# IEC TR 63282

Edition 2.0 2024-08

# TECHNICAL REPORT

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## LVDC systems – Assessment of standard voltages and power quality requirements



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## LVDC systems – Assessment of standard voltages and power quality requirements



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# LVDC SYSTEMS – ASSESSMENT OF STANDARD VOLTAGES AND POWER QUALITY REQUIREMENTS

## FOREWORD



IEC TR 63282 has been prepared by IEC technical committee 8: System aspects of electrical energy supply. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2020. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Optimized terms and definitions in Clause 3:

   Introduction of new terms and definitions and refining of existing ones.

b) Modified the definition of voltage bands:

   In Clause 5, the definition of voltage limits in voltage bands is added, from $U_1$ to $U_6$. The definition of voltage bands, from B4 to B7, is modified.

c) Distinguished the difference between oscillation and power quality phenomenon:

In Clause 3, the definition of oscillation is added based on IEV 103-05-04. In 6.3, relationship between oscillation and power quality is clarified. Annex B gives a LDC oscillation typical example which has really happened in a MV&LVDC system in China.

d) Modified the recommended voltage for distribution DC network:

The factors considered in voltage values definition is clarified. And the voltage is divided in two domains, distribution domain and installation domain. The voltage recommendation in LVDC is listed corresponding to voltage bands.

e) Modified the voltage immunity level assessment:

It is mentioned in 7.2 that the assessment of voltage immunity levels of mass LVDC power electronic devices need to be further discussed, ripple as an example is introduced.

f) Added DC power quality measurement methods:

In 7.3, DC power quality measurement methods is introduced based on AC methodologies. And some additional DC power quality indices are recommended to assess the DC system.

DC electric power and power quality measurement methods are introduced in 7.4, defining the electric value integration time and frequency ranges.

Typical electric power and power quality computation methods are modified in Annex D.

g) Added an annex on MVDC system:

A use case of a typical MV&LVDC distribution system is added in Annex F, to support developments of TS of 8A and 8B on DC microgrids.

h) Added an annex on Current OS voltage level:

The voltage level applied in Current OS is introduced in Annex L to give more information on the LVDC voltage level recommendation.



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

| Draft | Report on voting |
|---|---|
| 8/1695/DTR | 8/1704/RVDTR |



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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

- reconfirmed,
- withdrawn, or
- revised.

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# INTRODUCTION

LVDC (low voltage direct current) distribution systems have recently been recognized by a number of stakeholders as an alternative approach to provide efficient power supply to the consumers. LVDC covers a wide range of power applications from USB-C up to megawatts for aluminium melting. LVDC is seen as a solution for greener and more sustainable energy systems in developed economies as well as an alternative option for electricity access in developing countries.

In industrial applications, LVDC is utilized where processing of resources results in the production, distribution and storage of physical goods, especially in a factory or special area of a factory.

The standardization of DC voltages is a key issue, and urgent work is needed. Existing LVAC systems have different standard voltages, depending on the geography and application. LVDC distribution voltages are optimized to provide a good context for industries that import and export equipment but also for general travellers. Appropriate international LVDC voltage ranges will provide a basis for design and testing of electrical equipment and systems and ease of transition for equipment from AC to DC supply.

LVDC voltages meet the range of use cases where LVDC systems can make a difference. The list of standard voltages is as short as possible and allow for cost-effective and safe operation.

The PQ (power quality) issues in DC power systems are not identical to those in AC systems, but there are some common issues. Power quality considerations are well studied and standardized on AC power systems, but many power quality phenomena and EMC have not yet been fully identified and evaluated for DC distribution systems.



Power electronic converters/inverters add further demands. Power quality phenomena in LVDC distributed systems can be related to the structure of the entire system, and the operating condition of sources and loads. At the same time, the DC output performance of a single converter and the coordination among several converters can also result in different power quality issues and grid stability.



Requirements for power quality and EMC in LVDC distribution are established in order to provide a solid basis for the planning and operation of LVDC distribution systems. In addition, the design and configuration of the protection system is addressed with the objective of enhancing the availability of the source, the reliability, and the lifetime of the system.

Generally, the standardization of voltage level and PQ phenomena of LVDC distribution greatly stimulate the wide adoption of LVDC.

This document provides information on the following topics: standard voltages, EMC requirements, power quality, and measurement methods.

# LVDC SYSTEMS – ASSESSMENT OF STANDARD VOLTAGES AND POWER QUALITY REQUIREMENTS

## 1 Scope

The purpose of this document is to collect information and report experience for the standardization of voltage levels and related aspects (power quality, EMC, measurement, etc.) for LVDC systems (systems with nominal voltage up to and including 1 500 V DC).

Rationale for the proposed voltage values is given. Variation of parameters for the voltage (power quality) for their boundaries are defined. Nevertheless, some of the technical items are not exhaustively explained in this document and some gaps are identified for future work.

Attention is paid to the definition of DC voltage.

Systems in which a unipolar voltage is interrupted periodically for certain purposes, e.g. pulse voltage, are not considered.

Traction systems are excluded from this document.



This document gives technical inputs to TCs in charge of the standardization of different issues and coordinated by SyC LVDC.

## 2 Normative references

There are no normative references in this document.



## 3 Terms and definitions

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

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

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

**3.1**
**nominal system voltage**
suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60050-601:1985, 601-01-21, modified − The term has been changed from "nominal voltage of a system" to "nominal system voltage".]

**3.2**
**DC supply voltage**
line-to-line or line-to-mid-point voltage at the supply terminals

**3.3**
**bipolar DC system**
DC system comprising a positive and negative line, and a mid-point, distributed or not

**3.4**
**unipolar DC system**
DC system comprising a positive or a negative line, and a mid-point

**3.5**
**DC system nominal voltage**
$U_n$
value of the voltage by which the electrical installation or part of the electrical installation is designated and identified

Note 1 to entry: The DC system nominal voltage $U_n$ is within the nominal band [$U_2$; $U_3$] but not always half-way between $U_2$ and $U_3$. In all cases

$$U_2 \leq U_n \leq U_3$$

Note 2 to entry: For a bipolar system, it is recommended to use a dual notation, for example, "$\pm U_{L-M}$" or "$U_{L-M}$ / $U_{L-L}$".

**3.6**
**DC voltage deviation**
voltage deviation due to the slow change in power system operation state

Note 1 to entry: Voltage deviation is the difference between actual voltage and nominal system voltage when the change rate of the average DC voltage is in the appropriate speed in order to limit the deviation in an acceptable range.

**3.7**
**voltage unbalance**
condition in a bipolar system in which the line to mid-point voltages are not equal



**3.8**
**ripple**
set of unwanted periodic deviations with respect to the average value of the measured or supplied quantity, occurring at frequencies which can be related to that of the mains supply, or of some other definite source, such as a chopper or load changes



Note 1 to entry: Ripple is determined under specified conditions and is a part of PARD (Periodic and/or random deviation). It may be assessed by instantaneous value or RMS value.

Note 2 to entry: Sources of ripple may include, but are not limited to, voltage regulation instability of the DC power source, commutation/rectification within the DC power source, and load variations within utilization equipment.

Note 3 to entry: Ripple is determined as well in percentage to the DC component and in RMS value computed in line with CISPR for conducted disturbances. Ripple can be hundreds of kHz.

[SOURCE: IEC 60050-312:2001, 312-07-02, modified – "or load changes" has been added at the end of the definition, a sentence has been added to Note 1 to entry; Notes 2 and 3 to entry have been added.]

**3.9**
**over-voltage**
voltage the value of which exceeds a specified limiting value

[SOURCE: IEC 60050-151:2001,151-15-27]

**3.10**
**under-voltage**
voltage the value of which is lower than a specified limiting value

[SOURCE: IEC 60050-151:2001,151-15-29]

**3.11**
**voltage swell**
sudden increase of the voltage at a point in the electrical supply system followed by voltage recovery after a short period of time

Note 1 to entry: Application: for the purpose of this document, the swell start threshold is equal to the 110 % of the reference voltage (see CLC/TR 50422: 2013, Clause 3, for more information).

Note 2 to entry: For the purpose of this document, a voltage swell is a two-dimensional electromagnetic disturbance, the level of which is determined by both voltage and time (duration).

**3.12**
**voltage dip**
sudden decrease of the voltage at a point in the electrical supply system followed by voltage recovery after a short period of time

Note 1 to entry: The residual voltage can be expressed as a value in volts, or as a percentage or per unit value relative to the reference voltage.

[SOURCE: IEC 60050-614:2016, 614-01-08, modified – "Reduction" has been changed to "decrease", " electric power system" has been changed to "electrical supply system", "time interval" has been changed to "period of time", reference to sinusoidal voltage has been removed.]

**3.13**
**voltage surge**
transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage

[SOURCE: IEC 60050-161:1990, 161-08-11]



**3.14**
**voltage supply interruption**
disappearance of the supply voltage for a time interval whose duration is between two specified limits



[SOURCE: IEC 60050-161:1990, 161-08-20, modified – In the term, "short interruption (of supply voltage)" has been changed to "voltage supply interruption", the note has been deleted.]

**3.15**
**rapid voltage change**
**RVC**
quick transition in voltage occurring between two steady-state conditions, and during which the voltage does not exceed the under-voltage/over-voltage thresholds

**3.16**
**oscillation**
physical phenomenon characterized by one or more alternately increasing and decreasing quantities

Note 1 to entry: Oscillation in LVDC system is characterized by an electromagnetic parameter (voltage current, power, etc.) in the system alternately increasing and decreasing. The phenomenon can be caused by interference, parameter mismatch or control stability issues.

[SOURCE: IEC 60050-103:2019,103-05-04, modified – Note 1 to entry has been completely changed.]

**3.17**
**DNO**
**distribution network operator**
party operating a distribution network