

Components for low-voltage surge protective devices —

Part 341: Specification for thyristor surge suppressors (TSS)

The European Standard EN 61643-341:2001 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 61643-341:2001. It was derived by CENELEC from IEC 61643-341:2001.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by common modification tags **Ⓒ** **Ⓓ**.

The UK participation in its preparation was entrusted by Technical Committee PEL/37, Surge arresters, to Subcommittee PEL/37/2, Surge arresters — Low voltage, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Components for low-voltage surge protective devices
Part 341: Specification for thyristor surge suppressors (TSS)
(IEC 61643-341:2001)

Composants pour parafoudres
basse tension
Partie 341: Spécifications pour
les parafoudres à thyristor
(CEI 61643-341:2001)

Bauelemente für
Überspannungsschutzgeräte
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Suppressordioden (TSS)
(IEC 61643-341:2001)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 37B/58/FDIS, future edition 1 of IEC 61643-341, prepared by SC 37B, Specific components for surge arresters and surge protective devices, of IEC TC 37, Surge arresters, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61643-341 on 2001-12-01.

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- latest date by which the EN has to be implemented
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2004-12-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annex B is informative.

Annex ZA has been added by CENELEC.

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COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

Part 341: Specification for thyristor surge suppressors (TSS)**1 Scope**

This part of IEC 61643 is a test specification standard for thyristor surge suppressor (TSS) components designed to limit overvoltages and divert surge currents by clipping and crowbarring actions. Such components are used in the construction of surge protective devices, particularly as they apply to telecommunications.

This standard contains information on

- terms, letter symbols, and definitions
- basic functions, configurations and component structure
- service conditions and fault modes
- rating verification and characteristic measurement

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61643. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61643 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191), *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60050(702), *International Electrotechnical Vocabulary – Chapter 702: Oscillations, signals and related devices*

IEC 60099-4, *Surge arrestors – Part 4: Metal-oxide surge arrestors without gaps for  A.C.  systems*

IEC 60721-3-3, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weather-protected locations*

IEC 60721-3-9, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 9: Microclimates inside products*

IEC 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*

IEC 60747-2: 1983, *Semiconductor devices Discrete devices and integrated circuits – Part 2: Rectifier diodes*

IEC 60747-6:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 6: Thyristors*

NOTE The TSS has substantially different characteristics and usage to the type of thyristor covered by IEC 60747-6. These differences necessitate the modification of some characteristic descriptions and the introduction of new terms. Such changes and additions are indicated in clause 3.

IEC 60749:1996, *Semiconductor devices – Mechanical and climatic test methods*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61083-1:1991 *Digital recorders for measurements in high-voltage impulse tests – Part 1: Requirements for digital recorders*

ITU-T Recommendation K.20:1996 *Resistibility of telecommunication switching equipment to overvoltages and overcurrents*

ITU-T Recommendation K.21:1996 *Resistibility of subscribers' terminal to overvoltages and overcurrents*

ITU-T Recommendation K.28:1993 *Characteristics of semi-conductor arrester assemblies for the protection of telecommunications installations*

3 Terms, letter symbols and definitions

For the purpose of this part of IEC 61643, the following definitions apply.

3.1 Parametric terms, letter symbols and definitions

Where appropriate, terms, letter symbols and definitions are used from existing thyristor (IEC 60747-6) and rectifier diode (IEC 60747-2) standards.

NOTE 1 IEC 60747-1, chapter V, clause 2.1.1, states "IEC 60027 recommends the letters *V* and *v* only as reserve symbols for voltage; however, in the field of semiconductor devices, they are so widely used that in this publication they are on the same plane as *U* and *u*." This standard uses the letters *V* and *v* for voltage with the letters *U* and *u* as alternatives.

NOTE 2 When several distinctive forms of letter symbol exist, the most commonly used form is given first.

3.1.1

main terminal ratings

listed ratings cover the appropriate requirements of the blocking, conducting and switching quadrants

3.1.1.1

repetitive peak off-state voltage, V_{DRM}

rated maximum (peak) instantaneous voltage that may be applied in the off-state conditions including all $\square$ D.C. $\square$ and repetitive voltage components

3.1.1.2

repetitive peak on-state current, I_{TRM}

rated maximum (peak) value of $\square$ A.C. $\square$ power frequency on-state current of specified waveshape and frequency which may be applied continuously

3.1.1.3**non-repetitive peak on-state current, I_{TSM}**

rated maximum (peak) value of $\square$ A.C. $\square$ power frequency on-state surge current of specified waveshape and frequency which may be applied for a specified time or number of $\square$ A.C. $\square$ cycles

3.1.1.4**non-repetitive peak impulse current, I_{PPSM} , I_{TSM}**

rated maximum value of peak impulse current of specified amplitude and waveshape that may be applied

NOTE There are several symbols that are used for this rating. The merits of these symbols are as follows:

I_{PPSM} This is technically correct as it is the maximum or peak (M) non-repetitive (S) value of I_{PP} .

I_{TSM} For short duration impulses this is not technically correct as the maximum (M) value of non-repetitive (S) current may not occur when the device is in the on-state (T) condition.

I_{PPM} The use of this symbol for a non-repetitive value is discouraged. This symbol is the rated maximum (M) repetitive value of I_{PP} .

I_{PP} The use of this symbol for a rated value is discouraged. The term peak impulse current is a circuit parameter and is defined as the peak current for a series of essentially identical pulses.

3.1.1.5**repetitive peak reverse voltage, V_{RRM}**

rated maximum (peak) instantaneous voltage that may be applied in the reverse blocking direction including all $\square$ D.C. $\square$ and repetitive voltage components

3.1.1.6**non-repetitive peak forward current, I_{FSM}**

rated maximum (peak) value of $\square$ A.C. $\square$ power frequency forward surge current of specified waveshape and frequency which may be applied for a specified time or number of $\square$ A.C. $\square$ cycles

3.1.1.7**repetitive peak forward current, I_{FRM}**

rated maximum (peak) value of $\square$ A.C. $\square$ power frequency forward current of specified waveshape and frequency which may be applied continuously

3.1.1.8**critical rate of rise of on-state current, di/dt , $(di_T/dt)_{cr}$**

rated value of the rate of rise of current which the device can withstand without damage

3.1.2 Main terminal characteristics**3.1.2.1****off-state voltage, V_D**

$\square$ D.C. $\square$ voltage when the device is in the off-state

3.1.2.2**off-state current, I_D**

$\square$ D.C. $\square$ value of current that results from the application of the off-state voltage, V_D

3.1.2.3**repetitive peak off-state current, I_{DRM}**

maximum (peak) value of off-state current that results from the application of the repetitive peak off-state voltage, V_{DRM}

3.1.2.4

breakover voltage, $V_{(BO)}$

maximum voltage across the device in or at the breakdown region measured under specified voltage rate of rise and current rate of rise

NOTE Where a breakdown characteristic has several $V_{(BO)}$ values that need to be referenced, a numeric suffix can be added and the relevant part of the breakdown current range specified, e.g.

$$V_{(BO)1}, 0 < I_{(BR)} < 10 \text{ mA}$$

3.1.2.5

holding current, I_H

minimum anode, principal, or thyristor current that maintains the thyristor in the on-state

3.1.2.6

off-state capacitance, C_o , C_J

differential capacitance at the specified terminals in the off-state measured at specified frequency, f , amplitude, V_d and $\square$ D.C. $\square$ bias, V_D

3.1.2.7

repetitive peak reverse current, I_{RRM}

maximum (peak) value of reverse current that results from the application of the repetitive peak reverse voltage, V_{RRM}

3.1.2.8

peak forward recovery voltage, V_{FRM}

maximum value of forward conduction voltage across the device upon the application of a specified voltage rate of rise and current rate of rise following a zero or specified reverse-voltage condition

3.1.2.9

critical rate of rise of off-state voltage, dv/dt , $(dv_D/dt)_{cr}$

maximum rate of rise of voltage (below V_{DRM}) that does not cause switching from the off state to the on state

3.1.3 Additional and derived parameters

The following derived and measured parameters may be necessary or useful for comparison, certain applications or statistical process controls.

3.1.3.1

breakdown voltage, $V_{(BR)}$

voltage across the device in the breakdown region (prior to the switching point) at a specified breakdown current, $I_{(BR)}$

NOTE For positive breakdown slope devices, $V_{(BR)}$ may be used as an alternative to V_{DRM} .

3.1.3.2

breakdown current, $I_{(BR)}$

current through the device in the breakdown region

3.1.3.3

breakover current, $I_{(BO)}$

instantaneous current flowing at the breakover voltage, $V_{(BO)}$

3.1.3.4**switching voltage, V_S**

instantaneous voltage across the device at the final point in the breakdown region prior to switching into the on-state

3.1.3.5**switching current, I_S**

instantaneous current flowing through the device at the switching voltage, V_S

3.1.3.6**on-state voltage, V_T**

voltage across the device in the on-state condition at a specified current I_T

3.1.3.7**on-state current, I_T**

current through the device in the on-state condition

3.1.3.8**forward voltage, V_F**

voltage across the device in the forward conducting state at a specified current I_F

3.1.3.9**forward current, I_F**

current through the device in the forward conducting state

3.1.3.10**switching resistance, R_S**

derived equivalent slope resistance of the breakdown region, R_S , computed by:

$$(V_{(BO)} - V_S) / (I_S - I_{(BO)}) \quad (1)$$

3.1.3.11**insulation resistance**

derived equivalent insulation resistance of the device, computed by:

$$V_D / I_D \quad (2)$$

3.1.4 Temperature related parameters

All the semiconductor-related TSS parameters are temperature dependent. The need for temperature dependence information can often be removed by specifying that a parameter's maximum or minimum value should be valid over the intended operating temperature range. Some common temperature related terms are shown hereafter.

3.1.4.1**temperature coefficient of breakdown voltage, $\alpha V_{(BR)}$, $dV_{(BR)}/dT_J$**

ratio of the change in breakdown voltage, $V_{(BR)}$, to changes in temperature

NOTE Expressed as either $\square$ millivolt $\square$ per $\square$ kelvin $\square$ (mV/K) or per cent per $\square$ kelvin $\square$ (%/K) with reference to the 25 °C value of breakdown voltage. Alternatives to mV/K and %/K are mV/°C and %/°C.

3.1.4.2**variation of holding current with temperature**

change in holding current, I_H , with changes in temperature and shown as a graph

3.1.4.3

temperature derating

derating with temperature above a specified base temperature, expressed as a percentage, such as may be applied to peak pulse current

3.1.4.4

thermal resistance, R_{thJL} , R_{thJC} , R_{thJA} ($R_{\theta JL}$, $R_{\theta JC}$, $R_{\theta JA}$)

effective temperature rise per unit power dissipation of a designated junction, above the temperature of a stated external reference point (lead, case or ambient) under conditions of thermal equilibrium

NOTE Thermal resistance is usually expressed as K/W with °C/W as an alternative.

3.1.4.5

transient thermal impedance, $Z_{thJL(t)}$, $Z_{thJC(t)}$, $Z_{thJA(t)}$ ($Z_{\theta JL(t)}$, $Z_{\theta JC(t)}$, $Z_{\theta JA(t)}$)

change in the difference between the virtual junction temperature and the temperature of a specified reference point or region (lead, case, or ambient) at the end of a time interval, divided by the step function change in power dissipation at the beginning of the same time interval which causes the change of temperature difference

NOTE 1 Thermal impedance is usually expressed as K/W with °C/W as an alternative.

NOTE 2 It is the thermal impedance of the junction under conditions of change and is generally given in the form of a curve as a function of the duration of an applied power pulse.

3.1.4.6

(virtual) junction temperature, T_J , T_{VJ}

theoretical temperature representing the temperature of the junction(s) calculated on the basis of a simplified model of the thermal and electrical behaviour of the device

NOTE The term "virtual-junction temperature" is particularly applicable to multijunction semiconductors and is used to denote the temperature of the active semiconductor element when required in specifications and test methods. The term "junction temperature", T_J , is used interchangeably with the term "virtual junction temperature", T_{VJ} , in this standard.

3.1.4.7

maximum junction temperature, T_{JM}

maximum value of permissible junction temperature, due to self heating, which a TSS can withstand without degradation

3.1.4.8

storage temperature range, $T_{stg\min.}$ to $T_{stg\max.}$

temperature range over which the device can be stored without any voltage applied

NOTE Preferred temperature ranges (selected from IEC 60747-1, chapter VI, clause 5 and IEC 60749, chapter III, clause 1.2) are

0 °C to 125 °C

–55 °C to 125 °C

–65 °C to 150 °C

3.1.5 Gate terminal parameters

3.1.5.1

gate trigger current, I_{GT}

lowest gate current required to switch a device from the off-state to the on-state

3.1.5.2

gate trigger voltage, V_{GT}

gate voltage required to produce the gate trigger current, I_{GT}

3.1.5.3**gate-to-adjacent terminal peak off-state voltage,**

maximum gate to cathode voltage for a P-gate device or gate to anode voltage for an N-gate device that may be applied such that a specified off-state current, I_D , at a rated off-state voltage, V_D , is not exceeded

3.1.5.4**peak off-state gate current, I_{GDM}**

maximum gate current that results from the application of the peak off-state gate voltage, V_{GDM}

3.1.5.5**gate reverse current, adjacent terminal open, I_{GAO} , I_{GKO}**

current through the gate terminal when a specified gate bias voltage, V_G , is applied and the cathode terminal for a P-gate device or anode terminal for an N-gate device is open-circuited

3.1.5.6**gate reverse current, main terminals short-circuited, I_{GAS} , I_{GKS}**

current through the gate terminal when a specified gate bias voltage, V_G , is applied and the cathode terminal for a P-gate device or anode terminal for an N-gate device is short-circuited to the third terminal

NOTE This definition only applies to devices with integrated series gate blocking diodes.

3.1.5.7**gate reverse current, on-state, I_{GAT} , I_{GKT}**

current through the gate terminal when a specified gate bias voltage, V_G , is applied and a specified on-state current, I_T , is flowing

NOTE This definition only applies to devices with integrated series gate blocking diodes.

3.1.5.8**gate reverse current, forward conducting state, I_{GAF} , I_{GKF}**

current through the gate terminal when a specified gate bias voltage, V_G , is applied and a specified forward conduction current, I_F , is flowing

NOTE This definition only applies to conducting unidirectional devices with integrated series gate blocking diodes.

3.1.5.9**gate switching charge, Q_{GS}**

charge through the gate terminal, under impulse conditions, during the transition from the off-state to the switching point, when a specified gate bias voltage, V_G , is applied

3.1.5.10**peak gate switching current, I_{GSM}**

maximum value of current through the gate terminal during the transition from the off state to the switching point, when a specified gate bias voltage, V_G , is applied

3.1.5.11**gate-to-adjacent terminal breakover voltage, $V_{GK(BO)}$, $V_{GA(BO)}$**

gate-to-cathode voltage for a P-type device or gate to anode voltage for an N-gate device at the breakover point

NOTE This is equivalent to the voltage difference between the breakover voltage, $V_{(BO)}$, and the specified gate voltage, V_G .

3.2 Terms and definitions for TSS, terminals and characteristic terminology

3.2.1 TSS

3.2.1.1

asymmetrical bidirectional TSS

thyristor having substantially different switching behaviour in the first and third quadrants of the principal voltage-current characteristic

3.2.1.2

bidirectional TSS

thyristor having switching behaviour in the first and third quadrants of the principal voltage-current characteristic

3.2.1.3

forward-blocking TSS

TSS that switches only for negative main terminal-2 (cathode) voltage and exhibits a blocking state for positive main terminal-2 voltage

3.2.1.4

forward-conducting TSS

TSS that switches only for negative main terminal-2 (cathode) voltage and conducts large currents at positive main terminal-2 voltage comparable in magnitude to the on-state voltage

3.2.1.5

negative breakdown resistance TSS

TSS, whose static breakdown characteristic has a net negative resistance slope prior to switching

3.2.1.6

N-gate thyristor

gated thyristor in which the gate terminal is connected to the N-region adjacent to the P-region to which the anode is connected and that is normally switched to the on-state by applying a negative signal between the gate and anode terminals

3.2.1.7

P-gate thyristor

gated thyristor in which the gate terminal is connected to the P-region adjacent to the N-region to which the cathode is connected and that is normally switched to the on-state by applying a positive signal between the gate and cathode terminals

3.2.1.8

positive-breakdown-resistance TSS

TSS whose static breakdown characteristic has a net positive-resistance slope prior to switching

3.2.1.9

reverse-blocking TSS

TSS that exhibits a blocking state for positive cathode voltage

3.2.1.10

reverse-conducting TSS

TSS that exhibits a conducting state for positive cathode voltage

3.2.1.11

symmetrical bidirectional TSS

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

3.2.1.12

thyristor

bistable semiconductor device comprising three or more junctions that can be switched from the off state to the on state or vice versa, such switching occurring within at least one quadrant of the principal voltage-current characteristic

3.2.1.13

unidirectional TSS

TSS that has switching characteristics in only one quadrant of the principal voltage-current characteristic

3.2.2 Terminals

3.2.2.1

anode

electrode by which current enters the thyristor, when the thyristor is in the on-state with the gate open-circuited

[IEC 60747-6]

NOTE This term does not apply to bidirectional thyristors.

3.2.2.2

cathode

electrode by which current leaves the thyristor, when the thyristor is in the on-state with the gate open-circuited

NOTE This term does not apply to bidirectional thyristors.

3.2.2.3

gate

electrode connected to one of the semiconductor regions to introduce a control current

3.2.2.4

main terminals

the two terminals through which the principal current flows

NOTE The main terminals may be named by application usage, e.g. in telecommunications, terminals may be named after line connections: R (ring), T (tip) and G (ground) or A, B and C (common)

3.2.2.5

main terminal 1

main terminal that is named 1 by the device manufacturer

3.2.2.6

main terminal 2

main terminal that is named 2 by the device manufacturer

3.2.2.7

(electrical) terminal

externally available point of connection

3.2.3 Characteristic terminology

3.2.3.1

blocking

term describing the state of a semiconductor device or junction that imposes high resistance to the passage of current

3.2.3.2

breakdown

phenomena occurring in a reverse biased semiconductor junction, the initiation of which is observed as a transition from a region of high dynamic resistance to a region of substantially lower dynamic resistance for increasing magnitude of reverse current

3.2.3.3

breakdown region

portion of the characteristic that starts with the transition from the high dynamic resistance off-state to a substantially lower dynamic resistance and extending to the switching point

3.2.3.4

breakover point

any point in the breakdown region voltage-current characteristic for which the differential resistance is zero and where the principal voltage reaches a maximum value

[IEC 60747-6, definition 2.16, modified]

NOTE If more than one breakover point exists in the breakdown region, the one with the highest voltage value is characterized.

3.2.3.5

characteristic

inherent and measurable property of a device

NOTE Such a property may be electrical, mechanical, thermal, hydraulic, electromagnetic or nuclear and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

3.2.3.6

clipping (clamping)

form of limiting in which all the instantaneous values of a signal exceeding a predetermined threshold value are reduced to values close to that of the threshold, all other instantaneous values of the signal being preserved

[IEV 702-04-33]

NOTE The word *clamping* is often used instead of *clipping*, although IEC 702-04-37 defines clamping as "a process in which some feature of a recurrent signal, for instance its $\langle \text{C} \rangle$ D.C. $\langle \text{C} \rangle$ component, is held at a reference value".

3.2.3.7

crowbarring

form of limiting whereby when the instantaneous value of a signal becomes greater than a predetermined threshold value a low impedance shunt is activated. When active, the shunt, in conjunction with the signal source impedance, reduces the signal amplitude

3.2.3.8

forward/reverse blocking quadrant

quadrant of the principal voltage-current characteristic in which the device exhibits a reverse blocking state

[IEC 60747-6, modified]

NOTE This will be the first quadrant for a forward blocking TSS and the third quadrant for a reverse blocking TSS.

3.2.3.9**forward/reverse conducting quadrant**

quadrant of the principal voltage-current characteristic in which the device exhibits a forward direction conduction state

[IEC 60747-6, modified]

NOTE This will be the first quadrant for a forward conducting TSS and the third quadrant for a reverse conducting TSS.

3.2.3.10**forward direction**

- 1) direction of current in a P-N junction that results when the P-type semiconductor region is at a positive potential relative to the N-type region
- 2) direction of current in a semiconductor device that results when the P-type semiconductor region connected to one terminal is at a positive potential relative to the N-type region connected to the other terminal

NOTE This definition does not apply if one or more junctions are connected in series with at least one other junction whose P and N regions are reversed.

3.2.3.11**maximum rating (absolute maximum rating)**

rating that establishes either a limiting capability or a limiting condition beyond which damage to the device may occur

NOTE A limiting condition may be either a maximum or a minimum.

3.2.3.12**negative differential-resistance (region)**

region of the principal voltage-current characteristic in the switching quadrant where the differential resistance is negative and the thyristor switches between the breakdown and on-state regions

[IEC 60747-6, modified]

3.2.3.13**non-repetitive current rating**

maximum rating that may be applied to the device for a minimum of 100 times over the life of the device without failure

NOTE During the rated condition, the device is permitted to exceed its maximum rated junction temperature for short periods of time. The device is not required to block voltage or retain any gate control during or immediately following this rated condition until the device has returned to the original equilibrium conditions. This rated condition may be repeated after the device has returned to the original thermal equilibrium conditions.

3.2.3.14**off state (region)**

state of the TSS in a quadrant in which switching can occur, that corresponds to the high dynamic-resistance portion of the characteristic between the origin and the beginning of the breakdown region

[IEC 60747-6, modified]

3.2.3.15**on state (region)**

condition of the TSS corresponding to the low-resistance low-voltage portion of the principal voltage-current characteristic in the switching quadrant(s)

3.2.3.16**parameter**

device descriptor that is measurable or quantifiable, such as a characteristic or rating

3.2.3.17

principal current

generic term for the current through the device excluding any gate current

NOTE It is the current through both main terminals.

3.2.3.18

principal voltage

voltage between the main terminals

NOTE 1 In the case of reverse blocking and reverse conducting thyristors, the principal voltage is called positive when the anode potential is higher than the cathode potential, and called negative when the anode potential is lower than the cathode potential.

NOTE 2 For bidirectional thyristors, the principal voltage is called positive when the potential of main terminal 2 is higher than the potential of main terminal 1.

NOTE 3 For forward-conducting thyristors the principal voltage is called positive when the cathode potential is higher than the anode potential, and called negative when the cathode potential is lower than the anode potential.

3.2.3.19

principal voltage-current characteristic (principal characteristic)

function, usually represented graphically, relating the principal voltage to the principal current

3.2.3.20

quadrant

when the principal voltage-current characteristic is expressed graphically, the voltage, v , and current, i , axes create four areas called quadrants. These quadrants are termed counter clockwise as first, second, third and forth quadrants. The characteristic occurs in the first quadrant, $+v$ and $+i$, and the third quadrant, $-v$ and $-i$

3.2.3.21

rating

nominal value of any electrical, thermal, mechanical, or environmental quantity assigned to define the operating conditions under which a component, machine, apparatus, electronic device, etc., is expected to give satisfactory service

NOTE 'Rating' is a generic term. See also **maximum rating** (3.2.3.11).

3.2.3.22

repetitive rating

maximum rating that may be continuously applied to the thyristor

3.2.3.23

reverse direction

- 1) direction of current in a P-N junction that results when the N-type semiconductor region is at a positive potential relative to the P-type region
- 2) direction of current in a semiconductor device that results when the N-type semiconductor region connected to one terminal is at a positive potential relative to the P-type region connected to the other terminal

NOTE This definition may not apply if one or more junctions are connected in series with at least one other junction whose P and N regions are reversed.

3.2.3.24

switching point

point in the principal voltage-current characteristic at which the thyristor regenerates and initiates switching into the on-state

NOTE This point occurs at the termination of the breakdown region and the start of the negative differential-resistance region

3.2.3.25 switching quadrant

quadrant of the principal voltage-current characteristic in which the device is intended to switch between the off-state and the on-state

NOTE For a bidirectional thyristor the switching quadrants are the first quadrant and the third quadrant. For a reverse blocking or reverse conducting thyristor the switching quadrant is the first quadrant. For a forward conducting or reverse conducting thyristor the switching quadrant is the third quadrant.

4 Basic function and component description

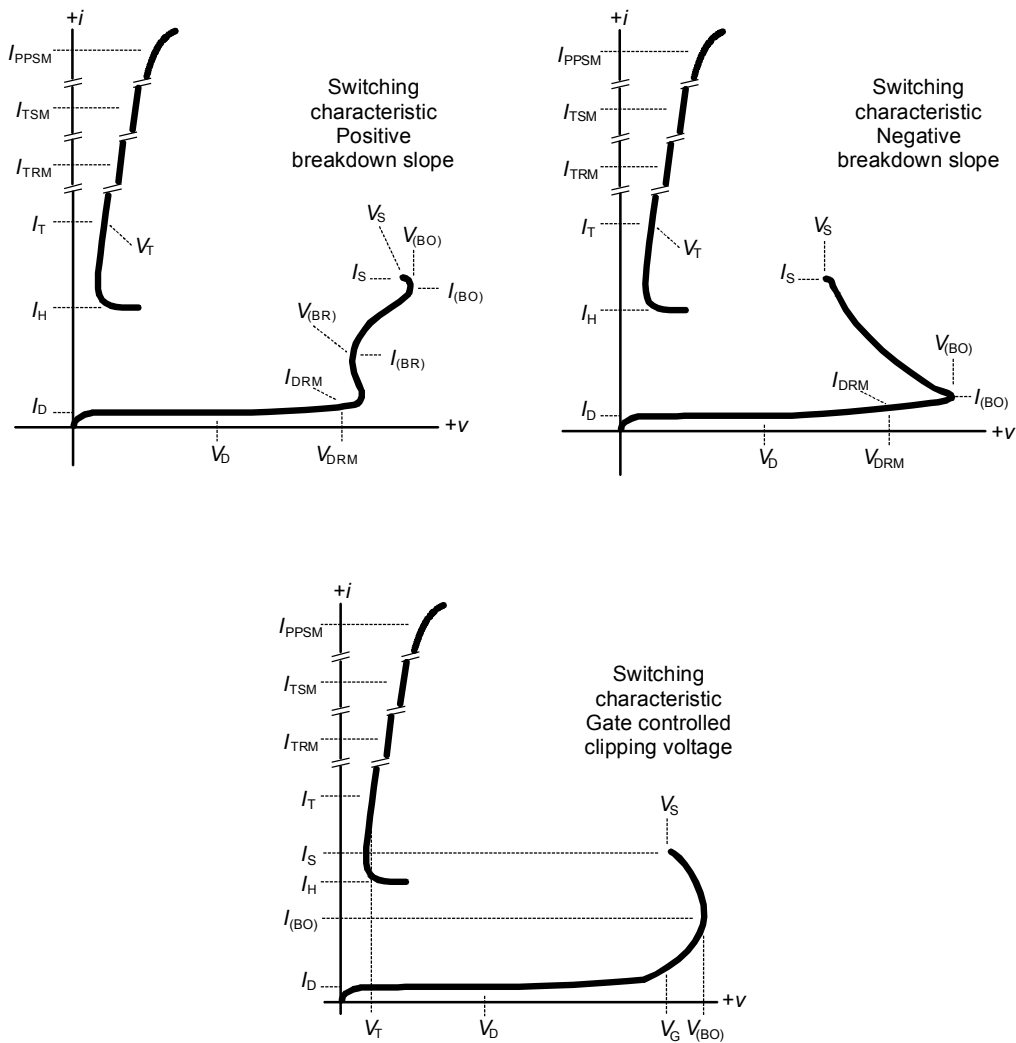
This clause covers the TSS types, basic device structure, its equivalent circuit, characteristic values, operational parameters and structures with increased functions.

4.1 TSS types

The TSS is classified by the type of characteristic in the first and third quadrants), and the number of terminals. At least one quadrant will have a switching characteristic (see figure 1). The other quadrant may have a switching, blocking or diode conduction characteristic (see figures 1 and 2). Devices with only one switching quadrant are called unidirectional and may have two (diode), three (triode) or four (tetrode) terminals. In addition, devices with two switching quadrants are called bidirectional and may have up to five (pentode) terminals (see table 1).

Table 1 – Types of TSS

Number of terminals	Other quadrant characteristics		
	Blocking	Conducting	Switching
2 (diode)	Reverse blocking or forward blocking diode TSS	Reverse conducting or forward conducting diode TSS	Bidirectional diode TSS
3 (triode)	Reverse blocking or forward blocking triode TSS P-gate or N-gate	Reverse conducting or forward conducting triode TSS P-gate or N-gate	Bidirectional triode TSS P-gate or N-gate or combined P-gate and N-gate (TRIAC)
4 (tetrode)	Reverse blocking or forward blocking tetrode TSS P-gate and N-gate	Reverse conducting or forward conducting tetrode TSS P-gate and N-gate	Bidirectional tetrode TSS 2 gates
5 (pentode)			Bidirectional pentode TSS 3 gates



IEC 1898/01

Figure 1 – Switching characteristics