



BSI Standards Publication

Semiconductor devices

Part 6: Discrete devices — Thyristors

National foreword

This British Standard is the UK implementation of IEC 60747-6:2025. It supersedes BS IEC 60747-6:2016, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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© The British Standards Institution 2025
Published by BSI Standards Limited 2025

ISBN 978 0 539 21166 5

ICS 31.080.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2025.

Amendments/corrigenda issued since publication

Date	Text affected



IEC 60747-6

Edition 4.0 2025-09

INTERNATIONAL STANDARD

**Semiconductor devices -
Part 6: Discrete devices - Thyristors**

ICS 31.080.20

ISBN 978 2-8327-0705-0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Semiconductor devices -
Part 6: Discrete devices - Thyristors**

FOREWORD

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IEC 60747-6 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2016. This edition constitutes a technical revision.

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

- a) the terms and definitions for partial thermal resistance junction-to-case and voltages related to ratings and characteristics (properties) have been added;
- b) Clauses 3, 4, 5, 6 and 7 were amended with some deletions of information no longer in use and with some necessary additions.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47E/863/FDIS	47E/865/RVD

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 International Standard 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.

This International Standard is to be used in conjunction with IEC 60747-1:2006 and its Amendment 1:2010.

A list of all parts in the IEC 60747 series, published under the general title *Semiconductor devices*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

1 Scope

This part of IEC 60747 specifies product specific standards for terminology, letter symbols, essential ratings and characteristics (properties), measuring and test methods, requirements for type tests, routine tests, endurance tests and marking for the following discrete semiconductor devices:

- reverse blocking triode thyristors;
- reverse conducting (triode) thyristors;
- bidirectional triode thyristors (triacs);
- turn-off thyristors.

If no ambiguity is likely to result, any of the above will be referred to as thyristors.

2 Normative references

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 60050-521, *International Electrotechnical Vocabulary (IEV) - Part 521: Semiconductor devices and integrated circuits*, available at <http://www.electropedia.org>

IEC 60747-1:2006, *Semiconductor devices - Part 1: General*
IEC 60747-1:2006/AMD1:2010

IEC 60749-23, *Semiconductor devices - Mechanical and climatic test methods - Part 23: High temperature operating life*

IEC 60749-25, *Semiconductor devices - Mechanical and climatic test methods - Part 25: Temperature cycling*

IEC 60749-34, *Semiconductor devices - Mechanical and climatic test methods - Part 34: Power cycling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60747-1, in IEC 60050-521 and the following 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 General

3.1.1

reverse blocking triode thyristor

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

Note 1 to entry: The P-gate thyristor (see IEC 60050-521:2002, 521-04-69) and the N-gate thyristor (see IEC 60050-521:2002, 521-04-70) are two kinds of reverse blocking triode thyristors.

[SOURCE: IEC 60050-521:2002, 521-04-63, modified – Note 1 to entry has been added.]

3.1.2

bidirectional triode thyristor

triac

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

[SOURCE: IEC 60050-521:2002, 521-04-67]

3.1.3

turn-off thyristor

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

EXAMPLE Gate turn-off thyristor (GTO), gate-commutated thyristor (GCT) and integrated gate-commutated thyristor (IGCT).

[SOURCE: IEC 60050-521:2002, 521-04-68, modified – The example has been added.]

3.1.4

reverse conducting triode thyristor

three-terminal thyristor that conducts large currents in the reverse direction at reverse voltages comparable in magnitude to the forward on-state voltage

[SOURCE: IEC 60050-521:2002, 521-04-65, modified – The wording “which for negative anode voltage does not switch and” has been deleted and the words “at voltages” replaced with “in the reverse direction at reverse voltages”.]

3.2 Principal voltages

3.2.1

repetitive peak reverse voltage

V_{RRM}

maximum instantaneous value of the reverse voltage, including all repetitive transient voltages, but excluding all non-repetitive transient voltages

Note 1 to entry: The repetitive voltage is usually a function of the circuit and increases the power loss of the device. A non-repetitive transient voltage is usually due to an external cause, and it is assumed that its effect has completely disappeared before the next transient arrives.

3.2.2

non-repetitive peak reverse voltage

peak transient reverse voltage

V_{RSM}

maximum instantaneous value of any non-repetitive transient reverse voltage

Note 1 to entry: The repetitive voltage is usually a function of the circuit and increases the power loss of the device. A non-repetitive transient voltage is usually due to an external cause, and it is assumed that its effect has completely disappeared before the next transient arrives.

3.2.3**off-state voltage** V_D

anode, principal or thyristor voltage while the thyristor is in the off state

3.2.4**repetitive peak off-state voltage** V_{DRM}

maximum instantaneous value of the off-state voltage, including all repetitive transient voltages, but excluding all non-repetitive transient voltages

Note 1 to entry: The repetitive voltage is usually a function of the circuit and increases the power loss of the device. A non-repetitive transient voltage is usually due to an external cause, and it is assumed that its effect has completely disappeared before the next transient arrives.

3.2.5**non-repetitive peak off-state voltage**

peak transient off-state voltage

 V_{DSM}

maximum instantaneous value of any non-repetitive transient off-state voltage

Note 1 to entry: The repetitive voltage is usually a function of the circuit and increases the power loss of the device. A non-repetitive transient voltage is usually due to an external cause, and it is assumed that its effect has completely disappeared before the next transient arrives.

3.2.6**direct off-state voltage** $V_{D(D)}$

off-state voltage that is independent of time or in which the changes are so small that they can be neglected

3.2.7**on-state voltage** V_T

anode, principal or thyristor voltage which results from the flow of current while the thyristor is in the on state

3.2.8**peak on-state voltage** V_{TM}

anode, principal or thyristor voltage which results from the specified peak on-state current

3.2.9**critical rate of rise of commutating voltage** $dv_{(com)}/dt_{cr}$

<reverse conducting triode thyristor> maximum value of the rate of rise of off-state voltage, immediately following reverse current conduction, that will not cause switching from the off state to the on state

Note 1 to entry: The measuring method for the rate of rise of commutating voltage is to be specified.

Note 2 to entry: If no ambiguity is likely to result, the shorter expression of the letter symbol " $dv_{(com)}/dt$ " may be used.

3.2.10**critical rate of rise of commutating voltage**

critical rate of rise of re-applied off-state voltage

$$dv_{(com)}/dt_{cr}$$

<bidirectional triode thyristor> maximum value of the rate of rise of off-state voltage, immediately following on-state current conduction in the opposite direction, that will not cause switching from the off state to the on state

Note 1 to entry: The measuring method for the rate of rise of commutating voltage is to be specified.

Note 2 to entry: If no ambiguity is likely to result, the shorter expression of the letter symbol " $dv_{(com)}/dt$ " may be used.

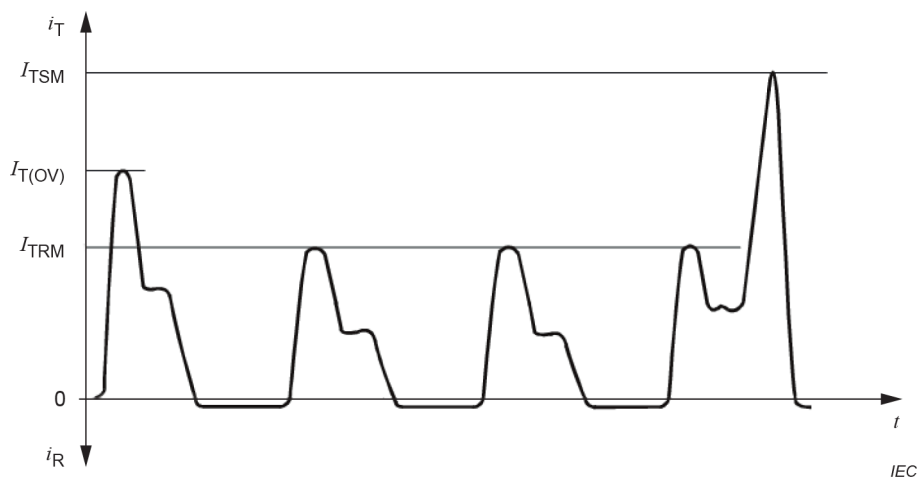
3.3 Principal currents**3.3.1****non-repetitive surge on-state current**

$$I_{TSM}$$

on-state current pulse with short duration and specified waveform

SEE: Figure 1.

Note 1 to entry: Occurrence of the non-repetitive surge on-state current causes or would cause the maximum rated virtual junction temperature to be exceeded, but which is assumed to occur rarely and with a limited number of such occurrences during the service life of the device and to be a consequence of unusual circuit conditions (e.g., a fault).

**Figure 1 – Peak values of on-state currents****3.3.2** **I^2t value**

integral of the square of non-repetitive surge on-state current over the duration of the current surge

3.3.3**repetitive peak on-state current**

$$I_{TRM}$$

peak value of the on-state current, including all repetitive transient currents

SEE: Figure 1.

3.3.4 overload on-state current

$I_{T(OV)}$

on-state current whose continuous application would cause the maximum rated virtual junction temperature to be exceeded

SEE: Figure 1.

3.3.5 overload reverse conducting current

$I_{RC(OV)}$

<reverse conducting triode thyristor> reverse conducting current whose continuous application would cause the maximum rated virtual junction temperature to be exceeded

3.3.6 non-repetitive surge reverse current

I_{RCSM}

<reverse conducting triode thyristor> non-repetitive peak reverse current pulse with short duration and specified waveform

3.3.7 tail current

i_z

<turn-off thyristor> anode current flowing during the tail time

Note 1 to entry: Refer to 3.6.4.

3.3.8 peak tail current

I_{zM}

<turn-off thyristor> peak value of the tail current that occurs shortly after the beginning of the tail time

Note 1 to entry: Refer to 3.6.4.

3.3.9 peak case non-rupture current

I_{RSMC}

peak value of reverse current that will not cause bursting of the case or the emission of a plasma beam under specified conditions, waveform and duration of the current as well as temperature

Note 1 to entry: This definition implies that a fine crack in the case could also be found in a device subjected to the peak case non-rupture current, provided that no plasma beam was emitted. Parts of the case shall not break away, nor shall the device melt externally or burst into flames.

3.4 Gate voltages and currents

3.4.1 on-state gate bias current

I_{FGB}

forward gate current flowing after the thyristor has been turned on

3.4.2 sustaining gate current

I_{FGsus}

<turn-off thyristor> minimum forward gate current required ensuring that, if the anode current drops below the value required to maintain all the subdivided cathode areas in conduction, they will all return to conduction when the anode current is increased again

3.4.3**off-state gate bias voltage** V_{RGB}

<turn-off thyristor> reverse gate voltage applied after the thyristor has been turned off

3.4.4**turn-off gate voltage** V_{RGQ}

<turn-off thyristor> reverse gate voltage during the time interval within which the thyristor is turning off

3.4.5**turn-off gate current** I_{RGQ}

<turn-off thyristor> reverse gate current during the time interval within which thyristor is turning off

3.4.6**peak turn-off gate voltage** V_{RGQM}

<turn-off thyristor> peak value of the turn-off gate voltage at the end of its rapid rise after the peak turn-off gate current has been reached

3.4.7**peak turn-off gate current** I_{RGQM}

<turn-off thyristor> peak value of the reverse gate current reached at the end of its rapid rise in the beginning of the turn off process

Note 1 to entry: Specifications refer to the minimum value of the peak turn-off gate current that the gate turn-off pulse source is capable of supplying as a function of the peak on-state current to be switched off under specified conditions.

3.4.8**turn-off gate bias voltage** V_{RGQB}

<turn-off thyristor> essentially constant value of the turn-off gate voltage that occurs towards the end of the turn off process, in the case where the gate control circuit supports this process by maintaining the turn-off gate voltage at a value that is higher than the off-state gate bias voltage

3.4.9**turn-off gate bias current** I_{RGQB}

<turn-off thyristor> reverse gate current associated with the turn-off gate bias voltage

3.5 Power and energy dissipation

NOTE All definitions are written in terms of triode thyristors. Where appropriate, they apply also to diode thyristors.

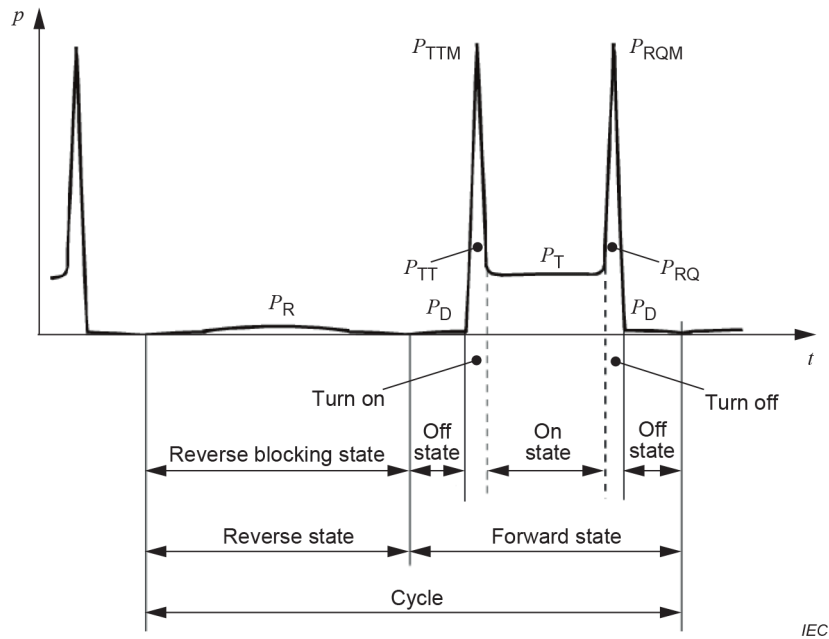
All definitions for power and power dissipation refer, if not otherwise specified, to the product of anode or principal current and anode or principal voltage. The definitions are general. It is not considered that the beginning and ending of the particular time interval are necessary to be identified in order to make specifications for the derived characteristics "average partial power dissipation" and "partial energy dissipation" meaningful. However, guidance for the specification of these time intervals is given in the relevant notes.

3.5.1 Instantaneous power in a whole period of cycle

3.5.1.1 reverse power
 P_R

power while the thyristor is in the reverse blocking state

Note 1 to entry: If not otherwise specified, the term refers to the power in the time interval between the ending of the turn-off time and the change from the reverse blocking state to the off state (either $I = 0$ or $V = 0$) (see Figure 2).



Key

P_D	off-state power	P_T	on-state power
P_{RQ}	turn-off power	P_{TT}	turn-on power
P_R	reverse power		

Figure 2 – Partial power (dissipation) of reverse blocking triode thyristor in a whole period of cycle

3.5.1.2 off-state power
 P_D

power while the thyristor is in the off state

Note 1 to entry: If not otherwise specified, the term refers to the power generated during the time interval between the crossing of the origin from the reverse blocking (or conducting) state to the off state (either $I = 0$ or $V = 0$) and the beginning of the turn-on time and, in addition, during the time interval between the ending of the turn-off time and the crossing of the origin from the off state to the reverse blocking (or conducting) state.

3.5.1.3 on-state power
 P_T

power while the thyristor is in the on state

Note 1 to entry: If not otherwise specified, the term refers to the power in the time intervals between the ending of the turn-on time and the beginning of the turn-off time.

3.5.1.4**turn-on power** P_{TT}

power in the time interval during which the thyristor is turning on

Note 1 to entry: If not otherwise specified, the corresponding time interval is the turn-on time.

3.5.1.5**turn-off power** P_{RQ}

power in the time interval during which the thyristor is turning off

Note 1 to entry: If not otherwise specified, the corresponding time interval is the turn-off time.

Note 2 to entry: For turn-off thyristors, the letter symbol P_{RQ} is replaced with P_{DQ} .**3.5.1.6****reverse conducting power** P_{RC}

<reverse conducting triode thyristor> power while the thyristor is in the reverse conducting state

Note 1 to entry: If not otherwise specified, the term refers to the power in the time interval between the ending of the turn-off time and the change from the reverse conducting state to the off state (either $I = 0$ or $V = 0$).**3.5.2 Average power dissipation****3.5.2.1****average partial power dissipation**

average value of the instantaneous power dissipation in a particular time interval of the cycle, averaged over a whole period of cycle

3.5.2.2**average total power dissipation** $P_{\text{tot(AV)}}$

sum of all average partial power dissipation and the average gate power dissipation, in a whole period of cycle

Note 1 to entry: The average total power dissipation can be expressed as Formula (1):

$$P_{\text{tot(AV)}} = P_{T(\text{AV})} + P_{\text{add(AV)}} + P_{G(\text{AV})} \quad (1)$$

where

 $P_{T(\text{AV})}$ is the average on-state power dissipation; $P_{\text{add(AV)}}$ is the average additional power dissipation; $P_{G(\text{AV})}$ is the average gate power dissipation.**3.5.2.3****average on-state power dissipation** $P_{T(\text{AV})}$

average partial power dissipation resulting from the on-state power

3.5.2.4 average additional power dissipation

$P_{\text{add(AV)}}$

sum of all power dissipation except on-state power dissipation and gate power dissipation

Note 1 to entry: The average additional power dissipation can be expressed as Formula (2):

$$P_{\text{add(AV)}} = P_{\text{TT(AV)}} + P_{\text{RQ(AV)}} + P_{\text{D(AV)}} + P_{\text{R(AV)}} \quad (2)$$

where

$P_{\text{TT(AV)}}$ is the average turn-on power dissipation;

$P_{\text{RQ(AV)}}$ is the average turn-off power dissipation;

$P_{\text{D(AV)}}$ is the average off-state power dissipation;

$P_{\text{R(AV)}}$ is the average reverse power dissipation.

Note 2 to entry: For turn-off thyristors, the letter symbol $P_{\text{RQ(AV)}}$ is replaced with $P_{\text{DQ(AV)}}$.

3.5.2.5 average turn-on power dissipation

$P_{\text{TT(AV)}}$

average partial power dissipation resulting from the turn-on power

3.5.2.6 average turn-off power dissipation

$P_{\text{RQ(AV)}}$

average partial power dissipation resulting from the turn-off power

Note 1 to entry: For turn-off thyristors, the letter symbol $P_{\text{RQ(AV)}}$ is replaced with $P_{\text{DQ(AV)}}$.

3.5.2.7 average off-state power dissipation

$P_{\text{D(AV)}}$

average partial power dissipation resulting from the off-state power

3.5.2.8 average reverse power dissipation

$P_{\text{R(AV)}}$

average partial power dissipation resulting from the reverse power

3.5.2.9 average gate power dissipation

$P_{\text{G(AV)}}$

gate power dissipation averaged over a whole period of cycle

3.5.2.10 partial thermal resistance junction to case at anode side

$R_{\text{th(j-c)A}}$

thermal resistance between the junction and the anode side of the case

3.5.2.11
partial thermal resistance junction to case at cathode side

$R_{th(j-c)K}$

thermal resistance between the junction and the cathode side of the case

3.5.3 Energy dissipation

3.5.3.1
dynamic on-state energy dissipation

E_T

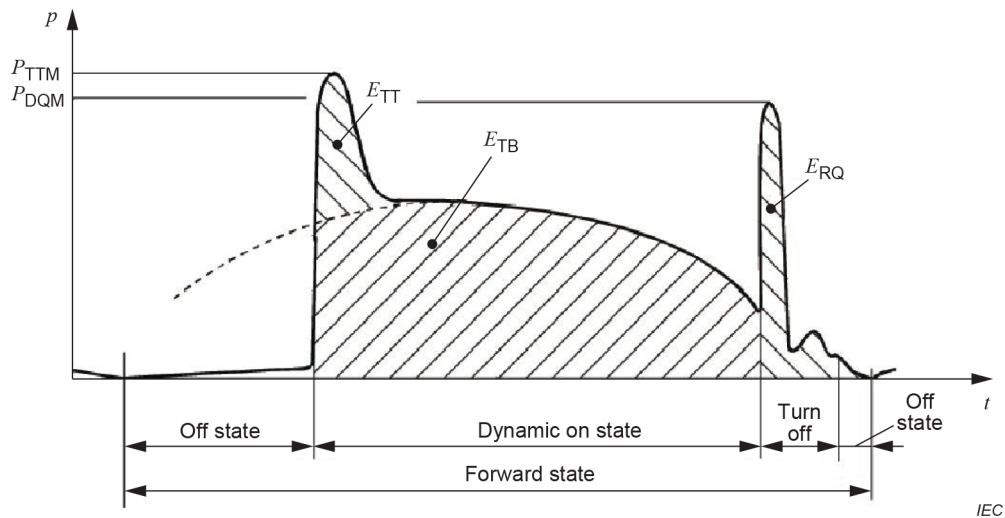
total energy dissipation from the instant when the rising on-state current reaches a specified low value to the instant that defines the beginning of the turn-off time

3.5.3.2
basic on-state energy dissipation

E_{TB}

energy dissipation resulting from the flow of on-state current when the thyristor is fully turned on during the entire on-state period

Note 1 to entry: This energy dissipation can only be determined by calculations based on the observed waveform of the current. The calculation method is to be specified (see Figure 3).



Key

- E_{RQ} turn-off energy dissipation
- $E_T = E_{TB} + E_{TT}$ dynamic (total) on-state energy dissipation
- E_{TB} basic on-state energy dissipation
- E_{TT} additional turn-on energy dissipation

Figure 3 – Components of dynamic on-state energy dissipation of reverse blocking triode thyristor in forward state

3.5.3.3 additional turn-on energy dissipation

E_{TT}

calculated difference between the dynamic on-state energy dissipation and the basic on-state energy dissipation

Note 1 to entry: The additional turn-on energy dissipation can be expressed as Formula (3):

$$E_{TT} = E_T - E_{TB} \quad (3)$$

3.5.3.4 turn-off energy dissipation

E_{RQ}

energy dissipation during the turn-off time

Note 1 to entry: For turn-off thyristors, the letter symbol E_{RQ} is replaced with E_{DQ} .

3.6 On-state, recovery and other characteristics

3.6.1 On-state characteristics

3.6.1.1 on-state slope resistance

R_T

value of the resistance calculated from the slope of the straight-line approximation of the on-state characteristic that crosses this characteristic at two specified points

3.6.1.2 on-state threshold voltage

$V_{T(TO)}$

$V_{(TO)}$

value of the on-state voltage obtained at the intersection of its straight-line approximation with the voltage axis

3.6.2 Recovery times

3.6.2.1 reverse recovery time

t_{rr}

<reverse blocking triode thyristor> time interval between

- the instant when the current passes through zero while changing from the on state to the reverse blocking state, and
- the instant when either the reverse current reaches a specified low value which may be zero during reducing from its peak value I_{rrm} , or the extrapolated reverse current reaches zero

Note 1 to entry: The specified values of reverse recovery time refer to a specified waveform of the preceding on-state current pulse, which may be either a half sinusoidal waveform (solid line) or a trapezoidal waveform (dashed line) in Figure 4.

Note 2 to entry: The specified low value of the reverse current is as I_b given in Figure 4a). The extrapolation is carried out with respect to specified points A and B, as shown in generalized form in Figure 4b). The point A may be specified at the peak value of the reverse current.

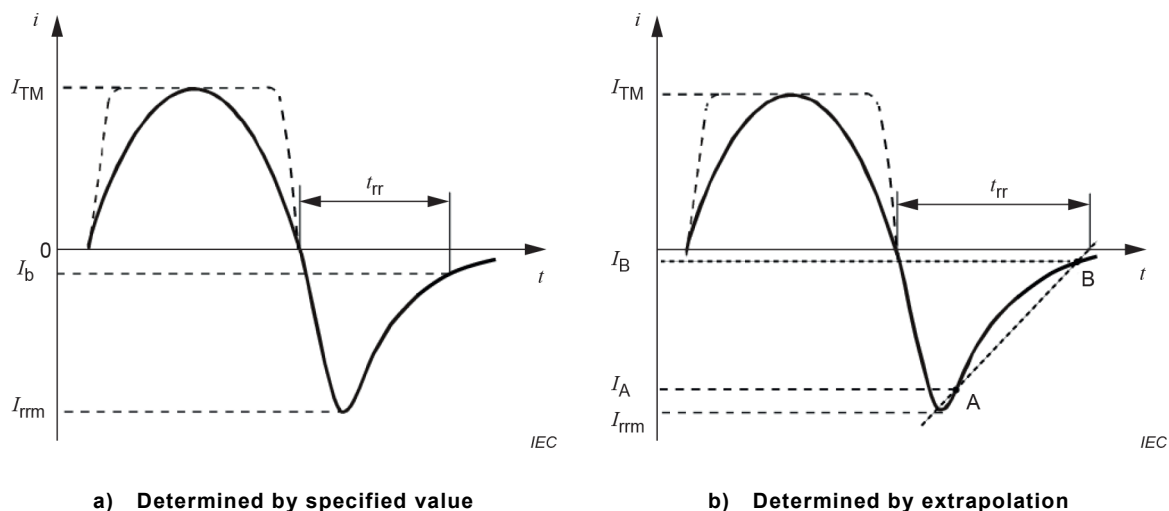


Figure 4 – Reverse recovery time of reverse blocking triode thyristor

3.6.2.2

off-state recovery time

t_{dr}

<reverse conducting triode thyristor> time interval between

- the instant when the current passes through zero while changing from the reverse conducting state to the off state, and
- the instant when either the off-state current reaches a specified low value during reducing from its peak value I_{DM} , or the extrapolated off-state current reaches zero

Note 1 to entry: The specified values of off-state recovery time refer to a specified waveform of the preceding reverse current pulse, which may be either a half sinusoidal waveform (solid line) or a trapezoidal waveform (dashed line) in Figure 5.

Note 2 to entry: The specified low value of the reverse current is as I_b given in Figure 5 a). The extrapolation is carried out with respect to specified points A and B, as shown in generalized form in Figure 5 b). The point A can be specified at the peak value of the off-state current.

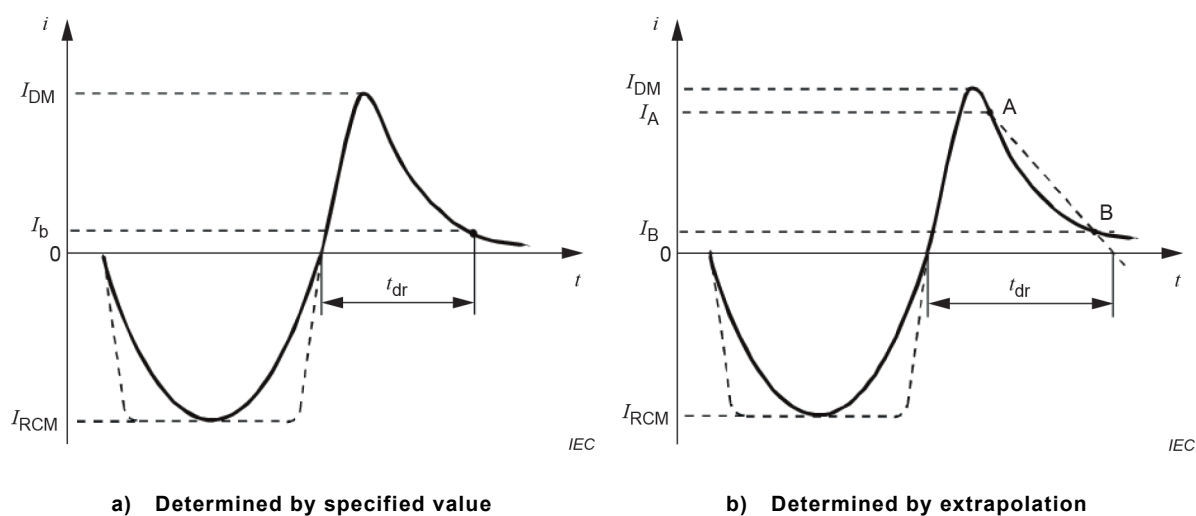


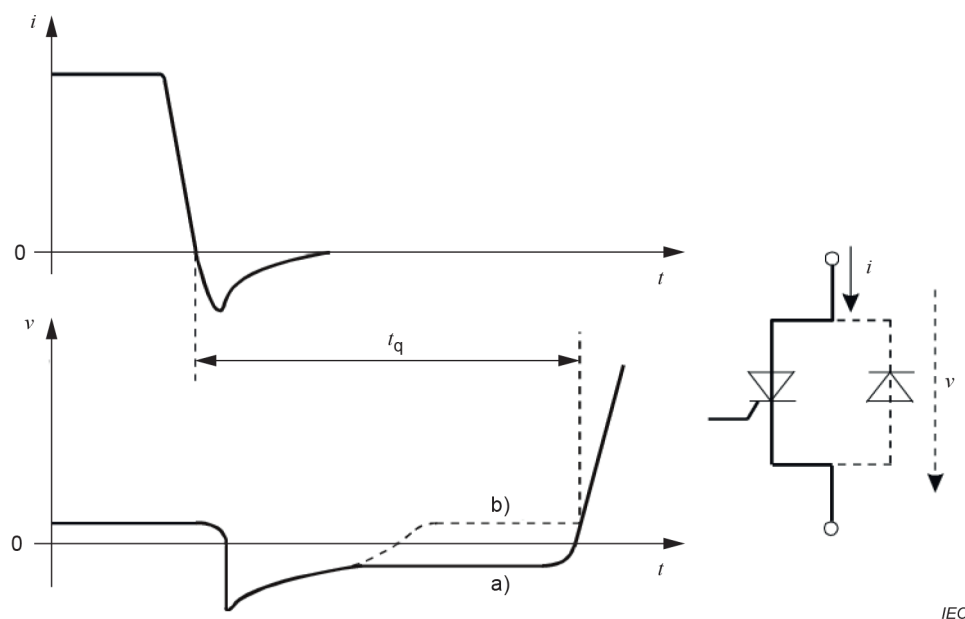
Figure 5 – Off-state recovery time of reverse conducting triode thyristor

3.6.2.3**circuit commutated turn-off time** t_q

time interval between

- the instant when the on-state current has decreased to zero after external switching of the main circuit, and
- the earliest instant when a steeply rising off-state voltage that the thyristor is capable of supporting without breaking over either passes through zero or begins from a low positive value

Note 1 to entry: The curve a) in Figure 6 shows that the steeply rising off-state voltage of a reverse blocking triode thyristor passes through zero without breakover. The curve b) in Figure 6 shows that the steeply rising off-state voltage of the thyristor begins from a low positive value, which can appear, if the thyristor is bypassed by an external or internal inverse diode (for reverse conducting triode thyristor), due to the lead inductance of the diode.

**Figure 6 – Circuit commutated turn-off time****3.6.2.4****hold-off interval** t_H

<in a converter> time interval between

- the instant when the anode current of the thyristor in a converter has decreased to zero, and
- the instant when the same thyristor is subjected to the off-state voltage

Note 1 to entry: The hold-off interval is not a characteristic of the thyristor but a service condition of the converter. It will exceed the longest expected individual circuit commutated turn-off time, which also depends on the service conditions of the converter.

3.6.3 Times and rates of rise characteristics gate controlled turn on

NOTE The defined terms refer to the switching of a thyristor from the off state to the on state by means of a forward gate drive current pulse (see Figure 7).

3.6.3.1

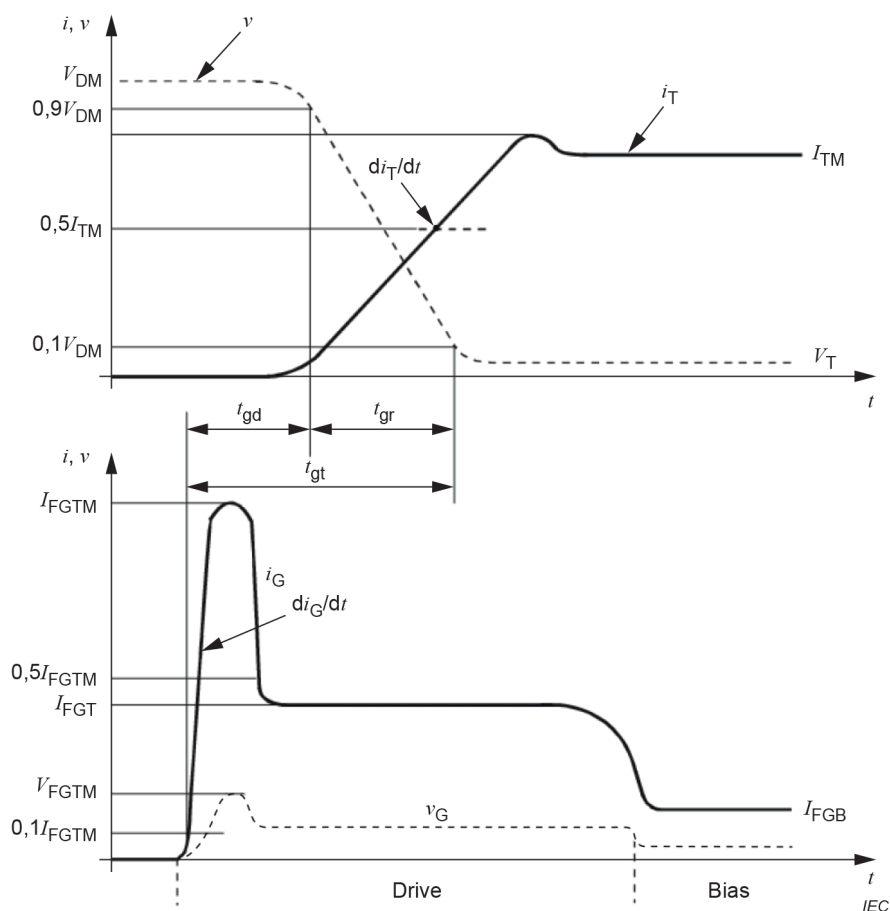
gate controlled turn-on delay time

turn-on delay time

t_{gd}

time interval between the instant when the rising gate current reaches 10 % of the peak forward gate current and the instant when the decreasing off-state voltage reaches 90 % of its peak value before the turn on

Note 1 to entry: If no ambiguity is likely to result, the term may be abbreviated to “turn-on delay time” and the shorter expression “ t_d ” can be used.



NOTE The reference values of current and voltage are usually specified as follows:

- Peak forward gate current I_{FGTM} :
 - specified low value: 10 % of I_{FGTM} ,
 - specified level for the measurement of di_G/dt : 50 % of I_{FGTM} .
- Peak anode voltage V_{DM} , which is the peak off-state voltage before the turn on:
 - upper specified value: 90 % of V_{DM} ,
 - lower specified value: 10 % of V_{DM} .
- Peak anode current I_{TM} :
 - specified level for the measurement of di_T/dt : 50 % of I_{TM} .

Figure 7 – Gate controlled turn-on time

3.6.3.2**gate controlled turn-on rise time**

turn-on rise time

 t_{gr}

time interval between the instants when the decreasing off-state voltage reaches 90 % and 10 % of its peak value before the turn on

Note 1 to entry: If no ambiguity is likely to result, the term may be abbreviated to “turn-on rise time” and the shorter expression “ t_r ” may be used.

3.6.3.3**gate controlled turn-on time**

turn-on time

 t_{gt}

sum of gate controlled turn-on delay time and gate controlled turn-on rise time

Note 1 to entry: The additional turn-on energy dissipation can be expressed as Formula (4):

$$t_{gt} = t_{gd} + t_{gr} \quad (4)$$

Note 2 to entry: If no ambiguity is likely to result, the term may be abbreviated to “turn-on time”.

3.6.4 Times and rates of rise characterizing gate controlled turn off

NOTE The defined terms refer to the switching of a turn-off thyristor from the on state to the off state by means of a reverse gate drive current pulse that is supported by an additional reverse gate drive voltage pulse and that is followed by a smaller reverse gate bias current (see Figure 8).



- Peak turn-off gate current I_{RGQM} :
 - specified low value near zero: 10 % of I_{RGQM} ,
 - specified level for the measurement of di_{RG}/dt : 50 % of I_{RGQM}
- Peak anode current I_{TM} :
 - upper reference value: 90 % of I_{TM} .
- Peak anode voltage V_{DQM} :
 - specified level for the measurement of dv/dt : 50 % of V_{DQM} .

3.6.4.1
gate controlled turn-off delay time
turn-off delay time

time interval between the instant when the rising reverse gate current reaches 10 % of peak turn-off gate current and the instant when the decreasing anode current reaches 90 % of its peak value before the turn off

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3.6.4.2**gate controlled turn-off fall time**

turn-off fall time

 t_{fq}

time interval between the instant when the decreasing anode current reaches 90 % of its peak value before the turn off and the instant at the end of its steep decrease, the valley point current I_{ZV}

Note 1 to entry: If no ambiguity is likely to result, the term may be abbreviated to “turn-off fall time”.

3.6.4.3**gate controlled turn-off time**

turn-off time

 t_{gq}

sum of gate controlled turn-off delay time and gate controlled turn-off fall time

Note 1 to entry: There is an expression as Formula (5).

$$t_{gq} = t_{dq} + t_{fq} \quad (5)$$

Note 2 to entry: If no ambiguity is likely to result, the term may be abbreviated to “turn-off time”.

3.6.4.4**tail time** t_z

time interval between the instant when the anode current has decreased to the end of its steep decrease, the valley point current I_{ZV} , and the instant when the extrapolated tail current reaches zero

Note 1 to entry: Unless otherwise specified, the extrapolation is carried out between the peak value of the tail current I_{ZM} and its specified low value $I_{ZL} = 0,25I_{ZM}$ (see Figure 8).

3.6.5 Charges

3.6.5.1

recovered charge

Q_r

<reverse blocking triode thyristor> total charge recovered from the thyristor during a specified integration time after switching from a specified on-state current condition to a specified reverse condition as Formula (6)

$$Q_r = \int_{t_0}^{t_0+t_i} i_{rr} \cdot dt \quad (6)$$

where

t_0 is the instant when the current passes through zero;

t_i is the specified integration interval.

Note 1 to entry: This recovered charge includes components due to both carrier storage and depletion layer capacitance.

Note 2 to entry: The specified integration interval refers to Figure 9.

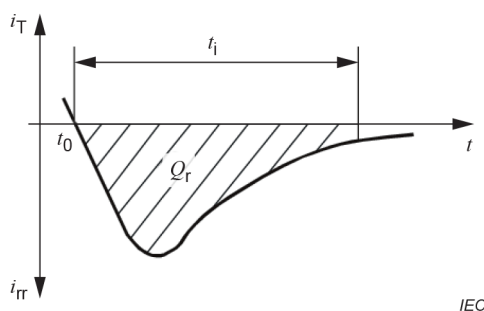


Figure 9 – Recovered charge

3.6.5.2

off-state recovered charge

Q_{dr}

<reverse conducting triode thyristor> total charge recovered from the thyristor during a specified integration time after switching from a specified reverse current condition to a specified off state condition

Note 1 to entry: Formula (6) and Figure 9 in 3.6.5.1 apply analogously.

3.6.5.3

gate turn-off charge

Q_{gq}

<turn-off thyristor> total charge derived from the integration of the reverse gate current between the instant when the falling forward gate current crosses zero and the instant at which the reverse gate current reaches the peak turn-off gate current

SEE: Figure 8.

3.7 Mechanical ratings

3.7.1

mounting torque

M

torque applied to rotate a screw or stud to mount a thyristor

Note 1 to entry: For thyristors with screw connections, the minimum and maximum values of the rated mounting torque shall be specified.

3.7.2

clamping force

F

force applied to disc type devices by external means to ensure electrical and thermal contact

4 Letter symbols

4.1 General

The general rules given in IEC 60747-1:2006, Clause 4, are applicable in part.

4.2 Additional general subscripts

In addition to the lists of recommended general subscripts given in IEC 60747-1:2006, Clause 4, the special subscripts given in Table 1 are recommended for the thyristors.

Table 1 – Additional general subscripts

Subscripts	Significance	Remarks
A, a	Anode	
(com)	Commutating	
G, g	Gate, gate controlled	
H	Holding	
L	Latching	
Q, q	Turn off	
RC	Reverse conducting	
(SP)	Spike	
sus	Sustaining	
T	On state	
T, t	Turn on, trigger	
V (in uppercase letter)	Valley	For the letter symbol I_{ZV} only
W (in uppercase letter)	Working, average pulse duration	
Z, z	Tail	

4.3 List of letter symbols

The letter symbols contained in Table 2 to Table 7 are recommended for use in the thyristors.

Table 2 – Principal voltages (anode-cathode voltages)

Letter symbol	Name and designation	Remarks
V_D	Off-state voltage	See 3.2.3 and 5.2.3.8
V_{DM}	Peak off-state voltage	Refer to 3.6.3.1 and 5.2.4.6
V_{DRM}	Repetitive peak off-state voltage	See 3.2.4 and 5.2.3.2
V_{DSM}	Non-repetitive peak off-state voltage	See 3.2.5 and 5.2.3.1
V_{DWM}	Peak working off-state voltage	See 5.2.3.3
V_R	Reverse voltage	See 5.2.3.7
V_{RRM}	Repetitive peak reverse voltage	See 3.2.1 and 5.2.3.6
V_{RSM}	Non-repetitive peak reverse voltage	See 3.2.2 and 5.2.3.5
V_{RWM}	Peak working reverse voltage	See 5.2.3.4
V_T	On-state voltage	See 3.2.7 and 5.3.2.1
V_{TM}	Peak on-state voltage	See 3.2.8 and 5.3.2.2
$V_{T(To)}$	On-state threshold voltage	See 3.6.1.2 and 5.3.3.2

Table 3 – Principal currents (anode currents and cathode currents)

Letter symbol	Name and designation	Remarks
I_D	Off-state current	See 5.3.8
I_H	Holding current	See 5.3.4
I_L	Latching current	See 5.3.5
I_R	Reverse current	See 5.3.6
I_{RC}	Reverse conducting current	For reverse conducting triode thyristor, see 5.2.4.11
$I_{RC(OV)}$	Overload reverse conducting current	For reverse conducting triode thyristor, see 3.3.5
I_{RRM}	Repetitive peak reverse current	See 5.3.7
I_{rrm}	Peak reverse recovery current	See 5.3.18.2
I_T	On-state current	See 5.2.4.3
$I_{T(AV)}$	average on-state current	See 5.2.4.1
I_{TM}	Peak on-state current	Refer to 3.6.3.1, 3.6.4 and 5.3.17.4
$I_{T(OV)}$	Overload on-state current	See 3.3.4 and 5.2.4.7
$I_{T(RMS)}$	RMS on-state current	See 5.2.4.2
I_{TRM}	Repetitive peak on-state current	See 3.3.3 and 5.2.4.6
I_{TSM}	Non-repetitive surge on-state current	See 3.3.1 and 5.2.4.4

Table 4 – Gate voltages and currents

Letter symbol	Name and designation	Remarks
I_{FG}	Forward gate current	
I_{GD}	Gate non-trigger current	See 5.3.11
I_{GT}	Gate trigger current	See 5.3.10
V_{GD}	Gate non-trigger voltage	See 5.3.11
V_{GT}	Gate trigger voltage	See 5.3.10

Table 5 – Characteristic time intervals

Letter symbol	Name and designation	Remarks
t_{dr}	Off-state recovery time	For reverse conducting triode thyristor, see 3.6.2.2
t_{gd} or t_d	Turn-on delay time	t_d used only when misinterpretation will not result, see 3.6.3.1 and 5.3.15.1
t_{gq}	Turn-off time	See 3.6.4.3 and 5.3.15.5
t_{gr} or t_r	Turn-on rise time	t_r used only when misinterpretation will not result, see 3.6.3.2
t_{gt}	Turn-on time	See 3.6.3.3
t_H	Hold-off interval	See 3.6.2.4
t_q	Circuit commutated turn-off time	See 3.6.2.3 and 5.3.15.2

Table 6 – Power and energy dissipation

Letter symbol	Name and designation	Remarks
E_{TB}	Basic on-state energy dissipation	See 3.5.3.2
E_{RQ} or E_{DQ}	Turn-off energy dissipation	See 3.5.3.4 and 5.3.17.6, E_{DQ} for turn-off thyristor
P_D	Off-state power	See 3.5.1.2
P_{FGM}	Peak forward gate power	See 5.2.5.3.6
P_R	Reverse power	See 3.5.1.1
P_{RC}	Reverse conducting power	See 3.5.1.6
$P_{RQ(AV)}$ or $P_{DQ(AV)}$	Turn-off power dissipation	See 3.5.2.6
P_{RQ} or P_{DQ}	– average turn-off power dissipation	See 3.5.1.5
P_{DQM}	– turn-off power	Refer to 3.5.3.2
P_T	On-state power	See 3.5.1.3
$P_{TT(AV)}$	Turn-on power dissipation	See 3.5.2.5
P_{TT}	– average turn-on power dissipation	See 3.5.1.4
	– turn-on power	

Table 7 – Other characteristics

Letter symbol	Name and designation	Remarks
di/dt_{cr}	Critical rate of rise of on-state current	See 5.2.4.8
$dv_{(com)}/dt_{cr}$	Critical rate of rise of commutating voltage	See 3.2.9 and 3.2.10
dv/dt_{cr}	Critical rate of rise of off-state voltage	See 5.3.15.3
Q_{dr}	Off-state recovered charge	For reverse conducting triode thyristor, see 3.6.5.2
Q_r	Recovered charge	See 3.6.5.1 and 5.3.18.1
R_T	On-state slope resistance	See 3.6.1.1 and 5.3.3.3

5 Essential ratings and characteristics

5.1 General

Many of the ratings and characteristics (properties) are required to be quoted at a temperature of 25 °C and at one other specified temperature.

5.2 Ratings (limiting values)

5.2.1 Storage temperature (T_{stg})

Minimum and maximum values of the ambient temperature during storing devices.

5.2.2 Operating ambient, case, heatsink or junction temperature (T_a , T_c , T_s or T_{vj})

Minimum and maximum values of the ambient, case, heatsink or junction temperature during operating.

NOTE The case temperature is normally measured on the body of the device. For some thyristors, the case temperature is specified on one of the terminals.

5.2.3 Principal voltages

5.2.3.1 Non-repetitive peak off-state voltage (V_{DSM})

Maximum value of an off-state voltage pulse with half sinusoidal waveform, the pulse duration of which shall be specified. If this value has to be derated at higher operating frequencies, the derating factor or curve shall be given.

5.2.3.2 Repetitive peak off-state voltage (V_{DRM})

Maximum value of off-state voltage pulses with half sinusoidal waveform, the pulse duration and repetition rate of which has to be specified. If this value has to be derated at higher operating frequencies, the derating factor or curve shall be given.

5.2.3.3 Peak working off-state voltage (V_{DWM})

Maximum value of off-state voltage pulses with half sinusoidal waveform at mains frequency, usually 50 Hz or 60 Hz.

5.2.3.4 Peak working reverse voltage (V_{RWM})

Maximum value of reverse voltage pulses with half sinusoidal waveform at mains frequency, usually 50 Hz or 60 Hz.

5.2.3.5 Non-repetitive peak reverse voltage (V_{RSM})

Maximum value of a reverse voltage pulse with half sinusoidal waveform, the pulse duration of which shall be specified. If this value has to be derated at higher operating frequencies, the derating factor or curve shall be given.

5.2.3.6 Repetitive peak reverse voltage (V_{RRM})

Maximum value of reverse voltage pulses with half sinusoidal waveform, the pulse duration and repetition rate of which has to be specified. If this value has to be derated at higher operating frequencies, the derating factor or curve shall be given.

5.2.3.7 Reverse voltage (V_R) (where appropriate)

Maximum value of direct voltage.

NOTE For turn-off thyristor, the letter symbol $V_{R(D)}$ can be used.

5.2.3.8 Off-state voltage (V_D) (where appropriate)

Maximum value of direct voltage under specified conditions of control signal and gate.

NOTE For turn-off thyristor, the letter symbol $V_{D(D)}$ can be used.

5.2.4 Principal currents**5.2.4.1 Average on-state current ($I_{T(AV)}$)**

Maximum value for continuous operation with half sinusoidal waveform of 180° conduction angle and with rectangular pulses of various conduction angles, at least 180° and 120°, at 50 Hz or 60 Hz, versus ambient or case temperature.

5.2.4.2 RMS on-state current ($I_{T(RMS)}$)

Maximum value for continuous operation with half sinusoidal waveform of 180° conduction angle and with rectangular pulses of various conduction angles, at least 180° and 120°, at 50 Hz or 60 Hz, versus ambient or case temperature.

NOTE The RMS on-state current is given on the assumption that no overload occurs.

5.2.4.3 On-state current (I_T)

Maximum value at a specified ambient, case, heatsink or junction temperature.

5.2.4.4 Non-repetitive surge on-state current (I_{TSM})

Maximum value with initial conditions corresponding to maximum rated virtual junction temperature (see Figure 1).

These ratings shall be given for the following time periods:

- a) For times smaller than one half cycle (at 50 Hz or 60 Hz), but greater than approximately 1 ms, in terms of maximum value of

$$\int i^2 \cdot dt$$

These ratings may be given by means of a curve or by specified values. No immediate subsequent application of reverse voltage or off-state voltage is assumed.

For fast turn-on thyristors or fast plasma-spreading thyristors such as those with distributed gate or inter-digitated gate structures (e.g., in turn-off thyristor), values for times below 1 ms can be necessary;

- b) For a time equal to one cycle, with no reverse voltage applied;
- c) For times equal to or greater than one half cycle, and for at least 15 cycles (at 50 Hz or 60 Hz) in the form of a curve showing the rated surge current versus time. Temporary loss of gate control shall be assumed to occur.

These ratings should preferably be given for a reverse voltage of 80 % of the rated repetitive peak reverse voltage. Additional ratings may be given for reverse voltages of 50 % or 100 % of the rated repetitive peak reverse voltage.

NOTE Although non-repetitive surge on-state current ratings are given for half sinusoidal waveform, they are, according to experience, also applicable to approximately triangular current waveform, which occur when a sinusoidally rising fault current is interrupted by a current-limiting fuse.

5.2.4.5 I^2t value (of non-repetitive surge on-state current) (I^2t)

Maximum value used for the specification of non-repetitive surge on-state current, given in Formula (7)

$$I^2t = \int_0^{t_i} i^2 \cdot dt \quad (7)$$

for a specified short integration time t_i .

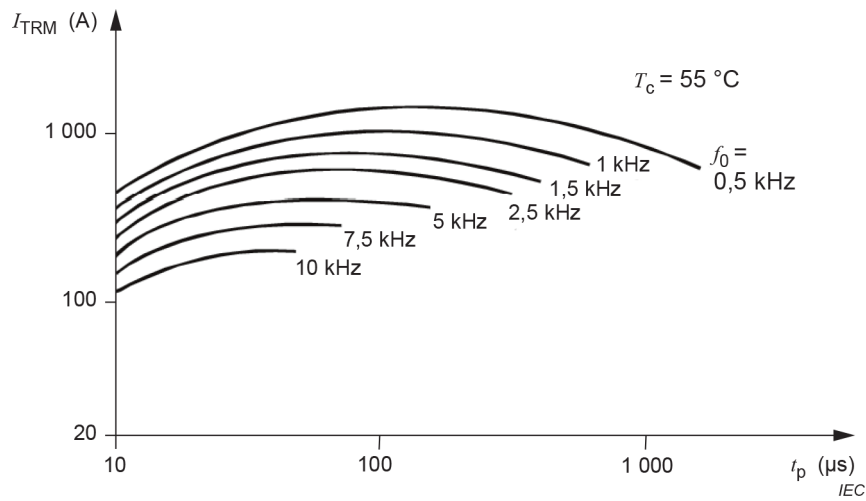
5.2.4.6 Repetitive peak on-state current (I_{TRM}) (where appropriate)

5.2.4.6.1 Repetitive peak sinusoidal on-state current (where appropriate)

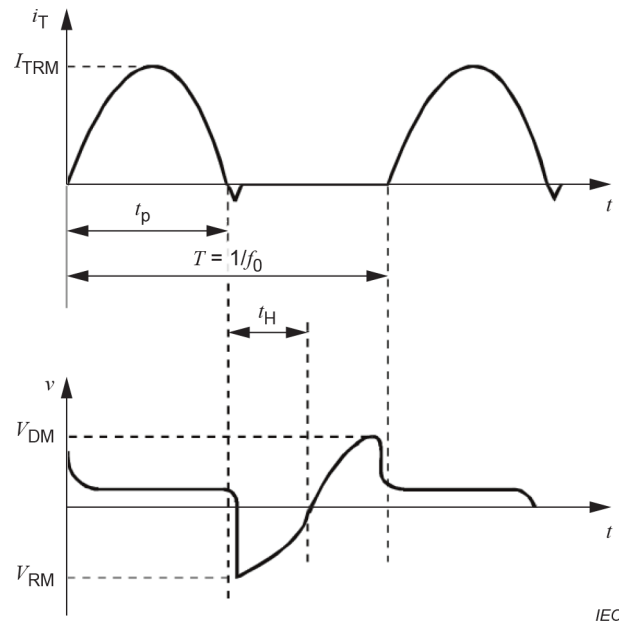
Maximum values given in form of curves, as functions of the pulse duration of half sinusoidal current, with the repetition frequency f_0 as a parameter, under the following specified conditions:

- case temperature T_c ;
- off-state voltage V_{DM} before the turn on;
- reverse voltage V_{RM} ;
- gate conditions during the turn on and turn off;
- RC damping network (snubber).

Figure 10a) is given as an example. Figure 10b) is given for explanatory purposes only.



a) Repetitive peak sinusoidal on-state current I_{TRM} as a function of pulse duration t_p with repetition frequency f_0



b) Typical current and voltage waveform for repetitive peak sinusoidal on-state current pulses

Key

t_H hold-off interval (see 3.6.2.4)

NOTE The pulse waveform includes the current pulse due to the RC damping network.

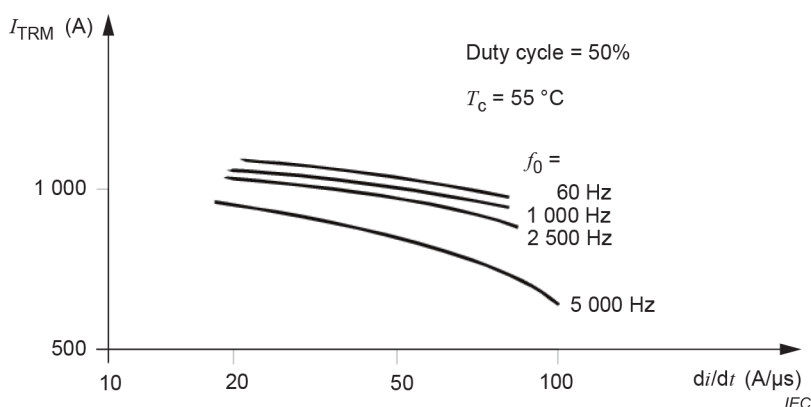
Figure 10 – Peak sinusoidal currents and typical waveform at higher frequencies

5.2.4.6.2 Repetitive peak trapezoidal on-state current (where appropriate)

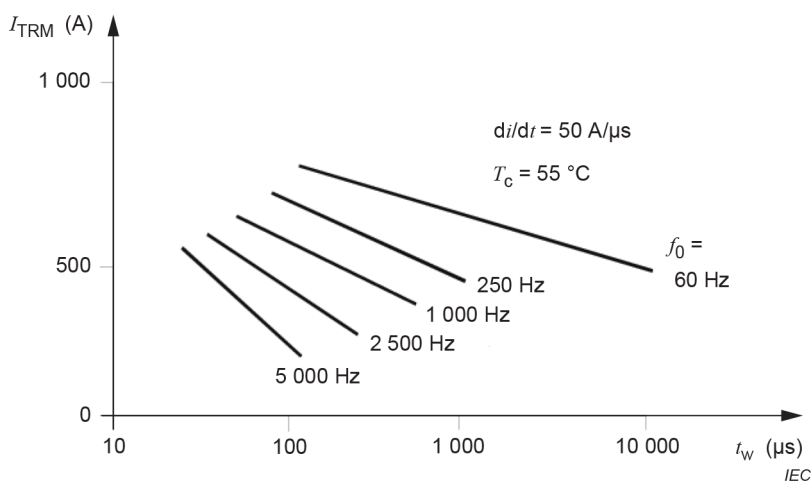
Maximum values given in form of curves, related to the rate of rise of on-state current, the repetition frequency and either the duty cycle or average pulse duration, under the following specified conditions:

- case temperature T_c ;
- off-state voltage V_{DM} before the turn on;
- reverse voltage V_{RM} (two or more families of curves should be given as there is a significant dependence on the applied reverse voltage);
- gate conditions during the turn on and turn off;
- RC damping network (snubber);
- duty cycle or average pulse duration.

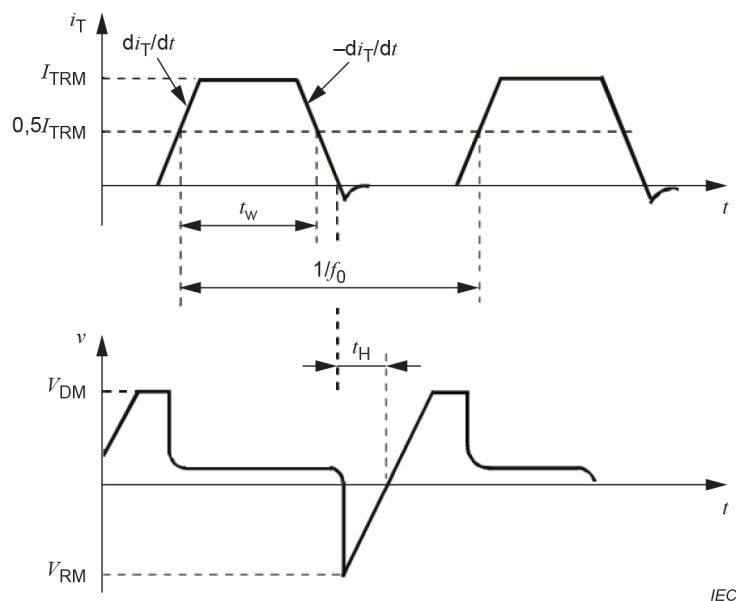
Figure 11a) and Figure 11b) are given as an example. Figure 11c) is given for explanatory purposes only.



a) Repetitive peak trapezoidal on-state current I_{TRM} for a specified t_w as a function of the rate of rise of on-state current with repetition frequency f_0



b) Repetitive peak trapezoidal on-state current I_{TRM} with a specified di/dt as a function of t_w with repetition frequency f_0



c) Typical current and voltage waveform for repetitive peak trapezoidal on-state current pulses

Key

t_H hold-off interval (see 3.6.2.4)

Figure 11 – Peak trapezoidal currents and typical waveform at higher frequencies

Different sets of curves are required for different values of di/dt .

5.2.4.7 Overload on-state current ($I_{T(OV)}$)

Where this rating is appropriate, it shall be given by stating the initial maximum rated virtual junction temperature and the maximum transient thermal impedance. In addition, overload current ratings can be given by means of graphs. Sometimes, figures corresponding to lower initial junction temperatures can be given.

5.2.4.8 Critical rate of rise of on-state current (di/dt_{cr})

Maximum value under the following specified conditions:

- off-state voltage before the turn on, preferably equal to a half or two-thirds the maximum rated repetitive peak off-state voltage in 5.2.3.2;
- peak value of on-state current,
 - preferably equal to specified on-state current in 5.2.4.1 specified at 45 °C ambient or 85 °C case temperature,
 - in case of triac: preferably equal to $\sqrt{2}$ times the rated RMS on-state current in 5.2.4.2 specified at 45 °C ambient or 85 °C case temperature,
 - in case of turn-off thyristors: preferably equal to the rated repetitive peak controllable on-state current, with current waveform and average pulse duration specified.
- repetition rate, preferably 50 Hz or 60 Hz;
- ambient, case or junction temperature equal to the maximum value at which the peak value of on-state current is permitted;
- gate trigger conditions;
- test duration (should be longer than the thermal time constant of the thyristor under test, e.g., 30 s).

NOTE 1 If no ambiguity is likely to result, the shorter expression “ di/dt ” can be used.

The rated value of di/dt should be given where there is no RC network connected in parallel with the thyristor. If an additional di/dt rating is given where an RC network is present, the permissible amplitude and duration of the surge from this network or the parameters of this network shall be stated.

NOTE 2 The di/dt ratings are not applicable to low current thyristors.

5.2.4.9 Peak reverse conducting current (I_{RCM}) (for reverse conducting thyristor)

Maximum value for continuous operation with half sinusoidal waveforms of 180° conduction angle and with rectangular pulses of various conduction angles, at least 180° and 120°, at 50 Hz or 60 Hz, versus ambient or case temperature.

5.2.4.10 Average reverse conducting current ($I_{RC(AV)}$) (for reverse conducting thyristor)

Maximum value for continuous operation with half sinusoidal waveforms of 180° conduction angle and with rectangular pulses of various conduction angles, at least 180° and 120°, at 50 Hz or 60 Hz, versus ambient or case temperature.

5.2.4.11 Reverse conducting current (I_{RC}) (for reverse conducting thyristor)

Maximum value at a specified ambient, case, heatsink or junction temperature. Refer to IEC 60747-2.

NOTE The letter symbol $I_{RC(D)}$ can be used.

5.2.4.12 Non-repetitive surge reverse current (I_{RCSM}) (for reverse conducting thyristor)

Maximum value under specified pulse conditions. Refer to IEC 60747-2.

5.2.4.13 Non-repetitive peak controllable on-state current (I_{TQSM}) for turn-off thyristors

Maximum value under the following specified conditions:

- a) maximum rated virtual junction temperature;
- b) re-applied off-state voltage, preferably a half or two-thirds of the rated repetitive peak off-state voltage;
- c) rate of rise of the re-applied off-state voltage;
- d) turn-off spike voltage;
- e) turn-off gate voltage, preferably equal to the rated turn-off gate voltage;
- f) rate of rise of the turn-off gate current.

5.2.4.14 Repetitive peak controllable on-state current (I_{TQRM}) for turn-off thyristors

Maximum value under the following specified conditions:

- a) maximum rated virtual junction temperature reached at the end of the turn off procedure;
- b) re-applied off-state voltage, preferably a half or two-thirds of the rated repetitive peak off-state voltage;
- c) rate of rise of the re-applied off-state voltage;
- d) turn-off spike voltage;

- e) turn-off gate voltage, preferably equal to the rated turn-off gate voltage;
- f) rate of rise of the turn-off gate current.

5.2.4.15 Short-time and intermittent duty current (for turn-off thyristors)

Maximum on-state current under short-time or intermittent duty. This rating can be calculated from the resulting total power loss, the transient thermal impedance and the maximum rated virtual junction temperature.

5.2.4.16 Peak case non-rupture current (I_{RSMC}) (where appropriate)

Maximum value for the reverse current, at specified waveform, average pulse duration and rate of rise of the current, as well as specified initial case or junction temperature.

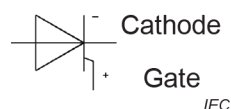
NOTE The value of the peak case non-rupture current depends considerably on the location of the initial breakdown, on the chip and is usually lowest if the breakdown occurs near the edge.

5.2.5 Gate voltages, current and power

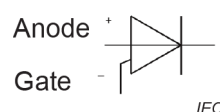
5.2.5.1 Gate voltages

5.2.5.1.1 General

Gate voltages are applied between gate and cathode terminals of a P-gate thyristor (gate positive for a forward gate voltage), and between anode and gate terminals of an N-gate thyristor (anode positive for a forward gate voltage). See Figure 12.



a) P-gate thyristor



b) N-gate thyristor

Figure 12 – Application of gate voltages for thyristors

5.2.5.1.2 Peak forward gate voltage (V_{FGM})

Maximum value of the forward gate voltage including all transient voltages.

5.2.5.1.3 Peak reverse gate voltage (V_{RGM})

Maximum value of the reverse gate voltage including all transient voltages.

5.2.5.2 Peak forward gate current (I_{FGM})

Maximum value with anode-cathode voltage polarity specified and any qualifications (e.g., of time, energy, etc.) applicable to this rating.

5.2.5.3 Gate power

5.2.5.3.1 General

If these ratings are dependent on temperature or pulse repetition rate, derating information shall be given.

5.2.5.3.2 Average gate power dissipation ($P_{G(AV)}$)

Maximum value of the gate power dissipation averaged over a full cycle.

5.2.5.3.3 Peak gate power (P_{GM})

Maximum value for specified average pulse duration.

5.2.5.3.4 Average forward gate power ($P_{FG(AV)}$) for turn-off thyristors

Maximum value of the forward gate power averaged over a full cycle.

5.2.5.3.5 Average reverse gate power ($P_{RG(AV)}$) for turn-off thyristors

Maximum value of the reverse gate power averaged over a full cycle.

5.2.5.3.6 Peak forward gate power (P_{FGM}) for turn-off thyristors

Maximum value for specified average pulse duration and repetition rate.

5.2.5.3.7 Peak reverse gate power (P_{RGM}) for turn-off thyristors

Maximum value for specified average pulse duration and repetition rate.

5.2.6 Total power dissipation (P_{tot})

Where thermal resistance is not given in the characteristics (properties), maximum total power dissipation as a function of temperature over the range of operating temperatures shall also be given.

5.2.7 Frequency ratings

Where applicable, maximum and/or minimum frequencies for which the voltage and current ratings apply.

5.2.8 Mechanical ratings**5.2.8.1 Mounting torque (M) (where appropriate)**

Minimum and maximum values applied to rotate a screw or stud type thyristor.

5.2.8.2 Clamping force (F) (where appropriate)

Minimum and maximum values applied to a disc type thyristor. The planarity of the mounting surface shall also be specified.

5.3 Characteristics**5.3.1 General**

Characteristics (properties) shall be given at $T_{vj} = 25\text{ °C}$ except where otherwise stated and at one other specified temperature.

In the case of a triac the characteristics (properties) recommended here are based on symmetrical operation of the device, and therefore shall be based on limiting values for either direction of operation. If a characteristic is sensitive to the gate triggering mode, the mode(s) applicable shall be specified.

5.3.2 On-state voltages

5.3.2.1 on-state voltage (V_T)

Maximum value at the rated on-state current.

5.3.2.2 Peak on-state voltage (V_{TM})

Maximum value at the specified peak on-state current and at a case or ambient temperature of 25 °C or at the maximum rated virtual junction temperature. The value of the specified peak on-state current shall be stated when the peak on-state voltage is given.

NOTE If the peak on-state current is specified as π times the rated average on-state current, π herein can be replaced with 3.

In case of a triac, this is the maximum value at a current which the peak value equal to $\sqrt{2}$ times the rated RMS on-state current.

In case of a turn-off thyristor, this is the maximum value at the rated repetitive peak controllable on-state current (I_{TQRM}).

The reference value for calculating the on-state power dissipation under operating conditions is the peak on-state voltage at maximum rated virtual junction temperature. If, however, a well-established correlation exists between this value and the value at 25 °C, the latter may be given for convenience of testing.

5.3.3 On-state characteristics (where appropriate)

5.3.3.1 General

On-state characteristics may be shown in curves with instantaneous values of on-state voltage versus on-state current up to the maximum rated value of the repetitive peak on-state current, at an ambient or case temperature of 25 °C and at one other higher temperature, preferably equal to the maximum rated virtual junction temperature. These characteristics shall be measured using a pulse method, so that the junction temperature is approximately equal to the case temperature.

5.3.3.2 On-state threshold voltage ($V_{T(TO)}$ or $V_{(TO)}$)

Maximum value at maximum rated virtual junction temperature.

5.3.3.3 On-state slope resistance (R_T)

Maximum value at maximum rated virtual junction temperature.

5.3.4 Holding current (I_H)

Maximum value and, where appropriate, minimum value under the following specified conditions:

- source voltage in the principal circuit (off-state voltage), preferably equal to 12 V;
- gate bias conditions;
- peak initial on-state current.

NOTE The maximum value of the holding current is the smallest current that will maintain all thyristors of a given type in the on state. The minimum value of the holding current is the highest current below which all thyristors of a given type will return to the off state.

5.3.5 Latching current (I_L)

Maximum value under the following specified conditions:

- a) source voltage in the principal circuit (off-state voltage), preferably equal to 12 V (24 V in case of a turn-off thyristor);
- b) triggering pulse: rise time, fall time, average pulse duration, repetition rate, voltage amplitude and resistance of the trigger pulse source.

NOTE The maximum value of the latching current is the smallest current that will maintain all thyristors of a given type in the on state immediately after the triggering condition has been removed.

5.3.6 Reverse current (I_R)

Maximum value at the rated continuous (direct) reverse voltage and at 25 °C and one other higher temperature.

NOTE A specific value, not a limit, is given sometime at a lower value of reverse voltage and at 25 °C and one other higher temperature.

5.3.7 Repetitive peak reverse current (I_{RRM})

Maximum value at the rated repetitive peak reverse voltage at 25 °C and, where appropriate, at the maximum rated virtual junction temperature.

5.3.8 Off-state current (I_D)

Maximum value at the rated continuous (direct) off-state voltage and at 25 °C and one other higher temperature.

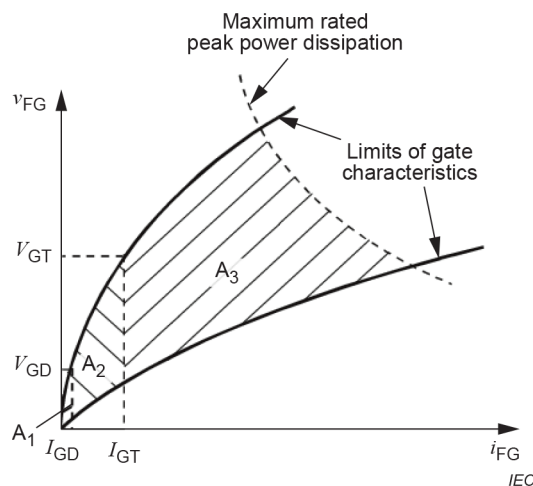
NOTE A specific value, not a limit, is given sometime at a lower value of off-state voltage and at 25 °C and one other higher temperature.

5.3.9 Repetitive peak off-state current (I_{DRM})

Maximum value at the rated repetitive peak off-state voltage at 25 °C and, where appropriate, at the maximum rated virtual junction temperature.

5.3.10 Gate trigger current (I_{GT}) and gate trigger voltage (V_{GT})

Values of gate current and gate voltage required to turn on all thyristors of a given type. Limiting values and characteristics for the gate are preferably given with reference to a graph as shown in Figure 13.

**Key**

I_{GD}	gate non-trigger current	A_1	area of non-triggering
I_{GT}	gate trigger current	A_2	area of uncertain triggering
V_{GD}	gate non-trigger voltage	A_3	area of certain triggering
V_{GT}	gate trigger voltage		

Figure 13 – Forward gate voltage versus forward gate current

The following conditions shall be specified:

- off-state voltage, preferably equal to 12 V (24 V in case of a turn-off thyristor);
- gate circuit conditions;
- ambient, case or junction temperature;
- in case of a turn-off thyristor, specified maximum source resistance that will provide sufficient on-state current to assure conduction of all cathode islands.

The values of gate trigger voltage and current should be given at 25 °C and at minimum operating temperature.

5.3.11 Gate non-trigger voltage (V_{GD}) and gate non-trigger current (I_{GD})

Values of the gate voltage and gate current which will not turn on any thyristor of a given type (see Figure 13).

The following conditions shall be specified:

- off-state voltage, preferably equal to a half or two-thirds of the rated repetitive peak off-state voltage (V_{DRM});
- ambient or case temperature, preferably equal to the maximum rated virtual junction temperature;
- gate circuit conditions.

The values of gate non-trigger voltage and current should be given at maximum rated virtual junction temperature. If the characteristics given in Figure 13 are different for different quadrants of a triac, this should be stated.

5.3.12 Sustaining gate current (I_{FGsus}) (for turn-off thyristors only)

Minimum value for specified temperature and repetition rate.