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**Lastnosti visokonapetostnih enosmernih sistemov z vodovno komutiranimi pretvorniki - 1. del: Pogoji v ustaljenem stanju (IEC/TR 60919-1:2005)  
(istoveten CLC/TR 60919-1:2005)**

Performance of high-voltage direct current (HVDC) systems with line-commutated converters - Part 1: Steady-state conditions (IEC/TR 60919-1:2005)

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TECHNICAL REPORT

**CLC/TR 60919-1**

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

December 2005

ICS 29.200; 29.240.99

English version

**Performance of high-voltage direct current (HVDC) systems  
with line-commutated converters  
Part 1: Steady-state conditions  
(IEC/TR 60919-1:2005)**

Fonctionnement des systèmes à courant  
continu haute tension (CCHT)  
à convertisseurs commutés par le réseau  
Partie 1: Spécification des conditions de  
fonctionnement en régime établi  
(CEI/TR 60919-1:2005)

Betriebsverhalten netzgeführter  
Stromrichter in Hochspannungs-  
gleichstrom (HGÜ)-Systemen  
Teil 1: Bedingungen im eingeschwungenen  
Zustand  
(IEC 62102:2001)

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This Technical Report was approved by CENELEC on 2005-07-09.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Comité Européen de Normalisation Electrotechnique  
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**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of the Technical Report IEC/TR 60919-1, prepared by SC 22F, Power electronics for electrical transmission and distribution systems, of IEC TC 22, Power electronic systems and equipment, was submitted to the formal vote and was approved by CENELEC as CLC/TR 60919-1 on 2005-07-09 without any modification.

Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the Technical Report IEC/TR 60919-1:2005 was approved by CENELEC as a Technical Report without any modification.

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## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

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.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60146-1-1 + A1	1991 1996	Semiconductor convertors - General requirements and line commutated convertors Part 1-1: Specifications of basic requirements	EN 60146-1-1 + A1	1993 1997
IEC 60146-1-2	1991	Part 1-2: Application guide	-	-
IEC 60146-1-3	1991	Part 1-3: Transformers and reactors	EN 60146-1-3	1993
IEC 60633	1998	Terminology for high-voltage direct current (HVDC) transmission	EN 60633	1999
IEC 61803	1999	Determination of power losses in high-voltage direct current (HVDC) converter stations	EN 61803	1999
CISPR 16	series	Specification for radio disturbance and immunity measuring apparatus and methods	EN 55016	series
ISO 1996-1	2003	Acoustics – Description, measurement and assessment of environmental noise Part 1: Basic quantities and assessment procedures	-	-
CIGRE Brochure No. 139		Guide to the specification and design evaluation of AC filters for HVDC systems	-	-
CIGRE Report 14-97		Protocol for reporting the operational performance of HVDC transmission systems	-	-

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# TECHNICAL REPORT

**IEC  
TR  
60919-1**

Second edition  
2005-03

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## **Performance of high-voltage direct current (HVDC) systems with line-commutated converters –**

### **Part 1: Steady-state conditions**

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

—————

**PERFORMANCE OF HIGH-VOLTAGE DIRECT CURRENT  
(HVDC) SYSTEMS WITH LINE-COMMUTATED CONVERTERS –**
**Part 1: Steady-state conditions**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60919-1, which is a technical report, has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition, published in 1988, and constitutes a technical revision.

This edition includes the following main changes with respect to the previous edition:

- a) this report concerns only line-commutated converters;
- b) significant changes have been made to the control system technology;

- c) some environmental constraints, for example audible noise limits, have been added;
- d) the capacitor coupled converters (CCC) and controlled series capacitor converters (CSCC) have been included.

The text of this technical report is based on the following documents:

Enquiry Draft	Report on voting
22F/95A/DTR	22F/104/RVC

Full information on the voting for the approval of this technical report 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 60919 consists of the following parts, under the general title: *Performance of high-voltage direct current (HVDC) systems with line-commutated converters*:

Part 1: Steady-state conditions

Part 2: Faults and switching

Part 3: Dynamic conditions

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date<sup>1</sup> 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; [SIST-TP CLC/TR 60919-1:2007](https://standards.iteh.ai/catalog/standards/sist/9e55f514-ce70-4ef6-b4bc-b2045ae40a88/sist-tp-clc-tr-60919-1-2007)
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- replaced by a revised edition, or
- amended.

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

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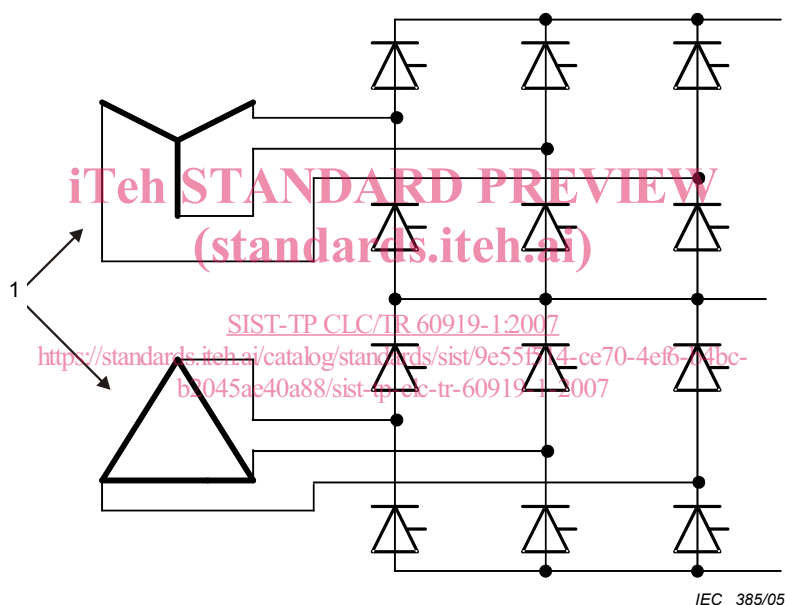
<sup>1</sup> The National Committees are requested to note that for this publication the maintenance result date is 2010.

# PERFORMANCE OF HIGH-VOLTAGE DIRECT CURRENT (HVDC) SYSTEMS WITH LINE-COMMUTATED CONVERTERS –

## Part 1: Steady-state conditions

### 1 Scope

This technical report provides general guidance on the steady-state performance requirements of HVDC systems. It concerns the steady-state performance of two-terminal HVDC systems utilizing 12-pulse converter units comprised of three-phase bridge (double-way) connections (see Figure 1), but it does not cover multi-terminal HVDC transmission systems. Both terminals are assumed to use thyristor valves as the main semiconductor valves and to have power flow capability in both directions. Diode valves are not considered in this report.



**Key**

- 1 Transformer valve windings

**Figure 1 – Twelve-pulse converter unit**

Only line-commutated converters are covered in this report, which includes capacitor commutated converter circuit configurations. General requirements for semiconductor line-commutated converters are given in IEC 60146-1-1, IEC 60146-1-2 and IEC 60146-1-3. Voltage-sourced converters are not considered.

This technical report, which covers steady-state performance, will be followed by additional documents on dynamic performance and transient performance. All three aspects should be considered when preparing two-terminal HVDC system specifications.

The difference between system performance specifications and equipment design specifications for individual components of a system should be realized. Equipment specifications and testing requirements are not defined in this report. Also excluded from this report are detailed seismic performance requirements. In addition, because there are many variations between different possible HVDC systems, this report does not consider these in detail;

consequently, it should not be used directly as a specification for a particular project, but rather to provide the basis for an appropriate specification tailored to fit actual system requirements.

Frequently, performance specifications are prepared as a single package for the two HVDC substations in a particular system. Alternatively, some parts of the HVDC system can be separately specified and purchased. In such cases, due consideration should be given to co-ordination of each part with the overall HVDC system performance objectives and the interface of each with the system should be clearly defined. Typical of such parts, listed in the appropriate order of relative ease for separate treatment and interface definition, are:

- a) d.c. line, electrode line and earth electrode;
- b) telecommunication system;
- c) converter building, foundations and other civil engineering work;
- d) reactive power supply including a.c. shunt capacitor banks, shunt reactors, synchronous and static VAR compensators;
- e) a.c. switchgear;
- f) d.c. switchgear;
- g) auxiliary systems;
- h) a.c. filters;
- i) d.c. filters;
- j) d.c. reactors;
- k) converter transformers;
- l) surge arresters;
- m) series commutation capacitors;
- n) valves and their ancillaries;
- o) control and protection systems.

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NOTE The last four items are the most difficult to separate, and, in fact, separation of these four may be inadvisable.

A complete steady-state performance specification for a HVDC system should consider Clauses 3 to 21 of this report.

Terms and definitions for high-voltage direct current (HVDC) transmission used in this report are given in IEC 60633.

Since the equipment items are usually separately specified and purchased, the HVDC transmission line, earth electrode line and earth electrode (see Clause 10) are included only because of their influence on the HVDC system performance.

For the purpose of this report, an HVDC substation is assumed to consist of one or more converter units installed in a single location together with buildings, reactors, filters, reactive power supply, control, monitoring, protective, measuring and auxiliary equipment. While there is no discussion of a.c. switching substations in this report, a.c. filters and reactive power sources are included, although they may be connected to an a.c. bus separate from the HVDC substation, as discussed in Clause 16.