# Generalities and Discrimination Between RCDs

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Generalities and Discrimination Between Residual Current Devices (RCDs)

## Generalities on Residual Current Circuit-Breakers

The operating principle of the residual current release is basically the ***detection of an earth fault current***, by means of a toroid transformer which embraces all the live conductors, included the neutral if distributed.

In absence of an earth fault, the vectorial sum of the currents $\mathbf{I_{\Delta}}$ is equal to zero.

In case of an earth fault, if the $\mathbf{I_{\Delta}}$ value exceeds the rated residual operating current $\mathbf{I_{\Delta n}}$, the circuit at the secondary side of the toroid sends a command signal to a dedicated opening coil ***causing the tripping of the circuit-breaker***.

### Classifications of RCDs

***A first classification of RCDs can be made according to the type of the fault current they can detect:***

1. ***AC type:*** the tripping is ensured for residual sinusoidal alternating currents, whether suddenly applied or slowly rising;
2. ***A type:*** tripping is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising;

3. ***B type:*** tripping is ensured for residual direct currents, for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising.

***Another classification referred to the operating time delay is:***

1. Undelayed type;
2. Time delayed S-type.

***RCDs can be coupled, or not, with other devices; it is possible to distinguish among:***

1. ***Pure residual current circuit-breakers (RCCBs)***
   They have only the residual current release and can protect only against earth fault. They must be coupled with thermomagnetic circuit-breakers or fuses, for the protection against thermal and dynamical stresses;
2. ***Residual current circuit-breakers with overcurrent protection (RCBOs)***
   They are the combination of a thermomagnetic circuit-breaker and a RCD; for this reason, they provide the protection against both overcurrents as well as earth fault current;
3. ***Residual current circuit-breakers with external toroid***
   They are used in industrial plants with high currents.

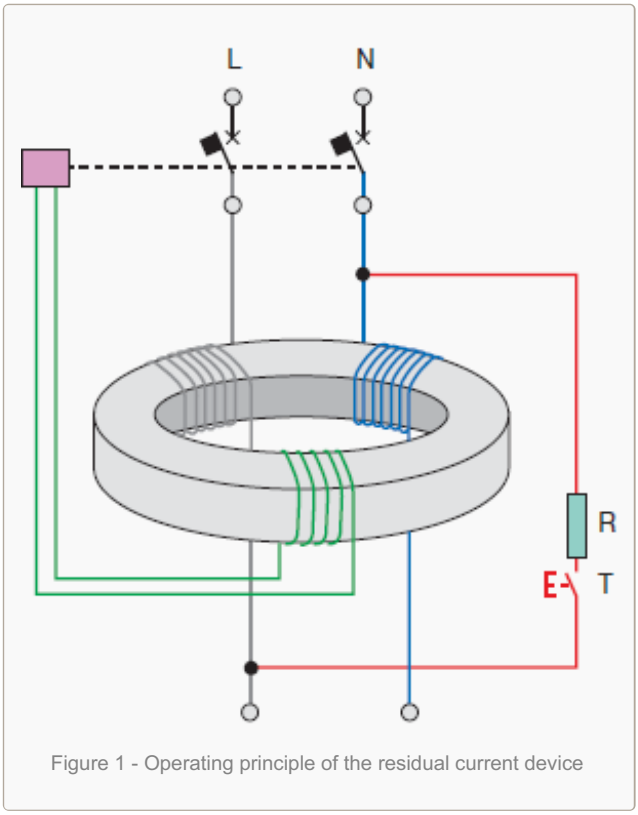

Figure 1 - Operating principle of the residual current device

They are composed by a release connected to an external toroid with a winding for the detection of the residual current; in case of earth fault, a signal commands the opening mechanism of a circuit-breaker or a line contactor.

### RCD Operation

Given $\mathbf{I_{\Delta n}}$ the operating residual current, a very important parameter for residual current devices is the ***residual non-operating current***, which represents the maximum value of the residual current which does not cause the circuit-breaker trip; it is equal to 0.5 IΔn.

***Therefore, it is possible to conclude that:***

- for $\mathbf{I_{\Delta} < 0.5 \cdot I_{\Delta n}}$ the RCD shall not operate;
- for $\mathbf{0.5 \cdot I_{\Delta n} < I_{\Delta} < I_{\Delta n}}$ the RCD could operate;
- for $\mathbf{I_{\Delta} > I_{\Delta n}}$ the RCD shall operate.

For the choice of the rated operating residual current, it is necessary to consider, in addition to the coordination with the earthing system, also the whole of the leakage currents in the plant.

Their vectorial sums on each phase shall not be greater than $\mathbf{0.5 \cdot I_{\Delta n}}$. in order to avoid unwanted tripping.

## Discrimination between RCDs

The Standard ***IEC 60364-5-53*** states that discrimination between residual current protective devices installed in series may be required for service reasons, particularly ***when safety is involved***, to provide ***continuity of supply*** to the parts of the installation not involved by the fault, if any.

This discrimination can be achieved by selecting and installing RCDs in order to provide the disconnection from the supply by the RCD ***closest to the fault***.

***There are two types of discrimination between RCDs:***

## Horizontal discrimination

It provides the protection of each line by using a dedicated residual current circuit-breaker; in this way, in case of earth fault, only the faulted line is disconnected, since the other RCDs do not detect any fault current.

However, it is necessary to provide ***protective measures against indirect contacts*** in the part of the switchboard and of the plant upstream the RCD;

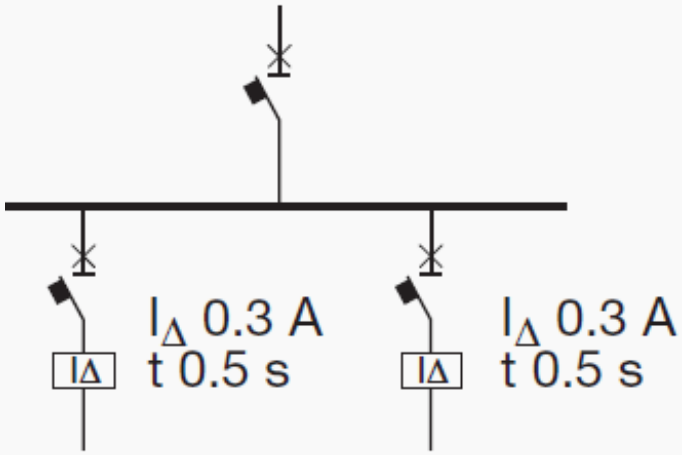


Figure 2 - Horizontal discrimination between RCDs

## Vertical discrimination

It is realized by using RCDs connected in series.

## Conditions

According to ***IEC 60364-5-53***, to ensure discrimination between two residual current protective devices in series, these devices shall satisfy both the following conditions:

1. The ***non-actuating time-current*** characteristic of the residual current protective device located on the supply side (upstream) shall lie above the total operating time-current characteristic of the residual current protective device located on the load side (downstream);
2. The ***rated residual operating current*** on the device located on the supply side shall be higher than that of the residual current protective device located on the load side.

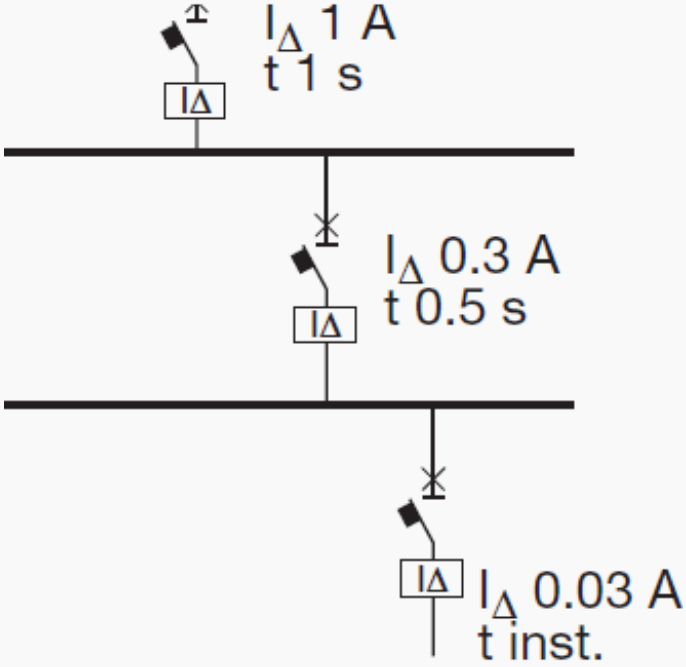


Figure 3 - Vertical discrimination between RCDs

## The Non-Actuating Time-Current Characteristic

The non-actuating time-current characteristic is the curve reporting the maximum time value during which a residual current greater than the residual non-operating current (**equal to 0.5.$I_{\Delta n}$**) involves the residual current circuit breaker ***without causing the tripping***.

***As a conclusion, discrimination between two RCDs connected in series can be achieved:***

1. ***For S type residual current circuit-breakers***, located on the supply side, (*complying with* ***IEC 61008-1*** *and* ***IEC 61009***), time-delayed type, by choosing general type circuit-breakers located downstream with **$I_{\Delta n}$** equal to one third of **$I_{\Delta n}$** of the upstream ones;

2. ***For electronic residual current releases*** by choosing the upstream device with time and current thresholds directly greater than the downstream device, keeping carefully into consideration the tolerances.

For the protection against indirect contacts in distribution circuits in TT system, the maximum disconnecting time at $\mathbf{I_{\Delta n}}$ shall not exceed **1 s** (*IEC 60364-4-41, §413.1*)

***Resource:*** *Electrical Installation Handbook (part II) – ABB*

Source: http://electrical-engineering-portal.com/generalities-and-discrimination-between-rcds