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TECHNICAL REPORT

Semiconductor converters – General requirements and line commutated converters –
Part 1-2: Application guide

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 1-2: Application guide

FOREWORD

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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 fourth edition cancels and replaces the third edition published in 1991. This fourth edition constitutes a technical revision.

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

a) re-edition of the whole document according to the current Directives;
b) correction of some errors.

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

Enquiry draft	Report on voting
22/170/DTR	22/173/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.

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 publication will remain unchanged until the stability 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- withdrawn,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.

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

SEMICONDUCTOR CONVERTERS – GENERAL REQUIREMENTS AND LINE COMMUTATED CONVERTERS –

Part 1-2: Application guide

1 Scope

This part of IEC 60146 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 should facilitate the use of IEC 60146-1-1:2009.

This technical report 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.

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 60050-521:2002, *International Electrotechnical Vocabulary – Part 521: Semiconductor devices and integrated circuits*

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

IEC 60146-1-3:1991, *Semiconductor converters – General requirements and line commutated converters Part 1-3: Transformers and reactors*

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

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

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, several of which are repeated here for convenience, and the following apply.

3.1 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

[IEC 60050-551:1998, 551-16-60]

NOTE 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.

3.1.2
false firing
firing of a latching valve device or an arm consisting of such devices at an incorrect instant

[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

[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

[IEC 60050-551:1998, 551-16-65]

NOTE See Figure 1b)

3.1.5
conduction through
in inverter operation, the situation that a valve arm continues conduction at the end of the normal conduction interval or at the end of the hold-off interval

[IEC 60050-551:1998, 551-16-64]

NOTE See Figure 1c)

3.1.6
commutation failure
failure to commutate the current from a conducting arm to the succeeding arm

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

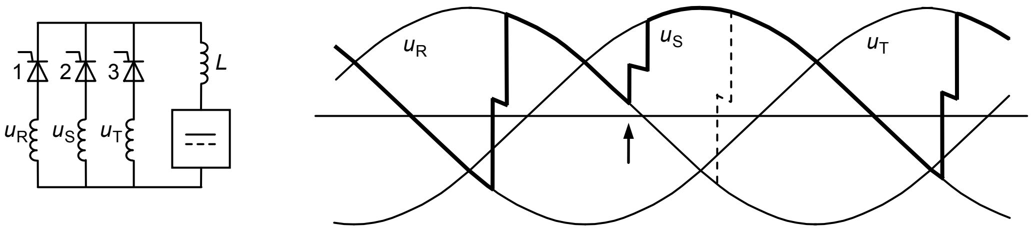

Figure 1a) Breakthrough in arm 2 *IEC 2983/10*

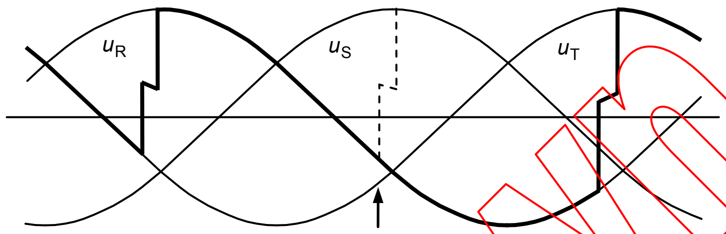

Figure 1b) Firing failure in arm 2 *IEC 2984/10*

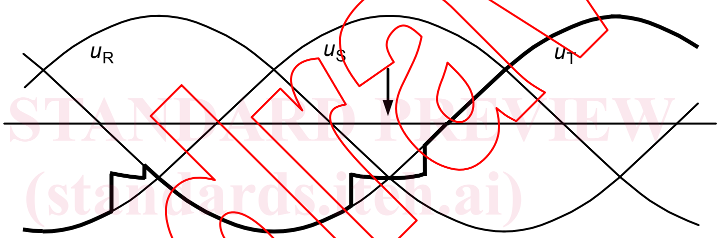

Figure 1c) Conduction through related to arm 3

IEC 2985/10

Figure 1 – Voltages at converter faults

3.2 Definitions related to converter generated transients

3.2.1
d.c. side transients
voltage transients produced by rapid changes of the d.c. voltage applied to the inductance and capacitance of the d.c. circuit

NOTE See 7.4

3.2.2
commutation transients on the line (repetitive transient)
voltage transients produced on the a.c. line after commutation

NOTE See 7.4

3.3 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

[IEC 60050-521:2002, 521-05-13, modified]

NOTE 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. Immediately before the beginning of this time interval, the distribution of temperature should have been constant with time.

NOTE Transient thermal impedance is given as a function of the time interval.

3.3.3
virtual (equivalent) junction temperature
T_j
virtual temperature of the junction of a semiconductor device

[IEC 60050-521:2002, 521-05-15]

NOTE 1 The virtual junction temperature is not necessarily the highest temperature in the semiconductor device.

NOTE 2 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.

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

[IEC 60050-521:2002, 521-05-14]

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.

4.1.2 Conversion equipment and systems

Examples of applications of conversion equipment and systems are as follows, and not limited in these applications.

a) D.C. load, stabilized/adjustable voltage/current control;

b) A.C. power controllers (a.c. or d.c. output);

c) A.C. variable frequency:

– line-commutated converters;

- slip energy recovery;
- machine-commutated converters;
- self-commutated converters:
  - voltage stiff (voltage source);
  - current stiff (current source);

d) Adjustable speed drives (covered by specific IEC standards, e.g. IEC 61800-1);

e) Uninterruptible power systems (UPS, covered by specific IEC standards, e.g. IEC 62040-3)

f) Chemical processes (electrolysis, electroplating, electrophoresis);

g) Computer power supplies;

h) Traction substations, railways, tramways, mines, electric vehicles;

i) Telephone power supplies;

j) Electromagnets, field supplies;

k) Radio transmitter d.c. supplies;

l) Arc furnace d.c. power supplies;

m) Solar photovoltaic energy conversion.

4.1.3 Supply source conditioning (active and reactive power)

Examples of supply source conditioning are as follows.

a) HV or MV systems (transmission and distribution, reactive power compensation);

b) LV systems (energy saving);

c) Isolated, standby or dispersed generating plants;

d) D.C. or a.c. supplies particularly from solar, wind or chemical energy.

NOTE Some of the applications listed above are the subject of particular IEC Publications now existing or in preparation.

4.2 Equipment specification data

4.2.1 Main items on the specification

See 6.6.2 of IEC 60146-1-1:2009: Rating plate.

4.2.2 Terminal markings

See IEC 61148.

4.2.3 Additional information

4.2.3.1 General

In addition to the essential data such as should appear on the rating plate as specified in IEC 60146-1-1:2009, the following list may prevent other important information being omitted from the specification, concerning the purchaser's requirements or the supplier's product.

4.2.3.2 Supply source

The following information is necessary to confirm the supply source conditions.

a) Voltage and frequency (if applicable); Range of rated values, unbalance, short time outage;

b) Short-circuit power (or description of cables, lines and transformers): minimum, statistical average, maximum values;