

# TECHNICAL REPORT

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**Semiconductor converters – General requirements and line commutated converters –  
Part 1-2: Application guide** (standards.iteh.ai)

IEC TR 60146-1-2:2019

<https://standards.iteh.ai/catalog/standards/sist/d969d640-795e-4ff9-a0e2-09b261d3bee6/iec-tr-60146-1-2-2019>



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**SEMICONDUCTOR CONVERTERS –  
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IEC TR 60146-1-2, which is a Technical Report, has been prepared by IEC technical committee 22: Power electronic systems and equipment.

This fifth edition cancels and replaces the fourth edition published in 2011. This edition constitutes a technical revision.

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

- a) addition of annexes concerning the applications of converter transformers and of fuses for overcurrent protection;

- b) changes of calculation methods related the inductive voltage regulation and changes of description on transformer losses to be consistent with the latest transformer standards;
- c) addition and updates of references based on the latest information.

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

Draft T	Report on voting
22/306/DTR	22/310/RVDTR

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

A list of all parts of the IEC 60146 series, under the general title *Semiconductor converters – General requirements and line commutated converters*, 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,
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# SEMICONDUCTOR CONVERTERS – GENERAL REQUIREMENTS AND LINE COMMUTATED CONVERTERS –

## Part 1-2: Application guidelines

### 1 Scope

This part of IEC 60146, which is a Technical Report, gives guidance on variations to the specifications given in IEC 60146-1-1:2009 to enable the specification to be extended in a controlled form for special cases. Background information is also given on technical points, which facilitates the use of IEC 60146-1-1:2009.

This document primarily covers line commutated converters and is not in itself a specification, except as regards certain auxiliary components, in so far as existing standards may not provide the necessary data.

This document will not take precedence on any product specific standard according to the concept shown in IEC Guide 108. IEC Guide 108 provides the information on the relationship between horizontal standards and product publications.

### 2 Normative references

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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 60050-551, *International Electrotechnical Vocabulary – Part 551: Power electronics* (available at [www.electropedia.org](http://www.electropedia.org))

IEC 60050-551-20, *International Electrotechnical Vocabulary – Part 551-20: Power electronics – Harmonic analysis* (available at [www.electropedia.org](http://www.electropedia.org))

IEC 60146-1-1:2009, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-4:2009, *Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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

IEC 61148, *Terminal markings for valve device stacks and assemblies and for power conversion equipment*

IEC 61378-1:2011, *Convertor transformers – Part 1: Transformers for industrial applications*

IEC/IEEE 60076-57-129, *Power transformers – Part 57-129: Transformers for HVDC applications*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60146-1-1:2009, IEC 60050-551, IEC 60050-551-20 and the following 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>

NOTE Several terms from IEC 60146-1-1:2009, IEC 60050-551, IEC 60050-551-20 are repeated here for convenience.

#### 3.1 Terms and definitions related to converter faults

##### 3.1.1 breakthrough

failure by which a controllable valve device or an arm consisting of such devices loses its ability to block voltage during the forward blocking interval

Note 1 to entry: See Figure 1a). Breakthrough can occur in rectifier operation as well as inverter operation and for various reasons, for example excessive junction temperature, voltage surges in excess of rated peak off-state voltage, excessive rate of rise of off-state voltage or spurious gate current.

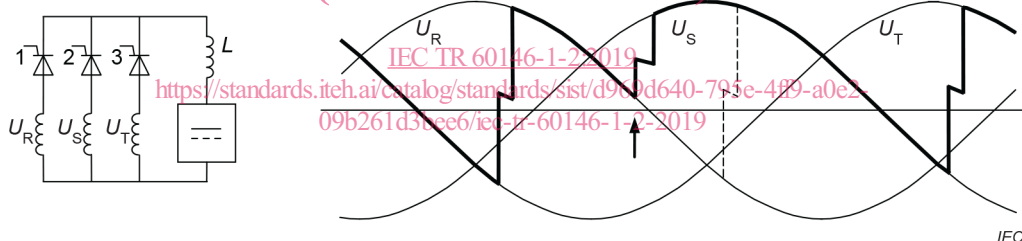


Figure 1a) Breakthrough in arm 2

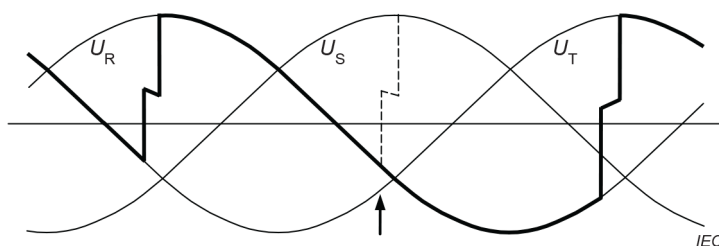


Figure 1b) Firing failure in arm 2

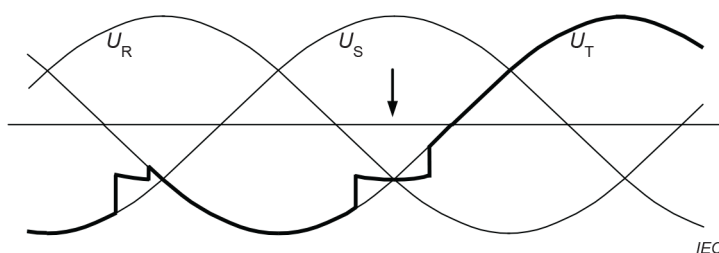


Figure 1c) Conduction through related to arm 3

Figure 1 – Voltages at converter faults

[SOURCE: IEC 60050-551:1998, 551-16-60, modified – Note 1 to entry has been added.]

### 3.1.2 false firing

firing of a latching valve device or an arm consisting of such devices at an incorrect instant

[SOURCE: IEC 60050-551:1998, 551-16-63]

### 3.1.3 breakdown

<of an electronic valve device or of a valve arm> failure that permanently deprives an electronic valve device or a valve arm of its property to block voltage

[SOURCE: IEC 60050-551:1998, 551-16-66]

### 3.1.4 firing failure

failure to achieve conduction in a latching valve device or an arm consisting of such devices during the conduction interval

Note 1 to entry: See Figure 1b).

[SOURCE: IEC 60050-551:1998, 551-16-65, modified – Note 1 to entry has been added.]

### 3.1.5 conduction through

situation where, in inverter operation, a valve arm continues conduction at the end of the normal conduction interval or at the end of the hold-off interval

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Note 1 to entry: See Figure 1c).

[SOURCE: IEC 60050-551:1998, 551-16-64, modified – The definition has been rephrased, and Note 1 to entry has been added.]

### 3.1.6 commutation failure

failure to commute the current from a conducting arm to the succeeding arm

[SOURCE: IEC 60050-551:1998, 551-16-59]

## 3.2 Terms and definitions related to converter generated transients

### 3.2.1 DC side transients

voltage transients produced by rapid changes of the DC voltage applied to the inductance and capacitance of the DC circuit

Note 1 to entry: See 7.4.

### 3.2.2 commutation transients on the line

voltage transients produced on the AC line after commutation

Note 1 to entry: See 7.4.

Note 2 to entry: The commutation transients are repetitive.

### 3.3 Terms and definitions related to temperature

#### 3.3.1

##### thermal resistance

 $R_{th}$ 

quotient of the difference between the virtual junction temperature and the temperature of a specified external reference point, by the steady-state power dissipation in the device under conditions of thermal equilibrium

Note 1 to entry: For most cases, the power dissipation can be assumed to be equal to the heat flow.

#### 3.3.2

##### transient thermal impedance

 $Z_{th}$ 

quotient of

- a) variation of the temperature difference, reached at the end of a time interval between the virtual junction temperature and the temperature of a specified external reference point, and
- b) step function change of power dissipation at the beginning of the same time interval causing the change of temperature

Note 1 to entry: Immediately before the beginning of this time interval, the distribution of temperature should have been constant with time.

Note 2 to entry: Transient thermal impedance is given as a function of the time interval.

#### 3.3.3

##### virtual equivalent junction temperature virtual junction temperature

 $T_j$ 

virtual temperature of the junction of a semiconductor device

Note 1 to entry: The virtual junction temperature is not necessarily the highest temperature in the semiconductor device.

Note 2 to entry: Based on the power dissipation and the thermal resistance or transient thermal impedance that corresponds to the mode of operation, the virtual junction temperature can be calculated using a specified relationship.

[SOURCE: IEC 60050-521:2002, 521-05-15, modified – The symbol  $T_j$  has been added, as well as the notes to entry.]

#### 3.3.4

##### virtual temperature internal equivalent temperature

<of a semiconductor device> theoretical temperature which is based on a simplified representation of the thermal and electrical behaviour of the semiconductor device

[SOURCE: IEC 60050-521:2002, 521-05-14, modified – The notes to entry have been deleted.]

## 4 Application of semiconductor power converters

### 4.1 Application

#### 4.1.1 General

Semiconductor power converters are used in most industries for the conversion of electrical power and also to facilitate the conversion of mechanical, chemical or other energy into electrical power and vice versa.

They also used in electrical power utilities for the supply source conditioning.