Part 4 – Protection for Safety

411 Fault Protection (Indirect Contact)
Automatic Disconnection (ADS)
SELV, PELV, FELV
The use of: RCD
Class II Equipment
These are additonal measures added to ADS and ELV

Automatic disconnection of supply is a protective measure in which

(i) basic protection is provided by basic insulation of live parts or by barriers or enclosures, in accordance with Section 416, and

(ii) fault protection is provided by protective equipotential bonding and automatic disconnection in case of a fault in accordance with Regulations 411.3 to 6.

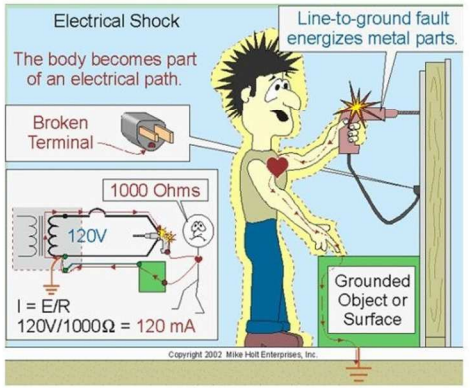
Where this protective measure is applied, Class II equipment may also be used.

Where specified, additional protection shall be provided by a residual current device (RCD) with rated residual operating current not exceeding 30 mA in accordance with Regulation 415.1.

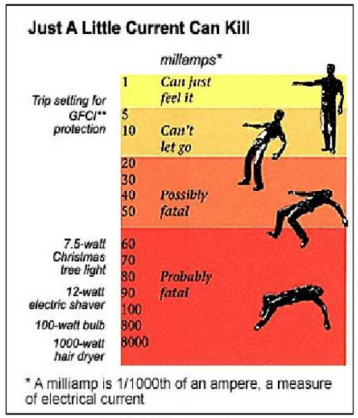
Part 4 – Protection for Safety

Why is RCD protection used for ordinary persons?

(Electricity is the same in the USA as in Europe!)



Part 4 – Protection for Safety



Part 4 – Protection for Safety

411.3.3 Additional requirements for socket-outlets and for the supply of mobile equipment for use outdoors

In AC systems, additional protection by means of an RCD with a rated residual operating current not exceeding 30 mA shall be provided for:

(i) socket-outlets with a rated current not exceeding 32A, and

(ii) mobile equipment with a rated current not exceeding 32A for use outdoors.

An exception to (i) is permitted where, other than for an installation in a dwelling, a documented risk assessment determines that RCD protection is not necessary.

The requirements of Regulation 411.3.3 do not apply to FELV systems according to Regulation 411.7 or reduced low voltage systems according to Regulation 411.8.

NOTE 1: See also Regulations 314.1(iv) and 531.3.2 concerning the avoidance of unwanted tripping.

NOTE 2: See Appendix 2, item 11 in respect of risk assessment.

NOTE 3: A lighting distribution unit complying with BS 5733, luminaire track system, installation coupler, LSC or DCL is not regarded as a socket-outlet for the purposes of this regulation.

Now becomes a general requirement for all socket outlets unless

specifically specified and underwritten by a technically skilled person

Part 4 – Protection for Safety

Additional Protection 411.3.3

30mA RCDs to be used on Socket outlets

Where…

1. All Socket outlets < 32A
2. Mobile equipment used outside < 32A

Exceptions permitted to 1. above:

1. Amendment 3 now discounts 'under the supervision of a competent person'
2. Identified and labelled for a specific item of equipment (freezers, fire alarm, sprinklers)

3. Documented Risk assessment justifying no RCDs

Part 4 – Protection for Safety

Shock Protection for Special Locations

410.3.3

– Automatic disconnection of supply

– Class II Equipment **(Double or Reinforced Insulation)**

– Electrical Separation (one item of equipment)

– SELV, PELV

Additional Protection - RCDs, Protective Bonding

Part 4 – Protection for Safety

411.3.3 Additional Protection for ADS in accordance with 415

Two methods are used:

415.1 Protection by Residual Current Devices

415.1.1 max value = 30mA, At 5 IΔN < 40ms

415.1.2 Not recognized as a sole means of protection

415.2 Supplementary Bonding

415.2.1 Supplementary Bonding to localised and generalized zones

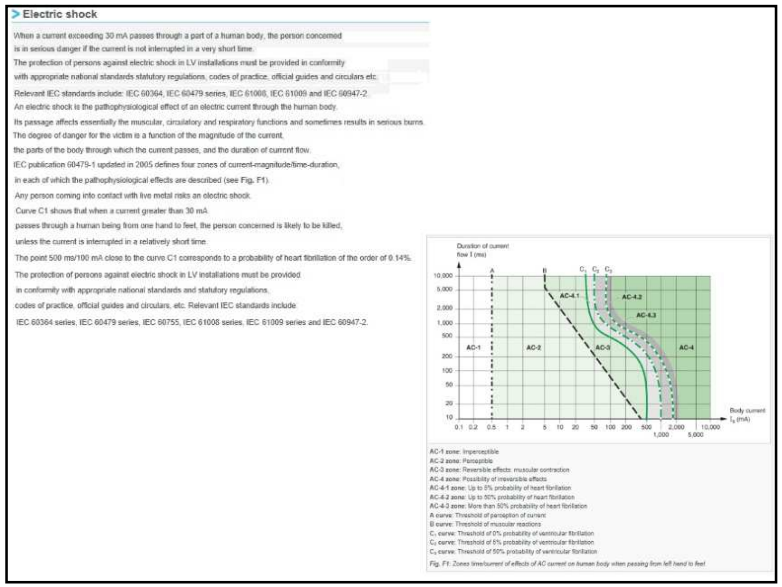
To include local cross-bonding to all extraneous and exposed conductive parts with structural elements and metallic service pipes

415.2.2 Where doubt exists to the effectiveness of supplementary bonding then it should be tested against

R ≤ 50 / Ia for AC systems and **R ≤ 120V / Ia** for DC systems

"I Δ Delta n" simply describes the way the RCD operates, i.e. "In" is normally the operating current of an OPD in terms of the current in any of the current carrying conductors in which the device is installed,

whereas in this case…5 "I Δ Delta n" describes a "Difference" 5 x , i.e. residual currents, in the current-carrying conductors that pass through the device.



Part 4 – Protection for Safety

The use of Supplementary bonding (415.2.2)

Where doubt exists regarding the effectiveness of extraneous conductive parts having the same potential then:

$$\text{AC Systems}: R \leq \frac{50V}{I_a} \qquad \text{DC Systems}: R \leq \frac{120V}{I_a}$$

Where protection is given by a RCD then:

$$R = \frac{50}{30 \times 10^{-3}} = 1.67k\Omega$$

Protection given by a 20A type B MCB (EN 60898) or RCBO (61009-1)...

$I_a = \frac{218.5}{2.19} = 100A$ or Appendix 3 Fig 3A4 Page 325 $R_2 = \frac{50}{100} = 0.5\Omega$

If the impedance of the circuit (exposed conductive part) is < 0.5Ω then the touch voltage on any simultaneously touchable metalwork for the time the fault is in operation will not rise above 50V

Part 4 Protection for Safety
The use of Supplementary bonding (415.2.2)
Protection against Shock

Stop the voltage potentials on exposed and extraneous conductive parts rising beyond the safety voltage - touch voltage – in fault conditions – 415.2

$$\text{AC Systems}: \mathbf{R} \leq \frac{50V}{I_a} \qquad \text{DC Systems}: \mathbf{R} \leq \frac{120V}{I_a}$$

Where **R** is the resistance between two simultaneously touchable exposed/extraneous metalwork

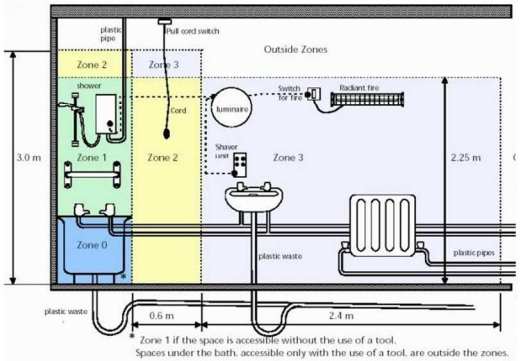
Use an RCD for additional protection to detect earth fault currents at...

50V≥ Zs x IΔN - 415.1.1

(Where IΔN ≤ 30mA, t ≤ 40mS at 5IΔN)

BS7671 2008: Protection

Fault Protection using SELV or/and local additional supplementary bonding by controlling the current flowing through the body



Protection against Shock

411.3.2 Automatic disconnection in case of a fault

411.3.2.1 Except as provided by Regulation 411.3.2.5, a protective device shall automatically interrupt the supply to the line conductor of a circuit or equipment in the event of a fault of negligible impedance between the line conductor and an exposed-conductive-part or a protective conductor in the circuit or equipment within the disconnection time required by Regulation 411.3.2.2, 411.3.2.3 or 411.3.2.4.

The protective device shall be suitable for isolation of at least the line conductor.

NOTE: For IT systems, automatic disconnection is not necessarily required on the occurrence of a first fault (see Regulation 411.6.1). For the requirements for disconnection in the event of a second fault, occurring on a different live conductor, see Regulation 411.6.5.

411.3.2.2 Maximum disconnection times stated in Table 41.1 shall be applied to final circuits with a rated current not exceeding:

(i) 63 A with one or more socket-outlets, and

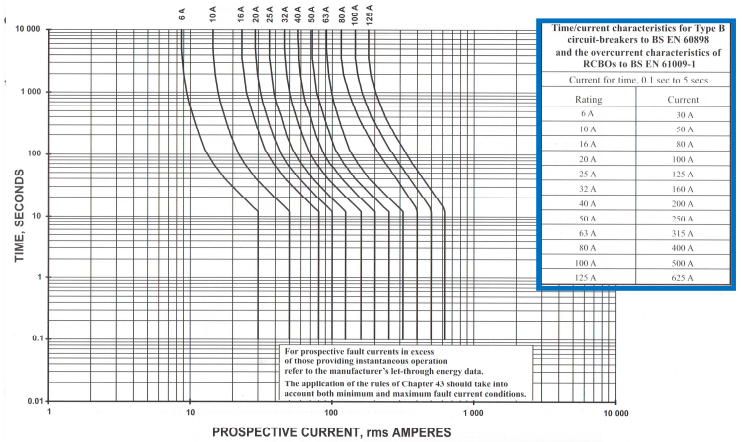
(ii) 32 A supplying only fixed connected current-using equipment. 58

TABLE 41.1 – Maximum disconnection times

System	$50 V < U_0 \leq 120 V$ (s)		$120 V < U_0 \leq 230 V$ (s)		$230 V < U_0 \leq 400 V$ (s)		$U_0 > 400 V$ (s)	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0.8	NOTE 1	0.4	1	0.2	0.4	0.1	0.1
TT	0.3	NOTE 1	0.2	0.4	0.07	0.2	0.04	0.1

Note 1: Disconnection times not required for shock, but for thermal effects

2018 BS7671 18th Edition (BLUE BOOK)
Appendix 3 Fig 3A4 Page 370
Type B circuit-breakers to BS EN 60898 and RCBOs to BS EN 61009-1



Time/current characteristics for Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1

Current for time: 0.1 sec to 5 secs

Rating	Current
6 A	30 A
10 A	50 A
16 A	80 A
20 A	100 A
25 A	125 A
32 A	160 A
40 A	200 A
50 A	250 A
63 A	315 A
80 A	400 A
100 A	500 A
125 A	625 A

Part 4 – Protection for Safety

- Protection provided by a Residual Current Device.

  Following condition applies:
- Regulation 411.5.2:
  - Z_s = Earth fault loop impedance in Ohms;
  - IΔn = rated residual operating current in Amps
- Protection in TT systems.
  - The use of over current protective devices are not excluded although it is preferred to use a RCD with a disconnection time of not greater than 1 sec 411.3.2.4
- Regulation 411.5.3
  - R_A = sum of all the resistances of earth electrode and protective conductors connected to the exposed conductive parts;
- Regulation 411.5.4
  - I_a =the current causing automatic operation of the protective device

Part 4 – Protection for Safety

411.5 TT system

411.5.1 Every exposed-conductive-part which is to be protected by a single protective device shall be connected, via the main earthing terminal, to a common earth electrode. However, if two or more protective devices are in series, the exposed-conductive-parts may be connected to separate earth electrodes corresponding to each protective device.

The neutral point or the midpoint of the power supply system shall be earthed. If a neutral point or midpoint is not available or not accessible, a line conductor shall be earthed. 63

411.5.4 Where an overcurrent protective device is used the following condition shall be fulfilled:

$$Z_s \times I_a \leq U_0 \times C_{min}$$

where:

Z_s is the impedance in ohms (Ω) of the earth fault loop comprising:
- the source
- the line conductor up to the point of the fault
- the protective conductor from the exposed-conductive-parts
- the earthing conductor
- the earth electrode of the installation and
- the earth electrode of the source

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in Regulation 411.3.2.2 or 411.3.2.4

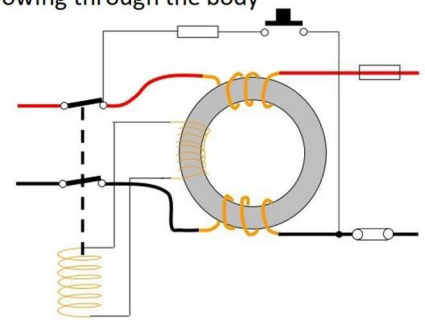
U_0 nominal AC rms or ripple-free DC line voltage to Earth

C_{min} is the minimum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations.

NOTE: For a low voltage supply given in accordance with the Electricity Safety, Quality and Continuity Regulations as amended, C_{min} is given the value 0.95. 64

Part 4 – Protection for Safety

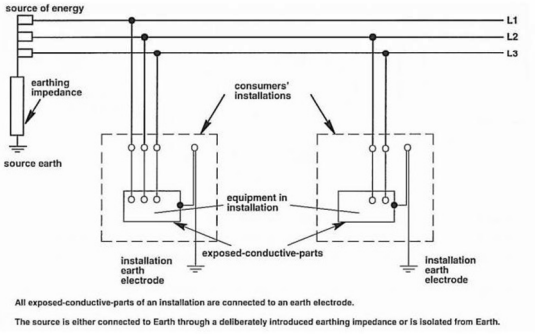
Fault protection using an RCD to BS EN 61008/9 by controlling the duration of current flowing through the body



You do not need an earth with RCDs but you do need an imbalance of current between the Line and Neutral.

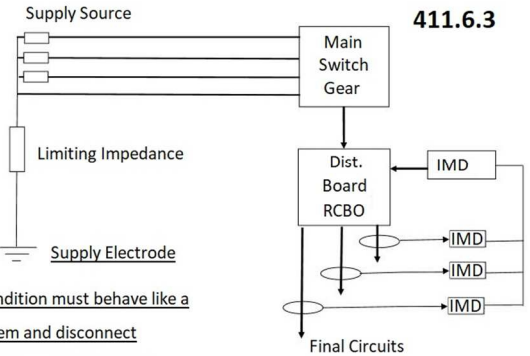
Protection against shock and Fire

The use of and terminology of IT systems are more prevalent in the 18th Edition (411.6.1). What is an IT system?
In an **IT system or network**, the electrical distribution system has no connection to earth at all,
or it has only a high impedance connection.



Basic and fault protection in IT systems

IT systems – Insulation Monitoring Devices IMDs

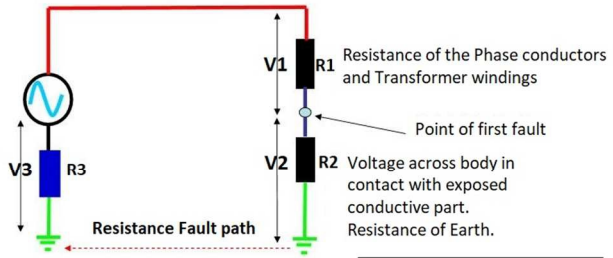


Single fault condition must behave like a TN system and disconnect within the times stated in 41.1

Basic and fault protection in IT systems

IT system of protection

$V_{poc(V2)} = V_S \times (R2 / R1 + R2 + R3) = 4.5V$



Where R3 is fixed by the distributor around 50,000 Ohms

$V_{poc(V2)} = V_S \times (R2 / R1 + R2 + R3)$

R2 is the resistance of the earth path across a human body (1.0kOhms)

and R1 is the resistance of the phase conductor (1.0 Ohm)

The Max voltage across body to the source (Voltage drop sits outside EQBZ) $= 230 \times \frac{1000\ (1.0kOhms)}{1.0\ Ohm + 1000 + 50000} = 4.5\ V$

Basic and Fault protection

Methods of protection IT systems

High impedance to earth means that the majority of the volt drop under fault conditions is outside of the equipotential bonding zone of the installation

(Earth to phase monitoring device < 50kΩ causes an alarm to sound IEC 60364)

Suitable Protective Devices 411.6.3

1. **I**nsulation **M**onitoring **D**evice (**IMD**)
2. **R**esidual **C**urrent **M**onitoring Device (**RCM**)
3. Insulation Fault Location System
4. **O**vercurrent **P**rotective **D**evice (**OPD**)
5. **R**esidual **C**urrent **D**evice (**RCD**)