Power Monitor — checks energy consumption

Use this simple Power Monitor to easily and safely measure the energy consumption of household appliances. You can then calculate running costs and thus minimise your energy bills.

by LEO SIMPSON

Don't let this happen to you!

There are two reasons why this project came into being. The first is the increasingly important energy consciousness of the community and the consumer's need to know the energy consumption of typical domestic electric appliances.

The second reason is far more cogent and arises out of a recent embarrassing event in the EA laboratory. A certain senior member of the technical staff was attempting to measure the mains current of a piece of equipment, with an eye to calculating the power requirement. He was doing this with the aid of a multimeter which had a ten-amp AC range and a couple of jumper leads. All very informal and quite dangerous!

Unfortunately for the said staff member he was twice interrupted by phone calls before he could complete this hazardous measurement and, when he finally applied power, splat! — there was a small explosion from within the multimeter and then a sad-looking puff of smoke wafted into the stunned staff member's twitching nostrils. How embarrassing — the other staff members present did not know where to look.

Needless to say, the aforesaid hapless staff member had somehow contrived to connect the multimeter directly across the mains! While you may well laugh, it is only too easy to do so, besides being quite "hairy" in the dangerous sense of the word.

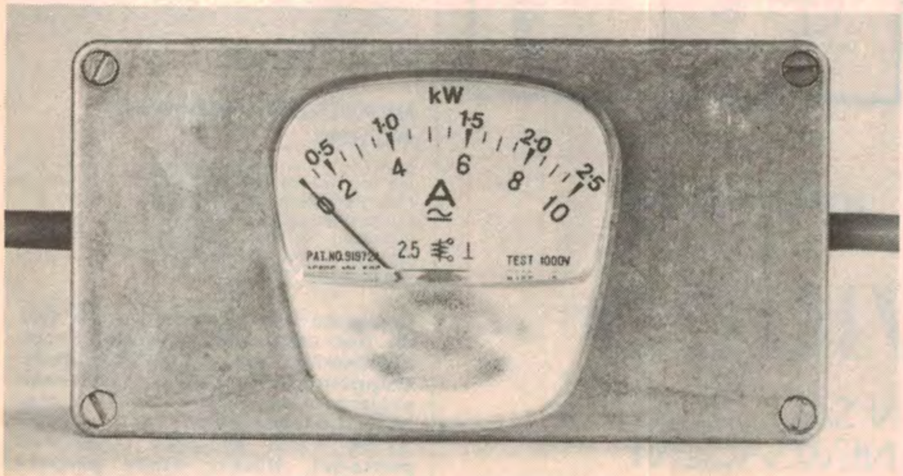
And so from the ashes of that wrecked multimeter (which incidentally was successfully repaired) arose the Power Monitor. It enables the current drain of any mains appliance to be quickly and safely measured, without any pyrotechnics.

Moving-iron meter

So simple is the circuit of this Power Monitor that we have not bothered to draw one. It consists solely of a moving-iron ammeter which is wired in series with the active mains lead. A moving-iron meter is particularly suited to this application since it responds closely to the RMS value of the current.

This response to the RMS value of current is important for two reasons. First, it means that a moving-iron meter will respond equally well to direct or alternating currents (of low frequency) and no rectifier is required. Second, some AC loads tend to distort the usual sinusoidal current waveform and this could lead to inaccuracies if the more common moving-coil meter with rectifier was used.

This is because a moving coil meter



Power Monitor lets you measure energy consumption directly in kilowatts.

PARTS LIST

- *1 0-10A moving iron meter*
- *1 diecast case, 120 × 65 × 40mm*
- *1 ten-amp plug*
- *1 ten-amp in-line socket*
- *1 length of ten-amp power flex, 60cm*
- *2 cord clamps, 2 solder lugs, 2 grommets,*
- *1 two-way insulated terminal block,*
- *4 screws and nuts to suit.*

responds to the average value of the current waveform and when calibrated to read RMS values, the assumption is that the waveform will be sinusoidal (ie, a pure sine wave).

As supplied, the moving iron meter we used is calibrated up to ten amps (AC or DC). We have added a "kW" designation and the necessary numerical values so that the meter also reads power up to 2.5kW.

In adding the extra power range we have avoided the need to draw in an extra scale by assuming that the mains voltage is 250VAC rather than the nominal 240VAC. This has enabled us to use the existing amp scale markings. Naturally, this will lead to a small error if the mains voltage is not exactly 250VAC when you make a measurement but in most cases this will not be important.

Power factor

We should add another important qualification to the power measurements made by this mains monitor. Power in an AC load is calculated by multiplying the applied voltage by the current but this calculation is only valid when the current is exactly in phase with the voltage, as is the case for a resistive load such as a radiator or toaster.

Another way of expressing this important criterion is the parameter known as power factor. This is the cosine of the phase angle between the voltage and current. For a resistive load, as mentioned above, the power factor is one ($\cos 0° = 1$). For all other loads, such as motors and transformers, the power factor is less than one which means that the voltage and current are not exactly in phase.

What this means as far as our Power Monitor is concerned is that the power reading for loads with less than unity power factor will be higher than reality. If you know the exact power factor of the load concerned you can calculate the power with the following formula:

$$\text{Power} = VI.\cos\alpha$$

where α is the phase angle and $\cos\alpha$ is the power factor.

Most people will not want to bother with that and will be reasssured to know that for the important energy consuming loads in the household, such as refrigerators and washing machines (where induction motors are used under more or less constant and heavy loads), the power factor will be close to unity and the Power Monitor readings will be reasonably close to reality.

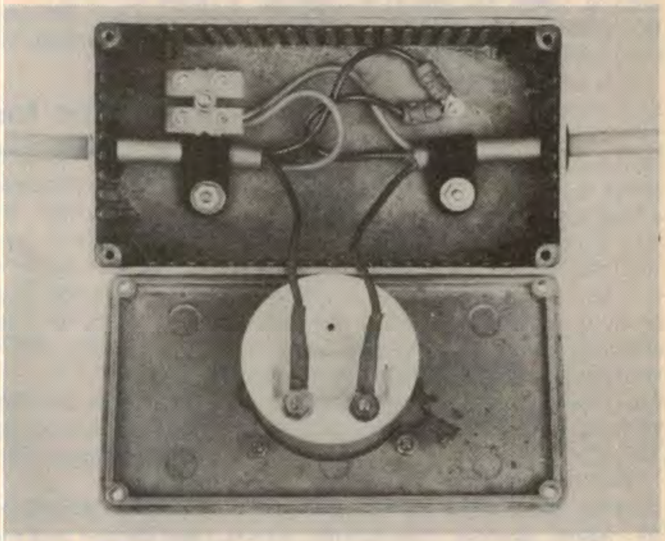
Another point we should make is that a typical domestic appliance will often draw more power than its nameplate rating. Often this discrepancy can be as much as +10% or more. This can be explained by the fact that the nameplate rating refers to a particular voltage (which is usually 240VAC) and the fact that manufacturing tolerances must be taken into account.

Construction

The moving iron ammeter we used is available from Dick Smith Electronics (cat Q-2090). Some readers may wonder why we did not incorporate the matching 20V moving meter which is also available from DSE to provide voltage monitoring as well. However, in common with all moving-iron meters, these movements consume about one watt at full scale deflection. If we were to add the necessary series multiplier resistor to run the 20V movement from 240VAC it would dissipate about 11W and consequently become very hot!

We housed the meter movement in a small diecast aluminium box which is more robust and safer than plastic or sheet metal boxes. After all, if you accidentally step on it you don't want your knee-cap impacted into your molars!

Start by cutting a 45mm diameter hole in the front panel of the box for the meter. A hole saw would be ideal for this purpose, provided that you have access to a drill press. If not, a hand drill can be used to drill numerous small holes around the inside of the circumference of the mounting hole. Use a coping saw to join the small holes and file the mounting hole out to size. Note that this hole is not centrally located on the front panel due to the eccentric shape of the meter.



The moving iron ammeter is simply wired in series with the mains active lead, while the neutral wires are terminated in an insulated terminal block.

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

$18.00

This includes sales tax.

A hole must be drilled in each end of the box for the power cord. The size of this hole will depend on the particular grommet you use – ours required a 12mm hole. A total of six 3mm holes will also need to be drilled. Two of these are in the front panel (lid), to retain the meter.

For the location of the other screw holes, check the inside photograph of the Power Monitor. The screws and terminal block must not foul the rear of the meter housing.

Mount the meter on the case lid to make it easier to handle when altering the scale. The clear escutcheon unclips easily to provide access to the scale itself. We used Letraset rub-on lettering to add the "kW" and numerical markings. We would suggest a 12pt medium or bold Helvetica type font as being suitable. If you make a mistake with the lettering it is easily lifted off with adhesive tape to enable you to start again. We also suggest you anchor the meter point with a small piece of adhesive tape to avoid it being damaged.

Wiring

You will need a 60cm length of ten-amp three-core power flex, plus a three-pin plug and an in-line socket which must also have ten-amp ratings. An alternative, which may be cheaper and more convenient, is to purchase a ready-made ten-amp extension lead with moulded-on plug and socket. Whichever way you do it, you must make sure that active and neutral conductors are not transposed between plug and socket.

The earth (green or green with yellow stripe) wire of each cord section should be connected via solder lugs to the case so that the earth connection between plug and socket is continuous. The neutral (black or light blue) wires should

Continued on page 102

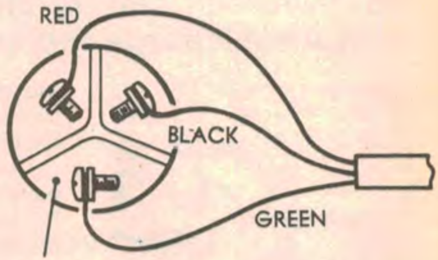
 ctd from p85

connect to the insulated terminal block. Finally the active (red or brown) wires from each cord section should connect to either side of the meter movement.

Use cord clamps to secure each cord section. Make a final check of your wiring and then screw the lid to the case. Now check with a multimeter that the earth connection is continuous between plug and socket and has no short circuits to active or neutral. Similarly, check that the active pin on the plug is connected to its respective slot on the socket. Do the same with the neutral connections.

Now you are ready to use the Power Monitor on the mains. Plug it into a power point with no load connected to the socket. There should be no pointer deflection on the meter. Then connect an appliance of known power rating and check that the meter reading is roughly the same.

One final point should be kept in mind in using the Power Monitor and that is the difference between power demand and energy consumption. Since many domestic appliances are thermostatically controlled (some radiators, stoves, ovens and grillers) while others are used intermittently (refrigerators), their maximum power demand is not necessarily a guide to their energy consumption over an extended period of time.



Wiring of the mains plug. See the text for the new mains wiring colour code.