Choice of earth leakage protection devices

Choice of sensitivity

The sensitivity of an earth leakage protection device depends mainly on the function it has to perform:
- Protection from electric shock by direct contact.
- Protection from electric shock by indirect contact.
- Protection from fire due to current leakage.

The following table gives a reminder of:
- The circuits that must be protected against these various risks (obligation or recommendation).
- The type of earth leakage protection device to be used in each case, its sensitivity, and its location in the distribution diagram.

Type of protection	Obligations		Recommended by Schneider Electric	Sensitivity (IΔn)		
	National standard *To be filled in according to the country standard*	**International standard IEC 60364**		**30 mA (*)**	**100 mA to 3000 mA** (depending on the earthing system)	**300 mA (or 500 mA)**
Protection from electric shock by direct contact						
DB123167 	*To be filled in according to the country standard*	Power supply for ■ General-purpose power sockets, up to 20 A ■ Appliances in the vicinity of a bathtub, shower, pond or swimming pool ■ Portable appliances for outdoor use, up to 32 A ■ Lighting for exhibition stands and shows ■ Outdoor lighting *To be modified according to national obligations (above)*	■ Lighting in the home	**Setup in final distribution switchboard** ■ Residual current device protecting a circuit ■ Residual current circuit breaker protecting a group of circuits		
Protection from electric shock by indirect contact						
DB123168 	*To be filled in according to the country standard*	The entire power distribution system, except for devices: ■ With class II insulation ■ Operating at Safety Extra Low Voltage (class III) *To be modified according to national obligations (above)*	–		**Setup in final distribution switchboard** ■ Residual current circuit breaker or device, on incoming feeder **Setup in subdistribution board or main switchboard** ■ Residual current device protecting a circuit ■ Residual current device or circuit breaker protecting a group of circuits ■ On incoming feeder: residual current circuit breaker or device	
Protection from fire due to current leakage						
DB123169 	*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)*	■ Dilapidated buildings or electrical installations ■ Humid atmospheres: agricultural buildings, public swimming pools ■ Presence of chemical agents			**Setup in final distribution switchboard** ■ Residual current circuit breaker or device, on incoming feeder **Setup in subdistribution board or main switchboard** ■ Residual current device protecting each circuit to a high-risk zone ■ Residual current device or circuit breaker protecting a group of circuits ■ On incoming feeder: residual current circuit breaker or device

(*) The 10 mA sensitivity is useful for certain very specific applications, where there is a risk that someone could sustain a non-dangerous current (10 to 30 mA) without being able to get free. Example: healthcare equipment for hospital beds. Generally, devices with this very high sensitivity are liable to cause frequent tripping, due to the natural leakage currents of the installation.

Choice of earth leakage protection devices (cont.)

Interference immunity

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

Operating conditions		Examples	Types			
			AC	A	SI	B
Loads						
DB123165 With no special characteristics		■ General-purpose power sockets ■ Incandescent lighting ■ Household appliances: microwave oven, dishwasher, clothes dryer ■ Electric heating, water heater	■	■	■	■
Including a rectifier	Single phase	■ Household appliances: induction cooking appliances, washing machines (variable speed) ■ Single-phase variable speed drives	–	■	■	–
	Three phase	■ Three-phase variable speed industrial drives ■ Three-phase uninterruptible power supplies	–	–	–	■
Generating high-frequency interference (current peaks, harmonics)		■ Fluorescent lighting powered by extra low voltage transformer, by electronic ballast ■ Variable luminosity lighting ■ Powerful IT equipment ■ Single-phase variable speed industrial drives ■ Air conditioning ■ Telecommunications equipment ■ Capacitor banks	–	–	■	■
Including an anti-harmonic filter in the power supply		■ Microcomputer systems ■ Computer peripherals (printers, scanners, etc.)	–	–	■	■
Electrical environment						
DB123166 Vicinity of equipment generating transient overvoltages		■ High-powered switching devices ■ Reactive energy compensation banks	–	–	■	■
Circuits powered by an uninterruptible power supply		■ Backed-up networks	–	–	■	■
"Isolated neutral" (IT) earthing system		–	–	–	■	■
Major risk of lightning strokes		■ Buildings protected by a lightning protection system ■ Mountainous or humid regions ■ Regions with high keraunic level	–	–	■	■
Atmosphere						
DB123164 Ambient temperature which could be less than -5°C		–	–	■	■	■
Presence of corrosive agents (AF2 to AF4) or dust		■ Indoor swimming pools ■ Yacht 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) SiE for C120 and NG125 circuit-breakers

Discrimination

Residual current devices of average sensitivity (100 mA and more) are available in a selective (S) and delayed (R) version.
This option ensures that, in the event of an earth fault downstream of the installation, only the defective part is switched off.
The table below shows (in green) which upstream/downstream equipment combinations provide this discrimination.

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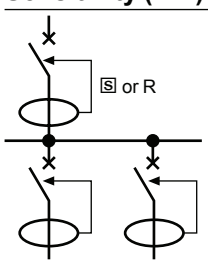
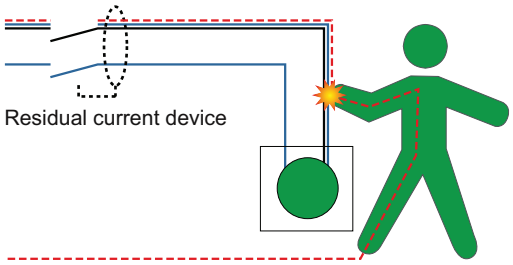


Sensitivity (mA) - Downstream		Sensitivity (mA) - Upstream												
		Instantaneous						Selective S					Delayed R	
		30	100	300	500	1000	3000	100	300	500	1000	3000	1000	3000
Instantaneous	30	-	-	-	-	-	-							
	100	-	-	-	-	-	-	-						
	300	-	-	-	-	-	-	-	-	-				
	500	-	-	-	-	-	-	-	-	-	-		-	
	1000	-	-	-	-	-	-	-	-	-	-		-	
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-
Selective S	100	-	-	-	-	-	-	-	-	-	-	-		
	300	-	-	-	-	-	-	-	-	-	-	-	-	
	500	-	-	-	-	-	-	-	-	-	-	-	-	
	1000	-	-	-	-	-	-	-	-	-	-	-	-	
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-
Delayed R	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
	3000	-	-	-	-	-	-	-	-	-	-	-	-	-

Earth leakage protection
Response time of high-sensitivity residual current devices

All the high-sensitivity residual current devices (30 mA) in the Acti 9 range conform to the IEC/EN 61008 and IEC/EN 61009 standards. The response times defined by these standards guarantee their effectiveness in protecting people against direct contacts.



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.

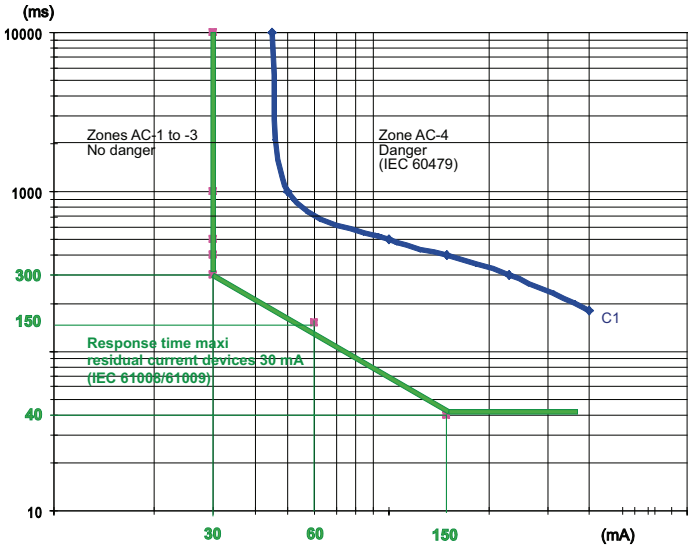
For a residual current device with a sensitivity of IΔn 30 mA:

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

These response times conform to the specifications of the **IEC/EN 61008 and IEC/EN 61009** standards.
They guarantee protection of people against direct contacts for the following reasons :

■ When a person comes into direct contact with a live conductor, the current passes directly through the human body.

■ This current, with the same magnitude, is detected by the residual current device.



■ The IEC 60479 technical report studies the sensitivity of the human body to the electric current. Curve c1 defines for each current value the maximum time before the current causes injury to a person.

■ 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.

Earth leakage protection
Response time of medium-sensitivity residual current devices

Response time of iC60 Vigi and iID60 residual current devices

The medium-sensitivity residual current devices (100…1000 mA) in the Acti 9 range conform to IEC/EN 61008 and 61009:

- their response time guarantees personal protection against indirect contacts and fire risks
- in the case of selective versions (S), a "non-tripping time" guarantees discrimination with the residual current devices installed downstream.

Instantaneous residual current devices

		Sensitivity (I∆n)			
		100 mA	300 mA	500 mA	
Fault current (mA)	**I∆n/2**	50	150	250	No tripping
					Max. response time
	I∆n	100	300	500	300 ms
	2 x I∆n	200	600	1000	150 ms
	5 x I∆n	500	1500	2500	40 ms
	500 A				40 ms

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

Residual current device		Sensitivity (I∆n)				Type			
		100 mA	300 mA	500 mA	1000 mA	Selective (S)		Time-delayed (R)	
Fault current (mA)	**I∆n/2**	50	150	250	500	No tripping		No tripping	
						Non-tripping time	Response time	Non-tripping time	Response time
	I∆n	100	300	500	1000	130 ms	500 ms	300 ms	1000 ms
	2 x I∆n	200	600	1000	2000	60 ms	200 ms	150 ms	500 ms
	5 x I∆n	500	1500	2500	5000	50 ms	150 ms	150 ms	300 ms
	500 A					40 ms	150 ms	150 ms	300 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.

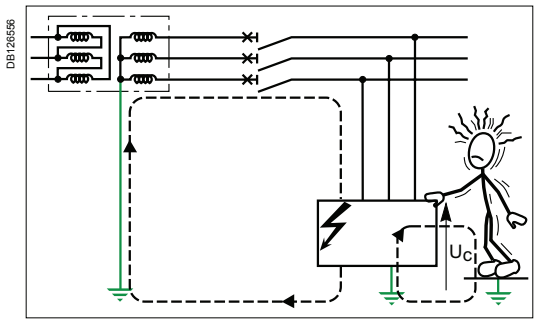
This fast disappearance of the leakage current can be due to:

- the transient nature of the fault (e.g. the 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 afford the user:

- better immunity against nuisance tripping
- total discrimination between residual current devices.

Earth leakage protection
Response time of medium-sensitivity residual current devices



Protection against indirect contacts

The response times of residual current devices guarantee personal protection against indirect contacts, in conformance with the requirements of the installation standards (IEC 60364 or equivalent).

Indirect contacts

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:

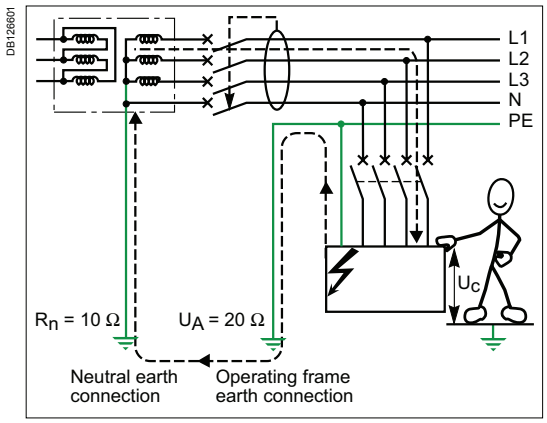
- the network voltage
- the earthing system.

Maximum breaking time for terminating circuits (ms)

Earthing system	Network phase/neutral voltage			
	50...120V	120...230V	230...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 discrimination with the devices installed on the terminating 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 authorised by technical report IEC 60479.



Example

On a three-phase phase/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 operating frame 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 phase/neutral voltage network in a TT system, the IEC 60364 standard 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 power down the circuit in less than 40 ms,
□ an instantaneous residual current device with a sensitivity of 500 mA will power down the circuit in less than 60 ms.

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

Use of the 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 (phase/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 phase/neutral voltage < 120 V.