Earth Fault Protection

How to design efficient earth fault protection with Residual Current Devices (RCD)

Guide 2020

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Schneider Electric

The aim of this guide is to provide advice for the selection and implementation of Residual Current Devices according to international series of standards IEC 60364 and based on Schneider Electric best practices and products.

Any work performed on an electrical installation must comply with all applicable local, regional and national regulations.

Failure to observe this information can result in injury or equipment damage.

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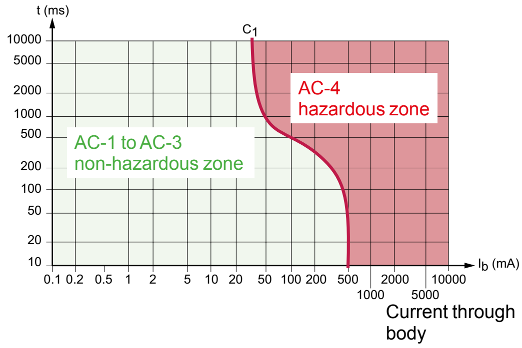
Why to use residual current devices

Principles for Electric shock protection and RCD contribution

A

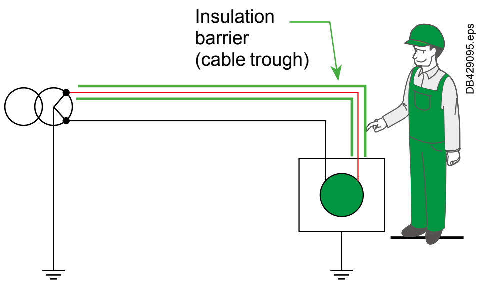
Current flow time



Residual Current Devices (RCD) are designed to provide protection against hazardous earth fault current.

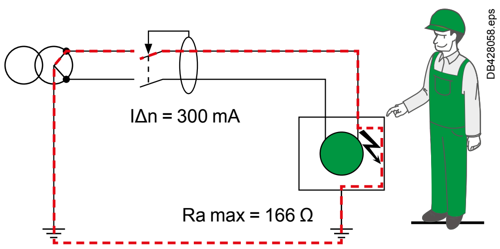
The principles of the protection of persons against electric shock refer to the serious physiological risks (respiratory paralysis, ventricular fibrillation) that can occur in the event of contact with a live part, causing an excessively high current to flow through the human body for too long a time.
The IEC 60479-1 publications updated in 2016 define the limit (C1) below which these principles must be come into play.

Protection of persons in low-voltage installations must comply with standards, installation rules, best practices, official guides, circulars, etc.
i.e.IEC 61140, IEC 60364, IEC 60479, IEC 61008, IEC 61009, IEC 60947-2, etc.
In accordance with IEC 61140, in low voltage installations, the triple level of protection is mandatory:



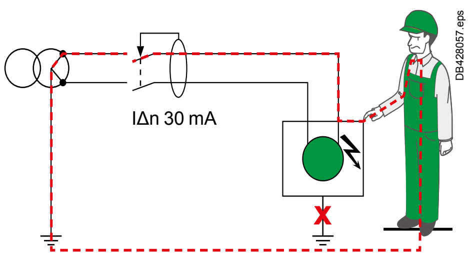
Level 1
Hazardous live-parts shall not be accessible

This level applies to any "normally" live part (for example electrical cable) to prevent any person to come into contact with it (direct contact).
The type of protection to be implemented is called **"basic protection"**.
An insulation barrier such as cable insulation, a cover, housing, cable protection troughs, etc. is required to ensure protection.



Level 2
Accessible-conductive-parts shall not become hazardous

This level applies to any accessible conductive part that is not "normally" live but which may become hazardous due to a failure of the basic protection that is not visible to the user (indirect contact) (for example metallic casing of a machine).
The type of protection to be implemented under these circumstances is called **"fault protection".**
This protection can be ensured by bonding and connection to earth of the accessible conductive parts and the use of an earth fault protection device. In the TT method of earthing, this earth fault protection device shall be a residual current device with adequate sensitivity.
A second insulation barrier also ensures protection.



Level 3

If **the two previous means of protection fail** or if **in presence of "hazardous" situation** (for example socket outlet that will be used by non skilled people), an ultimate protection device must be implemented.
This protection is called **"additional" protection.**

All the preceding protective measures cannot be regarded as being infallible. Some cases where the protective measures can fail are: immersion in water, improper earthing, wear and tear of insulation, etc...
In order to protect users in such circumstances, highly sensitive RCD (IΔn ⩽ 30 mA) are used to disconnect the power supply automatically to prevent injury to, or death by electrocution.

Protection	Contact	Involvement of the residual current device
1- Basic	Direct	
2- Fault	Indirect	
3- Additional	Direct / Indirect	

Why to use residual current devices

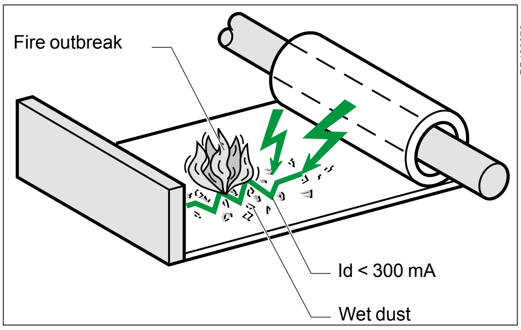
Installation standard requirement for additional protection with high sensitive RCD (30 mA)

	Additional Protection against electric shock with RCD		
	International	**France**	**Other countries**
Circuits supplying socket-outlet up to 32 A for any type of buildings	Mandatory (1)	Mandatory	■ Mandatory in European countries ■ For other countries, to check specific rules
Circuit supplying mobile equipment up to 32 A for outdoor use	Mandatory (2)	Mandatory	■ Mandatory in European countries ■ For other countries, to check specific rules
Dwelling: circuits supplying luminaires	Mandatory (3)	Mandatory	Depends on the country local regulation
Dwelling: circuits supplying fixed appliances for electrical heating		Mandatory	Depends on the country local regulation
Dwelling: other circuits		Mandatory	Depends on the country local regulation
Bathroom: all circuits supplying equipments and circuits passing in the bathroom	Mandatory (4)	Mandatory	See local regulation
Swimming pool: all circuits in swimming pools or locations with fountains except circuits protected by SELV or electrical separation	Mandatory (5)	Mandatory	See local regulation
Saunas: all circuits	Mandatory (6)	Mandatory	See local regulation
Construction sites: circuits supplying socket-outlets up to 32 A and hand held equipments	Mandatory (7)	Mandatory	See local regulation
Agricultural premises: ■ circuits supplying socket outlets up to 32 A (protection by 30 mA RCD) ■ other circuits: protection by 300 mA RCD	Mandatory (8)	Mandatory	See local regulation
Caravan park and camping parks: all circuits to be protected by 30 mA RCD	Mandatory (9)	Mandatory	See local regulation
Marina and pleasure crafts: all circuits supplying socket-outlets up to 63 A and circuits supplying the fixed connection of a supply to a boat	Mandatory (10)	Mandatory	See local regulation
External lighting installations: circuits to be protected by 30 mA RCD	Mandatory (11)	Mandatory	See local regulation
Exhibitions, shows and stands: all circuits to be protected by 30 mA RCD	Mandatory (12)	Mandatory	See local regulation
Supply of electric vehicle: each connected point to be protected by 30 mA RCD	Mandatory (13)	Mandatory	See local regulation
Circuit supplying heating cables and heating embedded systems (heating floor) to be protected by 30 mA RCD	Mandatory (14)	Mandatory	See local regulation

(1) See IEC 60364-4-41 § 411.3.3, 1st paragraph
(2) See IEC 60364-4-41 § 411.3.3, 2nd paragraph
(3) See IEC 60364-4-41 § 411.3.4
(4) See IEC 60364-7-701 § 701.415
(5) See IEC 60364-7-702 § 702.410.3
(6) See IEC 60364-7-703 § 703.412
(7) See IEC 60364-7-704 § 704.410.3
(8) See IEC 60364-7-705 clause 705.411
(9) See IEC 60364-7-708 § 708.531
(10) See IEC 60364-7-709 § 709.531.2
(11) See IEC 60364-7-714 § 714.411
(12) See IEC 60364-7-711 § 711.410.3
(13) See IEC 60364-7-722 § 722.411.3
(14) See IEC 60364-7-722 § 753.411.1.

Why to use residual current devices

RCD contribution to protect against fire hazards



Protection against fire hazards

Many fires of electrical origin are caused by the creation and propagation of electric arcs in building materials, in the presence of moisture, dust, pollution, etc.
These arcs appear and develop due to the wear and tear or ageing of the insulating materials. The fire hazard occurs when the leakage currents reach a few hundred milliamps for a few seconds.
For fault currents of this magnitude, residual current devices with a sensitivity of 300 mA or 500 mA trip in less than a second, whether they be instantaneous, selective or time-delayed.

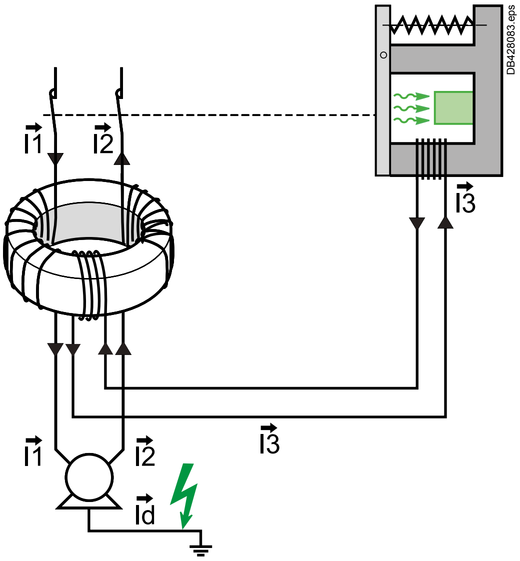
IEC 60364-4-42 (subclause 422.3.10) states that it is mandatory to install a residual current device with a sensitivity less than or equal to 300 mA:

- on premises with a risk of explosion (BE3)
- on premises with a risk of fire (BE2)
- in agricultural and horticultural buildings
- for circuits supplying fair, exhibitions and entertainment equipment
- on temporary outdoor leisure facilities.

In some countries, installation rules and/or local safety regulations require a sensitivity of 300 mA.

What are the technologies used in RCD

How does RCD work



Residual Current Devices (RCDs)

The basic characteristics of the operation of a RCD are shown opposite:

- a magnetic toroid surrounds all the active conductors, including the neutral conductor, if present, supplying an electrical circuit. The magnetic flux generated in the magnetic toroid depends at all times on the vector sum of the currents in the active conductors
- in the case of a single-phase circuit, the incoming current $\vec{I_1}$ (from source to use) is considered to be positive, while the outgoing current $\vec{I_2}$ is considered to be negative
- for a healthy electrical circuit, $\vec{I_1} + \vec{I_2} = 0$, there is no magnetic flux: no electromotive force created in the secondary winding
- in case of earth leakage, a fault current $\vec{I_d}$ flows through the magnetic toroid from source to use but returns through the protective conductors (TN method of earthing) or via the earth (TT method of earthing). Consequently, the sum of the incoming and outgoing currents is not zero, i.e. $\vec{I_1} + \vec{I_2} = \vec{I_d}$, and this difference in current creates a magnetic flux. The difference in current is called "residual current"
- the resulting alternating flux in the magnetic toroid consequently induces an electromotive force in the secondary winding so that a current $\vec{I_3}$ flows through the tripping control winding of the device.

If the residual current $\vec{I_d}$ exceeds the value (the threshold) required to trip the device directly or via an electronic relay, this will cause the associated disconnection device (switch or circuit breaker) to open

With the **Voltage Dependent (VD) technology**, the summation current transformer measures residual current. An electronic circuit detects the tripping level and then sends an order to tripping unit to open the protected circuit

- in this case, the power supply of electronic circuit and energy for tripping unit come from the line voltage
- with this technology, the RCD will be able to detect but not to trip if the line voltage is too low, because the electronic circuit and tripping units needs to be powered.

B

What are the technologies used in RCD

Categories of RCDs (RCCB, RCBO, add-on Vigi, SRCD) and standards

The different residual current device categories

IEC 60755 describes general requirements for residual current operated protective devices.

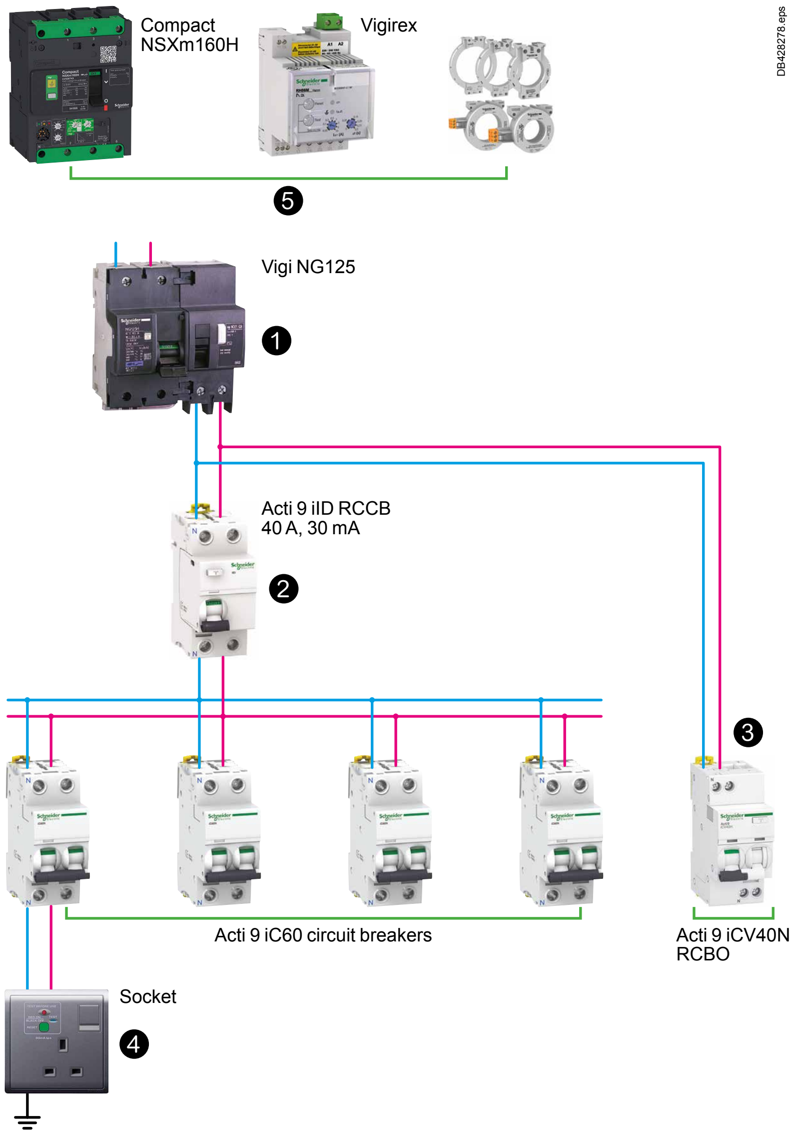
1 **Vigi modules** (**Vigi NG125**, see example in the figure)
The add-on Vigi module is the most flexible residual current device
(it is installed in combination with a **circuit breaker**).
Vigi are covered by the IEC 61009 and IEC 62423 series of standards.

2 **Residual Current operated Circuit Breakers without integral overcurrent protection (RCCB)** (**Acti9 iID**, see example in the figure)
The Acti 9 iID RCCB is the main residual current device in the facility and is used as the main incomer.
RCCB are covered by the IEC 61008 and IEC 62423 series of standards.

3 **Residual Current operated circuit Breakers with integral Overcurrent protection (RCBO)** (**Acti 9 iCV40N**, see example in the figure)
RCBO = combination of circuit breaker and residual current device function in the same product. This can be obtained by combining the circuit breaker with its Add-on Vigi Module.
RCBO are covered by the IEC 61009 and IEC 62423 series of standards.

4 **Socket RCD (SRCD)** (see example in the figure)
SRCD are covered by the IEC 62640 series of standards.

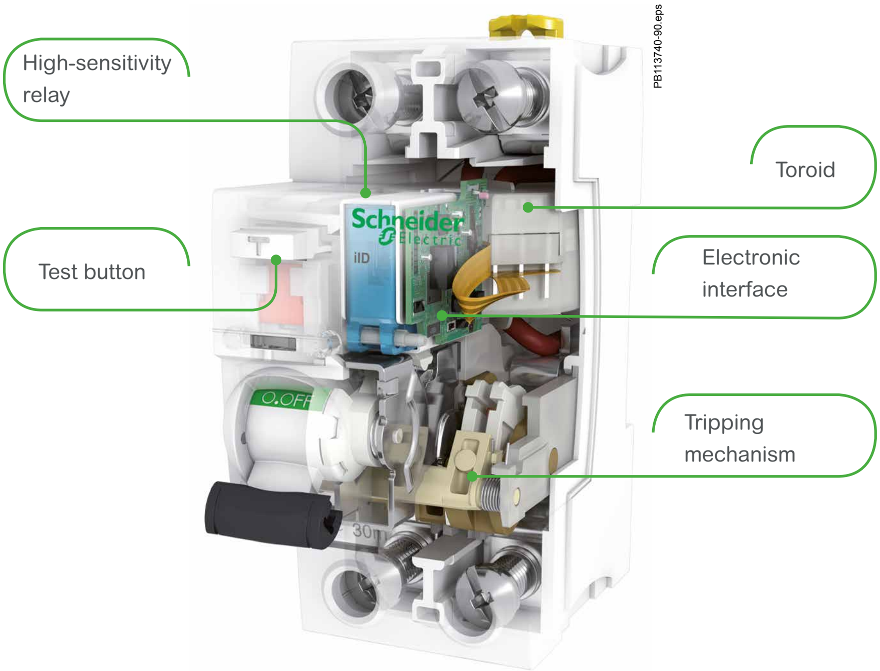
5
Industrial type circuit breakers incorporating the RCD function must comply with Annex B of IEC 60947-2.
Residual current devices with a separate toroid are standardized in Annex M of IEC 60947-2.



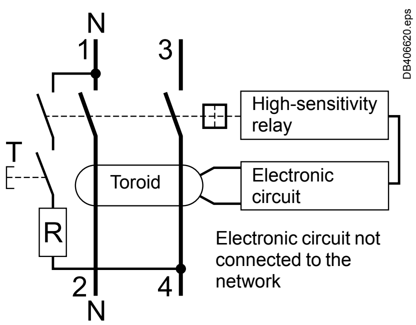
What are the technologies used in RCD

Technology: Voltage Independent Technology

Residual current devices using Voltage Independent Technology can continue to operate in the event of a complete voltage loss or neutral break.



The residual current device consists of:
- high magnetic performance core (ex: nanocristalline)
- a high-sensitivity relay
- an electronic interface analyzing the signal.



- The toroid provides information on the leakage current and the power required to trip the device.

- The electronic circuit and the relay are not connected to the electrical network. Power is provided only by the leakage current.

- Even if there is an accidental break of the neutral conductor or a voltage drop, the entire electromechanical system will continue to operate, allowing the residual current device to trip.

What are the technologies used in RCD

Technology: Voltage Independent Technology (continued)

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Standards associated with the technology "Voltage Independent Technology"

- **Voltage Independent RCCBs** must comply with two international standards:
  - □ IEC/EN 61008-1 - General rules for RCCBs,
  - □ IEC/EN 61008-2-1 - Particular rules for line voltage-independent RCCBs.

- **Voltage Independent RCBOs** must comply with these two international standards:
  - □ IEC/EN 61009-1 - General rules for RCBOs,
  - □ IEC/EN 61009-2-1 - Particular rules for line voltage-independent RCBOs.

- conformity with the particular rules implies conformity with the general rules. In practice, the products are certified IEC/EN 61008-2-1 or IEC/EN 61009-2-1.

- conformity with the standards is confirmed by a national conformity mark on the product. The mark is assigned by a third-party organization independent of Schneider Electric. This involves regular sampling at the production site to ensure continued conformity with the standards in question.

- the international series of installation standards (IEC 60364) highly recommends the use of residual current devices independent of the network voltage in buildings occupied by persons not trained in the prevention of electrical hazards (residential buildings, tertiary buildings, etc.).

In some countries, it is required to use RCD with voltage independant technology (VIT) for final circuits.

What are the technologies used in RCD

Technology: Voltage Dependent Technology (with and without FE)

A voltage source is required to operate this technology.
For Schneider Electric residual current devices, earth fault protection is provided in the event of a voltage drops down to 50 V.


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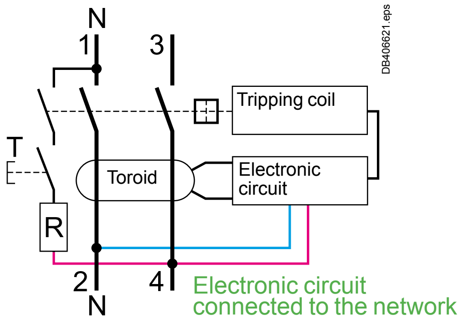
According to the standard requirements, all electrical equipment protected by VD with FE RCDs must be earthed to ensure maximum earthing resistance as follows:

- Ue = 110 V: 50 ohm,
- Ue = 230/240 V: 100 ohm.



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In the case of VDT technology ("Voltage Dependent Technology"), the toroid only provides information about the leakage current.
The power required for tripping is supplied by the electrical network.

Standards associated with "Voltage Dependent Technology"

- **Voltage Dependent Technology RCCBs** comply with two international standards:
  - IEC 61008-1 - General rules for RCCBs,
  - IEC 61008-2-2 - Particular rules for line voltage-dependent RCCBs.
- **Voltage Dependent Technology RCBOs** comply with two international standards:
  - IEC 61009-1 - General rules for RCBOs,
  - IEC 61009-2-2 - Particular rules for line voltage-dependent RCBOs.

"Voltage Dependent Technology" RCDs supplied via the FE (Functional Earth)

In the event of loss of supply (required to address the fault and trip), there are two categories of behavior:

- **Category 1:** the RCD does not open and continuity of service is optimum, because the load is powered on when the voltage is restored, but the RCD is unable to operate if the loss of power supply is the result of a neutral break.
The presence of line voltage is a hazard because the RCD is no longer able to perform its protection function in the event of contact with the line potential
- **Category 2:** the RCD opens if there is loss of power supply (including in the event of neutral break).After the voltage is restored, the RCD must be reclosed to power on the load again.

To improve the level of protection provided by category 1 RCD, in the event of neutral breaking, the product is supplied by redundancy via the FE (line to FE supply instead of line to neutral), allowing it to continue to perform its protection function.
This configuration allows the behavior of VDT RCDs to be compared with that of VIT RCDs.

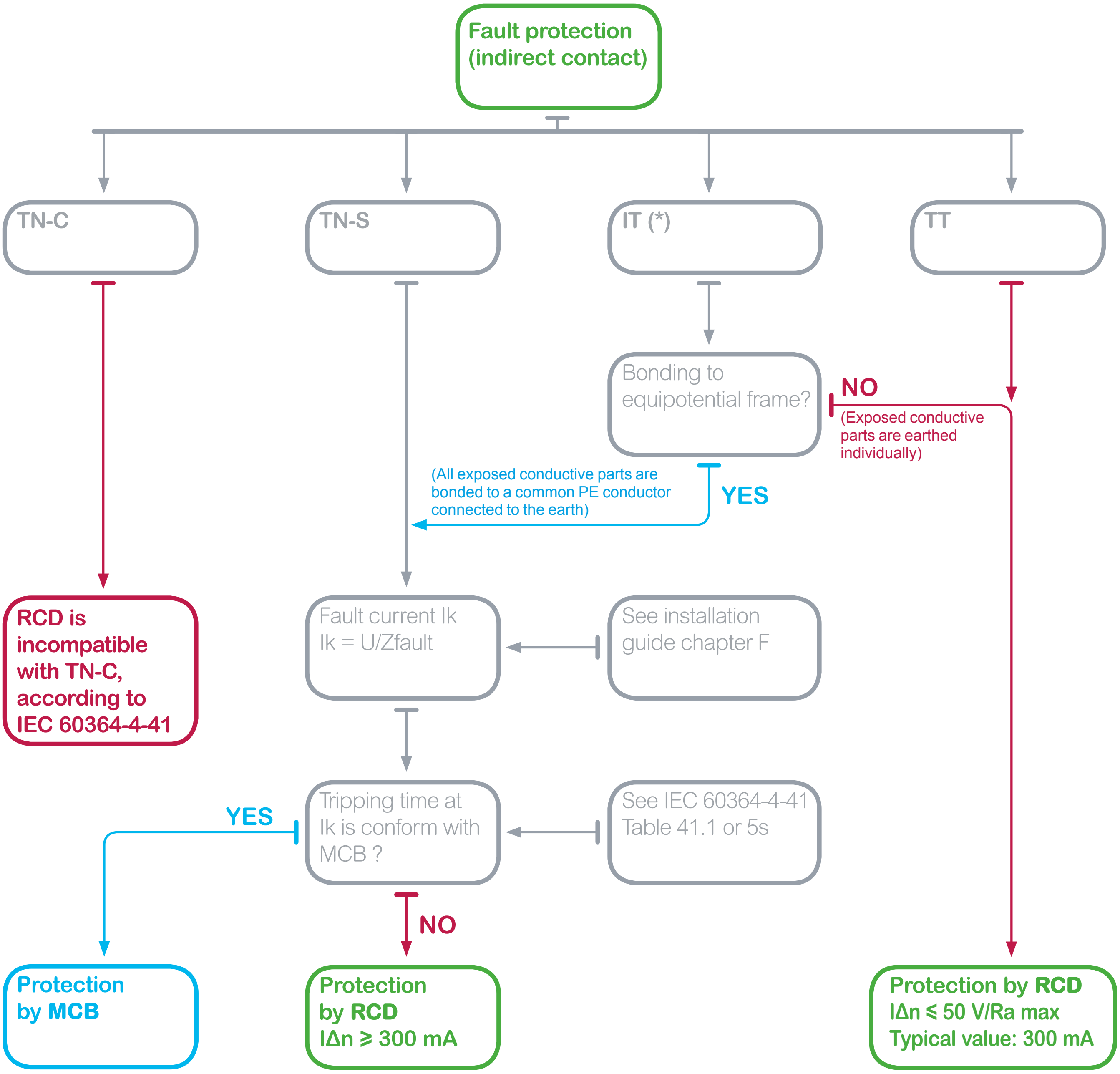
Note
Parts 2-1 and 2-2 of IEC/EN 61008 and IEC/EN 61009 must be applied for a product to be able to claim full conformity with the standards in question.

- conformity with the standards is confirmed by a national conformity mark on the product. The mark is assigned by a third-party organization independent of Schneider Electric. This involves regular sampling at the production site to ensure continued conformity with the standards in question.

How to select and install residual current devices

How to choose fault protection (indirect contact) according to method of earthing

Selector no. 1: Involvement of RCD depends on method of earthing



Additionnal protection

If installation rules impose **30 mA RCD** additional protection (see Selector no. 2), this requirement is applicable **whatever the method of earthing**.

Note for IT system:
Only circuits with socket-outlet without high level of availability can be protected with 30 mA RCD because risk of unwanted tripping is high.

Compared to a TT/TN single-phase leakage current, in IT system, leakage current increases significantly when a first failure occurs. This can lead to sympathetic tripping of RCD on parallel circuits.

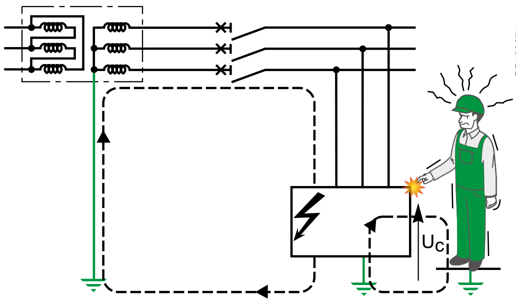
- It is multiplied by 4 in 4-wire system.
- It is multiplied by 3 in 3-wire system.
- It is multiplied by √7 in single-phase system.

This first failure creates inrush currents due to non symmetric system and a low transient impedance.
A **A-SI type RCD** is highly recommended.

(*) This case considers the occurence of 2 phase-to-chassis faults.

How to select and install residual current devices

How to choose fault protection (indirect contact) according to method of earthing (continued)



Protection against indirect contacts

The response times of residual current devices are in conformance with the requirements of the installation standards (IEC 60364 for protection against indirect contact).

Indirect contact

A person who comes into contact with an accidentally live frame caused by an insulation fault experiences an indirect contact: the contact voltage Uc creates a current that passes through the human body.

Maximum breaking time

The maximum breaking time required by the installation standards, in the event of an insulation fault, depends on:

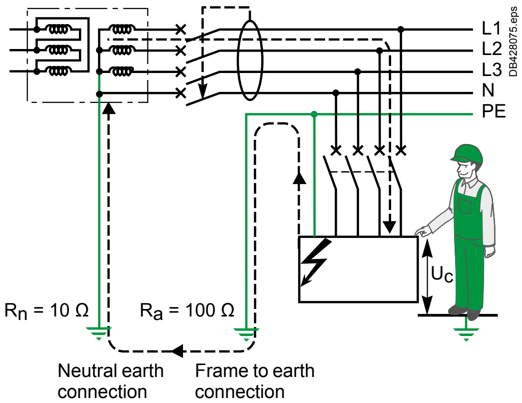
- the network voltage
- the method of earthing.

Maximum breaking time for terminating circuits (ms)

Method of earthing	Network line/neutral voltage			
	≤ 120V	120 < U ≤ 230V	≤ 400V	> 400 V
TN or IT	800	400	200	100
TT	300	200	70	40

Note

A breaking time of no more than 5 s is permitted for distribution circuits, to ensure selectivity with the devices installed on the terminal circuits.
This time should be reduced to the essential minimum.
These times are based on the maximum prospective values of the contact voltage Uc and on the contact times authorized by technical report IEC 60479.



Example

On a three-phase line/neutral voltage network Uo = 230 V in a TT system:

- the resistance of the neutral earth connection Rn is 10 Ω
- the resistance of the frame to earth connection Ra is 100 Ω.

In the event of an insulation fault, the leakage current Id is equal to: Uo/(Ra+Rn) i.e. 230 V/110 Ω = 2.1 A.
The contact voltage Uc is therefore Id x Ra, i.e. 2.1 A x 100 Ω = 210 V.

Protection sensitivity

The residual current device must trip as soon as the leakage current corresponds to a hazardous situation, i.e. a contact voltage of 50 V (in a dry atmosphere).
Hence, IΔn = 50 V/Ra, i.e. 50 V/100 Ω = 500 mA.

Maximum breaking time

For a 230 V line/neutral voltage network in a TT system, the IEC 60364 series of standards requires a maximum breaking time of 200 ms.
For the 2.1 A leakage current:

- an instantaneous residual current device with a sensitivity of 300 mA will open the circuit in less than 40 ms
- an instantaneous residual current device with a sensitivity of 500 mA will open the circuit in less than 150 ms.

Medical environment: the reference contact voltage is 25 V.

Note

For well-designed and regularly maintained electrical installations, the resistance of the frame to earth connection can be less than 100 Ω.

Use of time-delayed residual current devices

In accordance with the breaking times required by the installation standards (above), the selective and time-delayed residual current devices can be used in the following cases:

Circuit	Network voltage (line/neutral)	Residual current device		
		Instantaneous I	Selective S	Time-delayed R
Terminating circuit	≤ 230 V	■	■	(1)
	> 230 V	■		
Sub-distribution or general		■	■	■

(1) Only in a TN system for a line/neutral voltage < 120 V.

C

How to select and install residual current devices

Sensitivity of RCD is selected by type of installation and protection need

Choice of sensitivity

The sensitivity of a residual current device depends mainly on its function:

- protection from electric shock by direct contact
- protection from electric shock by indirect contact
- protection from fire due to leakage current.

The following table indicates:

- the circuits that must be protected against these various risks (obligation or recommendation)
- the type of residual current device to be used in each case, its sensitivity and its location in the distribution diagram.

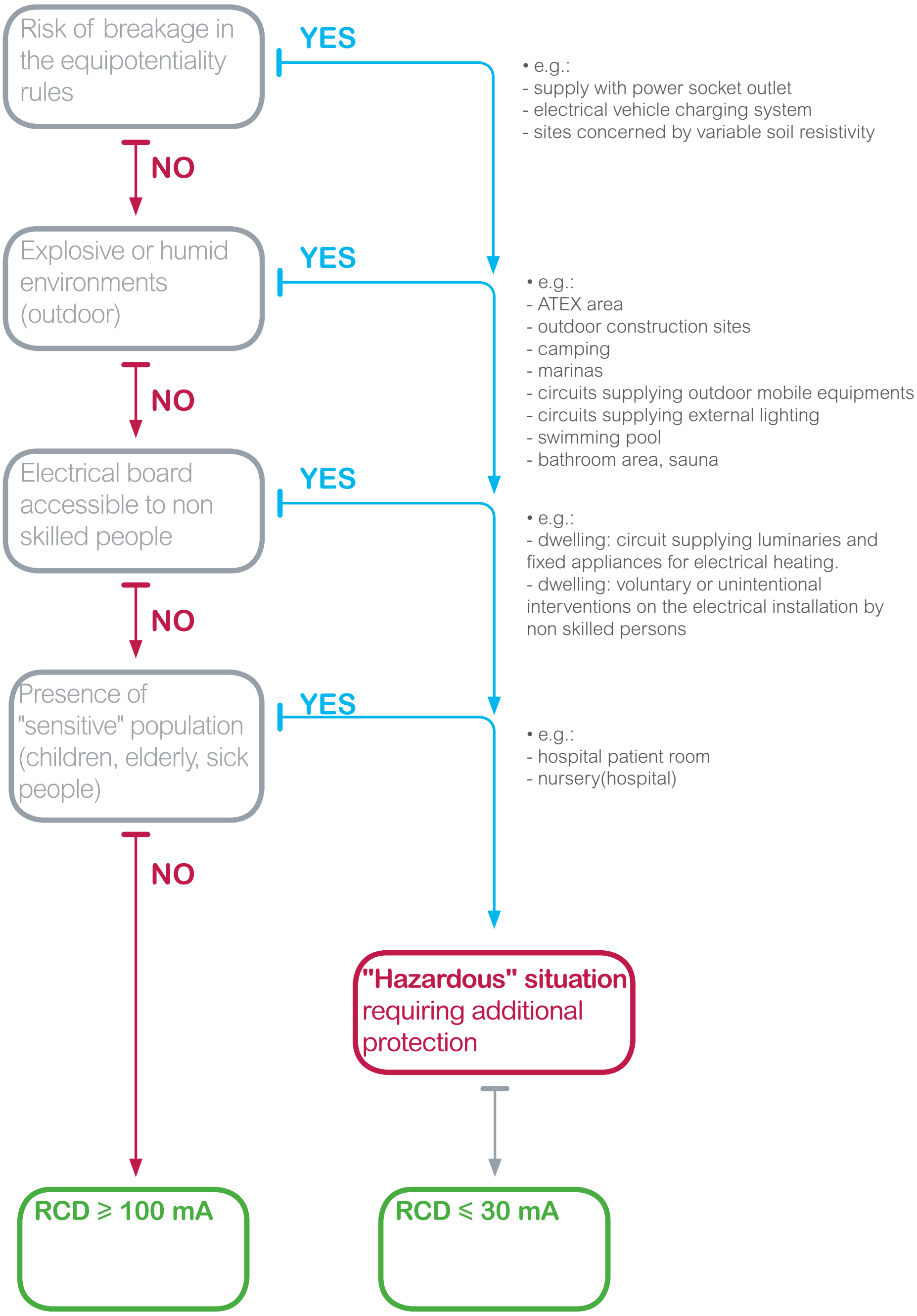
Type of protection	Standard requirements		Additional Schneider Electric recommandations	Sensitivity (IΔn)
	National standard *To be filled in according to the country standard*	**International series of standards IEC 60364**		
Protection from electric shock by direct contact				
	To be filled in according to the country standard	Power supply for: ■ general purpose power sockets, up to 20 A ■ appliances in the vinicity of bathtub, shower, pond or swimming pool ■ portable appliances for outdoor use, up to 32 A ■ lighting To be modified according to national obligations (above)	None	**30 mA (*)**
Protection from electric shock by indirect contact				
	To be filled in according to the country standard	The entire power distribution, except for devices: ■ with Class II insulation ■ operating at Safety Extra Low Voltage (Class III) To be modified according to national obligations (above)	None	**100 mA to 3000 mA** (depending on the method of earthing)
Protection from fire due to leakage current				
	To be filled in according to the country standard	■ High-risk premises: □ explosion (BE3) □ fire (BE2) ■ Agricultural and horticultural buildings ■ Equipment for fairs, exhibitions and shows ■ Temporary outdoor recreational installations To be modified according to national obligations (above)	■ Dilapilated buildings or electrical installations ■ Humid atmospheres: agricultural buildings, public swimming pools ■ Presence of chemical agents ■ Where particular risk of fire exists or where consequences of fire are unacceptable. See "Electrical Fire Prevention Guide"	**300 mA (or 500 mA)**

(*) 10 mA sensitivity is useful for certain very specific applications where there is a risk that someone could sustain a 10 to 30 mA current without being able to get free. This type of residual current can be recommended in public buildings visited by children, the elderly and animals; it can also be used in the terminal sockets of hospital rooms. Generally, devices with this very high sensitivity are liable to cause frequent tripping, due to the natural leakage currents of the installation.

How to select and install residual current devices

Sensitivity of RCD is required by installation and persons risks

Selector no. 2: Choosing the sensitivity of earth fault protection according to the risks factors



Note

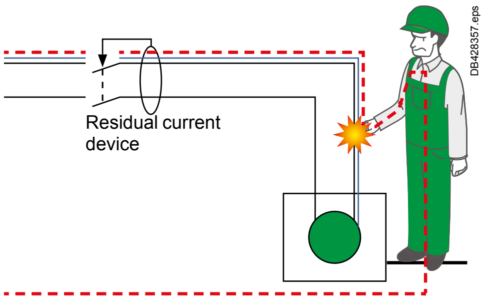
- These requirements depend on local regulation.
- If electrical power availability is essential for safety (ex: medical operating theater, intensive care room...), RCD is not allowed according to IEC 60364-7-710.

C

How to select and install residual current devices

RCD coordination is key for continuity of service

All the high-sensitivity residual current devices (30 mA) in the Acti9 range are conform to the IEC/EN 61008, IEC/EN 61009 and IEC/EN 62423 series of standards.



1- High-sensitivity 30 mA

Response time

The response time of a residual current device is the time between the appearance of a dangerous leakage current and the interruption of the circuit.

AC, A, A-SI, F, B types: alternating leakage current (AC)

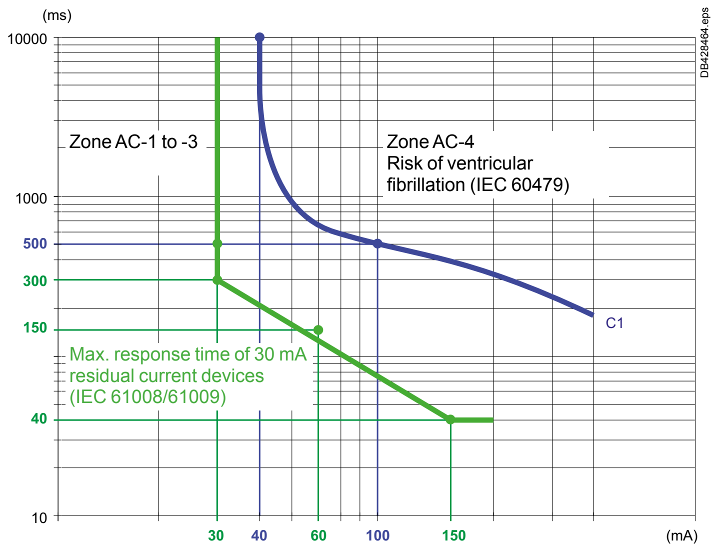
Fault current (mA)		Maximum response time (ms)
IΔn/2	15 mA	No tripping
IΔn	30 mA	300 ms
2 x IΔn	60 mA	150 ms
5 x IΔn	150 mA	40 ms

B type: direct leakage current (DC)

DC fault current (mA)		Maximum response time (ms)
IΔn/2	15 mA	No tripping
2 x IΔn	60 mA	300 ms
4 x IΔn	120 mA	150 ms
10 x IΔn	300 mA	40 ms

These response times comply with the specifications of the IEC/EN 61008, IEC/EN 61009 and IEC/EN 62423 series of standards (DC leakage current).

High sensitivity differential protection (< 30 mA) must not be delayed because it is used when there is a risk that the earth leakage fault passes directly through the human body.



- The IEC 60479 international standard studies the sensitivity of the human body to the electric current. Curve C1 defines for each current value the maximum time before a person is at risk of ventricular fibrillation.
- Superimposing the two curves shows that the above response times protects the users.

Measuring the response time

If the user wishes to check the response time of his residual current devices, he should follow a specific procedure to:
- establish a leakage current of calibrated magnitude
- measure the exact response time.

Procedure

The measuring instruments must conform to IEC/EN 61557-6. Carry out the operations in the following order according to the safety instructions:
- disconnect the loads
- install the measuring instrument downstream of the residual current device to be tested (for example on a power outlet)
- perform the measurement.

How to select and install residual current devices

RCD coordination is key for continuity of service (continued)

2- Medium-sensitivity 100 mA...1000 mA

Response time of Acti9 iC60 Vigi and Acti9 iID residual current devices

The residual current devices of medium-sensitivity (100...1000 mA) in the Acti9 range comply with the IEC/EN 61008, IEC/EN 61009 and IEC/EN 62423 series of standards (DC leakage current).
In the case of selective versions (S), a "non-tripping time" guarantees selectivity with the residual current devices installed downstream.

Instantaneous residual current devices

Residual current devices		Sensitivity (IΔn) 100 mA	300 mA	500 mA	
AC, A, A-SI, F, B types: alternating leakage current (AC)					
Fault current (mA)	**IΔn/2**	50	150	250	No tripping
					Max. response time
	IΔn	100	300	500	300 ms
	2 x IΔn	200	600	1000	150 ms
	5 x IΔn	500	1500	2500	40 ms
	500 A				40 ms

Selective (S) and time-delayed (R)residual current devices

Residual current devices		Sensitivity (IΔn) 100 mA	300 mA	500 mA	1000 mA	Type Selective (S)		Time-delayed (R)	
AC, A, A-SI, F, B types: alternating leakage current (AC)									
Fault current (mA)	**IΔn/2**	50	150	250	500	No tripping		No tripping	
						Non-tripping time	**Response time**	**Non-tripping time**	**Response time**
	IΔn	100	300	500	1000	130 ms	500 ms	300 ms	1000 ms
	2 x IΔn	200	600	1000	2000	60 ms	200 ms	150 ms	500 ms
	5 x IΔn	500	1500	2500	5000	50 ms	150 ms	150 ms	300 ms
	500 A					40 ms	150 ms	150 ms	300 ms

Note: In UL1053 standard, non tripping current of IΔn/2 is replaced by 0.74 IΔn.

Instantaneous residual current devices

Residual current devices		Sensitivity (IΔn) 300 mA	500 mA	
B type: direct leakage current (DC)				
Fault current (mA)	**IΔn/2**	150	250	No tripping
				Max. response time
	2 x IΔn	600	1000	300 ms
	4 x IΔn	1200	2000	150 ms
	10 x IΔn	3000	5000	40 ms
	5 A...200 A			40 ms

Selective (S) residual current devices

Residual current devices		Sensitivity (IΔn) 300 mA		
B type: direct leakage current (DC)				
Fault current (mA)	**IΔn/2**	150	No tripping	
			Non-tripping time	**Response time**
	2 x IΔn	600	130 ms	500 ms
	4 x IΔn	1200	60 ms	200 ms
	10 x IΔn	3000	50 ms	150 ms
	5 A...200 A		40 ms	150 ms

Definitions

Response time
Time between the appearance of a hazardous leakage current and circuit power down.

Non-tripping time
For selective and time-delayed devices, the non-tripping time is the time between the appearance of a hazardous leakage current and the device tripping.
If the leakage current disappears before this time, the device does not trip.
The fast disappearance of the leakage current can be due to:
- the transient nature of the fault (e.g. current generated by a switching surge)
- the interruption of the fault current by another faster residual current device situated downstream

Selective and time-delayed devices therefore provide:
- better immunity against nuisance tripping
- total selectivity between the residual current devices.

C

How to select and install residual current devices

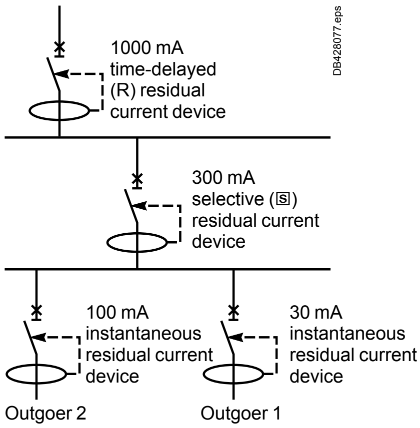
RCD coordination is key for continuity of service (continued)

Selectivity of residual current devices

The non-tripping times of type (S) and (R) residual current devices ensure selectivity with those located downstream, given the following rules are respected:

- the sensitivity of the upstream device must be at least three times the sensitivity of the downstream residual current device
- the upstream residual current device must be:
  - Selective (S) if the downstream residual current device is instantaneous,
  - Time-delayed (R) if the downstream residual current device is selective (S).

The figure below shows how compliance with these rules provides selectivity on three levels: whatever the fault current amplitude, and whatever the location of the fault, the maximum tripping time of downstream RCD is lower than the minimum non actuating time of the just upstream RCD.

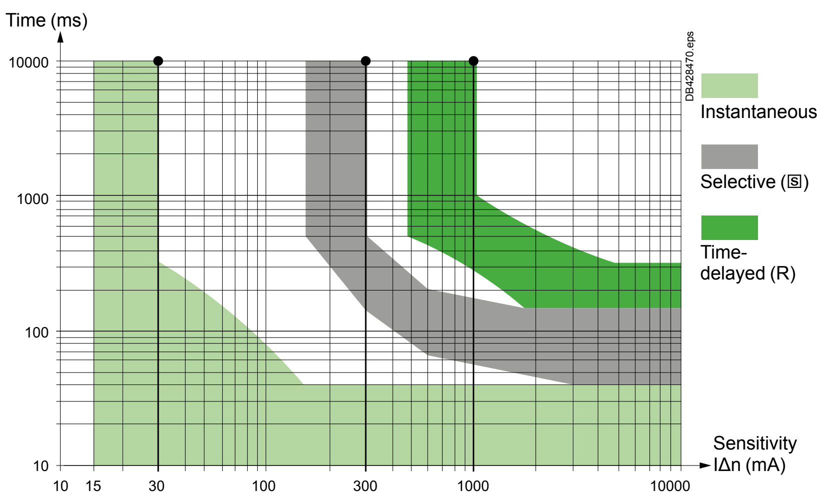


Example

In the above graph, for a fault current of 1000 mA:

- if the fault occurs downstream of the 30 mA residual current device, the latter will interrupt the current in less than 40 ms, whereas the type S and type R devices "wait" for about 100 ms and about 500 ms respectively. Therefore, neither of the two devices trips.

If these cascading combination rules are complied with, the level of continuity of service provided to the user depends on the way in which the loads are distributed into final circuits, each protected by a residual current device.

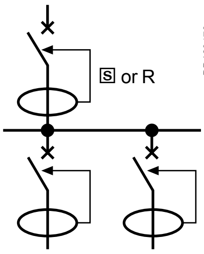


How to select and install residual current devices

RCD coordination is key for continuity of service (continued)

Selectivity

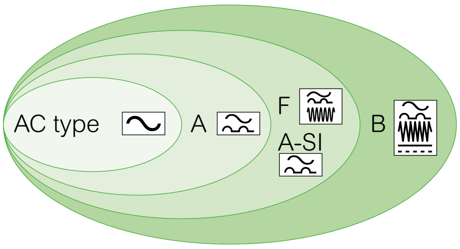
Residual current devices with medium-sensitivity (100 mA and above) are available in the selective (S) and time-delayed (R) versions.
This option ensures that when an earth leakage fault occurs downstream of the device, only this circuit is taken out of service. The following table indicates (green areas) the upstream/downstream device combinations that provide such selectivity.



Sensitivity (mA) - Downstream		Sensitivity (mA) - Upstream												
		Instantaneous						Selective S					Time-delayed R	
		30	100	300	500	1000	3000	100	300	500	1000	3000	1000	3000
Instantaneous	30	-	-	-	-	-	-							
	100	-	-	-	-	-	-	-						
	300	-	-	-	-	-	-	-	-	-				
	500	-	-	-	-	-	-	-	-	-	-		-	
	1000	-	-	-	-	-	-	-	-	-	-		-	
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-
Selective S (60 ms)	100	-	-	-	-	-	-	-	-	-	-	-		
	300	-	-	-	-	-	-	-	-	-	-	-		
	500	-	-	-	-	-	-	-	-	-	-	-	-	
	1000	-	-	-	-	-	-	-	-	-	-	-	-	
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-
Time-delayed R (150 ms)	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-

How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads

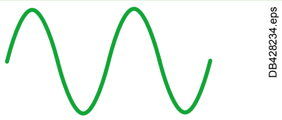
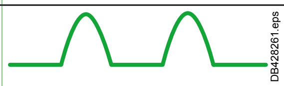
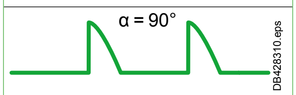
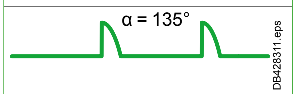
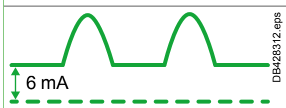
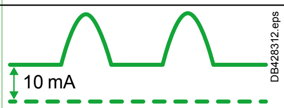
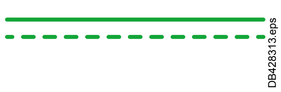


The increase in use of electronic loads can result in earth leakage current with different waveform characteristics. This situation must be carefully analyzed as it affects the performance of RCD. That is why the IEC series of standards has defined four types of RCD.

Example:
When an insulation fault occurs in the DC stage of a switch-mode power supply (e.g. variable speed drive) or on a DC network supplied by a converter, the leakage current is rectified and is no longer a sine wave. This current waveform may not be detected correctly by the residual current device.

In order to select the residual current devices that are appropriate to each situation, the IEC 60755, IEC 61008, IEC 61009 and IEC 62423 standards define four types of residual current device, according to the waveforms that cause them to trip.

Standards

Type of residual current device				Waveform characteristics		Supply circuit protection
				Waveform shape	**Frequency**	
			AC type		IΔn at 50 Hz	Current loads
					1.4 IΔn at 50 Hz	Loads including rectifiers (low-power speed drivers, rectifiers / chargers...) powered by single-phase network
	F type	A type				
	A-SI type					
B type					DC offset up to 6 mA	
					DC offset up to 10 mA IΔn composed of signals at 10 Hz, 50 Hz, 1 kHz	Loads including single-phase speed drives: washing machine, air-conditioning unit, heat pump, food processor...
					■ 2 IΔn direct current ■ 1.4 IΔn ■ Frequency of current 150 Hz 0.5 to 2.4 IΔn ■ Frequency of current 400 Hz 0.5 to 6 IΔn ■ Frequency of current 1000 Hz 1 to 14 IΔn	■ Loads including rectifiers used in lifts, cranes, HVAC (three-phase AC/DC converters as high-power industrial speed drives, three-phase UPS...) powered by three-phase network ■ Single-phase DC boost power supply in some EV chargers

See appendix for circuit detail

How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads (continued)

Choice of type

Schneider Electric provides various equipment technologies capable of overcoming the consequences of interference of all kinds.

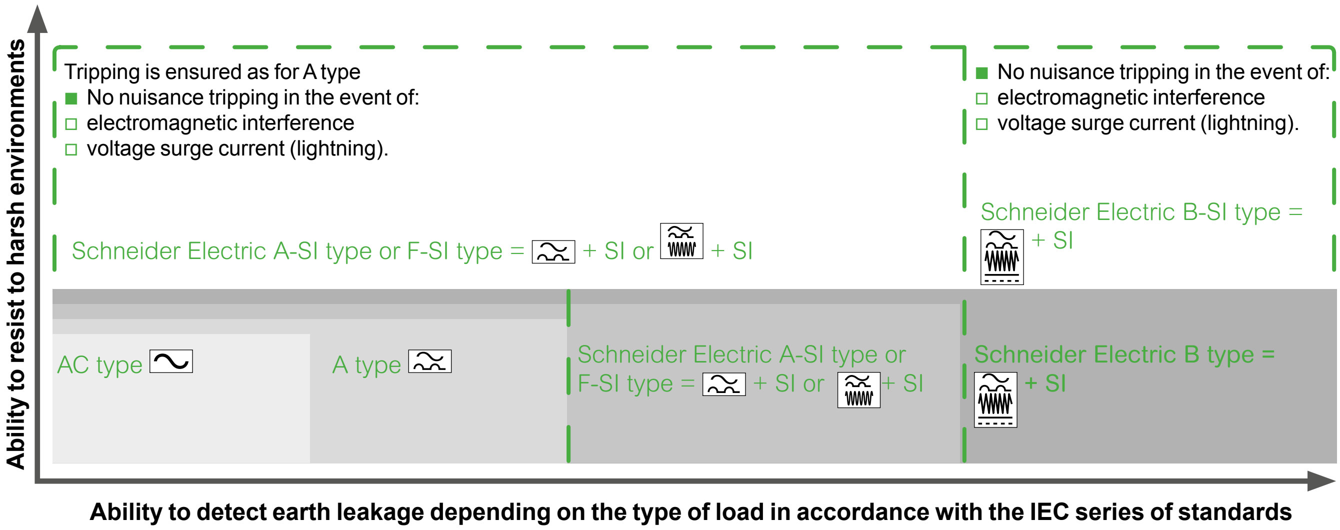
Operating conditions		Examples	Types AC	A	A-SI	F	B-SI
Load							
DB123165.eps With no special characteristics		■ General purpose power sockets ■ Incandescent or LED lighting ■ Class II consumer electronic: hair dryer, TV, etc. ■ Electric heater, water heater	■	■	■	■	■
Including a rectifier	Single-phase	■ Class I domestic appliances: induction cooking appliances, washing machines, tumble-dryer ■ Single-phase UPS ■ Single-phase photovoltaic system ■ Machines including diodes, capacitors and rectifiers ■ Motors ■ Machine tools	-	■	■	■	■
	Three-phase	■ Three-phase variable speed industrial drives (motors: cranes, elevators, heating, ventilation, air conditioning, pumps) ■ Single-phase/three-phase chargers for electric vehicles ■ Three-phase UPS (rectifier and inverter) ■ Motors: cranes, elevators, heating, ventilation, air conditioning (HVAC), pumps ■ Three-phase photovoltaic system ■ Medical equipment with DC current loads	-	-	-	-	■
Generating high frequency interference (current peaks, harmonics)		■ Single-phase variable speed industrial drives: air-conditioning, heating pump ■ Powerful IT equipment, telecommunication equipment ■ Heated floor ■ Fluorescent lighting powered by a extra low voltage transformer, by electronic ballast ■ Variable luminosity lighting ■ Capacitor banks ■ Freezer, cold room	-	-	■	■	■
Including an anti-harmonic filter in the power supply or with high availability requirement		■ Computer peripheral devices (printers, scanners, etc.) ■ Rack of computers and servers ■ Hospital ■ Supermarket cash registers	-	-	■	-	■
Electrical environment							
DB123166.eps Vicinity of equipment generating transient overvoltages		■ High-powered switching devices, medium voltage switchgear ■ Reactive energy compensation banks	-	-	■	■	■
Circuits powered by an uninterruptible power supply		■ Backed-up network	-	-	■	-	■
"Isolated neutral" (IT) method of earthing		-	-	-	■	-	■
Risk of lightning strokes		■ Buildings protected by a lightning protection system ■ Mountainous or humid regions ■ Regions with a high keraunic level	-	-	■	■	■
Atmosphere							
DB123164.eps Ambient temperature which could be less than -5°C		-	- (2)	■	■	■	■
Severe environments whose code varies between AF2 and AF4 according to IEC 60364-5-51		■ Indoor swimming pools ■ Yatch harbours, marinas, camping grounds ■ Water treatment ■ Chemical industries, heavy industries, paper mills ■ Mines and cellars, road tunnels ■ Markets, stock raising, food-processing industries	-	-	■ (1)	■	■ (1)

(1) Atmosphere with high concentrations of chemicals or dust: see tables 1 and 2, page 30 of this document, for a description of corrosive atmosphere classes and appropriate additional protection.
(2) for type AC products, check catalog pages.

How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads (continued)

Conclusion



See appendix for details depending on power converters architectures

C

How to select and install residual current devices

RCD coordination rules in case of risk of DC current in the installation

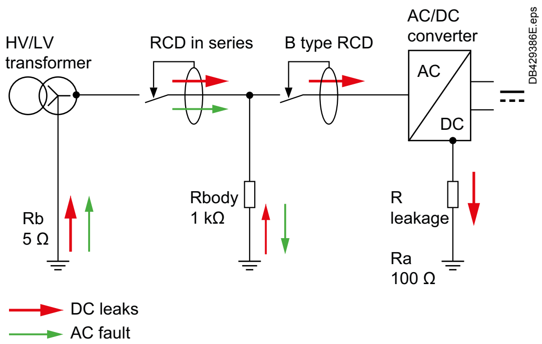
Principles of coordination of types of RCD connected in series and in parallel with B type RCD

In case of a load potentially generating DC earth leakage current, a B type RCD is necessary. The RCDs connected in series or in parallel must not be blinded by a DC current in order to ensure that they can always provide protection in the event of a fault on the part of the network for which they were specified.

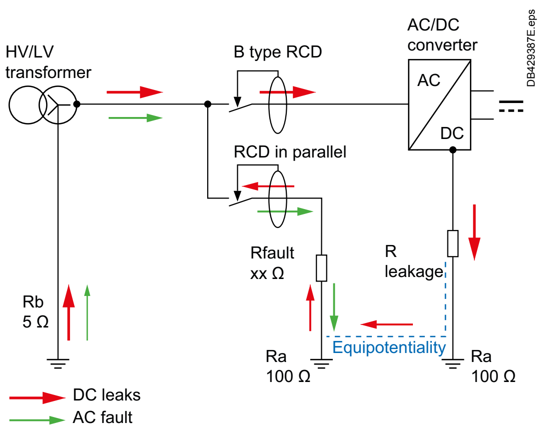
In normal operation, a purely permanent or transient DC current up to **60 mA** can pass through a RCD connected in series or in parallel if the B type RCD current is 30 mA.

- IEC 61008 / 61009 standard series consider a maximum current of 6 mA for A type RCDs and no DC current for AC type RCDs.
- IEC 62423 standard, which covers F type RCDs, considers a maximum current of 10 mA.

The DC leakage current generated by the DC voltage source and produced by the AC/DC converter (DC bus) flows continuously through the RCD connected in series.
The RCD connected in series must provide protection, within the area, against contact between the RCD connected in series and B type RCDs.

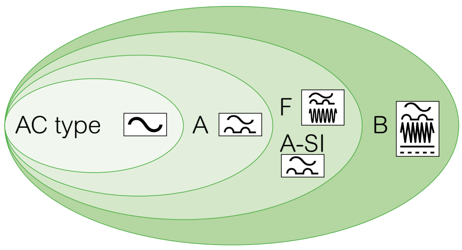


The DC leakage current generated by the DC voltage source and produced by the AC/DC converter (DC bus) only flows through the RCDs connected in parallel in the event of an insulation fault in a parallel load or in the event of contact with the parallel outgoer.
The RCD connected in parallel must provide protection against a downstream contact.
The level of direct current "seen" by the residual current device connected in parallel depends on the equipotentiality level of the exposed conductive parts and their earthing resistance.



How to select and install residual current devices

RCD coordination rules in case of risk of DC current in the installation (continued)



Reminder: in the following recommendations, compliance with the previous coordination rules (protection and selectivity) is always required.

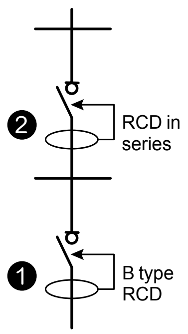
Selector no. 3: Impacts of integration of a RCD B type in an installation with RCDs of other types

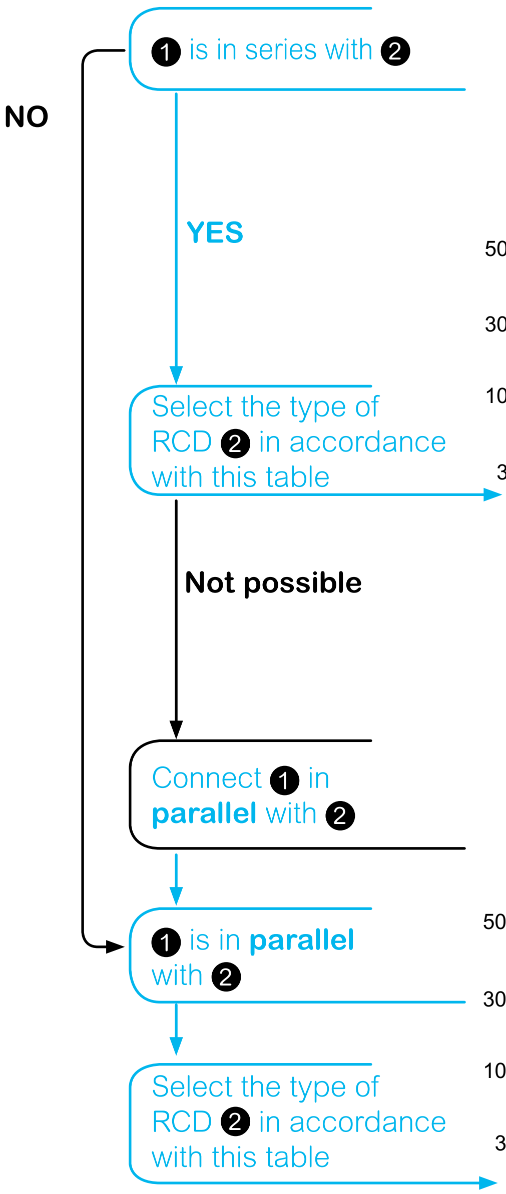
If an outgoer requiring a B type 1 RCD is installed, 2 RCDs connected in series or in parallel must not be blinded by a DC current in order to ensure that they can always provide protection in the event of a fault on the part of the network for which they were specified.
This can be achieved by using B type RCDs upstream 2.
An alternative solution to optimize installation is to use the coordination tables below.
The following conditions are necessary:

- all RCDs are Schneider Electric offer
- TT or TN method of earthing is used
- only one B type RCD is necessary in the installation.

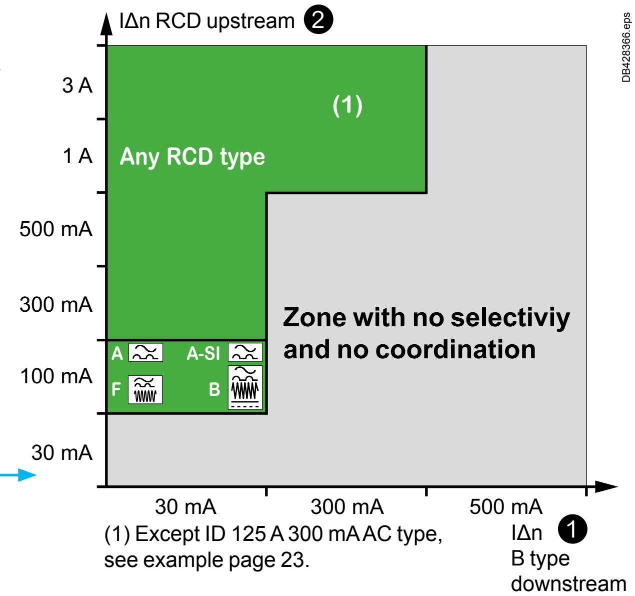
C

In series



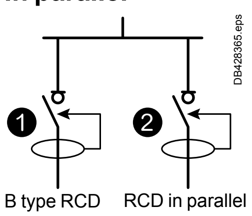


Coordination table for Schneider Electric RCDs connected in series

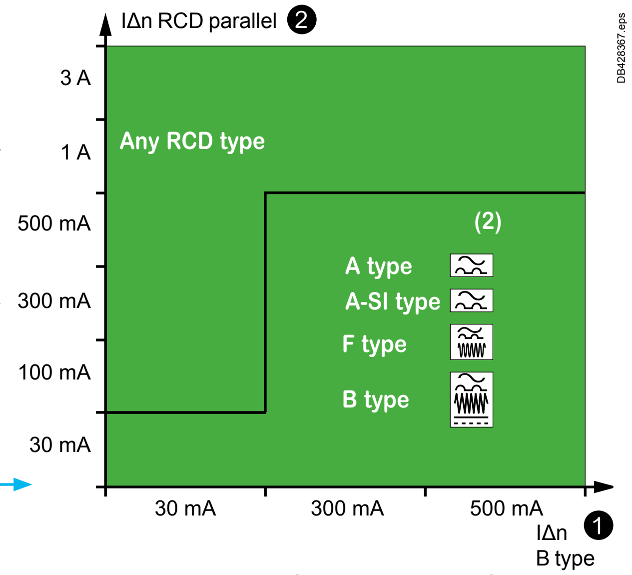


(1) Except ID 125 A 300 mA AC type, see example page 23.

In parallel



Coordination table for Schneider Electric RCDs connected in parallel

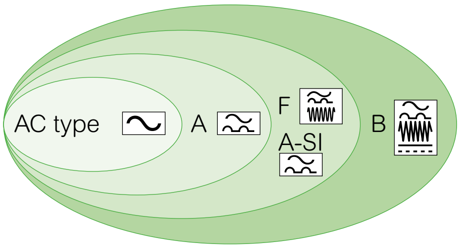


(2) For TN method of earthing, any type of RCDs can be used

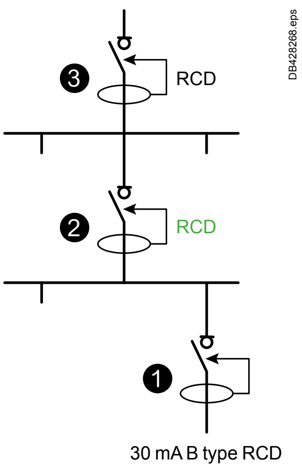
If more than one RCD B type is connected in series and in parallel in the installation, the RCD 2 shall be in accordance with Selector no. 7

How to select and install residual current devices

RCD coordination rules in case of risk of DC current in the installation (continued)



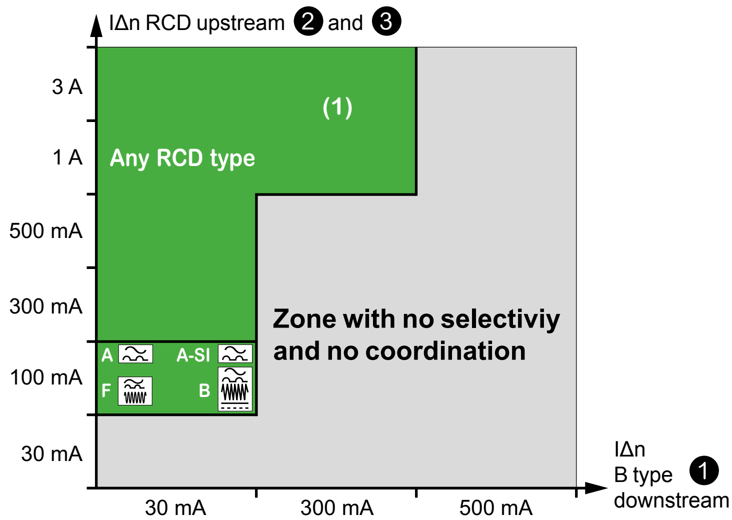
In series



Example: connecting a 30 mA B type downstream of my existing facility

I want to add a 30 mA B type 1 downstream of my existing facility. What other type of RCDs should I have installed?

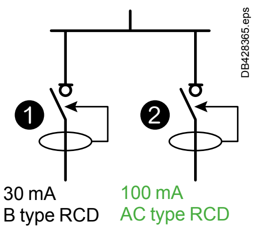
- all the RCDs are Schneider Electric.
- I am using the coordination table for RCDs connected in series to determine 2 and 3
- I can connect my 30 mA B type RCD in series with the existing ones.



According to the above table, the following options for upstream RCDs are possible to meet coordination and selectivity rules:

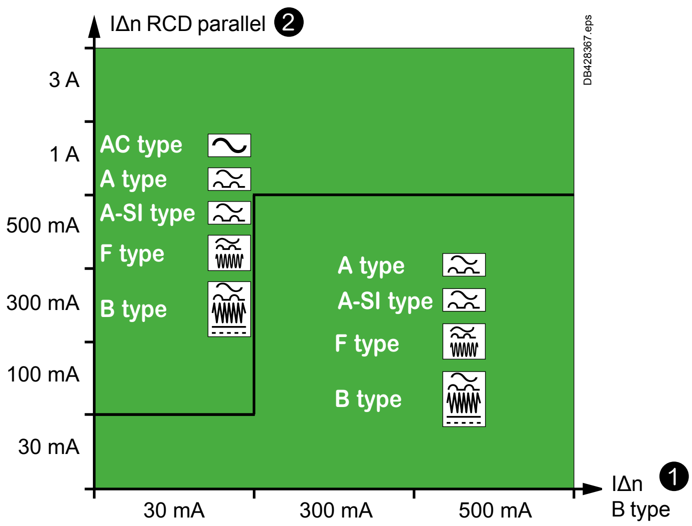
	2	3
Option 1	100 mA, A type selective	300 mA, AC type delayed
Option 2	300 mA, AC type selective	1 A, AC type delayed
Option 3	1 A, AC type selective	3 A, AC type delayed

In parallel



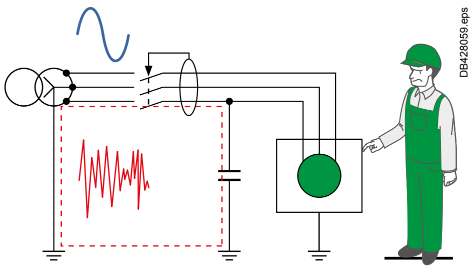
If, in the case above, 2 is a 100 mA AC type and I don't want to change it.

- I have to connect my 30 mA B type RCD 1 in parallel with 2.
- I confirm, using the coordination table for RCDs connected in parallel, that the 100 mA AC type RCD will not be blinded.
- I confirm, using the same coordination table for all the RCDs connected in parallel, that they are not blinded.



How to select and install residual current devices

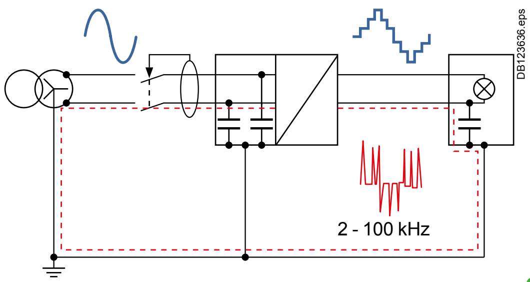
For continuity of service, RCD must withstand the leakage currents in the installation



As RCDs are designed to detect very low currents (e.g.: 30 mA), interference due to the network or its environment can, in certain cases, result in RCD tripping.

■ **Nuisance tripping** is disconnection of the power supply when no hazardous situation exists. This type of tripping is often repetitive, which is highly detrimental to the quality of the electricity supply and causes operational interference for the user.

■ The risk of interference must be taken into account when selecting residual current devices, according to the loads supplied and the environment.
■ The explanations given below specify the main types of interference, their origin and how Schneider Electric residual current devices respond, according to their type.



Nuisance tripping

Nuisance trippings are due to non dangerous leakage currents existing in the installation.
They can come from:
■ Transient or permament high-frequency currents (high-frequency harmonics)
■ Low-frequency leakage currents..

Rule 1: use a Schneider Electric A-SI type residual current device

High frequency harmonics
■ The current absorbed by non-linear loads such as IT equipment power supplies, frequency converters, variable speed drive motor controls, electronic ballast lights, etc. contains high-order harmonics.
■ If the natural capacitances of the protected circuit are significant (between cables and earth, or between the live parts of the devices and their frames), residual current devices may be tripped, but the earth leakage current is not dangerous.
■ Electronic loads generating high-frequency common mode currents are fitted with EMC filters to ensure that they do not disturb the sensitive environment.
On power-up or during various voltage surges, these filters, which consist of capacitors, produce transient current inrushes that can cause nuisance tripping.

Rule 2: limit the number of loads on the same residual current device

To ensure satisfactory operation, it is important to ensure that these continuous leakage currents do not exceed 30% of the sensitivity (IΔn) of the residual current device by limiting the number of "interfering" loads protected by the same residual current device.

Low-frequency leakage currents
This risk of nuisance tripping is all the more likely to occur when a large number of identical loads are supplied in parallel and protected by the same residual current device.

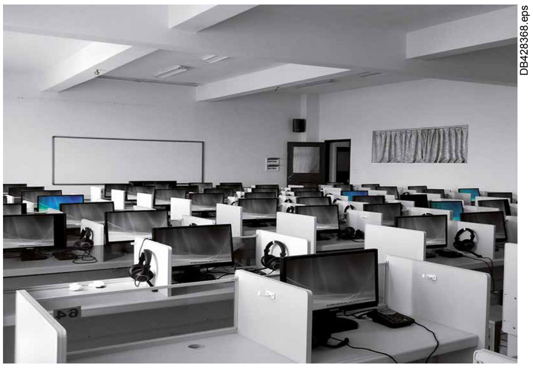
These leakage currents are mainly generated by the filtering capacitors in the power supply stage of electronic devices. Depending on the number of devices protected by the same residual current device, these leakage currents may:
■ increase the risk of tripping in the event of high-frequency interference
■ cause frequent tripping.

Rule 3: limit the total length of cables to 300 meters downstream a 30 mA RCD

Impact of cable length
If long cables are installed downstream of the residual current devices, it may be necessary to take the natural capacitance formed by the cable/earth pair into account (order of magnitude: at 230 V, approximately 1.5 mA for 100 m).

How to select and install residual current devices

For continuity of service, RCD must withstand the leakage currents in the installation (continued)



Low-frequency leakage currents

To ensure satisfactory operation, it is important to ensure that these continuous leakage currents do not exceed 30% of the sensitivity (IΔn) of the residual current device.

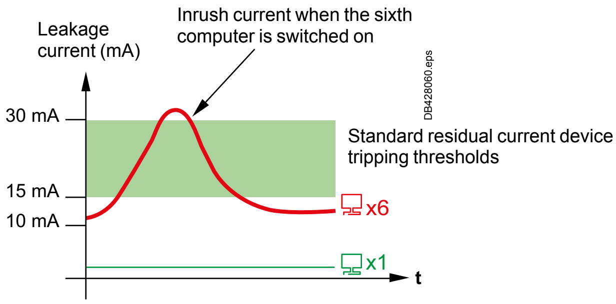
General requirements

In accordance with IEC 60335-1, the leakage current will not exceed the following values:

- for class II appliances and for parts of class II construction: 0.25 mA
- for class 0, 0I and III appliances: 0.5 mA
- for class I portable appliances: 0.75 mA
- for class I fixed motor-operated appliances 3.5 mA
- for class I fixed heating appliances: 0.75 mA or 0.75 mA/kW of rated power, with a maximum of 5 mA, whichever is the higher.

Exemple of causes of residual current device tripping

Electronic loads



- The estimated continuous leakage current of a computer is approximately 2 mA. This leakage current is very weak and therefore not dangerous.
- The sum of all the continuous leakage currents can cause what may be considered as nuisance tripping (as it is not related to a hazardous situation).
- To avoid this risk, a continuous leakage current of less than 30% of the sensitivity of the residual current device is recommended, i.e. 10 mA for a 30 mA residual current device.
- This gives an order of magnitude of a maximum of six computers downstream of a 30 mA residual current device.

C

How to select and install residual current devices

For continuity of service, RCD must withstand the leakage currents in the installation (continued)

Type of load	Standard	Allowed leakage current	Maximum leakage current
Fixed PC, workstation	Estimated (230 V/50 Hz)		2 mA
Portable computer	IEC 60335-1		0.5 mA (with EMC filter)
Printer	Estimated (230 V/50 Hz)		1 mA
Photocopier	Estimated (230 V/50 Hz)		1.5 mA
Heating floor	IEC 60335-1	0.75 mA or 0.75 mA/kW of rated power, whichever is the higher	5 mA
Dishwasher (fixed class 1)	IEC 60335-2-5	3.5 mA or 1 mA/kW of rated power, whichever is the higher	5 mA
Cooking ranges hobs, ovens and equivalent fixed appliances	IEC 60335-2-6	1 mA or 1 mA/kW of rated power, whichever is the higher	10 mA
Washing machines (fixed class 1)	IEC 60335-2-7	3.5 mA or 1 mA/kW of rated power, whichever is the higher	5 mA
Drum tumble-dryer (fixed class 1)	IEC 60335-2-11	3.5 mA or 1 mA/kW of rated power, whichever is the higher	5 mA
Grills toasters and similar portable cooking appliances	IEC 60335-2-9		■ 0.75 mA (earthed metal) ■ 0.25 mA (no earthed metal)
Pads	IEC 60335-2-17		0.5 mA
Blankets and mattresses		1 mA/m² of the heated area	2.5 mA
Refrigerating appliances, ice cream appliances and ice makers	IEC 60335-2-24		■ 0.75 mA (class 0I appliances) ■ 1.5 mA (class I appliances)
Massage fixed class 1 appliances	IEC 60335-2-32		0.75 mA
Instantaneous class I water heaters	IEC 60335-2-35		0.25 mA
Class 1 electric cookers, ovens, hobs and hot plates for collective use	IEC 60335-2-36	1 mA/kW of rated power	■ 10 mA (with a power supply cord and power socket-outlet) ■ No maximum (for other)
Class 1 electric griddles for collective use	IEC 60335-2-38		
Class 1 electric fryer for collective use	IEC 60335-2-39		
Electric heat pumps, air conditioners and dehumidifiers (fixed class 1)	IEC 60335-2-40	2 mA/kW of rated power	■ 10 mA (appliances accessible to the general public) ■ 30 mA (appliances not accessible to the general public)
Electric kitchen machines for collective use	IEC 60335-2-64		3.5 mA (without a heating element)
		1 mA/kW of rated power (with heating element)	■ 10 mA (with heating elements power supply cord and power socket-outlet) ■ No maximum (other appliances with heating element)
Commercial vending machines with or without means of payment (fixed class 1)	IEC 60335-2-75	1 mA/kW of rated power (professional type appliances)	No maximum (professional type appliances designed to be permanently connected to fixed wiring)
			10 mA (other professional type appliances)
		0.75 mA or 0.75 mA/kW of rated power, whichever is higher (non professional type appliances)	5 mA (non professional type appliances)
Humidifiers	IEC 60335-2-98		0.25 mA
Class 2 hand held kitchen machines	IEC 60335-2-14		0.25 mA
Stationnary class 1 vacuum cleaners and water-suction cleaning appliances	IEC 60335-2-2		3.5 mA
Stationary class 1 fans	IEC 60335-2-80		3.5 mA

Consult IEC 60335-2-X for other types of loads generally in accordance with general requirements depending on classification.

How to select and install residual current devices

For continuity of service, RCD must withstand the leakage currents in the installation (continued)

Leakage current for luminaries

IEC 60598-1 specifies that the leakage current that may occur during the normal operation of a luminaire, between each pole of the supply source and the body of the luminaire, must not exceed the values given in the table below.

Leakage current for luminaires

Type of luminaire	Max. rms values of the leakage current
Perturbations permanentes	**mA**
Continuous interference	0.5
Class 0 and Class II,	1
Portable, Class I	1
Fixed, Class I up to 1 kVA of rated power	Increasing in steps of 1 mA/kVA up to a maximum of 5 mA

C

To limit unwanted tripping, it's recommended to agree with the 3 following rules:

Rule 4: limit the number of circuit under the same RCCB (Ex: 10 lights or 10 sockets)

Rule 5: use RCBO for critical/important loads (Note : MCB + Vigi = RCBO)

Rule 6: for Outdoor lighting & circuits, install dedicated RCCB (higher risk of tripping due to humidity).

Unwanted tripping limitation for a 30 mA RCD

How to select and install residual current devices

Which types of RCD are adapted to "harsh electromagnetic" environment

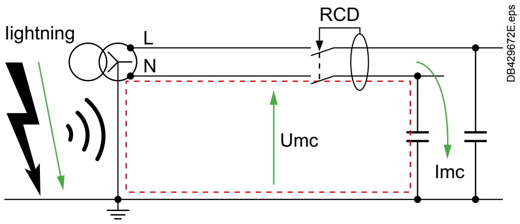


Fig. 1: lightning current discharge to earth

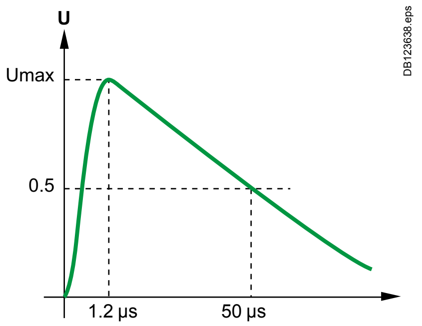


Fig. 2: normalized voltage waveform 1.2/50 µs

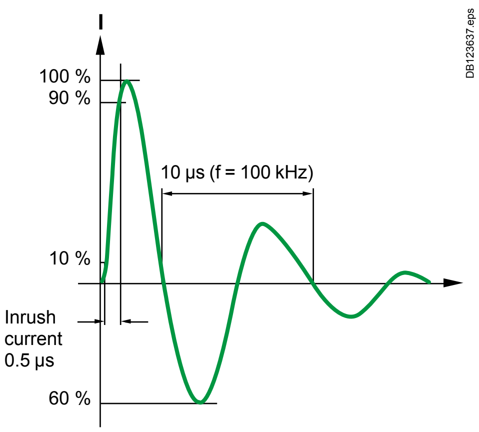


Fig. 3: normalized current waveform 0.5 µs/100 kHz

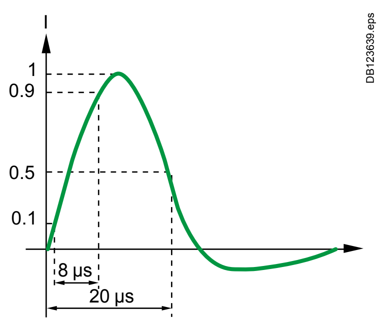


Fig. 4: normalized current waveform 8/20 µs

High-frequency transient currents

Network voltage surges

A lightning current discharge to earth (Fig. 1) generates a voltage surge in the loop made up of Phase+Neutral conductors on the one hand and the earth on the other. This common-mode voltage surge at the input to the facility causes a common mode current due to the common mode capacitance of the cables and of the EMC filters on the loads.
This current is "seen" by the RCD and can lead to nuisance tripping if the latter is not super immunised (SI).
The other types of surge use the same principle to create the common mode currents seen by the RCD.

Common mode voltage surges and associated transient currents
Electrical networks can be exposed to transient voltage surges caused by:
- lightning strikes: these voltage surges are represented normatively by a 1.2/50 µs voltage waveform (Fig. 2). The currents induced in the lines by these voltage surges are represented by a normalized 8/20 µs waveform (Fig. 4)
- sudden changes in network operating conditions (faults, blown fuses, inductive load switching, MV switchgear operations, etc.)
- switching on capacitors creates a transient inrush current similar to that shown in waveform (Fig. 3)
- switching off inductive components, such as power supply transformers used for lighting (halogen or fluorescent) creates brief voltage surges, the frequency of which can reach 10 MHz.

Note
When a fault occurs in an IT method of earthing (isolated neutral), a transient leakage current is created due to the sudden change in potential with respect to earth.
A similar phenomenon can occur when a UPS switches between the main supply and the battery supply, whilst the output neutral is briefly disconnected from the earth (then reconnected with a slight phase lag).

Rule 7: use A-SI, F-SI or B-SI type in harsh electromagnetic environment (high frequency transient current).

Rule 8: drive away polluted cables from others

- The cables that feed motors with speed drives for example causes high frequency magnetic fields.
- These magnetic fields are catched by the loop between L/N and earth/mass of an other circuit protected by RCD. This coupling increases with surface of loop and proximity between polluted cables and clean cables.

How to select and install residual current devices

Which types of RCD are adapted to "harsh electromagnetic" environment (continued)

Immunity of Schneider Electric residual current devices

The A-SI residual current devices exclusive to Schneider Electric demonstrated their immunity to nuisance tripping in all cases of interference indicated below:

Interference	Non-tripping test conditions	Performance required by the IEC 61008/61009 series of standards	Performance of Schneider Electric A-SI type residual current devices
Continuous interference			
Flow of harmonic currents to earth	1 kHz sine wave	None	8 x IΔn
Transient interference			
Voltage surge induced by a lightning strike	Voltage surge (1.2/50 μs) (IEC/EN 61000-4-5)	4 kV between conductors (differential mode) 5 kV between all conductors together and ground (common mode)	4.5 kV between conductors (differential mode) 5.5 kV between all conductors together and ground (common mode)
Current induced by a lightning strike	Current surge 8/20 μs pulse	250 A peak	3 kA
Operating transient current, indirect lightning strike current	Current waveform: 0.5 μs/100 kHz (IEC/EN 61008)	200 A peak	400 A peak
Surge protective device operation downstream of the RCD, switching on capacitors	10 ms current pulse (half sinusoidal wave)	None	500 A peak
Electromagnetic compatibility			
Switching of inductive loads, fluorescent lighting, motors, etc.	Repeated bursts (IEC 61000-4-4)	4 kV/2.5 kHz	5 kV/2.5 kHz 4 kV/400 kHz
Immunity against superimposed 1 kHz to 150 kHz conducted RF waves	Superimposed current 1 kHz to 150 kHz conducted RF waves to 0.3 IΔn 50Hz (IEC 61000-4-16) Non Tripping (Tripping test at 1.25 IΔn 50Hz)	Level 3	Level 3
Fluorescent lighting, circuits controlled by thyristors	Conducted current 150 kHz to 80 MHz RF waves (IEC 61000-4-6)	3 V (IEC) 3 V (EN)	30 V
Radio waves (TV and radios, transmitters, telecommunication, etc...)	Radiated fields 80 MHz to 1 - 6 GHz RF waves (IEC 61000-4-3)	3 V/m (IEC) 10 V/m (EN)	30 V/m

Note: Reference Standard IEC/EN 61543 Residual current-operated protective devices (RCDs) for household and similar use - Electromagnetic.

Note

Schneider Electric A-SI residual current devices have been designed to answer to environments with special conditions, as lightning strikes.

How to select and install residual current devices

Which solutions are adapted to "harsh climatic" environment

Harsh environments

Schneider Electric's A-SI type residual current devices have been designed to answer to environments with special conditions:

- low air temperature: A-SI type devices can operate under temperatures down to -25°C, according to IEC 61008-1 and IEC 61009-1 standards
- atmospheres with high concentrations of chemicals or dust: A-SI type devices can operate in this kind of environment if the appropriate protective measures are taken (see table 1).

Table 1: classification for external influences in the presence of corrosive or polluting substances and required protective measures (IEC 60364-5-51)

Class as per IEC 60364-5-51	External influence	Characteristics	Applications and examples	Recommendations for equipment characteristics and protective measures
AF1	Negligible	Negligible quantity or nature of corrosive or polluting agents	-	Normal
AF2	Atmospheric	Presence of corrosive or polluting atmospheric agents	Installations situated by the sea or near industrial zones producing serious atmospheric pollution, such as chemical works, cement works; this type of pollution arises especially in the production of abrasive, insulating or conductive dusts	According to the nature of the substances (compliance to salt mist test according to NF C 20-702: test Ka)
AF3	Intermittent or accidental	Intermittent or accidental action of certain common chemicals	Locations where some chemical products are handled in small quantities and where these products may come only accidentally into contact with electrical equipment; such conditions are found in factory laboratories, other laboratories or in locations where hydrocarbons are used	■ Protection against corrosion according to equipment specification ■ Cabinet made of unprotected ferrous materials or natural rubber are unsuitable ■ Plastic cabinets are generally suitable
AF4	Continuous	Permanent action of corrosive or polluting chemicals	■ Chemical works ■ Farms (piggery or dairies) ■ Technical room of swimming pool	Equipment specifically designed according to the nature of substances. It is necessary to specify the nature of the chemical agent to allow the manufacturer to define the type of protection of the equipment. Protection is provided by special paints, appropriate coatings or surface treatments or by choice of material.

Example: a technical local of swimming pool must be considered as AF4, because it is subject to the permanent presence of corrosive chlorinated derivatives.
The materials must be specially studied according to the nature of the agents: reinforced A-SI type of Acti9 offer and cabinet in overpressure.

Table 2: choice of residual current device

Product function	Product range	Class as per IEC 60364-5-51			
		AF1	**AF2**	**AF3**	**AF4**
RCCB	Acti9 iID, Acti9 iID K, Acti9 iID bico, RCCB-ID A-SI 125 A	■	A-SI	A-SI and sealed cabinet, class IP65 or higher	**A-SI and IP65 electrical cabinet + ventillated room with clean outdoor air**
	RCCB-ID 125 A, REDs, REDtest		Sealed cabinet, class IP65 or higher	Sealed cabinet, class IP65 or higher	**IP65 electrical cabinet + ventillated room with clean outdoor air**
RCD Vigi add-on	Vigi iC60, Vigi C120, Vigi NG125		A-SI	A-SI and sealed cabinet, class IP65 or higher	**A-SI and IP65 electrical cabinet + ventillated room with clean outdoor air**
RCBO	iSPN Vigi, Acti9 iC60 RCBO				

Examples of exposed sites	External influences
Iron and steel plants	Presence of sulfur, sulfur fumes, hydrogen sulfide
Pleasure-craft harbors, trading ports, ships, seasides, shipyards	Saline environments, humid environments, low temperatures
Swimming pools, hospitals, food and drink sector	Chlorinated compounds
Petrochemicals	Hydrogen, combustion gas, nitrogen oxides
Livestock facilities, discharges	Hydrogen sulfide

How to select and install residual current devices

RCD must be coordinated with overvoltage protections

RCD coordinated with overvoltage protections

If there is a RCD at the head of the installation, the surge arrester will preferably be placed upstream of the RCD.
If this is not allowed by the energy distributor, the RCD must be delayed (type Ⓢ).

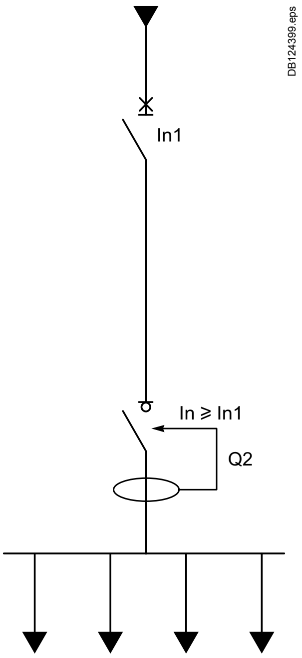
If there is no RCD at the head of the installation, but a circuit breaker, a RCBO associated with the surge arrester, is connected in series with the surge arrester.

Another RCD can be used for the rest of the installation.
This arrangement will avoid triggering the RCD of the installation if a fault current remains in the arrester.

The RCBO in series with the surge arrester provides protection against indirect contacts on the surge arrester itself.

How to select and install residual current devices

RCD must be coordinated with overcurrent protections



Introduction

The following coordination data is valid only for Schneider Electric products.

Protection of residual current circuit breakers

Residual current circuit breakers must be protected in the same way as all the components of the electrical installation:

- against overloads
- against short-circuits.

Coordination between the residual current circuit breaker and its protection device must be guaranteed and proven by the manufacturer.
Moreover, in a TN method of earthing, it must be ensured that the protection devices are capable of interrupting earth fault currents of high amperage.

Overload protection

- The current rating of the residual current circuit breaker is the maximum permanent current for which the product is designed.
- It is protected against overloads by the circuit breaker located upstream on its power supply line (1).

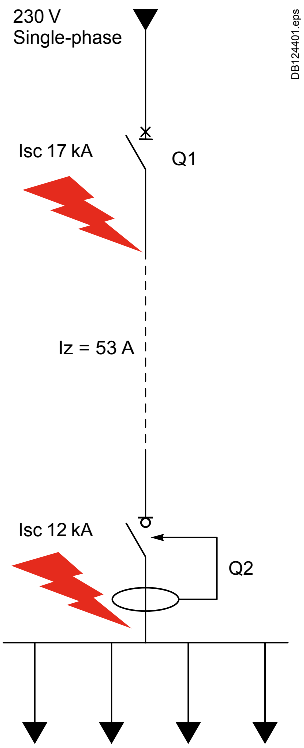
As a consequence:

The rating of the residual current circuit breaker must be equal or greater than the rating of the circuit breaker located upstream.

Example

On a circuit protected by an Acti9 iC60 32 A, a residual current circuit breaker of rating 40 A or 63 A must be installed.

(1) In some countries, the installation standards consider that overload protection can be provided by all the downstream circuit breakers if the sum of their ratings is less than or equal to the rating of the residual current circuit breaker.



Short-circuit protection

- The switch is protected against short-circuits by the circuit breaker (or fuse) located upstream on its power supply line.
- To prevent any damage, the circuit breaker must sufficiently limit any short-circuit current that may pass through the switches (up to the maximum short-circuit current Isc at its installation point).

The short-circuit withstand of the switch or residual current circuit breaker is given in the tables below, as a function of the upstream circuit-breaker.
It must be greater than or equal to the prospective short-circuit current Isc at its installation point.

Example

Choice of Q1 and Q2 protection devices in the diagram opposite:

Circuit breaker Q1		
Rated current	Less than or equal to the cable withstand Iz	50 A
Breaking capacity	Greater than or equal to short-circuit current Isc (17 kA)	Acti9 iC60N 2P or C120N 2P (20 kA at 230 V)
Residual current circuit breaker Q2		
Rated current	Greater than or equal to that of circuit breaker Q1	63 A
Short-circuit withstand (Inc)	Greater than or equal to short-circuit current Isc (12 kA)	Acti9 iID 63 A : ■ with Acti9 iC60N: 20 kA is appropriate ■ with C120N: 20 kA is appropriate

How to select and install residual current devices

RCD must be coordinated with overcurrent protections (continued)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Acti9 iID B type

Protection against earth fault currents

In the event of an insulation fault in the TN system, the line-to-earth fault current is equal to the line-to-neutral fault current.

- The residual current circuit breaker interrupts this current if it does not exceed its specific breaking capacity IΔm.
- If the fault current exceeds this value, it must be interrupted by the circuit breaker located upstream.

Therefore, the magnetic threshold (instantaneous tripping threshold) of the circuit breaker must always be less than or equal to the breaking capacity of the residual current circuit breaker (IΔm).

Breaking and making capacity (IΔm) of Acti9 iID residual current circuit breakers

Rating (A)	AC, A, A-SI, F type	B type
≤ 80	1500	1500
100	1500	-
125	1250	1250

The combination of an Acti9 iID residual current circuit breaker and a suitably rated Acti9 iC60 circuit breaker naturally fulfils this condition.

Example

- Acti9 iID40 residual current circuit breaker, rating 63 A: IΔm = 1500 A.
- Acti9 iC60N circuit breakers, rating 63 A:
  - □ B curve: magnetic threshold 189 to 315 A,
  - □ C curve: magnetic threshold 315 to 630 A,
  - □ D curve: magnetic threshold 630 to 882 A.

The condition is met, whichever Acti9 iC60 circuit breaker is used (maximum rating 63 A).

If a fuse is used, the user must check that the fuse melting time is less than the response time of the residual current circuit breaker for a fault current greater than IΔm, i.e. for a type Ⓢ residual current circuit breaker: 40 ms.

Note
See coordination table, module CA908023.

The residual current devices (RCBO and circuit breakers + Vigi) are coordinated by virtue of their design, due to the thermomagnetic protection of the circuit breaker function.


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Acti9 iID40


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Acti9 iC60N


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Acti9 iCV40


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Acti9 iC60N and Vigi iC60

How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC)

Our products are designed for 50 Hz networks and are compliant with the IEC/EN 61008 and IEC/EN 61009 series of standards.

50 Hz networks

As seen above, the various IEC/EN 61008, IEC/EN 61009 and IEC 62423 series of standards define the specifications of residual current devices. Our products are designed to protect people against indirect and direct contacts, with the accessible metal parts of the facility connected to an appropriate method of earthing. They are designed for AC networks, with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz.
Most of Schneider Electric's residual current devices have been designed for networks with a rated frequency of 50 Hz.

Our UL/CSA certified products for the U.S. are compatible with 60 Hz networks.

60 Hz networks

We also have UL/CSA certified products for North American markets, which are compatible with 60 Hz networks.
However, as our earth leakage systems were designed for a frequency of 50 Hz, a sensitivity derating of approximately 86% must be applied to VI products.

Sensitivity of residual current devices (mA)

Sensitivity	
To IEC 61008, 61009, 62423 (50 Hz)	**To UL 1053 (60 Hz)**
30 mA	26 mA
100 mA	86 mA
300 mA	260 mA

These VI RCDs including B type can be used for 60 Hz networks. They have a sensitivity that is derated by the same order of magnitude as the table above. They therefore do not correspond to the non-tripping at IΔn/2 specification.

VD RCDs don't have sensitivity derating between 50 Hz and 60 Hz and can be used at both 50 Hz and 60 Hz..

Products compatible with 60 Hz networks

- Acti9 iDPN Vigi (230 V):
  - 30 mA type AC, A,
  - 300 mA type AC.
- Acti9 iC60N/H/H2 RCBO
- Acti9 DB60
- Acti9 iID
- Acti9 Vigi iC60
- Acti9 Vigi iC40
- Acti9 iID40
- Acti9 iCV40 N/H
- Acti9 iC60H RCBO PoN
- QOvs RCBO
- QOvs RCCB
- Acti9 xID biconnect RCCB
- Acti9 Vigi xC60.

How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

The 400 Hz frequency is mainly used in the aerospace and aeronautics sectors, as well as in some specific applications such as the computer power supplies or portable machine tools.

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400 Hz networks

Fields of application

The main advantage that led to the use of the highest frequency is that transformers and motors designed for a frequency of 400 Hz are far more compact and lightweight than those built for the common frequencies of 50 or 60 Hz. On the other hand, power cannot be carried economically over long distances at such frequencies, which is why the use of 400 Hz is limited to particular sectors and has been specifically adopted as standard for supplying power to commercial and military aircraft.
The increase in frequency allows the weight of embedded generators to be reduced.

Focus on the use of the 400 Hz network in the aeronautics sector

Four types of applications use a 400 Hz network:
- aircraft power distribution
- infrastructures for supplying aircraft on the ground or embedded on ships
- maintenance workshop for embedded devices
- aircraft assembly workshop (planes, helicopters).

How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

The performance level of products designed for household frequencies of 50 or 60 Hz is impacted by the particular properties of 400 Hz frequency networks.

Special features and impacts on the performance of final distribution switchgear

Phenomena due to the increased frequency influence the behavior of the copper components of transformers, cables and switchgear in devices designed to ensure the production of the distribution of a 400 Hz network.
For circuit breakers and Residual Current Devices (RCDs), the impacts concern:

- the performance of: magnetic, heat and breaking stage functions
- the level of sensitivity of residual current devices.

Protection against indirect contacts

Protection against indirect contacts is ensured according to the rules specified in the installation regulations in force:

- section 411.3 of NF C 15-100
- part 4-41 of the IEC 60364 series of standards.

The breaking times defined in these regulations are considered valid for frequencies up to 1000 Hz.
Although the electrical impedance of the human body decreases, the perception, retention and ventricular fibrillation thresholds increase with the frequency.

The various studies on the protection of persons against electrical hazards have defined the ventricular fibrillation threshold which, for a signal of 50 Hz to 1000 Hz, is shown on a "current/contact time" curve specified by international standard IEC 60479-2.
These studies also show that at 50 Hz and above, the human body becomes less and less sensitive to current flow as the frequency increases.
The relationship between current frequency and level of risk to the human body is also covered in information given in IEC 60479-2, which can be used for risk assessment.
The ventricular fibrillation threshold determined at 30 mA at a frequency of 50 Hz increases depending on the signal frequency according to a curve defined by changes in frequency factor (Fig. 1).
(On the curve below, at 400 Hz, the frequency factor is 6. Consequently, the physiological effect of a 180 mA - 400 Hz current will be the same as that of a 30 mA - 50 Hz current).

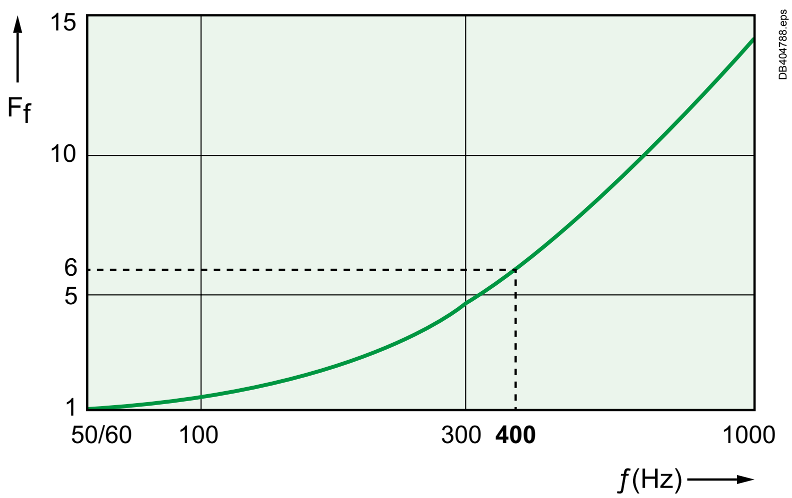

Fig. 1. Variations in the ventricular fibrillation threshold for shocks duration exceeding the period of cardiac cycle (as per IEC 60479-2).

Quality of service

Leakage currents are higher when the frequency increases, which increases the risk of nuisance tripping.
This should be taken into account when choosing a protection device.

How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

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Vigi iC60

Compatibility of final distribution switchgear

Protection of persons

Care should be taken in choosing the characteristics of a residual current device and ensuring that its performance levels are validated by the manufacturer.
The level and quality of protection may be affected by the type of residual current device used and the technology chosen.

The final distribution product range offers four types of earth fault protection for use on 50 or 60 Hz networks.

The following table lists the compatibility of the products with 400 Hz networks.

Type of protection	Possible use on 400 Hz networks (*)	Use	Continuity of service
			Product
A-SI type	Yes	Pulsating DC component + electrical interference (lightning strikes, industrial voltage surges, etc.)	Multi9 ID/GFP Acti9 iID Acti9 iDPN Vigi Multi9 Vigi C60 Acti9 Vigi iC60 Acti9 Vigi iC40 Acti9 Vigi iCG40 Acti9 iCV40
A type	No	AC currents that are sinusoidal or have a pulsating DC component	-
AC type	No	Sinusoidal AC currents	-
B-SI type	Yes	Applications with a three-phase supply, when Class 1 devices installed downstream are liable to generate DC component fault currents	Acti9 iID

(*) Protection of persons is ensured in compliance with the requirements of IEC 60479-2.

At a frequency of 400 Hz, only A-SI and B-SI types are compatible, according to the characteristics defined by IEC 60479-2.
The A type, for its part, has an incompatible response curve that exceeds the maximum limit required by the standard.

At a frequency of 400 Hz, the earth leakage TEST function of a product designed for 50/60 Hz networks does not work, as the threshold for this function is calibrated for a frequency of 50/60 Hz.
Use the RCD tester instead of test button to test the RCD.

How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

Acti9 iID40

Acti9 Vigi iC40

Acti9 iCG40

Acti9 Vigi iC60

Acti9 iCV40

Acti9 iID B type

Multi9 ID

AC Type

Provides the degree of protection required for the safety of persons, but has a higher level of sensitivity and a risk of premature tripping.
This type of protection is not recommended on the 400 Hz network, in particular for applications requiring a very high quality of service.

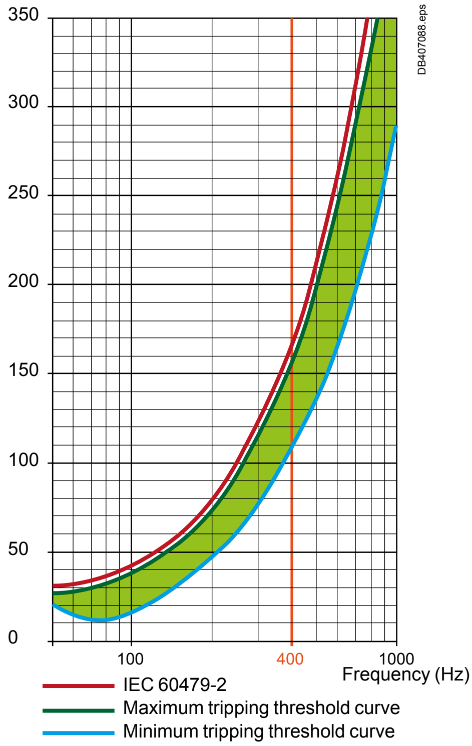
A-SI Type

Provides the response curve closest to the fibrillation level without exceeding it.
Combines both the required degree of protection and a service continuity requirement.

Each category of products providing protection against indirect contacts has its own tripping curve profile, depending on the technology used and the frequency of the current, within a housing defined by a low and a high threshold.
Tripping will be effective and guaranteed between:

- a maximum tripping threshold that must be as close as possible to, but remain below the curve specified by IEC 60479-2
- and a minimum tripping threshold that must be as close as possible to the high threshold curve to ensure the best quality of service.

While ensuring the safety of persons, the reduction in tripping thresholds has a direct impact on the level of quality of service. The lower the curves, the greater the risk of nuisance tripping.



How to select and install residual current devices

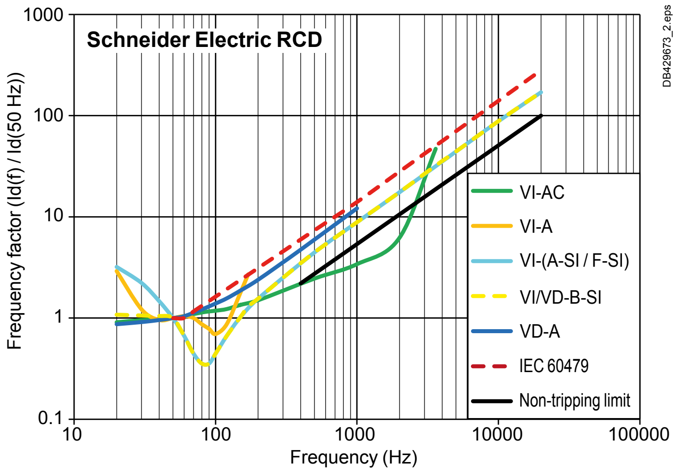
Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

Frequency performance of our RCDs for the different types

Increasingly frequently used power converter applications generate contact voltages (U) "rich" in high harmonic frequencies (a few kHz) created by "electronic switching". These switching frequencies can reach 20 kHz, for example on a variable speed drive.
Schneider Electric has developed **SI** RCDs that have been integrated into the **A-SI**, **F** and **B-SI** products. They guarantee the protection of persons, while optimizing continuity of service with respect to non-hazardous capacitive leakage currents. These currents are proportional to the frequency (EMC filters, long cable lengths, etc.).

The tripping characteristics of these RCDs are below the safety curve and above the curve leading to nuisance openings (non-tripping limit of Schneider Electric RCDs).

Performance of Schneider Electric RCDs



How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

Environment		Maximum non dangerous voltage for human	
		AC	**DC**
Dry environment Zman = 1200 Ohm	Uc = Z x If	50 V	120 V
Wet environment Zman = 600 Ohm	Uc = Z x If	25 V	60 V
Underwater environment Zman = 300 Ohm	Uc = Z x If	12 V	30 V

With **Z** corresponding to the impedance of the human body in different types of environment,
If being the current passing through the body and **Uc** the minimum contact voltage required to reach the hazard current.

24-48 V direct current networks

Protection against electric shocks

In 24 or 48 V DC applications, the "extra-low-voltage" (SELV or PELV) is usually the protective measure for protection of persons against electrical shocks in case of fault. The table below shows the voltage limits according to the IEC 60479-2 standard. In that case, the circuit breakers are required only for circuit protection against over-currents (overload, short-circuit and earth fault).
The voltage level is not enough to ensure compliance with SELV or PELV requirements: the source and circuits must also comply with IEC 60364-4-41-414 (isolation/separation from higher voltage system).

Under normal operating conditions, this voltage range (24 V-48 V DC) is therefore not dangerous to human beings.

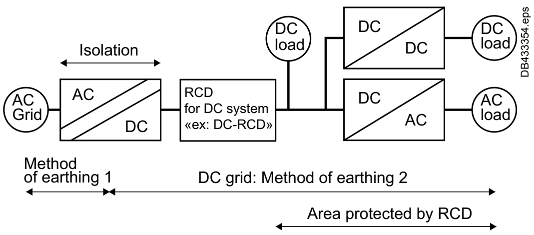
How to select and install residual current devices

Which categories of RCD are adapted to specifics distribution network (50 Hz, 60 Hz, 400 Hz, DC) (continued)

Higher than 120 V direct current distribution

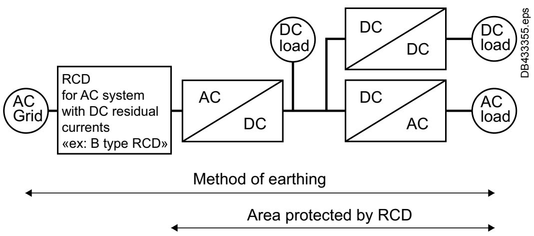
Protection against electric shocks

The protective measure is usually "automatic disconnection of the supply" for this voltage. The circuit-breaker tripping time for a minimum earth fault shall be checked according to table 41.1 of IEC 60364-4-41.



DC networks isolated from AC networks

Residual current devices intended for AC networks will not work with a direct current distribution powered directly by a battery, a generating set, photovoltaic cells or a rectifier with galvanic isolation.
New IEC TS 63053 standard defines the operating and safety characteristics of residual current devices for DC systems (also called DC-RCDs).



DC networks connected to an AC network

In the case of direct current distribution powered by an AC/DC converter (without galvanic isolation), earth fault protection can be provided by circuit breakers or residual current circuit breakers installed on the AC network upstream of the converter.

Protection against direct contacts

High-sensitivity earth fault protection (IΔn = 30 mA) is mandatory if there is a risk of some DC circuits exposing live parts (see installation standards + protection level 3 defined in the introduction). This protection must be:
- A-SI type (bipolar), if the converter is powered by a single-phase supply with double insulation
- B-SI type, if the converter is powered by a three-phase supply or a single-phase supply without double insulation.

Note
A description of how to select the right type of earth fault protection for applications can be found in the Annex.

The choice of earth fault protection does not depend on the method of earthing.

Protection against indirect contacts

Protection against indirect contacts		Medium sensitivity earth fault protection IΔn ≥ 300 mA			
Upstream power supply		Three-phase		Single-phase	
Characteristics of direct current circuits to be protected		Without double insulation	With double insulation	Without double insulation	With double insulation
Upstream method of earthing	**TT** or **IT** with non-interconnected exposed conductive parts	B-SI type	B-SI type	B-SI type	A-SI type
	TN-S	A-SI type(1)			
	IT				

(1) There is a possibility that conventional short-circuit protection may not trip, due to the current limitations caused by electronic power converters.

Fire protection

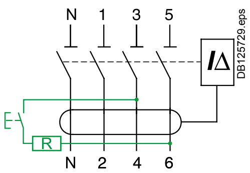
Fire protection	Medium sensitivity earth fault protection IΔn = 300 mA
Upstream supply	Single-phase or three-phase
Characteristics of of direct current circuits to be protected	Humid, dusty environments, facilities and buildings in poor condition
Upstream method of earthing	No effect
	A type

How to ensure maintenance of installation

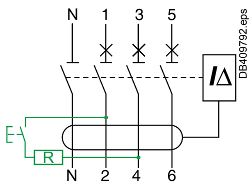
Routine operating checks of residual current devices: local test and loop test

Residual current devices are designed to protect against hazardous earth fault current. That is why:
- the electrical installation operation and maintenance standards require these protection devices to be tested at regular intervals
- the IEC 61008 and IEC 61009 series of product standards require such devices to be fitted with a test button (marked "T") on the front panel.
The user can therefore check and be certain that the device is working correctly.

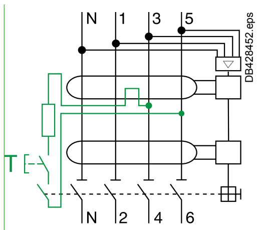
The test button allows the user to check if the RCD is able to trip in presence of an earth leakage current. If the device doesn't trip, it must be examined to determine if the device is out of service.



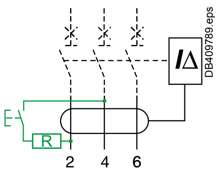
Acti9 iID 4P



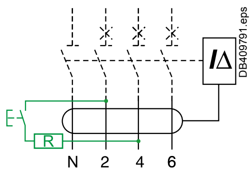
DPN Vigi 3P+N
Acti9 iCV40 3P+N



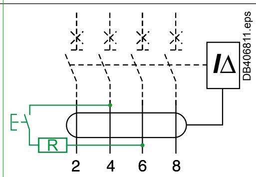
Acti9 iID 3P+N B type



Acti9 Vigi C60 3P



Acti9 Vigi iC40 3P+N



Acti9 Vigi iC40 4P

1- Test frequency

Residual current devices must be tested as required by local regulations or guidelines on electrical installation inspection and maintenance.
In the absence of any local regulations or guidelines, Schneider Electric recommends that the test is carried out:

For Voltage independent RCDs:
- after initial connection and any subsequent reconnection
- **every six months**, for devices installed in AF1* environmental conditions (no dust, corrosion, high humidity, etc.)
- **every month**, for devices installed in AF2* to AF4* environmental conditions or highly exposed to voltage surges.

(*) Refer to table 2 in page 30 for definition of classes of environmental conditions.

For Voltage dependent RCDs:
- after initial connection and any subsequent reconnection
- **every month**, whatever the environmental conditions or exposition to voltage surges.

2- Procedure

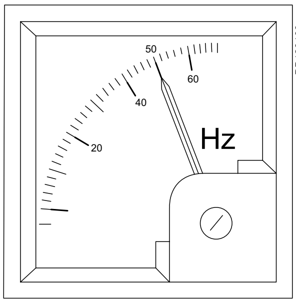
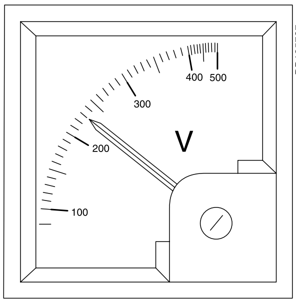
The residual current device is powered on and the loads are connected	Briefly press the test button marked "T" on the front panel **Note** It is recommended to disconnect the loads before testing	The residual current device should trip instantly. If it doesn't trip, the additional checks described next page should be performed	When the test is finished, put the residual current device device back into service
			

How to ensure maintenance of installation

Routine operating checks of residual current devices: local test and loop test (continued)

3- If the RCD doesn't trip during the test

This event is mainly due to a cause that is external to the residual current device.
The table below shows the possible causes, the additional checks and tests to be carried out and the corrective actions to be taken, depending on the results.
After a corrective action has been performed, repeat the test.

Cause of non tripping			
Network frequency	**Network voltage**	**Connection (three-pole or four-pole device)**	**Load leakage currents**
Additional action			
Check that the network frequency is the same as the frequency read on the device or in the catalog	Check that the main voltage is the same as that indicated on the front face of the device	Measure the voltage between terminals: ■ 3 and 6 for Acti9 iID 4P ■ 2 and 4 for Acti9 Vigi C60 3P ■ at the middle for Acti9 Vigi iC40 or DPN Vigi 3P+N or 4P This voltage must be between 85% and 110% of the voltage indicated on the device	Disconnect the loads and press the test button again
 DB428463.eps	 DB125727.eps		 DB125726.eps
Result after additional action			
If the network frequency is different, the test button test is not significant	■ If the voltage measured is less than 85% of that indicated on the device, the test button may not work, although the protection device will continue to function ■ If the voltage measured is more than 110% of the voltage indicated on the device, there is a risk to damage the device.	■ The incorrect voltage may be due to a connection error (e.g. line/neutral inversion, missing phase, etc.) ■ Acti9 three-pole and four-pole residual current devices cannot be used on single-phase circuits ■ Acti9 four-pole residual current devices can be used normally on three-phase circuits without neutral	If the device trips, the earth fault protection is not working correctly in the presence of the loads
Corrective actions			
The device must be checked by a RCD tester (IEC/EN 61557-6)	**If the voltage measured is different from the rated network voltage, look for the problem on the power supply or on the downstream circuits (lines, loads).** **Otherwise:** ■ if the rated network voltage is lower than that indicated on the device, the device must be replaced by one with a suitable rated voltage, the next time it is shut down ■ if the rated network voltage is higher than that indicated on the device, the device must immediately be replaced by one with a suitable rated voltage	**Modify the connection to obtain the rated voltage (line-line) between terminals**	**Measure the permanent leakage current of each load** ■ In the event of abnormal load leakage, correct the insulation fault ■ Separate the circuits to reduce the permanent leakage currents seen by each residual current device ■ Consider the replacement of the device by a different type of RCD adapted to the permanent leakage current **Note** Disconnect the loads in the event of a resistance leak

If the RCD doesn't trip after all the additional actions, it must be tested with an external RCD tester.

How to ensure maintenance of installation

Routine operating checks of residual current devices: local test and loop test (continued)

Some tertiary and industrial installation maintenance regulations require residual current devices to be checked with a specific device.

4- Checking with a RCD tester

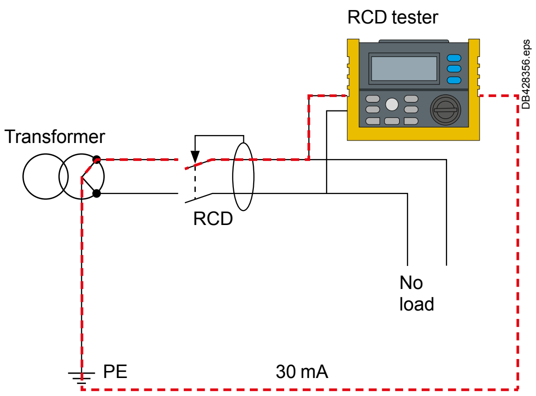
If the RCD doesn't trip after all the additional actions, it must be tested with an external RCD tester. If it is confirmed that it is out of service, it must be replaced immediately.

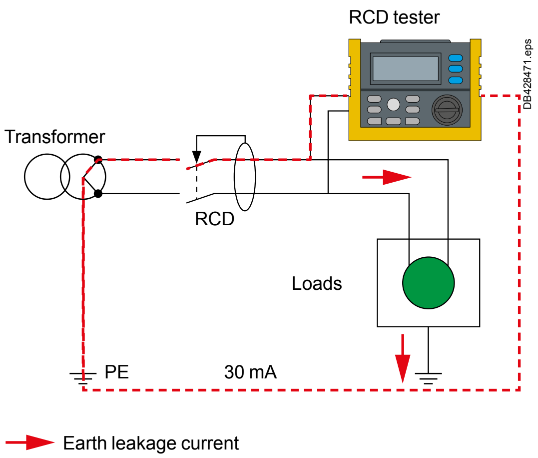
For the tests performed to be valid, these devices must comply with IEC/EN 61557-6.

These devices are used to check:
- the operating voltage
- the tripping threshold (according to the sensitivity IΔn) of the residual current device
- the tripping times (IΔn, 2 x IΔn, 5 x IΔn, etc.).

Procedure

- Disconnect the fixed and portable loads (if the residual current device protects the power outlets).
- Connect the test device to the downstream terminals of the residual current device or to a downstream power outlet.
- the residual current device (RCD) should trip.





In case of TN method of earthing with RCD short-circuit current, Ik calculated by some testers can be wrong if the measurement is done downstream of the RCD, especially if RCD is 30 mA.
Measurement shall be done upstream RCD to obtain correct values of Ik.
The protection provided by the RCD is independent from the value of Ik.

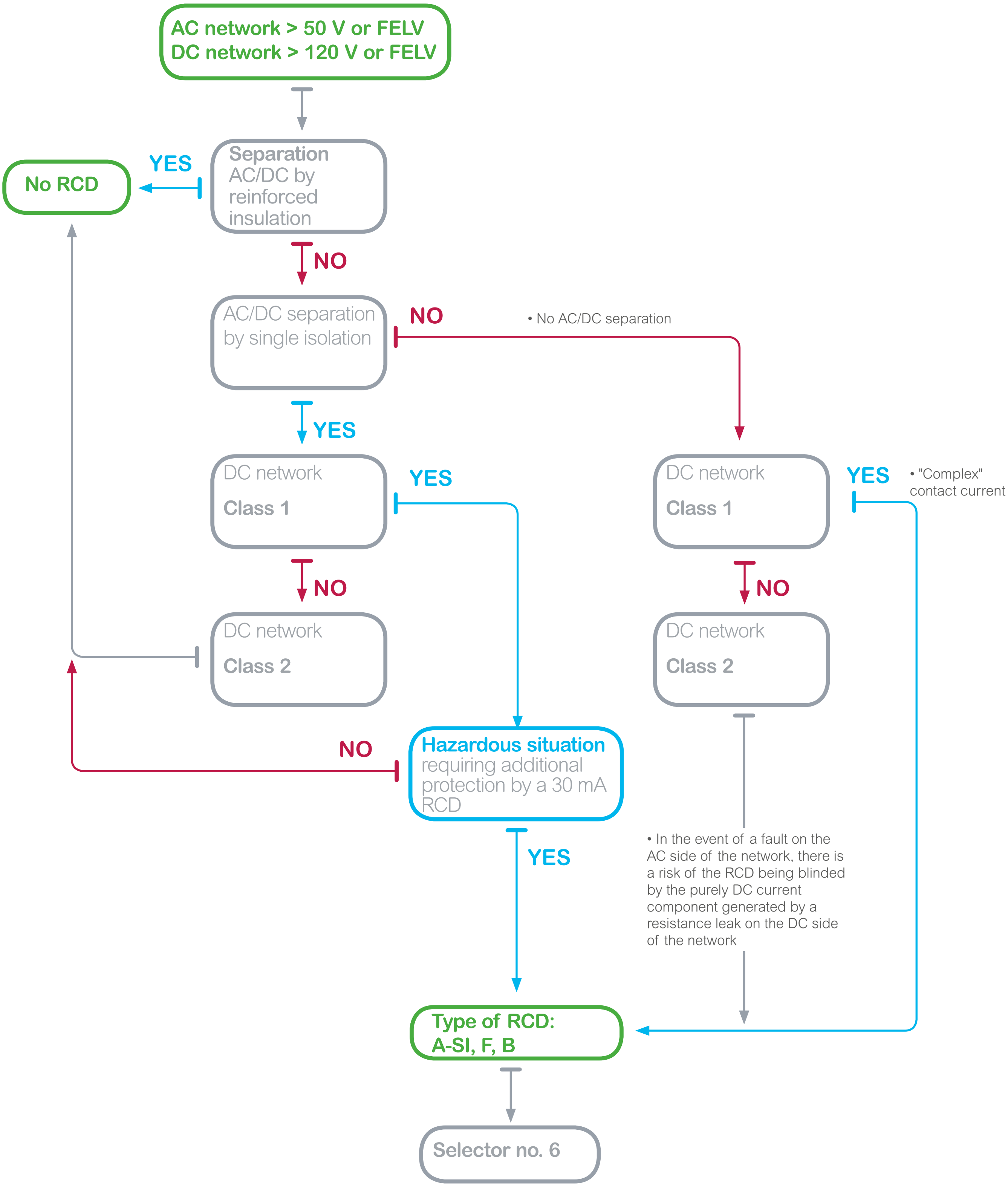
For more information, see appendix.

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation

Selector no. 4:

In a low voltage installation incorporating power converters (ex: AC/DC converters), the need for protection by RCD depends on the level of separation (no, single, reinforced) between AC and DC parts as well as the insulation of the DC network (class 1, class 2).
These requirements are based on the principles of 3 levels of protection.



Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

All applications described below concerns power converter without separation.

List of application sheets

Type	Application sheets
Protection for industrial speed drives	CA9SS079E
Protection for systems with HVAC and pumps	CA9SS080E
Home protection for my Electric Vehicle charging station	CA9SS074E
Protection for construction sites with cranes	CA9SS077E
Protection for installations with elevators	CA9SS078E
Protection for photovoltaïc installation	CA9SS076E
Protection for EV charger station installation	CA9SS075E
Electrical protection for home outdoor appliances	CR9SS008E (International)
	CR9SS008F (France)
Home protection for air conditioner and heat pump	CR9SS007E (International)
	CR9SS007F (France)
Protection for installations in swimming pools and similar environments	-

The following preconizations are common to all applications:
- in "normal situation" If TN method of earthing, power converters limit fault current and MCB will not trip, an RCD **500 mA** is needed to protect people according to installation and protection rules
- RCD types for upstream and parallel circuits must be compliant with coordination Selector no. 3.

Protection for industrial speed drives

(See Application sheet CA9SS079E)
- IEC 61800-5-1: Adjustable speed electrical power drive systems - Safety requirements.
- IEC 61800-3: Adjustable speed electrical power drive systems - EMC requirements and specific test methods.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

If situation is classified as hazardous (Selector no. 2) **30 mA** RCD is needed.

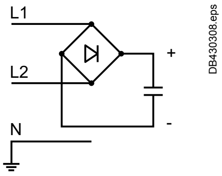
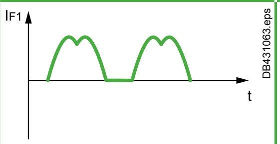
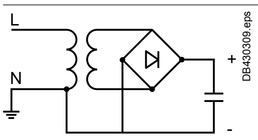
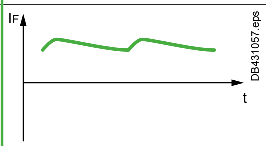
If not, sensitivity can be ⩾ **100 mA** according to selectivity plan.

Type of RCD (A-SI, F or B-SI) must be done in accord with Selector no. 6.

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

L/N converters and situations below needs B type RCD:

Architectures of the AC/DC converter input stage (network side)	Form of contact current on DC bus	Connection to AC network	Variable speed drive references	Type of RCD required	Comments
	 Between phases 6	L/L	**ATV 12H***M2** **ATV 320U**M2C** **ATV 320U**M2B** **ATV 31C**M2**	B type RCD	■ All countries ■ **The network is 220 V L/N** ■ **The "single-phase" 220 V variable speed drive is connected between phases** ■ The single-phase B type RCD is connected between phases
	 Non-isolated transformer 7	L/N	**ATV 12H***M2** **ATV 320U**M2C** **ATV 320U**M2B** **ATV 31C**M2**	B type RCD	■ All countries ■ **The network is 220 V L/N** ■ The 220 V "single-phase" variable speed drive is connected to the network via a transformer ■ **Polarity of the DC bus (accessible on the variable speed drive) is connected intentionally to the installation neutral** ■ No variable speed drive uses this architecture, but a user can potentially do this wiring himself using any "200-300 V range" single-phase variable speed drive

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

Converter and RCD are generally in the same panel, so the shielded cable length between converter and motor is high. If possible, increase L1 and reduce L2 is better for continuity of service (Selector no. 5).

Maximum length of cables depends on sensitivity of RCD (Selector no. 5). *However, the introduction of output EMC filters can limit these lengths of shielded cable. Consult the drive catalog for maximum lengths according to the EMC severity.*

Selector no. 5: Installation rules for B type RCDs ensuring protection and continuity of service in speed drive applications

Application requires B type RCD

Risk levels require RCD 30 mA

YES →

For good continuity of service, it is better to **use a 30 mA RCD for each load**

It is, however, possible to connect several loads to the same RCD if the combined cable lengths are less than the values below and if an external EMC filter is shared

Variable speed controller + shielded cables = high-frequency high-capacitive leakage currents

Three-phase power supply:
L2 max = 50 m
(shielded cable)

Max leakage current at 50 Hz:
0.3 IΔn (9 mA)
L1 max = 500 m
(non-shielded cable)

If Line to Neutral power supply:
Max. lengths are divided by 2 due to the EMC filter

Three-phase power supply:
L1 max (m) = 500 - 10xL2
L2 max (m) = 50 - L1/10
(L1+L2) max (m) = 500 - 9xL2

NO →

B type RCD ⩾ 100 mA

Whatever the method of earthing,
a RCD is required.
Including on internal converter fault (low short-circuit current) in the TN-S method of earthing
e.g.: IΔn ⩾ 300 mA

Total length of shielded cable < L2 max (table A)

Table A (L2):

IΔn	L2 (max)
100 mA	100 m
300 mA	300 m
500 mA	500 m

YES → Possible RCD sharing

NO → Circuit separation

At least 2 B type RCDs in parallel

NO → **Type of RCD connected in series and in parallel according to the coordination table (1)**

YES → **Type of RCD connected in series and in parallel shall be in accordance with "Selector no. 7"**

Check selectivity and coordination on short-circuit.
In a TT method of earthing, check that the sensitivity of the RCD corresponds to the earthing resistance of exposed conductive parts

Note
The maximum permissible distance between the RCD and the motor depends on the position of the EPCS.

L1: non-shielded cable
L2: shielded cable

(*) EPCS: Electronic Power Conversion System.
(1) See Selector no. 3.

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

If many converters, EMC filter must be mutualized and each internal filter must be disconnected to limit leakage current.

If many L/N Power converters are connected downstream a 3P+N RCD, they must be balanced on each phase and ideally delayed compared to other to avoid spike current when closing.

Protection for systems with HVAC and pumps

(See Application sheet CA9SS080E)

- IEC 61800-5-1: Adjustable speed electrical power drive systems - Safety requirements.
- IEC 61800-3: Adjustable speed electrical power drive systems - EMC requirements and specific test methods.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

Generally, fixed installation is not classified as hazardous situation and the required RCD sensitivity is **300 mA** or more (Selector no. 2).
Converter and RCD are generally in the same panel, so the shielded cable length between converter and motor is high. If possible, increase L1 and reduce L2 is better for continuity of service (Selector no. 5).

Maximum length of cables depends on sensitivity of RCD (Selector no. 5).
However, the introduction of output EMC filters can limit these lengths of shielded cable. Consult the drive catalog for maximum lengths according to the EMC severity.

RCD can be mutualized for many pumps if the total length of cable doesn't exceed maximum length given in Selector no. 5.

Type of RCD is F if converter is supplied between Line and Neutral.
Type of RCD is B if converter is supplied between 3 phases.

In case of home application, sensitivity is 30mA to be in accordance to installation rules (see application sheets CR9SS007E and CR9SS007F).

Protection for Electric Vehicle charging station (home and tertiary)

(See Application sheets CA9SS074E and CA9SS075E)

- IEC 60364-7-722: Low-voltage electrical installations - requirements for special installations or locations - Supplies for electric vehicles.
- IEC 61851-1 Ed3 8.5: Electric vehicle conductive charging system: General requirements.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

This installation is classified as hazardous situation (Selector no. 2), RCD sensitivity is **30 mA** (mandatory in standards).
Mutualization of RCD is forbidden: 1 RCD for 1 Electrical Vehicle (EV).

In residential application

Length of cables are short and are not shielded: Filters, Charger and batterie are in the same area. Leakage currents are essentially generated by filters.
If upstream RCD is a 500 mA and mass earthing resistance is compliant with 500 mA sensitivity (Ra < 100 ohm), this upstream RCD can be AC up to 4 EV, each protected by 30 mA B type RCDs.
For the same hypothesis, parallel RCD can be AC up to 4 EV, each protected by 30 mA B type RCDs if TT method of earthing and up to 10 EV, each protected by 30 mA B type RCDs if TN-S method of earthing.

In tertiary applications

Length of cables is higher but cable is not shielded, so the maximum length can be 250 m with a 30 mA RCD.
RCD **B type EV** type is needed whatever the number of poles: AC/DC architecture and batterie voltage are not known (Selector no. 6).

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

Protection for construction sites with cranes

(See Application sheet CA9SS077E)

- IEC 61800-5-1: Adjustable speed electrical power drive systems - Safety requirements.
- IEC 61800-3: Adjustable speed electrical power drive systems - EMC requirements and specific test methods.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

This installation is classified as hazardous situation (Selector no. 2), RCD sensitivity is **30 mA** (Wet environment, insulation of cables between ground and top of crane can be destroyed).

Distance between ground panel (RCD) and motor (on top of the crane) is high.
So, length of cables is high but this cable is not shielded because converter and motor are near.
RCD can be mutualized because max total length is generally less than 500 m (supply is 3 phases) (Selector no. 5).

Supply is 3 phases and RCD type must be **B**. (Selector no. 6).

Protection for installation with photovoltaic

- IEC 60364-7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems.
- NFC15712-1: Photovoltaic installations without storage and connected to the public distribution network.
- XPC15712-3 (new NFC15712-3): Photovoltaic installations with storage device and connected to a public distribution network.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

For conversion without galvanic insulation, even if the DC network (PV panels) is conform to double insulation, due to humid environment and large surface with earth, the insulation resistance must decrease and large DC leakage current may flow and blind AC type or A type RCD.

B type RCD is mandatory for tertiary and residential without galvanic insulation.
Sensitivity is **30 mA** for residential installations.
Sensitivity is **300 mA** for tertiary fixed installations without socket-outlet.

For L/N supply without galvanic insulation, RCD can be A type by default (*) but RCD F type is recommended.

(*) Some inverters may generate fault currents with continuous components that require the use of a B type RCD (see manufacturer's documentation).

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

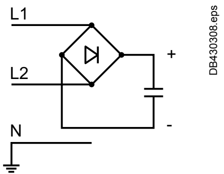
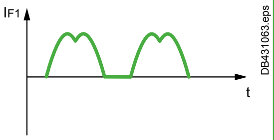
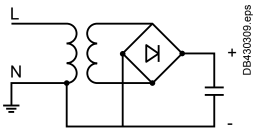
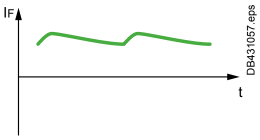
Protection for installations with elevators

(See Application sheet CA9SS078E)

- IEC 62477-1: Safety requirements for power electronic converter systems and equipment.
- EN 50178: Electronic equipment for use in power installations.
- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

Generally, fixed installation is not classified as hazardous situation and the required RCD sensitivity is **300 mA** or more (Selector no. 2).
Type of RCD (A-SI, F or B-SI) must be done in accord with Selector no. 6.

L/N converters and situations below needs B type RCD:

Architectures of the AC/DC converter input stage (network side)	Form of contact current on DC bus	Connection to AC network	Variable speed drive references	Type of RCD required	Comments
	 Between phases 6	L/L	**ATV 12H***M2** **ATV 320U**M2C** **ATV 320U**M2B** **ATV 31C**M2**	B type RCD	■ All countries ■ **The network is 220 V L/N** ■ **The "single-phase" 220 V variable speed drive is connected between phases** ■ The single-phase B type RCD is connected between phases
	 Non-isolated transformer 7	L/N	**ATV 12H***M2** **ATV 320U**M2C** **ATV 320U**M2B** **ATV 31C**M2**	B type RCD	■ All countries ■ **The network is 220 V L/N** ■ The 220 V "single-phase" variable speed drive is connected to the network via a transformer ■ **Polarity of the DC bus (accessible on the variable speed drive) is connected intentionally to the installation neutral** ■ No variable speed drive uses this architecture, but a user can potentially do this wiring himself using any "200-300 V range" single-phase variable speed drive

In general, converter and motor are in the same area and, in consequence, the shielded cable length is short.
Continuity of service is comparatively easy to obtain.

Protection for home Outdoor appliances

(See Application sheets CR9SS008E and CR9SS008F)

- IEC 61008: RCCBs General rules.
- IEC 61009: RCBOs General rules.
- IEC 62423: F type and B type RCCBs - RCBOs.

■ Protection must be adapted to outdoor electrical circuits feeding.
Barbecue, lights, gardening tools are exposed to outside conditions such as rain, dust, humidity and that may have damaged isolation protection.
■ Protection must insure a high continuity of service for critical loads supplying (freezer).

RCBO protection is recommended as a dedicated feeder for freezer. Thus, it will be segregated from the other equipment and will not be impacted by tripping of other loads.
A-SI or F (SI integrated) are recommended depending on the country local regulation.
30 mA is the sensitivity adapted to outdoor and plugged loads in accordance with installation rules. (IEC 60364; NFC15100...)

Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

Protection for installations in swimming pools and similar environments.

RCDs are mostly designed for household and similar environments.
Ingress protection (IP) for these devices is IP20 (touch by finger).
In environments with high humidity and aggressive chemical environment such as swimming pools, spa, etc., **high IP or forced ventilation of the switchboard with clean air must be provided**.
Condensation should be avoided because it acts as a catalyst with aggressive chemical component.

To ensure correct operation the following guidelines must be applied:

1- keep the electrical cabinet away from the aggressive environment

(Ideally beyond 50 m) from polluted areas (bathing area, chemicals storage room...).

Implantation study is recommended to separate and keep just needed functions in severe environment.

For example, keep if necessary, switches and sockets devices in the polluted area and place away control and protection devices (RCDs, MCBs, Contactors, …).

- If the electrical cabinet is in a different building it is recommended:
  - not to have connection with fluids (to avoid any corrosion),
  - not to have ventilation with polluted air coming from polluted area.
- If the electrical cabinet is in the same building of the swimming pool:
  - Install the electrical cabinet far away from the polluted area (ideally 50 m away) in a dedicated room,
  - Follow the recommendations bellow.

2- Concerning protection devices

- Including Residual protection at first (but MCB also are concerned), you must use RCBO or RCCB from **"SI" range**.
- You must also check the correct operation of the RCDs using the test button **every month**.

3- Concerning the electrical room

The following rules must be continuously respected all the year:

- The room must be maintained at a temperature higher than 18°C.
- The room should be ventilated using clean outdoor air, filtered, and heated to reduce its humidity.
- The room must not be used for storage of chemical products, plants, or other components that can store moisture (ex: wood...).

4- Concerning the electrical cabinet

- The electrical cabinet must have an IP higher or equal to IP65: this IP must be respected using appropriate cable glands and protection in all openings.

Example of enclosures: Kaedra.

- Make sure that the door of the enclosure is kept closed: the door should only be opened for manual action on devices and reclosed and locked just after.

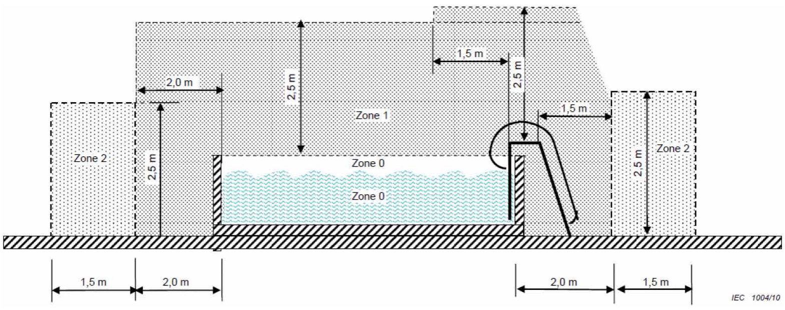
Example: ensure efficient earth fault protection

Key points for specific applications and RCD implementation (continued)

Annex

Concerning Installation rules, it is important to remember basics for safety in wet situations

- IEC 60364-7-702 - NF-C15-100 required that.
- Protection devices are forbidden in volumes 0 and 1.
- Protection devices are allowed in volume 2 but:
  - cabinets must be IPX5 minimum if the room can be cleaned with waterjet system,
  - do not use high pressure cleaners (ex: Kärcher).



Zone dimensions for basin above ground level (side view).

Note
The measured zone dimensions are limited by walls and fixed partitions.

Minimum IP number per zone

Zone	Outdoor, with waterjets during cleaning operation	Outdoor, without waterjets	Indoor, with waterjets during cleaning operation	Indoor, without waterjets
0	IPX5 / IPX8	IPX8	IPX5 / IPX8	IPX8
1	IPX5	IPX4	IPX5	IPX4
2	IPX5	IPX4	IPX5	IPX2

Complementary information's

- Devices which do not trip or not reclosing after the test button procedure must be returned to Schneider Electric for analysis (MCB and vigi **must not be separated**!).
- In case of RCBO replacement, if the device is composed of 2 separate parts (MCB + Vigi) it's mandatory to **replace the 2 parts** (MCB **AND** Vigi).
- When returning the products, make sure that the packaging provides adequate protection to avoid damage during transportation.

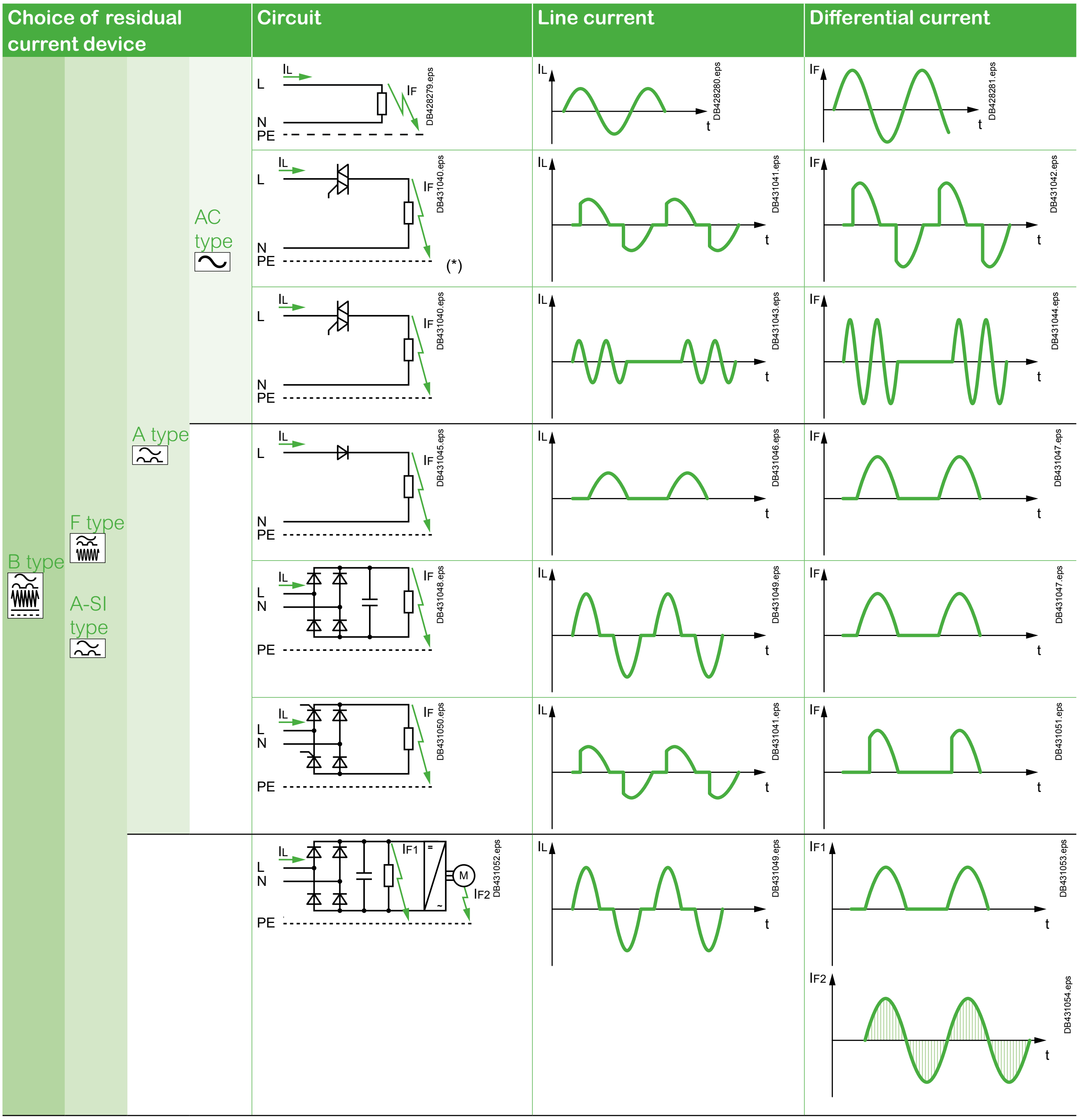
Selectors

Type	Designation	Page
Selector no. 1	Involvement of RCD depends on method of earthing	10
Selector no. 2	Choosing the sensitivity of earth fault protection according to the risks factors	13
Selector no. 3	Impacts of integration of a RCD B type in an installation with RCDs of other types	22
Selector no. 4	Involvement of RCD depends on power conversion insulation	45
Selector no. 5	Installation rules for B type RCDs ensuring protection and continuity of service in speed drive applications	48
Selector no. 6	Choosing the type of RCD according to power conversion architectures and their connection to the AC network	57
Selector no. 7	Coordination in types of RCD	Click Interactive table

Appendix: How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads

Electrical load profiles

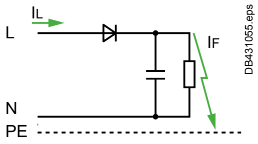
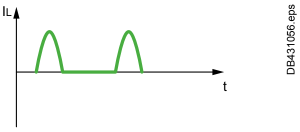
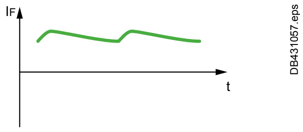
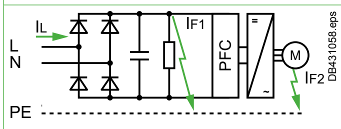
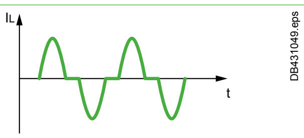
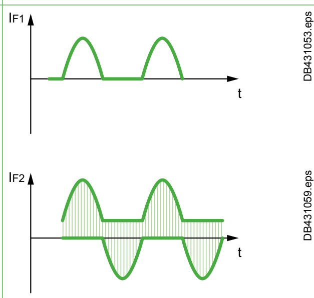
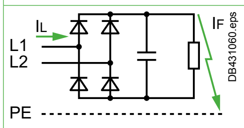
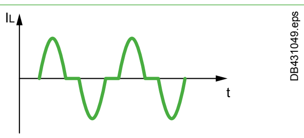
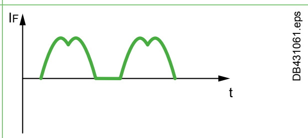
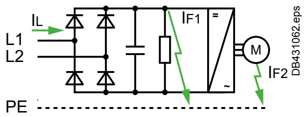
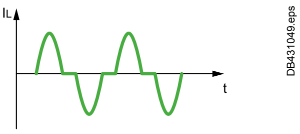
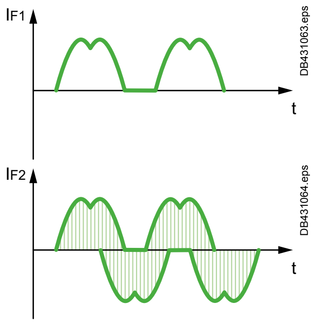
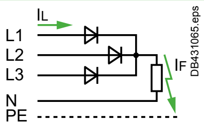
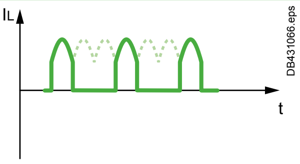
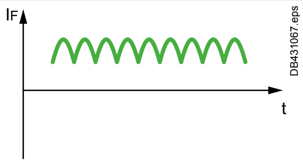
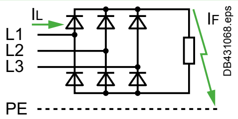
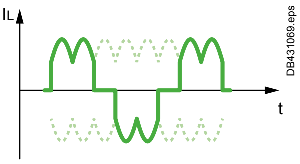
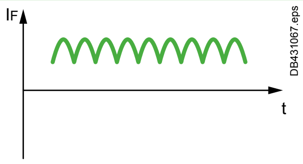
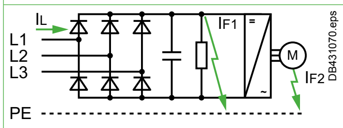
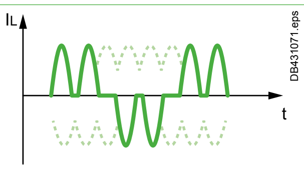
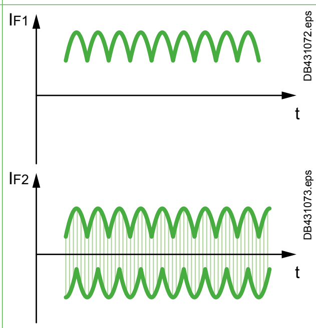


(*) To protect people whatever the dimmer adjustment an A-SI or F or B type is needed.

Appendix: How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads (continued)

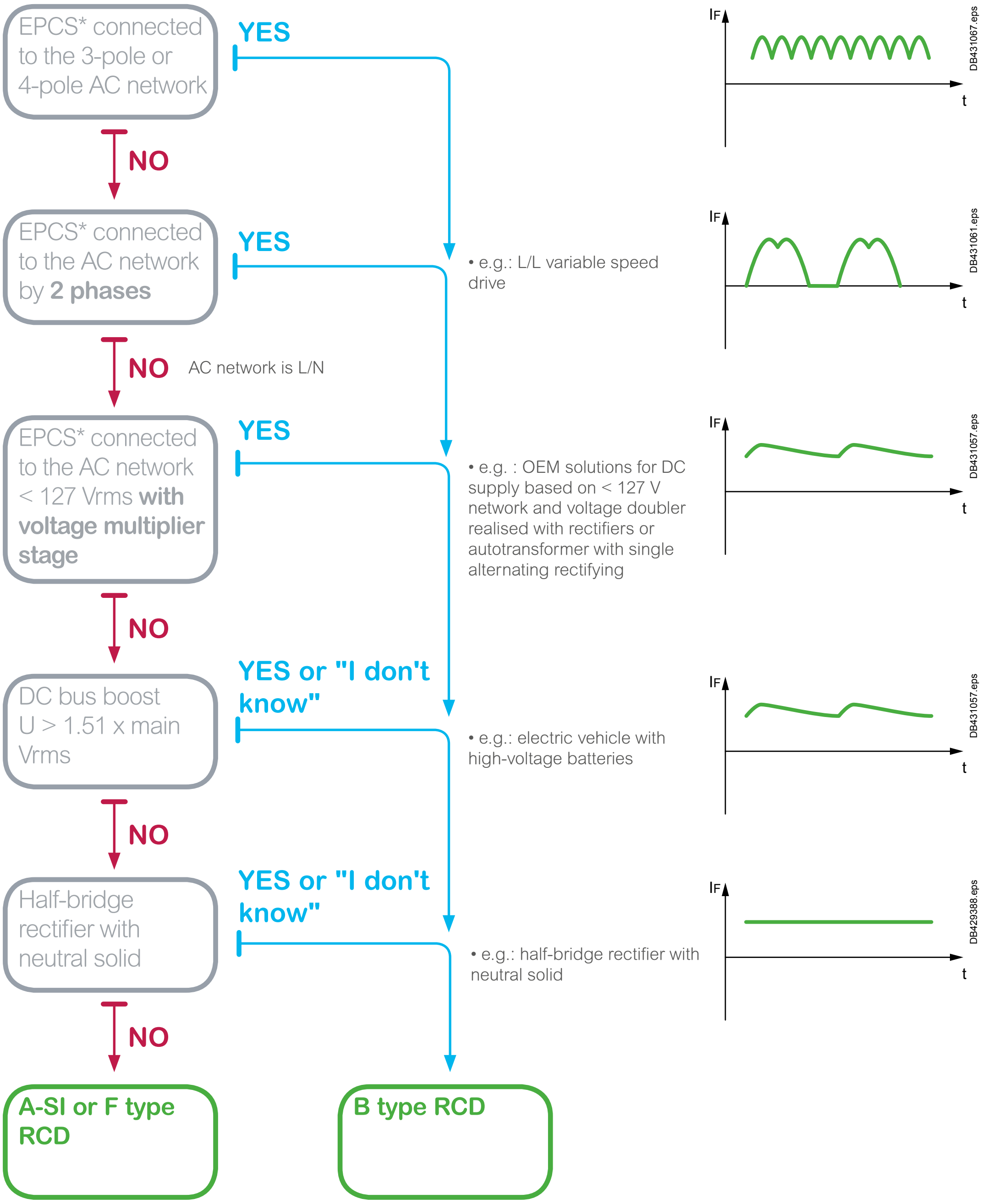
Electrical load profiles (continued)

Choice of residual current device	Circuit	Line current	Differential current
B type			
			
			
			
			
			
			

Appendix: How to select and install residual current devices

Types of RCD (AC, A, A-SI, F, B) must be adapted to different loads (continued)

Selector no. 6: Choosing the type of RCD according to power conversion architectures and their connection to the AC network



(*) EPCS: Electronic Power Conversion System

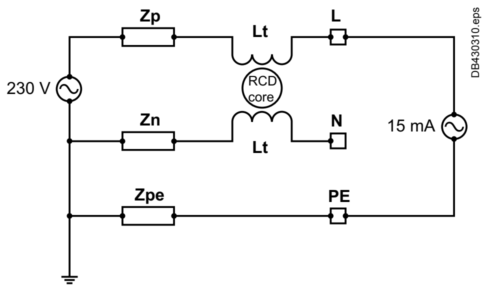
Appendix: How to ensure maintenance of installation

Short-circuit current (Ik: L/PE) evaluation by Fluke 1653B Multifunction Installation Tester

- Explain false low value calculated when measurement is realized downstream a RCD (method of earthing is TN-S).
- Propose solution to prove that protection plan provide people safety when RCD is used.

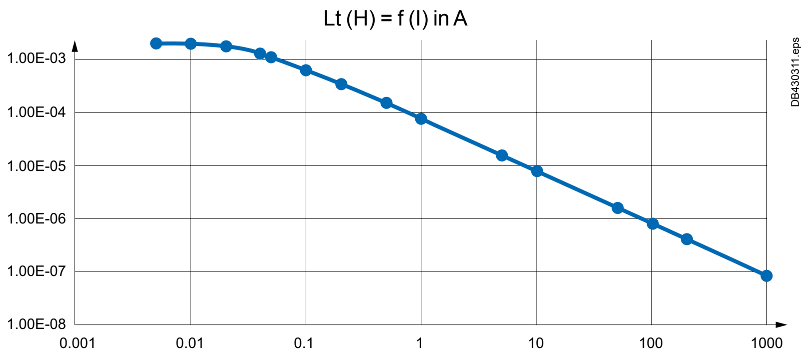
1- Short-circuit current **Ik L/PE** calculated by Fluke is **false** because measurement and calculation method use worst value of Impedance between Line and PE

Fluke inject between Line and PE a very low current of 15 mA to avoid tripping of RCD during test.



Z LPEvirtual = Zp + Z pe + Zt (Zt=Ltw).

- In this method, measurement current pass through **only one RCD winding** and furthermore the current amplitude is very low.
- For this current the Lt value for one winding is high (~2 mH) because the magnetic circuit (RCD core) is not saturated (μ is high: 200000). Zt is accordingly high and very higher than Zp + Zpe.
- This Lt depend on RCD architecture (core permeability, size, sensitivity, primary winding…).
- Ex for Lt = 2 mH: **Z LPEvirtual ~Zt ~0.628 ohm at 50 Hz.**
- Fluke use this Lt at 15 mA for extrapolate the real short-circuit situation.
- **Ik calculated by Fluke** = 230 V/ Z LPEvirtual ~**370 A.**
- In reality, in case of fault L/PE, the current is very higher than 15 mA and the value of Lt is very low because magnetic circuit of RCD is saturated (Ex: Lt ~0.3 μH at 300 A).



Zt real ~90 μohm !

- Ik real is limited by Zp and Zpe, Zt is negligible.
- **ZLPE real** ~Zp + Zpe ~**0.23 ohm at 50 Hz**.
- **Ik real** = 230 V/ ZLPE real ~**1000 A** (real short-circuit current is higher than that calculated by Fluke).

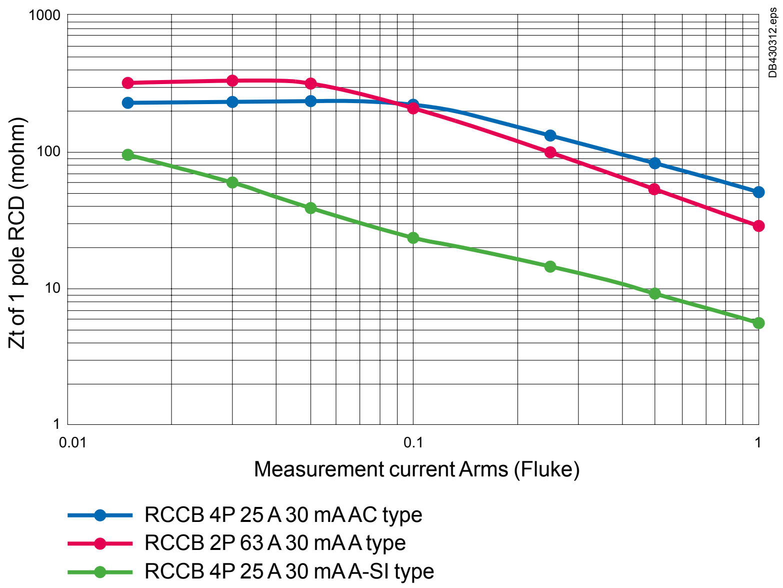
Appendix: How to ensure maintenance of installation

Short-circuit current (Ik: L/PE) evaluation by Fluke 1653B Multifunction Installation Tester (continued)

Measurements

- This example takes into account 3 architectures of Schneider Electric RCD 's.

Zt impedance of RCD used for Isc L/PE calculation

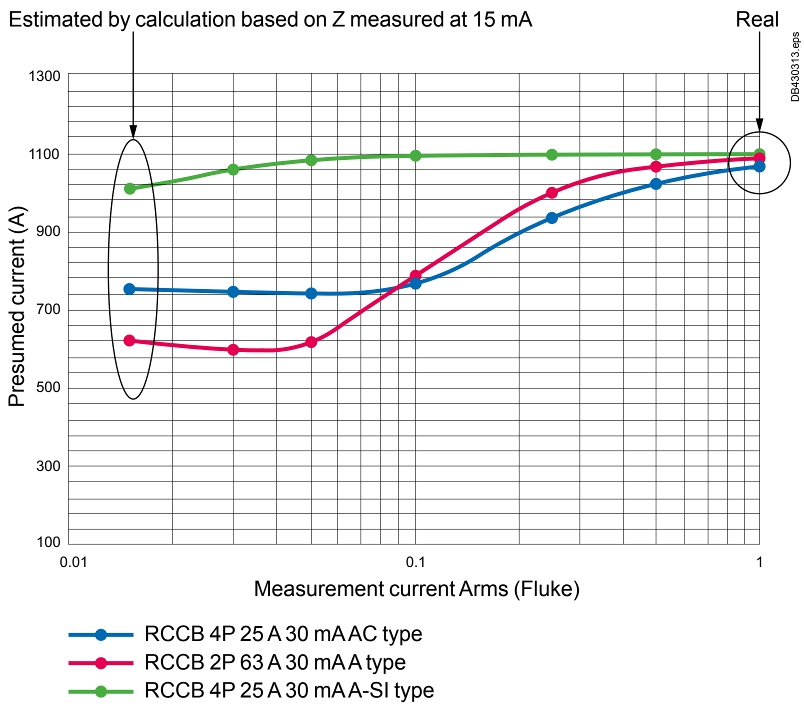


- Short-circuit current upstream is 1100 A: Z upstream = 218 mohm at 240 V.
- Short-circuit current calculated by Fluke based on value of Z measured downstream of RCD at a low current (Ex: 15 mA).

With different technologies of RCD's graph below show a dispersion of short-circuit current based on a Z value measured at low current (600 A to 1000 A).

The real short-circuit current is higher and not dispersed (1100 A).

Isc L/PE calculated

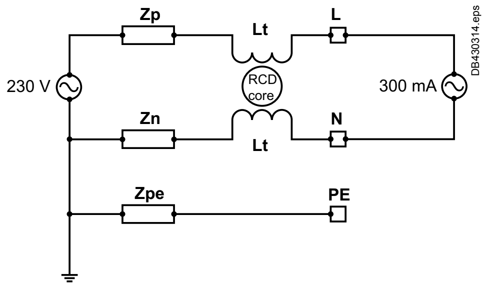


Appendix: How to ensure maintenance of installation

Short-circuit current (Ik: L/PE) evaluation by Fluke 1653B Multifunction Installation Tester (continued)

2- **Ik L/N** result given by Fluke is **good** because measurement and calculation method used by Fluke use real value of impedance between Line and N

Fluke inject between phase and neutral a current of ~300 mA.
This current can't trip either RCD or the overcurrent protection.



In this case measurement current pass through the 2 RCD windings in opposite polarity and the total Self L = Lt - Lt ~0. (magnetic leakage is negligible).

The impedance measured is the real Z phase + Z neutral impedance. This value is independent from current intensity (no magnetic saturation).

3- Propose solution to prove that protection plan provide people safety when RCD is used

In TN-S scheme, in case of insulation fault (indirect contact).

People protection is realized by the MCB if the tripping time is in accordance with IEC 60364. (<0.2 s at 240 V in TN).

- The Fluke measurement principle (at low current) give false values of RCD impedance (see above).
- On L/PE short-circuit, the 240 V network source impose a very higher current (>100 A) due to low impedances of cables and real low impedance of RCD (saturation).
- Furthermore, if calculated impedance is used, this RCD upstream impedance contribute to reduce touch voltage (between masse and earth).

- **Only an upstream measurement gives a correct value of presumed short-circuit current (downstream RCD impedance is negligible). This current must be higher than magnetic actuation zone (I max of MCB curve; for example, 10 x In for C curve)**.

Furthermore, if an RCD 30 mA is installed, the people protection is assured from a short-circuit current of 60 mA (t <0.2 s).
The corresponding maximum short-circuit impedance is 4000 ohm !

In this limit case, the touch voltage mass/earth is < 50 V and the direct contact protection is also assured.

Evaluation of short-circuit current is not necessary.

Control with RCD tester the tripping current and tripping time of the RCD to confirm protection.

Acronyms

Type	Designation
AC network	Alternating Current network
Add On Vigi	Residual current device installed in combination with a circuit breaker
AFi	Environment Classes
DC network	Direct Current network
EMC	Electromagnetic Compatibility
EPCS	Electronic Power Conversion System
FE	Functional Earth
FELV	Functional Extra Low Voltage
Ik	Short-circuit current
PE	Protective Earth
PELV	Protective Extra Low Voltage
Ra	Earthing resistance of exposed conductive parts of equipements
RCBO	Residual Current operated circuit Breakers with integral Overcurrent protection
RCCB	Residual Current operated Circuit Breakers without integral overcurrent protection
RCD	Residual Current Device
SELV	Safety Extra Low Voltage
SI	Super Immunized
SRCD	Socket RCD
TT, TN, IT	Method of earthing
VDT	Voltage Dependent Technology
VIT	Voltage Independent Technology

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