

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage electrical installations –
Part 1: Fundamental principles, assessment of general characteristics,
definitions**

**Installations électriques à basse tension –
Partie 1: Principes fondamentaux, détermination des caractéristiques générales,
définitions**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –**Part 1: Fundamental principles, assessment of
general characteristics, definitions**

FOREWORD

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International Standard IEC 60364-1 has been prepared by IEC Technical Committee 64: Electrical installations and protection against electric shock.

This fifth edition cancels and replaces the fourth edition, published in 2001. It constitutes a technical revision.

The main changes with respect to the previous edition are:

- in order to complete the scope, the new items external lighting and similar installations, medical locations, mobile or transportable units, photovoltaic power supply units and low-voltage generating sets are added;
- in Clause 131, "Fundamental principles", the list of hazards which may arise in electrical installations is completed; furthermore, a new subclause dealing with protection against voltage disturbances and measures against electromagnetic influences and a new subclause dealing with protection against power supply interruption are added;

- in Clause 132, "Design", the new subclause "Documentation for the electrical installation" is added;
- in Clause 134, "Erection and verification of electrical installations", the new subclause "periodic verification" is added;
- the former Clause 312, "Types of distribution system" is renamed "Conductor arrangement and system earthing" and, in the relevant subclauses, several new figures are included for better understanding of the different kind of a.c. and d.c. circuits and types of systems and their earthing being applied nowadays in IEC member countries;
- in 33.1, "Compatibility of characteristics", a new item for excessive PE conductor currents is added;
- a new Clause 36, "Continuity of service", is included;
- Annex B is aligned with the second edition of IEC 60050-826:2004.

The text of this standard is based on the following documents:

FDIS	Report on voting
64/1488/FDIS	64/1499/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 60364 consists of the following parts, under the general title *Low-voltage electrical installations*:

Part 1: Fundamental principles, assessment of general characteristics, definitions

Part 4: Protection for safety

Part 5: Selection and erection of electrical equipment

Part 6: Verification

Part 7: Requirements for special installations or locations

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of August 2009 have been included in this copy.

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 1: Fundamental principles, assessment of general characteristics, definitions

11 Scope ¹

IEC 60364-1 gives the rules for the design, erection, and verification of electrical installations. The rules are intended to provide for the safety of persons, livestock and property against dangers and damage which may arise in the reasonable use of electrical installations and to provide for the proper functioning of those installations.

11.1 IEC 60364-1 applies to the design, erection and verification of electrical installations such as those of

- a) residential premises;
- b) commercial premises;
- c) public premises;
- d) industrial premises;
- e) agricultural and horticultural premises;
- f) prefabricated buildings;
- g) caravans, caravan sites and similar sites;
- h) construction sites, exhibitions, fairs and other installations for temporary purposes;
- i) marinas;
- j) external lighting and similar installations (see, however, 11.3e));
- k) medical locations;
- l) mobile or transportable units;
- m) photovoltaic systems;
- n) low-voltage generating sets.

NOTE "Premises" covers the land and all facilities including buildings belonging to it.

11.2 IEC 60364-1 covers

- a) circuits supplied at nominal voltages up to and including 1 000 V a.c. or 1 500 V d.c.;
For a.c., the preferred frequencies which are taken into account in this standard are 50 Hz, 60 Hz and 400 Hz. The use of other frequencies for special purposes is not excluded.
- b) circuits, other than the internal wiring of apparatus, operating at voltages exceeding 1 000 V and derived from an installation having a voltage not exceeding 1 000 V a.c., for example, discharge lighting, electrostatic precipitators;

¹ The numbering system is explained in Annex A.

- c) wiring systems and cables not specifically covered by the standards for appliances;
- d) all consumer installations external to buildings;
- e) fixed wiring for information and communication technology, signalling, control and the like (excluding internal wiring of apparatus);
- f) the extension or alteration of the installation and also parts of the existing installation affected by the extension or alteration.

NOTE The rules of IEC 60364-1 are intended to apply to electrical installations generally but, in certain cases, they may need to be supplemented by the requirements or recommendations of other IEC standards (for example, for installations in explosive gas atmospheres).

11.3 IEC 60364-1 does not apply to

- a) electric traction equipment, including rolling stock and signaling equipment;
- b) electrical equipment of motor vehicles, except those covered in Part 7;
- c) electrical installations on board ships and mobile and fixed offshore platforms;
- d) electrical installations in aircraft;
- e) public street-lighting installations which are part of the public power grid;
- f) installations in mines and quarries;
- g) radio interference suppression equipment, except where it affects the safety of the installation;
- h) electric fences;
- i) external lightning protection systems for buildings (LPS);

NOTE Atmospheric phenomena are covered in IEC 60364-1 but only insofar as effects on the electrical installations are concerned (for example, with respect to selection of surge protective devices).

- j) certain aspects of lift installations;
- k) electrical equipment of machines.

11.4 IEC 60364-1 is not intended to apply to

- systems for distribution of energy to the public, or
- power generation and transmission for such systems.

NOTE 1 Countries wishing to do so may, however, use this standard in whole or in part for that purpose.

NOTE 2 According to IEC 61936 which provides common rules for the design and the erection of electrical power installations in systems with nominal voltages above 1kV a.c. and nominal frequency up to and including 60 Hz, low-voltage a.c. and d.c. protection and monitoring systems should be in accordance with IEC 60364 series.

11.5 Electrical equipment is dealt with only so far as its selection and application in the installation are concerned.

This applies also to assemblies of electrical equipment complying with the relevant standards.

12 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60050(691), *International Electrotechnical Vocabulary (IEV) – Chapter 691: Tariffs for electricity*

IEC 60050-826, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-42, *Electrical installations of buildings – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60364-4-43, *Electrical installations of buildings – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44, *Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-51, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

IEC 60364-5-52, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 60364-5-54, *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors*

IEC 60364-5-55:2001, *Electrical installations of buildings – Part 5-55: Selection and erection of electrical equipment – Other equipment*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

IEC 60446, *Basic and safety principles for man-machine interface, marking and identification – Identification of conductors by colours or numerals*

IEC 60617-DB:2001², *Graphical symbols for diagrams*

IEC 60721 (all parts), *Classification of environmental conditions*

² "DB" refers to the IEC on-line database.

13 Fundamental principles

NOTE 1 Where countries not yet having national regulations for electrical installations deem it necessary to establish legal requirements for this purpose, it is recommended that such requirements be limited to fundamental principles which are not subject to frequent modification on account of technical development. The contents of Clause 13 may be used as a basis for such legislation.

NOTE 2 This clause contains basic requirements. In other parts of this standard (see Table A.2), more detailed requirements may be given.

131 Protection for safety

131.1 General

The requirements stated in 131.2 to 131.7 are intended to provide for the safety of persons, livestock and property against dangers and damage which may arise in the reasonable use of electrical installations. The requirements to provide for the safety of livestock are applicable in locations intended for them.

NOTE In electrical installations, the following hazards may arise:

- shock currents;
- excessive temperatures likely to cause burns, fires and other injurious effects;
- ignition of a potentially explosive atmosphere;
- undervoltages, overvoltages and electromagnetic influences likely to cause or result in injury or damage;
- power supply interruptions and/or interruption of safety services;
- arcing, likely to cause blinding effects, excessive pressure, and/or toxic gases;
- mechanical movement of electrically activated equipment.

131.2 Protection against electric shock

131.2.1 Basic protection (protection against direct contact)

NOTE For low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact.

Protection shall be provided against dangers that may arise from contact with live parts of the installation by persons or livestock.

This protection can be achieved by one of the following methods:

- preventing a current from passing through the body of any person or any livestock;
- limiting the current which can pass through a body to a non-hazardous value.

131.2.2 Fault protection (protection against indirect contact)

NOTE For low-voltage installations, systems and equipment, fault protection generally corresponds to protection against indirect contact, mainly with regard to failure of basic insulation.

Protection shall be provided against dangers that may arise from contact with exposed-conductive-parts of the installation by persons or livestock.

This protection can be achieved by one of the following methods:

- preventing a current resulting from a fault from passing through the body of any person or any livestock;
- limiting the magnitude of a current resulting from a fault, which can pass through a body, to a non-hazardous value;
- limiting the duration of a current resulting from a fault, which can pass through a body, to a non-hazardous time period.

131.3 Protection against thermal effects

The electrical installation shall be so arranged to minimize the risk of damage or ignition of flammable materials due to high temperature or electric arc. In addition, during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

131.4 Protection against overcurrent

Persons and livestock shall be protected against injury and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in conductors.

Protection can be achieved by limiting the overcurrent to a safe value or duration.

131.5 Protection against fault currents

Conductors, other than live conductors, and any other parts intended to carry a fault current shall be capable of carrying that current without attaining an excessive temperature. Electrical equipment, including conductors shall be provided with mechanical protection against electromechanical stresses of fault currents as necessary to prevent injury or damage to persons, livestock or property.

Live conductors shall be protected against overcurrents arising from faults by the methods in 131.4.

NOTE Particular attention should be given to PE conductor and earthing conductor currents.

131.6 Protection against voltage disturbances and measures against electromagnetic influences

131.6.1 Persons and livestock shall be protected against injury and property shall be protected against any harmful effects as a consequence of a fault between live parts of circuits supplied at different voltages.

131.6.2 Persons and livestock shall be protected against injury and property shall be protected against damage as a consequence of overvoltages such as those originating from atmospheric events or from switching.

NOTE For protection against direct lightning strikes, see IEC 62305 series.

131.6.3 Persons and livestock shall be protected against injury and property shall be protected against damage as a consequence of undervoltage and any subsequent voltage recovery.

131.6.4 The installation shall have an adequate level of immunity against electromagnetic disturbances so as to function correctly in the specified environment. The installation design shall take into consideration the anticipated electromagnetic emissions, generated by the installation or the installed equipment, which shall be suitable for the current-using equipment used with, or connected to, the installation.

131.7 Protection against power supply interruption

Where danger or damage is expected to arise due to an interruption of supply, suitable provisions shall be made in the installation or installed equipment.

132 Design

132.1 General

For the design of the electrical installation, the following factors shall be taken into account to provide

- the protection of persons, livestock and property in accordance with Clause 131;
- the proper functioning of the electrical installation for the intended use.

The information required as a basis for design is listed in 132.2 to 132.5. The requirements with which the design shall comply are stated in 132.6 to 132.12.

132.2 Characteristics of available supply or supplies

When designing electrical installations in accordance with IEC 60364 series it is necessary to know the characteristics of the supply. Relevant information from the network operator is necessary to design a safe installation according to IEC 60364 series. The characteristics of the power supply should be included in the documentation to show conformity with IEC 60364 series. If the network operator changes the characteristics of the power supply this may affect the safety of the installation.

132.2.1 Nature of current: a.c. and/or d.c.

132.2.2 Function of conductors:

- for a.c.: line conductor(s);
neutral conductor;
protective conductor.
- for d.c.: line conductor(s);
midpoint conductor;
protective conductor.

NOTE The function of some conductors may be combined in a single conductor.

132.2.3 Values and tolerances:

- voltage and voltage tolerances;
- voltage interruptions, voltage fluctuations and voltage dips;
- frequency and frequency tolerances;

- maximum current allowable;
- earth fault loop impedance upstream of the origin of the installation;
- prospective short-circuit currents.

For standard voltages and frequencies, see IEC 60038.

132.2.4 Protective provisions inherent in the supply, for example, system earthing or mid-point earthing.

132.2.5 Particular requirements of the supply undertaking.

132.3 Nature of demand

The number and type of circuits required for lighting, heating, power, control, signalling, information and communication technology, etc. shall be determined by

- location of points of power demand;
- loads to be expected on the various circuits;
- daily and yearly variation of demand;
- any special conditions such as harmonics;
- requirements for control, signalling, information and communication technology, etc;
- anticipated future demand if specified.

132.4 Electric supply systems for safety services or standby electric supply systems

- Source of supply (nature, characteristics).
- Circuits to be supplied by the electric source for safety services or the standby electrical source.

132.5 Environmental conditions

The design of the electrical installation shall take into account the environmental conditions to which it will be subjected, see IEC 60364-5-51 and IEC 60721.

132.6 Cross-sectional area of conductors

The cross-sectional area of conductors shall be determined for both normal operating conditions and for fault conditions according to

- a) their admissible maximum temperature;
- b) the admissible voltage drop;
- c) the electromechanical stresses likely to occur due to earth fault and short-circuit currents;
- d) other mechanical stresses to which the conductors can be subjected;
- e) the maximum impedance with respect to the functioning of the protection against fault currents;
- f) the method of installation.

NOTE The items listed above concern primarily the safety of electrical installations. Cross-sectional areas greater than those required for safety may be desirable for economic operation.

132.7 Type of wiring and methods of installation

For the choice of the type of wiring and the methods of installation the following shall be taken into account:

- the nature of the locations;
- the nature of the walls or other parts of the building supporting the wiring;
- accessibility of wiring to persons and livestock;
- voltage;
- the electromagnetic stresses likely to occur due to earth fault and short-circuit currents;
- electromagnetic interference;
- other stresses to which the wiring can be subjected during the erection of the electrical installation or in service.

132.8 Protective equipment

The characteristics of protective equipment shall be determined with respect to their function which may be, for example, protection against the effects of

- overcurrent (overload, short-circuit);
- earth fault current;
- overvoltage;
- undervoltage and no voltage.

The protective devices shall operate at values of current, voltage and time which are suitably related to the characteristics of the circuits and to the possibilities of danger.

132.9 Emergency control

Where, in case of danger, there is the necessity for the immediate interruption of supply, an interrupting device shall be installed in such a way that it can be easily recognized and effectively and rapidly operated.

132.10 Disconnecting devices

Disconnecting devices shall be provided so as to permit switching and/or isolation of the electrical installation, circuits or individual items of apparatus as required for operation, inspection and fault detection, testing, maintenance and repair.

132.11 Prevention of mutual detrimental influence

The electrical installation shall be arranged in such a way that no mutual detrimental influence will occur between electrical installations and non-electrical installations.

132.12 Accessibility of electrical equipment

The electrical equipment shall be arranged so as to afford as may be necessary:

- sufficient space for the initial installation and later replacement of individual items of electrical equipment;
- accessibility for operation, inspection and fault detection, testing, maintenance and repair.

132.13 Documentation for the electrical installation

Every electrical installation shall be provided with appropriate documentation.

133 Selection of electrical equipment

133.1 General

Every item of electrical equipment used in electrical installations shall comply with such IEC standards as are appropriate. In the absence of an IEC standard the equipment shall comply with the appropriate national standards. Where there are no applicable standards, the item of equipment concerned shall be selected by special agreement between the person specifying the installation and the installer.

133.2 Characteristics

Every item of electrical equipment selected shall have suitable characteristics appropriate to the values and conditions on which the design of the electrical installation (see Clause 132) is based and shall, in particular, fulfil the following requirements.

133.2.1 Voltage

Electrical equipment shall be suitable with respect to the maximum steady-state voltage (r.m.s. value for a.c.) likely to be applied, as well as overvoltages likely to occur.

NOTE For certain equipment, it may be necessary to take account of the lowest voltage likely to occur.

133.2.2 Current

All electrical equipment shall be selected with respect to the maximum steady-state current (r.m.s. value for a.c.) which it has to carry in normal service, and with respect to the current likely to be carried in abnormal conditions and the period (for example, operating time of protective devices, if any) during which it may be expected to flow.

133.2.3 Frequency

If frequency has an influence on the characteristics of electrical equipment, the rated frequency of the equipment shall correspond to the frequency likely to occur in the circuit.

133.2.4 Load factor

All electrical equipment which is selected on the basis of its power characteristics shall be suitable for the duty demanded of the equipment taking into account the design service conditions, see IEC 691-10-02.

133.3 Conditions of installation

All electrical equipment shall be selected so as to withstand safely the stresses and the environmental conditions (see 132.5) characteristic of its location and to which it may be subjected. If, however, an item of equipment does not have by design the properties corresponding to its location, it may be used on condition that adequate additional protection is provided as part of the completed electrical installation.

133.4 Prevention of harmful effects

All electrical equipment shall be selected so that it will not cause harmful effects on other equipment or impair the supply during normal service including switching operations. In this context, the factors which can have an influence include, for example:

- power factor;
- inrush current;
- asymmetrical load;
- harmonics;
- transient overvoltages generated by equipment in the installation.

134 Erection and verification of electrical installations

134.1 Erection

134.1.1 Good workmanship by competent persons and proper materials shall be used in the erection of the electrical installation. Electrical equipment shall be installed in accordance with the instructions provided by the manufacturer of the equipment.

134.1.2 The characteristics of the electrical equipment, as determined in accordance with Clause 133, shall not be impaired during erection.

134.1.3 Conductors shall be identified in accordance with IEC 60446. Where identification of terminals is necessary, they shall be identified in accordance with IEC 60445.

134.1.4 Connections between conductors and between conductors and other electrical equipment shall be made in such a way that safe and reliable contact is ensured.

134.1.5 All electrical equipment shall be installed in such a manner that the designed heat dissipation conditions are not impaired.

134.1.6 All electrical equipment likely to cause high temperatures or electric arcs shall be placed or guarded so as to minimize the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, those parts shall be so located or guarded as to prevent accidental contact therewith.

134.1.7 Where necessary for safety purposes, suitable warning signs and/or notices shall be provided.

134.1.8 Where an installation is erected by using new materials, inventions or methods leading to deviations from the rules of IEC 60364 series, the resulting degree of safety of the installation shall not be less than that obtained by compliance with IEC 60364 series.

134.1.9 In the case of an addition or alteration to an existing installation, it shall be determined that the rating and condition of existing equipment, which will have to carry any additional load, is adequate for the altered circumstances. Furthermore, the earthing and bonding arrangements, if necessary for the protective measure applied for the safety of the addition or alteration, shall be adequate.

134.2 Initial verification

Electrical installations shall be verified before being placed in service and after any important modification to confirm proper execution of the work in accordance with this standard.

134.3 Periodic verification

It is recommended that every electrical installation is subjected to periodic verification.

20 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60050-826 apply. For further explanations to several terms of IEC 826, see Annex B.

30 Assessment of general characteristics

An assessment shall be made of the following characteristics of the installation in accordance with the clauses indicated:

- the purposes for which the installation is intended to be used, its general structure and its supplies (Clauses 31, 35 and 36);
- the external influences to which it is to be exposed (Clause 32);
- the compatibility of its equipment (Clause 33);
- its maintainability (Clause 34).

Those characteristics shall be taken into account in the choice of methods of protection for safety (see IEC 60364-4-41 to IEC 60364-4-44) and the selection and erection of equipment (see IEC 60364-5-51 to IEC 60364-5-55).

NOTE For other types of installation, for example, for telecommunication installations or Home and Building Electronic Systems (HBES) etc., account should be taken of IEC standards relevant to the type of installation concerned. For telecommunication installations, also the publications of the ITU-T and ITU-R are to be taken into account.

31 Purposes, supplies and structure

311 Maximum demand and diversity

For economic and reliable design of an installation within thermal and voltage drop limits, a determination of maximum demand is essential. In determining the maximum demand of an installation, or part thereof, diversity may be taken into account.

312 Conductor arrangement and system earthing

The following characteristics shall be assessed:

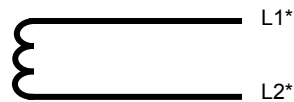
- arrangements of current-carrying conductors under normal operating conditions;
- types of system earthing.

312.1 Current-carrying conductors depending on kind of current

NOTE The conductor arrangements described in this clause are not exhaustive. They are included as examples of typical arrangements. It is recommended to report other arrangements to the IEC.

The following arrangements of current-carrying conductors under normal operating conditions are taken into account in this standard:

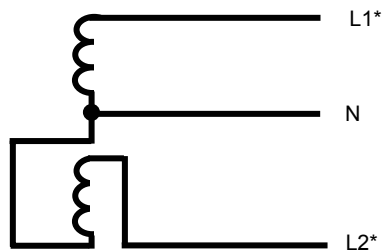
312.1.1 Current-carrying conductors in a.c. circuits



IEC 2263/05

* Numbering of conductors optional

Figure 1 – Single-phase 2-wire

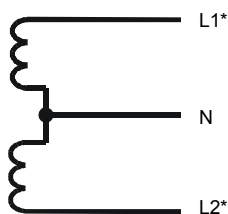


IEC 2264/05

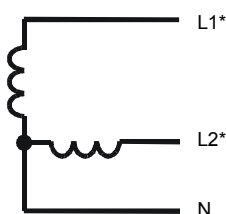
Phase angle 0°

* Numbering of conductors optional

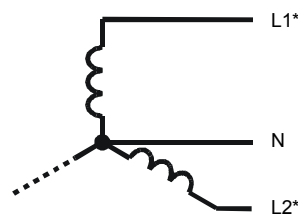
Figure 2 – Single-phase 3-wire



Phase angle 180°



Phase angle 90°

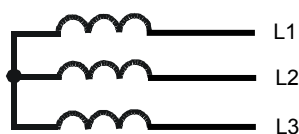


Phase angle 120°

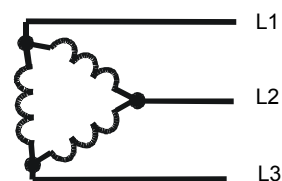
IEC 2265/05

* Numbering of conductors optional

Figure 3 – Two-phase 3-wire



Star connection



Delta connection

IEC 2266/05

Figure 4 – Three-phase 3-wire

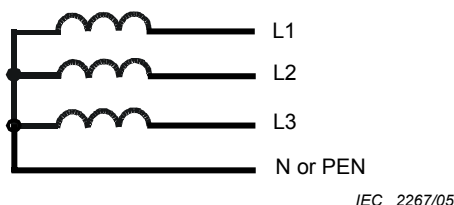


Figure 5 – Three-phase 4-wire

Three-phase, 4-wire with neutral conductor or PEN conductor. By definition, the PEN is not a live conductor but a conductor carrying an operating current.

NOTE 1 In case of a single-phase 2-wire arrangement which is derived from a three-phase 4-wire arrangement, the two conductors are either two line conductors or a line conductor and a neutral conductor or a line conductor and a PEN conductor.

NOTE 2 In installations with all loads connected between phases, the installation of the neutral conductor may not be necessary.

312.1.2 Current-carrying conductors in d.c. circuits

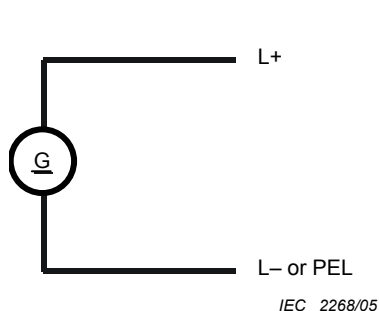


Figure 6 – 2-wire

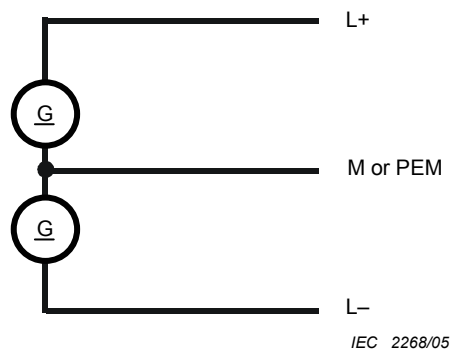


Figure 7 – 3-wire

NOTE PEL and PEM conductors are not live conductors although they carry operating current. Therefore, the designation 2-wire arrangement or 3-wire arrangement applies.

312.2 Types of system earthing

The following types of system earthing are taken into account in this standard.

NOTE 1 Figures 31A1 to 31G2 show examples of commonly used three-phase systems. Figures 31H to 31M show examples of commonly used d.c. systems.

NOTE 2 The dotted lines indicate the parts of the system that are not covered by the scope of the standard, whereas the solid lines indicate the part that is covered by the standard.

NOTE 3 For private systems, the source and/or the distribution system may be considered as part of the installation within the meaning of this standard. For this case, the figures may be completely shown in solid lines.

NOTE 4 The codes used have the following meanings:

First letter – Relationship of the power system to earth:

- T = direct connection of one point to earth;
- I = all live parts isolated from earth, or one point connected to earth through a high impedance.

Second letter – Relationship of the exposed-conductive-parts of the installation to earth:

- T = direct electrical connection of exposed-conductive-parts to earth, independently of the earthing of any point of the power system;
- N = direct electrical connection of the exposed-conductive-parts to the earthed point of the power system (in a.c. systems, the earthed point of the power system is normally the neutral point or, if a neutral point is not available, a line conductor).

Subsequent letter(s) (if any) – Arrangement of neutral and protective conductors:

- S = protective function provided by a conductor separate from the neutral conductor or from the earthed line (or, in a.c. systems, earthed phase) conductor.
- C = neutral and protective functions combined in a single conductor (PEN conductor).

Explanation of symbols for Figures 31A1 to 31M according to IEC 60617-11	
	Neutral conductor (N); mid-point conductor (M)
	Protective conductor (PE)
	Combined protective and neutral conductor (PEN)

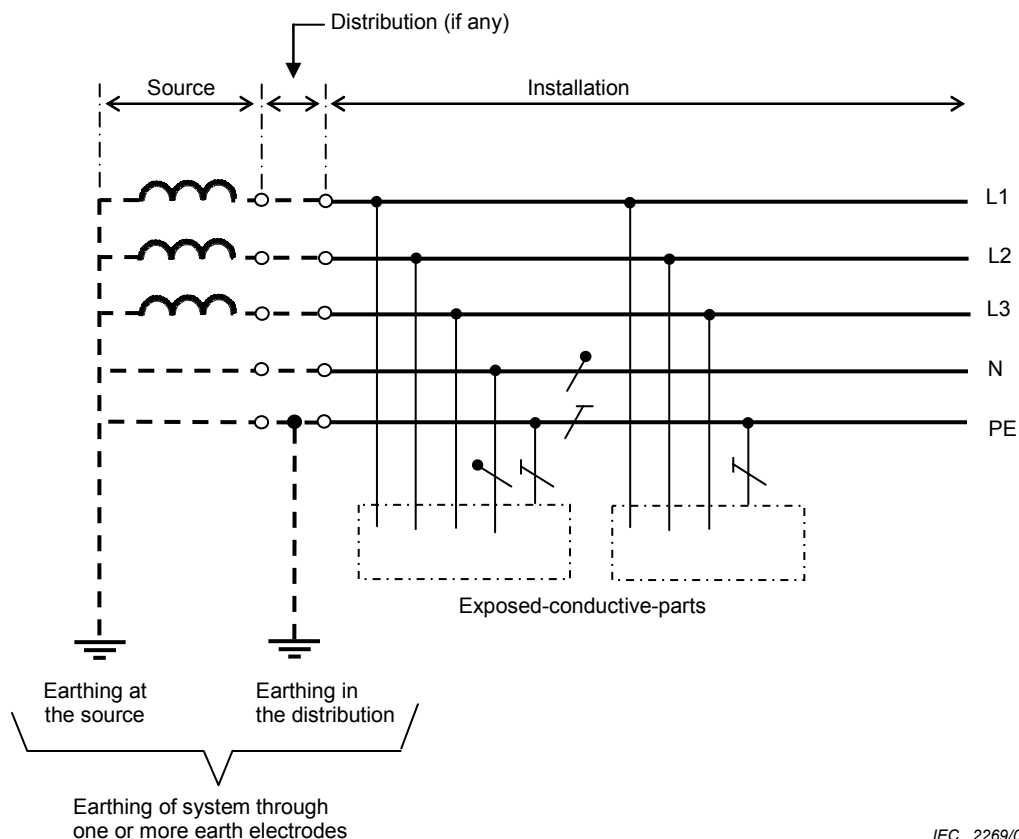
312.2.1 TN systems

312.2.1.1 Single-source systems

TN power systems have one point directly earthed at the source, the exposed-conductive-parts of the installation being connected to that point by protective conductors. Three types of TN system are considered according to the arrangement of neutral and protective conductors, as follows:

- TN-S system in which, throughout the system, a separate protective conductor is used (see Figures 31A1, 31A2 and 31A3).

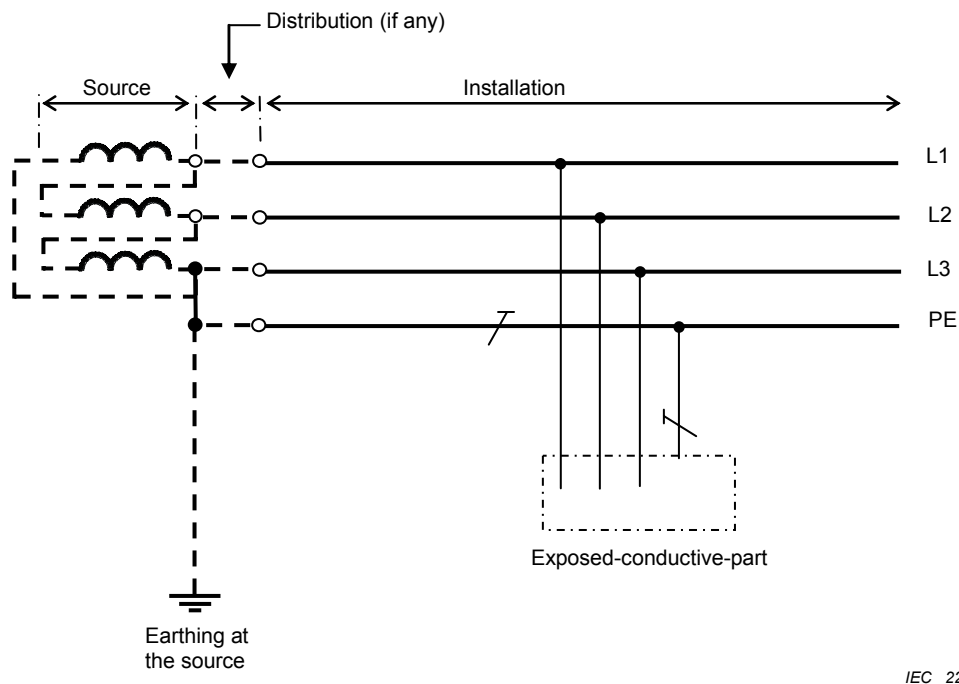
NOTE For symbols, see explanation given in 312.2.



IEC 2269/05

NOTE Additional earthing of the PE in the installation may be provided.

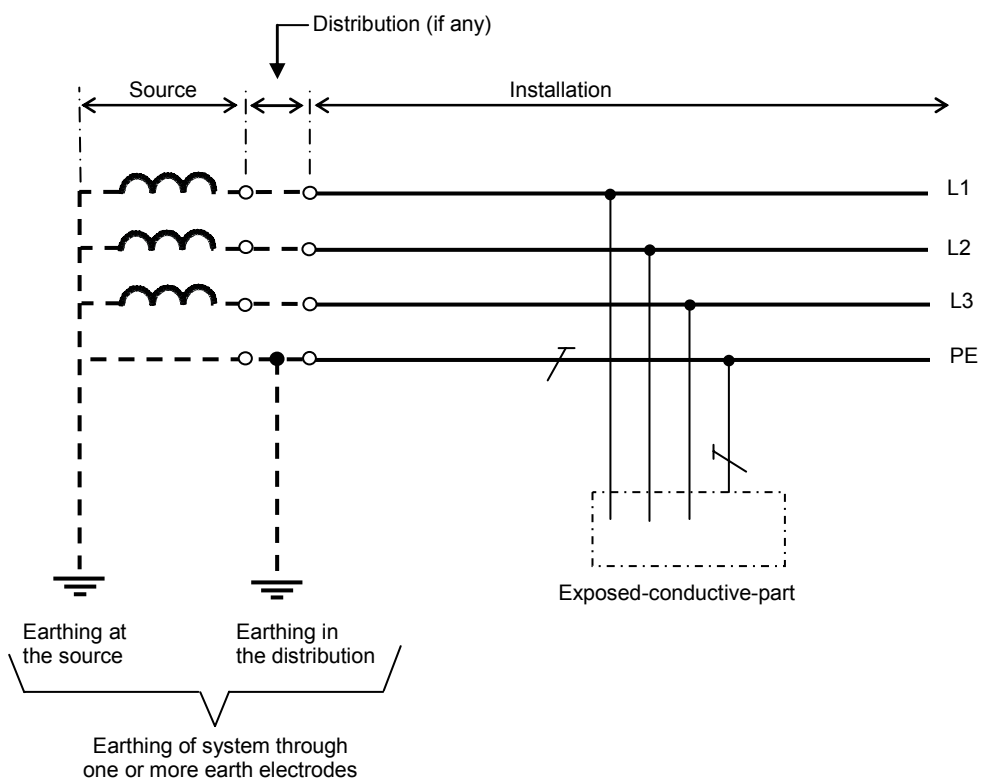
Figure 31A1 – TN-S system with separate neutral conductor and protective conductor throughout the system



IEC 2270/05

NOTE Additional earthing of the PE in the distribution and in the installation may be provided.

Figure 31A2 – TN-S system with separate earthed line conductor and protective conductor throughout the system



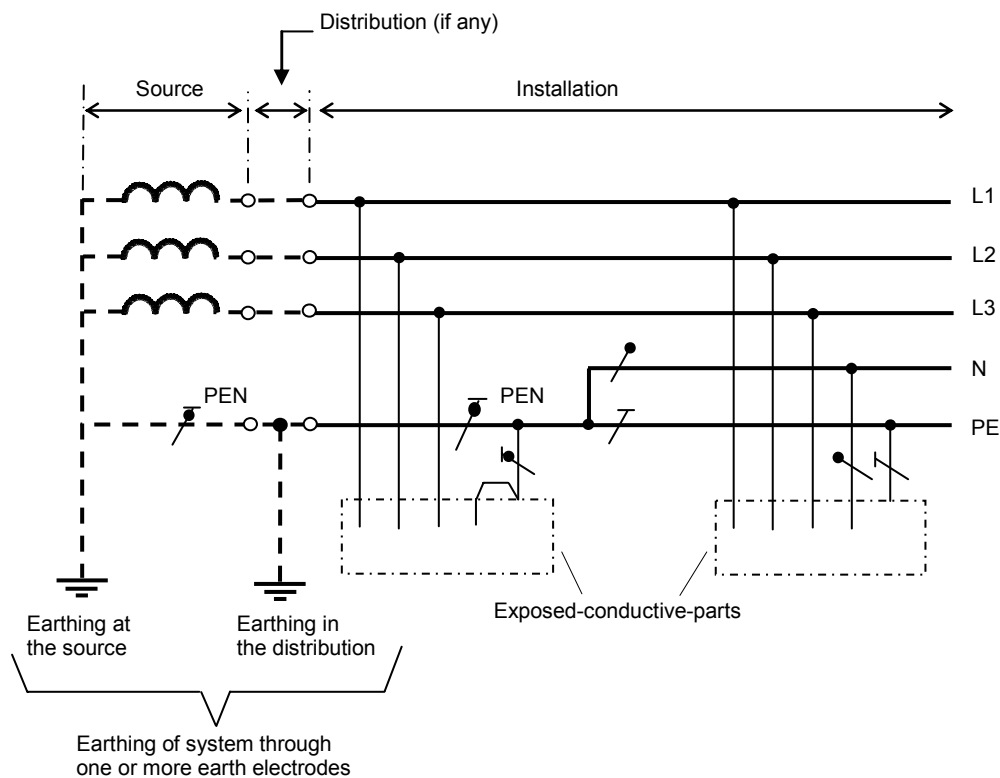
IEC 2271/05

NOTE Additional earthing of the PE in the installation may be provided.

Figure 31A3 – TN-S system with earthed protective conductor and no distributed neutral conductor throughout the system

- TN-C-S system in which neutral and protective conductor functions are combined in a single conductor in a part of the system (see Figures 31B1, 31B2 and 31B3).

NOTE For symbols, see explanation given in 312.2.

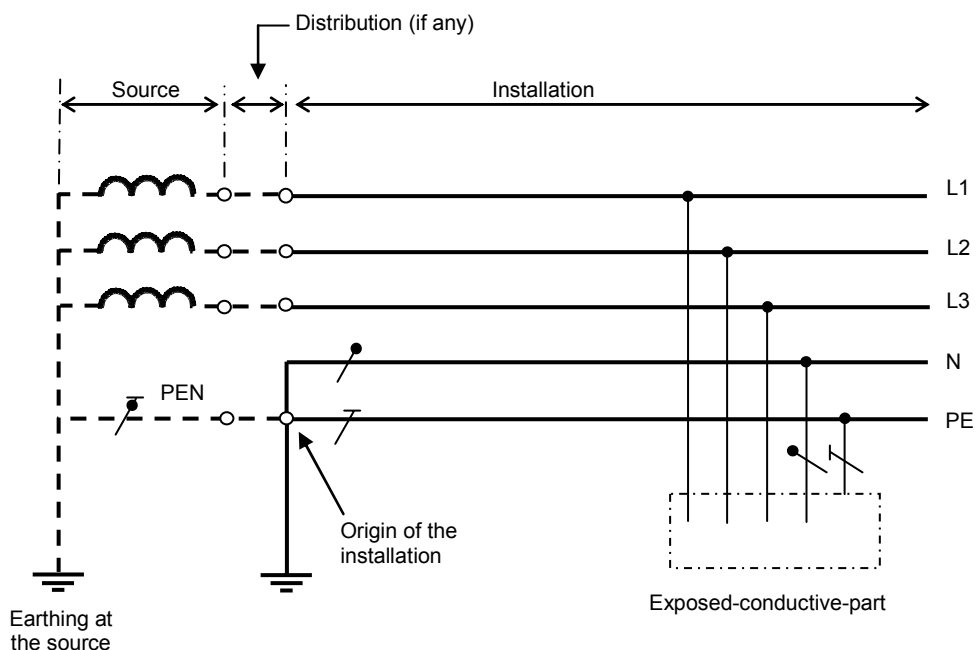


IEC 2272/05

Neutral and protective conductor functions combined in a single conductor in a part of the system

NOTE Additional earthing of the PEN or PE in the installation may be provided.

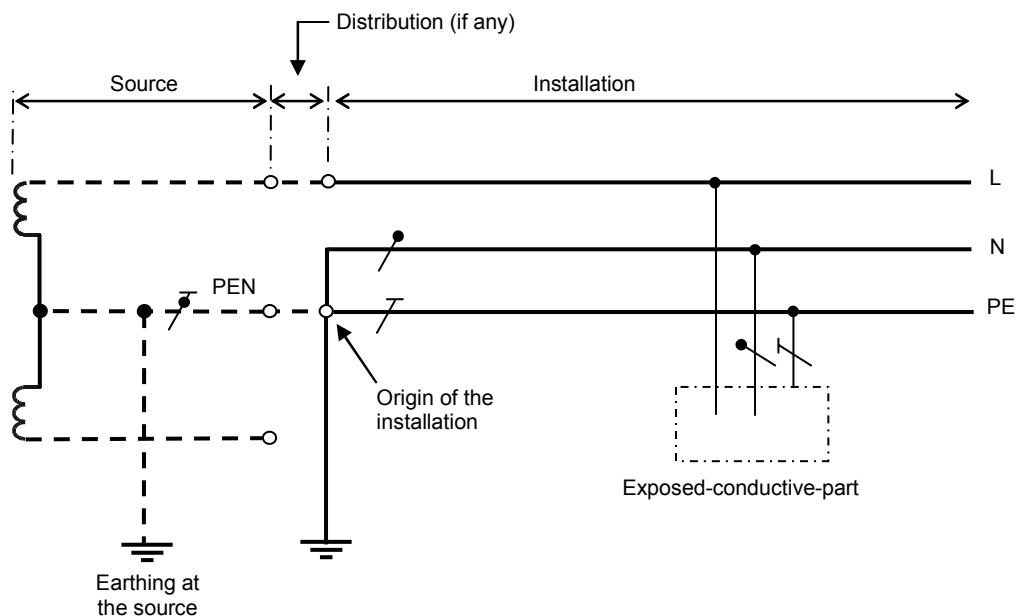
Figure 31B1 – TN-C-S system 3-phase, 4-wire, where the PEN is separated into PE and N elsewhere in the installation



IEC 2273/05

NOTE Additional earthing of the PEN in the distribution and of the PE in the installation may be provided.

Figure 31B2 – TN-C-S system 3-phase, 4-wire where the PEN is separated into PE and N at the origin of the installation



IEC 2274/05

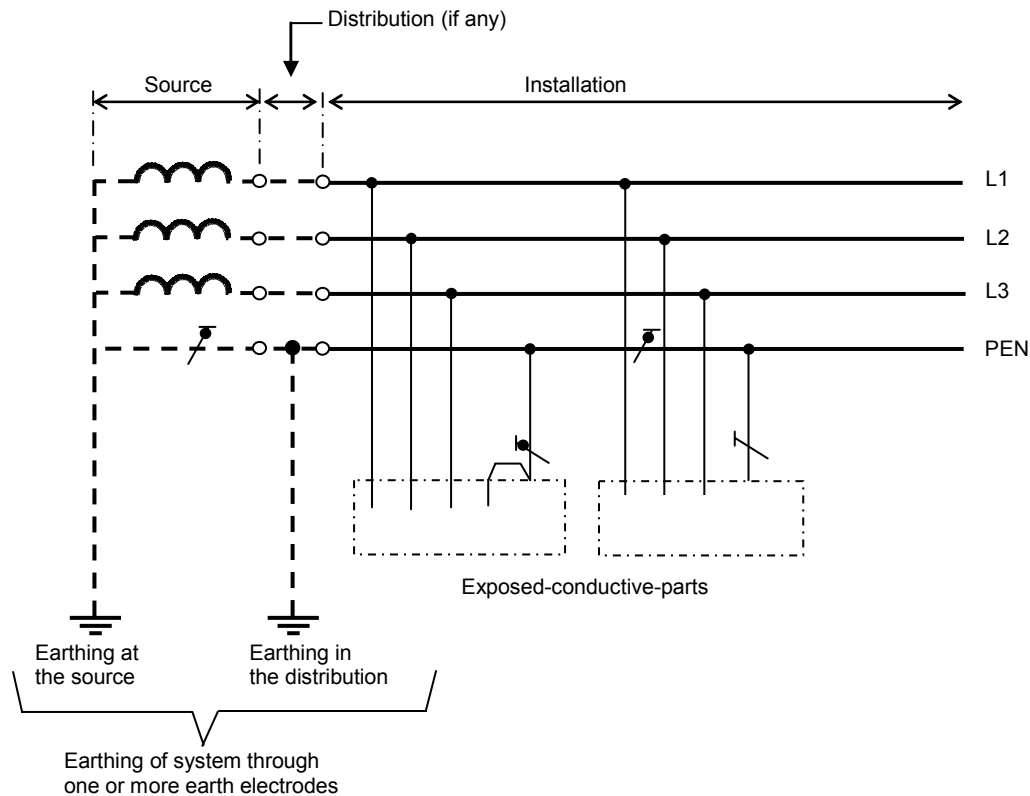
Neutral and protective conductor functions combined in a single conductor in a part of the system.

NOTE Additional earthing of the PEN in the distribution and of the PE in the installation may be provided

Figure 31B3 – TN-C-S system – single-phase, 2-wire where the PEN is separated into PE and N at the origin of the installation

- TN-C system in which neutral and protective conductor functions are combined in a single conductor throughout the system (see Figure 31C).

NOTE For symbols, see explanation given in 312.2.



IEC 2275/05

NOTE Additional earthing of the PEN in the installation may be provided.

Figure 31C – TN-C system with neutral and protective conductor functions combined in a single conductor throughout the system

312.2.1.2 Multiple source systems

NOTE The multiple source system is shown for the TN system with the unique aim of providing EMC. The multiple source system is not shown for IT and TT systems because these systems are generally compatible with regard to EMC.

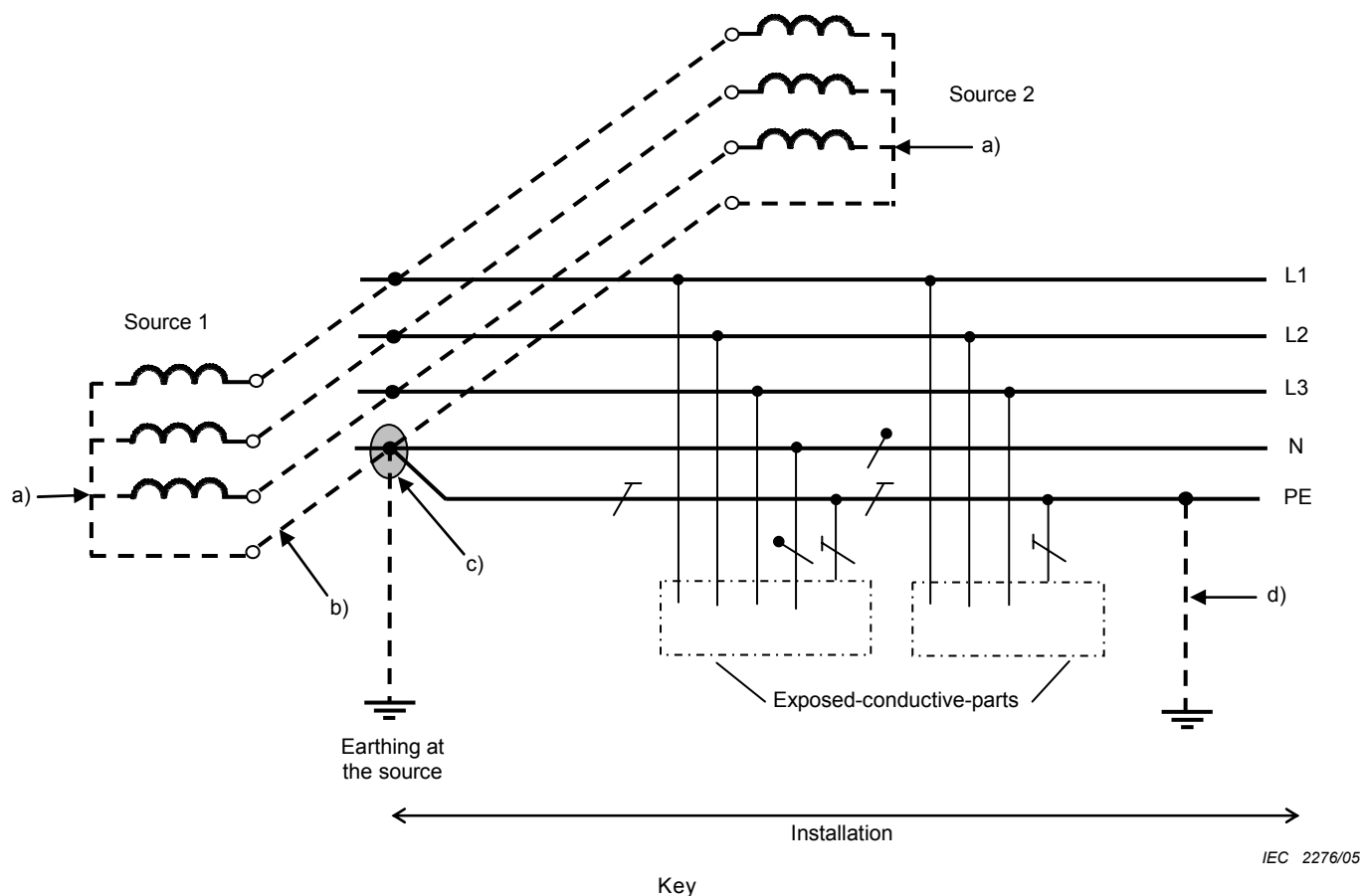
In the case of an inappropriate design of an installation forming part of a TN system with multiple sources some of the operating current may flow through unintended paths. These currents may cause

- fire;
- corrosion;
- electromagnetic interference.

The system shown in Figure 31D is a system where minor partial operating currents flow as currents through unintended paths. The essential design rules shown in Figure 31D from a) to d) are given in the legend below Figure 31D.

The marking of the PE conductor shall be in accordance with IEC 60446.

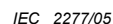
Any extension of the system shall be taken into account with regard to the proper functioning of the protective measures.



- a) No direct connection from either the transformer neutral point or the generator star point to earth is permitted.
- b) The interconnection conductor between either the neutral points of the transformers or the generator star points shall be insulated. The function of this conductor is like a PEN; however, it shall not be connected to current-using equipment.
- c) Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.
- d) Additional earthing of the PE in the installation may be provided.

Figure 31D – TN-C-S multiple source system with separate protective conductor and neutral conductor to current using equipment

In industrial plants with only 2-phase loads and 3-phase loads between line conductors, it is not necessary to provide a neutral conductor (see Figure 31E). In this case, the protective conductor should have multiple connections to earth.



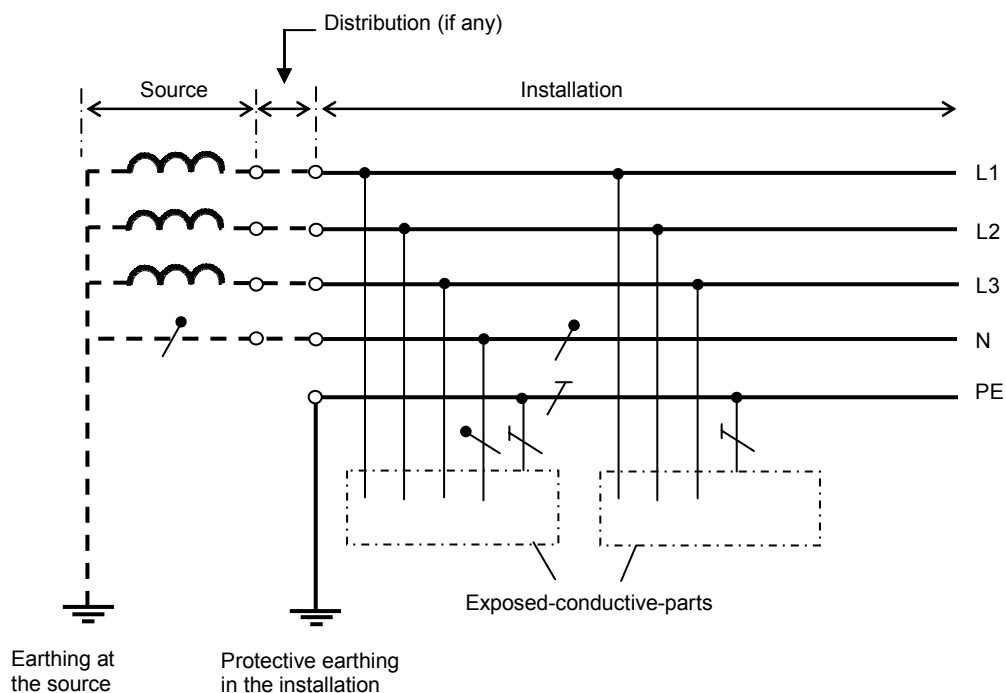
- a) No direct connection from either the transformer neutral point or the generator star point to earth is permitted.
- b) The interconnection conductor between either the neutral points of the transformers or the generator star points shall be insulated. The function of this conductor is like a PEN; however, it shall not be connected to current-using equipment.
- c) Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.
- d) Additional earthing of the PE in the installation may be provided.

Figure 31E – TN multiple source system with protective conductor and no neutral conductor throughout the system for 2- or 3-phase load

312.2.2 TT system

The TT system has only one point directly earthed and the exposed-conductive-parts of the installation are connected to earth electrodes electrically independent of the earth electrode of the supply system (see Figures 31F1 and 31F2):

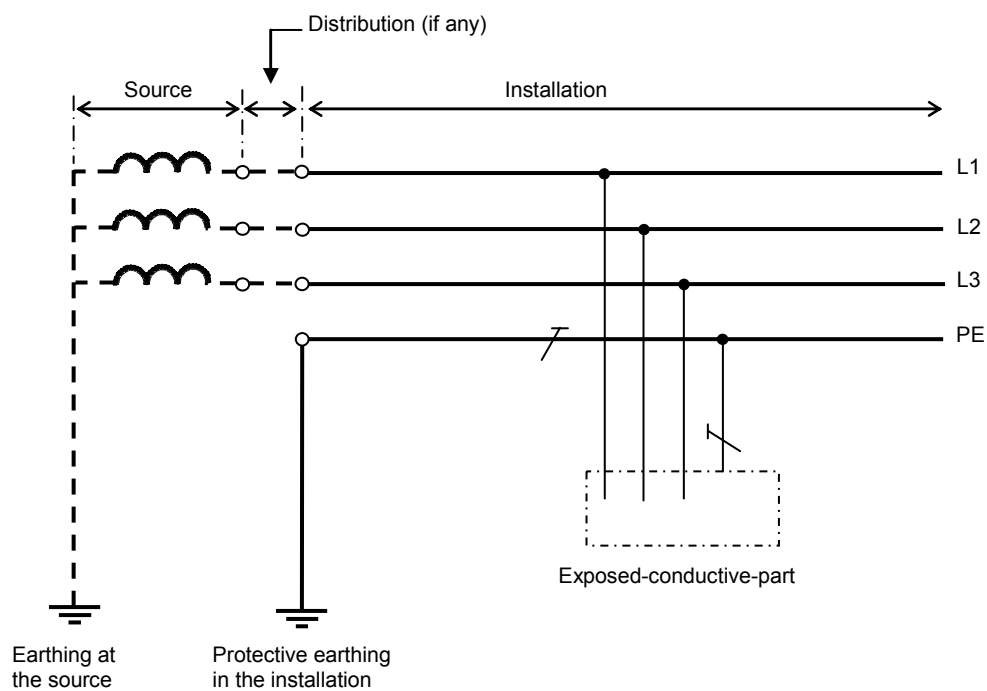
NOTE 1 In Sweden TT systems are only allowed under special conditions.



IEC 2278/05

NOTE 2 Additional earthing of the PE in the installation may be provided.

Figure 31F1 – TT system with separate neutral conductor and protective conductor throughout the installation



IEC 2279/05

NOTE Additional earthing of the PE in the installation may be provided.

Figure 31F2 – TT system with earthed protective conductor and no distributed neutral conductor throughout the installation