

A.C. POWER CUT-OFF DEVICE

Background to the Invention

5 This invention relates to an a.c. power cut-off device.

Summary of the Invention

10 According to the invention there is provided a power cut-off device for an a.c. mains having live and neutral conductors, the device comprising comparison means for comparing the voltage drop across an impedance in the live or neutral conductor with a threshold value, and disconnection means responsive to the comparison means for disconnecting the live conductor from the neutral conductor if the threshold value is exceeded, 15 wherein the comparison means includes first and second comparators each having a positive input and a negative input and an output providing a signal which assumes a predetermined level when the voltage at the positive input exceeds that at the negative input, wherein one side of the impedance is connected to the positive input of the first comparator and to the negative input of the second comparator, and wherein the other side of the 20 impedance is connected via a respective voltage divider to the negative input of the first comparator and to the positive input of the second comparator, the disconnection means being responsive to a signal of the predetermined level at the output of either of the first and second 25 comparators.

Brief Description of the Drawings

30 An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a circuit diagram of an a.c. power cut-off device,

35 Figures 2 and 3 are a circuit diagram for detecting an alternative current path to earth which provides an input to the circuit of figure 1, and

Figure 4 illustrates an alternative disconnection circuit to the triac shown in Fig. 1.

Description of the Preferred Embodiment

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In figure 1, an a.c. mains has live L and neutral N conductors carrying 240 volts a.c. supplying power to a load Z1, and an earth conductor E. A current sensor S1 is inserted in series in the live conductor L. The sensor is designed to develop 50 millivolts across it when the current in the live conductor L reaches a predetermined overload current, in this case 10
10 amps, at which it is desired that the power be cut off from the load Z1. The current sensor may be made from 6 turns of 12 S.W.G. wire or from a length of metal such as aluminium.

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The a.c. power cut-off device includes two comparators 10 and 12 respectively which may be implemented by a TLC 272 dual comparator. One side of the current sensor S1 is connected to the junction of the resistors R2 and R3 and the other side of the sensor S1 is connected both to the negative input of the comparator 10 and to the positive input of the
20 comparator 12, in each case via a respective decoupling capacitor C1 and current limiting resistor R5. Four resistors R1 to R4 are connected between 12v d.c. and ground and have the values indicated in figure 1. These set the threshold voltages at the positive input of the comparator 10 and at the negative input of the comparator 12 such that when a voltage of
25 50 millivolts is developed across the current sensor S1 one or other of the comparators 10 and 12 is triggered (depending upon whether such triggering is effected by a positive or negative half cycle) so that the point P goes high.

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This in turn triggers the output O/P of a 555 timer 14 to go low for a predetermined period which removes the 12v d.c. supply from a photo relay 15 which, as shown in Fig. 1, comprises a photodiode located close to a phototransistor. A triac 16 is inserted in series in the live conductor L, and in the absence of overload the phototransistor is conductive (due to
35 light falling on it from the photodiode) and connects the voltage on the live conductor L, taken off just before the triac 16, to the control input CTL of

the triac so that the latter normally conducts. However, removal of the 12v d.c. voltage from the photo relay 15 causes the photodiode to turn off and hence the phototransistor becomes non-conductive to remove the control voltage from the triac 16. Consequently, the triac 16 becomes
5 non-conductive and disconnects power from the load Z1. The triac 16 may be type TIC 246M and is selected in order to be able to handle overloads and be capable of switching inductive as well as reactive loads. A 100 milli-henry inductor L1 is connected in series in the live conductor L at the output of the triac 16 to reduce interference.

10 If the fault giving rise to the overload current is still present after the 555 timer 14 has finished its timing mode, the power will remain off because the point P will still be high. However, once the fault is corrected the output of the comparators 10 and 12 goes low whereupon once the timer 14
15 has timed out the 12v d.c. voltage is once again applied to the photo relay 15 and the triac 16 switches on again to restore power to the load Z1.

In addition to cutting off the power in the case of an overload current, caused for example by faulty equipment or a short circuit, the device also
20 includes circuitry (figures 2 and 3) for cutting off power when an alternative current return path exists, that is to say, when there is a current path to ground other than through the earth conductor E. This can occur when a person comes into contact with a live point on equipment.

25 Therefore, referring first to figure 2, a toroidal ferromagnetic core 20 has three windings W1, W2 and W3. The winding W1 is inserted in series with the live conductor L, the winding W2 is inserted in series with the neutral conductor N, and the winding W3 is inserted in series with the earth
30 conductor E. Current flowing in any one of the windings W1 to W3 alone would induce an eddy current in the core 20. However, the windings are configured such that when the current in the live conductor L precisely equals the sum of the currents in the neutral and earth conductors N and E the eddie currents induced in the core 20 by the three windings cancel out, so that the net result is that no eddy currents flow in the core 20.

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However, should there be an alternative current path, such as provided by

a person touching a live point, the sum of the currents in the neutral and earth conductors N and E will be less than the current in the live conductor L, so that there will be a net flow of eddy current in the core 20. This net flow is detected by a hall effect device 22 located within the toroidal core 20. The hall effect device 20 provides an a.c. voltage at an output 24 whose amplitude is approximately proportional to the amplitude of the eddy current flowing in the core 20.

The output 24 of the hall effect device is connected to the circuit shown in figure 3 including two comparators 28 and 30 which, like the comparators 10 and 12, may be implemented by a TLC 272 dual comparator. Four resistors R6 to R9 are connected between 12v d.c. and ground and set the threshold voltages at the positive input of the comparator 28 and at the negative input of the comparator 30. The output 24 from the hall effect device 20 is connected both to the negative input of the comparator 28 and to the positive input of the comparator 30, and also to the junction of the resistors R7 and R8.

The output of the comparators is connected to the point P, figure 1. Therefore, when the threshold of one of the comparators is exceeded (again depending upon whether it is a positive or negative half cycle) the point P goes high and cuts off the power to the load Z1 as described in connection with figure 1. The thresholds set at the comparators 28 and 30 may be selected to be very small, so that a current of only a few micro-amps in the alternative path is sufficient to trigger the comparators and cut off the power.

Fig. 4 illustrates an alternative disconnection circuit which uses a wheatstone bridge instead of the triac 16.

In Fig. 4 the live L and neutral N conductors are connected across a first pair of opposite corners of a wheatstone bridge, i.e. the junctions of the diodes D1/D4 and D2/D3 respectively, and the source-drain path of an n-type field effect transistor FET is connected across the other pair of opposite corners of the wheatstone bridge, i.e. at the junctions of the diodes D1/D3 and D2/D4 respectively. The gate of the FET is controlled by the

output of the photo relay 15 in a similar manner to the control of the triac in Fig. 1.

5 In normal operation the FET is normally held on by a control voltage from the photo relay 15. In the positive half cycles of the mains the FET provides a path through the diode D1, the FET and the diode D2, and in the negative half cycles of the mains the FET provides a path through the diode D3, the FET and the diode D4. In each case the FET is in series with the load Z1 and completes a path for current from the live conductor to the neutral conductor through the load. During normal operation as described, only 0.9v is dropped across each pair of diodes and the FET.

10 When there is a fault, as determined by the point P going high, the photo relay 15 turns off as before, removing the control voltage from the FET. This prevents current flowing from the live conductor to the neutral conductor via the load Z1.

15 The n-type FET can be fabricated integrally with the wheatstone bridge circuit or as a discrete component. In the latter case the FET can be a Philips FET with a 600v blocking voltage, 0.1 ohm on resistance and a switch speed of 200ns.

20 Although in the preceding embodiment the current sensor S1 is inserted in series in the live conductor L, it could alternatively be inserted in the neutral conductor N

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**CLAIMS**

1. A power cut-off device for an a.c. mains having live and neutral
5 conductors, the device comprising comparison means for comparing the
voltage drop across an impedance in the live or neutral conductor with a
threshold value, and disconnection means responsive to the comparison
means for disconnecting the live conductor from the neutral conductor if
10 the threshold value is exceeded, wherein the comparison means includes
first and second comparators each having a positive input and a negative
input and an output providing a signal which assumes a predetermined level
when the voltage at the positive input exceeds that at the negative input,
15 wherein one side of the impedance is connected to the positive input of the
first comparator and to the negative input of the second comparator, and
wherein the other side of the impedance is connected via a respective
voltage divider to the negative input of the first comparator and to the
positive input of the second comparator, the disconnection means being
20 responsive to a signal of the predetermined level at the output of either of
the first and second comparators.
2. A power cut-off device as claimed in claim 1, wherein the a.c. mains
has live, neutral and earth conductors, the device also comprising further
means for providing a further signal whose amplitude is dependent upon
25 the difference between the current flowing in the live conductor and the
sum of the currents flowing in the earth and neutral conductors, and further
comparison means for comparing the amplitude of the further signal with a
further threshold value, the disconnection means also disconnecting the live
conductor from the neutral conductor if the further threshold value is
30 exceeded.
3. A power cut-off device as claimed in claim 2, wherein the further
means includes a closed loop ferromagnetic core having three windings
respectively connected in series with the live, neutral and earth conductors
and arranged such that when the current in the live conductor equals the
35 sum of the currents in the neutral and earth conductors the net flow of eddy



currents in the core is a predetermined value, and means for providing the further signal corresponding to the net flow of eddy currents in the core.

5 4. A power cut-off device as claimed in claim 3, wherein the means for providing the further signal comprises a hall effect device.

10 5. A power cut-off device as claimed in claim 2, 3 or 4, wherein the further comparison means includes third and fourth comparators each having a positive input and a negative input and an output providing a signal which assumes a predetermined level when the voltage at the positive input exceeds that at the negative input, wherein the signal from the further means is connected to the positive input of the third comparator and to the negative input of the fourth comparator, and wherein the signal from the further means is also connected via a respective voltage divider to the
15 negative input of the third comparator and to the positive input of the fourth comparator, the disconnection means being responsive to a signal of the predetermined level at the output of either of the third and fourth comparators.

20 6. A power cut-off device as claimed in any preceding claim, wherein the disconnection means includes a photosensitive device which is normally maintained in a conductive state by a light emitting source located adjacent to the photosensor, and a switching device in series with the live conductor which is normally held closed by a control voltage supplied via the
25 conductive photosensitive device, the light emitting device being turned off in response to a signal from the comparison means whereby the control voltage is removed from the switching device and the latter disconnects the live conductor from the neutral conductor.

30 7. A power cut-off device as claimed in claim 6, wherein the switching device is a triac.

35 8. A power cut-off device as claimed in claim 6, wherein the live and neutral conductors are connected across a first pair of opposite corners of a wheatstone bridge and the switching device is connected across the other pair of opposite corners of the wheatstone bridge.



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9. A power cut-off device as claimed in any preceding claim, further including a timer which is triggered by a signal from the first or further comparison means to provide an output signal which persists for a predetermined period, the disconnection means being responsive to the said
- 5 timer output signal.