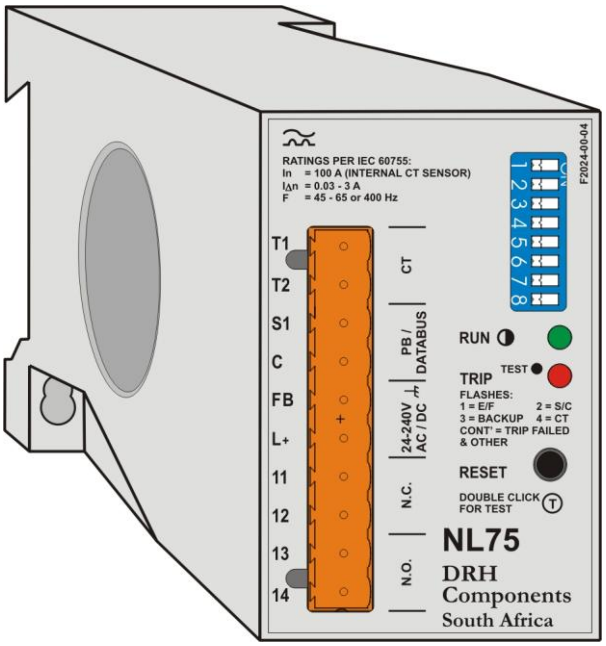
NL75 Intelligent Earth Fault Protection reference manual



DRH Components (Pty) Ltd

P O Box 1203
Hillcrest
3650
KZN

Unit 2
22 Assagay Road
Hillcrest
3610

Web: www.drhcomponents.co.za

Email: info@drhcomponents.co.za

1. FUNCTIONALITY 3

1.1 RESIDUAL CURRENT SENSING AND FAULT REPORTING 3
1.2 EXTERNAL CURRENT SENSOR 3
1.3 LED INDICATORS 3
1.4 RESET / TEST PUSHBUTTON 3
1.5 OPERATING MODES 4
1.6 TAMPER PROOF DIPSWITCHES 4
1.7 OPTIONAL EXTENSION UNITS 5
1.8 MASTER RESET PROCEDURE 6

2. DIPSWITCH SETTINGS 7

3. CONTROL VOLTAGE 7

4. CONNECTIONS AND PRECAUTIONS 8

5. TECHNICAL SPECIFICATION 9

1. FUNCTIONALITY

1.1 Residual current sensing and fault reporting

The NL75 employs either the built-in or an external 500:1 Current Sensor (CS) to measure residual current flowing to earth in electrical power distribution systems. The measured value is compared against two setpoints. The lower one, the Earth Fault (E/F) setpoint, is settable from 30 mA to 3 A in 7 steps and has an associated delay settable from 20 ms to 3 s in 4 steps. The higher one, the Short Circuit (S/C) setpoint is fixed at 50 A when the built-in CS is used and at 125 A otherwise. When the current exceeds the E/F setpoint for the set delay, but does not reach the S/C level, an 'E/F' is diagnosed and the unit trips by operating its internal relay. Now, should a fault be approaching a dead short to earth, causing a residual current exceeding the S/C setpoint, then without any delay the unit operates its relay diagnosing a 'S/C'.

Optionally, the user can select the operation of the relay to be Type 2 Co-ordinated with an upstream tripping device (fuse or breaker) to protect any local contactor contacts in the case of S/C faults. In this case the unit does not trip initially when the measured current exceeds the S/C setpoint, but waits for the upstream device to take care of current interruption and then trips. The latter trip flags the location of the fault to the user and also allows him to instantly re-close the upstream tripping device. Should the upstream device fail to perform, then automatic backup protection makes the NL75 trip -as a last resort- one second after the S/C occurred.

The relay contacts can be used in a trip or alarm circuit. Separate normally open and normally closed contacts are provided.

The NL75 is a Class A device as defined in the IEC 60755 standard; it is therefore fully characterised for operation with sinusoidal AC and pulsating DC currents.

1.2 External Current Sensor

The NL75 auto detects and registers the use of an external CS.

1.3 LED indicators

The unit has a green LED showing correct operation by slowly flashing (1 s on / 1 s off). Instead however, when the unit is in a tripped condition, a red LED shows short 0.25 s flashes as a code indicating the cause of the trip:

- One 0.25 s flash every few seconds means residual current exceeded the set E/F limit, but did not reach S/C levels. This trip is labelled 'E/F'.
- Two consecutive 0.25 s flashes every few seconds means residual current exceeded the S/C level. This trip is labelled 'S/C'.
  In case Type 2 Co-ordination is used, this code also means that the upstream device tripped correctly; after the current went to zero as a result, the NL75 activated its trip relay to isolate the faulty circuitry.
- Three consecutive 0.25 s flashes every few seconds can only occur when Type 2 Co-ordination is used. It means that residual current exceeded the S/C level, but the upstream device failed to trip. The NL75 then tripped as a last resort. This trip is labelled 'Backup'. The contactor should be replaced since its contacts may well be damaged.
- Four consecutive 0.25 s flashes every few seconds means that an external CS is being used and the connection to that CS is either open or shorted. Note that the trip is latched until reset; therefore intermittent failures will be captured, but may give the impression of the unit having tripped without reason.
- Continuous 0.25 s flashes indicate an extra 'trip failed' alarm state on top of one of the possible trips described above. Following the operation of the trip relay, measured residual current remained at a high level. When the local or remote reset button is first pressed, the trip is not yet reset, but the 'trip failed' alarm state is. Therefore the red LED will now show the original cause of the trip.

1.4 Reset / Test pushbutton

Either the built-in or an external normally open momentary pushbutton is used to reset the internal relay and/or the red LED (depending on the exact Operating Mode, see section 1.5). The built-in button will be referred to as 'local', the external one as 'remote'.

Both local and remote resets will only be granted if the cause of the trip is cleared. Otherwise the relay will remain activated without glitches. If the cause of the trip is cleared alright but another one is lurking, then pressing the local or remote button will reset the trip indication on the red LED, such that the new trip code can be shown. The relay however will remain activated without glitches.

Double-clicking local or remote buttons invokes a test which switches an AC voltage onto the built-in processor's CS sensor input. The voltage is scaled to simulate a residual current of 1.5 - 3 times the E/F trip level setpoint. The unit will trip on E/F after the set delay (plus 0.4 s) and then switch off the AC voltage. The button needs to be pressed again to reset the device. No external power supply is required.

1.5 Operating Modes

The NL75 user can select four distinct Operating Modes for the device. All modes have this in common:

- In the 'reset state' of the relay the normally open contact is open and the normally closed contact is closed.
- In the 'tripped state' of the relay the normally open contact is closed and the normally closed contact is open.

The differences between the modes are listed below.

1. <u>Continuous Non-Failsafe operation</u>
   After a trip the relay remains in the tripped state and the red LED remains active until a reset button is pressed. When control voltage is removed (and subsequently restored) the relay remains in the pre-power down state.
2. <u>Continuous Failsafe operation</u>
   Same as mode 1, except when control voltage is removed the relay goes to the tripped state unconditionally, and when control voltage is restored it goes to its pre-power down state.
3. <u>Pulsed Non-Failsafe operation (for shunt controlled breakers, or alarm only purposes)</u>
   When a trip occurs, the relay goes to the tripped state for 0.5 s, then resets. Irrespective of the trip cause, should measured current remain or go above the set E/F trip level, then this pulse is repeated every 3 s. The red LED remains active until one of the reset buttons is pressed, enabling the user to verify which NL75 tripped its associated breaker. If one forgets to reset the LED, then the functionality of the trip circuit is not impaired at all; in other words, in case of a trip condition the relay will correctly issue a pulse, even if the red LED is active.
   When control voltage is removed the relay will not issue a pulse (but note that this will reset the red LED).
4. <u>Pulsed Failsafe operation (for shunt controlled breakers, or alarm only purposes)</u>
   Same as mode 3, except when control voltage is removed the relay will issue a 0.2-0.3 s pulse.

If the NL75 is to be used for alarm only purposes (rather than to interrupt ongoing processes), and the alarm has to have an auto-resetting nature, then one has to resort to one of the Pulsed modes. The pulses will be repeated as long as current is above the set E/F level. Note however that a badly connected external CS would only generate one pulse. Also note that with earth faults the red LED will always show the 'trip failed' alarm.

1.6 Tamper proof dipswitches

Eight dipswitches enable the user to tailor the NL75 to his needs. However, to discourage unauthorised manipulation, settings (as opposed to switches) can only be changed by going through the procedure outlined below. When an attempt is made to change the settings without going through this procedure, the green and red LEDs start to blink alternately until the switches are returned to their original positions. Should the switches be left deviating from the original positions, the original settings, being stored in non-volatile memory, remain valid.

The proper procedure to change settings is as follows:

1. The dipswitches are placed in the projected positions (ignoring the blinking LEDs).
2. Within 15 s after the last change was made (or control power was applied), the system is brought in test mode <u>using the local pushbutton</u>, causing the new settings to become active. Since the system will trip now, changing the settings cannot go by unnoticed. See section 1.4 for a description of how to invoke test mode.

Note that any trips must be reset before this procedure can be completed.

1.7 Optional extension units

The functionality of the NL75 can be greatly extended by applying optional extension units, or 'options' in short. A maximum of three options can be connected at the same time. All units communicate through a simple one-wire serial datalink, that connects to the remote push-button terminal (in lieu of that button, which may now be connected to an input on some options). The NL75 auto-detects this usage of the terminal when control power is applied and registers this fact in its non-volatile memory. From then on the detected options are an integral part of the total protection system, and their presence is monitored.

Options may flag themselves as 'critical' to the NL75. This means that their absence on the datalink is declared unacceptable and would cause an alarm condition. The latter will either activate an alarm relay in an option, or, if an alarm relay is not available in the system, cause a trip on the NL75 itself (flagged 'other' near the red LED, that will continuously flash). An option that flags itself as 'non-critical' may go offline without further consequences.

Adding options to a system up to the maximum of three is simply a matter of connecting them to the datalink, then applying power to the total system. Should it ever become necessary to remove options, either partly or completely, or to exchange options with different types, then the user must execute a master reset procedure, which is described in section 1.8. If no options at all turn out to be connected after the procedure, the terminal is available for connecting a remote reset button again.

To date the following options are available with shown features (please refer to their manuals for detailed descriptions):

<u>NL75-AUX Auxiliary Unit</u>

- S/C Trip Level Definition Station
  Three dipswitches re-define the otherwise fixed S/C trip level of the NL75. With Type 2 Co-ordination this allows for more accurately matching the system to the breaking capacity of a contactor, and without Type 2 Co-ordination it allows for setting a more precise level above which the system trips without delay. Setpoints from 20 to 320 A are available in 6 steps.
- Leakage Alarm Station
  Three dipswitches allow for defining earth leakage alarms. Such alarms are generated when the measured residual current exceeds a limit settable to 20, 30 or 50 % of the E/F trip level (as set on the NL75). The alarms can be given auto or manual reset attribute, or they can be switched off altogether. Using this feature makes sense only if an 'Alarm Output' relay function and/or a NL75-DISP Display Unit are present in the system.
- Relay A Station
  Relay with a changeover contact that can be assigned the functions of 'Alarm Output' or 'Upstream Trip Output' (see below). Operating Mode is dipswitch settable to Continuous Non-Failsafe, Continuous Failsafe or Pulsed Non-Failsafe.
- Relay B Station
  Relay with a changeover contact that can be assigned the functions of 'Upstream Trip Output', 'Immediate E/F Trip Level Exceeded Output with delayed E/F trip' or 'Leakage Level Exceeded Output' (see below). Operating mode is settable as for Relay A.
- 'Alarm Output' relay function
  Indicates alarm conditions. Faults detected by the external CS supervisor will now cause alarms instead of trips. Also the 'Trip failed' condition will cause an alarm here, and it will no longer show up on the NL75's red LED. Of course, the Leakage Alarm Station described above is a source of alarms.
- 'Upstream Trip Output' relay function
  Actively trips an upstream breaker under Type 2 Co-ordination, or when a 'Trip failed' alarm condition is present. For the latter to work, the Alarm Output function may or may not be used.
- 'Immediate E/F Trip Level Exceeded Output with delayed E/F trip' relay function activates the relay when residual current exceeds the E/F trip level, at the same time inhibiting E/F trips on the NL75 for a maximum period settable from 5 s to 10 min in 7 steps by means of dipswitches. S/C trips are never inhibited though.
  This function can be used to switch in standby equipment before tripping, or for instance to stop feeding a conveyer belt and have it empty itself before tripping it out.
- Two Auxiliary Units can be used at the same time on the same datalink as long as the S/C Trip Level Definition Station is switched off on one of both.

NL75-DISP Self Powered LCD Display Unit

- Door mounted.
- Reset pushbutton with configurable 'Start Test' capability.
- 'Show trip' pushbutton. Remains functional even when supply power is switched off as a result of a trip: pressing the button will cause the LCD display to show whether or not the NL75 to which it is connected was in a tripped state at the instant of power loss. This way the user is able to verify which one of a group of units tripped their associated tripping device (a breaker normally). This information remains accessible for at least 10 hours after power is lost.
- Shows residual current as a percentage of the E/F trip level, or in Amps.
- Shows pre-trip residual current while the system is tripped.
- Shows trip and alarm causes. Alarms are normally processed even if the 'Alarm Output' relay function is not available in the system.

1.8 Master reset procedure

The master reset procedure erases the system configuration registration stored in non-volatile memory. It brings back the 'stand-alone' functionality of the NL75:

- No external CS
- No datalink with optional extension units

The procedure is executed as follows:

- Remove control power and wait 5 seconds
- Keep the local pushbutton pressed while re-applying control power; the green LED stays off
- Hold the button for 5 more seconds, i.e. until the green LED starts to flash
- Release the button and reset any trips and alarms

Any intentionally connected external CS or optional extension units may be left in place while performing the procedure. They will immediately be re-recognised again.

2. DIPSWITCH SETTINGS

In the table below 'R' denotes right and 'L' denotes left.

Switch nos.	Parameter	Set to	Meaning	Refer to section
1 2 3	Earth Fault Trip Level	L L L L L R L R L L R R R L L R L R R R L R R R	30 mA 100 mA 250 mA 370 mA 500 mA 1 A 3 A 60 mA	1.1
4 5 6	Earth Fault Trip Delay and Type 2 Co-ordination	L L L L L R L R L L R R R L L R L R R R L R R R	20 ms without Type 2 Co-ordination 20 ms with Type 2 Co-ordination 100 ms without Type 2 Co-ordination 100 ms with Type 2 Co-ordination 300 ms without Type 2 Co-ordination 300 ms with Type 2 Co-ordination 1 s without Type 2 Co-ordination 3 s without Type 2 Co-ordination	1.1
7 8	Operating Mode	L L L R R L R R	Continuous Non-Failsafe operation Continuous Failsafe operation Pulsed Non-Failsafe operation Pulsed Failsafe operation	1.5

3. CONTROL VOLTAGE

The NL75 has a universal control voltage input, accepting nominal voltages between 24 and 240 V AC or DC with a -20% / +10% tolerance. The total range of accepted voltages is therefore 19.2 to 264 V AC or DC. Power consumption is a mere 1.2 VA maximum with AC voltages and 0.5 W maximum with DC voltages.

Note that the built-in power supply circuit is non-isolated. This means that there is no electrical isolation between the control voltage input and the internal electronics, which therefore share a common earth reference. This reference is applied to the system through the FB (Frame Bond) terminal which must be firmly connected to local frame or chassis earth with the shortest possible lead for safety and proper EMC behaviour. Use a 2-2.5 mm^2 (14 AWG) stranded conductor. Control voltage is subsequently presented to the L+ terminal with respect to chassis earth. AC voltage sources connect their 'cold' N side to the chassis and distribute their 'hot' L side through wiring to the L+ terminals. DC voltage sources connect their 'cold' – side to the chassis and distribute their 'hot' + side through wiring to the L+ terminals. For good EMC behaviour it is important (as in any installation) to run all wiring close along the chassis or in metal ducts, avoiding excess lengths.

Cycling the control voltage will not reset a trip**.** See section 1.5 Operating Modes

4. CONNECTIONS AND PRECAUTIONS

Please consult the following checklist when applying the NL75.

1. If the NL75 is used for alarming only purposes, or if the E/F Trip Delay is set to 1 s or higher, verify that the NL75 cannot be subjected to conditions exceeding its Thermal Withstand Capability (see section 5: Technical Specification).
2. Place the NL75 in a clean dry enclosure. Locate the relay close to the isolating device (circuit breaker or contactor) that is protecting the circuit being monitored. Provide maximum clearance between the NL75 (and the external CS if being used) and any strong magnetic flux producing devices such as power transformers, autotransformers, control transformers, reactors, and high power conductors and other buswork.
3. Lead the power conductors of the circuit being monitored (including Neutral if any) through the internal OR external CS's opening. WARNING: Never lead conductors through both CSs at the same time.
4. All connections to the NL75 are by means of screw clamp pull-apart terminals rated 10 A, 300 V. Terminals will accept 0.5-2.5 mm^2, 20-14 AWG solid or stranded conductors. The user may want to identify the following terminals:

T1 and T2	for connecting an external CS
S1	for connecting an external pushbutton OR a datalink to extension units
C	common for external pushbutton OR datalink to a self powered extension unit
FB	for providing an absolute earth reference to the system (refer to section 3)
L+	for connecting control power's 'hot' side
11 and 12	for access to the normally closed contact of the relay
13 and 14	for access to the normally open contact of the relay

5. In order to meet the Electromagnetic Compatibility (EMC) requirements a firm and short connection is required between terminal FB and the nearest chassis earth point. This distance should be kept to an absolute minimum. If the NL75 is mounted on a 35 mm DIN rail a DIN rail mounted earth terminal block can be installed beside the unit to act as the chassis earth point. Use a 2-2.5 mm^2 (14 AWG) stranded conductor.
6. For good EMC behaviour it is important (as in any installation) to run all wiring, especially if unshielded, close along the chassis or in metal ducts, avoiding excess lengths.
7. Connect AC or DC control power's 'hot' side to terminal L+. Control power's 'cold' side must be connected to chassis earth (refer to section 3).
8. Integrate the relay contacts into the projected control circuit. Apply appropriate fusing to protect the contacts (13 A maximum).
9. If an external CS is being used, connect the two secondary terminals of the Current Sensor to terminals T1 and T2 of the NL75 using 2 mm^2 (14 AWG) shielded twisted pair cable. Connect the shield to chassis earth by means of a clamp, close to the NL75 (where the FB terminal is bonded to chassis earth as well). From the clamp to terminals T1 and T2 the wires can be left unshielded.
   CAUTION: Terminals T1 and T2 are NOT isolated. They are connected to the FB terminal internally via a 2.5 V DC voltage source, shunted with a 7 V transients suppressing zener diode. DO NOT connect the external Current Sensor otherwise to earth. Doing so may damage the NL75.
   NOTE: Use the correct type of CS as specified in section 5.
10. If an external Reset/Test pushbutton is being used, connect it to terminals S1 and C of the NL75 using twisted pair cable (of any gauge accepted by the terminals). If the distance between the button and the NL75 exceeds 1 m, shielded cable is recommended, the shield being connected to chassis earth by means of a clamp, close to the NL75 (where the FB terminal is bonded to chassis earth as well). From the clamp to the terminals the wires can be left unshielded.
    NOTE: Terminals S1 and C are NOT isolated. Terminal C is internally connected to terminal FB.
11. Up to six NL75 units in the same enclosure may share a common remote Reset/Test button. Connect one terminal of the button to terminal C of one of the units, and connect the other terminal of the button to terminals S1 of all the units in parallel.
12. If instead of a pushbutton a datalink to extension units is used, please consult the manuals of those units for installation instructions.

5. TECHNICAL SPECIFICATION

Terminals	
Type	Pull-apart
UL/CSA rating	300 V AC, 10 A
VDE rating	250 V AC, 12 A, pollution degree 3, over-voltage category III
Insulation stripping length	7 mm
Torque	0.4 - 0.6 Nm
Field wiring	0.5 - 2.5 mm^2 (VDE), 20 - 14 AWG (UL/CSA), Cu, solid or stranded
Control power	
Voltage range	Nominal: 24 – 240 V AC/DC, -20% / +10% Total: 19.2 – 264 V AC/DC
Frequency range on AC	45 – 450 Hz
Power consumption	AC 1.2 VA max, DC 0.5 W
Isolation voltage	Not electrically isolated from electronics
Loss of supply tolerance (no impaired operation)	250 ms at 24 V ac 1 s at 120 V ac 4 s at 230 V ac 80 ms at 24 V dc 350 ms at 48 V dc 750 ms at 110 V dc
Power-up time	500 ms for E/F detection [1] 100 ms for S/C detection
System power	
Voltage and current range (internal CS)	0 – 660 V AC, 0 – 100 A
Voltage and current range (external CS)	Any, providing the power conductors are insulated for the system voltage
Frequency range	45 – 65 Hz or 400 Hz
Isolation voltage (internal CS)	2.5 kV rms, 1 minute
Earth fault circuit	
E/F Trip Level (settable)	0.03, 0.1, 0.25, 0.375, 0.5, 1, 3, 0.06 A
Accuracy of E/F trip point	-15% / +0% of Trip Level [2]
E/F Trip Delay (settable)	0.02, 0.1, 0.3, 1, 3 s [3]
Accuracy of E/F trip delay	-2 / +5 ms or ±2.5% of Trip Delay, whichever is greater

S/C Trip Level	Current wave shape	Internal CS	External CS
	Sine	50 A ac	125 A ac
	IEC 60755 DC 0°	43 A rms	110 A rms
	IEC 60755 DC 90°	32 A rms	80 A rms
	IEC 60755 DC 135°	24 A rms	60 A rms

Accuracy of S/C trip point	± (10 % + 2 A)			
S/C Trip Delay	5 ±2 ms			
Type 2 Co-ordination on S/C	Selectable on / off with 0.02, 0.1 and 0.3 s E/F Trip Delay settings			
Thermal withstand capability (internal CS)	300 A	infinitely	1500 A	500 ms
	500 A	2000 ms	≥ 2000 A	300 ms
	1000 A	700 ms		
Thermal withstand capability (external CS)	300 A	infinitely	2000 A	125 ms
	500 A	2000 ms	5000 A	20 ms
	1000 A	500 ms		

Suitable external CS types	CS500-46 46 mm inner diameter CS500-65 65 mm inner diameter CS500-90 90 mm inner diameter CS500-150 150 mm inner diameter CS500-250 250 mm inner diameter Other sizes, including split rectangular sensors, on request
<u>External CS Supervision circuit</u>	
CS loop resistance causing a fault (O/C)	> 1 kΩ
CS shunt resistance causing a fault (S/C)	< 50 Ω
CS Fault Trip Delay	1.5 s
<u>Relay contacts</u>	
Configuration	Voltage free form "Z" (1 N.O. and 1 N.C. contact, 4 terminals)
UL/CSA rating	5 A @ 250 V AC, general use 5 A @ 30 V DC, resistive 1/8 hp, 250 V AC 2 A, 250 VA, @ 125 V AC, pilot duty 1 A, 250 VA, @ 250 V AC, pilot duty 0.88 A, 26.4 VA, @ 30 V DC, pilot duty
EN 60947 rating	5 A @ 250 V ac, utilisation category AC-12 4 A @ 250 V ac, utilisation category AC-13 3 A @ 250 V ac, utilisation category AC-14 3 A @ 250 V ac, utilisation category AC-15 5 A @ 30 V dc, utilisation category DC-12 3 A @ 24 V dc, utilisation category DC-13 Maximum fuse rating 13 A
Isolation voltage	2 kV rms, 50 – 60 Hz, 1 minute
Breakdown voltage between open contacts	1 kV rms
Breakdown voltage between N.O. and N.C. contact	2 kV rms
<u>External pushbutton circuit</u>	
Type of pushbutton	Single pole, normally open, momentary
Voltage across / current through contact	5 V DC, 1 mA
Maximum number of units that can be controlled in parallel from one button	6, all in the same enclosure
<u>Environment</u>	
Operating temperature	-35 °C to +60 °C
Storage temperature	-40 °C to +80 °C
Humidity	85% max (no condensation)
Ingress protection	IP20
Shock resistance (no malfunction)	10 G
Vibration resistance (no malfunction)	10 G, 10 – 55 Hz at 1.5 mm double amplitude
<u>Mechanical properties</u>	
Height	45 mm 1.77"
Width	70 mm 2.76"
Depth (not including terminal block)	103 mm 4.03"
Depth (including terminal block)	126 mm 4.95"
Internal CS opening diameter	28 mm 1.1"
DIN rail if DIN rail mounted	35 mm
Screws if screw mounted	M4 x 20 #8 x ¾" (2 needed)
Weight (open)	0.40 kg 0.88 lbs.

Weight (packaged)	0.49 kg	1.08 lbs.

Applicable standards

EN 61000-6-3	Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments (=lowest levels) 30-230 MHz 30 dBμV at 10 m distance 230-1000 MHz 37 dBμV at 10 m distance
EN 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments (=highest levels) 80-1000 MHz with 80% AM modulation up to 10 V/m at 3 m distance from source
EN 61000-4-2	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-2: Electrostatic discharge (ESD) immunity
EN 61000-4-3	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-3: Radiated electromagnetic field immunity
EN 61000-4-4	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-4: Electrical fast transient/burst immunity
EN 61000-4-5	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-5: Surge immunity
EN 61000-4-6	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-6: Conducted radio frequency field immunity
EN 61000-4-11	Electromagnetic compatibility (EMC) for industrial-process measurement and control equipment – Part 4-11: Voltage dips/drops/variations immunity
EN 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices
IEC 60755	General requirements for residual current operated protective devices
UL	UL 1053 Ground-Fault Sensing and Relaying Equipment, Class 1
CSA	C22.2 No. 144-M91 Ground Fault Circuit Interrupters
CE	CE mark – Declaration of Conformity

[1] If an earth fault causing a residual current above the E/F Trip Level but below the S/C Trip Level is already present when power is applied, the system trips just as soon as possible, irrespective of the E/F Trip Delay setting (rationale: the fault may be present much longer than the delay set).

[2] The accuracy of the trip point refers to the value of the real world leakage current (assuming a purely sinusoidal wave shape) that just causes a trip when slowly increased from zero.

[3] The earth fault detection mechanism has a 'thermal' behaviour for greatly reduced noise sensitivity: the quoted delays are valid for sinusoidal currents exceeding the setpoint by >10 times; for reduced current excursions the delay increases as follows:

current = 6 x setpoint: add 3 ms
current = 4 x setpoint: add 8 ms
current = 2 x setpoint: add 20 ms
current = 1.2 x setpoint: add 60 ms

For IEC 60755 'pulsating DC' currents, the delay increases by a further 50 ms maximum.