PRACTICAL ELECTRONICS

Mains wiring: what you need to know

While you're likely to start off in electronics by building up some simple battery projects, sooner or later you're going to want to build a project that's powered from the mains. So let's find out how to wire mains plugs and sockets, and how to install mains wiring into a metal chassis.

by GREG SWAIN

When dealing with mains wiring, it's very important to know exactly what you are doing. Let's get one thing straight right now. Mains voltages are extremely dangerous and if you receive a shock, it could be fatal!

The above warning is not intended to discourage you from building or using mains operated equipment. Far from it. Rather, it is intended to make you safety conscious. In this chapter, you will learn how to use the mains safely, so that when you do come to wire up a mains project you can tackle the job with confidence.

The power point

The familiar power point (or general purpose outlet — GPO) in our homes delivers a nominal 240V AC — that is 240 volts of alternating current. This is the theoretical supply voltage to which household appliances and light machinery are connected. In fact, the actual voltage can vary, depending on the load placed on the supply network, although most supply authorities try to keep it within plus or minus 5% of the nominal voltage.

The maximum current that can be drawn from any one power point is usually 10 amps (10A). If more than this is drawn, the outlet may overheat and be damaged. In practice, the wiring is arranged so that several power points are connected in parallel and protected by a common 15A fuse at the fusebox.

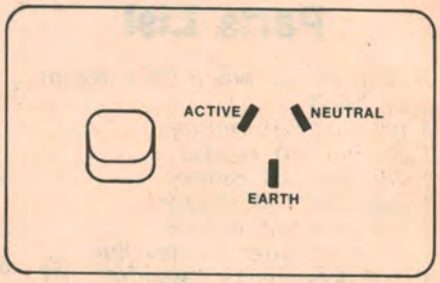


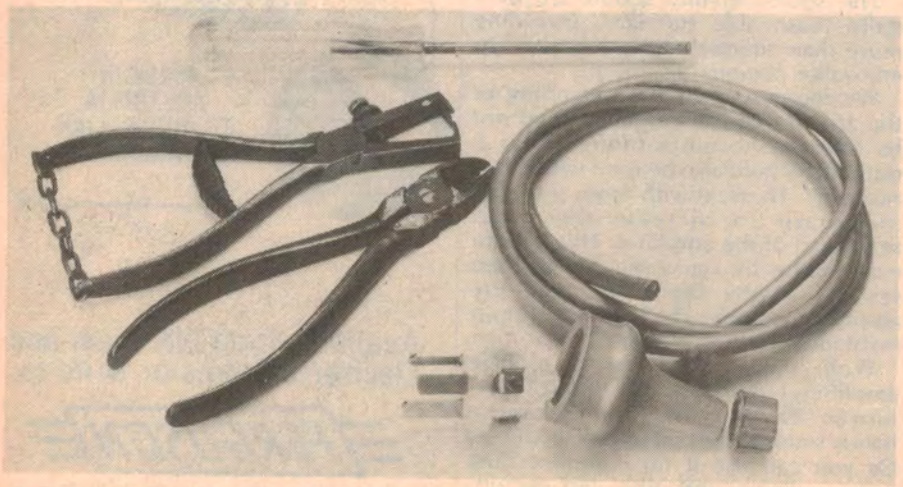
Fig. 1: the recommended wiring connections for a general purpose outlet.

What this means is that you can blow a fuse simply by drawing heavy currents from two power points connected to the same circuit — this in spite of the fact that less than 10A is being drawn from each outlet!

If you ever get the chance to examine the back of a power point, you will probably notice the letters A, N and E. These stand for the words "active", "neutral" and "earth", and are the names given to the three wires which connect to the power point.

Two of the wires, the active and the neutral, connect to wires coming into the house from the street. Both wires go back to the substation, where the neutral is earthed. The neutral is also earthed at various distribution points, and to the main earth system at the customer's fusebox.

The third wire in the system, the earth wire, is connected to a good earth connection — typically a water pipe —



The items needed to wire a mains plug — screwdriver, wire strippers, side cutters, length of 3-core mains flex, and the mains plug itself.

within the boundaries of the property.

In terms of safety, it is the active wire that is the most dangerous. This is because it is at 240V with respect to the neutral and, because the neutral is earthed, with respect to any earthed object. If a person completes a circuit between the active wire and the neutral or an earthed object, he will receive a shock. Just how severe the shock will depend on how good a connection is made to earth. The victim may receive a nasty "bite" — or he may be killed!

Wiring standards

Fig. 1 shows the recommended wiring connections for a general purpose outlet, as laid down by the Standards Association of Australia. The recommendation is that the left hand contact, when looking at the front of the outlet, should be the active. The remaining contacts are then neutral and earth in a clockwise direction.

The switch for the outlet must, by regulations, be in the active line.

Most modern installations conform to these recommendations. However, there are some installations which do not, particularly older ones and those installed by amateur electricians. The most common fault is for the active and neutral wires to be transposed, and the switch installed in the neutral line.

A correctly wired appliance will still work from an outlet wired in this fashion. The problem is that it can lead to dangerous situations when used with incorrectly wired appliances or extension plugs.

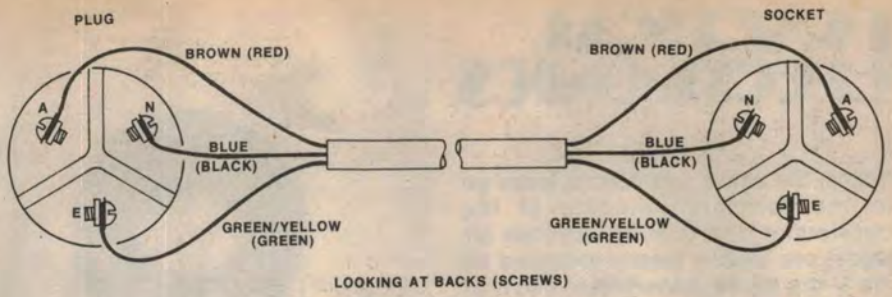


Fig. 2: how to wire an extension cable. Check it by pushing the plug into the socket — the three lead colours should correspond.

Another problem arises because the active line is no longer switched. This means that the active wire coming into the appliance will still be "live" (ie at 240V with respect to earth), even though the switch at the outlet is in the off position. For this reason, you should never assume that mains wiring is safe just because the switch is off. It's only safe to touch when the plug has been pulled out!

Wiring a mains plug

Inside a mains cord are three separately insulated colour coded wires. These must be connected to the plug terminals in the right order so that, when it is plugged into the socket, the active, neutral and earth wires all go to their correct socket contacts.

The three colours used in Australia in the past have been red, black and green. Other countries have used other combinations. However, a new international colour code has now been adopted by most countries, including Australia. The new colours are brown, blue and a green/yellow stripe pattern.

For the time being though, you will probably come across a brown, blue and plain green colour code, at least in Australia.

The brown wire (red) should be used for the active lead, the blue wire (black) for the neutral, and the green/yellow wire (green) for the earth. Fig. 2 shows how the various colours should be connected to the mains plug.

The same figure also shows how an extension cable is wired.

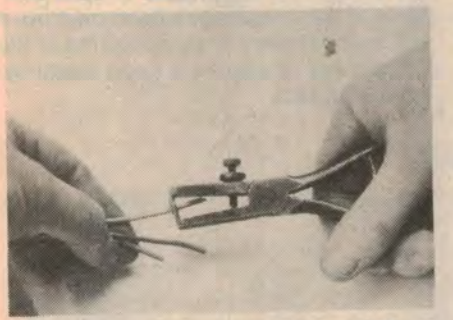
It's quite easy to recognise the earth pin on a mains plug, by the way. It's slightly longer than the other two pins, and is set at a different angle.

Mains-powered projects

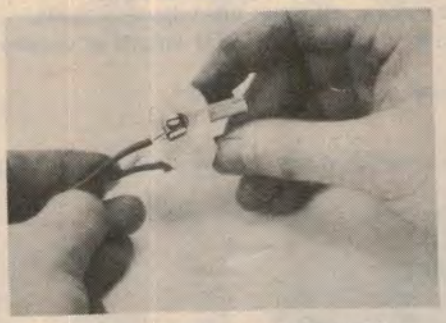
In an electronic project, the active and neutral wires are almost always connected to the appropriate leads or terminals of a mains transformer —

How to wire a mains plug

REMEMBER: brown = active; blue = neutral; green/yellow = earth.

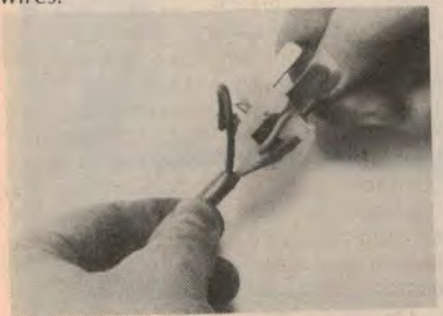


1. Remove outer sheath and bare wires.

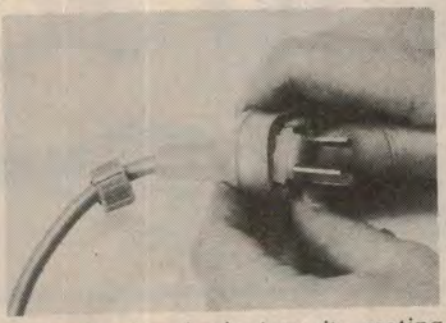


2. Attach wires to screw terminals.

3. Tighten terminal screws firmly.



4. Loop each lead under the spigot adjacent to its terminal.



5. Push plug body into its mating plastic cover and do up cord clamp.

6. Check carefully — each wire colour should be adjacent its correct pin.

that is, the active and neutral leads go to the "primary" winding of the transformer. The primary terminals (or leads) are usually clearly indicated by markings on the transformer body, or the leads are colour coded red or red and black.

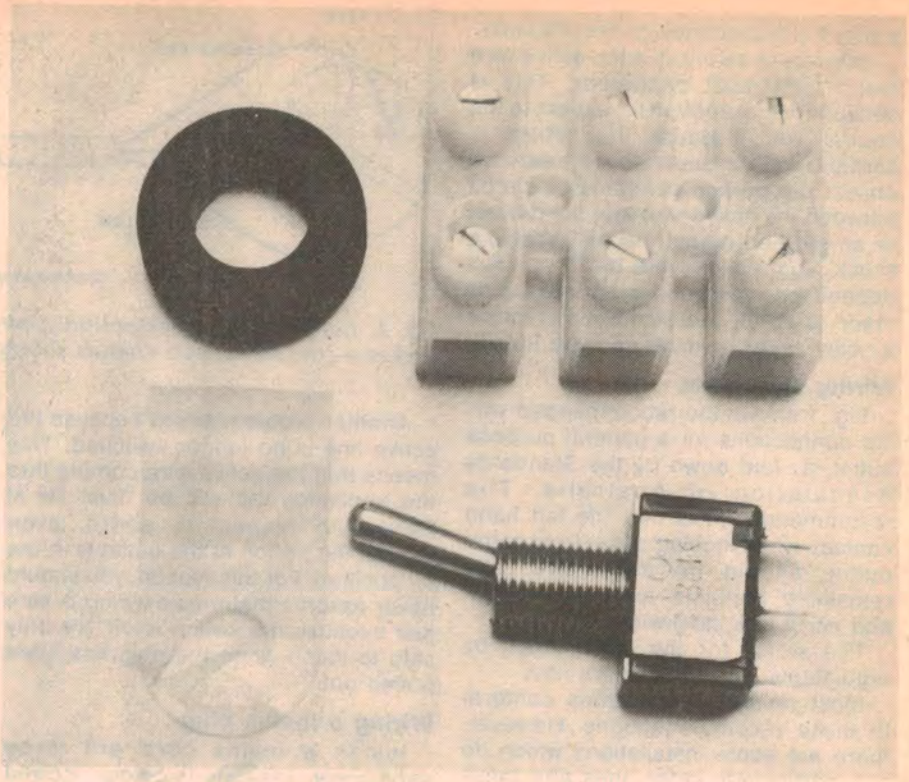
In general, it does not matter which way round the active and neutral leads are connected to the transformer (or to other mains devices such as heating elements and motors). However, if there is a mains on/off switch on the appliance, it should be in the active line.

The earth wire, green or green/yellow, connects to the metal chassis or frame of the appliance. It is vitally important that this lead is not confused with either of the other two leads. Transposed active and earth leads will result in the active lead being connected to the appliance frame, a very dangerous situation to say the least.

A transposed earth and neutral can be just as dangerous, but is more subtle. The appliance will work in a correctly wired power point, and is not particularly dangerous. But in a power point with transposed active and neutral contacts it will not work and again the active will be connected to the appliance frame.

Correctly connected, the earth wire provides a very high order of protection. An insulation breakdown between the active lead and the metal chassis will result in a short circuit across the supply, causing a blown fuse or a tripped circuit breaker at the fusebox.

This not only disconnects the supply voltage, but also draws attention to the fact that there is a fault.



Clockwise from top left: rubber grommet, 3-way mains terminal block, 240V AC on/off switch, and plastic cord clamp.

Wiring a project

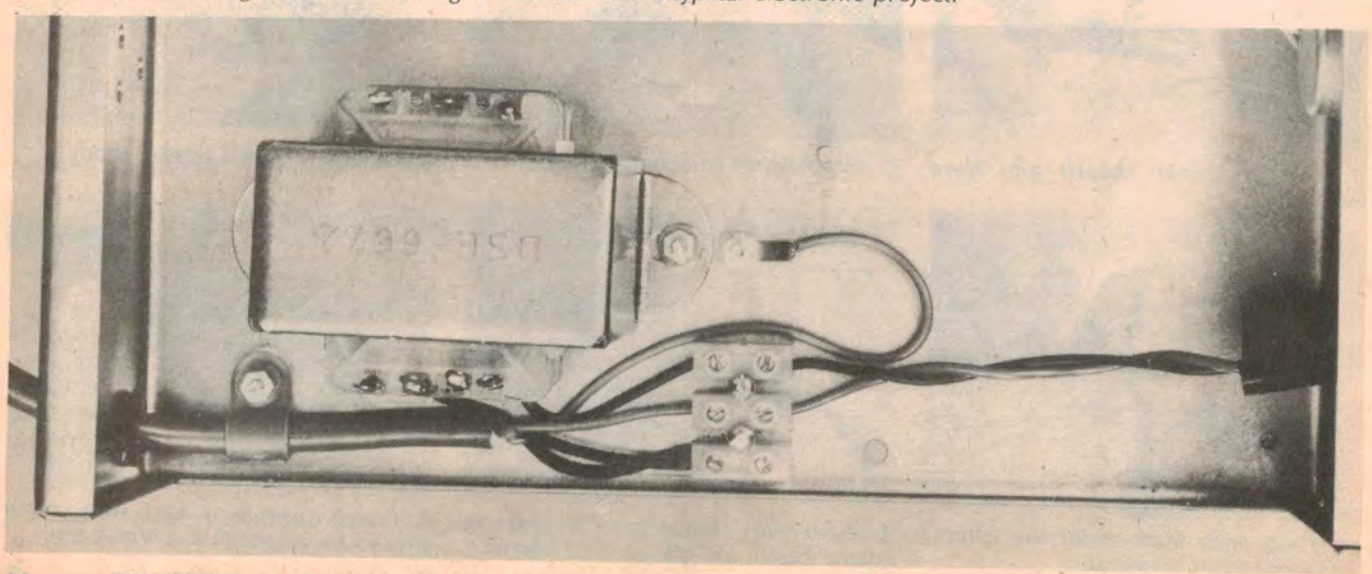
Fig. 3 shows how mains wiring is typically installed into the chassis of a project. This could for example, be an amplifier, a radio tuner, a piece of test equipment, or even a variable DC (direct current) power supply.

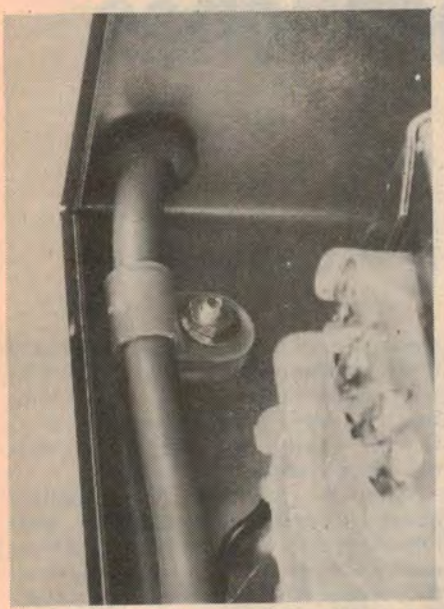
You will need the following items:

- 1 mains plug and length of 3-core mains cord;
- 1 rubber grommet;
- 1 cord clamp;
- 1 3-way mains terminal block; and
- 1 240V AC rated on/off switch

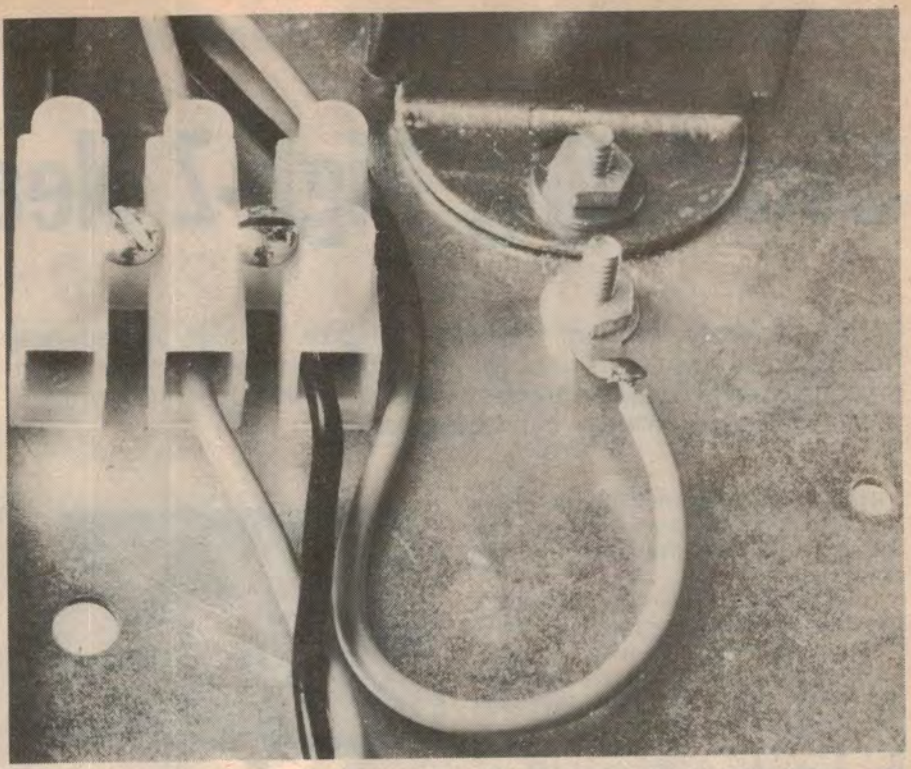
The first step is to mount all the chassis hardware such as the on/off switch, the power transformer, the mains terminal block, and the earthing solder lug. You should make sure that both the power transformer frame and the solder lug make good chassis contacts. If the chassis has been painted, it will be necessary to scrape some of the paint away to ensure a good metal-to-metal contact.

Below: view showing how mains wiring is installed into a typical electronic project.





The mains cord should enter through a rubber grommet and be securely clamped.



All wiring to the terminal block should be kept neat and tidy. Note how the earth wire is looped so that it will be the last to break in a situation of stress.

You can use a multimeter switched to the low-ohms range to ensure that a good contact has been made.

The rubber grommet is installed in the cord entry hole in the rear of the chassis. The mains cord passes through this grommeted hole, and is then securely anchored to the bottom of the chassis with the cord clamp. The earth lead is soldered to the solder lug near the transformer, while the active and neutral wires connect to the terminal block.

The terminal block is also used to terminate the two wires from the mains switch and the transformer primary leads. Before soldering the wires to the mains switch, it's a good idea to push a length of suitable plastic sleeving over the wires. After soldering, the sleeves can be pushed over the terminals of the switch to make it as shock proof as possible.

Alternatively, the switch terminals can be wrapped in insulation tape.

Things to watch

Before plugging in and applying power, you should check the following:

- Make sure that there are no connections between either the active or neutral lines and earth. You can easily check this with a multimeter switched to the ohms range. If the needle swings across the meter face, you've got a problem which must be traced and fixed before power is applied.
- Is the mains cord securely clamped? If not, any strain on the cord could pull the active and neutral wires out of the terminal block, and they could short to chassis. It's best to make the earth wire longer than the active and neutral wires, so that it will be the last to break in this situation. While it remains connected, it will continue to provide protection, even if the other wires are pulled from the terminal block.
- Examine the terminal block carefully. All wires should be tightly connected, and there should be no bared wire protruding beyond the edge of the terminal block insulation.
- Finally, go over your wiring carefully, to make sure that you haven't made any mistakes.

Note that the wiring for some projects may differ slightly from that shown in Fig. 3. Some projects do not require an on/off switch, for example. However, the basic principles still apply — just follow the wiring diagram for the project that you're working on.

That's it! As you can see, it's not a particularly difficult job, but one that should be done neatly and carefully to ensure personal safety.

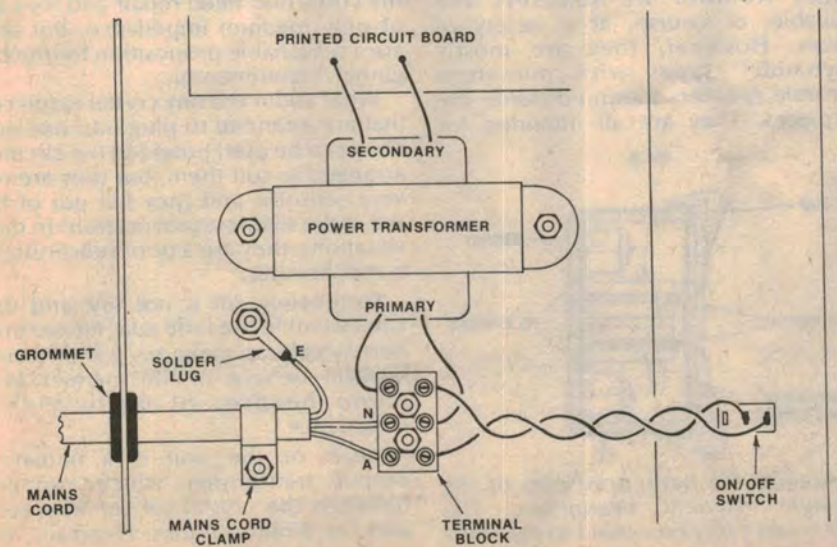


Fig. 3: typical mains wiring diagram.