



DPC: 25 / 30477826 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: + 44 (0)20 8996 9000

Fax: + 44 (0)20 8996 7400

www.bsigroup.com

Date: 24 June 2025

Origin: National

Latest date for receipt of comments: 10 September 2025

Project No. 2023/01701

Responsible committee: GEL/600 Earthing

Interested committees: GEL/600

Title: BS 7430 Protective earthing of electrical installations - Code of practice

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 10 September 2025**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: + 44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Editorial Project Manager: Paul Cuddeford

Direct tel: 020 8996 7284

E-mail: paul.cuddeford@bsigroup.com

Introduction

Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international and European standards, comments will be reviewed by the relevant UK national committee before submitting the consensus UK vote and comments. If the draft standard is approved, it is usual for the resulting published standard to be adopted as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

Annotated drafts are not acceptable and will be rejected.

All comments should be submitted online at <http://standardsdevelopment.bsigroup.com>. You will need to register in order to comment.

BS 7430, Protective earthing of electrical installations – Code of practice

DRAFT

Contents

Foreword	4
1 Scope	6
2 Normative references	6
3 Terms and definitions	10
4 General recommendations for industrial and commercial installations	12
Figure 1 – Low voltage supply and metering – TN-S system derived from TT system via 1:1 isolating transformer	13
5 Earthing of HV derived LV supplies (i.e. from public/private transformers)	14
6 Generators	15
Table 1 – Selection of maximum earth electrode resistance (Ω) where all circuits are protected by RCD in TN and TT systems	17
Figure 2 – Arrangement of protective conductor in I-S generator arrangement	18
Figure 3 – Floating generator configuration without earth electrode	19
Figure 4 – Example of circulating currents in parallel generating sets connected to an external common busbar	21
Figure 5 – Example of single point of connection between the neutral and protective conductor and Earth to limit circulating currents	21
Figure 6 – Low voltage standby generators with star-point switching	22
Figure 7 – Low voltage standby generators with neutral earthing transformers	23
Figure 8 – Example of the fault path when the supply is isolated to an inverter based system	24
Figure 9 – Example of a correct neutral-earth connection and fault path for parallel supplies	25
Figure 10 – Example of fault path with a transformer on the output of an inverter	25
7 Installations having particular considerations for earthing	26
8 Earth electrode systems	28
Table 2 – Examples of soil resistivity in Ωm	30
Figure 11 – Measurement of earth resistivity	31
Figure 12 – Impedance to earth of horizontal earth electrodes buried in homogeneous soil	32
Figure 13 – Effect of inter electrode spacing on combined resistance	34
Figure 14 – Miscellaneous electrode configurations	37
Table 3 – Factors for vertical electrodes arranged in a hollow square	39
Table 4 – Geometric mean distance z for closely spaced reinforcing rods in a symmetrical pattern	41
Figure 15 – Ground surface potentials around a single rod and three rods in line	44
Table 5 – Earth fault current densities for 1 s duration for earthing conductors with initial conductor temperature of 30 °C	47
Table 6 – Earth fault currents (in kA) for copper strip earthing conductors	49
Table 7 – Earth fault currents (in kA) for aluminium strip earthing conductors	50
Table 8 – Values of K and β	51
Table 9 – Corrosion resistance of some electrodes materials related to soil parameters	58
Table 10 – Minimum sizes of components for earth electrodes	59
Table 11 – Recommended materials for the manufacture of earthing components (WGs to review the BS and BS EN reference are correct and still applicable)	60
9 Inspection and testing of the earthing system	64
Figure 16 – Measurement of soil resistivity	66
Figure 17 – One rod soil resistivity measurement	67
Figure 18 – Measurement of earth electrode resistance	69
Figure 19 – Earth resistance curves	70
Table 12 – 61.8% test probe spacing for various grid sizes	71
Figure 20 – 3-terminal tester with CT clamp	71
Figure 21 – Clamp-on tester	72

Figure 22 – 90°/180° test 73

Figure 23 – Typical 90°/180° test results 74

Table 13 – Ground mounted plant installation model inspection form 76

Table 14 – Acceptable bonding readings within distribution substations 77

Annex A (informative) Earthing principles 78

Annex B (informative) Guidance on typical HV/LV interfaces 81

Figure B.1 – 1 Representative diagram for connections to Earth in a PNB system (TN-S with RE and RB separated) in the substation and the LV installation and the overvoltages occurring in case of faults 81

Figure B.2 – Representative diagram for connections to Earth in a TN-S system with RE and RB combined in the substation and the LV installation and the overvoltages occurring in case of faults 82

Figure B.3 – Segregated HV and LV earthing 84

Figure B.4 – External HV switch supply 85

Figure B.5 – Common external HV/LV interface to supply multiple buildings 86

Figure B.6 – External HV/LV interface and generator backup 87

Annex C (informative) Typical simple installation of an earthing system for a small LV substation 88

Figure C.1 – Assumed electrode arrangement for a small substation with a soil resistivity of 400 Ωm 88

Bibliography 90

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on **XX Month 202X**. It was prepared by Technical Committee GEL/600, *Earthing*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Supersession

This British Standard supersedes BS 7430:2011+A1:2015, which is withdrawn.

Relationship with other publications

This element gives the following information as appropriate:

- the standard's relationship to other standards, incl. Eur. and int. standards;
- list of other parts of this standard;
- reference to relevant international work.

Information about this document

This is a full revision of the document, and introduces the following principal changes:

- [list items]
- [list items]

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a code of practice, this British Standard takes the form of recommendations and guidance. It is not to be quoted as if it were a specification. Users are expected to ensure that claims of compliance are not misleading.

Users may substitute any of the recommendations in this British Standard with practices of equivalent or better outcome. Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions of this document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. "organization" rather than "organisation").

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or

WARNING. THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND **10 SEPTEMBER 2025**.

reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope)

This British Standard provides recommendations for earthing of electrical installations, including:

- a) protective earthing of low voltage installations to BS 7671;
- b) the interface between LV and HV substations conforming to BS EN IEC 61936-1:2021 within buildings;
- c) protective earthing arrangements for generators running in parallel with a distribution network operators (DNO) or a private HV/LV transformer supplying low voltage installations;
- d) protective earthing and changeover switch arrangements for UPS and generators supplying low voltage installations; and
- e) AC supplies derived from DC supplies, e.g. solar, batteries, wind.

NOTE 1 The earthing arrangement of a system or installation is typically provided for safety reasons and is not to be confused with the bonding arrangement required by other British Standards (e.g. BS 7671).

This British Standard applies to land-based installations in and around buildings.

NOTE 2 Whilst many of the principles of this British Standard can be applied equally to low voltage DC systems, this British Standard does not cover issues such as protection against galvanic corrosion that might be necessary for DC systems.

This British Standard does not include recommendations for maintenance of earthing systems and referenced conductors.

NOTE 3 Attention is drawn to the Regulation 4 of the Electricity at Work Regulations 1989 [2] and Regulation 3 of the Electricity, Safety Quality and Continuity Regulations (NI) 2012 [3] with regard to maintenance.

This British Standard does not apply to:

- 1) ships, aircraft, offshore or mining installations;
- 2) earthing of medical equipment [see BS EN 60601 (all parts)];
- 3) special problems encountered with solid state electronic components;
- 4) equipment sensitive to static electricity;
- 5) requirements for functional earthing;
- 6) railway traction equipment, rolling stock and signalling equipment;
- 7) earthing of overhead lines between electrical installations; and
- 8) the internal protection of electrical equipment and apparatus.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 215-2:1970, *Specification for aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission – Aluminium conductors, steel-reinforced (withdrawn)*

BS 951, *Electrical earthing – Clamps for earthing and bonding – Specification*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

BS 1400, *Specification for copper alloy ingots and copper alloy and high conductivity copper castings (withdrawn)*

BS 1449:1991 (all parts), *Steel plate, sheet and strip (withdrawn)*

BS 1473:1972, *Specification for wrought aluminium and aluminium alloys for general engineering purposes – Rivet, bolt and screw stock*

BS 1474:1987, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections (withdrawn)*

BS 1561:1997, *Founding – Grey cast irons*

BS 1562:1997, *Founding – Malleable cast irons*

BS 1377-3, *Methods of test for soils for civil engineering purposes – Part 3: Chemical and electro-chemical tests*

BS 2871-1:1971, *Specification for copper and copper alloys – Tubes – Part 1: Copper tubes for water, gas and sanitation (withdrawn)*

BS 2871-2:1972, *Specification for copper and copper alloys – Tubes – Part 2: Tubes for general purposes (withdrawn)*

BS 2871-3:1972, *Specification for copper and copper alloys – Tubes – Part 3: Tubes for heat exchangers (withdrawn)*

BS 2873:1969, *Specification for copper and copper alloys – Wire (withdrawn)*

BS 2874:1986, *Specification for copper and copper alloy rods and sections (other than forging stock) (withdrawn)*

BS 3288-1, *Insulator and conductor fittings for overhead power lines – Part 1: Performance and general requirements*

BS 7375, *Distribution of electricity on construction and demolition sites – Code of practice*

BS 7671:2018+A2:2022/A3:2024, *Requirements For Electrical Installations – IEE Wiring Regulations – Seventeenth edition*

BS EN 485-2:2008, *Aluminium and aluminium alloys – Sheet, strip and plate – Part 2: Mechanical properties*

BS EN 586-2:1994, *Aluminium and aluminium alloys – Forgings – Part 2: Mechanical properties and additional property requirements*

BS EN 755-2:2008, *Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 2: Mechanical properties*

BS EN 1011-4, *Welding – Recommendations for welding of metallic materials – Part 4: Arc welding of aluminium and aluminium alloys*

BS EN 1652:1998, *Copper and copper alloys – Plate, sheet, strip and circles for general purposes*

BS EN 1780-1:2002, *Aluminium and aluminium alloys – Designation of alloyed aluminium ingots for remelting, master alloys and castings – Part 1: Numerical designation system*

BS EN 1982:2008, *Copper and copper alloys – Ingots and castings*

BS EN 10025-2:2004, *Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels*

BS EN 10088-1:2005, *Stainless steels – List of stainless steels*

BS EN 10263-4:2001, *Steel rod, bars and wire for cold heading and cold extrusion – Technical delivery conditions for steels for quenching and tempering*

- BS EN 12163:2011, *Copper and copper alloys – Rod for general purposes*
- BS EN 12165:2011, *Copper and copper alloys – Wrought and unwrought forging stock*
- BS EN 12167:2011, *Copper and copper alloys – Profiles and bars for general purposes*
- BS EN 12420:1999, *Copper and copper alloys – Forgings*
- BS EN 12449:1999, *Copper and copper alloys – Seamless, round tubes for general purposes*
- BS EN 13601:2002, *Copper and copper alloys – Copper rod, bar and wire for general electrical purposes*
- BS EN 50122-1, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*
- BS EN 50122-2, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 2: Provisions against the effects of stray currents caused by d.c. traction systems*
- BS EN 50522:2022, *Earthing of power installations exceeding 1 kV a.c.*
- BS EN 60228:2005, *Conductors of insulated cables*
- BS EN IEC 60309, *Plugs, socket-outlets and couplers for industrial purposes*
- BS EN 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use*
- BS EN 61140, *Protection against electric shock – Common aspects for installation and equipment*
- BS EN 61557/IEC 61557 (all parts), *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures*
- BS EN 61936-1:2010+A1:2014, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*
- BS EN 62305-2, *Protection against lightning – Part 2: Risk management*
- BS EN 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*
- BS EN 62305-4, *Protection against lightning – Part 4: Electrical and electronic systems within structures*
- BS EN IEC 62368-1:2024+A11:2024 *Audio/Video, information and communication technology Equipment – Part 1: Safety requirements*
- BS EN ISO 1461:2022 *Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods*
- BS IEC 60050-195, *International electrotechnical vocabulary – Part 195: Earthing and protection against electric shock*
- ER G59, *Recommendations for the connection of embedded generating plant to the Regional Electricity Companies' distribution systems*
- ER G83, *Recommendations for the connection of small-scale embedded generators (up to 16 A per phase) in parallel with public low-voltage distribution networks*
- ER G84, *Recommendations for the connection of mobile generating sets to public distribution networks*
- ER S36-1, *Identification and recording of "Hot Sites" – Joint electricity industry/BT procedure*

WARNING. THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND **10 SEPTEMBER 2025**.

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

IEC 60050-604, *International electrotechnical vocabulary – Part 604: Generation, transmission and distribution of electricity – Operation*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

PD 970:2005, *Wrought steels for mechanical and allied engineering purposes – Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels*

DRAFT

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 7671 and BS IEC 60050-195, together with the following apply.

3.1 earth grid

earth electrode in the form of two overlapping groups of buried, parallel, horizontal electrodes, typically laid approximately at right angles to each other, with the electrodes bonded at each intersection

3.2 earth potential

electric potential with respect to the general mass of earth which occurs in, or on the surface of, the ground around an earth electrode when an electric current flows from the electrode to earth

3.3 earth potential rise

voltage between an earthing system and reference earth

[SOURCE: BS EN 50522:2022]

3.4 earth resistance

resistance to earth of an earth electrode or earth grid

3.5 earthing system

arrangement of connections and devices necessary to earth equipment or a system separately or jointly

[SOURCE: IEC 60050-604, 604-04-02]

3.6 global earthing system

equivalent earthing system created by the interconnection of local earthing systems that ensures, by the proximity of the earthing systems, there are no dangerous touch voltages

NOTE 1 Such systems permit the division of the earth fault current in a way that results in a reduction of the earth potential rise at the local earthing system. Such a system could be said to form a quasi-equipotential surface.

NOTE 2 The existence of a global earthing system can be determined by sample measurements or calculation for typical systems. Typical examples of global earthing systems are in city centres; urban or industrial areas with distributed low- and high-voltage earthing.

[SOURCE: BS EN 50522:2011]

3.7 hot zone

area around a high-voltage installation whose earth potential rise in normal operation or when an earth fault occurs, is over the limits given in ITU-T K.68 for typical fault situations

NOTE An example of a high-voltage installation is a substation, transformer or pylon.

[SOURCE: BS EN 50174-3:2013+A1:2017]

3.8 Impressed voltage

collective term for conditions such as Induced Voltages or Currents, differences in earth potential or voltage differences across any break in the conductive path.

Coupling Mechanisms are as following: -

- Capacitive coupling (arising from the electric field and voltage source)
- Inductive coupling (arising from the magnetic field and current source)
- Conductive coupling (arising from current flow through a connection with earth)

- Trapped charge (arising from residual charge left on the capacitance of an item of equipment).

These conditions could cause dangerous levels of induced voltages or current

3.9 potential gradient (at a point)

rate of change of voltage measured at that point in the direction in which it is a maximum

3.10 transferred potential

potential rise of an earthing system caused by a current to earth transferred by means of a connected conductor into areas with low or no potential rise relative to reference earth resulting in a potential difference occurring between the conductor and its surroundings

NOTE 1 The definition also applies where a conductor, which is connected to reference earth, leads into the area of the potential rise.

NOTE 2 Transferred potentials can result in electrocution paths through the human body other than the “touch voltage” path, e.g. hand to hand.

NOTE 3 A connected conductor could be, e.g. a metallic cable sheath, Protective, Earth Neutral (PEN) conductor, pipeline, rail.

[SOURCE: BS EN 50522:2011]

3.11 (effective) touch potential

voltage between conductive parts when touched simultaneously

NOTE The value of the effective touch voltage could be appreciably influenced by the impedance of the person in electric contact with these conductive parts.

[SOURCE: BS IEC 60050-195, 195-05-11, modified]

3.12 prospective touch potential

voltage between simultaneously accessible conductive parts when those conductive parts are not being touched

[SOURCE: IEC 195-05-09, modified]

3.13 step voltage/step potential

voltage between two points on the earth's surface that are 1 m distant from each other, which is considered to be the stride length of a person

[SOURCE: BS IEC 60050-195, 195-05-12]

3.14 transferred potential

potential rise of an earthing system caused by a current to earth transferred by means of a connected conductor into areas with low or no potential rise relative to reference earth resulting in a potential difference occurring between the conductor and its surroundings

NOTE 1 The definition also applies where a conductor, which is connected to reference earth, leads into the area of the potential rise.

NOTE 2 Transferred potentials can result in electrocution paths through the human body other than the “touch voltage” path, e.g. hand to hand.

NOTE 3 A connected conductor could be, e.g. a metallic cable sheath, Protective, Earth Neutral (PEN) conductor, pipeline, rail.

[SOURCE: BS EN 50522:2011]

4 General recommendations for industrial and commercial installations

4.1 General

The following should be taken into account in the design of all protective conductors and their terminations:

- a) the effect that earthing might have on such design;
- b) where instrumentation and data circuits are involved, the interconnection of earthing systems;
- c) transients or circulating currents in the earthing system that might introduce unwanted voltages within electronic circuits by magnetic induction; and
- d) direct earthing of exposed metalwork that could interfere with other systems that employ the general mass of earth as a current transmission path.

NOTE 1 Typical examples are telephony and cathodic protection.

In hazardous areas, installations where problems related to flammable liquids/gases and combustible dusts are concerned, or if there is a need for detailed knowledge of protective earthing that is not directly related to electrical safety, reference should be made to the relevant British Standards.

NOTE 2 Further information is available from the Health and Safety Executive concerning statutes, codes and standards that apply to particular processes.

NOTE 3 BS EN 60079-14 states that a TN-C system is not permitted to supply circuits in a hazardous area.

NOTE 4 TN-C systems use the protective conductor and the neutral in a single conductor (PEN) which could lead to unacceptable circulating currents within the installation circuits or the bonding system resulting from a fault, for example a neutral fault.

NOTE 5 Regulation 8(4) of the Electricity Safety, Quality and Continuity Regulations (ESQCR) [1] prohibits the use of a public distribution network neutral as a protective conductor in consumers' installations.

For supplies related to installations containing hazardous areas, a TN-C-S system should be converted to either:

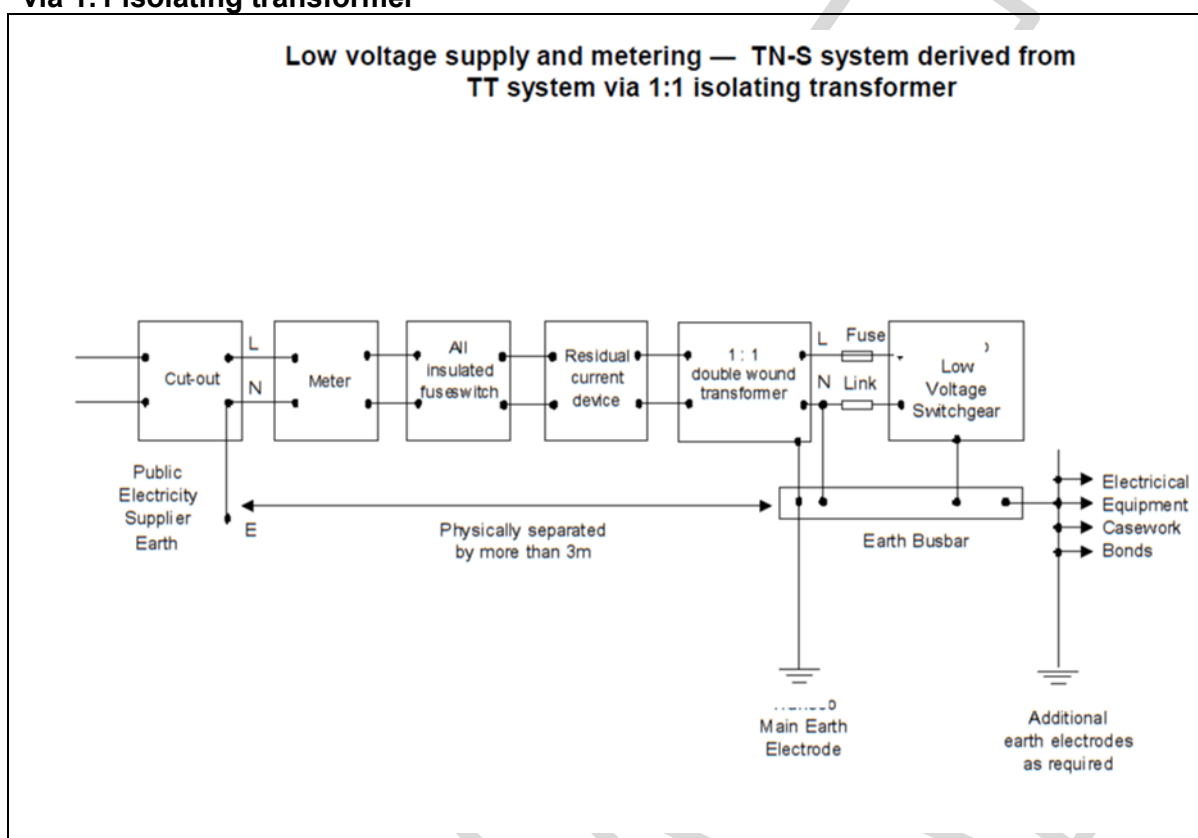
- a) a TN-S system by the installation of a dedicated isolation transformer feeding the hazardous area part of the site with its own earthing system on the secondary side of the transformer. If separation of the neutral and protective conductor PE is performed on the primary side of the transformer the protective conductor should not be connected to the transformer; or

NOTE 6 This requires suitable separation distances between the primary and secondary earthing rods.

NOTE 7 See Figure 12.

- b) a TT system with suitable separation of the TN-C-S and TT earthing systems.

Figure 1 – Low voltage supply and metering – TN-S system derived from TT system via 1:1 isolating transformer



NOTE 7 A TN-S system is permitted providing it can be guaranteed that the neutral and protective conductor PE are not connected together except at the point where the star point of the transformer is earthed.

NOTE 8 In all supply systems, stray circulating currents in earth conductors can also occur from other sources within an installation, e.g. unbalanced phases in an asynchronous motor; broken/faulty neutral conductors; static electricity; EMC; etc.

For hazardous area installations which form only a part of a complex industrial site, the pipework connecting the hazardous and non-hazardous areas forming a path into the hazardous areas for stray circulating currents should be taken into account.

NOTE 9 In these instances, the installation of an insulating section on the pipeline can be required, with the necessary protection for touch potential by separation/insulation.

4.2 Earth fault loop impedance

As in the case of high voltage supplies, low resistance paths should be used for the return of earth fault current in low voltage industrial systems; the total loop impedance should be sufficiently low as to allow the operation of a suitably chosen protective device, fuse, circuit-breaker or RCD within the time given in BS 7671:2018+A2:2022+A3:2024.

4.3 Single-core cables

NOTE 1 Where single-core cables are used in a low voltage installation, it is typically preferable to bond and earth all metallic sheaths or armour at both ends of each run (solid bonding).

Induced voltages in the sheaths or armour should be reduced to low values and the sheaths or armour can then be used as a protective conductor, in parallel if necessary with an additional conductor.

NOTE 2 Currents circulating in the armour or sheath reduce the current-carrying capacity of the cables; where this reduction is not acceptable, sheaths and armour can be bonded at one end of a run only (single-point bonding) and a separate protective conductor is then necessary.

NOTE 3 Recommendations regarding the values of standing voltage which appear at the open circuit ends of the sheaths or armour is covered in 9.12.2.

5 Earthing of HV derived LV supplies (i.e. from public/private transformers)

5.1 General

The criteria to determine whether the HV and LV system earthing is to be combined or separated should be in accordance with BS EN IEC 61936-1:XXXX, Clause 10 and BS EN 55022.

5.2 Combined HV/LV earthing systems

Interconnection of HV and LV system earthing should be in accordance with BS EN IEC 61936-1, where this is practicable and safe.

The HV and LV earthing systems should be combined:

- a) where the LV installation is confined within the physical area covered by the HV earthing system; or
- b) in other cases, where the earth potential rise (EPR) limits for touch voltage and stress voltage in BS EN IEC 61936-1:2021, Table 6 are not exceeded by interconnection. In such cases, the design process should be in accordance with BS EN IEC 61936-1:2021, 10.3 and Annex D.

5.3 HV/LV separation

Where it is necessary to separate HV and LV earthing systems, physical separation of conductive parts connected to the HV and LV systems below ground should be used to reduce the proportion of HV earth potential rise imposed on the LV earthing system. Physical separation of conductive parts connected to the HV and LV systems above ground should be maintained to prevent simultaneous contact, and reduce or remove the risk of touch and step potentials.

The design process should be in accordance with BS EN IEC 61936-1:2021, 10.3 and Annex D.

The most onerous requirements for arms' reach should be used (typically BS 7671:2018+A2:2022+A3:2024, Figure 417).

5.4 LV/LV separation

COMMENTARY ON 5.3

A broken combined protective and neutral (PEN) conductor in a TN-C-S distribution system might lead to hazardous touch voltages. In certain cases, the risks associated with earth potential rise due to a broken PEN conductor are to be avoided. BS 7671 does not permit connection of PME earthing terminals to:

- a) *caravans (BS 7671:2018+A2:2022+A3:2024, Section 708);*
- b) *boats (BS 7671:2018+A2:2022+A3:2024, Sections 709 and 730);*
- c) *except where the requirements of Regulation 717.411.4.1 are met, mobile and transportable units (BS 7671: 2018+A2:2022+A3:2024, Section 717); and*
- d) *except where the requirements of Regulation 722.411.4.1 are met, electric vehicle charging equipment (BS 7671: 2018+A2:2022+A3:2024, Section 722).*

NOTE: *The ESQCR [1] prohibits a distributor offering their PME earthing terminal for use in caravans and boats.*

BS EN 60079-14 prohibits PEN conductors in LV installations in hazardous areas. In installations supplied by a TN-C-S distribution network, where the PME earthing terminal is not used, it is common to form a TT earthing arrangement, by provision of consumer's electrodes. Alternatively, a transformer with at least simple separation can be used, and a TN-S earthing arrangement established.

Where a TN-C-S or TN-C earthing arrangement is used within the vicinity of a TT or TN-S earthing arrangement serving equipment or locations where PME or PEN conductors are not permitted, physical separation below ground of conductive parts connected to each earthing system should be provided to maintain a sufficiently low impressed voltage on the TT or TN-S earthing system. The impressed voltage should not exceed:

- a) 25 V AC or 60 V DC for hazardous areas, and supplies to boats;
- b) 50 V AC or 120 V DC for supplies to caravans; or
- c) 50 V AC or 120 V DC for supplies to electric vehicle charging equipment installations.

The separated earthing systems should not have common extraneous-conductive-parts, as these defeat the separation.

Regardless of separation distance below ground, exposed-conductive-parts and extraneous-conductive-parts connected to different earthing systems should not be simultaneously accessible (see BS 7671:2018+A2:2022+A3:2024, Figure 417).

6 Generators

COMMENTARY ON CLAUSE 6

In the public distribution network, a connection of the electrical distribution system to the mass of Earth is used to enable faults in the network to be detected.

Where a generator is operating independently to the public supply, it might not require a connection to Earth as protective measures such as automatic disconnection of supply (see BS 7671,) can operate effectively regardless of whether the system is connected to Earth or not.

Depending on the method of fault protection chosen, a connection with Earth could be used to assist in detecting insulation faults in the distribution cabling, such as might arise from mechanical damage to temporary distribution cables at e.g. a construction site. There is no correlation between the capacity of a generating set and the earthing arrangements deployed. A safe and effective system coordinates both the generator earthing topology and the protective measure(s) selected.

Four main configurations of generating set are considered in this clause:

- a) stand-alone generating sets (TN-S, IN-S and I-S);
- b) generating set(s) and other sources in parallel;
- c) generating sets operating as switched alternatives to another source; and
- d) UPS systems.

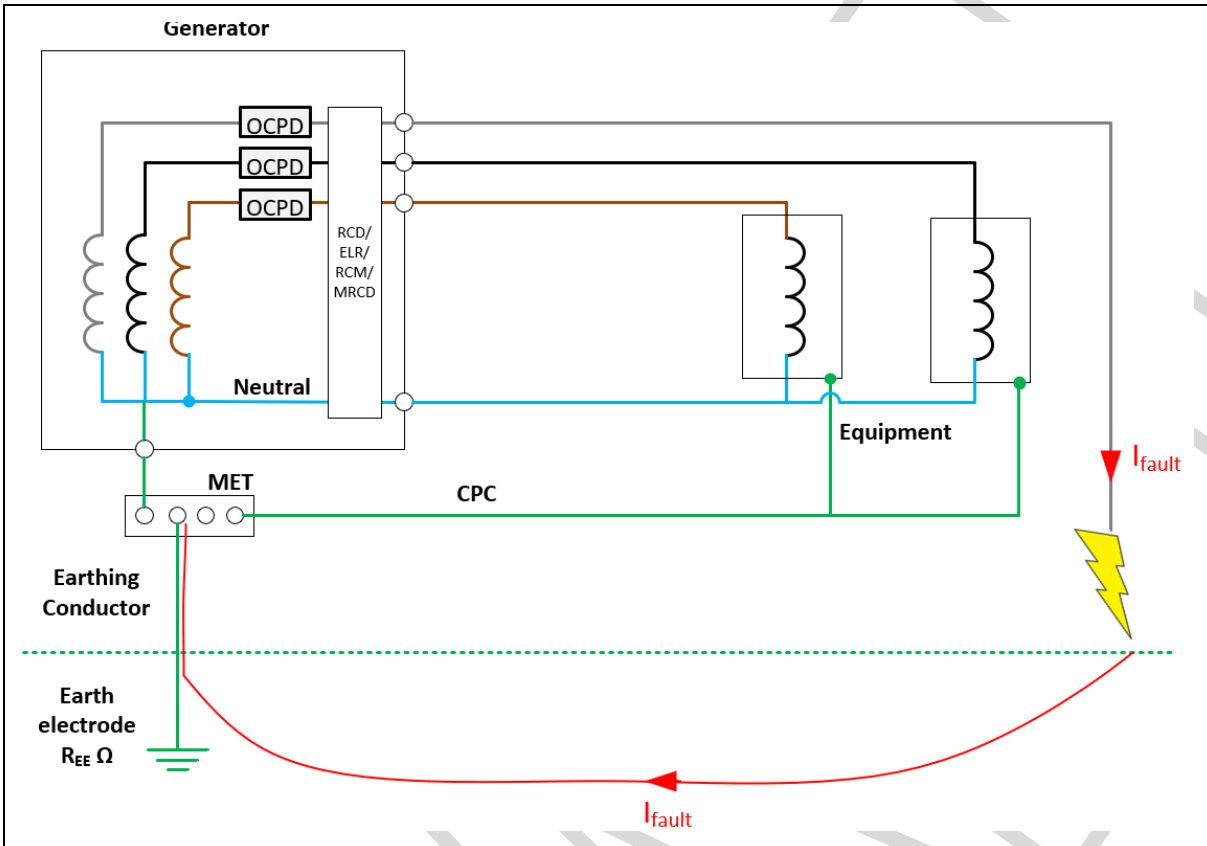
Generating sets could comprise electro-mechanical or electrochemical devices, or solid-state electronic types, or a combination of such equipment. For the purposes of this clause, traditional alternator windings are depicted in the figures to illustrate the text.

6.1 Earthed generating sets

Where a generating set(s) supplying an installation is connected to Earth for the purposes of insulation fault detection, one winding, the star point or electronic equivalent should be reliably connected to the MET of the generating set.

NOTE 1 Where appropriate, this connection might need to be removed to prevent circulating currents in parallel systems, see Regulation 444.4.6 of BS 7671:2018+A2:2022+A3:2024).

Where a system is rFor fault detection, the resistance of the earth electrode network should have a resistance sufficiently low to enable operation of the protective device fitted to the output of the generator (see Figure 1).



To enable the fault in Figure 1 to be cleared, sufficient current should flow through Earth and back to the source via the earth electrode. The resistance of the earth electrode(s) should therefore fulfil the following requirement:

$$R_{EE} \leq \frac{U_0}{I_a}$$

where

R_{EE}	is the electrode resistance;
U_0	is the phase voltage; and
I_a	is the current causing operation of the protective device on the output of the generator within 0.1–5.0 s

As the electrode resistance is likely to be in the order of tens of ohms, depending on the soil type, circuit-breakers or fuses on the output of the generator are unlikely to be effective for fault protection; an RCD, RCM or IMD should be used to protect the distribution cable and equipment.

Where generating sets are operating in parallel, the RCD should be placed after the point of common coupling to avoid unwanted operation (see clause 6.3.1.1).

If a generating set is Earthed, the means of Earth connection should be independent and verifiable. It should not rely on the earthing arrangements of other electrical supplies beyond the control of the owner of the installation.

NOTE 2 See BS 7671:2018+A2:2022+A3:2024, Regulation 551.4.3.2.1.

For independent earth electrodes associated with the local earthing of the star point of generating plant, the earth electrode resistance should not exceed 20 Ω . Where all circuits (including distribution circuits) are protected by RCDs in TN and TT systems, a value not exceeding 200 Ω should be applied.

NOTE 3 Table 1 provides guidance on selecting the maximum earth electrode resistance (Ω) where all circuits are protected by RCD in TN and TT systems.

Table 1 – Selection of maximum earth electrode resistance (Ω) where all circuits are protected by RCD in TN and TT systems

Largest RCD residual current rating $I_{\Delta n}$ in installation (mA)	TN systems or circuits	TT systems or circuits
10	200	200
30	200	200
100	200	200
300	200	50
500	200	20

NOTE 4 If the generating set is permanently installed, other earthing facilities associated with the installation might be necessary.

NOTE 5 The earthing of the electrical system might require that the neutral point of the AC generator is connected to earth, either directly or via an impedance.

NOTE 6 For TN systems, the earth electrode plays no part in the earth fault path, and therefore a value of 200 Ω is acceptable. Values above 200 Ω might not be stable. The earth fault loop impedance Z_s should be less than the figures in Table 41.5 to BS 7671:2018+A2:2022+A3:2024.

NOTE 7 For TT systems, the earth fault path includes the source earth electrode and the installation earth electrode. RCDs with residual current rating not exceeding 100 mA require total loop impedance not exceeding 500 Ω (see Table 41.5 of BS 7671:2018+A3:2024), and therefore it would be acceptable broadly for both electrodes in the TT system to have values up to 200 Ω .

Where the largest RCDs exceed 100 mA, the acceptable values should be reduced as recommended in Table 1.

Where an installation is supplied by more than one source of energy (e.g. a supply from a distributor and a supply from a generating set), the earthing system of the installation should be designed so that either:

- each source that can operate independently of other sources and remain earthed if all the other sources are not connected; or
- sources without an independent means of earthing are disconnected when there are no earthed sources operating.

NOTE 8 There are many variations in system design and, for any particular application, the precise method of earthing of each energy source is subject to the recommendations of the equipment supplier and to the system parameters.

NOTE 9 Public low voltage distribution networks have to be directly earthed in conformity to the current ESQCR (Regulations 7 to 10) [1] and ESQCR (NI) [3]. Since an installation connected to a distributors network might be expected to be designed accordingly, direct earthing is also normally adopted for any generating set which supplies such an installation.

Where it is intended that a private generating set be used to supply any part of a consumer's system normally supplied by a distributor, the distributor and supplier should be consulted.

NOTE 10 The ESQCR [Regulation 22(1)(d)] [1] and ESQCR (NI) Regulation 23(1)(d) [3] require that, where operation in parallel with a distributors network is intended, the agreement of the distributor has to be obtained first, subject to Regulation 22(2) {Regulation 23(2) in ESQCR (NI) [3]} for generators rated up to a total of 16 A per phase. Where an installation is supplied by more than one source of energy (e.g. a supply from more than one generating set), the earthing system of the installation should be designed so that either:

- each source that can operate independently of other sources and remain earthed if all the other sources are not connected; or
- sources without an independent means of earthing are disconnected when there are no earthed sources operating.

NOTE 11 There are many variations in system design and, for any particular application, the precise method of earthing of each energy source is subject to the recommendations of the equipment supplier and to the system parameters.

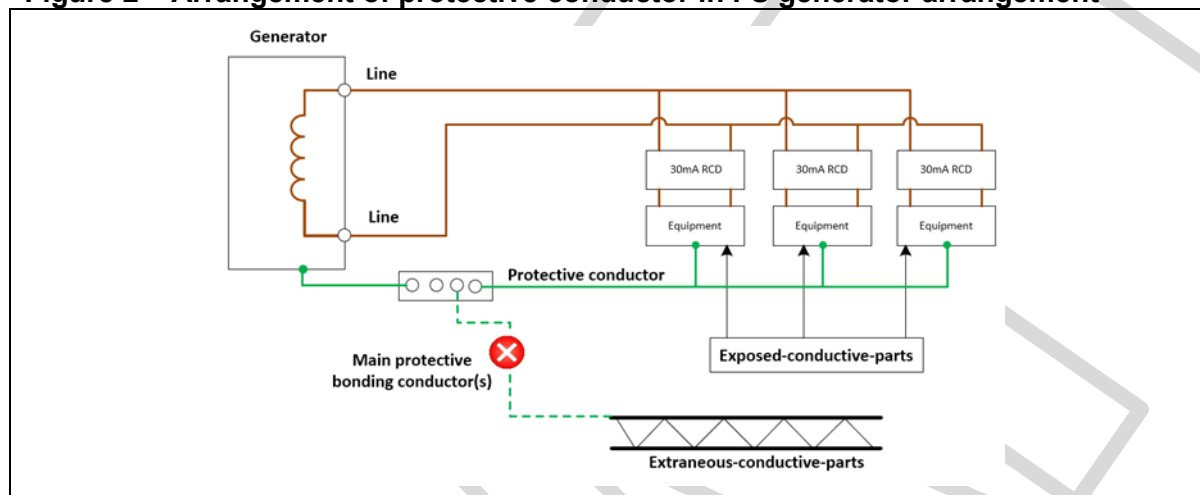
6.2 Unearthed stand-alone generating sets

6.2.1 I-S Earthing arrangement and applied protective provisions

NOTE 1 This earthing arrangement shares some characteristics of electrical separation as a protective measure and is a variant of earth-free equipotential bonding. In this arrangement the protective conductor is not connected to the mass of Earth, or a live part. First faults will go undetected but second faults will result in disconnection, thereby taking the system back to the first-fault condition.

Where there is no connection between a generator winding, star-point or electronic equivalent, the generator frame and enclosure should be bonded to all exposed-conductive-parts of the load equipment, using a correctly terminated protective conductor in the connecting cable, in accordance with Figure 2.

Figure 2 – Arrangement of protective conductor in I-S generator arrangement



There should be no connection with the mass of Earth, However where this is unavoidable, treating the system as IT and appropriate protection, in accordance with BS 7671 should be taken into account.

NOTE 2 Examples of where this might be common include small single phase generating sets used to power electric tools in construction.

NOTE 3 With this earthing arrangement, the lack of connection between the protective conductor and the generator winding could lead to equipment requiring a functional earth connection not working properly.

Where the system is practically isolated from Earth, one of the applied protective provisions in 6.2.2 should be used.

6.2.2 Applied protective provision: electrical separation

6.2.2.1 General

NOTE In this applied protective provision, protection from electric shock is only required when a second fault occurs.

Electrical separation can be used for any number of Class II items of equipment, or one item of Class I equipment; where more than one item of Class I equipment is connected, each individual item should be connected to a dedicated RCD with an $I_{\Delta n}$ rating of 30 mA and disconnecting with 300 ms to provide disconnection in the event of a second fault. Type AC RCDs should not be used.

All cables and distribution equipment used in the distribution should conform to 6.5.

6.2.2.2 Applied protective provision: insulation monitoring and automatic disconnection of supply

Where the insulation value between line conductors and the protective bonding conductor drops below 100 Ω/V (referred to U_0), an insulation monitoring device (IMD) should be used to disconnect the generating set within 1 s.

first, subject to Regulation 22(2) (Regulation 23(2) in ESQCR (NI) [3]) for generators rated up to a total of 16 A per phase.

Where a generator is to supply part or all of an installation, as a switched alternative (such as an emergency backup), the following should be carried out:

- a) switching arrangements should disconnect all poles of the incoming supply before the generator is connected unless formal agreements are in place with the owner of the main supply;
- b) poles of the generator should be disconnected before reconnection to the main supply unless formal agreements are in place with the owner of the main supply;
- c) the generator should have an independent connection to Earth. The electrode value should conform to 6.1 and the electrode should be connected to the main earthing terminal of the installation;
- d) the disconnection times for electric shock and overcurrent protection in the installation should not be diminished when operating from the generator; and
- e) the requirements in BS 7671 Part 6 should be verified for all supply configuration and documented.

NOTE 4: Attention is drawn to the following ENA Engineering Recommendations, where relevant:

- *ER G59, Recommendations for the connection of embedded generating plant to the Regional Electricity Companies' distribution systems;*
 - *ER G83, Recommendations For The Connection Of Small-Scale Embedded Generators (Up To 16 A Per Phase) In Parallel With Public Low-Voltage Distribution Networks; and*
 - *ER G84, Recommendations for the Connection of Mobile Generating Sets to Public Distribution Networks.*
- ER G84 gives recommend working procedures for the connection of small portable generating sets and larger mobile generating sets for the purposes of providing a temporary supply to customers or for network support. It addresses direct connections to the low voltage network and connections via a step-up unit to the high voltage network.*

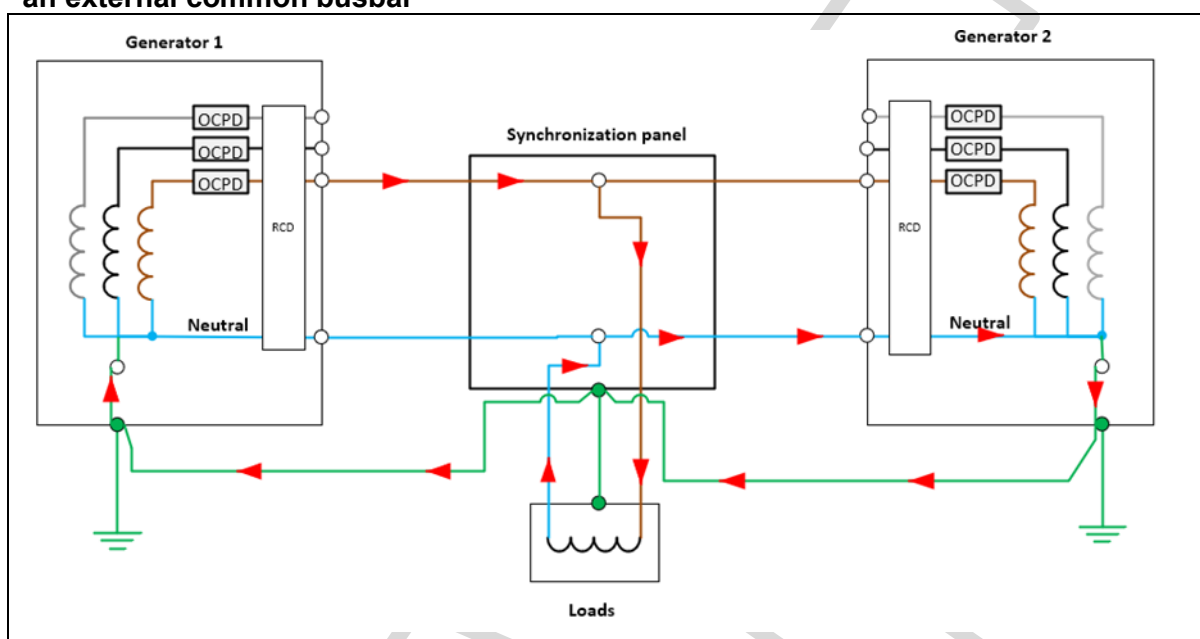
6.3.1 Two or more sources operating in parallel

6.3.1.1 Stand-alone generating sets operating in parallel

When two or more generating sets, operating in parallel, are used to supply an installation, the chosen method of supply system earthing for the generator windings should take into account the magnitude of the circulating currents, commonly third harmonic, which can flow in the neutral/earthing conductors.

NOTE 1 Figure 4 provides examples of circulating currents.

Figure 4 – Example of circulating currents in parallel generating sets connected to an external common busbar

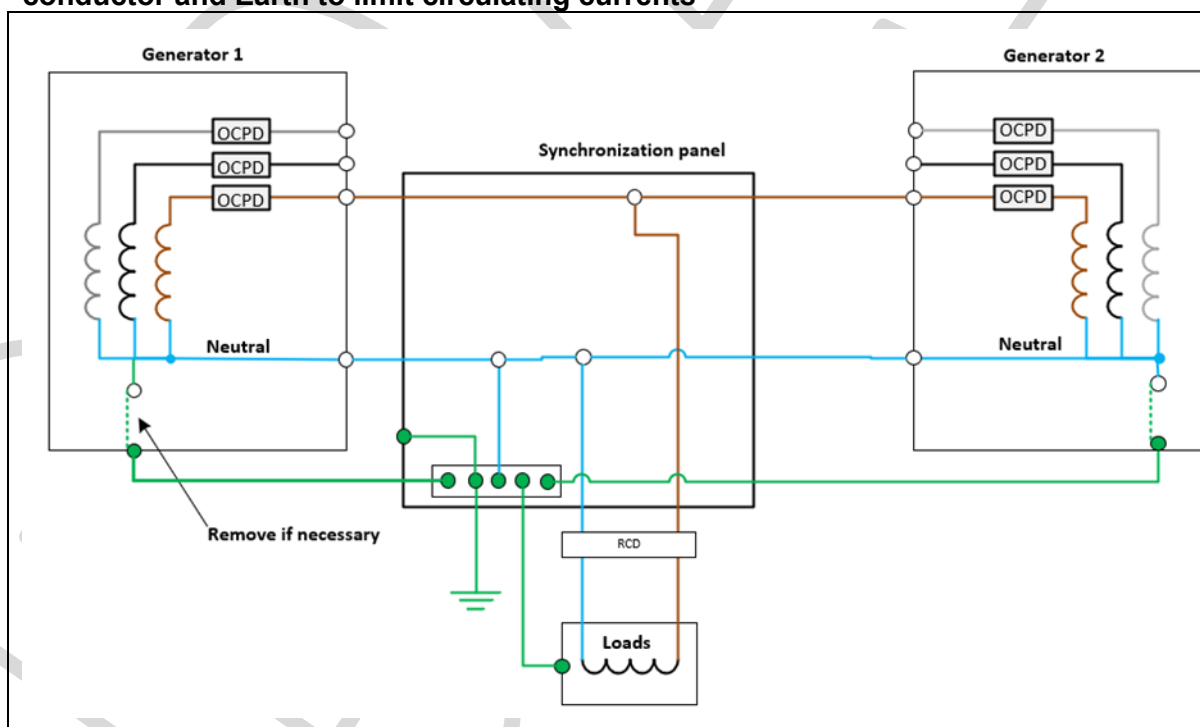


NOTE 2 Such an arrangement causes unintended operation of RCDs or RCMs where fitted in the generating sets.

To limit circulating currents, the neutral or star point of the sources should only be connected to the protective conductor and Earth at one point.

NOTE 3 Such an arrangement is shown in Figure 5.

Figure 5 – Example of single point of connection between the neutral and protective conductor and Earth to limit circulating currents



Depending on the physical contact between the generator chassis and Earth, the need to disconnect more than one of the neutral-earth links within the generator enclosures should be taken into account. Where carried out, there should be a good connection between the enclosure and the main earthing terminal to enable generator fault protective measures to be effective.

For installations where harmonic current mitigation measures are required, one of the following arrangements should be selected:

- generating sets that have AC generators with compensated windings e.g. zigzag wound alternators);
- star-point switching to connect the star point of only one generator to earth during parallel operation (a star point switching arrangement is exemplified in Figure 7. Electrical and mechanical interlocks on the star-point switches should maintain the integrity of the neutral/earth connection at all times and under all possible operating conditions;
- a neutral earthing transformer connected between the line conductors and earth; this enables the neutral of the installation to be permanently earthed, with the generators connected to the busbars as three-wire machines (a neutral earthing transformer arrangement is exemplified in Figure 8); or
- a suitable reactor in the neutral connection of each generator which attenuates higher frequency currents without offering significant impedance at mains frequency.

Figure 6 – Low voltage standby generators with star-point switching

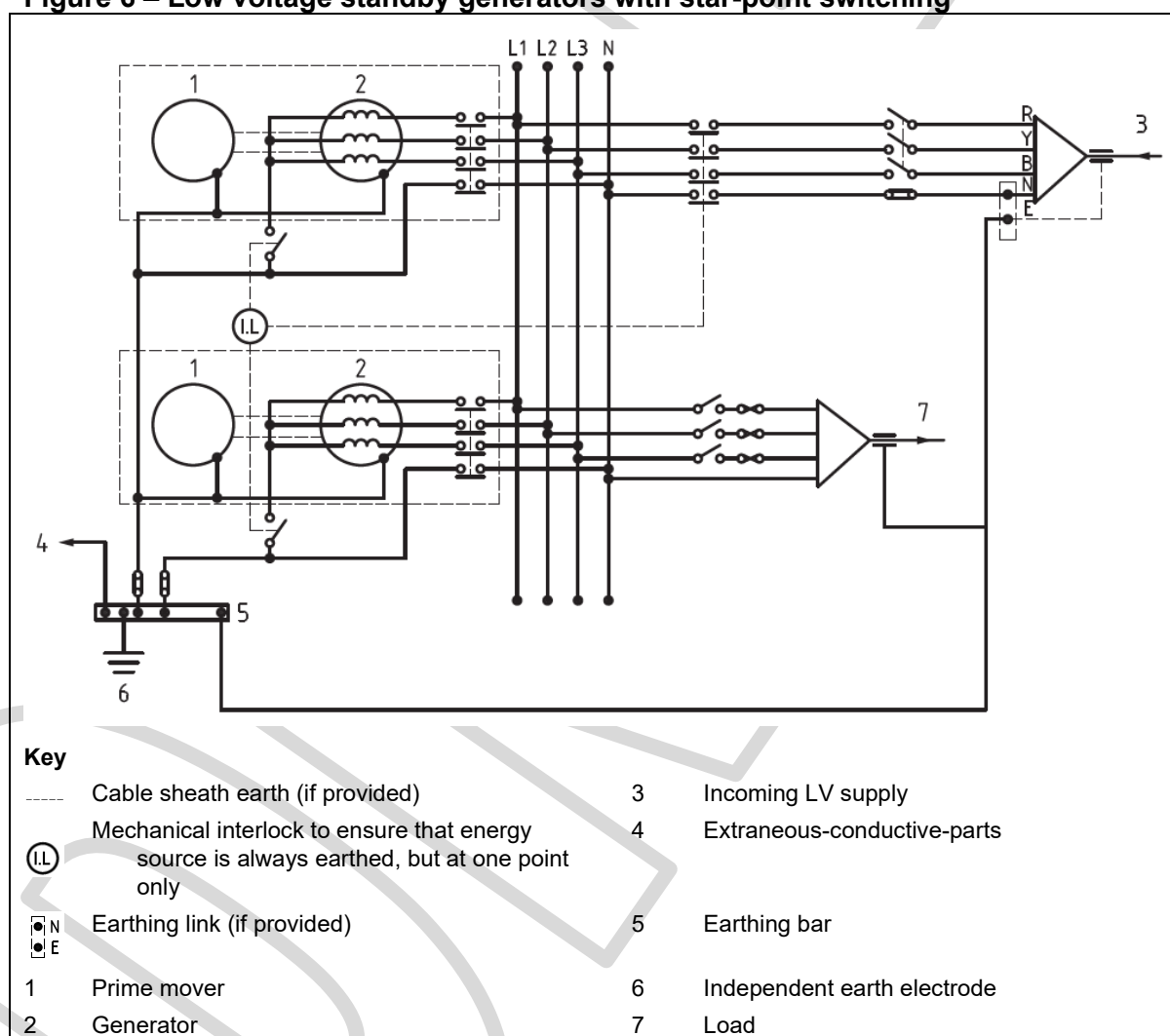
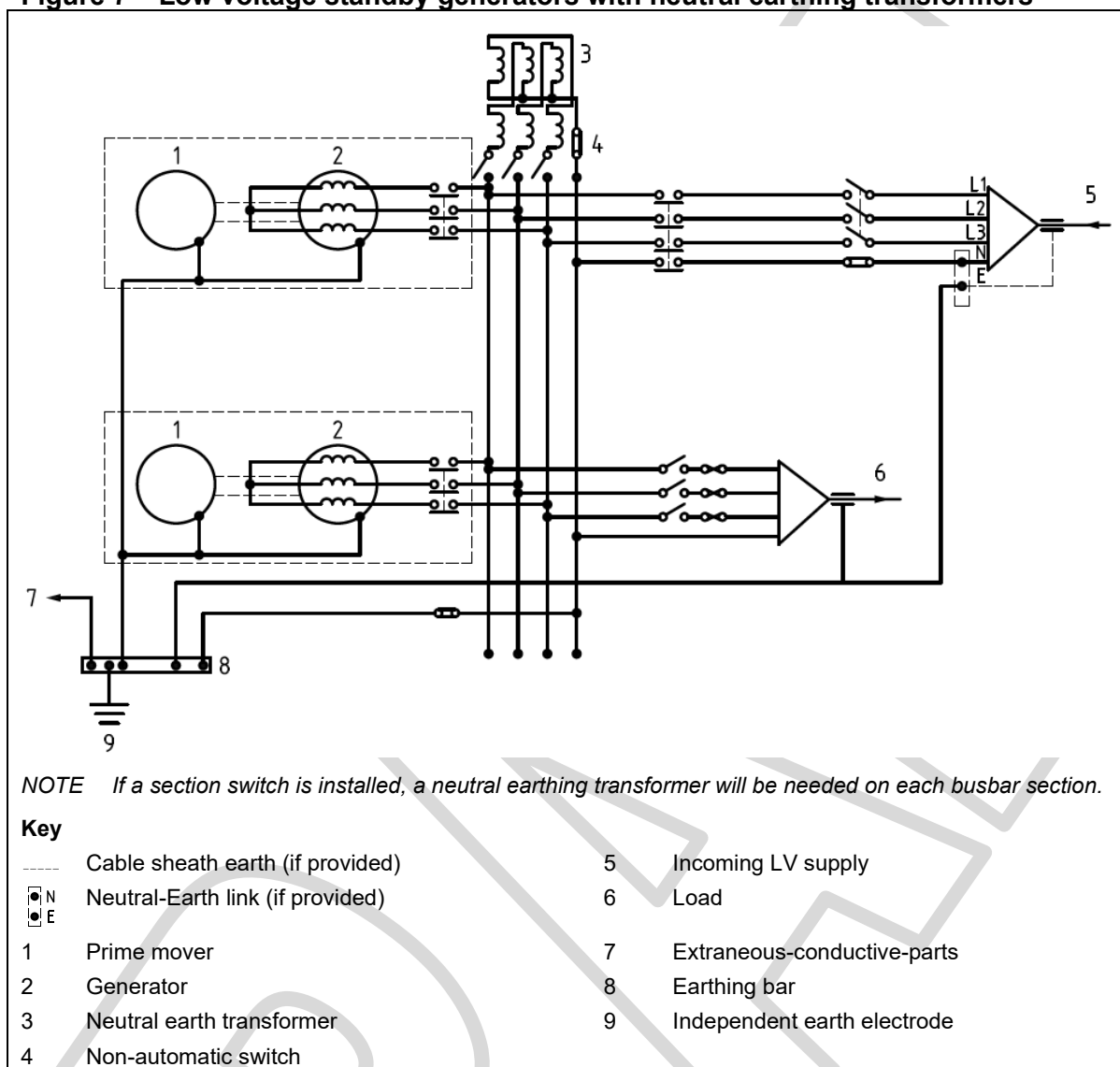


Figure 7 – Low voltage standby generators with neutral earthing transformers



6.4 Uninterruptible power supplies (UPSs) and other inverter-based systems

COMMENTARY ON CLAUSE 6.4

UPS and inverter designs vary considerably between manufacturers and topologies (off-line, line interactive and online). This subclause provides recommendations on the treatment of the earthing arrangements for protection in the event of a fault. While the subclause refers to inverters, commonly used in most types of UPS, it can also be used for other inverter-based systems, such as hybrid generation packages. An inverter is classed as a generator, therefore the recommendations elsewhere in this British Standard can be applied.

6.4.1 Required information

The designer of a system using inverters for power generation should consult the manufacturer of the inverter for the:

- connection arrangement of the neutral and protective conductors when operating in bypass or off-line mode as well as when operating in online mode;
- inverter operation in the event of a fault to earth;
- inverter operation in the event of a short-circuit between live conductors; and
- operating time of any fault protective measures (e.g. voltage limiting or bypass) after the occurrence of a fault of negligible impedance between a protective conductor and a line conductor.

The information gathered should be included with the installation completion records.

6.4.2 Protection using ADS

Where the installation supplied by an inverter uses ADS as the fault protective measure, the operation of the protective devices in the installation should be verified by design or testing.

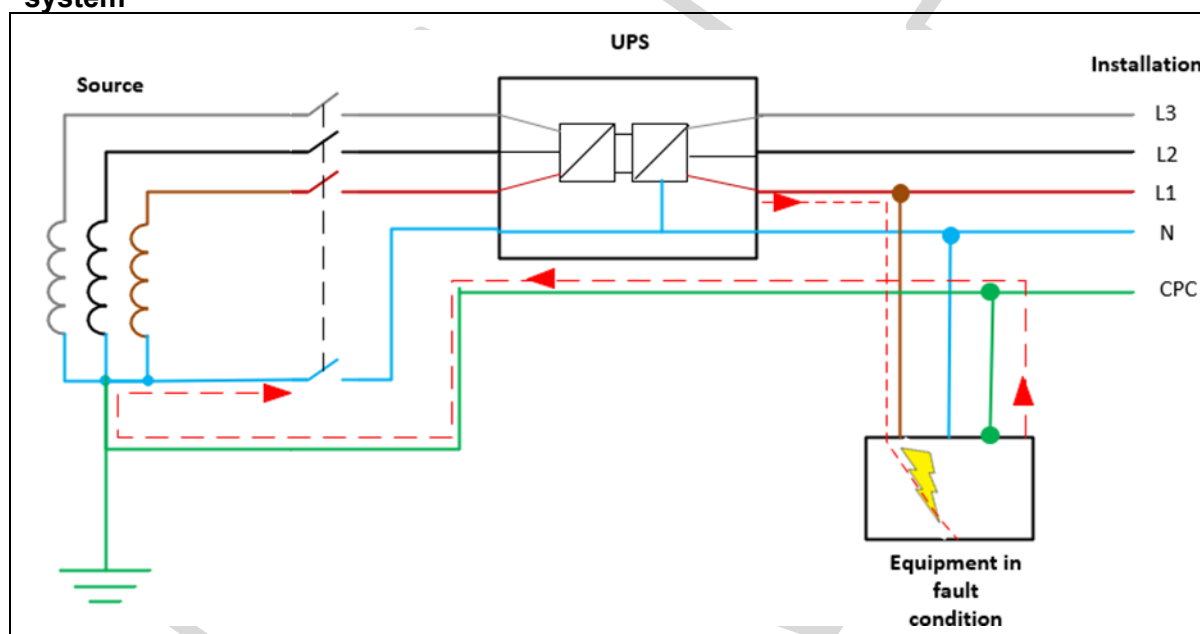
Where the inverter operates in parallel with another supply, there should only be one connection between the neutral and the protective earthing conductors. Preference should be given to inverters that incorporate a switchable neutral-earth link for use when the main supply is disconnected, or which use a transformer-based output. In either instance, the earthing arrangement should be treated as either TN-S or IN-S.

6.4.3 ADS and neutral switching

The neutral switching arrangements in the supply to the inverter should be taken into account.

NOTE 1 Where an inverter relies upon an upstream neutral-earth connection, this might prevent faults downstream of the inverter output from being cleared when the supply is isolated as shown in Figure 8.

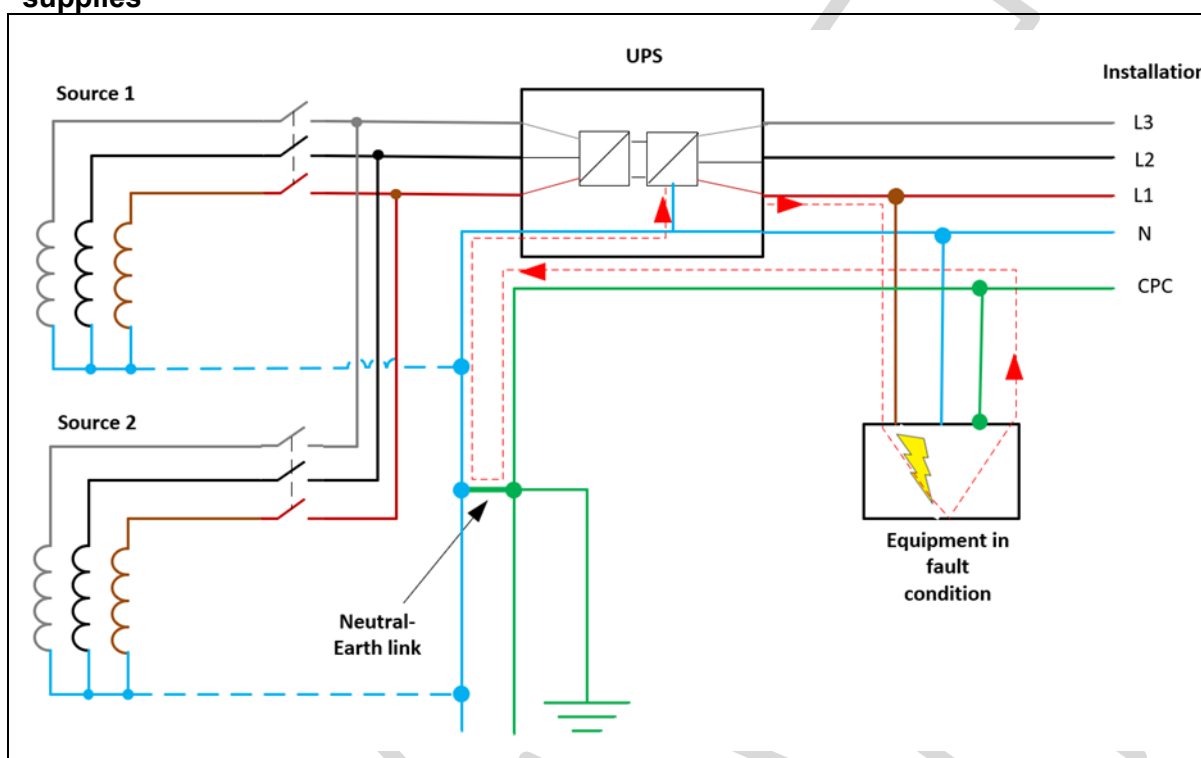
Figure 8 – Example of the fault path when the supply is isolated to an inverter based system



Where supplies to an inverter operate in parallel, there should be one neutral-earth connection, as shown in Figure 9. In this arrangement, if the UPS is the only load and is balanced, the design should determine whether the supply neutral connections are required in order to limit circulating currents, as depicted in Figure 9.

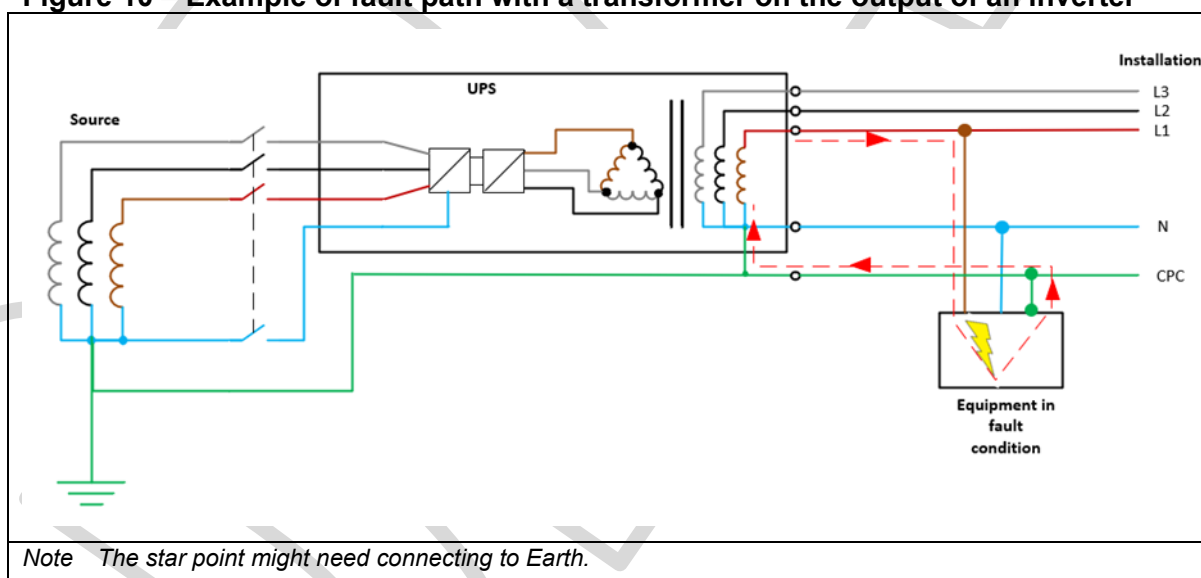
NOTE 2 Although the loads might be balanced at 50 Hz, unbalanced harmonic currents might be present.

Figure 9 – Example of a correct neutral-earth connection and fault path for parallel supplies



An alternative to Figure 9 is to use a transformer on the output of the inverter, as shown in Figure 10; this arrangement has the advantage of not relying on the supply earthing arrangements for protection, however the star-point (or other earthed point) should be connected to Earth, as required.

Figure 10 – Example of fault path with a transformer on the output of an inverter



6.5 General requirements for temporary generators

Cables, plugs, socket-outlets and cable couplers should be suitable for their environmental exposure.

NOTE For general industrial applications, the BS EN 60309 series is preferred for circuits rated at ≤ 125 A.

Cables should be a flexible rubber type, such as H07-RN-F or equivalent. All cables should conform to BS EN 50525-2-21. PVC cables should not be used for temporary generating

sets and distribution unless suitable mechanical protection is given or the system is using Reduced Low Voltage for protection against electric shock in accordance with Regulation 411.8 of BS 7671:2018+A2:2022+A3:2024.

Cables, plugs and socket-outlets should be inspected frequently and if defective should be replaced or repaired.

Distribution units should conform to the relevant parts of BS EN 61439.

7 Installations having particular considerations for earthing

7.1 Foundation earthing

7.1.1 General

NOTE 1 A low resistance earth electrode can be achieved by forming a concrete-embedded foundation or soil-embedded ring earth electrodes. Where implemented for low voltage installations, such arrangements also provide an earthing facility for prosumers' electrical installations operating in island mode and assists in mitigating electromagnetic interference. Besides its earthing effect the concrete-embedded foundation earth electrode provides a good basis for the main protective bonding of the installation.

To provide a low resistance earth electrode, there should be good contact with the soil, either directly or through concrete, and the soil should be damp and not liable to freezing or drying out. For concrete foundations without metal reinforcement, concrete-embedded foundation earth electrodes should be coordinated with the type and dimensions of the foundation.

NOTE 2 One or more closed rings or rectangles mutually connected are preferred.

NOTE 3 The methods of 7.2.2 and 7.2.3 can also be applied for an extension to existing premises.

To enable a first approximation of the earth electrode resistance, a calculation should be made, using average soil resistivity values for the soil type.

NOTE 4 Calculations made from these values only give an approximate result of an earth electrode resistance.

Horizontally buried conductors should be laid down in one of two ways:

- a) concrete embedded foundation earth electrode, and/or
- b) soil embedded ring earth electrode.

7.1.2 Soil-embedded ring Earth electrode

If the building foundation is to be protected against loss of heat energy by thermal insulation using non-conductive materials, or if the foundation is to use protective measures against water ingress, e.g. using plastic sheets, earthing using the foundation concrete should not be considered; in such cases a soil-embedded ring earth electrode should be installed buried in the soil outside the foundations to an equivalent depth to that which an electrode would be in the foundations.

NOTE 1 The constituent parts of earth electrodes could include buried elements of:

- a) steel (hot-dip galvanized);
- b) steel (copper-sheathed);
- c) steel (electro-deposited copper coated);
- d) stainless steel;
- e) bare copper; or
- f) copper alloy.

Other metals and alloys should not be used.

Joints between dissimilar metals should not be made. Minimum thickness and diameters of the parts should take into account the usual risks of chemical and mechanical deterioration.