TECHNICAL NOTE

How to choose your residual current monitor (RCM)

When **energy** matters

socomec
Innovative Power Solutions

Contents

Glossary

I_{Δ} = Residual current, also called residual differential current, differential current or leakage current

$I_{\Delta n}$ = Operating residual current of the RCD (maximum value at which it must trip)

I_{PE} = Current flowing in the PE (Protective Earth) conductor

RCD = Residual Current Device

RCCB = Residual Current Circuit Breaker

RCBO = Residual Current Breaker with Overcurrent protection

RCM = Residual Current Monitor

Introduction

Many critical applications must ensure continuity of service, such as an industrial production line where the process must not be interrupted or a data centre where data must not be lost or corrupted. The consequences of losing continuity of service can be disastrous, with significant capital costs, high recovery costs, and quality problems.

The choice of earthing system will strongly guide the continuity of service strategy, in particular to guard against the risks of triggering protective devices. Especially in the case of a TN-S or TT system, it is important to anticipate the risks of tripping differential protections by constantly monitoring the leakage currents to earth. This monitoring is carried out using devices called residual current monitors (RCMs).

After a brief recap of earthing systems, this technical note describes the source of earth leakage currents, also known as residual currents, and details how RCMs work, how they are installed in the electrical distribution and their benefits. The final section is dedicated to the RCM solutions offered by Socomec.

Insulation monitoring

There is a simple way to remember the meaning of the two letters of the different systems: the first letter refers to the position of the neutral on the supply transformer in relation to Earth and the second letter refers to the connection of equipment's exposed conductive parts.

Reminder of earthing systems and related applications

The IEC 60364 international installation standard allows three 'earthing systems' for electrical installations TT, TN and IT systems.

TT earthing system

In the TT earthing system, the transformer's neutral is connected directly to earth. The exposed-conductive-parts of the electrical installation are connected to earth electrodes which are electrically independent of that of the transformer.
In the event of an insulation fault, there is an automatic shutdown of all or part of the supply of all loads.

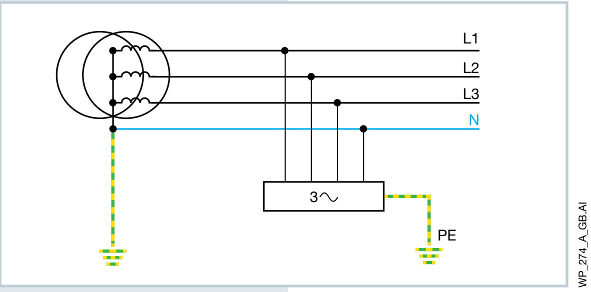


Fig. 1 – TT system

In the TT system, personal safety is ensured by avoiding indirect contact with the use of residual current devices (RCDs). The shutdown is mandatory from the first fault. An RCD must be positioned at least at the origin of the installation.

- Transformer's neutral connected to earth (T).
- Equipment's exposed-conductive-parts to earth (T).

Protection: Residual current device (RCD).

The TT system is mainly found in the residential and small business sector.

TN earthing system

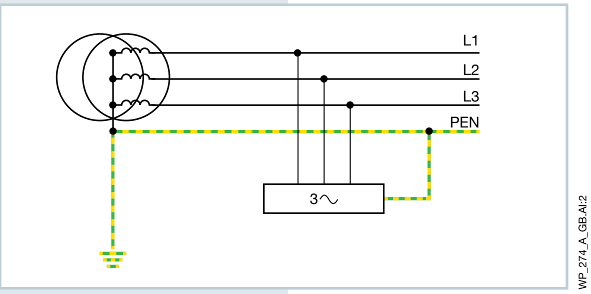


Fig.2 – TN-C system

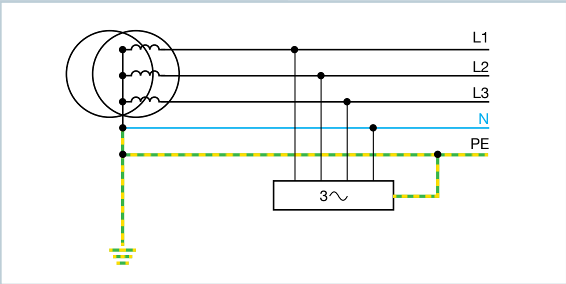
In the TN system, the transformer's neutral is connected directly to earth. The exposed-conductive-parts of the electrical installation are connected to the protective conductor distributed throughout the installation.

The neutral conductor (N) and protective conductor (PE) can be combined (TN-C) or separated (TN-S). A clean insulation fault leads to a short-circuit: the overcurrent protective devices protect the installation.

Residual current devices (RCDs) are also used in the TN-S system.

- Transformer's neutral connected directly to earth (T).
- Equipment's exposed-conductive-parts connected to the protective conductor.
- Neutral (N) and protective (PE) conductors are combined (C). The resulting PEN conductor (Protective and Neutral) must never be disconnected.

Protection: protective device against short-circuits.



WP_274_A_GB.AI:3

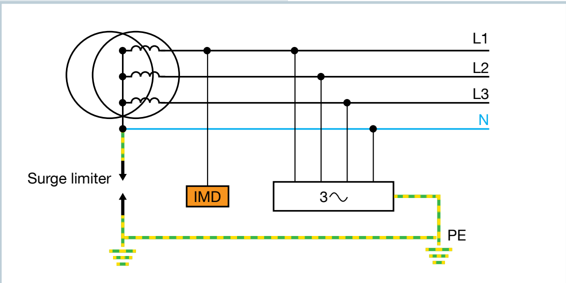
Fig.3 – TN-S system

- Transformer's neutral connected directly to earth (T).
- Equipment's exposed-conductive-parts connected to the protective conductor.
- Neutral (N) and protective (PE) separate (S).

Protection: short-circuit protective devices and residual current devices (RCD).

TN networks are typically found in industry, infrastructure, service and data centres. More cost-effective to implement than the TN-S system, the TN-C system is rolled out at large industrial sites.

IT earthing system



WP_274_A_GB.AI:4

Fig.4 – IT system

In the IT system, unlike other systems, the transformer's neutral is not connected to the earth. The exposed-conductive-parts of the electrical installation are connected to earth sockets. Compared to other systems, the advantage of the IT system is that an insulation fault will not lead to a supply interruption.

- Transformer's neutral not connected to earth or voluntarily connected via a high-value impedance (usually 1500 Ω).
- Equipment's exposed-conductive-parts connected to the protective conductor (T).
- Neutral (N) and protective (PE) conductors are separate.

First fault: Insulation Monitoring Device (IMD).
Protection: if there is a second fault short-circuit protective devices and residual current devices (RCD).

The IT system is used in highly critical installations such as hospital operating rooms, public reception facilities, cooling plants, power plants and photovoltaic fields.

This technical note focuses on RCM devices encountered in the TT and TN-S earthing systems directly impacted by residual currents. In particular, the suggested examples are based on TN-S systems commonly found in non-residential facilities.

What is a residual current?

The residual current I_Δ is commonly referred to as the earth leakage current.

Residual current

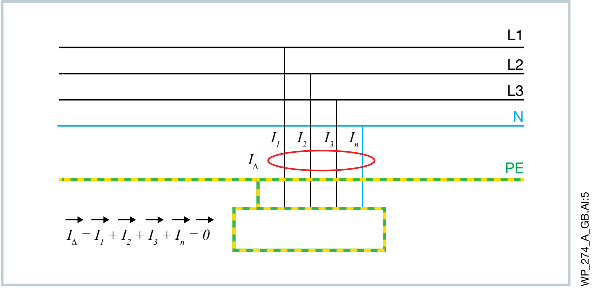


Fig.5 – TN-S system without residual current

In a fault-free system, the vector sum of all phase and neutral currents is zero.

Earth leakage current: current flowing from the live parts of the installation to earth, in the absence of an insulation fault [IEC 60050-442, 442-01-24]

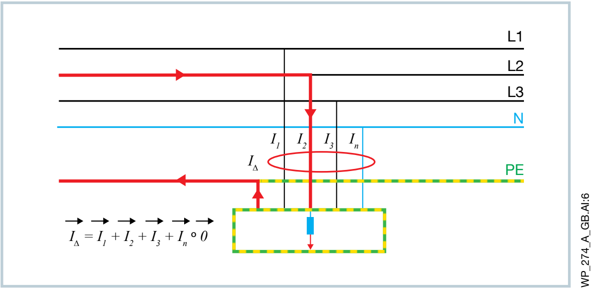


Fig.6 – TN-S system with residual current circulating through the PE

If a current I_Δ is flowing through the PE conductor or another route, the vector sum of all phase and neutral currents is no longer zero. The resulting current I_Δ is called a leakage current or residual current. A residual current transformer enclosing all live and neutral conductors can measure the value of this residual current.

Earth fault current: current flowing to earth due to an insulation fault [IEC 60050-442, 442-01-23]

Source of residual currents

Residual currents are naturally present in electrical installations. Each load generates on average a residual current of a few mA.
The residual currents are composed of a capacitive part and a resistive part.

- The capacitive currents, present in normal operating conditions, flow to the earth through the capacitors of the machine's EMC filters, for example. These filters are intended to limit electromagnetic interference.
- Resistive currents are created by insulation faults between phase voltages and earth.

The risk for the installation comes mainly from the increase in residual resistive currents generated by:

- insufficient insulation due to mechanical damage of cables connected to the equipment,
- insulation resistance that is too low due to moisture or dust,
- a deterioration in the insulation of electrical cables due to heating.

Any change in the insulation lowers the electrical resistance of the insulating materials and leads to an increase in residual currents. If they become too high, these residual currents can lead to disturbances in the electrical system, in which case we refer to earth fault currents.

Consequences of fault currents

Fault currents lead to incidents that can affect both industrial equipment in manufacturing units with potential fire risks, and the safety of those working there with the risk of electric shock.

Relevant standards

The international installation standard for low voltage installations is the IEC 60364 series. It comprises several sections that each describe a specific part of the electrical installation and in particular the rules to implement to protect against fault currents.

National transpositions exist in many countries. They adopt the requirements of IEC 60364 in addition to the country-specific requirements.

Low voltage installation standards	
Low voltage electrical installations	IEC 60364 series
Low voltage electrical installations – Part 4-41: Protection against electric shock	IEC 60364-4-41
Low voltage electrical installations – Part 4-42: Protection against thermal effects	IEC 60364-4-42
IEC 60364-6 Low voltage electrical installations – Part 6: Verification	IEC 60364-6
Transposition of IEC 60364 in France	NF C 15-100
Transposition of IEC 60364 in Germany	DIN VDE 0100-100
Transposition of IEC 60364 in UK	BS7671

Table 1 – Standard list of low voltage electrical installations linked to fault current

Fault protection (protection against indirect contact)

The standard for electric shock protection is the IEC 60364-4-41.
The following table summarises the protective devices to be used according to the earthing system, to prevent faults related to indirect contacts.

Earthing systems	TT	TN-S	TN-C
Overcurrent protective device		X	X
Residual current protective device (RCD)	X	X	

Table 2 – Earthing systems and indirect contact protective devices
Source IEC 60364-4-41

Residual current protective device (RCD)

The residual current device (RCD) is a mechanical protective device whose function is to break currents by opening contacts when the residual current reaches a set value.

Product standards describe the requirements for devices that protect and monitor residual currents.

Product standards	
General safety requirements for residual current operated protective devices (RCD)	IEC 60755
Residual current monitors (RCM)	IEC 62020-1
Modular residual current devices (MRCD)	IEC 60947-2 Appendix M

Table 3 – Product standards related to residual current

Selecting an RCD based on risk

Fire-risk premises

- RCDs with a sensitivity of < 300 mA must be used, in accordance with IEC 60364-4-42 § 422.3.9.

Protecting people

- RCDs with a sensitivity of < 30 mA are recognised as additional protection in the event of failure of the provision for basic protection and/or the provision for fault protection or carelessness by users (IEC 60364-4-41 § 415.1.1).
- The IEC 60364-4-41 § 411.3.3 standard imposes this additional protection (regardless of the earthing system) for:
    - socket-outlets with a rated current ≤ 20 A (32 A for some countries, including France, Spain or Ireland),
    - mobile equipment with a rated current ≤ 32 A for outdoor use.

However, an exemption for the use of RCDs can be made in the following situations, often encountered in commercial/industrial or data centres:

- socket-outlets for use under the supervision of skilled or instructed persons, e.g., in some commercial or industrial locations
- specific socket-outlet provided for connection of a particular item of equipment

In these situations, an RCM solution will guarantee the continuity of operation by constantly monitoring the residual current. The next section describes the RCM solution in detail.

Good practice in choosing an RCM solution

RCD: Residual current protective device → Trip if residual current is too high

RCM: residual current monitor → Alarm without tripping if residual current rises

An RCM monitors the residual current and activates an alarm when the residual current reaches a preset value.

Anticipating the occurrence of the fault current with the RCM

The RCM is used in applications where continuity of service is paramount. In fact, to protect against the increase of residual currents that can cause a fault current and therefore trip the RCDs, it is important to constantly monitor the residual currents to anticipate this risk and quickly put actions in place.

The measurement of residual currents is carried out using RCMs.

The principle of the RCM is as follows: An RCM combined with a residual current transformer measures residual currents. If the residual current exceeds a preset alarm threshold based on the installation settings, the RCM immediately alerts the user.

Increase in residual currents → **Appearance of fault currents** → **Risk of tripping**

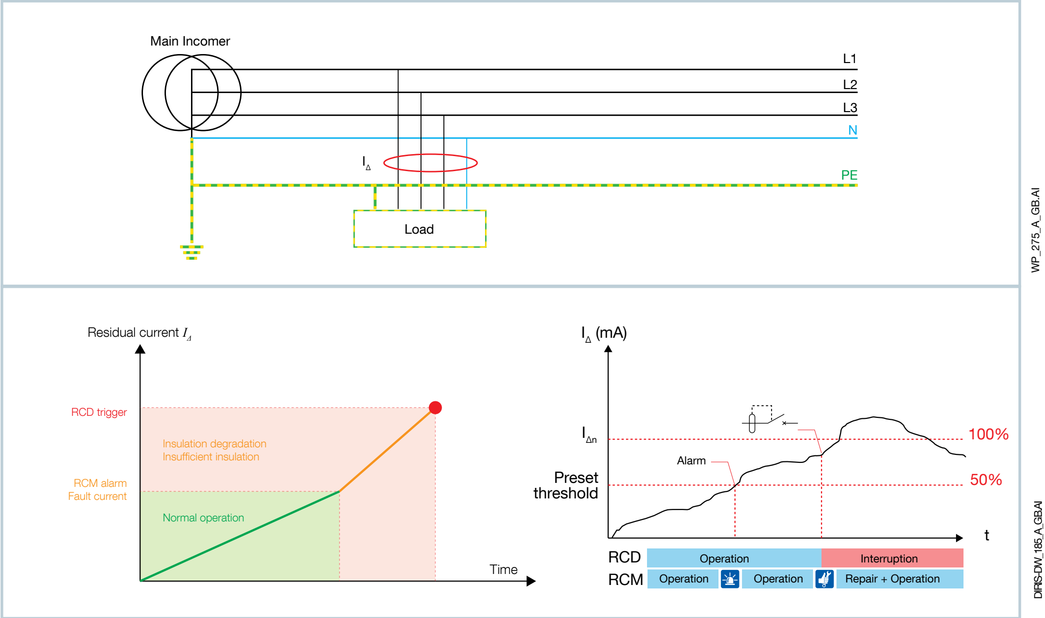


Fig. 7 – Temporal evolution of residual currents and difference between RCDs and RCMs

Applications requiring the use of RCMs

As described above, the RCM warns the user of an increase in residual currents and therefore of the potential occurrence of fault currents. So, by intervening as soon as possible before the fault current, you can avoid the RCDs tripping.

In the case of installations where there are no RCDs, the RCM provides passive protection by alerting the user to the presence of dangerous currents (electric shock, fire, explosion).
For example, in data centres, RCDs are not recommended for avoiding unnecessary trips, and it is best to use RCMs.

RCMs make a significant contribution to the safety of your installation and personnel. They are used in any application where the RCD tripping can lead to critical situations:
- industrial sites: interruption of a production line,
- data centres: loss of redundancy, shutdown of IT servers,
- fire risk premises,
- infrastructure: services interrupted,
- public spaces: people safety.

Apart from activating alarms, the RCM brings the following benefits:
- permanent and continuous measurement of the fault current,
- accessible in real-time,
- records variations based on the hour, day, week...

to identify variations in residual current depending on the equipment operating in the installation.

Positioning the RCM in the TN-S installation

Case of a three-phase network and three-phase loads

To be effective, residual current monitoring devices (RCMs) must be installed as close as possible to the loads in a TN-S earthing system.

The sum of the residual currents in the electrical installation is actually a vector sum. This implies that not only the value of the residual current must be taken into account, but also its phase. To this effect, in the majority of cases, the residual current measured on the main incomer $||I_\Delta||$* will be lower than the sum of residual currents measured at the individual loads. As such, a residual current measured only on the main incomer of the installation will therefore not be necessarily representative of all the residual currents flowing in the installation.

** The residual current measured corresponds to the module $||I_\Delta||$ of the vector $\vec{I_\Delta}$*

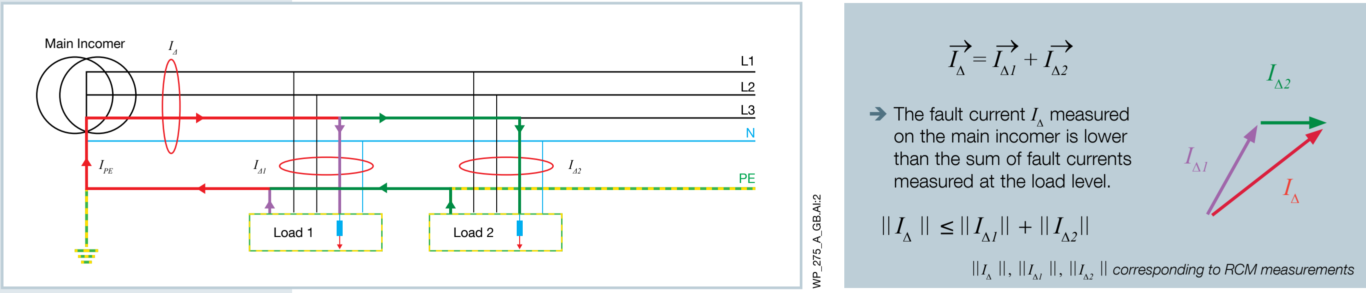


Fig. 8 – Relationship between the residual currents of the installation for a network and three-phase loads

The example below shows that a fault current alarm can be triggered at the load level without triggering an alarm on the main incomer.

Residual current measured upstream < the sum of residual currents measured at the load level.

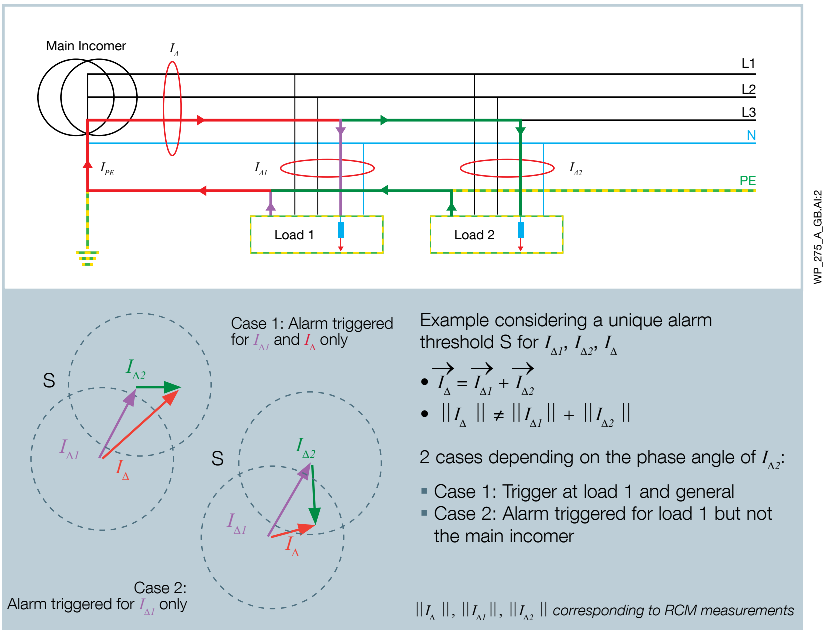


Fig. 9 – Example showing an alarm triggered at load level without triggering an alarm on the main incomer

Case of a three-phase network and single-phase loads

The scenario of a three-phase network feeding single-phase loads balanced over the 3 phases is typically found in data centres where single-phase servers are spread over the three phases. In this type of installation, the residual current I_Δ measured on the main incomer will not be representative of all residual currents at load level.
If, for example, $I_{\Delta 1}$, $I_{\Delta 2}$ and $I_{\Delta 3}$ are equal in module ($||I_{\Delta 1}|| = ||I_{\Delta 2}|| = ||I_{\Delta 3}||$) and phase-shifted by 120° between one another, then I_Δ equals zero.

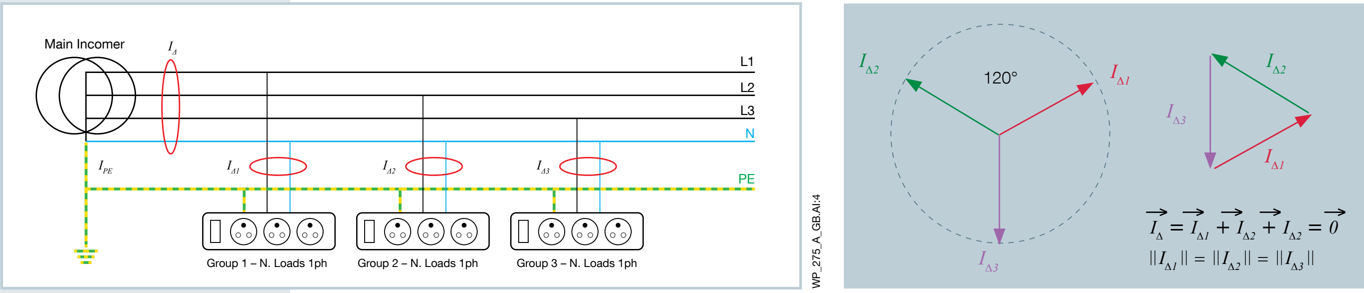


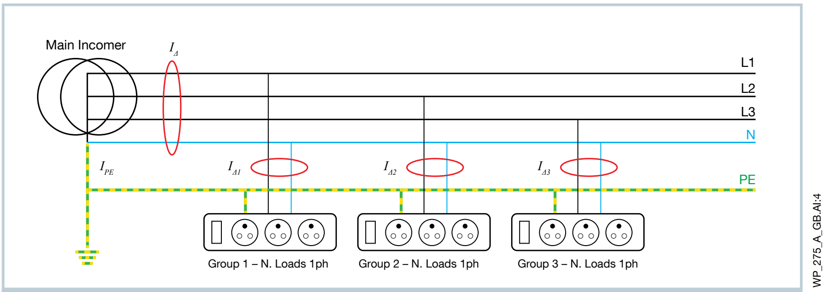
Fig. 10 – Example of a three-phase network with equal residual currents for each phase and phase-shifted by 120° between them

Residual current measured upstream < the sum of residual currents measured at the load level.

For economic reasons, it can be difficult to implement an RCM on each load. A group of several single-phase loads can then be monitored by a single RCM. In this case it should be taken into account that:

- each load naturally generates a fault current related to its EMC capacitance,
- successive switching of loads in parallel naturally increases the residual current.

The RCM alarm threshold will therefore have to be able to adapt to the number of switched loads in the installation, ideally using a self-adaptive alarm threshold.



Influence of leakage capacitance on the residual current for each single-phase branch L1, L2, L3

Impedance per load = $\frac{1}{j2\pi fC}$ *; C = EMC capacitance*

Capacitive residual current for 1 load = voltage x 2πfC
Equivalent capacitance for N loads in parallel = N x C
Capacitive residual current for N loads
= N x capacitive residual current for 1 load

Fig. 11 – Increase in residual current based on the number of single-phase loads

Example of typical capacitive residual current calculation, based on the number of loads

- EMC capacitance of a load C = 15 nF.
- Phase-Neutral network voltage = 230 V, Network frequency f = 50 Hz.

Considering that there are no resistive losses, switching on an additional load will add a residual current of 1 mA:

Capacitive residual current by load = voltage x 2πfC = 230 x 2π x 50 x 15 x 10^{-9} ≈ 1 mA.

For example, for a group of 10 single-phase loads on phase L1, the capacitive residual current will be 10 mA:

Capacitive residual current for 10 loads on phase L1 = 10 x 1 mA ≈ 10 mA.

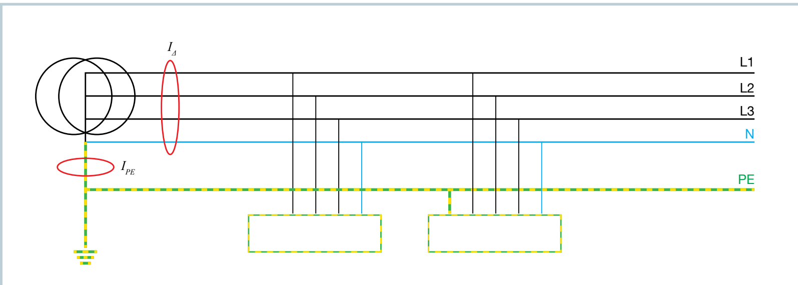
Measurement of the protective earth (PE) conductor

Measurement of the upstream PE conductor

On some installations, measuring the residual current on the main incomer can sometimes be difficult in practice:

- excessively wide copper bars,
- not enough available space.

These constraints make it difficult to add a residual current transformer to enclose all phases. As the currents I_Δ and I_{PE} are identical on the main incomer, one solution is to measure, instead of the residual current I_Δ, the current flowing in the protective earth conductor (PE) I_{PE}.



$$I_\Delta = I_{PE}$$

Fig. 12 – Measurement of the upstream PE conductor

The measurement of the current flowing through the PE conductor also allows to detect a break of this conductor when no current is flowing.

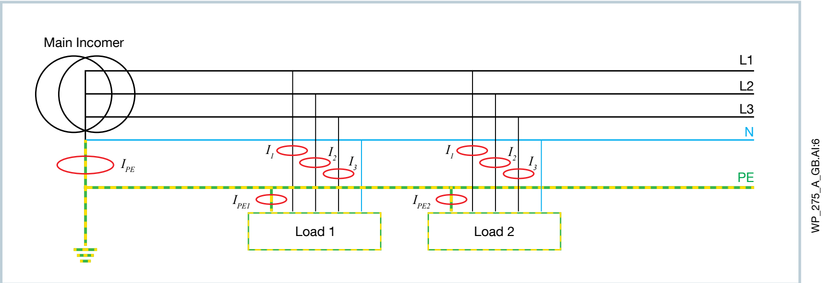
The I_{PE} current will be in the range of a few mA to a few hundred mA. To measure it with enough accuracy, a residual CT is required. A standard current transformer would not be sensitive enough.

Measurement of the PE conductor at the load level

The PE conductor measurement can also be implemented at the load level.
The absence of the I_{PE} current (I_{PE} = 0) indicates three possible scenarios:

- The current circulating in the PE is lower than the natural noise level (noise floor) → The current circulating in the PE conductor is very low
- Loads are not powered, for example, machines stopped → No current in the PE conductor
- The loads are in a normal state of operation, the PE current is known → There is a break in the PE conductor

This last situation is particularly critical because it can lead to a risk of interruption, for example of an industrial process, and a danger to operators. It is therefore important to monitor the status of the PE conductor. This monitoring can be implemented by activating an alarm as soon as the current flowing through the PE conductor is lower than a measured value during normal operation.



Alarm if
A load current is present

and *$I_{PE1} < I_{PE1}$ in normal operation*
and/or *A load current is present*
and *$I_{PE2} < I_{PE2}$ in normal operation*

Fig. 13 – Measuring PE current at the loads

The periodic verification includes the following tests: continuity of conductors, insulation resistance, polarity, automatic disconnection of supply, additional protection, phase sequence, functional testing, voltage drop.

Periodic verification and RCM

The IEC 60364-6 standard for Low voltage electrical installations – Part 6: Verification requires that a periodic verification of the installation be carried out by an approved third-party agency. The maximum interval between two periodic verifications is usually set by legal or national regulations.
In most countries the verification interval is one year.
The cost of the periodic verification is not neglectable, and can reach tens of thousands of euros depending on the size of the electrical installation.

The verification includes testing the installation's insulation resistance. This test is invasive; it requires injecting high voltages of 500 VDC and may therefore present a risk to people and equipment. One alternative is to install an RCM as advised in IEC 60364-6 § 6.5.1.2. This clause specifies that where a circuit is subject to permanent monitoring by an IEC 62020-compliant RCM, then the periodic measurement of the insulation resistance is not necessary.

This alternative is also mentioned in the installation standard in Germany
DIN VDE 0105-100 / A1:2017-6 and UK BS7671 18th Edition regulation 651.2.
It is also being implemented in many local transpositions of the IEC 60364-6 standard.

Permanent RCM is an alternative to testing the insulation resistance

Measuring the insulation resistance of the installation with an RCM present	Benefits for the installation
Fewer measurements during periodic verifications	Shorter intervention time and lower costs for the periodic verification
Sensitive parts within the installation do not need be disconnected to carry out measurements	Better availability, for example in a critical process industry or data centre
No risk of error when reconnecting	Better availability and increased security

Table 4 – Periodic verification of the installation with RCM present

Checking that the RCD is working properly

The RCD can trip at 50% of the $I_{\Delta n}$ (operating residual current of the RCD) and must trip before 100% of the $I_{\Delta n}$ as stipulated in IEC 60755 § 8.5.2.1 on the safety of RCD.

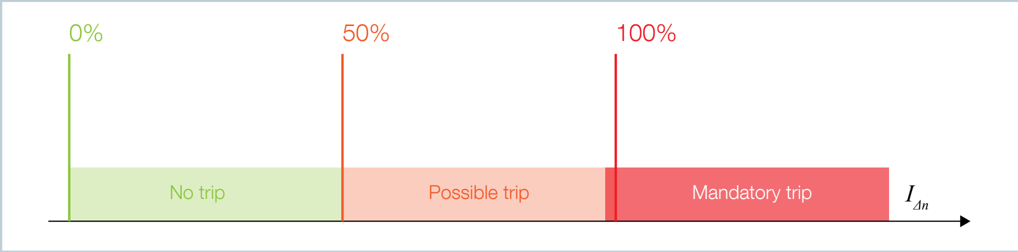


Fig. 14 – Trip thresholds of an RCD

In order to verify the proper functioning of the trip, RCD must be routinely tested with a test device that simulates the flow of a residual current, as described in IEC 60755 § 8.11. RCMs, thanks to its measurement of the residual current can help in this verification: if the residual current value measured by the RCM is greater than the trip threshold of the RCD, then the RCD is defective and must be replaced as soon as possible.

Types of RCM

The RCM requirements are set out in the product standard IEC 62020-1. This standard lists several types of RCM.

RCM	Application
Type AC	RCM for which an alarm is activated for: • residual sinusoidal alternating currents.
Type A	Type AC and in addition for: • residual pulsating direct currents superimposed on a smooth direct current of 6 mA.
Type F	Type A and in addition for: • composite residual currents intended for circuits supplied between phase and neutral or phase and earth, • residual pulsating direct currents superimposed on a smooth direct current of 10 mA.
Type B	Type F and more for: • residual sinusoidal alternating currents up to 1000 Hz, • alternating residual currents superimposed on a smooth direct current of 0.4x$I_{\Delta n}$ (rated residual current) or 10 mA, with the highest value retained, • residual pulsating direct currents superimposed on a smooth direct current of 0.4x$I_{\Delta n}$ or 10 mA, with the highest value retained, • residual direct currents which may result from rectifying circuits: > 2-pulse bridge between phases, > 3-pulse star or a 6-pulse bridge, • residual smooth direct currents.

Table 5 – Types of RCM and applications – Source IEC 62020-1

Appropriate choice of RCM type based on the loads

RCD use the same classifications as RCM. As such, the criteria for installing Type A or Type B RCD in the electrical installation will also apply to Type A or Type B RCM.

Type A RCD and RCM

Type A is used for the majority of loads.
For informational purposes, the table taken from the RCD standard IEC 60755 Appendix B presents different configurations of electronic equipment switched mode power supplies and the corresponding waveforms of residual currents in the event of an earth fault. It indicates which loads to use Type A with.

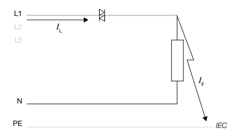
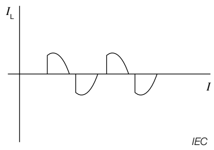
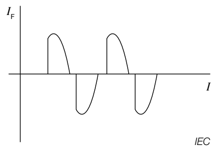
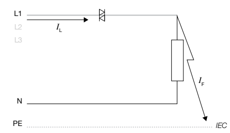
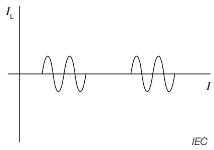
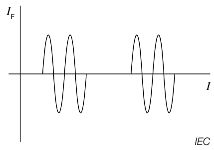
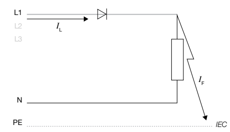
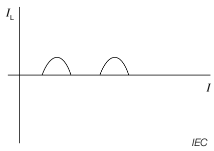
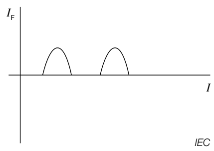
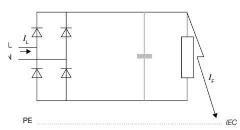
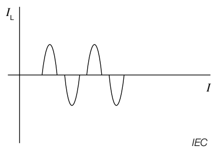
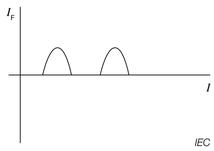
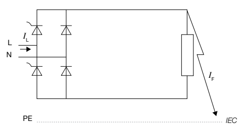
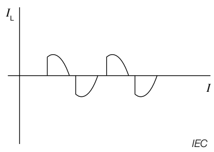
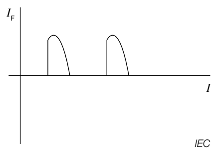
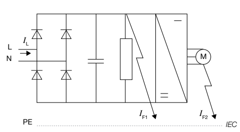
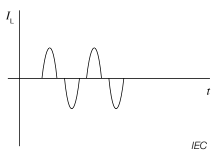
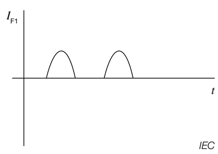
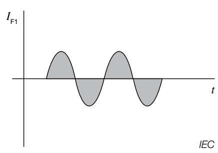
	Circuit system with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD tripping characteristic
1	Phase control 			AC, A, F, B
2	Burst control 			AC, A, F, B
3	Single-phase 			A, F, B
4	Two-pulse bridge 			A, F, B
5	Two-pulse bridge, half controlled 			A, F, B

Table 6 – Extract from IEC 60755 "Possible load and fault currents" – using Type A

The advantage of using Type A RCD and RCM is that it gives you low-cost, reliable residual current measurements.

Type B RCD and RCM

The use of Type B is related to the generation of fault currents with high DC components. The table below taken from IEC 60755 shows when to use Type B devices.

	Circuit system with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD tripping characteristic
6	Frequency inverter with two-pulse bridge 		 	F, B

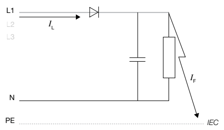
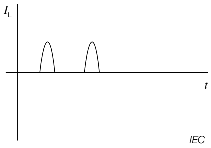
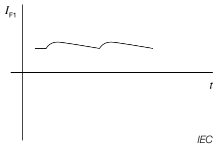
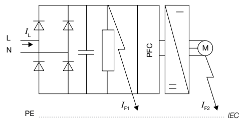
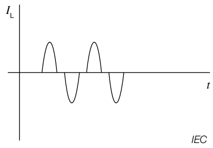
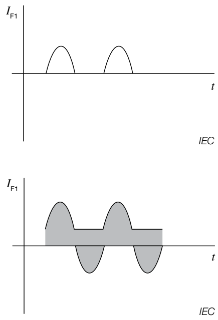
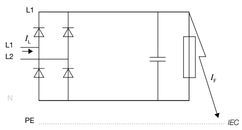
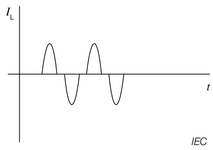
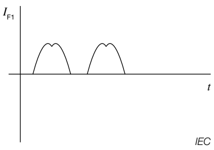
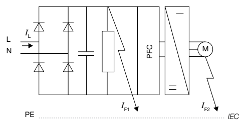
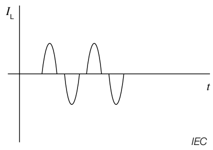
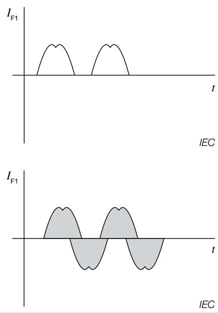
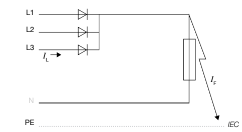
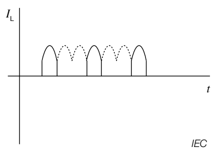
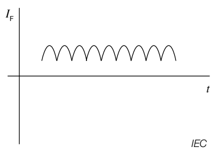
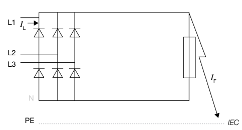
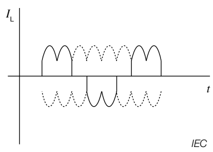
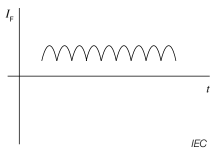
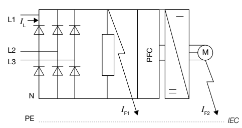
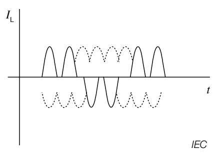
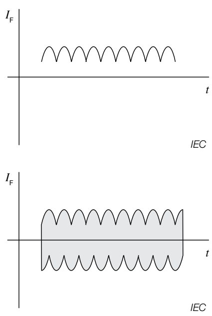
	Circuit system with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD tripping characteristic
7	Single-phase with smoothing 			B
8	Frequency inverter with two-pulse bridge and PFC 			B
9	Two-pulse bridge between phases 			B
10	Frequency inverter with two-pulse bridge between phases 			B
11	Three-phase star 			B
12	Six-pulse bridge 			B
13	Frequency inverter with six-pulse bridge 			B

Table 7 – Extract from IEC 60755 "Possible load and fault currents" – using Type B

The use of Type B is also required for DC installations, such as photovoltaic and electric vehicle power described in IEC 60364-7-712 Requirements for special installations or locations – Solar photovoltaic power supply systems and IEC 60364-7-722 Requirements for special installations and locations – Supplies for electric vehicles.

In order to correctly perform a measurement comprising both AC and DC high components, RCD and RCM will be associated with specific differential toroids. These toroids are complex to make and require high performance control electronics. As such, Type B RCD and RCM are more expensive than Type A RCD and RCM.

It is therefore important to study the normative context to identify which loads with DC components will be present in an installation.

IEC 60364-4-41 Protection for safety – Protection against electric shock

This international installation standard describes the protections to be put in place against electric shocks. It specifies that RCDs, and therefore potentially RCMs, are used for TT and TN-S earthing systems. It allows the use of any type (AC / A / F / B) of RCD and RCM.

IEC 61000-3-x Electromagnetic Compatibility (EMC) – Limits for harmonic current emissions

In order to limit harmonic current emissions, symmetrical control methods (i.e. resulting in identical waveforms for positive half-wave and negative half-wave) of loads are permitted by EMC IEC 61000-3-x standards under most normal operating conditions. On the other hand, asymmetrical control methods (for example, with only a positive half-wave), which will naturally generate DC components, are not permitted for most loads.

Electromagnetic Compatibility (EMC) Limits for harmonic current emissions	Load input current	Asymmetrical control method
IEC 61000-3-2 (§ 6.1)	< 16	Possible in some cases
IEC 61000-3-4 (§ 4.1)	> 16 A	Not permitted
IEC 61000-3-12 (§ 5.1)	>16 A and ≤ 75 A	Not permitted

Table 8 – Asymmetrical control method – Source IEC 61000-3-x EMC

Equipment in an electrical installation must comply with EMC IEC 61000-3-x standards and therefore those using an asymmetrical control method, source of DC components, will be rarely present, as detailed in the table above. This normative requirement naturally limits the presence of DC components in electrical installations and the need to systematically use Type B RCMs.

In conclusion

In most fault currents measurements, the use of a Type A RCM is the most suitable and also the least expensive solution.
When choosing a Type A or Type B RCM, it is therefore important to clearly identify the mesured loads that can induce the presence of DC currents, so as not to generate unnecessary extra costs.

DC components are rarely present in electrical installations. Type A RCD and RCM devices are sufficient for most loads.

General conclusion on RCM

As detailed in this section, the RCMs, located at strategic points within the installation, offer many benefits for applications where continuity of service is paramount.

- Early detection of insulation faults caused by degradations in the installation (mechanical, thermal, humidity, pollution, etc.).
- Location of insulation faults by measuring the residual current as close as possible to the loads.
- Ensures personal safety.
- Increased fire risk prevention.
- Preventive maintenance supported by the generation of alarms.
- Limits the risk of disruption of a sensitive industrial process thanks to a continuous monitoring.
- Data security in data centres.
- Permanent control of insulation resistance.

DIRIS Digiware RCM: mastering your installation's performance with an intelligent and versatile system

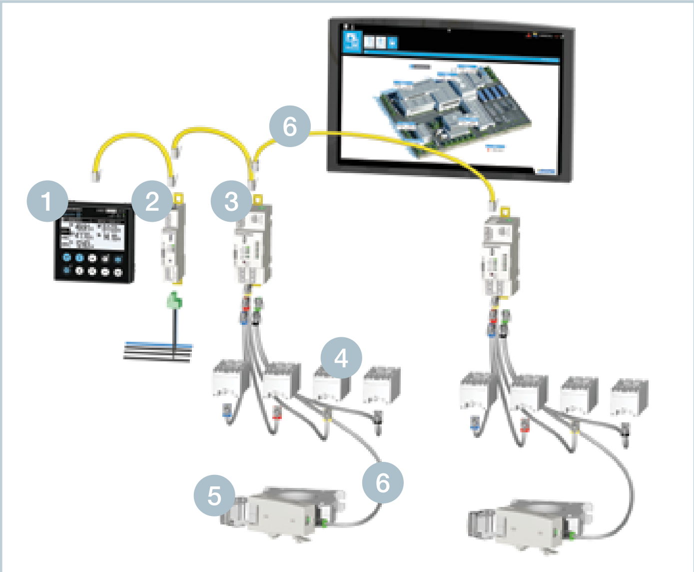
DIRIS Digiware RCM is a power monitoring system that also includes residual current monitoring for TN-S and TT electrical installations. The system is based on a modular concept for monitoring multiple circuits.
It is composed of:

1 A **power and communication interface**, acting as a point of access to measurements. It comes in the form of a DIRIS Digiware M-50 / M-70 communication gateway or a panel-mount DIRIS Digiware D-50 / D-70 display.

2 A single DIRIS Digiware U **voltage acquisition module**, used as the voltage reference for the other modules.

3 **One or more residual current monitoring modules** combined with the functions of measuring load currents:
DIRIS Digiware R-60.

The DIRIS Digiware RCM system can be complemented by DIRIS Digiware I, S or IO measurement modules that provide additional features such as analysing power quality, monitoring the status of external devices or collecting pulses from multi-utility meters.



1.	A single point of access to data • 24 VDC power supply for the whole system • RS485 and Ethernet communication via multiple protocols • Local or remote visualisation of measurements	DIRIS Digiware D-50/D-70 DIRIS Digiware M-50/M-70
2.	A single voltage acquisition module, distributed to downstream measurement modules	DIRIS Digiware U-10/U-20/U-30
3.	Modules combining load current and residual current monitoring functions	DIRIS Digiware R-60
4.	Current sensors	TE (solid-core), TR / iTR (split-core), TF (flexible)
5.	Residual CTs	*ΔIC* (solid-core), *ΔIP-R* (split-core), WR and TFR (rectangular)
6.	Cables connecting the measuring modules to the sensors and residual CTs	RJ12 cables
7.	A communication bus connecting each component of the system	RJ45 Digiware bus

Table 9 – Description of the DIRIS Digiware RCM system

Multi-circuit concept

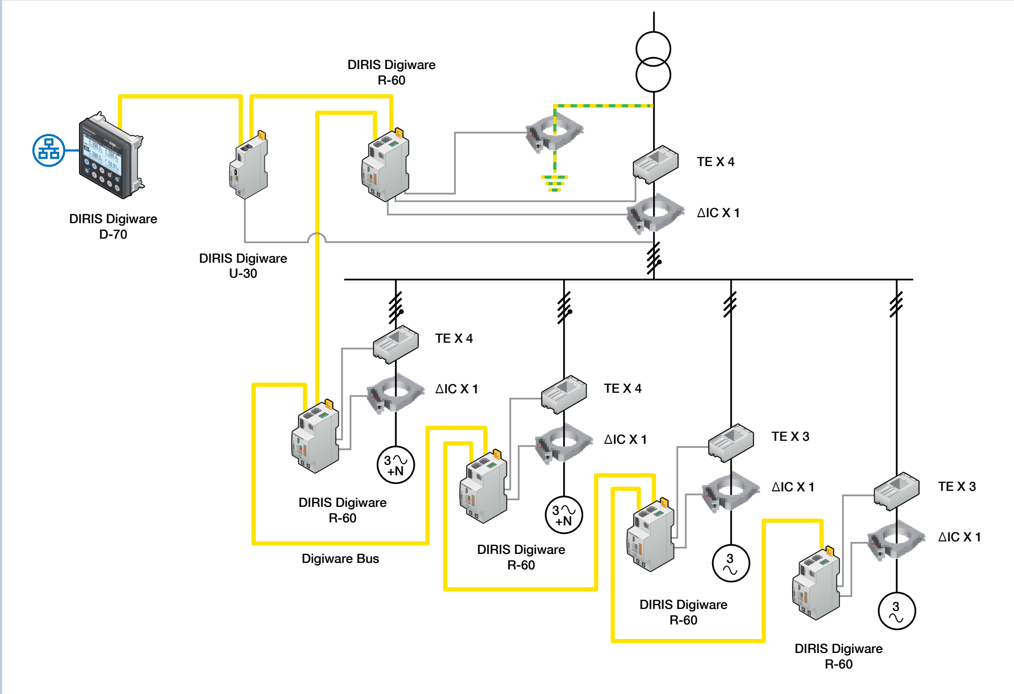


Fig. 15 – Example of an installation equipped with the DIRIS Digiware RCM system.

The DIRIS Digiware R-60 module can also be added to an existing DIRIS Digiware system, initially used for its power metering and monitoring functions.

As explained in the first section of this technical note, a single RCM on the main incomer is not enough to know the insulation level of the electrical installation.

The modular DIRIS Digiware concept measures the residual current not only on the main incomer but also at the circuit level. This allows to equip multiple circuits with residual current monitoring, for a detailed knowledge of the insulation level throughout your electrical installation.

The DIRIS Digiware R-60 module has 6 x RJ12 inputs to equip up to 6 three-phase or single-phase circuits with residual current monitoring.

2-in-1 for greater performance

A high-performance installation distributes efficient electrical energy. It minimises losses, avoids malfunctions and premature ageing and safeguards people and equipment.

PERFORMANCE =

EFFICIENCY: Identify and minimise energy losses

+ AVAILABILITY: Anticipate outages and reduce intervention times

+ QUALITY: Ensure high-quality power to avoid malfunctions

+ SECURITY: Help keep property and people safe

The DIRIS Digiware RCM system is based on a 2-in-1 approach that combines load current and residual current monitoring.

Thanks to its metering functions, it fits perfectly into your efforts to continuously improve the installation’s energy efficiency (ISO 50001), by highlighting the loads and areas consuming the most energy.

The system also monitors the quality of the power supply by measuring relevant electrical parameters such as voltage, frequency, harmonic distortion (THD), unbalances... and setting up threshold alarms to alert in real-time when values are exceeded.

Monitoring residual currents improves the availability and safety of the electrical installation by helping to anticipate insulation faults.

The following paragraph shows the various alarms proposed by the DIRIS Digiware RCM system.

Numerous smart alarms to ensure smooth operation

Alerts on residual current I_Δ

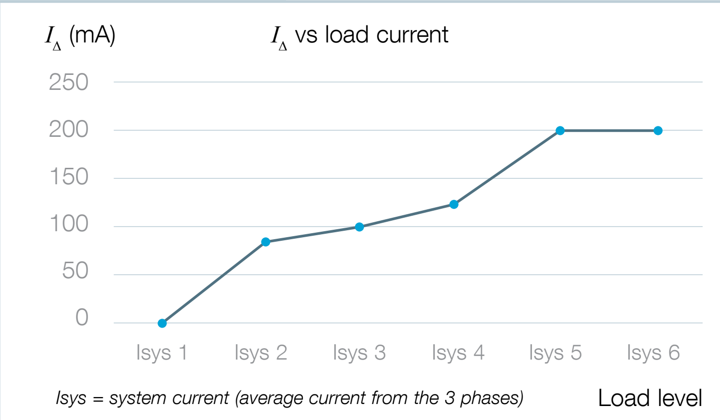
I_Δ measurement alarms are based on a threshold chosen by the user.
These alarms have several roles:

- to alert that the residual current is approaching the RCD trip threshold,
- to warn of a deterioration in the installation's insulation that could lead to insulation faults, electric shocks or fires.

With a 300 mA RCD that can trip from 150 mA, it is wise to set up an alarm at 140 mA.

Dynamic alarms for residual currents I_Δ

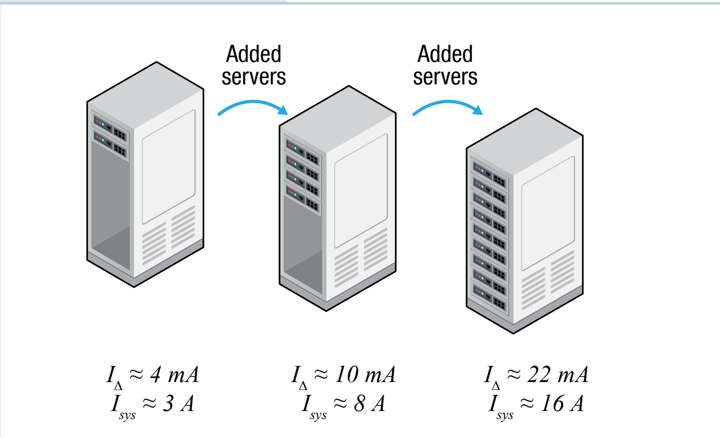
Many users do not know the acceptable level of residual current to ensure the normal and safe operation of their electrical installation.
The DIRIS Digiware RCM system offers a patented self-learning feature for your electrical installation, including 6 dynamic alarm thresholds for currents I_Δ and I_{PE} depending on variations in the load current.
Thanks to this feature, the alarm thresholds of residual currents I_Δ and I_{PE} automatically adjust according to the number of switched loads.



Application example:
One practical application is the gradual addition of servers in a rack of a data centre.

Each server generates an earth leakage current, so the more servers added to the rack, the greater the rack's overall residual current, without being abnormal.

A rack fully equipped with servers will then naturally generate an earth leakage current of several dozen mA. On the other hand, it is not normal to observe such values for a rack containing only a few servers.



By configuring different alarm thresholds for the residual current, based on the average load current of the rack and therefore its occupancy, the DIRIS Digiware RCM system avoids nuisance alarms while guaranteeing the safety and availability of the data centre.

Alarms on the current of the PE conductor of the loads

You can also set a measurement alarm based on the I_{PE} current of the protective conductor, so the user is alerted when the value drops below a low preset threshold.

$$I_{PE} \approx I_{\Delta}$$

$$I_{PE} << I_{\Delta}$$

This will allow to detect a potential break in the PE conductor if the value reaches an abnormally low level while the load is operating.
A comparison alarm can be set between the residual current of a load and the current of its protective conductor. An excessive difference in readings (I_{PE} well below I_{Δ}) may mean that the leakage current of the load is not flowing through the PE conductor only.

Protection alarms

When combined with the VirtualMonitor technology (available with iTR current sensors), the DIRIS Digiware R-60 module offers three types of alarm for protective devices:

When an alarm is activated, the user can be alerted by email for maximum responsiveness.

- Warning if the protective device is opened, regardless of the type (switch, circuit breaker, fuse, etc.),
- Warning if the circuit breaker trips.

This alerts maintenance teams to a loss of power or loss of redundancy; valuable information for applications like data centres.

- In addition, if the protective device is an RCD, a specific “Defective RCD” alarm is activated if the measured residual current is higher than the RCD’s rated current $I_{\Delta n}$.

Maintenance teams are warned even before the periodic installation verification, that the RCD must be replaced because it no longer fulfills its functions of protecting property and people.

Analysing the cause of tripping

Thanks to the VirtualMonitor technology, the DIRIS Digiware R-60 module used with iTR sensors can identify the tripping of the RCD: overcurrent or excessive residual current.

When a Residual Current Circuit Breaker (RCCB) is used, a trip is detected if the R-60 measures a residual current that exceeds the I_{Δ} trip threshold chosen by the user.

When a Residual Current Breaker with Overcurrent protection (RCBO) is used, the technology analyses if the trip was caused by an excessive residual current or by an overcurrent.

The cause of the trip is an excessive residual current if:
- the iTR sensor detects an opening of the RCBO,
- the I_{Δ} reading exceeds the “trip threshold” chosen by the user.

The cause of the trip is an overcurrent if:
- the iTR sensor detects an opening of the RCBO,
- the iTR sensor detects an overcurrent.

The table below lists the events identified by the VirtualMonitor technology:

		Protection event				
		Opening	Trip on residual current	Trip on overcurrent	Defective device	Defective RCD
Protective device	Switch	X			X	
	Fusible switch	X			X	
	Fuse	X				
	Circuit breaker	X		X	X	
	RCCB (differential switch)	X	X		X	X
	RCBO (differential circuit breaker)	X	X	X	X	X

Table 10 – Summary of protection events identified by VirtualMonitor.

Alarm on overloaded neutral conductor

Computer equipment in some facilities such as data centres generates harmonic pollution and in particular the 3rd harmonic.

Currents from the 3rd harmonic accumulate in the neutral conductor and can cause overheating with the risk of causing a fire.

The DIRIS Digiware R-60 module can measure or calculate the current flowing in the neutral conductor. An alarm can be set to alert if the current reaches a high value. This will go a long way to reducing the risk of fire, especially in data centres.

Compliance with standards

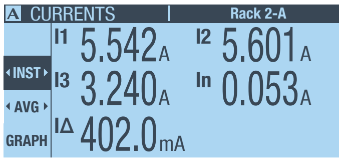
DIRIS Digiware RCM complies with the product standard IEC 62020 – Residual current monitors (RCM). In accordance with the installation standard IEC 60364-6 – Verification, if a DIRIS Digiware RCM system is permanently installed within the electrical installation, the organisation can be exempted from having to measure insulation resistance during the periodic verification.
The investment in the system quickly pays for itself.

In addition, the periodic measurement only provides a picture of the insulation resistance at a given time. DIRIS Digiware RCM offers an alternative, monitoring and time-stamping residual currents so immediate actions can be taken as soon as an anomaly is detected.

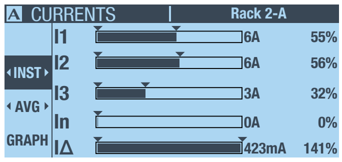
A visualisation of the system's performance

DIRIS Digiware D-50/D-70 display

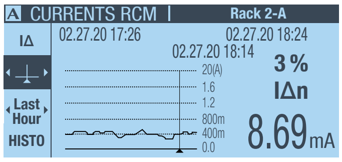
The residual currents of each circuit can be monitored directly from the DIRIS Digiware D-50 or D-70 display. Several screens allow to visualise the real-time values of I_{Δ} and I_{PE} as well as historical values, while a dedicated screen lists the most critical active RCM alarms.



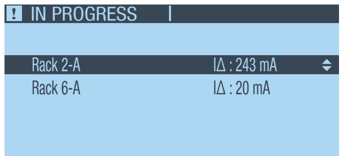
Visualisation of load currents and residual currents in real-time on the same screen.



Visualisation in the form of bar charts.



Monitoring of residual currents I_{Δ} and I_{PE} for the last hour, day, week or month.



List of RCM alarms sorted by criticality.

WEBVIEW: the preferred tool of site operators

With WEBVIEW, the software embedded in Socomec displays, gateways and dataloggers, you can remotely visualise and analyse measurement data for a facilitated maintenance.

Intuitive and with no license fees, WEBVIEW is the ideal tool for maintenance teams and site operators who want to ensure that their installation is operating smoothly.

WEBVIEW consists of several menus showing measurement data in different ergonomic formats for the user.

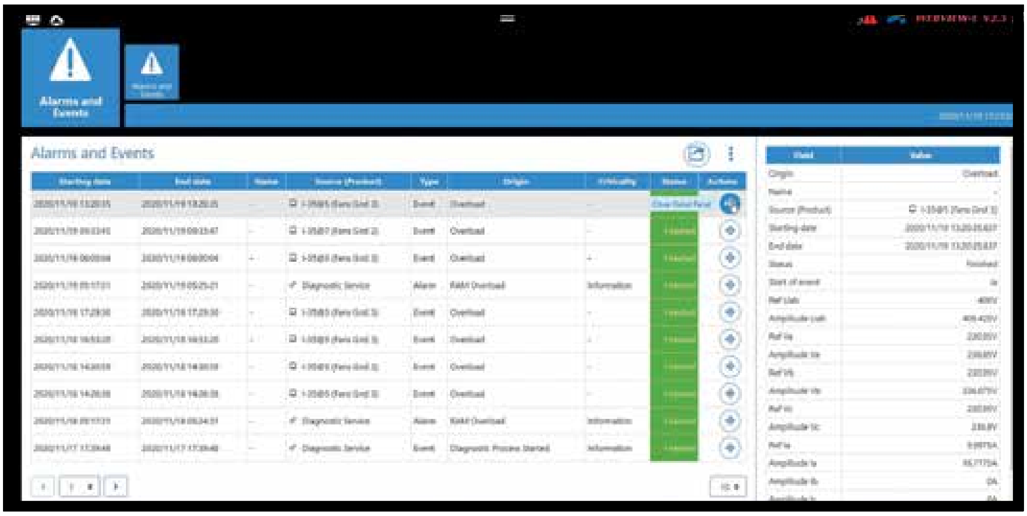
- **The Consumption menu** in the form of histograms or pie charts break down consumption by area, usage and load, to easily identify the most energy-intensive areas for any kind of utility type (electricity, water, gas).

SOFT_147

- **The Trends menu** allows you to monitor electrical parameters over time to identify drifts and then anticipate potential malfunctions.

SOFT_077

- **The Alarms menu** shows all ongoing and finished alarms, including residual current alarms, sent by the measurement modules to alert the operator to an event or defect. It also gives a detailed description of each alarm, including the source of the fault and its location.



SOFT_074

• **The Photoview application** provides an overview of real-time measurements and alarms directly displayed on a customised background. Simply upload a relevant picture of the installation (electrical diagram, site map, picture of a cabinet, etc.) and position the measurements onto the picture, including residual current measurements and potential related alarms. This allows to easily locate growing anomalies.

For example, if the residual current of a load rises, an alarm is generated and the insulation fault is immediately located on the installation picture.

SOFT_064

Conclusion

Residual current monitoring offers many advantages, in particular better availability and safety of the electrical installation. It is also highly recommended from a normative point of view. But to take full advantage of it and to guarantee a high-performance installation, it is wise to opt for a 2-in-1 system that combines energy metering, power monitoring and residual current monitoring (RCM) into one system across all levels of the electrical installation.

DIRIS Digiware RCM is the perfect solution, offering innovative alarms to anticipate and understand anomalies throughout your electrical installation.

Socomec: our innovations supporting your energy performance

1 independent manufacturer

3,600 employees worldwide

10 % of sales revenue dedicated to R&D

400 experts dedicated to service provision

Your power management expert

POWER SWITCHING

POWER MONITORING

POWER CONVERSION

ENERGY STORAGE

EXPERT SERVICES

The specialist for critical applications

- Control, command of LV facilities
- Safety of persons and assets

- Measurement of electrical parameters
- Energy management

- Energy quality
- Energy availability
- Energy storage

- Prevention and repairs
- Measurement and analysis
- Optimisation
- Consultancy, commissioning and training

A worldwide presence

12 production sites
- France (x3)
- Italy (x2)
- Tunisia
- India
- China (x2)
- USA (x3)

28 subsidiaries and commercial locations
- Algeria • Australia • Belgium • China • Canada
- Dubai (United Arab Emirates) • France • Germany
- India • Indonesia • Italy • Ivory Coast • Netherlands
- Poland • Portugal • Romania • Serbia • Singapore
- Slovenia • South Africa • Spain • Switzerland
- Thailand • Tunisia • Turkey • UK • USA

80 countries
where our brand is distributed

HEAD OFFICE

SOCOMEC GROUP
SAS SOCOMEC capital 10 589 500 €
R.C.S. Strasbourg B 548 500 149
B.P. 60010 - 1, rue de Westhouse
F-67235 Benfeld Cedex
Tel. +33 3 88 57 41 41 - Fax +33 3 88 57 78 78
info.scp.isd@socomec.com

www.socomec.com

YOUR DISTRIBUTOR / PARTNER

ENERGY SPECIALIST SINCE 1922

socomec
Innovative Power Solutions

DOT 62013i - 12/20 – Photo: Martin Bernhart - Produced by: SOCOMEC - Gyss Imprimeur Obernai