ resistor, placing it in parallel with the two 82kΩ resistors already connected to the active lead.

The effective value of these resistors is 8kΩ, low enough to supply the current required to hold the relay on. When the voltage on the active lead drops to zero Q2 is cut off and no current flows through the relay. This condition is very brief, and the relay, which has a release time of 3ms, will not have time to let go.

As the active lead goes negative, current flows through the 1N5404 diodes but in the opposite direction. This biases on Q1, which completes the circuit from the 47μF capacitor through the relay, thus holding the relay on. The capacitor



Transistors Q1 and Q2 form the heart of the circuit and activate the relay whenever current flows in the controlling appliance.

discharges to its lowest point during this period (about 4.2V).

In the next half cycle Q2 turns on as before, and the relay is held on by current via the two 82kΩ and the 10kΩ resistors in parallel. At the same time the 47μF capacitor is partially recharged (to around 7.2V) via the above resistors.

This cycle of events continues while ever the controlling appliance is turned on. If an appliance is plugged into one of the switched outlets and the controlling appliance is turned on, power will be supplied to the switched appliance when the relay contact closes.

As the energy to pull in the relay comes from the 47μF capacitor, it is essential that this capacitor be given time to charge before the relay is asked to operate. As already mentioned, this charging cycle takes several seconds, and at least three seconds should be allowed between switching on the power point and switching on the appliance. This same time should be allowed between off-on cycles of the controlling appliance.

No damage will result if the above period is not maintained; the relay simply will not operate and the switched outlets will remain off. To correct this situation, switch the controlling appliance off, wait three seconds, then switch on again. The switched outlets should now be energised.

The function of the 220Ω resistor in parallel with the 1N5404 diodes is to prevent current under 2.5mA from turning on Q1 and Q2. This is necessary as the suppression capacitors placed across the mains switches of most electronic equipment will pass enough current to partially turn on Q1 and Q2.

If this happens, Q1 and Q2 will prevent the 47μF capacitor from fully charging and there is a good chance there will not be enough voltage to pull in the relay. This problem only occurs when a suppression capacitor is fitted to the controlling appliance. The 1N5404 diodes do not pass current from the switched appliances and so capacitor currents from these appliances will not trouble the circuit.

The final components to discuss are the diode across the relay coil, and the capacitor across the relay contacts. Both these components act as suppressors by limiting voltage spikes.

When Q1 and Q2 turn off, the current in the relay coil drops to zero in a very short time. This induces a large voltage spike across the relay coil which could damage Q1 and Q2. The diode prevents the build up of such a voltage by appearing as a short circuit across the relay whenever the spike exceeds 0.6V.

The .01μF capacitor suppresses the arc that would appear between the relay contacts when they open while carrying current. The capacitor appears as a short circuit at the instant the contacts open and the current flows through the capacitor. By the time the capacitor is charged the contacts are too far apart for an arc to form. This is a precaution against thumps in any speakers in the system.

This suppression capacitor must be rated for 250VAC operation. This means that it must either be a metallised paper or dual dielectric (paper plus polyethylene terephthalate) type rated at 250VAC, a metallised polypropylene type with a rating of 250VAC or 1kV or 1600VDC or a ceramic disc capacitor rated at 2kV or higher.

Do not use polyester or polypropylene capacitors rated at 630VDC or 220VAC. They could be a potential fire hazard.

PARTS LIST

1 PCB coded 82pc10, 106 × 56.5mm
1 Zippy Box, 196 × 112 × 60mm
1 Scotchcal front panel, 106 × 48mm
1 240V surface mounting socket
2 240V double wall sockets
1 mains cord and plug
1 2-way insulated mains terminal block
4 earth lugs
1 grommet to suit mains cord
1 cable clamp to suit mains cord
1 metre brown 240V AC rated mains wire (active)
1 metre blue 240V AC rated mains wire (neutral)
½ metre green/yellow 240V AC rated wire (earth)
1 24V relay, code VF24HN (see text)
4 adhesive rubber feet

SEMICONDUCTORS
1 1N4007 or A14P diode
4 1N5404 diodes
1 1N4001 diode
1 33V 1 watt zener diode
2 BC547 transistors

RESISTORS (10% tolerance)
2 × 82kΩ 1W, 1 × 10kΩ 10W, 2 × 1kΩ ¼W, 1 × 220Ω ¼W

CAPACITORS
1 47μF/63VW PC electrolytic
1 .01μF/250V AC rated mains suppression capacitor (see text)

MISCELLANEOUS
Nuts, bolts, washers and lockwashers for mounting hardware.

Construction

Our prototype was assembled into a commonly available Zippy Box measuring 196 x 112 x 60mm. These boxes have multiple internal slots for mounting printed circuit boards (PCBs) or other hardware. The PCB for this project is designed to fit into these slots.

The PCB is coded 82pc10 and measures 106 × 56.5mm. Before mounting components on it, trim it so that it fits exactly into the last set of slots in one end of the box. The metal lid should be able to fit flush with the box without the PCB fouling it.

Mount the components on the board, beginning with the smallest, such as the resistors, diodes and transistors. Take particular care with the orientation of the diodes as mistakes could be spectacular. Now mount the larger components, the 47μF capacitor, the 10 watt resistor and the relay. Solder the suppression capacitor directly across the relay contact terminals.

The VF24HN relay used was supplied by Associated Controls Pty Ltd. It has a 24V coil and contacts designed to switch up to 25A and 240V. The relay may be purchased directly from Associated Controls, 55 Fairford Rd, Padstow, NSW 2211 for $3.85 plus sales tax.

We would not suggest substituting any other type of relay unless it has specifications equal to or better than the above relay.

We estimate that the current cost of components for this project is

$33

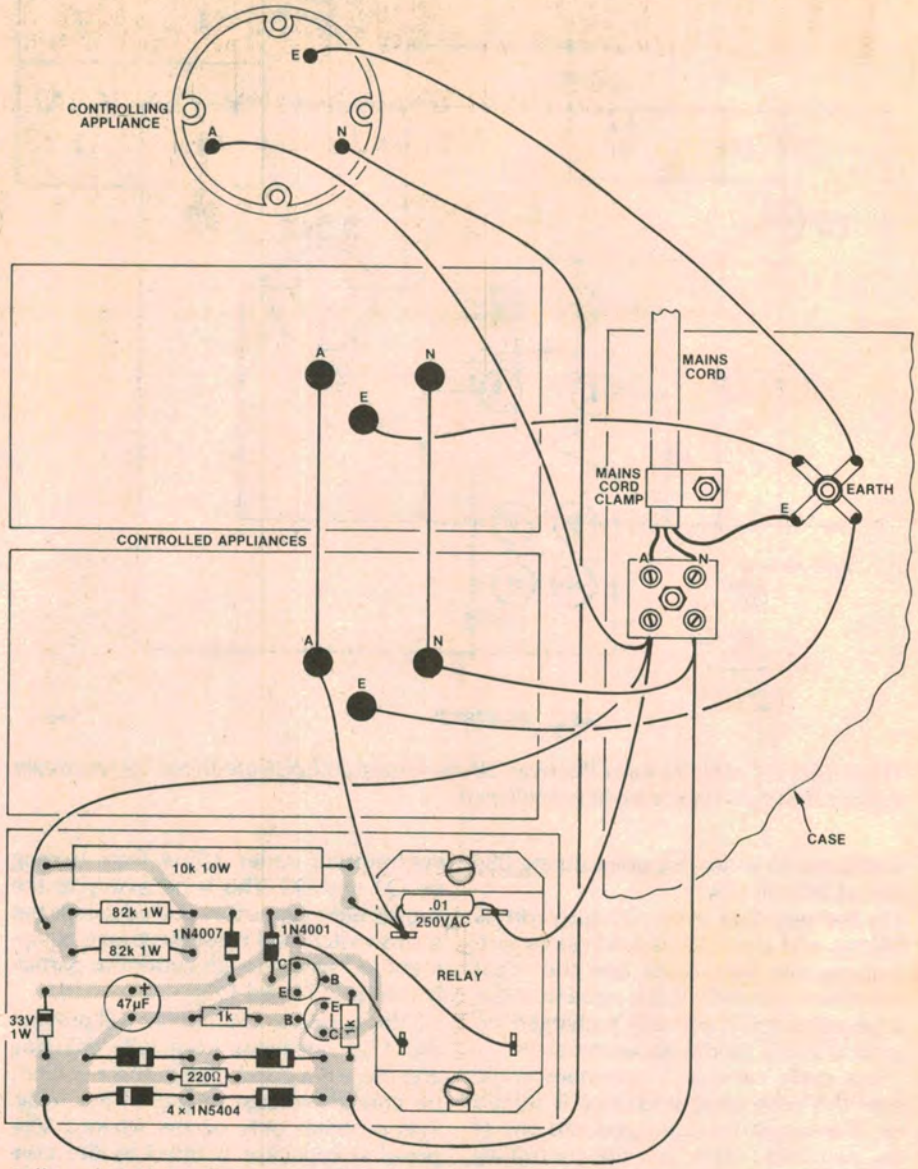
This includes sales tax.

Next, mount the 240V outlets on the box. The positions we use for the prototype can be seen from the photo. Holes for the double sockets can be made quite easily in the soft plastic with the aid of a drill and small saw. The single surface socket mounts on the end of the case opposite the PCB. Use the socket itself as a template for locating the mounting holes and cable holes.

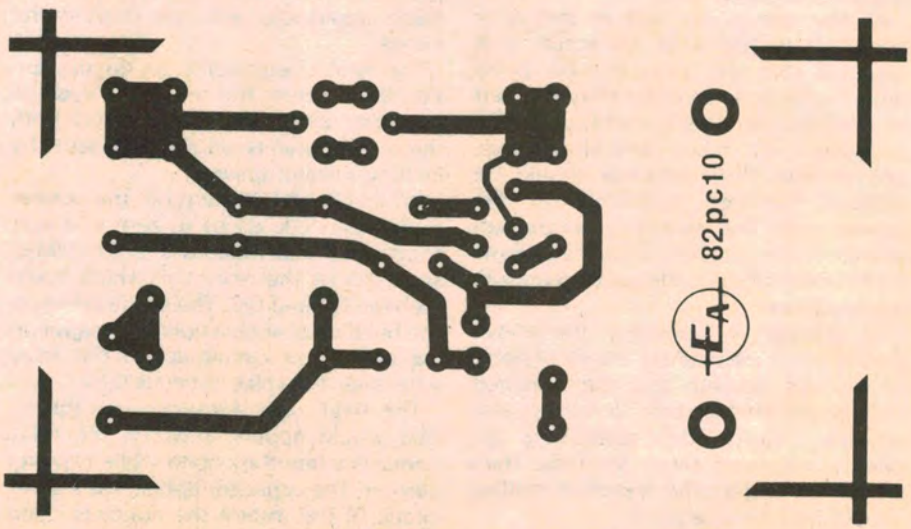
In the same end of the case, drill a hole large enough to take the mains cord grommet. Locate this hole in one corner near the lid (as in the prototype), to allow the mains cord to be terminated easily. Use a 2-way piece of insulated terminal block for the termination, and secure the mains cord to the lid with a cable clamp.

The earth lug from the mains cable is attached to a central earth point on the lid with a separate nut and bolt.

All wiring within the Power Up should be done with 240V-rated mains cable. Follow the wiring diagram carefully, crossing off wires on the diagram as they are run on the project. For maximum protection, run separate earth wires to each socket. Do not simply link the



Follow this wiring diagram carefully when building the Power Up and make sure that you keep all mains wiring neat and tidy.



Above is an actual size reproduction of the printed circuit board.

earths together as the loss of just one link may remove the entire earth protection.

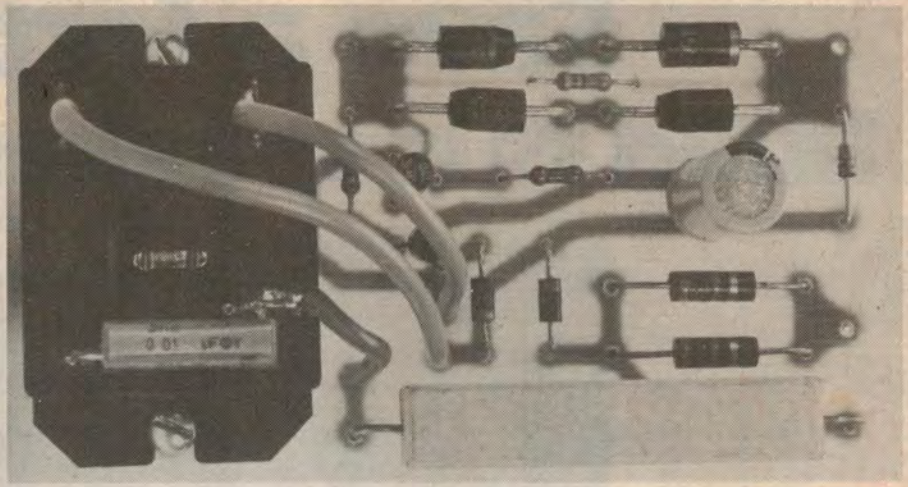
To give the finished unit a professional appearance we have prepared a label to fit on the front panel below the two power outlet blocks. The artwork is reproduced herewith, and copies of it have been distributed to various component suppliers, who normally provide Scotchcal versions. They should be available by the time this article appears.

If necessary, trim the Scotchcal label using scissors or a sharp knife. Stick it into place on the top of the box then screw the lid of the box into position. If you are using adhesive rubber feet, peel off the backing tape and stick the feet to the metal lid. Construction is now complete and after a final error check power can be applied.

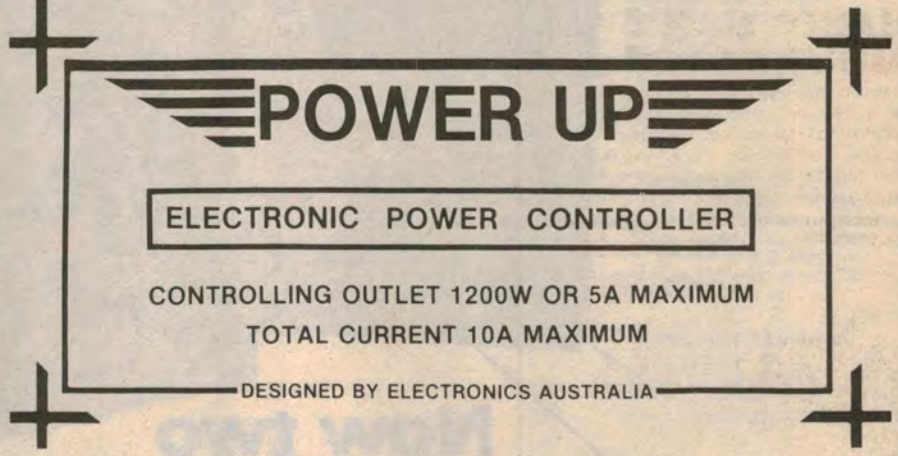
If everything is OK, switch off and plug an appliance into the controlling outlet, and another into one of the switched outlets. Turn on the switched outlet, and the appliance plugged into it. Switch on the power point, wait three seconds, and switch on the controlling appliance. There should be a click from the relay and the other appliance should come on.

If, for any reason, the Power Up fails to perform as expected, turn it off immediately and double check the circuit for errors. Do not reapply power until the fault has been found and corrected.

During operation the front panel of the Power Up will get warm. This is quite normal, and is due to the 10 watt resistor mounted underneath the front panel.



Above is a view of the assembled PCB. We recommend that you use the VF24HN relay from Associated Controls Pty Ltd (see text).



Here is an actual size artwork for the front panel.