

# Fault Current Monitoring in Electrical Installations

Foundations, Applications and Methods of Measuring Residual Current in AC and DC Systems - With Residual Current Monitors (RCMs) according to IEC 62020 and other International Standards

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## 7 Residual Current Monitors (RCMs)

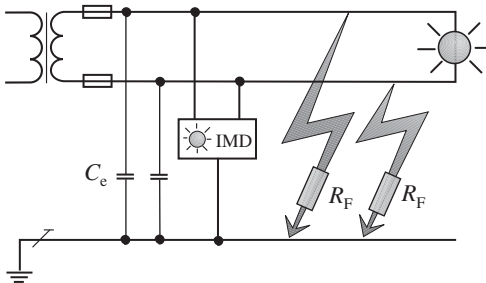
### 7.1 The distinction between residual current monitor (RCM) and insulation monitoring device (IMD)

Residual current monitoring devices (RCMs), for the application in earthed systems and insulation monitoring devices (IMDs) for the application in IT systems, place importance on similar aspects:

- Indication instead of disconnection
- Early warning alarm before disconnection, pre-warning indication
- Trend recognition when insulation levels drop
- High availability of current supply
- Reduced fire level
- Fast fault location
- Recognition of faulty outgoing circuit

A distinction between RCM and IMD is therefore required.

In 1991 the International Electrotechnical Commission (IEC) passed a resolution in Pretoria, to establish a standard for insulation monitoring devices (IMDs). The application was based on a Norwegian document 23E (Norway)<sup>18</sup>. The task was allocated to Working Group 6 of sub-committee IEC SC 23E. Working Group 6 defined, for the first time ever, distinguishing characteristics between active insulation resistance monitoring and passive residual current monitoring. It was decided that IEC SC 23E shall establish a standard for passive monitoring devices, which was



**Figure 7.1** Symmetrical insulation faults

based on the method of measurement for residual current measurement. Their work resulted in the international standard IEC 62020:1998-08, Electrical accessories – Residual current monitors for household and similar uses (RCMs).

Since then passive monitoring devices were referred to as RCMs. The note in the scope of IEC 62020 makes a distinction between RCM and IMD: The RCM is passive in its monitoring function and only responds to an unbalanced fault current in the installation being monitored. The IMD is active in its monitoring and measuring functions – it can measure the balanced and unbalanced insulation resistance or impedance in the installation (see IEC 61557-8) (**Figure 7.1**).

## **7.2 Residual current monitor (RCM) according to IEC 62020:1998-08**

IEC 62020 was published in August 1998, the first amendment to the standard in September 2003. The title of the standard is: Electrical accessories – Residual current monitors for household and similar uses (RCMs). It formed the basis for the European standard DIN EN 62020. The following are extracts of the International Standard. They are referring only to the passages that are relevant for operators or constructors of electrical installations.

The introduction refers to RCM:

*“The purpose of a residual current monitor (hereinafter referred to as RCM) is to monitor an electrical installation or circuit for the presence of an unbalanced earth fault current and to indicate, by means of alarm, the presence of a residual current when it exceeds a predetermined level. An RCM may be used in conjunction with protective devices (see IEC 60364-4).*

*Installation and application rules are given in IEC 60364.”*

### **7.2.1 Scope**

The scope of the standard in the original says:

*“This International Standard applies to residual current monitors having rated voltages not exceeding 440 V a.c. and rated currents not exceeding 125 A for household and similar purposes.*

*These devices are intended to monitor the residual current of the installation and to give a warning if the residual current between a live part and an exposed conductive part or earth exceeds a predetermined level.*

*RCMs detect residual alternating currents and residual pulsating direct currents whether suddenly applied or slowly rising.*

*This standard applies to monitors performing simultaneously the functions of detection of the residual current, of comparison of the value of this current with the re-*

*residual operating current of the device and of providing the prescribed warning signal(s) when the residual current exceeds this value.*

*RCMs having internal batteries are not covered by this standard.*

*The requirements of this standard apply for normal environmental conditions. Additional requirements may be necessary for RCMs used in locations having severe environmental conditions.*

*This standard does not cover Insulation Monitoring Devices (IMDs) which are covered by the scope of IEC 61557-8.”*

## **7.2.2 Definitions (IEC 62020:1998-08)**

For the purpose of the standard the following definitions apply (also see chapter 2.3.1 of this book):

### **7.2.2.1 Pulsating direct current**

current pulsating wave form which assumes, in each period of the rated power frequency, the value 0 or a value not exceeding 0.006 A d.c. during one single interval of time, expressed in angular measure, of at least 150°. [3.1.3]

### **7.2.2.2 Energizing quantity**

electrical excitation quantity which alone, or in combination with other such quantities, shall be applied to an RCM to enable it to accomplish its function under specified conditions. [3.2.1]

### **7.2.2.3 Energizing input-quantity**

energizing quantity by which the RCM is activated when it is applied under specified conditions.

These conditions may involve, for example, the energizing of certain auxiliary elements. [3.2.2]

### **7.2.2.4 Residual operating current**

value of residual current which causes the RCM to operate under specified conditions. [3.2.4]

### **7.2.2.5 Residual non-operating current ( $I_{\Delta no}$ )**

value of residual current at which and below which the RCM does not operate under specified conditions. [3.2.5]

#### **7.2.2.6 RCMs functionally independent of line voltage**

RCMs for which the functions of detection, evaluation and actuation do not depend on the line voltage. [3.3.2]

#### **7.2.2.7 RCMs functionally dependent on line voltage**

RCMs for which the functions of detection, evaluation or actuation depend on the line voltage.

NOTE – It is understood that the line voltage is applied to RCMs for detection, evaluation or actuation. [3.3.3]

#### **7.2.2.8 RCM type A**

RCM for which actuation is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising. [3.3.8]

#### **7.2.2.9 Operation**

alteration of the state of the RCM from the non-alarm state to the alarm state or vice versa. [3.7.1]

#### **7.2.3 Classification**

RCMs are classified according to:

- Method of operation
- Type of installation
- Number of current paths
- Possibility of adjusting the residual current
- Possibility of adjusting the time-delay
- Protection against external influences
- Method of mounting
- Method of connection
- Type of fault indication
- Ability to directionally discriminate between residual currents on supply side and load side

#### **7.2.4 Characteristics of RCM**

This chapter of the standard is rather extensive. For the purpose of this book, only the most important characteristics for the user are listed:

- Preferred value of rated voltage  $U_n$  are 230 V and 400 V.
- Preferred value of rated current  $I_n$  are 10 – 13 – 16 – 20 – 25 – 32 – 40 – 63 – 80 – 100 – 125 A.

- Preferred value of rated residual current  $I_{\Delta n}$  are 0.006 – 0.01 – 0.03 – 0.1 – 0.3 – 0.5 A.
- Standard value of residual non-operating current is  $0.5 I_{\Delta n}$ .
- Preferred value of rated frequency is 50 Hz and/or 60 Hz.
- Maximum actuating time equal to or greater than  $I_{\Delta n}$  shall not exceed 10 s.
- RCM shall be protected against short-circuits by means of circuit-breakers or fuses complying with their relevant standards according to the installation rules of IEC 60364.

### **7.2.5 Marking and other product information**

The standard states that each RCM shall be marked in a durable manner with all or, for small apparatus, part of the following data:

- Manufacturer's name or trade mark
- Type designation, catalogue number or serial number
- Rated voltage(s)
- Rated frequency, if the RCM is designed for frequencies other than 50 Hz and/or 60 Hz
- Rated current
- Rated residual operating current
- Settings of residual operating current in case of RCMs with multiple residual operating current settings
- Installation instructions, including identification of CT which may be used with the RCM

Listed here are only the most important markings for the user. The standard itself has to be referenced for more detailed information.

### **7.2.6 Requirements for construction and operation**

In general it should not be possible to alter the operating characteristics of the RCM by means of external intervention.

The RCM shall have the following features:

- The RCM shall be provided with a visual "Power On" indicator which shall be green.
- The RCM shall be provided with means for indicating a fault condition when the residual current exceeds the preset operating value, the primary indicating means being visual.
- RCMs shall be provided with a test device in order to allow a periodic testing of the ability of the RCM to operate. The test circuit shall be designed for continuous operation at 1.1 times the rated voltage.

For in-depth requirements on construction and operation the standard should be referenced.

### **7.2.7 Tests**

The clause on tests is the most extensive part of the standard, with very detailed requirements for type- and routine tests.

The requirements won't be commented on at this point, as it can be assumed that an RCM in accordance with IEC 62020:1998 has successfully passed all tests described in the standard.

### **7.2.8 Conclusion**

IEC 62020 surely has contributed to making RCMs widely known. The standard itself is being incorporated in other standards dealing with installations. International revision of the standard is currently on the way.

## **7.3 Principles**

Residual current protective devices (RCDs) and residual current monitors (RCMs) are devices, based on residual currents ( $I_{\Delta}$ ) measurement system. The fundamental principle demands that all conductors of power supply and distribution systems to be protected, are led through a current transformer (CT), with the exception of protective conductors. The vectorial sum of all currents in a fault-free system therefore equals zero, so that no voltage is induced in the CT. However if a fault current yields via earth, a current originating in the secondary winding of a CT will initiate electro-mechanical tripping or rather disconnection of the respective part of the installation.

Electro-mechanical residual current circuit-breakers (RCCB) function with a closed-circuit current relay, which is anchored with very low power on a magnet. If the relay coil is energized by the fault current, the anchor drops. Because the RCD doesn't require auxiliary power, in the fault scenario they have to off-set relatively strong contact forces with low energy. Residual-current release (DI) on the contrary are RCCBs functionally dependant on line voltage. The residual current detected by the CT is evaluated electronically. The electronics are also controlling a circuit element, for example a contactor or a circuit-breaker [7.1].

## **7.4 New definitions**

In the course of a harmonization process the International Electrotechnical Commission, the IEC, established new definitions for residual current protective devices

(RCDs). Since 2001 the definition „Residual Current Protective Device” (RCD) has been incorporated in all new respective standards.

The following are defining variations on the devices:

**Residual current protective device (RCD)**

An RCD is a mechanical switching device or an interconnection of devices, which task it is, to trigger the opening of contacts, when the residual current reaches a pre-determined value under specified conditions (IEC 60755:1983-05, General requirements for residual current operated protective devices).

NOTE – Installations according to this International recommendation can be operated with or without auxiliary supply.

**Residual current circuit-breaker (RCCB)**

A mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions (IEC 61008:1996, Title see below).

**Table 7.1** lists the new definitions in accordance with their respective international standards.

Abbreviation	New definition	Standard
RCD	Residual current protective device	IEC 60755
PRCD	Portable residual current protective device	IEC 61540
SRCD	Fixed socket-outlets residual current protective device	IEC 61541
RCCB	Residual current operated circuit breakers without integral over-current	IEC 61008
RCBO	Residual current operated circuit breakers with integral over-current	IEC 61008
RCM	Residual current monitors for household and similar uses	IEC 62020

**Table 7.1** Survey of new IEC definitions on residual current devices

**Residual current operated circuit breakers without integral overcurrent (RCCB)**

- IEC 61008-1:2002-10, Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules
- IEC 61008-2-1:1990-12, Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs); Part 2-1:



Applicability of the general rules to RCCBs functionally independent of line voltage

### **Residual current operated circuit breakers with integral overcurrent (RCBO)**

- IEC 61009-1:2003-02, 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 (RCBOs) – Part 2-1: Applicability of the general rules to RCBOs functionally independent of line voltage

### **Portable residual current protective device (PRCD)**

- IEC 61540:1999-03, Electrical accessories – Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs)

## **Reference**

- [7.1] Hofheinz, W.; Sellner, H.: Schützen ohne Überreaktion. Elektrische Energietechnik (1995) H. 2