

UNDERSTANDING RCDs

By John Ware

This article is based on information from 'The RCD Handbook, The BEAMA Installation Guide to the Selection and Application of Residual Current Devices'

IN THIS ARTICLE we discuss Residual Current Device (RCD) operation, which can occur due to electrical faults both downstream and upstream of the device. An RCD, when correctly selected and installed, can provide protection against electric shock due to indirect contact. RCDs are also used to provide supplementary protection against direct contact and protection against thermal effects. Operation of an RCD can occur due to a downstream fault such as a crossed neutral on a split-load board, high protective current or an upstream effect such as mains-borne disturbances.

1. Indirect contact. An RCD may be used to provide protection against

Faults existing downstream of the RCD

1	Faults existing	Indirect contact
2	downstream	Direct contact
3	of the RCD	Incorrect application
4		No discrimination between series-connected RCDs
5		Loose connection
6		Crossed neutral on split load board
7		Neutral to Earth fault
8		Nails and picture hooks
9		High protective conductor current
10		Mineral insulated cables
11		Moisture ingress
12		Double pole switching
13	Faults existing	Loose connections
14	upstream	Mains-borne disturbance including lightning strike
15	of the RCD	Site machinery or plant and installed services
16		Overhead lines

electric shock due to indirect contact in an installation in accordance with the requirements of Regulation 413-02-16 (for a TN system) or Regulation 413-02-20 (for a TT system) of BS 7671.

2. Direct contact. An RCD may be used to provide supplementary protection against direct contact in accordance with the requirements of Regulation 412-06 of BS 7671.

3. Incorrect application. An RCD must be correctly selected and erected for the particular application. For example, protecting an entire installation using a single high-sensitivity RCD can, in many cases, lead to unwanted tripping, particularly in industrial environments where inductive loads will cause greater transient overvoltages and where longer cable runs will result in larger values of capacitance to earth.

4. No discrimination between series-connected RCDs. A fault downstream of two series-connected RCDs may result in operation of either device. Figure 1 illustrates two RCDs connected in series. A fault downstream of the second device will be 'seen' by both devices. Inconvenience may result if the upstream device operates. Discrimination, where required, must be ensured by means such as selecting a time-delayed device for the upstream device (Refer to Regulation 531-02-09).

5. Loose connections. A loose connection downstream of an RCD may cause it to operate due to transient voltages or capacitive effects. Every connection must be properly constructed (Regulation 133-01-04) of durable electrical continuity and adequate mechanical strength (526-01-01), correctly selected (526-02) enclosed (526-03) and accessible, where required (526-04).

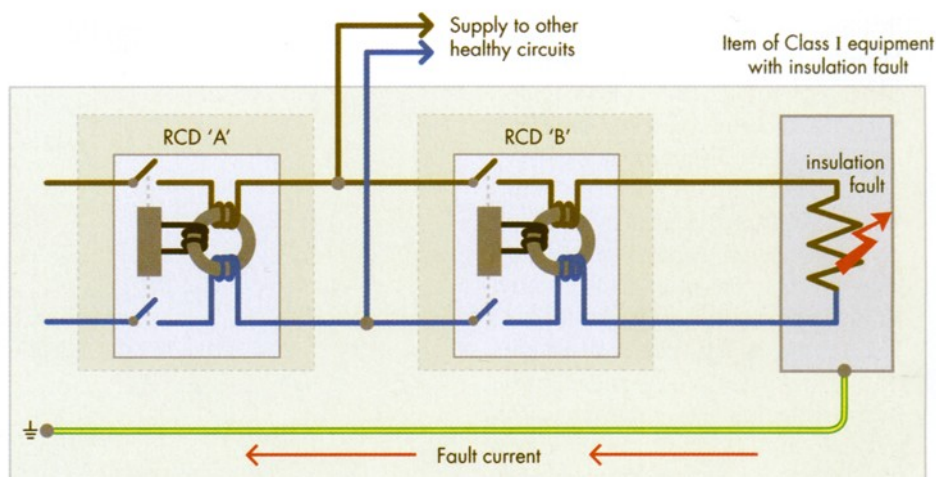


Figure 1: Series-connected RCDs

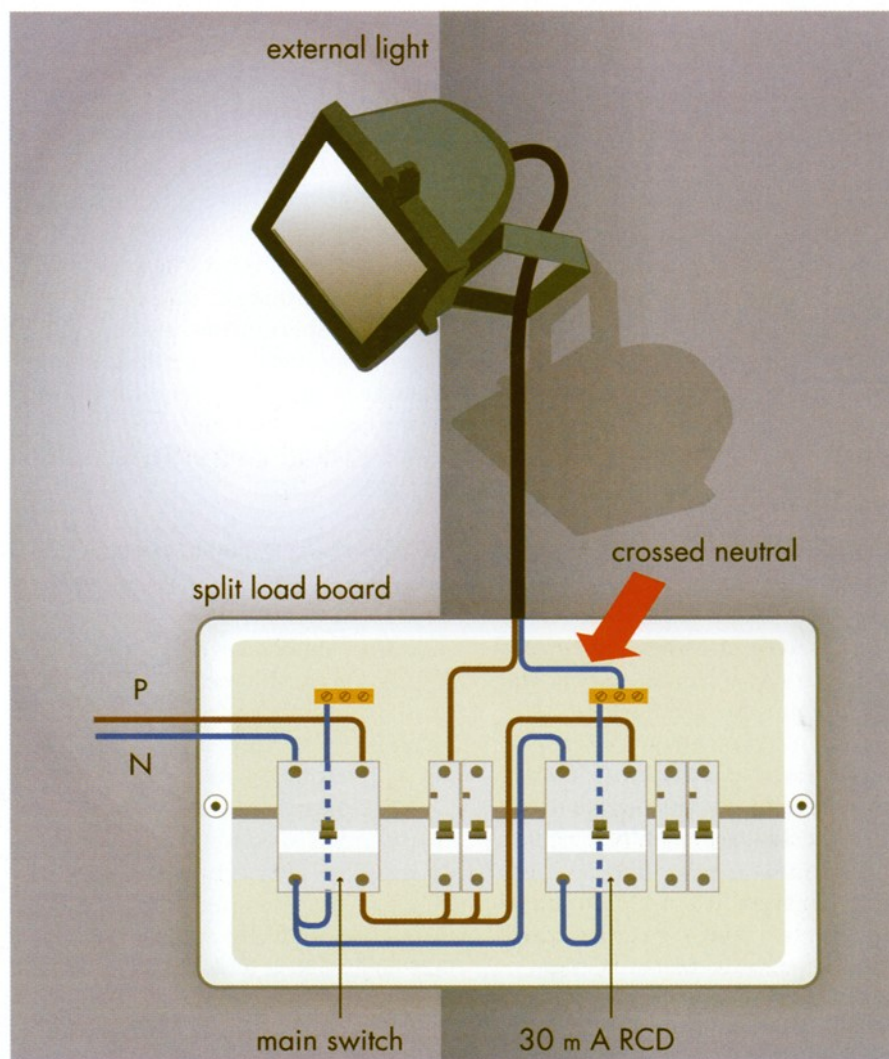


Figure 2: Crossed neutral on a split-load board

6. Crossed neutral on split load distribution board or consumer unit. In the diagram, fig 2, the external lighting circuit has been incorrectly connected. The miniature circuit-breaker supplying the circuit is connected to the non RCD-protected side of the split-load board but the neutral conductor for the circuit has been inadvertently connected downstream of the RCD. As soon as the outside light is energized, the RCD will 'see' a large imbalance and will operate. The neutral must be taken from the same final circuit, never from another circuit as has happened in this example. Circuits must be kept separate (Regulation 314-01-04). In this example a 'borrowed neutral' situation exists presenting a potential shock risk for an electrician attempting to troubleshoot the problem.

7. Neutral-to-Earth fault. A neutral-to-earth fault or inadvertent connection of neutral to earth downstream of an RCD will probably result in the device operating as part of the neutral current will flow in the circuit protective conductor resulting in the RCD 'seeing' an imbalance (see fig 3, above). A neutral-to-earth fault can be caused by:

- A neutral conductor touching an earthed mounting box or earthed metal conduit
- Reversed neutral and earth connections at an accessory or item of current-using equipment
- Withdrawal of a fuse or switching off a circuit-breaker in a final circuit resulting in an RCD tripping as the neutral is normally not interrupted.

The most effective way of testing for earth faults in the wiring or equipment is by measuring the insulation resistance as described in Section 713-04 of BS 7671.

8. Nails and picture hooks, screws and

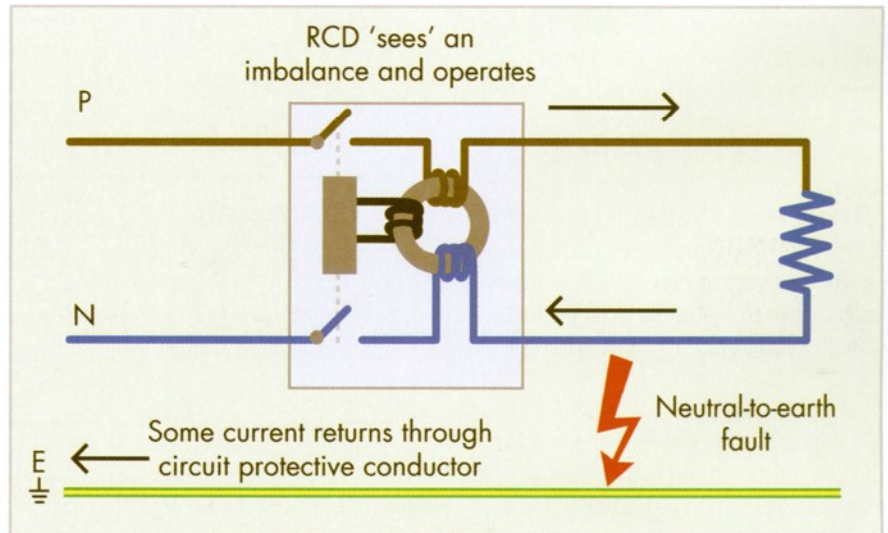


Fig 3: Neutral-to-Earth fault

power drills. A floorboard nail driven between the neutral and earth conductors creates a neutral to earth fault which is likely to cause an upstream RCD to trip. The fault can be located by insulation testing. The damaged cable must be replaced and either relocated to avoid further damage or protected. Requirements to protect cables from impact and penetration are given in Regulation 522-06 of BS 7671.

9. High protective conductor current. Equipment such as variable speed drives, computer equipment and high frequency luminaires often incorporate filters that cause a certain amount of earth leakage or protective conductor current. Protective conductor current levels below the operating current of the RCD cannot be ignored. The RCD sensitivity is effectively increased and becomes the difference between the RCD trip current and the standing protective conductor current. For example, an RCD with a rated residual operating current of 30mA will have a typical trip current of 22mA. If the standing protective conductor current due to computer equipment is 10mA it will only take an earth fault current of

12mA to operate the RCD. This could lead to unwanted tripping.

The electrical contractor can obtain an approximate measurement of protective conductor current by using a sensitive clamp-on a.c. milliammeter encircling the phase and neutral conductors. The instrument 'sees' the same current that an RCD would see at the same point in the installation.

The RCD selected to provide protection must be selected to take account of protective conductor currents, or, alternatively, the circuits must be subdivided so that any protective conductor current likely to occur during normal operation of the connected load is unlikely to cause unnecessary tripping of the device (Regulation 531-02-04).

10. Mineral insulated cables. Mineral insulated cables can absorb moisture if not correctly terminated resulting in reduced insulation which may cause an RCD to trip as a certain amount of outgoing phase current will return through the MI cable sheath causing the RCD to see an imbalance. Insulation testing should identify the problem.

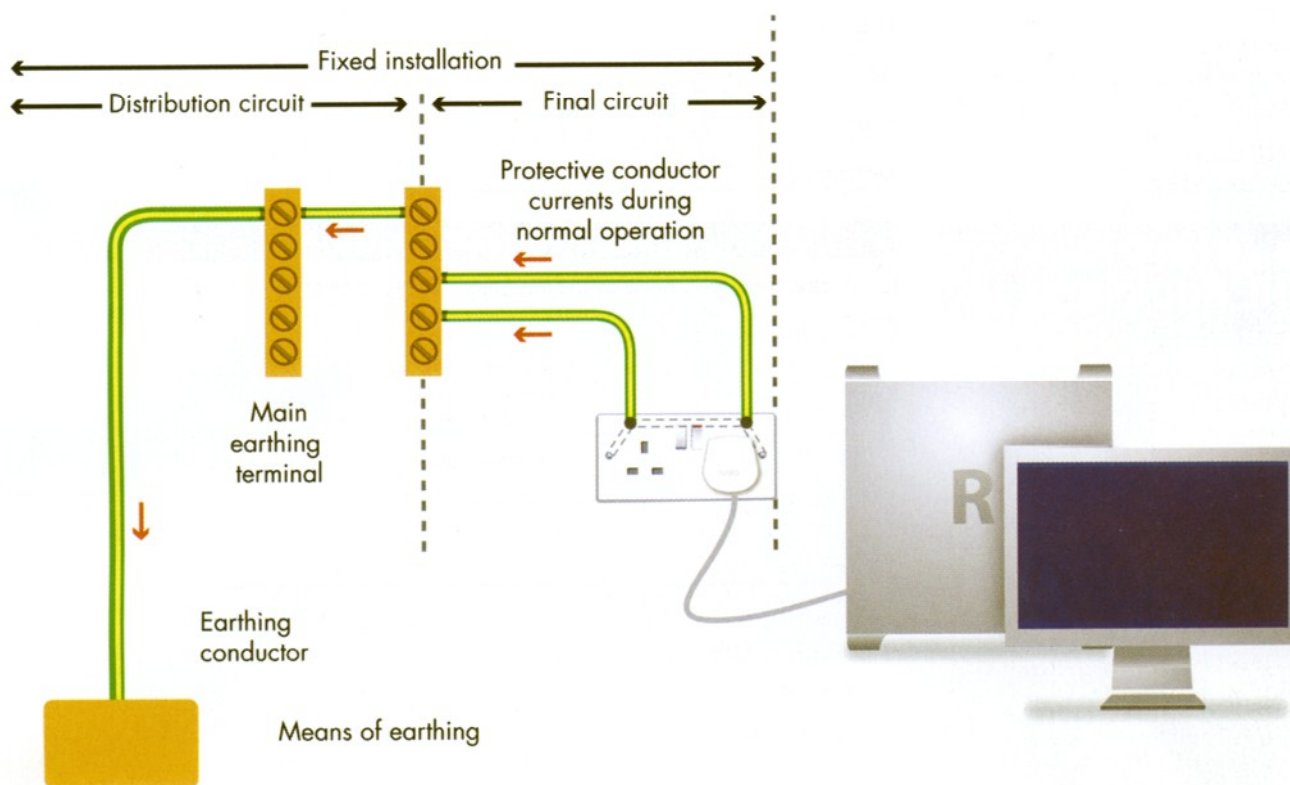


Fig 4: Protective conductor current caused by computer equipment.

11. Moisture ingress can cause reduced insulation resulting in RCD operation. Reduced insulation can result from wet plaster, condensation or water entry into accessories. Similarly some appliances may exhibit reduced insulation causing RCD operation. Certain installed services such as heating elements in cookers can have reduced insulation when cold; the insulation increasing when hot. Manufacturer's instructions should be consulted.

12. Double-pole switching. Double-pole switching within the fixed wiring is known to trip an RCD when switching off or on due to capacitive effects. Changing over from double-pole to single-pole switching can overcome the problem, where such replacement is permissible and safe.

Faults existing upstream of the RCD

13. A loose connection upstream of the RCD such as at the main switch or at the busbar connections can cause the device to operate.

14. Mains-borne disturbances such as spikes, voltage surges and dips, a lightning strike and the operation of distribution network switchgear and protective devices combined with capacitance to earth within the installation can cause unwanted RCD operation. A filter may be of assistance.

15. Site machinery or plant and installed services can cause mains-borne interference. Motors such as lift motors, control gear for discharge lighting and transformer inrush

currents can cause unwanted RCD operation. Although significant transients can arise within an installation they would normally only occur under fault conditions. They might, however, travel to other installations where they could cause unwanted tripping of an RCD.

16. Overhead lines. Unwanted tripping may occur more frequently in an installation supplied by overhead lines compared to one supplied by an underground concentric cable. An underground concentric cable is, by its very nature, a good attenuator of transient overvoltages. Spurious tripping may be avoided by installing a filter upstream of the RCD at the origin of the installation.