SLOVENSKI STANDARD
oSIST prEN IEC 60146-1-1:2023

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Polprevodniški pretvorniki - Splošne zahteve in linijsko komutirani pretvorniki - 1-1. del: Specifikacija osnovnih zahtev

Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements

Halbleiter-Stromrichter - Allgemeine Anforderungen und netzgeführte Stromrichter - Teil 1-1: Festlegung der Grundanforderungen

Convertisseurs à semiconducteurs - Exigences générales et convertisseurs commutés par le réseau - Partie 1-1: Spécification des exigences de base

Ta slovenski standard je istoveten z: **prEN IEC 60146-1-1:2022**

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SECRETARIAT: Switzerland	SECRETARY: Ms Chuanhong Zhao
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 14, TC 26, TC 27, SC 32B, SC 77A, ACEC	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	
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TITLE:

Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR CONVERTERS – GENERAL REQUIREMENTS AND LINE COMMUTATED CONVERTERS –

Part 1-1: Specification of basic requirements

FOREWORD

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International Standard IEC 60146-1-1 has been prepared by IEC technical committee 22: Power electronic systems and equipment.

This fifth edition cancels and replaces the fourth edition published in 2009. This fifth edition constitutes a technical revision.

This fifth edition introduces four main changes:

a) re-edition of the whole standard according to the current directives;
b) deletion of safety-related descriptions considering coordination with IEC 62477 series;
c) changes of calculation methods of inductive voltage regulation;
d) changes considering coordination with IEC 61378 series;

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

FDIS	Report on voting
to be determined	to be determined

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.

The main purposes of the IEC 60146-1 series are as follows.

Part 1-1, IEC 60146-1-1, Specification of basic requirements:

– to establish basic terms and definitions;
– to specify service conditions which influence the basis of rating;
– to specify test requirements for electronic power converters and assemblies, standard design, (for special design, see IEC TR 60146-1-2);
– to specify basic performance requirements;
– to give application oriented requirements for semiconductor power converters.

Part 1-2, IEC TR 60146-1-2, Application guideline:

– to give additional information on test conditions and components (for example: semiconductor valve devices), when required for their use in semiconductor power converters, in addition to or as a modification on existing standards;
– to provide useful reference, calculation factors, formulae and diagrams pertaining to power converter practice.

A list of all parts of the IEC 60146 series, under the general title: *Semiconductor converters*, can be found on the IEC website.

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.

SEMICONDUCTOR CONVERTERS – GENERAL REQUIREMENTS AND LINE COMMUTATED CONVERTERS –

Part 1-1: Specification of basic requirements

1 Scope

This International Standard specifies the requirements for the performance of all semiconductor power converters and semiconductor power switches using controllable and/or non-controllable electronic valve devices.

The electronic valve devices mainly comprise semiconductor devices, either not controllable (i.e. rectifier diodes) or controllable (i.e. thyristors, triacs, turn-off thyristors and power transistors). The controllable devices can be reverse blocking or reverse conducting and controlled by means of current, voltage or light. Non-bistable devices are assumed to be operated in the switched mode.

This standard is primarily intended to specify the basic requirements for converters in general and the requirements applicable to line commutated converters for conversion of AC power to DC power or vice versa. Parts of this standard are also applicable to other types of electronic power converter provided that they do not have their own product standards.

These specific equipment requirements are applicable to semiconductor power converters that either implement power conversion or use commutation (for example semiconductor self-commutated converters) or involve particular applications (for example semiconductor converters for DC motor drives) or include a combination of said characteristics (for example direct DC converters for electric rolling stock).

This standard is applicable to all power converters not covered by a dedicated product standard, or if special features are not covered by the dedicated product standard. Generally dedicated product standards for power converters should refer to this International Standard.

NOTE 1 This standard is not intended to define EMC requirements. It covers all phenomena and therefore introduces references to dedicated standards which are applicable according to their scope.

NOTE 2 For the information on converter transformers, related to this International Standard, see IEC 61378-1.

2 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 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60050-551:1998, *International Electrotechnical Vocabulary – Part 551: Power electronics*

IEC 60050-551-20:2001, *International Electrotechnical Vocabulary – Part 551-20: Power electronics – Harmonic analysis*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment with input current ≤ 16 A per phase)*

IEC 61000-3-12:2011, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase*

IEC 61000-4-7, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment - Part 1: General*

IEC 62477-2:2018, *Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC*

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:

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

In this standard, IEV definitions are used wherever possible, particularly those in IEC 60050-551 and IEC 60050-551-20.

All the terms listed in this clause are not necessarily used in this International Standard, however they are necessary to establish a common understanding in the application of semiconductor converters.

The policy adopted is as follows:

a) when an existing IEV definition needs amplification or additional information, the title, the reference and the additional text are given;

b) explanations and figures are given in 4.2;

c) terms used in connection with converter faults are defined in IEC TR 60146-1-2.

3.1 Semiconductor devices and combinations

3.1.1
semiconductor device
device, the essential electric characteristics of which are due to the flow of charge carriers within one or more semiconductor materials

[IEV 151-13-63]

3.1.2
electronic (power) switch
an operative unit for electronic power switching comprising at least one controllable valve device

[IEV 551-13-01]

3.1.3
semiconductor switch
an electronic power switch with semiconductor valve devices

[IEV 551-13-05]

Note 1 to entry: Similar terms are used for electronic switches or power controllers with specific electronic valve devices, for example thyristor controller, transistor switch.

3.1.4
non-controllable valve device
rectifier diode
a reverse blocking valve device the current path of which conducts in its conducting direction without any control signal being applied

[IEV 551-14-04]

3.1.5
thyristor
bi-stable semiconductor device comprising three or more junctions which can be switched from the off-state to the on-state or vice versa

[IEV 521-04-61]

Note 1 to entry: Devices having only three layers but having switching characteristics similar to those of four layers thyristors may also be called thyristors.

Note 2 to entry: The term "thyristor" is used as a generic term to cover the whole range of PNPN type devices. It may be used by itself for any member of the thyristor family when such use does not result in ambiguity or misunderstanding. In particular, the term "thyristor" is widely used for reverse blocking triode thyristor, formerly called "silicon controlled rectifier".

3.1.6
reverse blocking triode thyristor
three-terminal thyristor which for negative anode voltage does not switch, but exhibits a reverse blocking state

[IEV 521-04-63]

3.1.7
reverse conducting triode thyristor
three-terminal thyristor which for negative anode voltage does not switch and conducts large currents at voltages comparable in magnitude to the forward on-state voltage

[IEV 521-04-65]

3.1.8
bidirectional triode thyristor
triac
three-terminal thyristor having substantially the same switching behaviour in the first and third quadrants of the current-voltage characteristic

[IEV 521-04-67, modified]

3.1.9
turn-off thyristor
GTO
thyristor which can be switched from the on-state to the off-state and vice versa by applying control signals of appropriate polarity to the gate terminal

[IEV 521-04-68]

Note 1 to entry: Also known as gate turn-off thyristor.

3.1.10
power transistor
transistor designed for switching from the on-state to the off-state and vice versa by applying control signals of appropriate polarity to the base or gate terminal

Note 1 to entry: The structure of the device intrinsically provides the capability of amplification (see IEV 521-04-46)

Note 2 to entry: Different technologies of power transistors are used such as bipolar transistors, insulated gate bipolar transistors (IGBT), metal-oxide-semiconductor field-effect transistors, (MOSFET) etc.

3.1.11
valve device stack
a single structure of one or more electronic valve devices with its (their) associated mounting(s) and auxiliaries if any

[IEV 551-14-12]

3.1.12
valve device assembly
an electrically and mechanically combined assembly of electronic valve devices or stacks, complete with all its connections and auxiliaries in its own mechanical structure

Note 1 to entry: Similar terms are applied to stacks or assemblies comprising specific electronic valve devices, for example diode stack (rectifier diodes only), thyristor assembly (thyristors only or in combination with rectifier diodes).

[IEV 551-14-13]

3.1.13
electronic valve device
an indivisible electronic device for electronic power conversion or electronic power switching, comprising a non-controllable or bistably controlled unidirectionally conducting current path

[IEV 551-14-02]

3.1.14
semiconductor valve device
an electronic valve device which is a semiconductor device

[IEV 551-14-09]

Note 1 to entry: Typical semiconductor valve devices are thyristors, rectifier diodes, bipolar transistors, metal-oxide-semiconductor field-effect transistors (MOSFET) and insulated-gate bipolar transistors (IGBT).

Note 2 to entry: Two or more semiconductor valve devices may be integrated on a common semiconductor chip (examples: a thyristor and a rectifier diode in a reverse conducting thyristor, a power switching field effect transistor with its reverse diode) or packaged in a common case (semiconductor power module). These combinations are considered as separate semiconductor valve devices.

3.1.15
(electronic) (power) conversion
change of one or more of the characteristics of an electric power system essentially without appreciable loss of power by means of electronic valve devices

[IEV 551-11-02]

Note 1 to entry: Characteristics include, for example, voltage amplitude, number of phases and frequency, including zero frequency.

3.1.16
(electronic) (power) converter
an operative unit for electronic power conversion, comprising one or more electronic valve devices, and auxiliaries if any

[IEV 551-12-01, modified]

Note 1 to entry: Converter transformers and filters related to network interfacing in terms of electrical characteristics are excluded from the converter itself. Such devices are part of the system aspect. Any device necessary to the correct operation of the converter itself are included in the converter, for example filters for limitation of the d*u*/d*t* applied to the valve devices, surge arrestors, etc. Any auxiliary necessary to the correct operation of the converter itself are included in the converter, for example fans or cooling system.

3.1.17
trigger equipment
gating equipment
equipment which provides suitable trigger pulses from a control signal for controllable valve devices in a converter or power switch including timing or phase shifting circuits, pulse generating circuits and usually power supply circuits

3.1.18
system control equipment
equipment associated with a power conversion equipment or system which performs automatic adjustment of the converter output characteristics as a function of a controlled quantity (for example motor speed, traction force, etc.)

3.1.19
semiconductor converter
an electronic power converter with semiconductor valve devices

[IEV 551-12-42]

Note 1 to entry: Similar terms for converters in general or for specific kinds of converters or for converters with other or specific valve devices, for example thyristor converter, transistor inverter.

3.1.20
power conversion equipment
PCE
equipment including the electronic power converter and auxiliaries necessary for operation of the converter itself, or even other parts dedicated to the application and where these parts cannot be physically separated without preventing the operation of the converter

3.1.21
power conversion system
system consisting of a power conversion equipment and associated components for the application for example switchgear, reactors or transformers, dedicated filters, etc.

3.2 Arms and connections

3.2.1
(valve) arm
a part of the circuit of an electronic power converter or switch bounded by any two AC or DC terminals and including one or more simultaneously conducting electronic valve devices connected together and other components if any

[IEV 551-15-01]

3.2.2
principal arm
a valve arm involved in the major transfer of power from one side of the converter or electronic switch to the other

[IEV 551-15-02]

3.2.3
auxiliary arm
any valve arm other than a principal arm

Note 1 to entry: Sometimes an auxiliary arm temporarily fulfils more than one of the following functions: by-pass arm, free-wheeling arm, turn-off arm or regenerative arm.

[IEV 551-15-05]

3.2.4
by-pass arm
an auxiliary arm providing a conductive path which allows the current to circulate without an interchange of power between source and load

[IEV 551-15-06]

3.2.5
free-wheeling arm
a by-pass arm containing only non-controllable valve devices

[IEV 551-15-07]

3.2.6
turn-off arm
an auxiliary arm which temporarily takes over the current directly from a conducting valve arm, consisting of one or more latching valve devices which cannot be turned off by a control signal

[IEV 551-15-08]

3.2.7
regenerative arm
a valve arm which transfers a part of the power from the load side to the source side

[IEV 551-15-09]

3.2.8
converter connection
the electrical arrangement of valve arms and other components essential for the function of the main power circuit of a converter

[IEV 551-15-10]

Note 1 to entry: Common practice also uses the term “topology” of the converter with the same sense.

3.2.9
basic converter connection
the electrical arrangement of principal arms in a converter

[IEV 551-15-11]

3.2.10
single-way connection (of a converter)
a converter connection such that the current through each of the phase terminals of the AC circuit is unidirectional

[IEV 551-15-12]

3.2.11
double-way connection (of a converter)
a converter connection such that the current through each of the phase terminals of the AC circuit is bidirectional

[IEV 551-15-13]

3.2.12
bridge connection
a double-way connection of pairs of arms such that the centre terminals are the phase terminals of the AC circuit, and that the outer terminals of like polarity are connected together and are the DC terminals

[IEV 551-15-14]

3.2.13
uniform connection
a connection with either all principal arms controllable or all principal arms non-controllable

[IEV 551-15-15]

3.2.14
non-uniform connection
a connection with both controllable and non-controllable principal arms

[IEV 551-15-18]

3.2.15
series connection
connection of two-terminal networks so that they form a single path