

Installing RCDs

OBJECTIVE

Depending on the particular characteristics of the ‘electronic’ loads and controls connected to an electrical installation, an RCD could be exposed to a range of residual current waveforms and frequencies. Therefore, as discussed in this article, unless RCDs are selected that are compatible with the loads and other devices connected, the protection intended may be compromised.

Introduction

Electronic components are to be found in most electrical products installed in modern electrical installations – including, for example:

- LED lights,
- Variable speed drives,
- UPS systems,

- Lighting and heating controllers,
- Appliances such as washing machines, induction hobs, dishwashers and fridges.

Such ‘electronic’ products can, in normal operation, generate DC as well as residual current waveforms of high or mixed frequencies, as shown in Fig 1b. Furthermore, in the event of a fault, the current flowing is likely, depending on where the fault occurs, to be complex in shape rather than the sinusoidal waveform shown in Fig 1a. Therefore, an RCD exposed to such waveforms needs to be of a suitable type, otherwise a distorted waveform (or DC) could affect the time/current operation of an RCD and cause it to operate outside its correct operating characteristics – or, at worst, the RCD could fail to operate at all.

It should be recognised that the term RCD covers a range of residual current devices. While the selection of an RCD is primarily based on the residual current sensitivity required, other factors also need to be taken into account, including:

Fig 1 Effects of electronic loads on the sinusoidal waveform

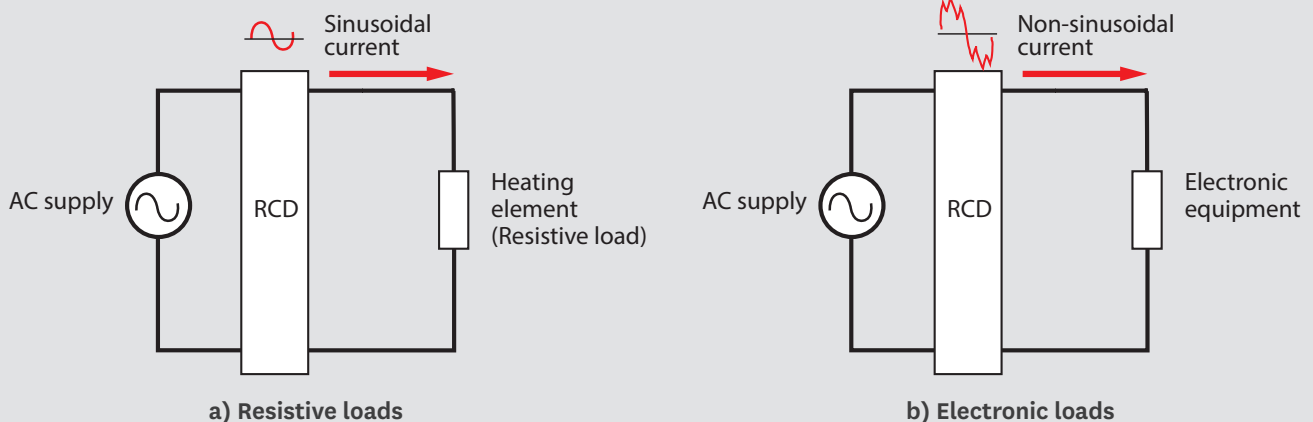


Table 1 Classification of RCDs

Type	Symbol	Operating Characteristic
AC		Operation assured for residual alternating currents, whether suddenly applied or slowly rising (for general use).
A		As for Type AC and, additionally, operation assured for: Residual pulsating direct currents, including those superimposed on a smooth direct current offset of up to 6 mA.
F		As for Type A and, additionally, operation assured for: - Composite residual currents, whether suddenly applied or slowly rising between line and neutral or line and earthed middle conductor. - Residual pulsating direct currents superimposed on smooth direct current of up to 10 mA.
B		As for Type F and, additionally, operation assured for: - Residual sinusoidal alternating currents up to 1000 Hz. - Residual alternating currents superimposed on a smooth direct current of up to 0.4 times the rated residual current ($I_{\Delta n}$) or 10 mA, whichever is the highest value. - Residual pulsating rectified direct current which results from two or more phases. - Residual smooth direct currents whether suddenly applied or slowly increased independent of polarity.

- the compatibility of the device with the type of loads connected,
- co-ordination between Types of RCDs, and
- selectivity between RCDs and other protective devices that may be connected in series.

Classification of RCDs

The operating characteristics of a general purpose RCD (Type AC) is designed for sinusoidal waveforms of 50 Hz. Exposure to high frequency waveforms or DC can saturate the core of the RCD, rendering the device unable to correctly detect residual currents¹, and as such unable to operate under fault conditions. Similarly, the correct operation of a Type A RCD cannot be assured where it is likely to be exposed to certain waveforms of mixed frequencies. For these reasons, Regulation 531.3.3 of *BS 7671* requires that an appropriate 'Type' of RCD is selected based on the frequencies and DC component likely to be present.

When used to describe the operating

- This is known as 'blinding'.
- Type S RCDs are covered by the *BS EN 61008* series (RCCBs) and *BS EN 61009* (RCBOs)
- Circuit-breakers incorporating residual current protection (CBRs) with time delay settings and Modular residual current devices (MRCDs) with time delay settings are covered by *BS EN 60947-2: 2006*. These RCDs could also be type S.

characteristics of an RCD, the term 'Type' relates to the frequency and shape of current waveform for which tripping is assured. A summary of the Types of RCDs detailed in Regulation 531.3.3 and the particular current waveforms for which they are designed is provided in Table 1. In addition, the recommendations given in Figure A53.1 of Annex A53 of *BS 7671*, for protection against possible fault currents in systems with semiconductors should also be taken into account.

Nothing introduced in the 18th edition makes the installation of RCD split consumer units unacceptable.

Regulation 531.3.3 details the different types of RCD that exist and may be selected for use.

Note: An RCD intended for operation by ordinary persons should comply with the relevant product standard listed in Regulation 531.3.4.1, whereas an RCD for use by skilled or instructed persons should comply with Regulation 531.3.4.2.

Co-ordination between RCD Types

Where RCDs are connected in series within an installation, the selection of one Type of RCD should not impair the operation of another device. As shown in Fig 2, the load characteristics which made it necessary for a Type F or B RCD to be installed could detrimentally affect the Type A device connected upstream, causing it to operate. Therefore, with reference to Table 1, RCDs should be co-ordinated whereby:

- a Type AC RCD should not be installed upstream of a Type A, F or B RCD,
- a Type A RCD should not be installed upstream of a Type F or B RCD, and
- a Type F RCD should not be installed upstream of a Type B RCD device.

Selectivity between RCDs

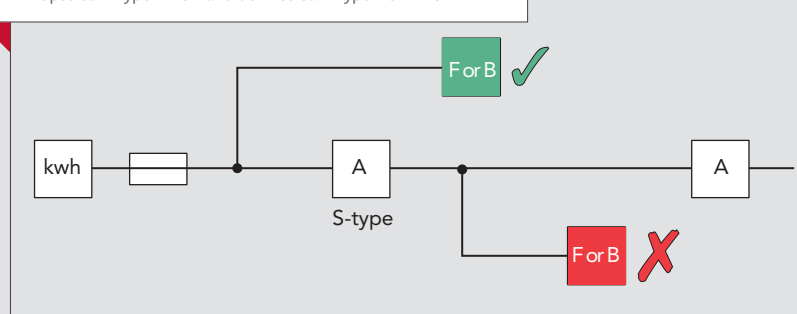
Given the RCD Types are compatible, selectivity between RCDs connected in series based on the residual current is achieved where:

- the upstream RCD is of selective type (Type S² or time-delayed type³ with appropriate time delay setting), and
- the ratio between the rated residual operating current ($I_{\Delta n}$) of the upstream RCD and the downstream RCD is at least 3:1 (Regulation 536.4.1.4 refers).

A residual current protective device connected upstream of an RCD providing additional protection (rated residual current ≤ 30 mA), should be a Type S device, incorporating a time-delay for selectivity purposes.

Note: A Type S RCD is not suitable for additional protection and where this device

Fig 2 Examples of correct and incorrect co-ordination between upstream Type A RCD and downstream Type F or B RCD



is installed it shall satisfy the disconnection requirements of Chapter 41 of BS 7671.

Requirements for selectivity between overcurrent protective devices and RCDs are contained in Regulation Group 536.4.1.5. It should be noted that a Residual Current Circuit Breaker RCCB is not designed to provide overload or short-circuit protection and so suitable devices providing such protection must be installed. In the case of RCCBs housed within a typical consumer unit to BS EN 61439-3, short-circuit protection is provided by an upstream device, generally the supplier's intake fuse, while overload protection is provided by the protective devices installed within the consumer unit. Therefore, the loads connected to a single RCCB must not cause the device to be subjected to a continuous overload exceeding its rating, and the short-circuit withstand capability of the RCCB should have a rating higher than the highest prospective fault current that could occur at its point of installation (Regulation 536.4.2.4 refers).

Compatibility with SPDs

Regulation 534.4.7 requires an RCD installed upstream of a Surge Protective Device to be a transient resistant type having an immunity to surge currents (8/20) of up to 3 kA. Both Type S (RCCBs) to BS EN 61008-1 series and (RCBOs) to the BS EN 61009-1 satisfy this requirement. However, the installation of a Type 1 SPD downstream of an RCD is not recommended.

Considerations for electrical testing

Irrespective of the function of an RCD, whether it is installed to provide fault protection, additional protection or protection against fire, its operation must be verified by testing (Regulation Group 643.7 refers). It should be confirmed that the test instrument is capable of subjecting the RCD to all the required tests.

In some circumstances, due to the compatibility of the RCD and the test instrument used, it may not be possible to obtain a measured value of earth fault loop impedance. Some earth fault loop impedance test instruments inject a DC current to saturate the core of the RCD prior to testing so that the actual test current is undetected by the RCD. This technique of applying a DC bias effectively 'blinds' the RCD and prevents it tripping during the test. Such a test is likely only to be suitable for certain devices such as Type AC and A RCDs. For other Types of RCD either a test instrument having a low current no trip facility or similar is required or the impedance value can be obtained by measuring the earth fault

loop impedance on the supply side of the RCD and adding this to the value of the combined resistance ($R_1 + R_2$) on the load side of the RCD.

Alternatively, automatic disconnection of supply (ADS) may be confirmed by verifying the effectiveness of the RCD, as covered in issue 207 of *Connections*.

Summary

In addition to providing the correct level of residual current protection required, an RCD should be selected so that it is compatible with the operating characteristics of the loads it protects and other devices connected in series. As the nature of loads and their operating characteristics become more complex, then confirming the suitability of existing RCDs should not be overlooked. ©



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