xEffect
RCDs for machines and equipment with electrical drives
Enhanced reliability in drive applications

Challenges for machine builders

The use of an RCD is an effective instrument for protection against electrical shock and fire prevention. Innovative electrical drive systems offer specific application solutions and improve the energy efficiency. In modern electrical equipments and machineries both components are used together in more and more cases.

Thereby it is mandatory to consider the compliance with all standards and regulations. Special attention must be paid here on the usual technical compatibility problems between RCDs and electrical drive systems. Unwanted trips of the RCDs can happen during the normal operation because of high system cause earth leakage currents which are generated in applications with frequency controlled drives. Increasing the level of the personal and equipment protection means very often a reduced system uptime.

Optimized interaction of Eaton drives and RCDs

Eaton takes up this problem and offers a complete solution from one hand. The interaction between Eaton drives and RCDs is harmonized. Unwanted trips because of system caused earth leakage currents will be avoided and a safe power disconnection in case of dangerous fault currents is guaranteed.

It is clearly recommended and in many cases already mandatory to use RCDs type F and Bfq for such applications. They give the possibility to offer a safe and reliable operation of the machine with a high system uptime.

To learn how harmonized RCDs and Eaton drive solutions can provide increased energy efficiency with maximum productivity and machine uptime, download the Whitepaper here www.eaton.eu/en/cp/rcd
Residual Current Devices Type F

Definition

The type F RCD is defined according to IEC/EN 62423. It provides safe and reliable protection against sinusoidal residual currents and pulsating DC fault currents (like type A devices). It is also capable of handling residual currents with mixed frequencies of up to 1 kHz (10, 50, 1000 Hz) in accordance with the IEC 62423 standard.

Type F RCDs can accept smooth DC residual currents of up to 10 mA without affecting their standard functionality, have a time delayed tripping and distinguish themselves from other devices thanks to their high resistance to power surges: this ensures minimal false tripping and a high degree of safety.

They are available as RCCBs (2-pole or 4-pole up to 100 A) as well as RCBOs (1N up to 40 A). With three versions for different protection levels (30 mA, 100 mA and 300 mA), the type F functionality is voltage independent and can be used for fault and additional protection. As a result, the recommendations for installations including variable frequency drives have been modified.

Eaton also offers a digital version of the type F RCBO, which displays fault currents at the device in real time.

Field of Application

Type F residual current devices are designed specifically for use in applications with single phase frequency converters such as pumps, welding units, vibrators or hammer drills. In this type of application, residual currents with mixed frequencies can arise which residual current devices type AC and A are unable to cope with.

The detection of mixed frequencies and the higher load rating with DC residual currents up to 10 mA enables the RCD type F to provide excellent protection for humans and the system in all applications which contain appliances and motors with single phase frequency converters.

The time delayed tripping and the high current withstands capability support in addition avoiding nuisance tripping. Overall, the RCD type F enables machine builders and plant manufacturers to develop equipment that is extremely reliable while ensuring high safety levels for the operator and maintenance staff.

Benefits:

- Reliable protection for machines with 1 phase frequency converters
- Increased protection due to
  - detection of mixed frequencies
  - higher load rating with DC residual currents up to 10 mA
- Reduction of nuisance tripping thanks to
  - time delayed tripping
  - high current withstand capability
Residual Current Devices Type B, Bfq and B+

Definition

The RCCB type B detects (acc. to IEC 62423) beside AC and pulsating DC residual currents also smooth DC residual currents. With the extended sensitivity of the RCCB type B, electrical installers and machinery builders can increase the safety considerably in power distribution and machineries.

The special adapted tripping curve (non-sensitive against system caused earth leakage currents at high frequencies) of the RCCB type Bfq complies to the specifications of the RCCB type B and avoid in addition unwanted tripping in industrial applications which contain frequency converter controls.

The RCCB type B+ is sensitive to all residual currents and is additionally equipped with a tripping curve that limits the tripping current to max. 420 mA for frequencies up to 20 kHz. This complies additionally to the specifications for superior fire protection according to the German standard VDE 066-440 (formerly VVDEV 0664-110).

Field of Application

Smooth DC residual currents can occur in industrial, commercial and residential applications which contain photovoltaic systems, frequency converters or electronic consumers. In this kind of applications only RCCBs type B, Bfq or B+ can guarantee a safe protection for persons and equipment.

They are also equipped with a time delayed tripping and a high current withstand capability to offer high reliability for the system.

RCCBs type Bfq with their special adapted tripping curve are the perfect choice for industrial applications with 3 phase frequency converters.

RCCBs type B+ are perfectly suitable for installers and machinery builders to increase safety in fire risk applications such as petrol stations, agriculture, paint shops, depots, warehouses and many more.

Benefits:

- Reliable protection for machines with 3 phase frequency converters
- Safe power disconnection at smooth DC and AC residual currents
- Detection of high frequency residual currents
- Highest system availability by digital technology and pre-warnings
Selection help RCDs Type F / Type B

Applications with:
- Appliances and motors with 1 phase frequency converters (supply: phase/neutral)
- Washing machines, dishwashers
- Heat pumps
- Motor applications
- Ventilation, cooling and air conditioning systems
- Welding equipment
- etc.

Applications with:
- Appliances and motors with 1 phase frequency converters with PFC (Power Factor Compensation) or
- 1 phase frequency converters supplied between phase/phase or
- 3 phase frequency converters
- DC systems (photovoltaic systems, UPS units...)
- PV systems
- Battery banks
- UPS units
- EV charging
- Medical devices
- etc.

Industrial applications which contain high-power frequency converter controls such as:
- 3 phase motor applications
- Speed regulated machine tools
- Fire risk applications such as:
  - Petrol stations
  - Agriculture
  - Paint shops
  - Warehouses
  - Biogas plants, etc.
  - VDE 0664-400

RCD **Type F**
(acc. to IEC 62423)
Standard type, multi-frequency residual currents up to 1 kHz

RCD **Type B**
(acc. to IEC 62423)
Standard type, sensitive to all residual currents up to 1 kHz

RCD **Type Bfq**
(acc. to IEC 62423)
Non-sensitive against system caused earth leakage currents at high frequencies up to 50 kHz

RCD **Type B+**
(acc. to VDE 0664-400)
For superior fire protection (max. tripping current of 420 mA for frequencies up to 20 kHz)

Applications with:
- Appliances and motors with 1 phase frequency converters with PFC (Power Factor Compensation)
- 1 phase frequency converters supplied between phase/phase or
- 3 phase frequency converters
- DC systems (photovoltaic systems, UPS units...)
- Washing machines, dishwashers
- Heat pumps
- Motor applications
- Ventilation, cooling and air conditioning systems
- Welding equipment
- etc.

Applications with:
- Appliances and motors with 1 phase frequency converters with PFC (Power Factor Compensation) or
- 1 phase frequency converters supplied between phase/phase or
- 3 phase frequency converters
- DC systems (photovoltaic systems, UPS units...)
- PV systems
- Battery banks
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- EV charging
- Medical devices
- etc.

Industrial applications which contain high-power frequency converter controls such as:
- 3 phase motor applications
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Standard type, multi-frequency residual currents up to 1 kHz

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Non-sensitive against system caused earth leakage currents at high frequencies up to 50 kHz

RCD **Type B+**
(acc. to VDE 0664-400)
For superior fire protection (max. tripping current of 420 mA for frequencies up to 20 kHz)
In general, RCDs type F are designed for applications with 1 phase frequency converters. But there are also 1 phase FC designs which require RCD type B protection.

RCDs type F are not suitable for appliances that can generate smooth DC residual currents, e.g. 1 phase FC with PFC or 1 phase FC supplied between phase/phase.

They are not suitable for installations in networks with frequencies that deviate from the rated frequency 50/60 Hz (not at the outgoing terminal of a frequency converter).

Electrical loads that can generate smooth DC residual currents in the event of a fault must be assigned to their own circuit with a universal current-sensitive residual current protective device (type B, type Bfq or type B+).
### Possible residual current waveforms and suitable RCDs

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Load Current</th>
<th>Residual Current</th>
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<tbody>
<tr>
<td>1</td>
<td><img src="image1" alt="Waveform 1" /></td>
<td><img src="image2" alt="Waveform 2" /></td>
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<tr>
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<td><img src="image3" alt="Waveform 3" /></td>
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<td>14</td>
<td><img src="image27" alt="Waveform 27" /></td>
<td><img src="image28" alt="Waveform 28" /></td>
</tr>
</tbody>
</table>

The table shows the possible residual current waveforms and the suitable RCDs. In general, RCDs type F are designed for applications with 1 phase frequency converters. But there are also 1 phase FC (frequency converters) designs which require RCD type B protection.

RCDs type F are not suitable for applications that can generate smooth DC residual currents, e.g. 1 phase FC with PFC or 1 phase FC supplied between phase/phase (see Table, Possible residual current waveforms and suitable RCDs, circuits 8 to 13).

The table shows the possible residual current waveforms in the event of a fault and the suitable RCDs.

Electrical loads that can generate smooth DC residual currents in the event of a fault must be assigned to their own circuit with a universal current-sensitive residual current protective device (type B, type Bfq or type B+).

For more details see Eaton Whitepaper „RCDs&Drives“.
Eaton's mission is to improve the quality of life and the environment through the use of power management technologies and services. We provide sustainable solutions that help our customers effectively manage electrical, hydraulic, and mechanical power – more safely, more efficiently, and more reliably. Eaton's 2019 revenues were $21.4 billion, and we sell products to customers in more than 175 countries. We have approximately 97,000 employees.

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