IEC TS 61200-101

Edition 1.0 2018-11

# TECHNICAL SPECIFICATION

colour inside

## Electrical installation guide –
## Part 101: Application guidelines on extra-low-voltage direct current electrical installations not intended to be connected to a public distribution network



IEC TS 61200-101:2018-11(en)

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INTERNATIONAL
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CONTENTS

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# ELECTRICAL INSTALLATION GUIDE –

# Part 101: Application guidelines on extra-low-voltage direct current electrical installations not intended to be connected to a public distribution network

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

IEC TS 61200-101, 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 |
|---|---|
| 64/2284/DTS | 64/2338/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 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

**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.

Many of these electrical sources using renewable energy generate direct current (e.g. photovoltaic system, wind turbines) and 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. Manufacturers of stationary secondary batteries have been investing a lot in these technologies and prices will soon become affordable to those people in need of access to electricity.

In addition, new technologies, such as light emitting diodes (LEDs) and/or other electronic equipment use direct current and connecting these types of current-using equipment to electricity sources using renewable energy through DC electrical installations is more and more realistic. For changing DC voltage, DC/DC converters are available.

All requirements and recommendations in this document comply with IEC 60364 (all parts) [1][1].

The voltage is limited to 60 V DC taking into account environmental conditions and use cases.



[1] Numbers in square brackets refer to the Bibliography.

# ELECTRICAL INSTALLATION GUIDE –

# Part 101: Application guidelines on extra-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 individual DC low-voltage electrical installations entirely supplied by local power sources, and not intended to be connected to a public distribution network and having a nominal voltage lower or equal to 60 V DC within the extra-low-voltage limit.

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 [2].

This document does not apply to shared or collective electrical installations which are covered in IEC 61200-102 [3].

## 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 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications) – Examples of standardized systems of fuses A to F*

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

IEC 60898-2, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 2: Circuit-breakers for AC and DC operation*

IEC 60898-3[2], *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 3: Circuit-breakers for DC operation*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

## 3 Terms and definitions

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

2 Under preparation. Stage at the time of publication: IEC/PRVC 60898-3:2018.

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**
**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

**3.4**
**overcurrent protective device**
**OCPD**
device provided to interrupt an electric circuit in case the conductor current in the electric circuit exceeds a predetermined value for a specified duration

[SOURCE: IEC 60050-826:2004, 826-14-14]

## 4 Concept of an 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. photovoltaic systems, wind turbine, batteries);
- distribution (e.g. distribution board, wiring systems, socket-outlets);
- consumption (e.g. fans, lighting, appliances, pumps, batteries).

NOTE Batteries can be considered as a power supply and as a consuming unit (prosumer).

The installation shall be designed to meet the requirements for safety extra-low-voltage (SELV) systems.

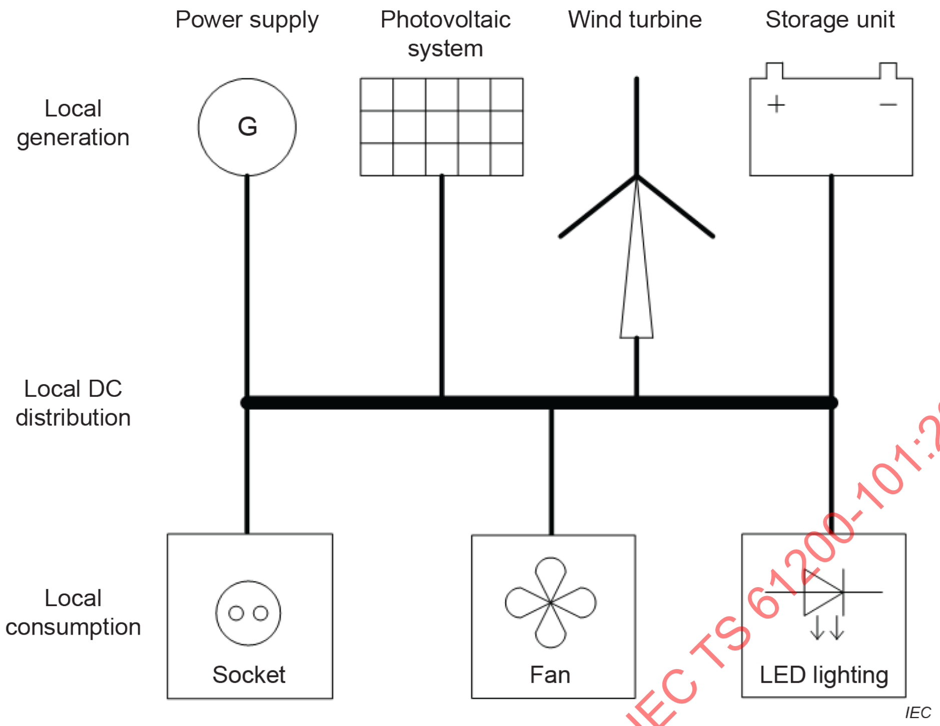


**Figure 1 – Concept of a low voltage electrical installation**



## 5 DC supplies

As the low-voltage electrical installation is not intended to be connected to a public distribution network (PDN), local power source(s) is (are) necessary. Examples of local power sources are:

- local DC generating set,
- storage units,
- photovoltaic system, and
- wind turbine.

Any combination of different types of local power sources is possible.

The output voltage of the installed sources shall meet the requirements for SELV systems.

Where power sources use renewable energy, which provides intermittent supply, storage of this energy provides flexibility and comfort to the users as consumption of the electrical energy becomes possible at almost any time.

## 6 Loads

### 6.1 Preferred nominal voltages

The selection of the rated voltage for the electrical installation has an impact on the length of cables and protective measures.

Derived from the Ohm's law, the use of ELV limits the lengths of cables as decreasing the voltage will increase the current and consequently the voltage drop along cables (see Annex A).

Preferred voltages for equipment in this document are given in Table 1 and derived from IEC 60038:2009 [5], Table 6.

All equipment should be suitable for the nominal voltage which is selected for the installation.

**Table 1 – Preferred voltages for equipment**

| **Preferred**<br>(V) | **Supplementary**<br>(V) |
|---|---|
| | 5 |
| 6 | |
| | 7,5 |
| | 9 |
| 12 | |
| | 15 |
| 24 | |
| | 30 |
| 36 | |
| | 40 |
| 48 | |



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

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

If no calculation is possible or no details from the batteries manufacturers are provided, the following minimum and maximum values may be used:

- maximum voltage: 1,2 x $U_n$;
- minimum voltage: 0,8 x $U_n$.

NOTE As in any circumstance, the maximum voltage is limited to 60 V, the nominal voltage cannot exceed 50 V.

## 7 Wiring systems

### 7.1 Type of wiring system

As a SELV supply system is used, the cable shall include at least two conductors:

- one conductor for positive polarity, and
- one conductor for negative polarity.

NOTE A cable with more than two conductors can be used, for example a third conductor for switching purposes.

### 7.2 Identification of conductors and terminals

Positive polarity shall be identified by the colour red and negative polarity shall be identified by the colour white according to IEC 60445.

If cabling, previously installed in an AC system, is re-used, circuit conductors shall be clearly marked as identified in Figure 2.

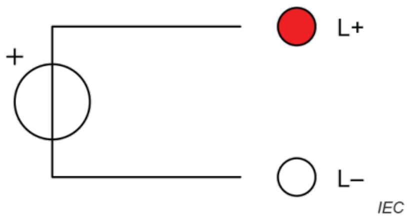


**Figure 2 – Colour identification of conductors in DC circuits**

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

NOTE In the USA, the colours used for conductor identification are specified in the National Electrical Code, NFPA 70.

### 7.3 Cross-sectional areas of conductors

The minimum cross sectional area of conductors shall be as follows:

- 0,75 mm$^2$ Cu for flexible cables;
- 1,5 mm$^2$ Cu for non-flexible cables.

All conductors of a circuit shall have the same cross-sectional area.

### 7.4 Selection of conductors

#### 7.4.1 12 V nominal voltage

Table 2 provides the maximum length of copper cables (in metres) with respect to the maximum voltage drop for specified overcurrent protective device (OCPD) rating.

**Table 2 – Maximum length with respect to maximum voltage drop (12 V nominal voltage)**

| | 2 A | 6 A | 10 A | 16 A |
|---|---|---|---|---|
| 0,75 mm$^2$ Flexible insulated conductors | 10 | 3,5 | | |
| 1,5 mm$^2$ | 20 | 7 | 4 | 3 |
| 2,5 mm$^2$ | 33 | 11 | 7 | 4 |
| 4 mm$^2$ | 53 | 18 | 11 | 7 |
| 6 mm$^2$ | 80 | 27 | 16 | 10 |

NOTE Calculation is made for a 10 % maximum voltage drop according to the method provided in Annex A.

#### 7.4.2 24 V nominal voltage

Table 3 provides the maximum length of copper cables (in metres) with respect to the maximum voltage drop for specified the OCPD rating.

**Table 3 – Maximum length with respect to maximum voltage drop (24 V nominal voltage)**

| | **2 A** | **6 A** | **10 A** | **16 A** |
|---|---|---|---|---|
| 0,75 mm$^2$<br>Flexible insulated conductors | 20 | 7,5 | | |
| 1,5 mm$^2$ | 40 | 13 | 8 | 5 |
| 2,5 mm$^2$ | 67 | 22 | 13 | 8 |
| 4 mm$^2$ | 107 | 36 | 21 | 13 |
| 6 mm$^2$ | 160 | 53 | 32 | 20 |

NOTE Calculation is made for a 10 % maximum voltage drop according to the method provided in Annex A.

### 7.4.3 36 V nominal voltage

Table 4 provides the maximum length of copper cables (in metres) with respect to the maximum voltage drop for the specified OCPD rating.

**Table 4 – Maximum length with respect to maximum voltage drop (36 V nominal voltage)**

| | 2 A | 6 A | 10 A | 16 A |
|---|---|---|---|---|
| 0,75 mm$^2$<br>Flexible insulated conductors | 30 | 10 | | |
| 1,5 mm$^2$ | 60 | 20 | 12 | 8 |
| 2,5 mm$^2$ | 100 | 33 | 20 | 13 |
| 4 mm$^2$ | 160 | 53 | 32 | 20 |
| 6 mm$^2$ | 240 | 80 | 48 | 30 |

NOTE Calculation is made for a 10 % maximum voltage drop according to the method provided in Annex A.

### 7.4.4 48 V nominal voltage

Table 5 provides the maximum length of copper cables (in metres) with respect to the maximum voltage drop for the specified OCPD rating.

**Table 5 – Maximum length with respect to maximum voltage drop (48 V nominal voltage)**

| | **2 A** | **6 A** | **10 A** | **16 A** |
|---|---|---|---|---|
| 0,75 mm$^2$<br>Flexible insulated conductors | 40 | 13,5 | | |
| 1,5 mm$^2$ | 80 | 27 | 16 | 10 |
| 2,5 mm$^2$ | 133 | 44 | 27 | 17 |
| 4 mm$^2$ | 213 | 71 | 43 | 27 |
| 6 mm$^2$ | 320 | 107 | 64 | 40 |

NOTE Calculation is made for a 10 % maximum voltage drop according to the method provided in Annex A.

# 8 Protection against electric shock

## 8.1 General

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

This requires that persons 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 or protection (basic and fault), or an enhanced protection, combining both types of protection in one single measure.

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

## 8.2 Provision for basic protection

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

For installations having a nominal voltage less or equal to 15 V DC, no additional measure for basic protection is required, but solid insulation is recommended.

For installations having a nominal voltage above 15 V DC, basic protection by solid insulation is required, for example insulated cables.

## 8.3 Provision for fault protection

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

## 8.4 Protection by safety extra-low voltage system (SELV system)

For the purposes of this document, the SELV protective measure shall be applied as follows:

- nominal voltage shall not exceed the upper limit of 60 V in any circumstance (including fault condition), and
- where a power source is used, it shall provide an equivalent level of safety as required by IEC 61558-2-6.

Both conditions are deemed to be satisfied as long as the electrical installation is supplied from local power sources with a nominal voltage lower than 60 V DC and remains an individual electrical installation.

The wiring system shall not include a PE conductor, and socket-outlets shall not include an earth pin.

SELV systems shall not be earthed.

# 9 Protection against overcurrent

Protection against overload and against short-circuit shall be integrated within the same protective device.

Every circuit connecting a power source or equipment shall be protected by an overcurrent protective device.

This protective device shall comply with IEC 60898-2, IEC 60898-3 or IEC 60269-3 and be installed at the origin of each circuit. Conductors are considered to be protected against overload and short-circuit currents where they are supplied from a source incapable of supplying a current exceeding the current carrying capacity of the conductors.

## 10 Arcing

Due to the nature of direct current, arcing may appear at any interruption of the circuit or during a short-circuit. The probability of arcing and the sustainability increases with, for example, voltage, power and humidity.

In order to avoid arcing, additional means shall be implemented, especially for circuits with a rated voltage from 36 V or more and a capability of the circuit to provide power above 200 W.

Circuit breakers, accessories and other making or breaking devices, for example switches and socket-outlets, shall be selected accordingly.

## 11 Example of a typical architecture

It is recommended to have a dedicated circuit for the following applications:

- one circuit for lighting;
- one circuit for socket-outlets;
- one circuit for a fan.

Other configurations, for example with combinations of loads, are possible. See Annex B.

# Annex A
(informative)

# Voltage drop limits for extra-low-voltage installations

## A.1 Voltage drop limits in consumers' installations

IEC 60364-5-52:2009 [6], Annex G, recommends the limitation of voltage drop within the electrical installation as given in Table A.1:

**Table A.1 – Maximum voltage drops**

| Type of installation | Lighting<br>% | Other uses<br>% |
|---|---|---|
| A – Low-voltage installations supplied from public network low-voltage distribution system | 3 | 5 |
| B- Low-voltage installations supplied from private low-voltage supply [a] | 6 | 8 |
| [a] As far as possible, it is recommended that voltage drop within the final circuits does not exceed those indicated in installation type A. | | |



## A.2 Estimation of voltage drop

For direct current, the voltage drop in given by the simplified formula as follows:

$$\Delta u = 2\left(\rho_1 \frac{L}{S}\right) I_B$$

Where:

$\Delta u$ is the voltage drop in volts;

$\rho_1$ is the resistivity of conductors in normal service, taken equal to the resistivity at the temperature in normal service, i.e. 1,25 times the resistivity at 25 °C, or 0,022 5 Ωmm$^2$/m for copper and 0,036 Ωmm$^2$/m for aluminium;

$L$ is the length of the wiring systems, in m;

$S$ is the cross-sectional area of conductors in mm$^2$;

$I_B$ is the design current in A.

The relevant voltage drop in per cent is equal to:

$$\Delta u\,[\%] = 100 \frac{\Delta u}{U_0}$$

where

$U_0$ is the voltage between conductors L+ and L- , in volts at supply.