Testing of Multipole RCDs

by Mark Coles

The IET's technical helpline has taken a number of calls of late asking how three- and four-pole RCDs operate and how they are to be physically tested. This article looks to answer these and related questions.

The requirements of BS 7671:2008 for testing of residual current devices have been covered a number times in previous issues of Wiring Matters (see the Further Information section at the end of this article on how to obtain back issues), therefore, this information will not be repeated.

Residual current devices
BS 7671:2008 carries the following definitions:

Residual current device (RCD)
A mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.

Residual current.
Algebraic sum of the currents in the live conductors of a circuit at a point in the electrical installation.

An RCD is a protective device used to automatically disconnect the electrical supply to a part of the electrical installation when an imbalance is detected between live conductors. Note that the term "live conductors" means a conductor or conductive part intended to be energised in normal use, including a neutral conductor but, by convention, not a PEN conductor.

RCD is the generic term for a device that operates when the residual current in the circuit reaches a predetermined

Thanks to MK for the images

Fig 1 - Split load board with RCCB protecting a number of circuits

Fig 2 - RCBO

value. The RCD is, therefore, the main component in an RCCB or one of the functions of an RCBO:

RCCB - Residual current circuit-breaker - an example is a main switch in a consumer unit protecting the circuits of a number of circuit-breakers in a split-load board.

RCBO - Residual current operated circuit-breaker with integral overcurrent protection is an RCD and (miniature) circuit-breaker combined

If a line-to-earth fault develops or current flows in the protective conductor, some of the line conductor current will not return to the source of supply through the neutral conductor. When this residual current reaches a preset limit (the residual operating current - IΔn), the RCD detects this imbalance, operates and disconnects the circuit from the supply.

Single-phase devices

In the case of a single-phase circuit, the RCD will be two-pole and the device will monitor the difference in currents between the line and neutral conductors. The monitoring or sensing component is usually a coil or toroid. In a healthy circuit, where there is no earth fault current or protective conductor current, the sum of the currents in the line and neutral conductors is zero. Note that faults between line and neutral conductors (short-circuit) are not detected by RCDs, these faults are detected by fuses, circuit-breakers or the overcurrent protection stage of an RCBO.

Test Circuit

A test circuit is always incorporated in the RCD. Operation of the test button connects a resistive load between the line conductor on the load side of the RCD and the supply neutral. The test circuit is designed to pass a current, in excess of the tripping current of the RCD, to simulate an out-of-balance condition. Operation of the test button checks the electromechanical integrity of the RCD only.

Regulation 514.12.2 of BS 7671:2008 requires that on all installations where RCDs are present, a notice shall be fixed in a prominent position at or near the origin of the installation, instructing the user to check the function of the RCD by pressing the test button every three-months and to observe that the RCD trips instantly.

It is important to note that the RCD should still be verified by regular periodic inspection, the testing requirements for which, are given in Regulation 621.2.

Multipole devices

Where RCD protection is required on three-phase installations, two configurations are possible, i.e. three-pole and four-pole devices. Three-pole devices are intended to be installed on parts of the installation where three-lines are used to supply an item of equipment without a neutral connection; an example of this would be a three-phase induction motor.

Four pole devices are intended to supply an item of equipment that requires a neutral connection.

The operation of multipole devices is similar to that of two-pole devices; current flow is monitored and, where an imbalance of sufficient magnitude is detected, the device will operate. Where the device is three-pole, all three poles are monitored simultaneously. For four-pole devices, all four poles are monitored

Regulation 531.2.2 of BS 7671:2008 requires that the magnetic circuit of the transformer of an RCD encloses all the live conductors of the protected circuit. The associated protective conductor is to remain outside the magnetic circuit.

Multipole RCDs should not be used to protect entire installations as Section 314 of BS 7671:2008 *Division of installation* requires that every installation shall be divided into circuits, as necessary, to:

- avoid hazards and minimize inconvenience in the event of a fault
- facilitate safe inspection, testing and maintenance
- take account of danger that may arise from the failure of a single circuit such as a lighting circuit
- reduce the possibility of unwanted tripping of RCDs due to excessive protective conductor currents produced

Testing

When testing RCDs, probes or clips from the test instrument are attached to the relevant point of the installation to simulate a fault condition. The connections made are dependent on the type of test instrument used as some instruments have two test leads, whilst others have three. Generally, RCD testers with three leads are those that require a connection to neutral whilst two-lead test instruments are simply connected between the line and earthing terminal. Two-lead test instruments will be considered only in this article.

When testing two-pole devices, one test probe is attached to the load side of the line pole, the other to the earthing terminal or associated CPC; when the test is initiated, the device should operate in the required time.

When testing multipole devices, one test probe is attached to the load side of line L1 pole, the other to the earthing terminal or associated CPC; when the test is initiated, the device should operate in the required time.

Should a multipole RCD be tested on each line or pole?

As each live conductor of the RCD is incorporated in the magnetic sensing circuit it is not necessary to perform the test for poles L2 and L3. However, if there is any doubt in the authenticity of the device in question - in terms of a fake or counterfeit device - the advice would be to repeat the test for poles L2 and L3. It goes without saying that such important devices, designed to protect life and property, should be obtained from trusted sources and made by reputable manufacturers.

If a decision is made to test the RCD on all three lines, there should be little on no discernable difference in operating times as each pole is incorporated in the magnetic sensing circuit. If, for example, the test performed on one pole did not meet the required disconnection time, yet, tests on the other two poles were satisfactory, the device should be considered faulty and replaced.

Where in the circuit should the RCD be tested?

Whether the RCD in question protects a number of circuits, e.g. on a split load board, or an RCBO is used to protect a single circuit, or an RCD is installed nearer to the item of equipment it is protecting, the tests can be carried out immediately on the load side of the device. Often, it is suggested that an RCD protected circuit should be tested at the extremity, i.e. at the same point at which a Zs measurement is taken and that result being the highest on that circuit which is recorded.

There is little to be gained in testing the RCD from the extremity of the circuit it is protecting; for two reasons. Firstly, the test is required to prove that the RCD operates correctly. As the circuit in question will meet all other requirements of the Regulations, i.e. earth fault loop impedance and voltdrop, a long run will add little to the operating time of the device. Remember that a 30 mA device providing additional protection should operate within 40 ms when tested at 5IΔn (Regulation 415.1 of BS 7671:2008) and that the maximum earth fault loop impedance should not exceed 1667 Ω (Table 41.5 of BS 7671:2008). Secondly, a second operative will be needed to reset the device after each test otherwise the tester may face a long walk returning to the device location. The RCD should be tested with the load switched off or the load disconnected from the circuit. The reason being that if the connected load has a standing leakage or has a designed protective conductor current, it will be added to the test current thus giving a false test result.

Legal requirements

And finally, just a quick line or two about the legal requirements and competency. When testing RCDs, it is necessary to work on live equipment. The Electricity at Work Regulations 1989 (EWR) recognises that some work, such as fault finding and testing, may require electrical equipment to remain energised during the work. In these cases, if there may be danger from live conductors, regulation 14 of the EWR makes particular requirements. Regulation 16 - dealing with competency - also applies, guidance on the EWR is available from HSE, see the Further Information section below.

Regulation 16
Persons to be competent to prevent danger and injury

No person shall be engaged in any work activity where technical knowledge or experience is necessary to prevent danger or, where appropriate, injury, unless he possesses such knowledge or experience, or is under such degree of supervision as may be appropriate having regard to the nature of the work.
The object of the regulation

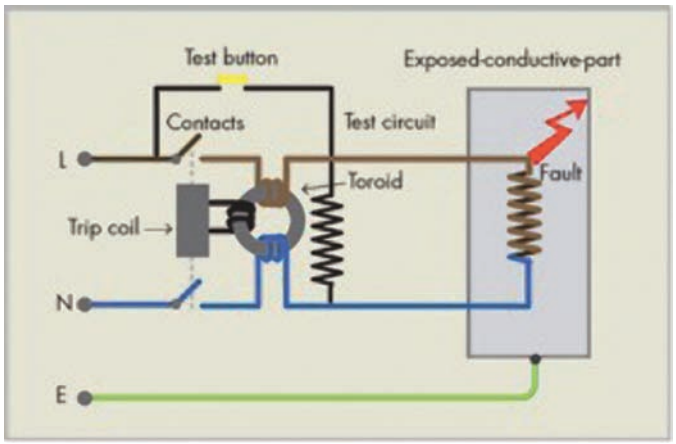

Fig 3 - Schematic diagram of an RCD

is to ensure that persons are not placed at risk due to a inadequacies in training or understanding. The key words prevent danger or, where appropriate, injury are highlighted. The regulations recognise those circumstances where danger is present, i.e. where there is a risk of injury, as for example where work is being done on live equipment using special techniques and under the terms of regulation 14. In these circumstances, persons must possess sufficient technical knowledge, be experienced or be so supervised to be capable of ensuring that injury is prevented.

The scope of 'technical knowledge or experience' may include:

- adequate knowledge of electricity
- adequate experience of electrical work
- adequate understanding of the system to be worked on and practical experience of that class of system
- understanding of the hazards and precautions which need to be taken
- ability to recognise at all times whether it is safe for work to continue.

Workers should be trained and instructed to ensure that they understand the safety procedures which are relevant to their work and should work in accordance with any instructions or rules directed at ensuring safety which have been laid down by their employer or site operator.

Regulation 16 recognises that in many circumstances persons will require to be supervised to some degree where their technical knowledge or experience is not of itself sufficient to ensure that they can otherwise undertake the work safely. The responsibilities of those undertaking the supervision should be clearly stated to them by those duty holders who allocate the responsibilities for supervision and consideration should be given to stating these responsibilities in writing. Where the risks involved are low, verbal instructions are likely to be adequate but as the risk or complexity increase there comes a point where the need for written procedures becomes important in order that instructions may be understood and supervised more rigorously. In this context, supervision does not necessarily require continual attendance at the work site, but the degree of supervision and the manner in which it is exercised is for the duty holders to arrange to ensure that danger or as the case may be, injury, is prevented.

The HSE publication *Safety in electrical testing at work* INDG354 contains guidance on good practice which are not compulsory but may be found helpful in considering what is necessary.

Post script

With the introduction of BS 7671:2008, a number of terms were changed as the UK adopted the technical requirements of CENELEC Harmonized Documents. In the adoption process, line conductor replaced phase conductor (not to be confused with live conductor) but we would still refer to three-phase supplies or three-phase motors.

Further information

- BS 7671:2008 Requirements for Electrical Installations, IEE Wiring Regulations, Seventeenth Edition
- Electricity at Work Regulations 1989 - www.opsi.gov.uk/si/si1989/Uksi_19890635_en_1.htm
- Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25) - free download - www.hse.gov.uk/pubns/books/hsr25.htm
- Safety in electrical testing at work, HSE publication INDG354
- www.hse.gov.uk/pubns/indg354.pdf
- Guidance Note 3 - Inspection and Testing, 5th Edition, published by the IET www.theiet.org/publishing/books/wir-reg/inspection-testing-5th-edition.cfm
- BEAMA are due to publish their updated guide to RCDs www.beama.org.uk/en/publications/

Previous issues of Wiring Matters can be downloaded from the IET's website at www.theiet.org/WM
Back issues relating to the testing of RCDs:
Summer 2005 - www.theiet.org/publishing/wiring-regulations/mag/2005/15-insp-test-rcd.cfm?type=pdf
Spring 2008 - www.theiet.org/publishing/wiring-regulations/mag/2008/26-rcdtest.cfm?type=pdf

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