

411.4.5 The characteristics of the protective devices (see Regulation 411.4.4) and the circuit impedances shall fulfil the following requirement:

$$Z_s \times I_a \leq U_0$$

where:

Z_s is the impedance in ohms (Ω) of the fault loop comprising:

- the source
- the line conductor up to the point of the fault, and
- the protective conductor between the point of the fault and the source.

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in Table 41.1 of Regulation 411.3.2.2 or, as appropriate, Regulation 411.3.2.3. Where an RCD is used this current is the rated residual operating current providing disconnection in the time specified in Table 41.1 or Regulation 411.3.2.3.

U_0 is the nominal a.c. rms or d.c. line voltage to Earth in volts (V).

NOTE: Where compliance with this regulation is provided by an RCD, the disconnection times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD.

411.4.6 Where a fuse is used to satisfy the requirements of Regulation 411.3.2.2, maximum values of earth fault loop impedance (Z_s) corresponding to a disconnection time of 0.4 s are stated in Table 41.2 for a nominal voltage (U_0) of 230 V. For types and rated currents of general purpose (gG) fuses other than those mentioned in Table 41.2, and for motor circuit fuses (gM), reference should be made to the appropriate British Standard to determine the value of I_a for compliance with Regulation 411.4.5.

TABLE 41.2

Maximum earth fault loop impedance (Z_s) for fuses, for 0.4 s disconnection time with U_0 of 230 V (see Regulation 411.4.6)

(a) General purpose (gG) fuses to BS 88-2.2 and BS 88-6						
Rating (amperes)	6	10	16	20	25	32
Z_s (ohms)	8.52	5.11	2.70	1.77	1.44	1.04
(b) Fuses to BS 1361						
Rating (amperes)	5	15	20	30		
Z_s (ohms)	10.45	3.28	1.70	1.15		
(c) Fuses to BS 3036					(d) Fuses to BS 1362	
Rating (amperes)	5	15	20	30	Rating (amperes)	
Z_s (ohms)	9.58	2.55	1.77	1.09	Z_s (ohms)	
					3	13
					16.4	2.42

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly. See Appendix 14.

411.4.7 Where a circuit-breaker is used to satisfy the requirements of Regulation 411.3.2.2 or Regulation 411.3.2.3, the maximum value of earth fault loop impedance (Z_s) shall be determined by the formula in Regulation 411.4.5. Alternatively, for a nominal voltage (U_0) of 230 V and a disconnection time of 0.4 s in accordance with Regulation 411.3.2.2 or 5 s in accordance with Regulation 411.3.2.3, the values specified in Table 41.3 for the types and ratings of overcurrent devices listed may be used instead of calculation.

TABLE 41.3

Maximum earth fault loop impedance (Z_s) for circuit-breakers with U_0 of 230 V,
for instantaneous operation giving compliance with the 0.4 s disconnection time of
Regulation 411.3.2.2 and 5 s disconnection time of Regulation 411.3.2.3

(a) Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)	3	6	10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	7.67		2.87		1.84		1.15		0.73		0.46		46 I_n	
	15.33		4.60		2.30		1.44		0.92		0.57		0.37	
(b) Type C circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)	6		10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	3.83		1.44		0.92		0.57		0.36		0.23		23 I_n	
			2.30	1.15		0.72		0.46		0.29		0.18		
(c) Type D circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1														
Rating (amperes)	6		10	16	20	25	32	40	50	63	80	100	125	I_n
Z_s (ohms)	1.92		0.72		0.46		0.29		0.18		0.11		11.5 I_n	
			1.15	0.57		0.36		0.23		0.14		0.09		

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly. See Appendix 14.

411.4.8 Where a fuse is used for a distribution circuit or a final circuit in accordance with Regulation 411.3.2.3, maximum values of earth fault loop impedance (Z_s) corresponding to a disconnection time of 5 s are stated in Table 41.4 for a nominal voltage (U_0) of 230 V. For types and rated currents of general purpose (gG) fuses other than those mentioned in Table 41.4, and for motor circuit fuses (gM), reference should be made to the appropriate British Standard to determine the value of I_a for compliance with Regulation 411.4.5.

TABLE 41.4

Maximum earth fault loop impedance (Z_s) for fuses, for 5 s disconnection time with U_0 of 230 V
(see Regulation 411.4.8)

(a) General purpose (gG) fuses to BS 88-2.2 and BS 88-6								
Rating (amperes)	6	10	16	20	25	32	40	50
Z _s (ohms)	13.5	7.42	4.18	2.91	2.30	1.84	1.35	1.04
Rating (amperes)								
Z _s (ohms)								
(b) Fuses to BS 1361								
Rating (amperes)	5	15	20	30	45	60	80	100
Z _s (ohms)	16.4	5.00	2.80	1.84	0.96	0.70	0.50	0.36
(c) Fuses to BS 3036								
Rating (amperes)	5	15	20	30	45	60	100	
Z _s (ohms)	17.7	5.35	3.83	2.64	1.59	1.12	0.53	
(d) Fuses to BS 1362								
Rating (amperes)	3	13						
Z _s (ohms)	23.2	3.83						

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly. See Appendix 14.

411.4.9 Where an RCD is used to satisfy the requirements of Regulation 411.3.2.2, the maximum values of earth fault loop impedance in **Table 41.5** may be applied for non-delayed RCDs to BS EN 61008-1 and BS EN 61009-1 for final circuits not exceeding 32 A. In such cases, an overcurrent protective device shall provide protection against overload current and fault current in accordance with Chapter 43.

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.

411.5.2 One or more of the following types of protective device shall be used, the former being preferred:

- (i) An RCD
- (ii) An overcurrent protective device.

NOTE 1: An appropriate overcurrent protective device may be used for fault protection provided a suitably low value of Z_s is permanently and reliably assured.

NOTE 2: Where an RCD is used for earth fault protection the circuit should also incorporate an overcurrent protective device in accordance with Chapter 43.

411.5.3 Where an RCD is used for earth fault protection, the following conditions shall be fulfilled:

- (i) The disconnection time shall be that required by Regulation 411.3.2.2 or 411.3.2.4, and
- (ii) $R_A \times I_{\Delta n} \leq 50 \text{ V}$

where:

R_A is the sum of the resistances of the earth electrode and the protective conductor connecting it to the exposed-conductive-parts (in ohms).

$I_{\Delta n}$ is the rated residual operating current of the RCD.

The requirements of this regulation are met if the earth fault loop impedance of the final circuit protected by the RCD meets the requirements of **Table 41.5**.

NOTE 1: Where discrimination between RCDs is necessary refer also to Regulation 531.2.9.

NOTE 2: Where R_A is not known, it may be replaced by Z_s .

TABLE 41.5
Maximum earth fault loop impedance (Z_s) to ensure RCD operation
in accordance with Regulation 411.5.3 for non-delayed RCDs
to BS EN 61008-1 and BS EN 61009-1 for final circuits not exceeding 32 A

Rated residual operating current (mA)	Maximum earth fault loop impedance Z_s (ohms)			
	50 V < $U_0 \leq 120 \text{ V}$	120 V < $U_0 \leq 230 \text{ V}$	230 V < $U_0 \leq 400 \text{ V}$	$U_0 > 400 \text{ V}$
30	1667*	1667*	1533*	1667*
100	500*	500*	460*	500*
300	167	167	153	167
500	100	100	92	100

NOTE 1: Figures for Z_s result from the application of Regulation 411.5.3(i) and 411.5.3(ii).

Disconnection must be ensured within the times stated in **Table 41.1**.

NOTE 2: * The resistance of the installation earth electrode should be as low as practicable. A value exceeding 200 ohms may not be stable. Refer to Regulation 542.2.2.

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

$$Z_s \times I_a \leq U_0$$

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