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Technical parameters for residual current operated protective devices with automatic reclosing feature for telecom applications

Recommendation ITU-T K.135

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Summary

Recommendation ITU-T K.135 provides an overview of the parameters of residual current operated protective devices with an automatic-reclosing feature for telecom applications.

Such devices with an automatic-reclosing feature (herein referred to as residual current devices with automatic reclosing (RCDAs)), also known as trip-free devices, are used in telecom applications based in central offices or in bureaux and/or stations. They are usually mounted as supplementary protection devices to other forms of protection against direct contact. The parameters reference built-in residual current operated protective devices with automatic-reclosing functionality.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.135	2018-11-13	5	11.1002/1000/13714

Keywords

Automatic-reclosing, overcurrent protection, residual current devices (RCDs), self-restoring, trip-free.

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Technical parameters for residual current operated protective devices with automatic reclosing feature for telecom applications

1 Scope

This Recommendation applies to residual current devices (RCDs) with automatic reclosing (RCDAs) and provides an overview of parameters and testing methods. RCDAs are equipped with an automatic-reclosing feature, called trip-free functionality. This Recommendation also covers built-in RCDAs.

The following device parameters are covered:

- appearance and structure;
- enclosure;
- dielectric properties;
- temperature rise;
- operating characteristics;
- mechanical and electrical life;
- performance at short-circuit current;
- test function of the device;
- technical requirements for RCDs functionally dependent on line voltage;
- working conditions upon over current of main circuits;
- surge current performance;
- technical requirements for automatic-reclosing devices;
- environmental adaption.

This Recommendation does not cover:

- quality assurance requirements.

This Recommendation covers RCDs with automatic reclosing which are owned by network operators and under the supervision of skilled persons, and used within restricted access areas.

NOTE – If there is an inconsistency between a requirement in this Recommendation and a requirement of the domestic laws and regulations which relates to electrical safety, the requirement of the domestic laws and regulations shall take priority.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[IEC 60529] IEC 60529 (2013), *Degrees of protection provided by enclosures (IP Code) Edition 2.2*.

[IEC 60898-2] IEC 60898-2 (2016), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 2: Circuit-breakers for AC and DC operation*.

[IEC 60947-2] IEC 60947-2 (2016), *Low-voltage switchgear and control gear – Part 2: Circuit-breakers*.

[IEC 61008-1] IEC 61008-1 (2013), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 automatic reclosing [b-IEC 61936-1]: Automatic reclosing of a circuit-breaker associated with a faulted section of a network after an interval of time which permits that section to recover from a transient fault.

3.1.2 auxiliary circuit (of a circuit-breaker) [b-IEC 60898-1]: All the conductive parts of a circuit-breaker intended to be included in a circuit other than the main circuit and the control circuit of the circuit-breaker.

3.1.3 conditional residual short-circuit current [b-IEC 62873-2], $I_{\Delta C}$: Value of the AC component of a residual prospective current which a residual current device (RCD) without integral short-circuit protection, but protected by a short-circuit protective device in series, can withstand under specified conditions of use and behaviour.

3.1.4 conditional short-circuit current (for a residual current device) [b-IEC 60050-442]: Value of the alternating component of a prospective current, which a residual current device (RCD) without integral short-circuit protection, but protected by a short-circuit protective device in series, can withstand under specified conditions of use and behaviour.

NOTE – The conditional short-circuit current value is represented by the symbol I_{NC}.

3.1.5 mechanical switching device [b-IEC 62873-2]: Switching device designed to close and open one or more electric circuits by means of separable contacts.

3.1.6 rated residual operating current [b-IEC 61557-6], $I_{\Delta N}$: Fault current for which the residual current protective device is designed.

3.1.7 residual current [b-IEC 62752], I_{Δ}: Vector sum of the instantaneous values of the current flowing in the main circuit of the residual current function (expressed as r.m.s. value).

3.1.8 residual current device (RCD) [b-IEC 60755]: Mechanical switching device or association of devices designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions.

NOTE – An RCD may also be referred to as a residual current operated protective device.

3.1.9 residual making and breaking capacity [b-IEC 62640], $I_{\Delta M}$: Value of the alternating component of a residual prospective current which a socket-outlet residual current device (RCD) can make, carry for its opening time and break under specified conditions of use and behaviour.

3.1.10 residual non-operating current [b-IEC 62640], $I_{\Delta NO}$: Value of residual current at which and below which the residual current device (RCD) does not operate under specified conditions.

3.1.11 restricted access area [b-IEC 62368-1]: Area accessible only to skilled persons and instructed persons with the proper authorization.

3.1.12 skilled person [b-IEC 62368-1]: Person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others.

3.1.13 trip-free mechanism of a residual current device [b-IEC 60755]: Mechanism, the moving contacts of which return to and remain in the open position when the opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained.

NOTE – To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

RCD Residual Current Device

RCDA Residual Current Device with Automatic reclosing

NOTE – In the USA, an RCD is referred to as a ground fault interrupter (GFI).

5 Conventions

None.

6 Technical requirements

6.1 Appearance and structure

An RCD is mechanical switching device, which breaks the main circuit current by opening the switch contacts when the residual current reaches or exceeds a predetermined value.

The device is equipped with a power disconnect mechanical indication. The RCD surface shall be even, clean, uniform in colour, and free from scratches, cracks and deformation. All fastening parts shall be firmly attached. All product labels shall be intact, clear and readable.

The test button should be functional, see clause 6.8.

RCDs' operational characteristics shall not be verified by any external loads except for the special equipment designed for verifying residual operation current levels.

In multi-pole RCDs the moving contacts on all poles shall be mechanically connected to enable simultaneous breaking and closing manually or automatically except for switched neutral poles (if any).

RCDs shall be trip-free and give a reliable indication of switch open and closed conditions.

If indicator lights are used, they should be clearly visible when RCDs are in the closed position. Indicator lights shall not be the only method indicating the closed position.

6.2 Enclosure requirement

6.2.1 Protection against electric shock

RCDs' structure shall ensure its electrified parts are inaccessible after they are installed and wired correctly.

RCDs' enclosure protection degree shall meet IP2X as specified in [IEC 60529].

6.2.2 Enclosure fire risks

Enclosure insulation components shall be non-flammable or self-extinguishing.

6.3 Dielectric properties

RCD insulation shall have adequate dielectric properties.

The DC high voltage generated from normal circuit insulation tests shall not damage the control circuit connected to the main circuit after RCDs are installed.

6.4 Temperature rise

The temperature rise of the accessible RCD parts shall not exceed the limits specified in Table 1. RCDs shall not suffer damage influencing their functions and safety use.

Table 1 – Limits of temperature rise (based on [IEC 61008-1])

Parts	Temperature rise / K
Terminals connecting outer conductors	60
Outer accessible parts during manual operation of RCDs including operating parts of insulation materials and insulated metal parts connecting poles	40
Outer metal parts of operating components	25
Other outer parts including the surface of RCDs directly in contact with mounting surfaces	60

Ambient air temperature: the temperature rise limits listed in Table 1 are applicable only if the ambient air temperature is kept at the range of normal working conditions.

6.5 Operating characteristics

The values required in this clause may vary depending on national requirements and laws and regulations.

6.5.1 Rated residual operating current ($I_{\Delta N}$)

The residual operating current value specified by manufacturers has preferred values of 0.006 A, 0.01 A, 0.03 A, 0.1 A, 0.3 A and 0.5 A. The levels of 0.03 A and below are intended to protect users from hazardous electric shock.

6.5.2 Rated residual non-operating current ($I_{\Delta NO}$)

The residual non-operating current value specified by manufacturers, has a preferred value of 50% of the rated residual operating current (0.5 $I_{\Delta N}$).

6.5.3 Rated make and break capacity (I_M)

This parameter refers to the rated connecting/breaking capacity of RCDs with short-circuit protection. RCDs shall conform to the requirements of [IEC 60898-2] when the parts perform main circuit making/breaking functions with circuit breakers used for household and similar installations; RCDs shall conform to the requirements of [IEC 60947-2] when the parts perform main circuit making/breaking functions using low-voltage circuit breakers.

Table 2 gives the minimum values of the rated making/ breaking current capability of RCDs without over-current protection. Table 3 gives corresponding power factors.

Table 2 – Minimum values of short-circuit test current (based on [IEC 61008-1])

I_N A	Prospective current for I_M, $I_{\Delta M}$, I_{NC} , $I_{\Delta C}$ tests A
IN ≤ 10	300
10 < IN ≤ 50	500
50 < IN ≤ 100	1000
100 < IN ≤ 150	1500
150 < IN ≤ 200	2000

Table 3 – Power factors of short-circuit tests

Short-circuit current I_C, A	Power factor
IC ≤ 500	1
500 < IC ≤ 1500	0.95
1500 < IC ≤ 3000	0.9

6.5.4 Rated residual making/breaking capacity ($I_{\Delta M}$)

Refer to Table 2 for the minimum values of rated residual making/breaking capacity and Table 3 for corresponding power factors.

6.5.5 Rated conditional short-circuit current (I_{NC})

Refer to Table 2 for the minimum values of rated conditional short-circuit current and Table 3 for corresponding power factors.

6.5.6 Rated conditional residual short-circuit current ($I_{\Delta C}$)

Refer to Table 2 for the minimum values of rated conditional residual short-circuit current and Table 3 for corresponding power factors.

6.5.7 Break time

Table 4 gives the maximum break time of RCDs for protection against indirect contact.

Table 4 – Maximum break time of RCDs for protection against indirect contact

$I_{\Delta M}$ A	I_N A	Maximum break time, s		
		$I_{\Delta M}$	$2I_{\Delta M}$	$5I_{\Delta M}$
I > 0.03	Any value	0.2	0.1	0.04
	≥ 40 (only applicable to RCDs assembled with independent components)	0.2	-	0.15

Table 5 gives the maximum break time of RCDs for direct contact protection.

Table 5 – Maximum break time of RCDs for protection against direct contact

$I_{\Delta M}$ A	I_N A	Maximum break time, s	
		$I_{\Delta M}$	$5I_{\Delta M}$
≤ 0.03	Any value	0.1	0.04

6.5.8 Delay operating time

For time delay operating characteristics, the preferred values of delay time are 0.2 s, 0.4 s, 0.8 s, 1 s, 1.5 s and 2 s. Time delay characteristics are only applicable to RCDs for indirect contact protection. This term does not apply to the products without any time delay operating characteristics.

6.6 Mechanical and electrical life

RCDs shall be able to withstand the number operations specified in Table 6 in which every operating cycle includes one time of connecting and one time of breaking.

Table 6 – Operating cycle times

Rated current In	Operating cycle times	Including	
		On-load operations	No-load operations
IN ≤ 25 A	4000	2000	2000
IN > 25 A	3000	2000	1000

6.7 Short-circuit current performance

RCDs shall be able to carry out the specified number of short-circuit operations. Short-circuit operations shall not bring danger to any operator or form flashover among electrified conductive parts or between electrified conductive parts and earthing bonding parts.

6.8 Test function of the device

The RCD shall incorporate a test function and be equipped with a test load to simulate an operate residual current level to do scheduled tests on the operating capacity of the RCD.

NOTE – A test device is used to check the trip function, but not to verify the validity of the function on the basis of rated residual operating current and break time.

At rated voltage, the residual current flowing in the test load shall not exceed 2.5 times that of the residual current equal to $I_{\Delta N}$ flowing through any main circuit of the protective device. If an RCD has more than one residual operating current setting, the lowest designed value shall be adopted.

Upon operating a test device, the protected conductor shall not be electrified. When an RCD is in the open position in normal use, the load side shall not supply power to a test load.

Test loads are not designed for breaking operation. Therefore, they are not to be used for routine disconnection.

6.9 Technical requirements for RCD functionally dependent on line voltage

RCDs are functionally dependent on the AC line voltage and shall work properly at any line voltage between 0.85 to 1.1 times the rated voltage. Under such conditions, multi-pole RCDs' all currents shall be supplied by phase lines and neutral lines (if any) of power sources.
At abnormal line voltage, RCDs have two operating functions of opening and closing main circuits.

6.10 RCD working conditions upon over current of main circuits

RCDs without overcurrent protection shall not operate under specified overcurrent conditions. For overcurrent protected RCDs, use [IEC 60898-2] or [IEC 60947-2] according to relevant product standards.

6.11 RCD performance with surge current

RCDs shall have sufficient resistance to surge current to earth when operating with a capacitive load, or in the event of a device flashover. Time delay RCDs shall have sufficient capacity to prevent a fault trip in the event of a surge current to earth due to flashover.

No fault operation shall occur when 1.2/50–8/20 combination wave, 2 kV is applied to power lines (L-N). A sample shall work normally without any damage when 1.2/50, 4 kV surge voltage is applied to power lines (L-N).

A sample shall work normally without any damage when an 8/20, 20 kA lightning current passes through the RCD L to N, when a surge protective device is installed. The device shall be able to operate and to open the circuit, in the event of short-circuit condition.

6.12 Technical requirements for automatic-reclosing devices

6.12.1 Automatic-reclosing devices without residual current detection function

If the RCDs do not have electric residual current detection function after the opening, the RCDs automatically reclose typically once after 20 s to 60 s of the opening; if this is not successful, the devices reclose for a second time typically after a 15-minute delay; if this is still not successful, the devices reclose for a third time typically after another 15-minute delay. If not successful, no further reclosing is allowed.

Successful reclosing means that the device shall stay closed for typically 5 s after it recloses.

When an RCD trips, the automatic recloser will check the circuit where the RCD is installed to avoid safety problems where residual current still exists after the RCD is reclosed.

6.12.2 Automatic-reclosing devices with electric residual current detection function

After automatic-reclosing devices open, the requirements on the residual current detection functions are as follows: 1) no further reclosing is allowed after 3 unsuccessful reclosing attempts, typically within 1 minute. 2) testing voltage is DC $\leq$ 24 V or AC typical value $\leq$ 17 V.

6.13 Environmental adaption

Operating environmental conditions:

Normal range: −5ºC ~+40ºC

Extended range: −40ºC ~+70ºC

Humidity: 5% to 95%

Atmospheric pressure: 70 kPa ~ 106 kPa.

6.14 Safety warning

To remind skilled persons of the potential electric shock risk in the insulation case, the following warning sign and language shall be required to be placed on the equipment case:

IEC 60417-6042

"WARNING " or equivalent word or text, and
"HIGH TOUCH CURRENT" or equivalent text
"Automatic-reclosing power devices" or equivalent text

Annex A

RCDAs with electric residual current detection function

(This annex forms an integral part of this Recommendation.)

A.1 Technical rationale

When an RCD trips, the automatic recloser will check the circuit where the RCD is installed to avoid safety problems where residual current still exists after the RCD is reclosed.

Figure A.1-1 and Figure A.1-2 show the leakage fault detection circuit separately, representing single-phase and three-phase main power.

The detecting signal passes through grounding, transformer and neutral line. The detecting circuit is installed on the output of an RCD phase and neutral line (a, b, c, n) respectively. Residual current detecting becomes a loop after checking the phase line, PE line, grounding resistance Re1 and Re2, the neutral line in the transformer and the detection circuit. The PE wire of the detection circuit does not need to connect to the equipment enclosure. The voltage of the detection circuit is 24 V d.c.

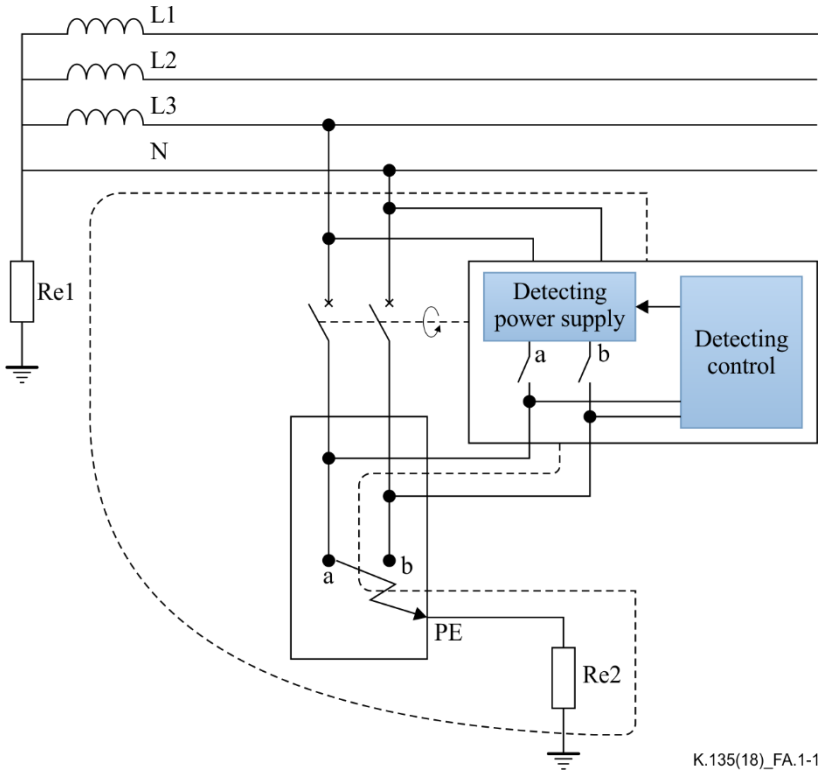

Figure A.1-1 – Dotted line represents single-phase residual current detection circuit

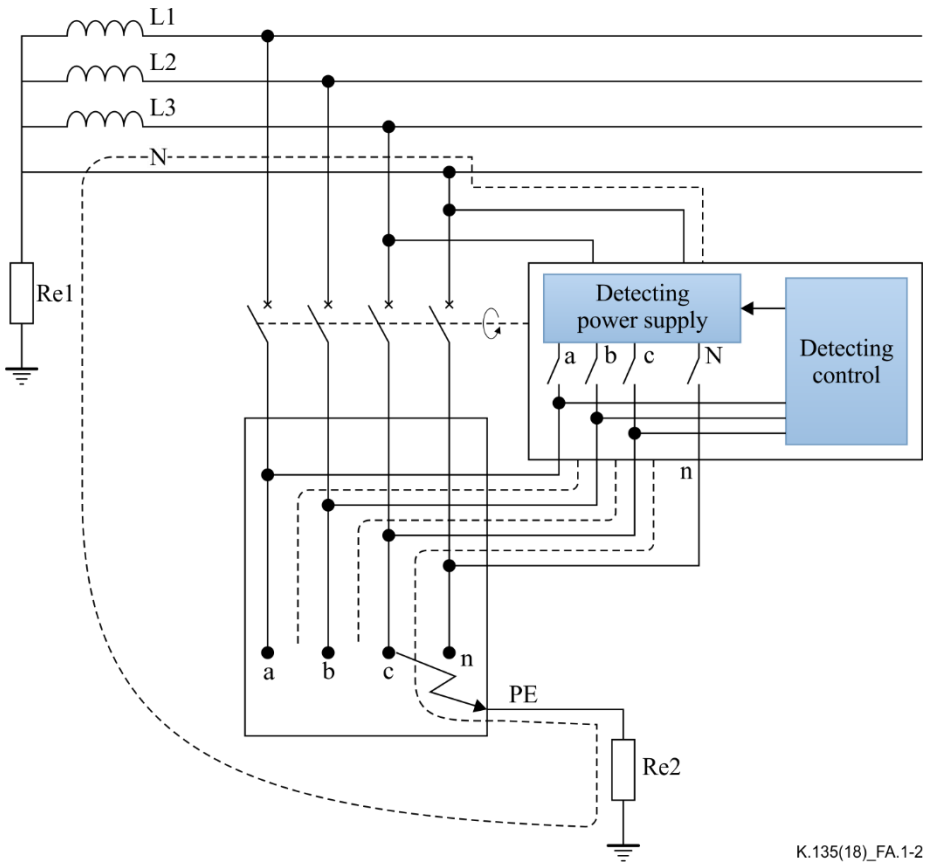

Figure A.1-2 – Dotted line represents 3-phase residual current detection circuit

Figure A.1-3 and Figure A.1-4 show reclosing devices for residual current detection.

The detecting signal passes through the device enclosure. The residual current detection becomes a loop after checking the phase line, the device enclosure and the PE line. The PE wire of the detection circuit needs to connect to the equipment enclosure. The voltage of the detection circuit is 24 V d.c.

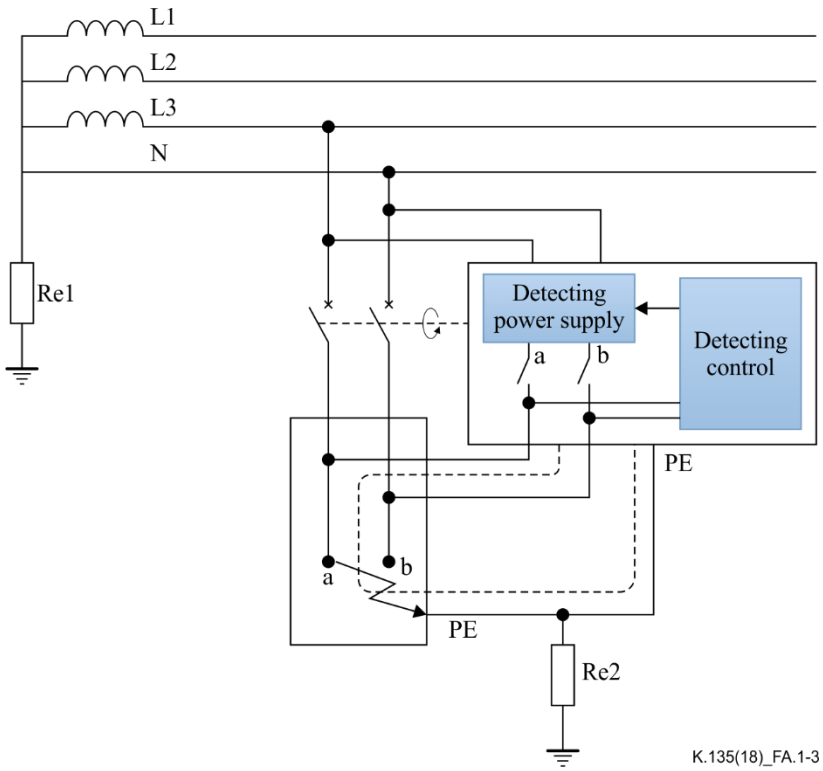

Figure A.1-3 – Dotted line represents single-phase residual current detection circuit

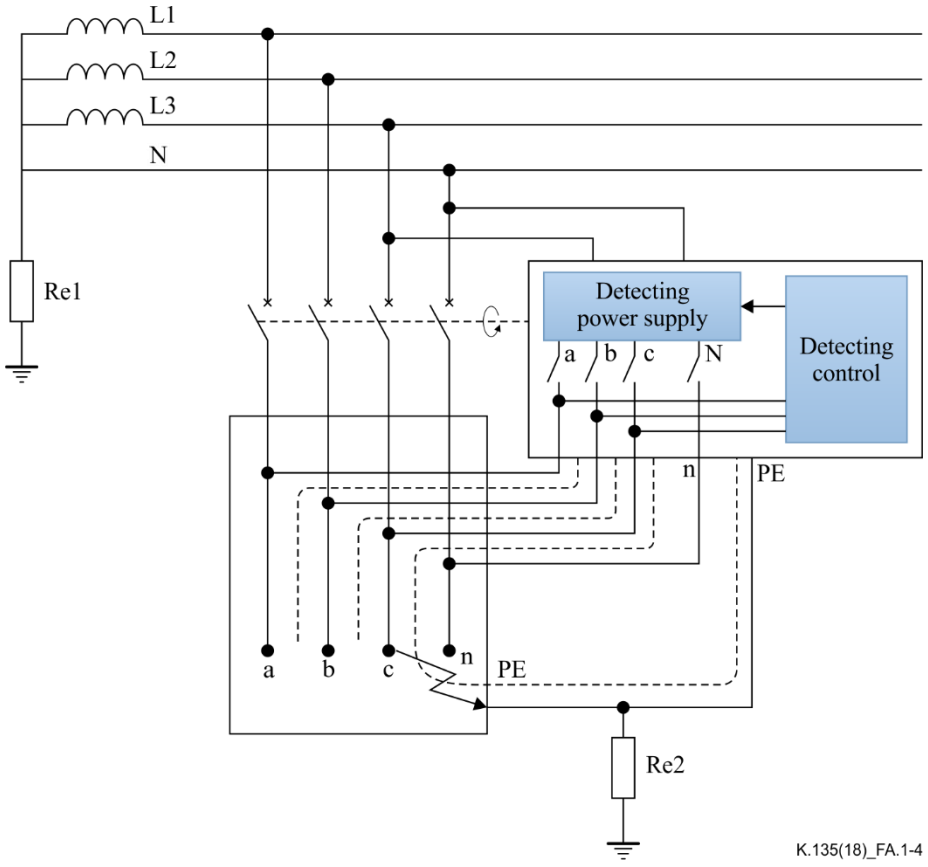

Figure A.1-4 – Dotted line represents 3-phase residual current detection circuit

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[b-IEC 61936-1] IEC 61936-1 (2014), *Power installations exceeding 1 kV a.c. – Part 1: Common rules*.

[b-IEC 62368-1] IEC 62368-1 (2018), *Audio/video, information and communication technology equipment – Part 1: Safety requirements*.

[b-IEC 62752] IEC 62752 (2016), *In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD).*

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