IEC TS 61200-102

Edition 1.0 2020-03

TECHNICAL SPECIFICATION

colour inside

Electrical installation guide –
Part 102: Application guidelines for low-voltage direct current electrical installations not intended to be connected to a public distribution network

IEC TS 61200-102:2020-03(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 91.140.50

ISBN 978-2-8322-8013-3

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ELECTRICAL INSTALLATION GUIDE –

Part 102: Application guidelines for low-voltage direct current electrical installations not intended to be connected to a public distribution network

FOREWORD

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 61200-102, which is a Technical Specification, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

The text of this Technical Specification is based on the following documents:

Draft TS	Report on voting
64/2385/DTS	64/2406/RVDTS

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

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

A list of all parts in the IEC 61200 series, published under the general title *Electrical installation guide*, can be found on the IEC website.

The reader's attention is drawn to the fact that Annex C lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Many people in the world who still have no access to electricity would benefit from access to electrical power. This can now be achieved with distributed electrical sources using renewable energy. These electrical sources using renewable energy are all operating in direct current (e.g. photovoltaic system, wind turbines).

Supply from these renewable energies is not constant, photovoltaic panels do not operate at night, and wind turbines require wind for generating electrical energy. Therefore, the use of storage units becomes a necessity and manufacturers of stationary secondary batteries are investing in these technologies so that they can become affordable.

In addition, lighting with light emitting diodes (LED), mobile phones and other electronic devices generally operate using direct current.

All requirements and recommendations in this document comply with IEC 60364 (all parts).

ELECTRICAL INSTALLATION GUIDE –

Part 102: Application guidelines for low-voltage direct current electrical installations not intended to be connected to a public distribution network

1 Scope

This part of IEC 61200 applies to low-voltage DC electrical installations entirely supplied by local power sources and having a nominal voltage lower or equal to the low-voltage limit. These installations can be connected to collective or shared private electrical installations.

This document also applies to DC installations according to use cases TIER 2 and TIER 3 of the World Bank defined in ESMAP 008/15 report: Beyond Connections Energy Access Redefined.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

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

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
individual electrical installation
single consuming and/or producing electrical installation

3.2
collective electrical installation
set of consuming electrical installations sharing one common set of local power supplies and energy storage equipment

3.3
shared electrical installation
set of consuming and/or producing electrical installations, similar to an individual electrical installation, and sharing their individual power supplies and energy storage equipment

3.4
autonomous mode
operating mode where the electrical installation operates while disconnected from the public distribution network

3.5
public distribution network
PDN
set of coordinated equipment intended to be used for the distribution of electrical energy to private electrical installations and operated by a public organization

3.6
prosumer
entity or party which can be both a producer and a consumer of electrical energy

4 General

4.1 Concept of electrical installation

Any low-voltage electrical installation is to be considered as a set of electrical equipment having the following functions (see Figure 1):

- supply (e.g. local generator, photovoltaic systems, wind turbine, batteries);
- distribution (e.g. distribution board, wiring systems, socket-outlets);
- consumption (e.g. fans, lighting, appliances, pumps, batteries).

NOTE Rechargeable batteries can be considered as a power supply and as a consuming unit.

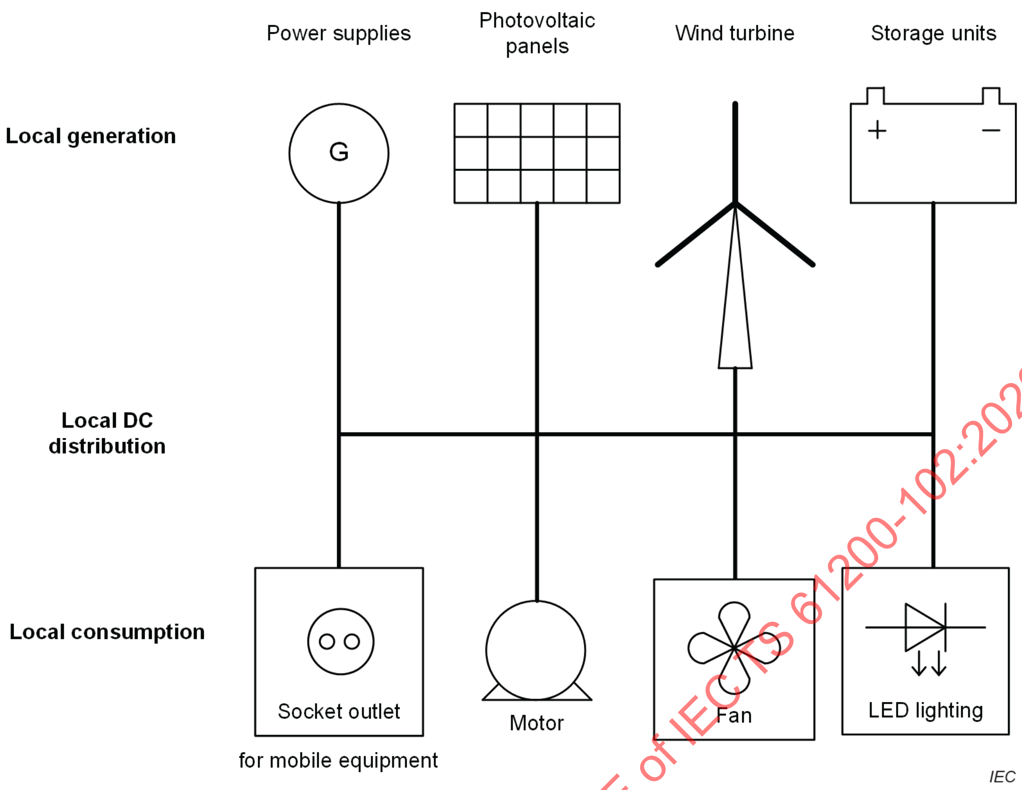


Figure 1 – Concept of DC low-voltage electrical installation

4.2 Architecture and operating modes of installation

Various architectures and operating modes of installations are defined in Annex A.

Selection of the appropriate installation architectures shall be undertaken according to the environment of the installation and its foreseeable future modification.

5 Local power sources (supplies)

Examples of local power sources are:

- local rotating generating set;
- storage units;
- photovoltaic system;
- wind turbine.

Any combination of different types of local power sources is possible. Where power sources use renewable energy, which provides intermittent supply, storage of this energy is recommended.

6 Loads

6.1 Possible nominal voltages

Table 1 provides recommended DC voltage values for equipment.

Table 1 – Preferred nominal DC voltages

Preferred V
220
350
400
440
700 or ±350
1 400 or ±700

Selection of voltage levels requires consideration of protective measures.

Using only one single nominal DC voltage within the installation might require voltage adaptation at different levels (e.g. through a DC/DC converter) as all power sources, storage units and current-using equipment may not operate at the same rated voltage.

6.2 Minimum and maximum voltage values

In case stationary secondary batteries (SSB) are used for supplying the DC electrical installation as backup power source, voltage level supplied by the batteries may be variable depending on their charge. This is particularly the case where no voltage regulation is used for the SSB. Large voltage tolerance for the nominal voltage (U_n) of the installation shall be considered for equipment selection.

Information from the battery/component manufacturer shall be considered.

NOTE If no calculation is possible or no details from the battery/component manufacturer is provided, the following minimum and maximum values can be used:

– maximum voltage: 1,2 U_n;

– minimum voltage: 0,8 U_n.

7 Wiring systems

7.1 Type of wiring system

Where automatic disconnection of supply is used as protective measure against electric shock, cables shall include three or four core conductors:

- one conductor for protective earth (PE), and
- one conductor for positive polarity, and
- one conductor for negative polarity, and/or
- one conductor for mid-point.

TN-C systems shall not be used.

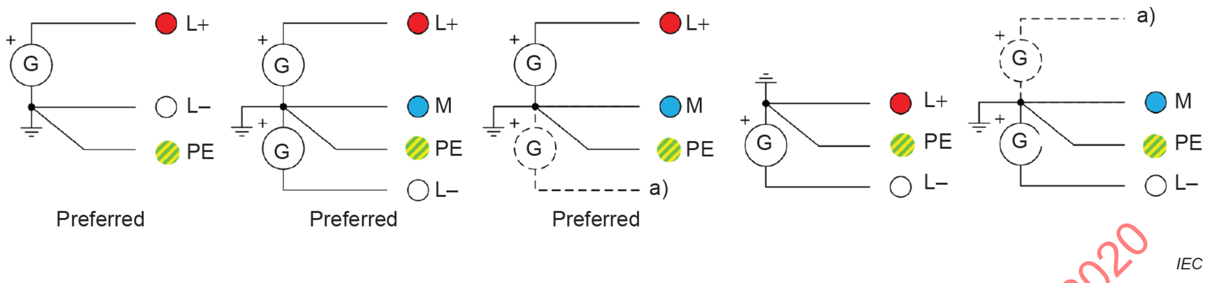
7.2 Identification of conductors and terminals

A positive polarity conductor shall be identified by the colour red and a negative polarity conductor shall be identified by the colour white according to IEC 60445.

A mid-point conductor shall be identified by the colour blue.

A PE conductor shall be identified by the bi-colour green and yellow.

If terminals have an identification then the symbols "+", "-", "M" and "PE" shall be used.



Key

a) Planned for future expansion to a bipolar system

Colours according to IEC 60445.

Figure 2 – Colours used for identification of conductors in DC electrical installations

If wiring with different colours is used, for example in previously installed AC systems, DC circuit conductors shall be clearly marked as identified in Figure 2.

7.3 Cross-sectional areas of conductors

For circuits up to and including nominal currents I_n of 16 A, the cross-sectional area of a conductor shall be a minimum of 1,5 mm^2 Cu. For nominal currents higher than 16 A, a larger cross-sectional area shall be selected based on the maximum current, the acceptable voltage drop and environmental conditions, see IEC 60364-5-52.

The same cross-sectional area shall be used for all conductors within a circuit.

8 Earthing

8.1 Direction of touch current

IEC 60479-1 states that the threshold of ventricular fibrillation for a downward current of a duration of 10 ms or more is about twice as high as for an upward current (see IEC 60479-1:2018, 6.4). For current pulses shorter than 10 ms there is no known directional sensitivity difference. See Figure 3.

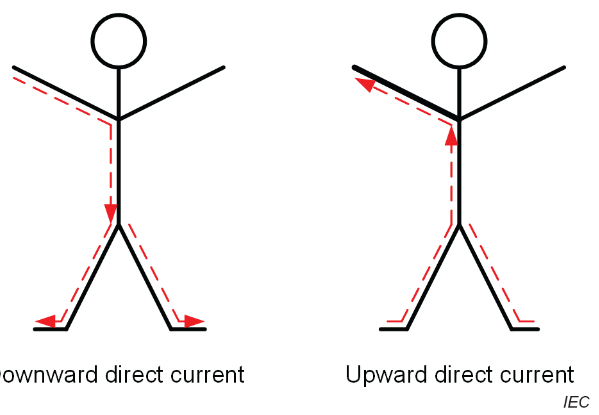


Figure 3 – Downward and upward direct current in human body

In a TN system, connecting the negative polarity to earth is recommended.

8.2 Earthing arrangement

In a TN system, mid-point or one polarity (positive or negative) of DC power supplies shall be connected to earth at one point only, and exposed-conductive parts shall be connected to this earthing arrangement.

In an individual installation, the earth connection shall be made on the main earthing busbar or main earthing terminal, thus ensuring connection of all possible power sources to earth.

8.3 Protective conductors

Each conductor connected to the main earthing terminal shall be able to be disconnected individually. This connection shall be reliable and such that it can only be disconnected by means of a tool.

8.4 Earthing conductors

Protective conductors shall be suitably protected against mechanical damage, chemical or electrochemical deterioration, electrodynamic forces and thermodynamic forces.

Every connection (e.g. screwed connections, clamp connectors) between protective conductors or between a protective conductor and other equipment shall provide durable electrical continuity and adequate mechanical strength and protection. Screws for connecting protective conductors shall not serve any other purpose.

Consideration shall be given to protect against corrosion.

9 Protection for safety

9.1 Protection against electric shock

9.1.1 General

Protection of persons and livestock against electric shock requires that hazardous-live-parts shall not be accessible and accessible conductive parts shall not be hazardous-live.

This requires that persons and livestock shall not have access to parts normally live (basic protection) and exposed-conductive parts shall not become hazardous resulting from an insulation fault (fault protection). Any protective measure against electric shock shall be an adequate combination of two separate types of protection (basic and fault), or an enhanced protection, combining both types of protection into one single measure.

In addition, protective measures to be implemented shall consider that unskilled persons having access to electrical equipment are deemed not to be aware of the dangers of electricity.

9.1.2 Provision for basic protection

Unskilled persons having access to electrical equipment are deemed not to be aware of dangers of electricity; so basic protection shall be applied.

9.1.3 Provision for fault protection

9.1.3.1 General

Unskilled persons having access to electrical equipment are deemed not to be aware of the dangers of electricity; so fault protection shall be applied.

9.1.3.2 Protective measures

9.1.3.2.1 General

The implementation of the relevant requirements and recommendations given in this document allow the installation to comply with IEC 60364-4-41.

9.1.3.2.2 Automatic disconnection of supply

9.1.3.2.2.1 TT systems

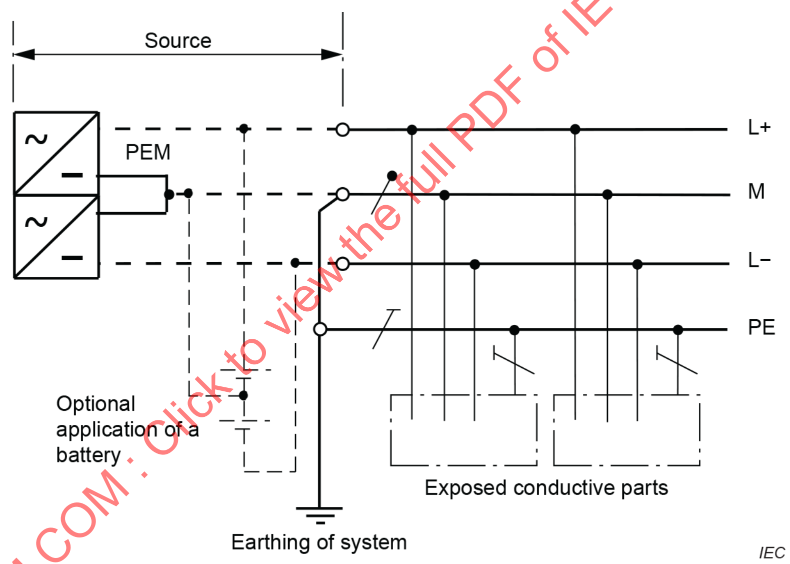
TT systems are not considered in this document.

The use of TT systems requires additional measures for example corrosion protection and devices for automatic disconnection of supply.

9.1.3.2.2.2 TN system

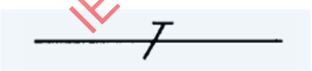
9.1.3.2.2.2.1 General

DC electrical installations according to this document shall be designed as a TN-S system (see Figure 4).



Key

 Mid-point conductor (M)

 Protective conductor (PE)

NOTE This figure complies with the general requirements of IEC 60364-1.

Figure 4 – Example of electrical installation in TN-S system

9.1.3.2.2.2.2 Use of devices for short-circuit protection

In a TN system, the value of an earth fault current is similar to a short-circuit current. Usually short-circuit protective devices can be used for protection against electric shock. Consideration should be given for such cases (e.g. where only photovoltaic systems are used), where the short-circuit current may not be high enough to operate the devices for short-circuit protection within the time specified in IEC 60364-4-41.

Where stationary secondary batteries are permanently connected to the electrical installation, short-circuit current will also be supplied by these batteries, increasing the magnitude of the short-circuit current. Use of overcurrent protective devices for short-circuit protection becomes possible for protection against electric shock (see Figure 5).

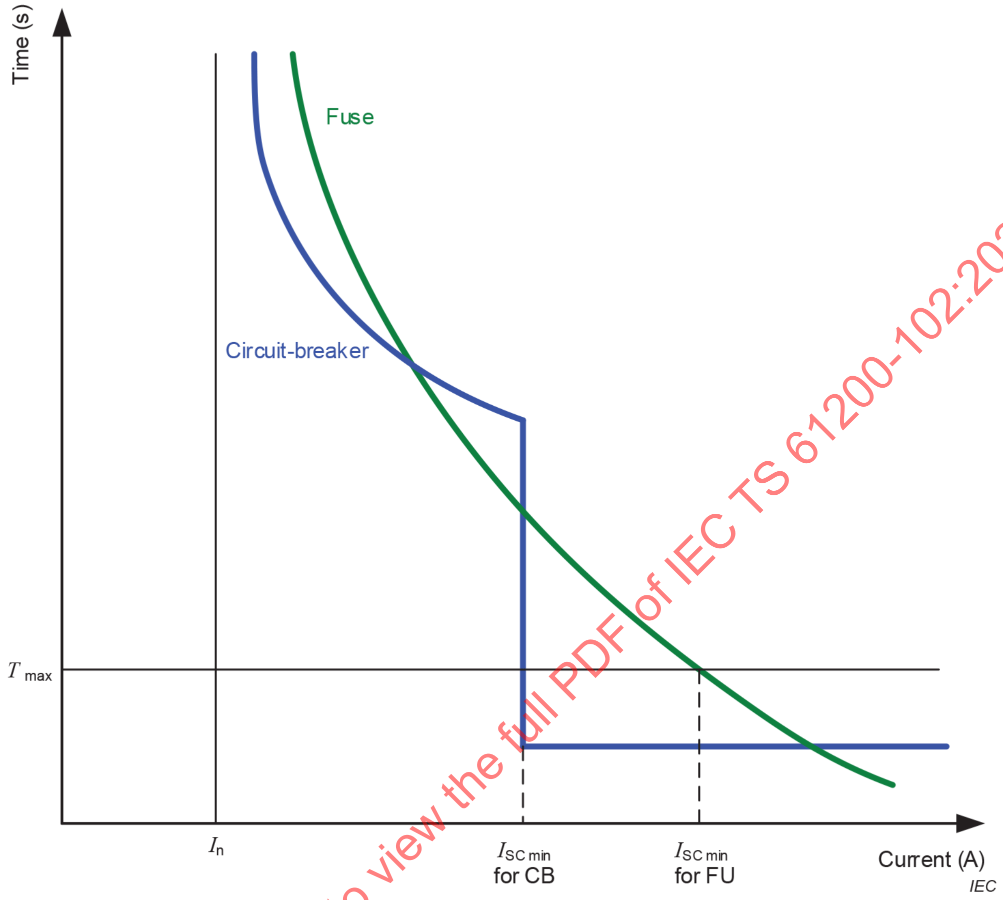


Figure 5 – Estimation of short-circuit level in TN system

For providing protection against electric shock in a TN system, the minimum short-circuit current shall always be higher than the estimated "$I_{sc\ min}$ for circuit breaker (CB)" or "$I_{sc\ min}$ for fuse (FU)".

9.1.3.2.2.2.3 Types of TN system

IEC 60364-1 recognizes three types of TN systems, but only TN-S is used in this document. TN-C and TN-C-S shall not be used.

TN-S system: The protective earth (PE) conductor is separate and only at the source connected to the mid-point conductor or a polarity. The protective earth (PE) is also connected to earth and is called the PE conductor (see Figure 6).

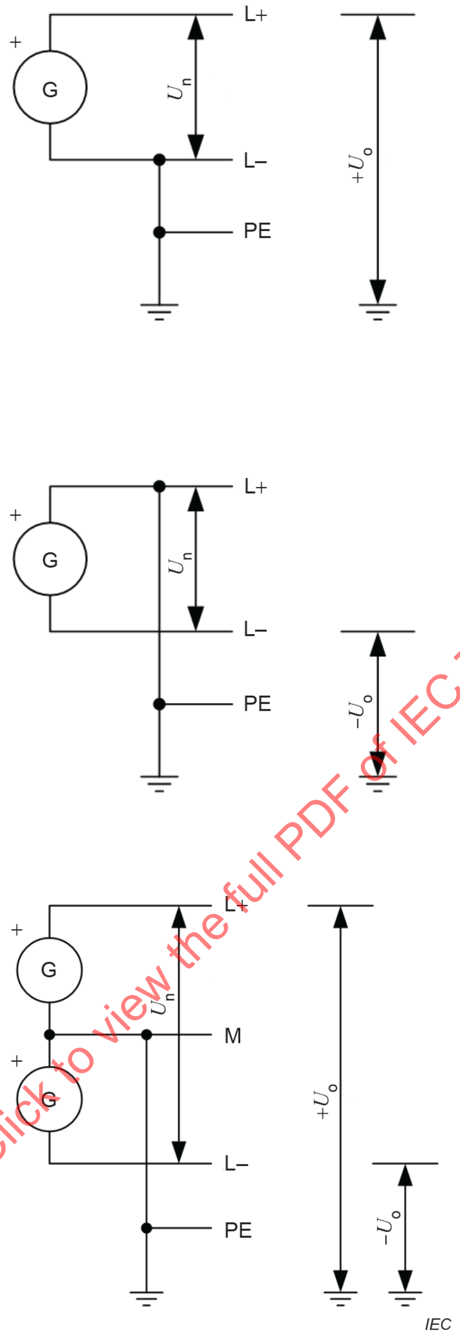


Figure 6 – Examples of TN-S systems in DC installation

DC electrical installations according this document shall be designed using a TN-S system. Where stationary secondary batteries are connected in the installation they shall not influence the architecture of the installation.

9.1.3.2.2.3 IT systems

The use of IT systems are not covered in this document. For the use of IT systems see IEC 60364 (all parts).

9.1.3.2.3 Electrical separation

Requirements proposed by IEC 60364-4-41 concern mainly the supply of one item of current-using equipment.

The protective measure of electrical separation shall not be used.

9.1.3.2.4 Double or reinforced insulation

Some parts of a DC installation that are not accessible to the user may employ double or reinforced insulation (e.g. a PV system).

As it would be essential that all equipment connected to the installation is designed with double or reinforced insulation, this protective measure shall not be used as the only protective measure for the whole DC electrical installation.

Unskilled persons using this type of installation are deemed not to be aware of dangers caused by electricity, therefore, equipment not having reinforced insulation which may be connected to this installation would create an unsafe situation.

9.1.3.2.5 Additional protection

In DC systems, the use of RCDs with a rated residual operating current not exceeding 80 mA, is recognized as additional protection in the event of failure of the basic protection and/or the fault protection or carelessness by users.

NOTE 80 mA is referenced in IEC TS 63053.

9.2 Protection against thermal effects

9.2.1 Protection against electric arc

Direct current once established does not cross the zero value as is the case for alternating current. In the case of a fault, an arc may be created between two conductive parts and due to the high impedance of the arc and low level of current drawn arc faults cannot be cleared by overcurrent protective devices. Additional care is necessary to reduce the risk of arcing, for example with the selection of electrical equipment (see Figure 7).

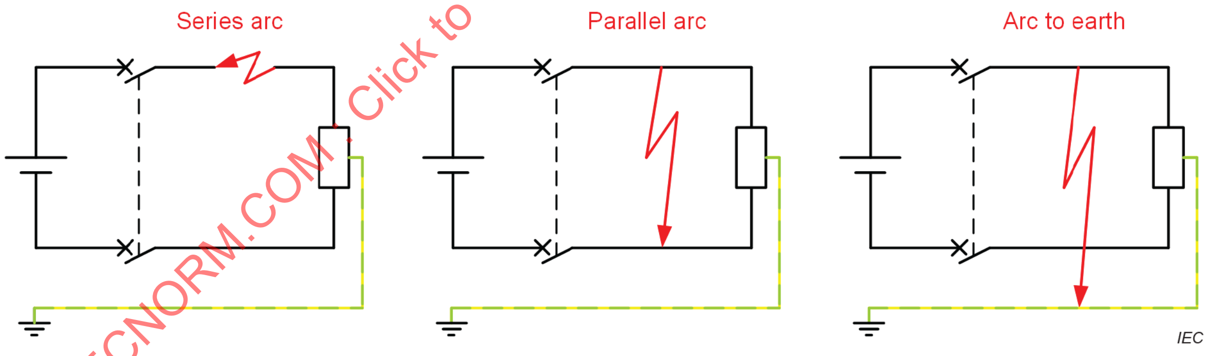


Figure 7 – Different types of arc fault to be considered

The internal impedance of the fault may vary, and it may be difficult for a normal overcurrent protective device to detect the presence of such a fault. An arc fault may not be detected by an overcurrent protective device as the current may be decreased compared to the operating current.

Measures shall be taken to protect against the harmful effects of arc faults. Arc fault detection can be used for such protection.

9.2.2 Risk of explosion with batteries

Hydrogen and oxygen gases can be released from a lead acid battery during normal operation and also in case of excess of charging current (overcharge).

Hydrogen concentration between 4 % and 72 % is considered flammable and may provoke explosion in case of ignition. The ventilation system in a stationary battery location should be designed to keep hydrogen concentration below 1 %.

Stationary secondary batteries installed in a room shall be provided with sufficient space and with adequate ventilation to avoid the risk of explosion. Additional information can be found in IEC 60364-5-57[1].

NOTE Reference to IEC 62485-2 can be made.

9.3 Protection against overcurrent

9.3.1 Overload protection

Each source and final circuit shall be individually protected against overload by one overcurrent protective device (OCPD) suitable for direct current (e.g. circuit-breaker or fuse).

As devices for overload protection are used for protecting insulation of wiring conductor against excessive temperature, they shall be installed at the origin of each circuit (e.g. distribution board).

9.3.2 Short-circuit protection

9.3.2.1 General

Each source and final circuit shall be individually protected against short-circuit by one overcurrent protective device suitable for direct current (e.g. circuit-breaker or fuse).

As devices for short-circuit protection are used for protecting the insulation of the wiring conductor against excessive temperature, they shall be installed at the origin of each circuit (e.g. distribution board).

9.3.2.2 Devices for short-circuit protection

Protection against overload and against short-circuit can be integrated within the same overcurrent protective device. This protective device shall be installed at the origin of each circuit.

9.3.2.3 Breaking capacity

The minimum breaking capacity of the overcurrent protective device shall be higher than the maximum short-circuit current at the point where the device for short-circuit protection is installed. For achieving this requirement all local power sources shall be considered as operating in parallel simultaneously (e.g. all photovoltaic panels and all stationary secondary batteries).

For an individual electrical installation, estimation of the maximum short-circuit current is possible when considering:

- contribution of all local power sources fully operational, and
- contribution of all local stationary secondary batteries fully charged, and
- no reduction from wiring cables.

For a collective electrical installation, estimation of the maximum short-circuit current is possible when considering:

———————

1 Under preparation. Stage at the time of publication: IEC CCDV 60364-5-57:2020.

- contribution of all local power sources fully operational, and
- contribution of all local stationary secondary batteries fully charged, and
- average reduction of short-circuit current from wiring cables.

For a shared electrical installation, estimation of the maximum short-circuit current is possible when considering:

- common contribution of all distributed power sources fully operational, and
- common contribution of all distributed stationary secondary batteries fully charged, and
- average reduction of short-circuit current from wiring system external to the electrical installation.

9.4 Protection against overvoltage

Consideration shall be given to the risk of overvoltage due to the atmospheric origin or due to switching.

Where overvoltage protective devices are installed, they shall be suitable for DC systems.

10 Inspection

10.1 Initial inspection

The following points need to be checked, before an installation is put into service:

- Overcurrent devices are correctly sized and have appropriate characteristics for load.
- Cable types are suitable for location and external influences.
- Cable cross sectional area is suitably sized for load and length (see Annex B).
- Cable routing is located and fixed so as not to cause hazard and reduce the risk of being damaged.
- Cable terminations are correctly made, secure, suitably shrouded and identified.
- Equipment is suitable for location and external influences, the nominal voltage of the supply, located so as not to cause hazard or be damaged and fixed so as not to cause hazard.
- Installation has been inspected, commissioned, tested and ready for service.
- Measures regarding stray current have to be considered.

Ensure that the inspection equipment used is suitable for the different tests and operates as intended (e.g. correct settings of the inspection equipment).

These tests should be documented, with installation location details, date, a provision to tick off and confirm that the required items have been checked.

The test results should be stored according to national requirements.

10.2 Periodic inspection

The periodic inspection ensures that the installation and its usage is on the same safety level as when it was when installed. The following checks shall be performed:

- Check for thermal or other damage to cables and electrical equipment.
- Cables and electrical equipment are in good order and suitable for location and external influences.
- Cable cross-sectional area remains suitable for load and length.

- Cable routing remains located and fixed so as not to cause hazard and reduce the risk of being damaged.
- Confirmation that all conductor connections are secure and suitably shrouded and identified.
- Nominal voltage of the supply and electrical equipment is within the designed range.
- Operation of the installation is inspected for continued service and functions tested for safe and continued use.

These tests should be performed regularly according to national requirements.

Ensure that the inspection equipment used is suitable for the different tests and operated as intended (e.g. correct settings of the inspection equipment).

These tests should be documented, with installation location details, date, a provision to tick off and confirm that the required items have been checked.

The test results should be stored according to national requirements.

Annex A
(normative)

Architecture and operating modes of installations

A.1 Architecture of installations

A.1.1 Individual installation

An individual installation corresponds to a single consuming and/or producing electrical installation. Such an installation always includes current-using equipment (or commonly named loads), and may also include local power supply units (e.g. photovoltaic panels, wind turbine) and may also include local storage units (e.g. stationary secondary batteries). See Figure A.1.

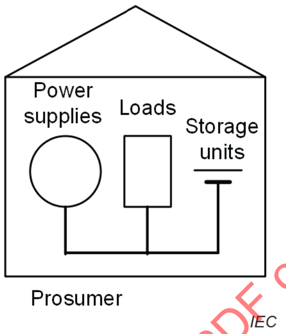


Figure A.1 – Example of an individual installation

Usually such an installation may include several electrical energy meters or measuring equipment.

A.1.2 Collective installation

A collective installation corresponds to several consuming electrical installations connected to the same private wiring system and sharing one common set of local power supplies and energy storage equipment. See Figure A.2.

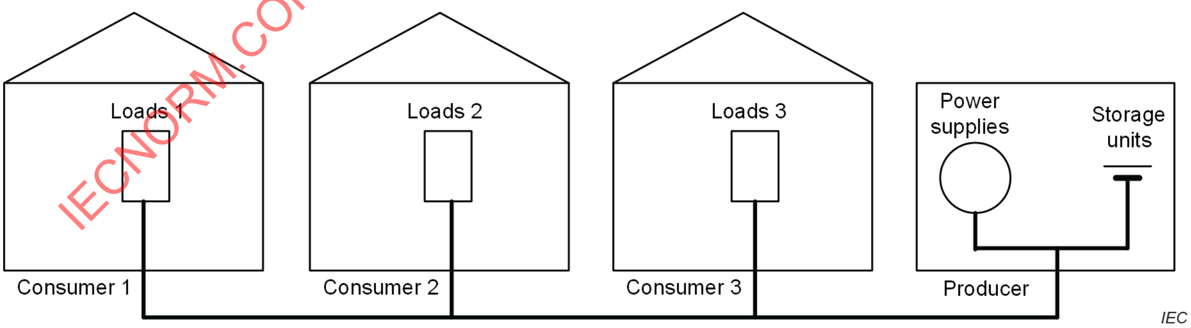


Figure A.2 – Example of a collective installation

Such installations may include several electrical energy meters or measuring equipment.

A.1.3 Shared installations

A shared installation corresponds to several consuming and/or producing electrical installations connected to the same private low-voltage distribution wiring system and sharing their individual power supplies and energy storage equipment between themselves. See Figure A.3.

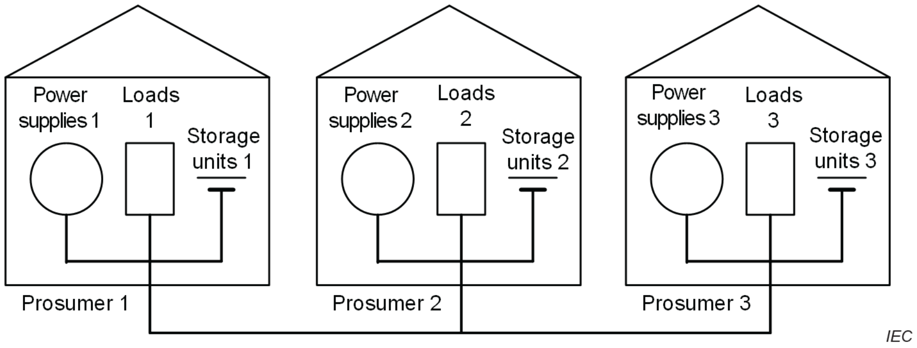


Figure A.3 – Example of a shared installation

Such an installation may include several electrical energy meters or measuring equipment.

A.2 Operating modes

A.2.1 Direct feeding mode

In this operating mode, the electrical DC installation is connected to the other electrical installations, and is partly or completely fed from them. See Figure A.4.

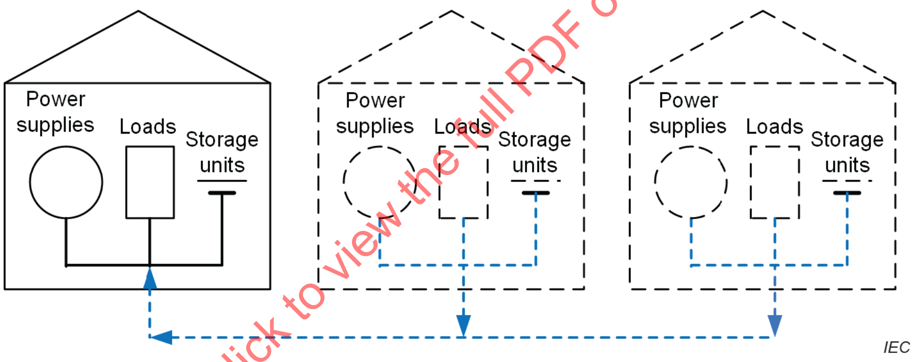


Figure A.4 – DC electrical installation in direct feeding mode

A.2.2 Reverse feeding mode

In this operating mode, the electrical DC installation is connected to the other electrical installations, and partly or completely feeds them. See Figure A.5.

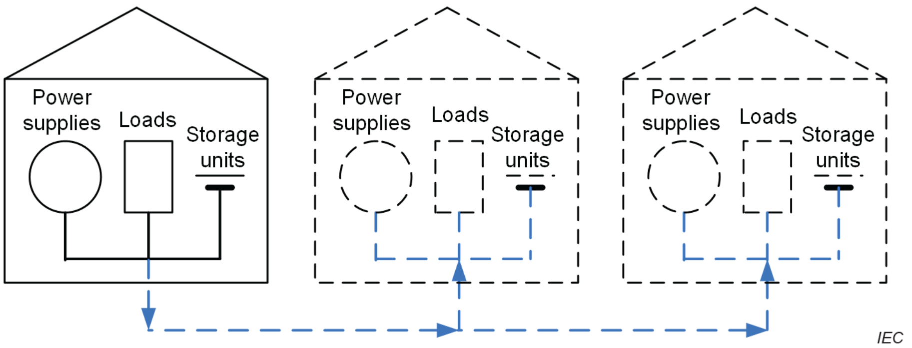


Figure A.5 – DC electrical installation in reverse feeding mode

A.2.3 Autonomous mode

In this operating mode, the electrical DC installation is not connected to the other electrical installations, and is fed directly from local power sources. See Figure A.6.

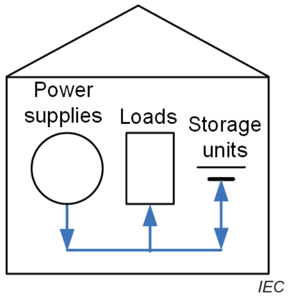


Figure A.6 – DC electrical installation in autonomous mode