Development Trend of Residual Current Circuit Breakers

The paper deals with the directions of the state-of-the-art changes in the field of residual current circuit breakers, with particular emphasis on standards changes due to new requirements of environment, reliability of operation, operation at high frequencies, and use of voltage-dependent switches.

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Protection switches, or residual current devices are in practice a widely used way of protection against indirect contact with live system parts, fire, and direct contact with live components, in various types and installation executions. The following types of installations can be distinguished: housing and similar installations, and industrial installations. And the executions refer first of all to the earthing systems, i.e. TT, TN and IT systems. The field of use of residual current devices is therefore wide and important enough to have to permanently follow the development. The state-of-the-art is defined by the state of standardization, therefore the paper gives in the first place an analysis of standards, with an emphasis on the IEC, EN and SIST standards, and the terminology usually used for individual product is added, too. In the continuation the actually usual use of residual current devices has been represented. The central part of the paper is dedicated to the development trend of these products, where the changes in market requirements should be emphasized, and as a result also the requirements for changes in the standardization area.

Terminology

This chapter includes some unfamiliar technical terms, and also some abbreviations derived from English language. Interesting is the standpoint of VDE (source: (1)), accepting all valid IEC, EN and VDE standards, but also indicating some uniform terms for individual product groups, together with English abbreviations, such as RCD (singular), and RCDs (plural).

The following table indicates basic terms for individual types of residual current devices. *

Tip	Angleški izrazi	Slovenski izrazi	Nemški izrazi
RCD	**R**esidual **C**urrent **D**evice	Naprava na diferenčni tok	Fehlerstrom-Schutzeinrichtung
RCCB	**R**esidual Current Circuit Breaker	Zaščitno stikalo na diferenčni tok	Fehlerstrom-Schutzschalter
RCBO	**R**esidual **C**urrent Circuit **B**reaker with **O**vercurrent protection	Zaščitno stikalo na diferenčni tok z nadtokovno zaščito	Fehlerstrom-Schutzschalter mit Ueberstrom-Schutzeinrichtung
RCU	**R**esidual **C**urrent **U**nit	Modularna prigradna enota na diferenčni tok	Fehlerstrom-ausloeser zum Anbau an Leitungsschutzschalter
CBR	**C**ircuit **B**reaker with **R**esidual device	Odklopnik z diferenčnim sprožnikom	Leitungsschalter mit Fehlerstrom-Ausloeser
SRCD	**S**ocket **R**esidual **C**urrent **D**evice	Vtičnica z napravo na diferenčni tok	Ortsfeste Fehlerstrom-Schutzeinrichtung in Stecdose
PRCD	**P**ortable **R**esidual **C**urrent **D**evice	Prenosna naprava na diferenčni tok	Ortsveraenderliche Fehlerstrom-Schutzeinrichtung
RCM	**R**esidual **C**urrent **M**onitor	Kontrolnik diferenčnega toka	Differenzstrom-Ueberwachungsgeraet
IMD	**I**solation **M**easuring **D**evice	Kontrolnik izolacije	**I**solations-Ueberwachungsgeraet

RCD	IEC	CENELEC EN	SIST	DIN EN / VDE
RCCB	**IEC 61008-1 (2002-10) Ed 2.1**. Amendment 1 - Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) General rules + am1(2002-06) **IEC 61008-2-1** (1990-12) Applicability of the general rules to RCCB's functionally independent of line voltage **IEC61008-2-2** (1990-12) Applicability of the general rules to RCCB's functionally dependent on line voltage	**EN 61008-1:1994** Electrical accessories - Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - - Part 1: General rules + A2+A11+A12+A13+A14+A17 **prEN 61008-1:2003** Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - - Part 1: General rules **EN 61008-2-1:1994** Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - - Part 2-1: Applicability of the general rules to RCCB's functionally independent of line voltage	**SIST EN 61008-1:1996** Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - Part 1: General rules (IEC 1008-1:1990 + A1:1992, modified) + A11+A12+A13+A14+A17 **SIST EN 61008-2-1: 1996** Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) - Part 2-1: Applicability of the general rules to RCCB's functionally independent of line voltage (IEC 1008-2-1:1990)	**DIN EN 61008-1 / VDE664 T10** (2000-09) Fehlerstrom-/Differenzstrom-Schutzschalter ohne eingebauten Überstromschutz (RCCBs) für Hausinstallationen und für ähnliche Anwendungen Allgemeine Anforderungen **DIN EN 61008-2-1 / VDE 664 T11** (1999-12) Fehlerstrom-/Differenzstrom-Schutzschalter ohne eingebauten Überstromschutz (RCCBs) für Hausinstallationen und für ähnliche Anwendungen Anwendung der allgemeinen Anforderungen auf netzspannungsunabhängige RCCBs
RCBO	**IEC 61009-1 (2003-02) Ed. 2.1 Consolidated Edition** + Corr1(2003-05) + am1 (2002-11) Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) - Part 1: General rules **IEC 61009-2-1 (1991-09)** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) - Part 2-1: Applicability of the general rules to RCBO's functionally independent of line voltage **IEC 61009-2-2 (1991-09)** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) - Part 2-2: Applicability of the general rules to RCBO's functionally dependent on line voltage	**EN 61009-1:1994** Electrical accessories - Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) - - Part 1: General rules + A1+A2+A11+A12+A13+A14+A15+A17+A19 **prEN 61009-1:2003** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCCO's) - - Part 1: General rules **EN 61009-2-1:1994** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) - - Part 2-1: Applicability of the general rules to RCBO's functionally independent of line voltage	**SIST EN 61009-1:1996** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCOB's) - Part 1: General rules (IEC 1009-1:1991, modified) +A1+A2+A11+A13+A14+A15+A17+A19 **SIST EN 61009-2-1:1996** Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCOB's) - Part 2-1: Applicability of the general rules to RCOB's functionally independent of line voltage (IEC 1009-2-1:1991)	**DIN EN 61009-1 / VDE 0664 T 20** (2000-09) Fehlerstrom-/Differenzstrom-Schutzschalter mit eingebautem Überstrom-schutz (RCBOs) für Hausinstallationen und für ähnliche Anwendungen Allgemeine Anforderungen **DIN EN 61009-2-1 /VDE 0664 T 21** (1999-12) Fehlerstrom-Schutzschalter mit Überstromschutz (RCBOs) für Hausinstallationen und ähnliche Anwendungen Anwendung der allgemeinne Anforderungen auf netzspannungsunabhängige RCBOs **DIN VDE 0664-101 /VDE 0664 T 101** (2003-10)Fehlerstrom/Differenzstrom-Schutzschalter ohne eingebauten Überstromschutz für Hausinstallationen und ähnliche Anwendungen (RCCBs) Teil 3: Anwendungen der allgemeinen Anforderungen auf RCCBs für Wechselspannungen über 440 V bzw. Bemessungsströme über 125 A
RCD	IEC	CENELEC	SIST	DIN EN / VDE
RCU	**IEC 61009-1 (2003-02)** Ed 2.1 Suplement G			**DIN EN 61009-1 / VDE0664 T20** (2000-09) Anhang G
CBR	**IEC 60947-2** (2003-4) Suplement B			**DIN EN 60947-2 /VDE 662 1993-10** Anhang B
SRCD				**E DIN VDE 0662 / VDE 0662**

				1993-08 Ortsfeste Schutzeinrichtungen in Steckdosenausführung zur Schutzpegelerhöhung
PRCD	**IEC 61540** - Consol. Ed. 1.1 (incl. am1) Electrical accessories - Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs) –			DIN VDE 0661-10 / VDE 0661 Teil 10 2002-12 Ortsveränderliche Fehlerstrom-Schutzeinrichtungen ohne eingebauten Überstromschutz für Hausinstallationen und ähnliche Anwendungen (PRCDs) (IEC 61540:1997 + A1:1998, modifiziert);
RCM	**IEC 62020** - Consol. Ed. 1.1 (incl. am1) Electrical accessories - Residual current monitors for household and similar uses (RCMs)	**EN 62020:1998** Electrical accessories - Residual current monitors for household and similar uses (RCMs)	**SIST EN 62020:2000** Electrical accessories - Residual current monitors for household and similar uses (RCMs) (IEC 62020:1998)	**DIN EN 62020 1999-07 VDE 0663** Differenzstrom-Überwachungsgeräte für Hausinstallationen und ähnliche Verwendung (RCMs)
IMD	**IEC 61557-6 -** Ed. 1.0 Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 6: Residual current devices (RCD) in TT and TN systems **IEC 61557-8** - Ed. 1.0 1997-02 Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 8: Insulation monitoring devices for IT systems	**EN 61557-6:1998** Electrical safety in low voltage distribution systems up to 1 kV a.c. and 1,5 kV d.c. – Equipment for testing, measuring or monitoring of protective measures -- Part 6: Residual current devices (RCD) in TT, TN and IT systems	**SIST EN 61557-6:1999** Electrical safety in low voltage distribution systems up to 1 kV a.c. and 1,5 kV d.c. - Equipment for testing, measuring or monitoring of protective measures -- Part 6: Residual current devices (RCD) in TT, TN and IT systems (IEC 61557-6:1997, modified)	DIN EN 61557-6 VDE 0413 Teil6 1999-05 Geräte zum Prüfen, Messen oder Überwachen von Schutzmaßnahmen Fehlerstrom-Schutzeinrichtungen (RCD) in TT-, TN- und IT-Netzen (IEC 61557-6:1997, mod.);

Summarized and Simple Description of Individual Products

- **RCD:** general term for residual current device.
- **RCCB:** residual current circuit breaker, without an overcurrent protection built-in, according to the old familiar terminology this is "FI switch".
- **RCBO:** residual current circuit breaker with overcurrent protection built-in; the term "combined protection switch" (KZS) or the abbreviation FI/LS are used, too. In the standard itself the requirements for a circuit breaker (IEC 60898) and RCCB (IEC 61008) are combined. It is a combination of a circuit breaker and residual current switch, hence the "familiar" term "combined protection switch".
- **RCU:** residual current unit. When producing and wiring the distributor, the modular unit is attached, and thereby mechanically and electrically connected with the circuit breaker of the same manufacturer. It is mostly used in Italy.
- **CBR:** circuit breaker with residual device; power circuit breakers according to IEC 60947-2 standard include a built-in residual device.
- **SRCD:** socket residual current device; special socket construction includes a built-in residual device. It is used as additional protection against direct contact with live parts. Its weak point is that this relatively expensive device is only used in that socket, which of course substantially increases the

installation costs. Currently a draft of a standard is being prepared in Germany, in other EU countries this product is unknown. However, electronic versions in English speaking countries outside Europe are known.

- **PRCD:** portable residual current device without built-in overcurrent protection: Its name alone tells us it is not a fixed part of an installation. Several arrangements are possible, and the most frequently used are those in the form of plug or socket.
- **RCM:** residual current monitor: It is used in IT systems, its task is failure reporting, and not disconnecting a faulty part of an installation.
- **IMD:** insulation measuring device, used for checking the installations where residual current devices are built-in.

State of Standardization

In the above summary an overview of standards in the field of residual current devices is shown. The following standards have been described: IEC, EN, SIST and DIN/VDE. It can be noticed that the

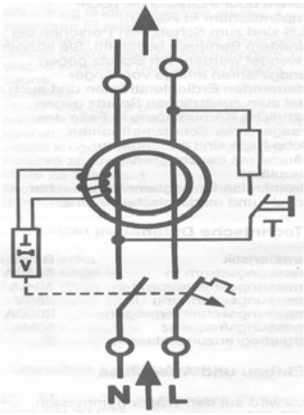


Figure 1: Wiring diagram of RCBO

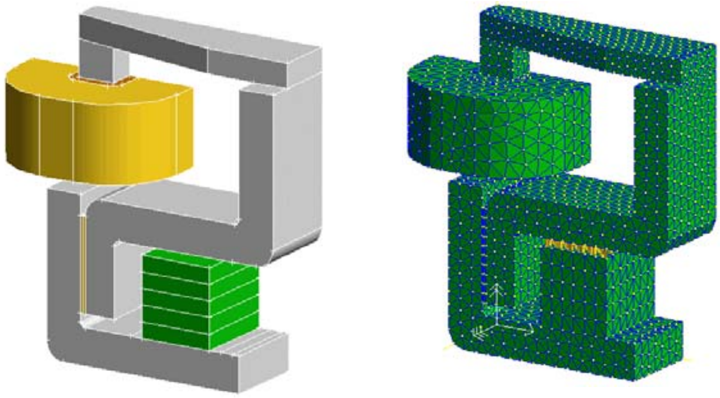


Figure 2: Geometry of magnetic circuit for the calculation of electromagnetic field

state of standardization is the most complete at the IEC level, whereas the state of Slovenian standardization is almost identical to that at the Cenelec level. It is also clear from it that the work in implementing changes was very intense during the last years. Generally, it can be said this is a technological domain quite well covered with standards. On the other hand, new technologies in this field require new changes of the standards.

All the standards (except those for IMD) at the IEC level have been discussed and adopted by the technical subcommittee IEC 23E, at the Cenelec level by CLC/SC 23E, and at the SIST level by SIST EPR committee (electrical instruments). Only the IEC 61557 has been adopted by technical committee IEC 85 or SIST/TC MOV (measuring equipment for basic electrical quantities).

The SIST standards have been derived from the EN standards by the method of promulgation, and at the moment Slovenian translations don't yet exist. Interesting is also the standpoint of the German Electrotechnical Commission DKE that has published an explanation by which the abbreviations mentioned could also be used in connection with full German terms (source (1)).

The intention of this paper is, inter alia, to bring closer, at least partly, the explanation of individual parts of standards to broader circle of technical public.

Classification RCCB and RCBO

These two residual current devices are the most important, and also the most used in contemporary installations, which holds true in the first place for RCCB, but lately also more and more for RCBO. Hereinafter will be exposed only the basic differences arising from individual standards.

Classification with regard to the Principle of Operation

- voltage-independent
- voltage-dependent

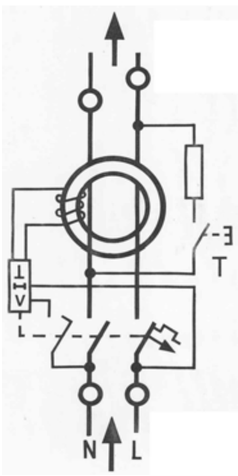
Voltage-independent RCCB, RCBO: A protection switch complying with this classification doesn't need supply voltage for its operation, i.e. for ensuring its protection function. It is a variety with summation transformer made of special magnetic material, in whose secondary circuit there is a polarized tripping relay delaying triggering of the mechanism by means of a permanent built-in magnet. At the moment when residual current arises in the primary winding conductors, a voltage is induced in the secondary winding, and the resulting current generates a magnetic field in the tripping relay, compensating the field of the permanent magnet. As a result the mechanism is triggered and contacts disconnected within 20-40msec. The energy for immediate operation is thus stored in the magnetic field of the tripping relay and maintained with the aid of the permanent magnet. Evidence how important is the manufacturing technology accuracy is provided by the fact that the relay needs for its tripping action very little power, viz. from 80 to 100 μVA.

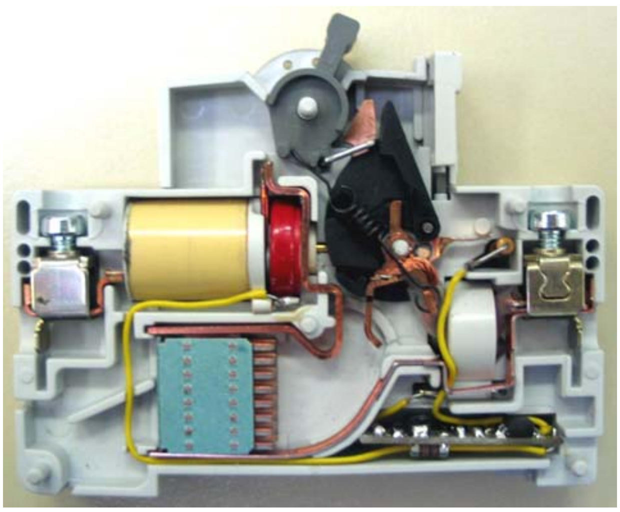
A peculiarity of these RCDs is first of all their operational capability even in failure conditions such as a rupture of neutral conductor, or essentially lowered mains voltage level. On the other hand the required manufacturing technology is quite complex, resulting in related higher costs, i.e. product price.

Voltage-dependent RCCB, RCBO: A protection switch complying with this classification does need supply voltage for its operation. It is a device including active electronic elements. The summation transformer is considerably smaller, and therefore cheaper, and needs less room. In the secondary circuit an electronic amplifier (powered from the mains voltage) is incorporated, ensuring the tripping pulse to be large enough to allow triggering a traditional electromagnetic trigger.

A peculiarity of these RCDs are first of all their small dimensions, reliability of electronic components and their resistance to voltage pulses, as to the state of the art in electronics, is not questionable.

Figure 3: Wiring diagram; voltage-dependent RCBO





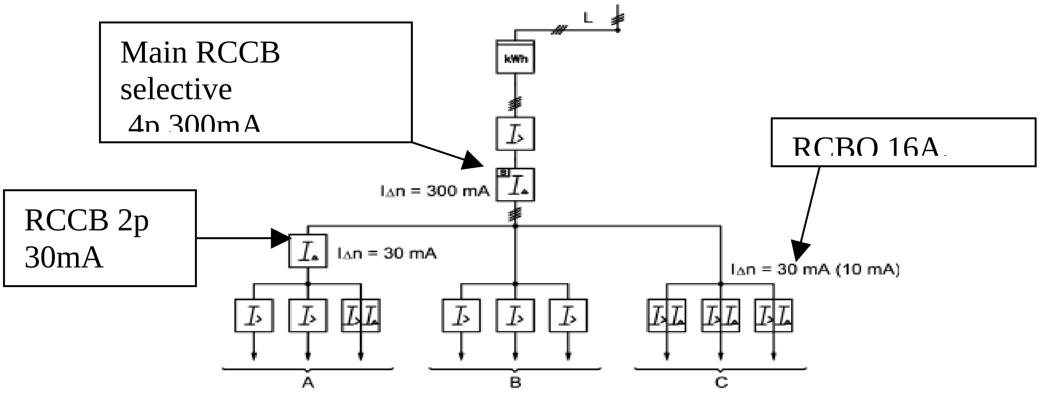


Figure 4: A contemporary installation

state of standardization is the most complete at the IEC level, whereas the state of Slovenian standardization is almost identical to that at the Cenelec level. It is also clear from it that the work in implementing changes was very intense during the last years. Generally, it can be said this is a technological domain quite well covered with standards. On the other hand, new technologies in this field require new changes of the standards.

Classification with regard to the Fault Current

- **AC:** response to sine-wave alternating fault (leakage) current;
- **A:** response to alternating, and pulsing direct-current fault current;
- **B**: response to alternating, pulsing direct-current, and smooth direct-current fault current.

In our country only AC types of protection switches are used. A-type switches are used in some West European countries, first of all in Germany. B-type switches are only used in special installations.

Classification with regard to the Break Time due to Fault Current

- **Undelayed:** Each RCCB without any additional marking corresponds to that criterion, maximum break time is 40msec.
- Selective RCCB has a marking, designating the following break times:
  - at $I_{\Delta n}$ 130 msec < t < 500 msec
  - at 2 $I_{\Delta n}$ 60 msec < t < 200 msec
  - at 5 $I_{\Delta n}$ 50 msec < t < 150 msec
  - at $I_{\Delta n}$ = 500 mA 40 msec < t < 150 msec

There is also a type having designation G, short-time delayed, whose break time lies between both ones mentioned above.

Use of RCDs (RCCBs, RCBOs) in Installations

A traditional installation in dwelling and similar installing conditions usually supposes the use of only one RCCB protection switch, immediately after the main fuses, to be precise. That RCCB ensures the main protection measure. The problem with such an installation is that at a failure condition, i.e. when a fault current arises at one of the installation's branches, this will cause the switching off of the entire installation. And that is from the standpoint of modern living, and of availability requirements for electric power, unacceptable.

Today a modern installation provides for the use of several residual current devices, as shown in Figure 4. The loads within an installation are distributed into several groups.

Group A: the loads (services) requiring a high degree of protection (30 mA): kitchens, living rooms;

Group B: the loads where the possibility of touching live parts is lesser: lighting;
Group C: the loads requiring a high degree of protection and availability of electric power: children's rooms, home workshops. In this case each branch should be provided with additional protection using RCD 30 mA, or even 10 mA.

International Standardization

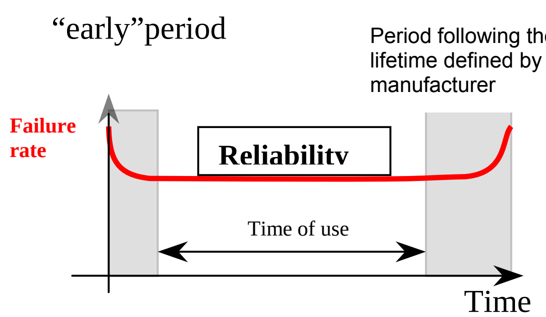
The residual current devices at the level of International Electrotechnical Committee are dealt with by the technical committee IEC TC23 (Electrical accessories), to be precise, the subcommittee SC 23E (Circuit breakers and similar equipment for household use). The preparation of proposals for changes of standards in the field of RCDs is carried out within the working group WG2 (Shock hazard protective devices), consisting of 45 experts from 20 countries, also from Slovenia.
The difference between the work of the SC subcommittee and the working group is that the WG prepares texts of the standards, whereas SC adopts them by voting, each member state having one vote. The WG2 meetings are quite frequent in the last years, at least twice a year, due to the preparation of standards changes in the field of RCDs.

Operational Reliability of Residual Current Devices

When speaking about the reliability in general, we speak about the availability of electric power in an installation, taking into account specific economic conditions. When RCD is used in an installation, we speak about the reliability of protection provided by that product. Since economic conditions are important for the user, the targeted reliability should be defined, taking into account an acceptable failure rate degree under specific conditions. It gives consideration to protection level, environmental conditions, product lifetime, product design and its conformity with standards. It is obvious, however, that the protection reliability doesn't depend only on the RCD itself, but includes the entire installation, including functional test at start-up and during the operation.
In the past there were elaborated in some countries several operational reliability analyses of RCDs and installations where they were built-in. Hereafter we shall give a short summary of the overview, elaborated for the needs of IEC SC23E working documents.

Germany: analysis from 1988 to 1991;
44,000 RCDs, installed from 1955 to 1990, were revised. General result of the failure rate was about 2.4%. By tracing failures in time (FIT), they have recognized that this value had been 300 (on average); the highest was with the RCDs dated from the year 1970 (440), and towards the year 1989 it has lowered to 168.

Italy: analysis from 1990 to 1992;
21,000 RCDs, installed from 1970 to 1991, were analyzed. General percentage of failures was 7.5%. However, 50% of RCDs analyzed have been built-in during the last five years of the study conducted. Failure rate in that part of the analysis was about 3.5%.



Germany: yearly report on RCDs failures;
24,000 RCDs, installed from 1985 to 1998, were revised; in total 310,000. Average failure rate was 4.6%; in the period 1985-1989 – 3.4%; and in the period 1993-1998 – 5.6%.

USA: Nema analysis in 2000;
About 2,700 RCDs, installed from 1974 to 1998, were examined. The analysis concerns two groups of products, 160 pieces that are very similar to those meeting the IEC 61008 and IEC 61009 standards, and 2500 socket-built-in ones (SRCDs). Result: RCDs – 14.4%, SRCDs – 8.3%, in total 8.8%.

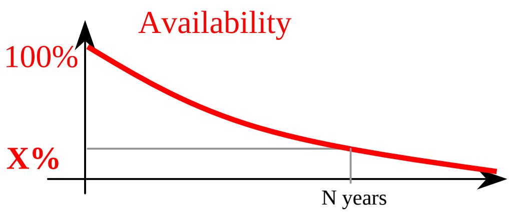
Switzerland: the study on RCDs operation, published in 2002;
The study has dealt with all the failures on installations from the year 1970 on. One of the crucial results was that 1.3% of installations didn't work.

A comment to the above studies:
- The USA products have been produced in compliance with UL 943 standard, whereas the European analysis considered both IEC 61008 and 61009 that were published in 1991.
- Quite a high percentage of RCDs malfunctions have been noticed; however, some later analyses have demonstrated that the actual value of failures was lower, and that the above stated numbers should be halved for correct evaluation.

Environmental influences noticed in the studies mentioned:
- Several studies have mentioned humidity of environment as a factor that significantly exerted influence on faulty operation of RCDs. This was mentioned by both American and German studies.
- Larger number of failures with RCDs of earlier date was attributed to the improved manufacturing technology for buckling mechanisms in modern switches.
- When RCDs were used in agricultural conditions, the degree of failures was increasing; it was also increasing with the age of the apparatus built-in.
- In electronic versions was the failure of electronic components one of the main reasons for the RCDs failure.

Definitions found in IEC working documents:

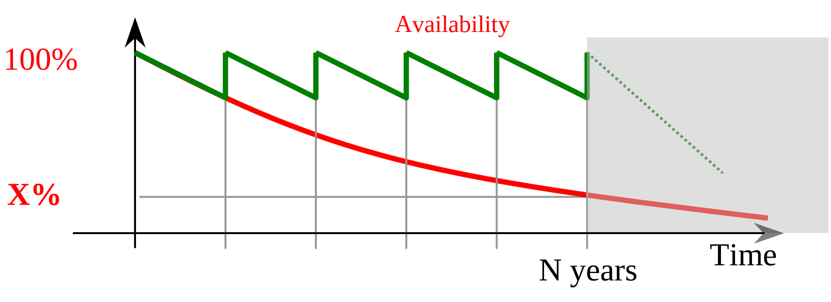
Reliability: Capability of a device to fulfil the required function according to conditions prescribed. And these conditions include the following parameters: required function, environmental conditions, acceptable fault level, and lifetime.



Availability: State of the protection measure that performs a required function at the right moment.

Periodical functional tests

The graph schematically describes how availability of a protection measure can be maintained by means of periodical functional tests of RCDs.



Operation of RCDs at high frequencies

The appearance of high-frequency residual currents increases with increased use of power electronics and frequency converters for motor drives. The working group WG2 has been already engaged in this problem for some time. The experts have found out that the appearance of high-frequency residual currents could cause the so-called "blinding", or undesired triggering. There are rather few information available for this area, therefore the working group has sent out to all national committees an information inquiry.
Figure 4 shows a simple case of two electric circuits. In circuit 1 a load is inserted causing no high-frequency interferences, and in circuit 2 with a motor drive a frequency converter is inserted that causes high-frequency interferences. Due to the capacitance present between loads, cables and PE conductor, high-frequency currents are generated that flow through PE conductor, and are superposed to the supply current. Both circuits are protected with RCD according to IEC 61008 0r 61009, providing protection for 50/60Hz frequencies.

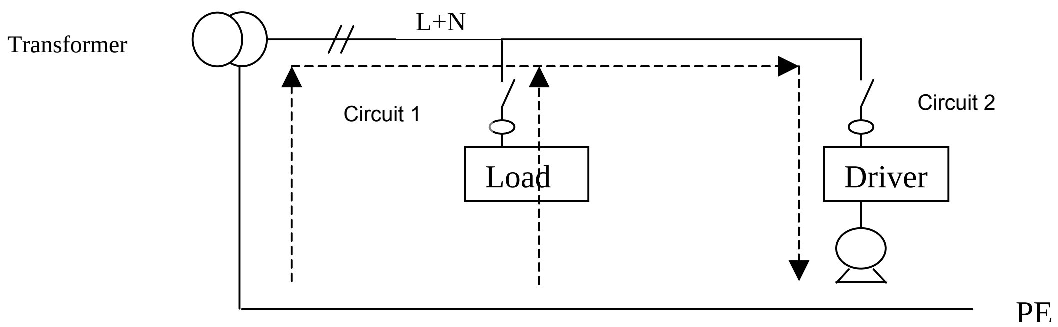


Figure 4: Influence of converter (driver) upon the load

Two problems could appear:

- In circuit 1 can appear a current with superposed components, whose level, form and frequency are not defined. In case of fault such a current could cause so-called RCD 'blinding', or undesired triggering on other side.
- In circuit 2, in normal situation (no fault) a permanent current through PE conductor will appear, whose frequency, form and level are not known or defined. In case of a failure, whether on electric motor, converter, or filter, a fault current will appear, whose frequency could be substantially higher. RCD that is inserted into that circuit must ensure protection even at frequencies, differing from 50/60Hz.

Several measurements have been cited that had been carried out in our area (*source 2).* The measurements were performed on products that are today absolutely in compliance with the existing valid standards IEC, EN and SIST. Type A and AC have been measured, both with a sine signal with frequencies from 50 to 400 Hz.

Type AC, 2p – tripping threshold depending on mains frequency for individual $I_{\Delta n}$.

Type A, 2p – tripping threshold with SIN signal depending on mains frequency for individual $I_{\Delta n}$.
In both cases, and especially in case A, there is quite high dependence of the tripping threshold on the fault current frequency.

Development trend in the field of residual current devices

The working group IEC 23E WG2 is very active, and currently is preparing proposals for documents that will introduce changes in the following areas:
Classification

- As to environmental conditions:
  - Category GU: **General Use:** normal conditions in buildings and normal conditions EMC.
- As to the principle of operation, RCD operates correctly when a fault current appears:

1. RCD operates at the voltage from 0 to 1.1 U_n, regardless of the number of conducting paths, it doesn't switch out when power supply is lost.
2. RCD with only two conducting paths operates within the voltage range between 85 V and 1.1U_n, it doesn't switch out when power supply is lost.
3. RCD with three or four conducting paths operates within the voltage range from 0.7U_n to 1.1U_n, it doesn't switch out when power supply is lost.
4. RCD from point 2 and 3 isn't able to perform its function, even if powered only by one phase; it doesn't switch out when power supply is lost.
5. RCD operates within voltage range from U_x to 1.1U_n, when power supply is lost, it switches out automatically, if the supply voltage falls under U_x.
6. RCD from point 5 that switches out when power supply is lost, but it switches in automatically, when power supply is re-established.

Work of the WG2 in accordance with the requirement definition for individual types of switches, and with the definition of test conditions. In any case, the present classification in voltage-dependent and voltage-independent RCDs will change in the future into a broader range of types.

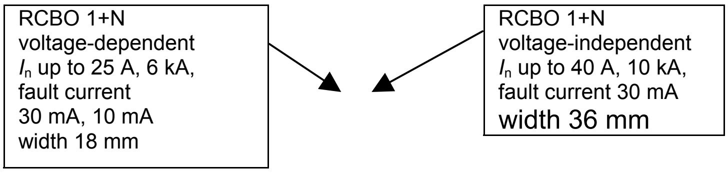
Use of RCDs

In residential and similar installations:

- increased use of selective RCDs, that will ensure the main protection measure;
- increased use of RCBOs, that will ensure with their functions additional protection against contact voltage;
- appearance of new RCBOs that will ensure with their dimensions of 18 mm (module's width) substantially higher protection degree.

Example:

- single-pole MCB, 18 mm in width, ensures the protection against overcurrent (overload, short circuit);
- 18 mm wide RCBO will replace for its dimension MCB, and additionally ensure residual current protection.



However, in the installations that substantially differ from the conditions in residential installations, RCDs will be used, complying with the conditions to be defined within international standardization.

Sources:

1. *Elektrotechnische Zeitschrift ETZ Heft 3-4/2003, page 58*
2. *Delovanje zaščitnih stikal na diferenčni tok pri višjih frekvencah omrežja, Franc Pikl, diplomsko delo, Univerza v Ljubljani, Fakulteta za elektrotehniko (Operation of Residual Current Circuit Breakers at higher Mains Frequencies)*
3. *Working documents IEC 23E*
4. *Technical documentation ETI d.d.*
5. *Standards IEC, CLC, DIN/VDE, SIST*

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