

JEDEC STANDARD

Transient Voltage Suppressor Standard for Thyristor Surge Protective Device Rating Verification and Characteristic Testing

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ELECTRONIC INDUSTRIES ALLIANCE

JEDEC Solid State Technology Association



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TRANSIENT VOLTAGE SUPPRESSOR STANDARD FOR THYRISTOR SURGE PROTECTIVE DEVICE RATING VERIFICATION AND CHARACTERISTIC TESTING

CONTENTS

	Page
Foreword	v
1 Introduction	1
2 Scope	1
3 Device definition	1
3.1 Thyristor surge protective device (TSPD)	1
3.1.1 Off state of a TSPD	1
3.1.2 Breakdown region of a TSPD	2
3.1.3 On state of a TSPD	2
3.2 Classes of thyristor surge protective devices	3
3.2.1 Forward-conducting diode TSPD	3
3.2.2 Forward-conducting triode TSPD	4
3.2.3 Reverse-blocking diode TSPD	4
3.2.4 Reverse-blocking triode TSPD	5
3.2.5 Bidirectional TSPD	5
3.2.6 Unidirectional TSPD	5
3.2.7 Negative-breakdown-resistance TSPD	5
3.2.8 Positive-breakdown-resistance TSPD	6
3.3 Definitions of characteristics, rating, and parameter	6
3.3.1 Characteristic	6
3.3.2 Rating	6
3.3.3 Parameter	7
3.4 Thyristor surge protective device parameters	7
3.4.1 Electrical parameters applicable to all device types	8
3.4.2 Thermal parameters applicable to all device types	10
3.4.3 Additional electrical parameters for positive-breakdown-resistance types	12
3.4.4 Additional parameters for negative-breakdown-resistance types	13
3.4.5 Additional parameters for reverse-blocking types	15
3.4.6 Additional parameters for forward-conducting types	15
3.4.7 Additional parameters for triode, gate accessible device types	16
3.4.8 Common telecommunications impulse waveform definitions	18
4 Rating verification tests	19
4.1 Maximum repetitive off-state voltage (V_{DRM})	19
4.1.1 Introduction (V_{DRM})	19
4.1.2 Test method (V_{DRM})	19
4.2 Nonrepetitive on-state surge current (I_{TSM})	21

TRANSIENT VOLTAGE SUPPRESSOR STANDARD FOR THYRISTOR SURGE PROTECTIVE DEVICE RATING VERIFICATION AND CHARACTERISTIC TESTING

CONTENTS *(continued)*

	page
4.2.1 Introduction (I_{TSM})	21
4.2.2 Test method for I_{TSM}	22
4.3 Nonrepetitive peak impulse current (I_{PPS})	23
4.3.1 Introduction (I_{PPS})	23
4.3.2 Test method for I_{PPS} testing	23
5 Characteristic tests	26
5.1 Off-state current (I_D) testing	26
5.1.1 I_D test method	26
5.1.2 Reverse gate current test, adjacent terminal open (triodes), I_{GAO} , I_{GKO}	27
5.1.3 Reverse gate current test, adjacent terminal shorted (triodes), I_{GAS} , I_{GKS}	28
5.1.4 On-state reverse gate current test (triodes), I_{GAT} , I_{GKT}	29
5.1.5 Forward-conducting state reverse gate current test, (triodes), I_{GAF} , I_{GKF}	30
5.1.6 Peak off-state gate current test for triode devices (I_{GDM})	31
5.2 Breakover voltage $V_{(BO)}$ testing	32
5.2.1 AC $V_{(BO)}$ test method (all device types)	32
5.2.2 Impulse $V_{(BO)}$ test method (all device types)	35
5.3 Breakover current ($I_{(BO)}$) testing	37
5.3.1 AC $I_{(BO)}$ test method (positive resistance types)	37
5.3.2 Impulse $I_{(BO)}$ test method (all device types)	39
5.4 Gate switching current (I_{GSM}) and charge (Q_{GS}) testing	40
5.4.1 Gate switching current (I_{GSM}) test method, triode types	40
5.4.2 Gate switching current (Q_{GS}) test method, triode types	42
5.5 Holding current (I_H) testing	43
5.5.1 I_H test circuit (impulse method)	45
5.5.2 I_H test circuit (ramp method)	46
5.6 On-state voltage (V_T) testing	47
5.6.1 Pulsed dc on-state voltage (V_T) test method	48
5.6.2 Impulse on-state voltage (V_T) test method	49
5.6.3 AC on-state voltage (V_T) test method	50
5.7 Off-state capacitance (C_O) testing	52
5.7.1 Two terminal TSPD capacitance (C_O) test method	53
5.7.2 DC voltage-biased multi-terminal TSPD capacitance (C_O) test method	55
5.8 Critical rate of rise of off-state voltage (dv/dt) test	56
5.8.1 Description (dv/dt)	56
5.8.2 Test method (dv/dt)	59
5.9 Critical rate of rise of on-state current (di/dt)	60
5.9.1 Description (di/dt)	60
5.9.2 Test method (di/dt)	61
5.10 Peak forward recovery voltage (V_{FRM}) test	63

TRANSIENT VOLTAGE SUPPRESSOR STANDARD FOR THYRISTOR SURGE PROTECTIVE DEVICE RATING VERIFICATION AND CHARACTERISTIC TESTING

CONTENTS (continued)

	page
5.10.1 Description (V_{FRM})	63
5.10.2 Test method (V_{FRM})	65
 Figures	
1 Symbols and terms for a forward-conducting positive-breakdown-resistance TSPD	2
2 Symbols and terms for a forward-conducting negative-breakdown-resistance TSPD	3
3 Symbols and terms for a gated TSPD	4
4 Symbols and terms for a reverse-blocking negative-breakdown-resistance TSPD	5
5 Symbols and terms for a reverse-blocking positive-breakdown-resistance TSPD	6
6 Bidirectional negative-breakdown-resistance TSPD	7
7 Symbols and terms for a bidirectional positive-breakdown-resistance TSPD	8
8 Maximum repetitive off-state voltage (V_{DRM}) test circuit	10
9 Example of current wave, I_{TSM} test	12
10 Nonrepetitive peak on-state surge current (I_{TSM}) test	13
11 Definition of double exponential impulse current waveform	14
12 Definition of double exponential impulse voltage waveform	14
13 Measurement of impulse $V_{(BO)}$, $I_{(BO)}$, and I_{PPS} : Example of a pulse forming network	16
14 Off-state current test circuit	18
15 P-gate reverse current, cathode terminal open test circuit	25
16 N-gate reverse current, anode terminal open test circuit	28
17 P-gate reverse current, cathode terminal shorted test circuit	29
18 N-gate reverse current, cathode terminal shorted test circuit	30
19 P-gate reverse current, on-state test circuit	31
20 N-gate reverse current, on-state test circuit	32
21 P-gate reverse current, forward-conducting state test circuit	34
22 N-gate reverse current, forward-conducting state test circuit	39
23 P-gate-to-cathode terminal peak off-state voltage test, peak off-state p-gate current test circuit	42
24 N-gate-to-anode terminal peak off-state voltage test, peak off-state n-gate current test circuit	44
25 AC $V_{(BO)}$ test circuit	46
26 Impulse $V_{(BO)}$, $I_{(BO)}$ test waveform	48
27 P-gate switching Q, I, and gate-to-cathode breakover voltage test circuit	49
28 N-gate switching Q, I, and gate-to-anode breakover voltage test	50
29 Impulse method test circuit for I_H verification	51
30 Test circuit for ramp down method of I_H measurement	52
31 I_H versus turn-off load line	54
32 Pulsed on-state voltage test	54
33 Impulse on-state voltage measurement	56
34 Single power source on-state voltage test	57
35 AC on-state voltage measurement	57
36 Capacitance measurement circuit	58
37 Capacitance measurement with external dc voltage bias	58

TRANSIENT VOLTAGE SUPPRESSOR STANDARD FOR THYRISTOR SURGE PROTECTIVE DEVICE RATING VERIFICATION AND CHARACTERISTIC TESTING

CONTENTS *(continued)*

	page
Figures <i>(continued)</i>	
38 Multi-terminal device capacitance measurement circuit	59
39 dv/dt test voltage waveform (exponential waveform)	62
40 dv/dt test voltage waveform (linear waveform)	63
41 Simplified exponential dv/dt test circuit	64
42 Simplified linear dv/dt test circuit	64
43 di/dt test circuit	66
44 Surge generator for di/dt test	66
45 di/dt test waveforms	67
46 Peak forward recovery voltage (V_{FRM}) waveforms	67
Tables	
1 Electrical parameters applicable to TSPDs	9
2 TSPD thermal parameters	11
3 Electrical parameters for positive-breakdown-resistance TSPDs	12
4 Electrical parameters for negative-breakdown-resistance TSPDs	13
5 Reverse-blocking TSPD parameters	15
6 Parameters for forward-conducting TSPDs	15
7 Additional parameters for gated TSPDs	17
8 Common impulse waveshape definitions	18

Foreword

This standard was prepared by JEDEC JC-22.5 Committee on Transient Voltage Suppressors. The intended users of this standard are those interested in Thyristor Surge Protective Device characterization and rating verification. These devices are used primarily by the telecommunications industry to protect circuits from harmful overvoltages.

Major contributions to the content of this standard come from recent work by the ANSI/IEEE in PC62.37, 1996 Standard Test Specification For Thyristor Diode Surge-Protective Devices, and from the JC-10 Committee in-process work on revisions to Standard No. 77, Terms, Definitions, and Letter Symbols for Discrete Semiconductor and Optoelectronic Devices, Section 7 - Transient Voltage Suppressors; Surge Protective Devices. Similar standards are presently being developed by the IEC.

This standard conforms with the work of other groups. However, work on this standard, and the others in-process has not progressed to the point where an exact and complete comparison of documents can be made.

TRANSIENT VOLTAGE SUPPRESSOR STANDARD FOR THYRISTOR SURGE PROTECTIVE DEVICE RATING VERIFICATION AND CHARACTERISTIC TESTING

(From JEDEC Board Ballot JCB-97-81, formulated under the cognizance of the JC-22.5 Committee on Transient Voltage Suppressors.)

1 Introduction

The Thyristor Surge Protective Device (TSPD) is a semiconductor device that is recently finding widespread application in the telecommunications industry. The intent of this standard is to provide information on test methods that will reduce the possibility of disagreement and misunderstanding between TSPD vendors and users, and facilitate the determination of device interchangeability. This publication is not intended to preclude or discourage other approaches that similarly represent good engineering practice, or that may be acceptable to, or have been accepted by, appropriate bodies. Parties who wish to bring other approaches to the attention of the formulating committee to be considered for inclusion in future revisions of this publication are encouraged to do so. It is the intention of the formulating committee to revise and update this publication from time to time as may be occasioned by changes in technology, industry practice, or government regulations, or for other appropriate reasons.

2 Scope

This standard is applicable to Thyristor Surge Protective Devices. It describes terms and definitions and explains methods for verifying device ratings and measuring device characteristics.

3 Device definitions

3.1 Thyristor surge protective device (TSPD)

A thyristor, designed for transient voltage suppression in telecommunication, data line, and similar applications. They limit voltage transients by conducting surge currents. It returns to a blocking state when the current decays below a critical value.

NOTE — The device is also known as a thyristor surge suppressor (TSS).

3.1.1 Off state of a TSPD

The state of a TSPD, 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.

3.1 Thyristor surge protective device (TSPD) (cont'd)

3.1.2 Breakdown region of a TSPD

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

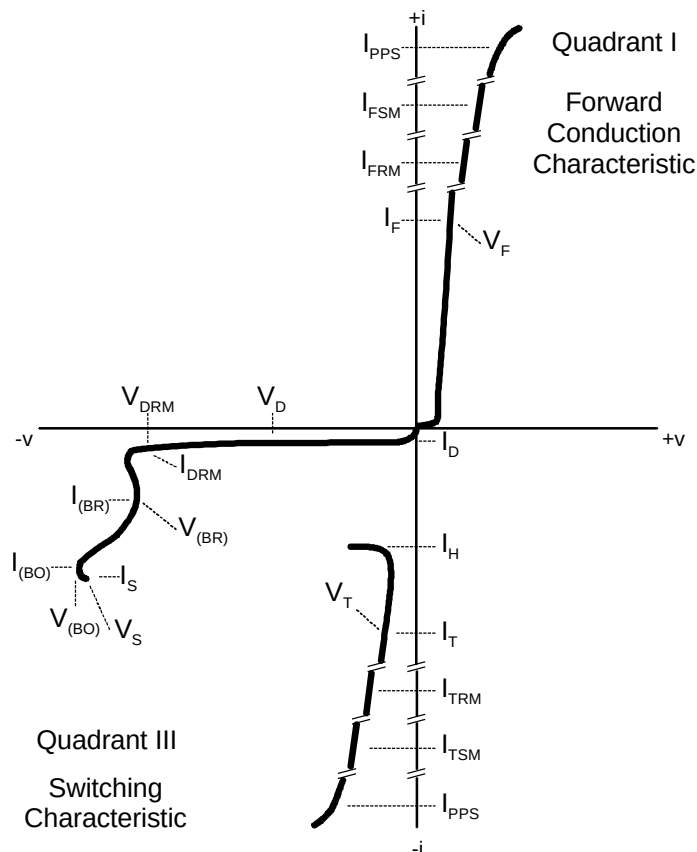


Figure 1 — Symbols and terms for a forward-conducting positive-breakdown-resistance TSPD

3.1.3 On state of a TSPD

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

3.2 Classes of thyristor surge protective devices

3.2.1 Forward-conducting diode TSPD

A two-terminal internally triggered TSPD that switches only for negative cathode voltage and conducts large currents at positive cathode voltages comparable in magnitude to the on-state voltage (see figures 1 and 2).

NOTES

- 1 In conventional SCR thyristor terminology, where the voltage is applied to the anode, this device would be called a reverse-conducting diode thyristor.
- 2 When the TSPD cathode is positive, the device characteristics are similar to those of a forward-biased diode.
- 3 When the TSPD cathode is negative, the device characteristics are similar to those of a breakover-triggered SCR thyristor.

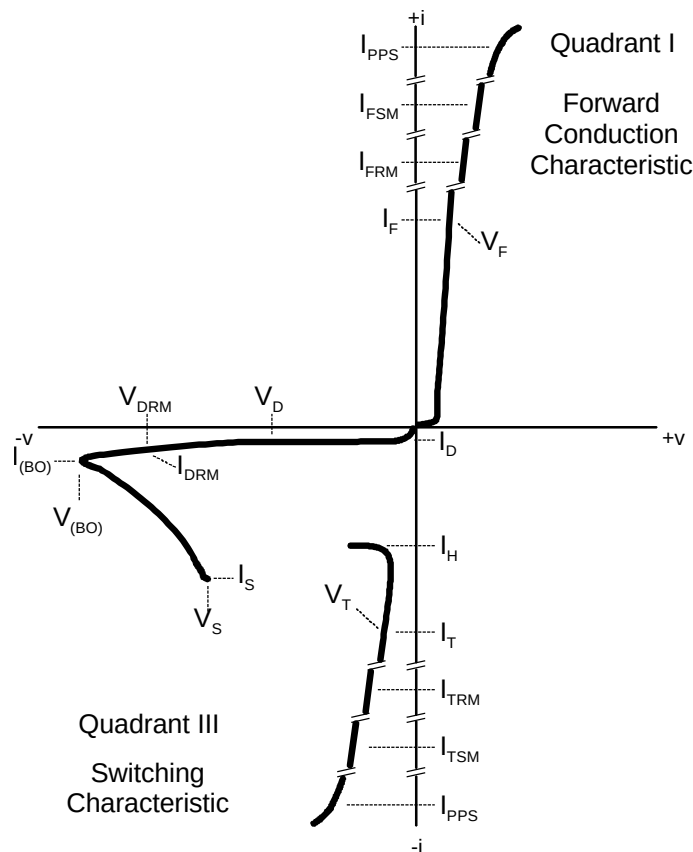


Figure 2 — Symbols and terms for a forward-conducting negative-breakdown-resistance TSPD

3.2 Classes of thyristor surge protective devices (cont'd)

3.2.2 Forward-conducting triode TSPD

A three-terminal TSPD that switches only for negative cathode voltage and conducts large currents at positive cathode voltages comparable in magnitude to the on-state voltage. Figure 3 shows the characteristic applicable to the switching quadrant of gated devices.

NOTES

- 1 In conventional SCR thyristor terminology, where the cathode is the common terminal, this device would be called a reverse-conducting triode thyristor.
- 2 Application of an appropriate fixed gate voltage allows switching to take place at voltages below the intrinsic breakover value.

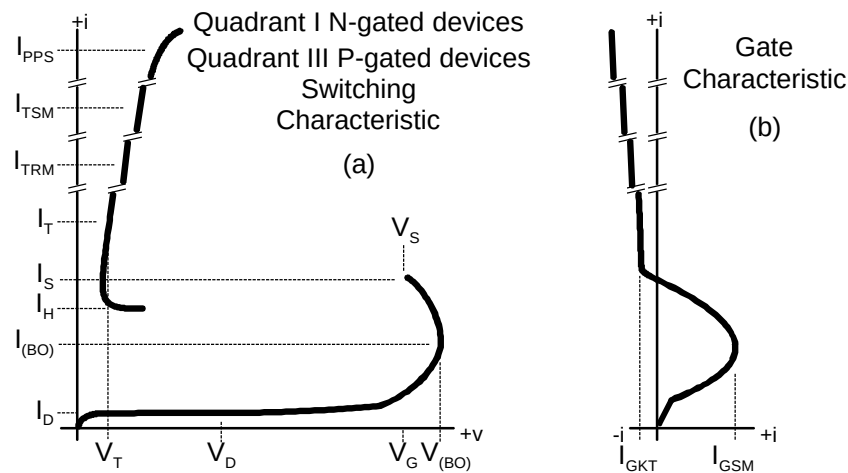


Figure 3 — Symbols and terms for a gated TSPD

3.2.3 Reverse-blocking diode TSPD

A two-terminal TSPD that exhibits a blocking state for positive cathode voltage. Figures 4 and 5 illustrate the device characteristic.

3.2 Classes of thyristor surge protective devices (cont'd)

3.2.4 Reverse-blocking triode TSPD

A three-terminal (gated) TSPD that exhibits a blocking state for positive cathode voltage. Figures 4 and 5 illustrate the device characteristic in quadrant three only.

3.2.5 Bidirectional TSPD

A TSPD having switching characteristics in the first and third quadrants. Figures 6 and 7 show the characteristic for this type device.

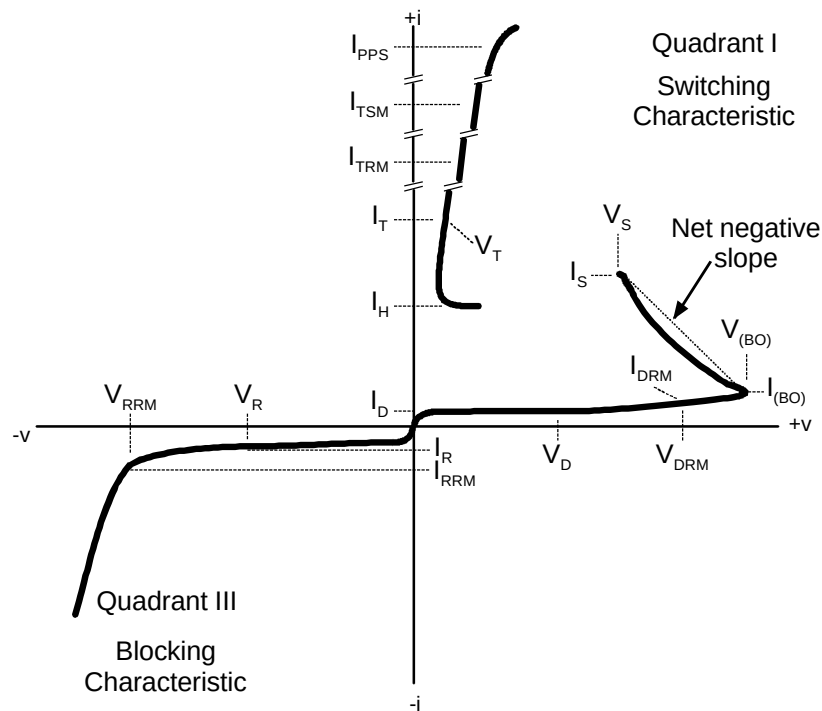


Figure 4 — Symbols and terms for a reverse-blocking negative-breakdown-resistance TSPD

3.2.6 Unidirectional TSPD

A TSPD that can switch in only one quadrant.

NOTE — There are two types: forward-conducting TSPDs and reverse-blocking TSPDs.

3.2.7 Negative-breakdown-resistance TSPD

A TSPD whose static characteristic has a negative-resistance slope between the breakover point ($V_{(BO)}$, $I_{(BO)}$) and a higher-current, lower-voltage point (V_S , I_S) at which switching occurs. Any of the device types described in 3.2.1 – 3.2.6 can have negative-breakdown resistance in the quadrants where switching occurs. Figures 2, 4, and 6 show devices with negative-breakdown resistance.

3.2 Classes of thyristor surge protective devices (cont'd)

3.2.8 Positive-breakdown-resistance TSPD

A TSPD whose static characteristic has a positive-resistance slope between the breakover point ($V_{(BR)}$, $I_{(BR)}$) and a higher-current, higher-voltage point (V_S , I_S) at which switching occurs. Any of the device types described in 3.2.1 – 3.2.6 can have positive-breakdown resistance in the quadrants where switching occurs. Figures 1, 3, 5, and 7 show devices with positive-breakdown resistance.

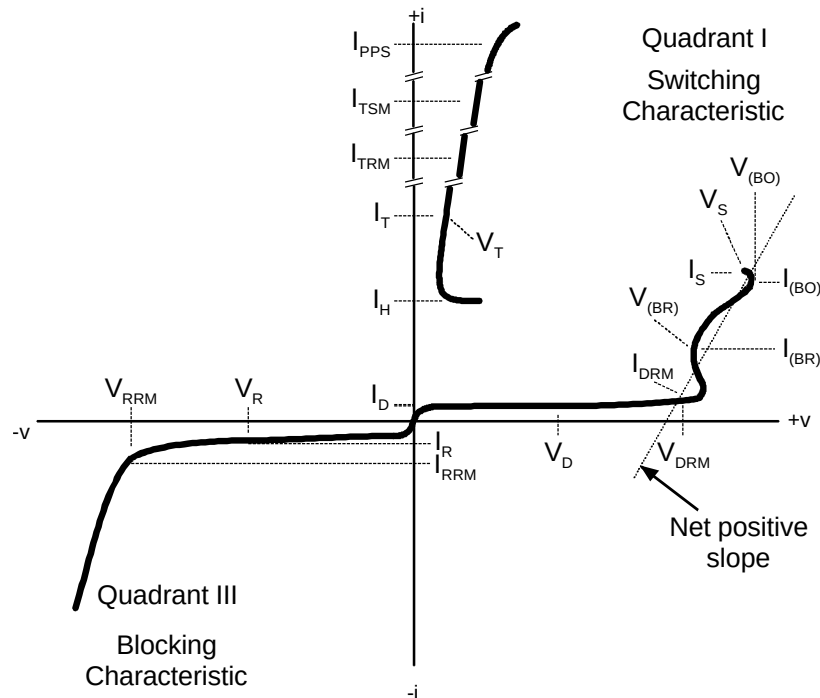


Figure 5 — Symbols and terms for a reverse-blocking positive-breakdown-resistance TSPD

3.3 Definitions of characteristic, rating, and parameter

The following definitions are offered to aid the reader in understanding the terms presented.

3.3.1 Characteristic

A characteristic is an inherent and measurable property of a device. It can be expressed as a value for stated or recognized conditions. A characteristic also may be a set of related values, usually shown in graphical form.

3.3.2 Rating

A rating is a value establishing either a limiting capability or limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms. Limiting conditions may either be maxima or minima.

3.3 Definitions of characteristic, rating, and parameter (cont'd)

3.3.3 Parameter

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

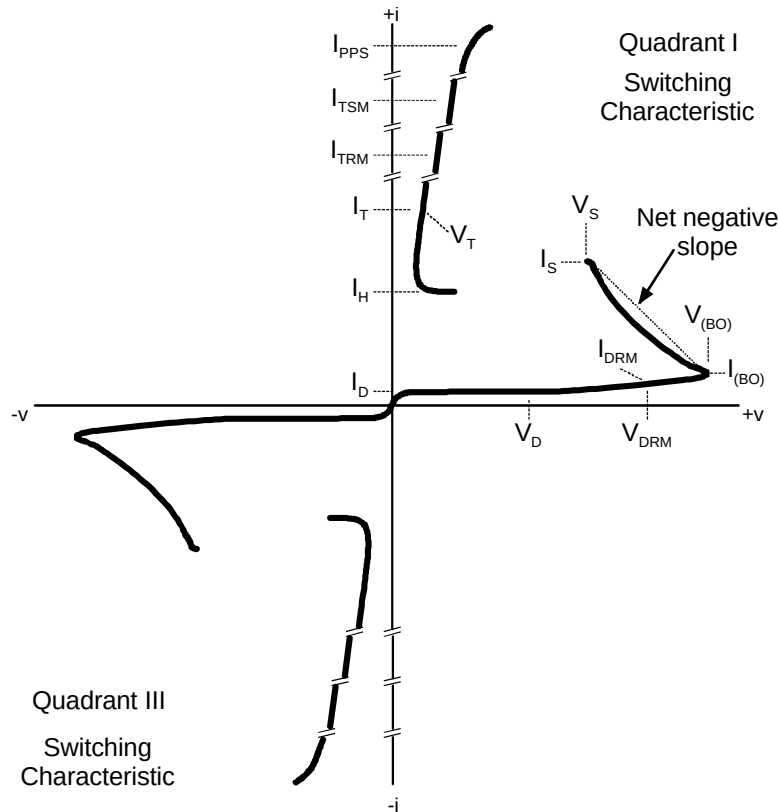


Figure 6 — Bidirectional negative-breakdown-resistance TSPD

3.4 Thyristor surge protective device parameters

The manufacturer establishes the values of device parameters according to statistical acceptance criteria. The specified tests are performed at nominal 25 °C ambient temperature unless otherwise stated. If the volt-ampere characteristics are asymmetrical, the characteristic values shall be specified for each (V,I) graph as illustrated in figures 1 – 7.

For the method of defining impulse waveforms, see figures 11 and 12 of this standard. For voltage waves with wavefront duration less than 30 μ s, the virtual duration of the impulse wavefront is 1.67 times the time for the voltage to increase from 30% to 90% of its crest value. For voltage waves with wavefront duration of 30 μ s or more, it is the time taken by the voltage to increase from actual zero to maximum crest value. For current waves, the virtual wavefront duration is 1.25 times the time for the current to increase from 10% to 90% of crest value.

The ac power frequency is the operating frequency of the ac power distribution system, which is often 50 or 60 Hz but can range up to 420 Hz.

3.4 Thyristor surge protective device parameters (cont'd)

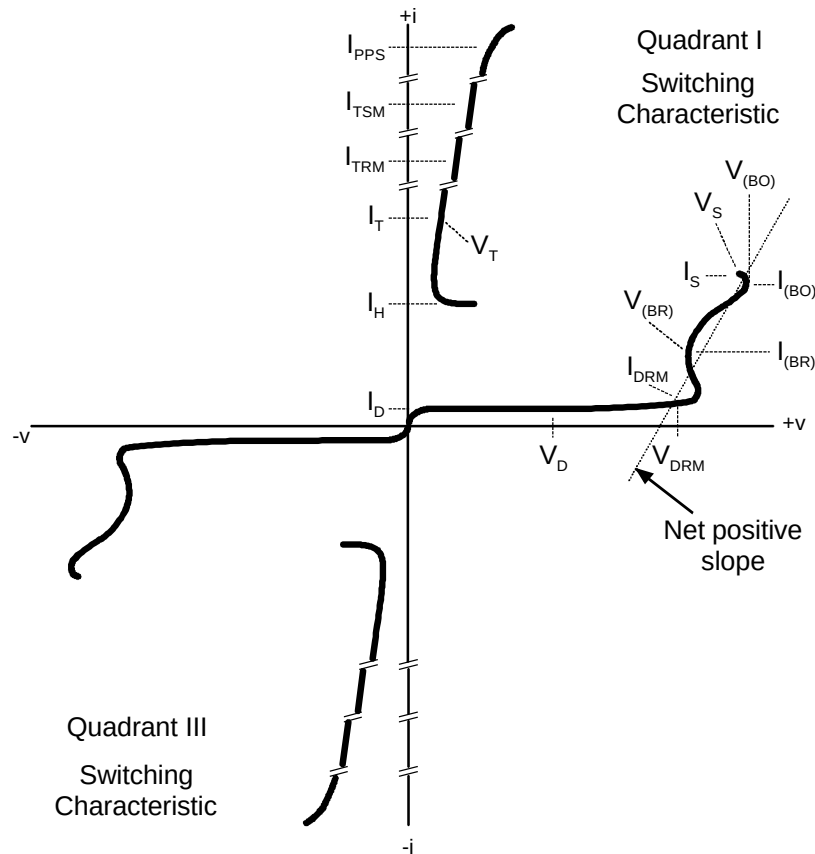


Figure 7 — Symbols and terms for a bidirectional positive-breakdown-resistance TSPD

3.4.1 Electrical parameters applicable to all device types

The parameters described in table 1 apply to all TSPDs (regardless of whether they are bidirectional, unidirectional, symmetrical, asymmetrical, reverse blocking, forward conducting, or any permutation or combination of the former) in their switching quadrant or quadrants.

3.4 Thyristor surge protective device parameters (cont'd)

3.4.1 Electrical parameters applicable to all device types (cont'd)

Table 1 — Electrical parameters applicable to all TSPDs

Term and description	Symbol	Reference
(1) Off-State Voltage. The principal voltage when the thyristor is in the off state.	V_D	Fig. 1 -7
(2) Off-State Current. The principal current when the thyristor is in the off state.	I_D	Fig. 1 -7
(3) Repetitive Peak Off-State Voltage. The highest instantaneous value of the off-state voltage, including all repetitive transient voltages but excluding all nonrepetitive transient voltages.	V_{DRM}	Fig. 1 and 2, 47
(4) Maximum Off-State Current. The maximum (peak) instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage.	I_{DRM}	Fig. 1 and 2, 47
(5) Breakover Voltage. The maximum voltage in the breakdown region.	$V_{(BO)}$	Fig. 1 -7
(6) Breakover Current. The principal current at the thyristor breakover voltage.	$I_{(BO)}$	Fig. 1 -7
(7) On-State Voltage. The principal voltage when the thyristor is in the on state.	V_T	Fig. 1 -7
(8) On-State Current. The principal current when the thyristor is in the on state.	I_T	Fig. 1 -7
(9) Repetitive Peak On-State Current. Rated maximum (peak) value of on-state current of specified waveshape and frequency which may be applied continuously.	I_{TRM}	Fig. 1 -7
(10) Nonrepetitive Peak On-State Current. The maximum (peak) value of on-state surge current of specified waveform, frequency, and duration or number of cycles.	I_{TSM}	Fig. 1 -7
(11) Nonrepetitive Peak Pulse Current. Rated maximum value of peak impulse pulse current of specified amplitude and waveform.	I_{PPS}	Fig. 1 -7
(12) Holding Current. The minimum, principal, or thyristor current that will maintain the thyristor in the on state.	I_H	Fig. 1 -7
(13) Off-State Capacitance. The capacitance in the off state.	C_O	
(14) Critical Rate of Rise of Off-State Voltage. The maximum rate of rise of voltage (less than or equal to V_{DRM}) that will not cause switching from the off state to the on state.	dv/dt	Fig. 39 -40
(15) Critical Rate of Rise of On-State Current. Rated value of the rate of rise of current which the device can withstand without damage.	di/dt	Fig. 45

3.4 Thyristor surge protective device parameters (cont'd)

3.4.1 Electrical parameters applicable to all device types (cont'd)

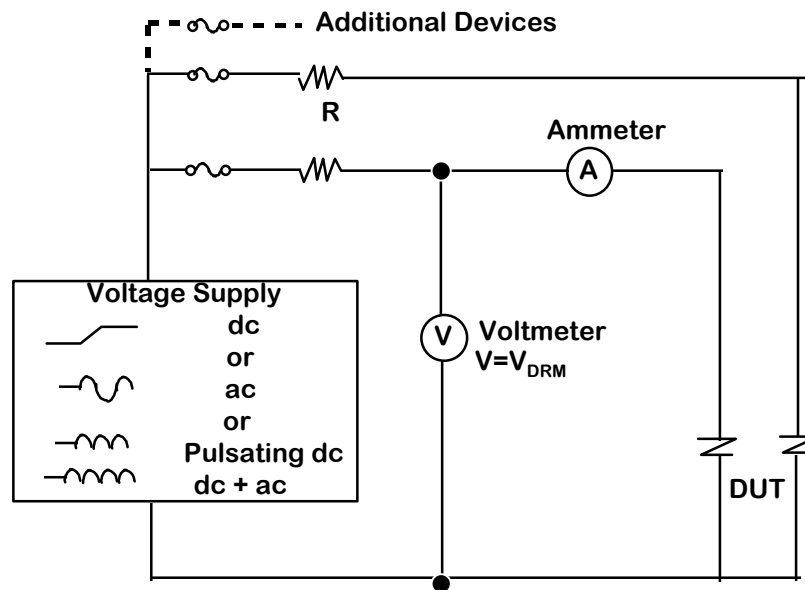


Figure 8 — Maximum repetitive off-state voltage (V_{DRM}) test circuit

3.4.2 Thermal parameters applicable to all device types

TSPD parameters often depend on temperature. Different temperatures may arise as a result of ambient conditions or because of power dissipation in the TSPD. Table 2 gives common parameters useful for thermal characterization of all TSPDs.

3.4 Thyristor surge protective device parameters (cont'd)

3.4.2 Thermal parameters applicable to all device types (cont'd)

Table 2 — TSPD thermal parameters

Term and description	Symbol	Unit
(1) Thermal Resistance. The 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.	$R_{\theta JL}$ $R_{\theta JC}$ $R_{\theta JA}$	$^{\circ}\text{C}/\text{W}$ (K/W)
(2) Transient Thermal Impedance. The 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 during the same time interval which causes the change of temperature difference. NOTE — It is the thermal impedance of the junction under conditions of changing time, and is generally given in the form of a curve as a function of the duration of an applied pulse.	$Z_{\theta JL(t)}$ $Z_{\theta JC(t)}$ $Z_{\theta JA(t)}$	$^{\circ}\text{C}/\text{W}$ (K/W)
(3) Temperature Coefficient of Breakdown Voltage. The ratio of the change in breakdown voltage, ($V_{(BR)}$) to changes in temperature expressed as either millivolts per $^{\circ}\text{C}$ or percent per $^{\circ}\text{C}$ with reference to the 25°C value of breakdown voltage.	$\alpha_{V(BR)}$ $dV_{(BR)}/dT_J$	$\text{mV}/^{\circ}\text{C}$ or $\%/^{\circ}\text{C}$ (mV/K or $\%/\text{K}$)
(4) Variation of Holding Current with Temperature. The change in holding current, I_H , with changes in temperature. It is shown as a graph of I_H versus T_J .		
(5) Temperature Derating. Derating with temperature above a specified base temperature, expressed as a percentage per degree C, may be applied to surge or operating current parameters.		$\%/^{\circ}\text{C}$ $\%/\text{K}$

3.4 Thyristor surge protective device parameters (cont'd)

3.4.2 Thermal parameters applicable to all device types (cont'd)

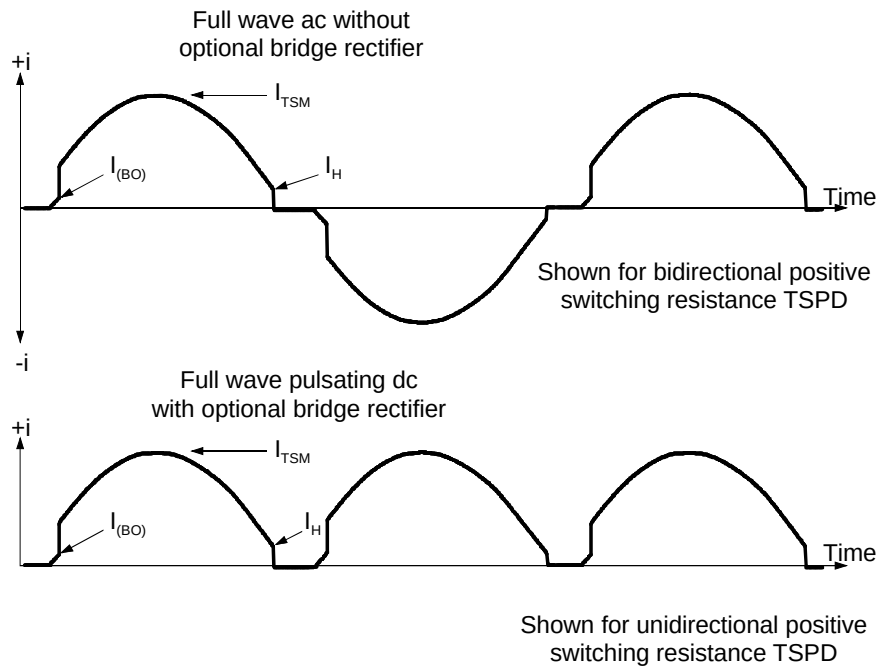


Figure 9 — Example of current wave, I_{TSM} test

3.4.3 Additional electrical parameters for positive-breakdown-resistance types

Table 3 gives parameters applicable to the switching quadrant or quadrants of positive-breakdown-resistance TSPDs.

NOTE — The switching voltage and current are useful only when the coordinate (V_S , I_S) is substantially different from ($V_{(BO)}$, $I_{(BO)}$) as in some negative-breakdown-resistance types. When (V_S , I_S) is coincident with ($V_{(BO)}$, $I_{(BO)}$), or not significantly different, the latter shall be used to describe the device characteristic.

Table 3 — Electrical parameters for positive-breakdown-resistance TSPDs

Term and parameter description	Symbol	Reference
(1) Breakdown Voltage. The voltage across the device in the breakdown region.	$V_{(BR)}$	Fig. 1, 5, and 7
(2) Breakdown Current. The anode, principal, or thyristor current at the breakdown voltage.	$I_{(BR)}$	Fig. 1, 5, and 7
(3) Switching Voltage. The instantaneous principal voltage at the highest current point in the breakdown region prior to switching to the on state.	V_S	Fig. 1 – 7
(4) Switching Current. The instantaneous principal current at which the thyristor begins to switch from the breakdown region to the on state.	I_S	Fig. 1 – 7

3.4 Thyristor surge protective device parameters (cont'd)

3.4.3 Additional electrical parameters for positive-breakdown-resistance types (cont'd)

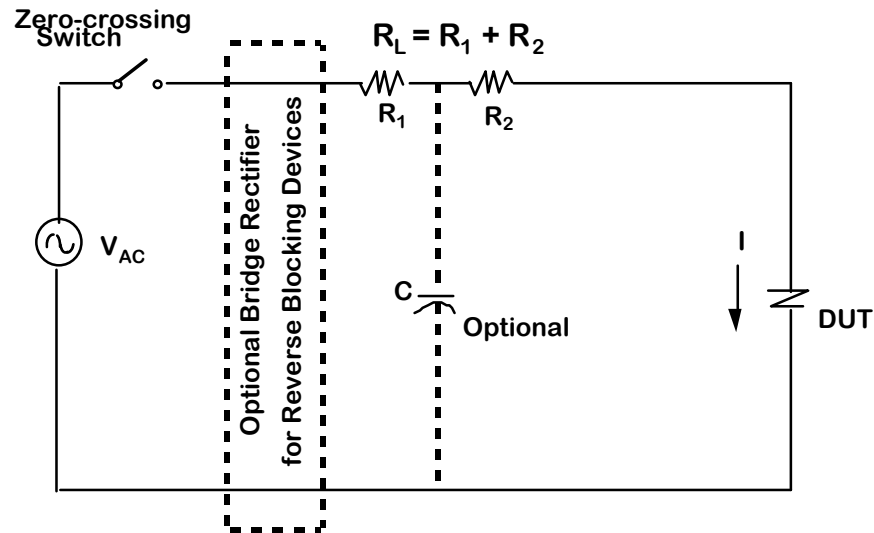


Figure 10 — Nonrepetitive peak on-state surge current (I_{TSM}) test

3.4.4 Additional parameters for negative-breakdown-resistance types

Table 4 gives electrical parameters applicable to the switching quadrant or quadrants of negative-breakdown-resistance TSPDs.

NOTE — These devices have a switching voltage much lower than their breakover voltage and a switching current much greater than their breakover current. They exhibit switchback in their volt-ampere characteristic which is observable on a curve tracer but is often difficult to measure. Specification of (V_S , I_S) is optional.

Table 4 — Electrical parameters for negative-breakdown-resistance TSPDs

Term and parameter description	Symbol	Reference
(1) Switching Voltage. The voltage at the high-current termination of the breakdown region prior to switching to the on state.	V_S	Fig. 1 - 7
(2) Switching Current. The current at the high-current termination of the breakdown region prior to switching to the on state.	I_S	Fig. 1 - 7
(3) Switching Resistance. The quotient of (a) the difference between the breakover voltage and the switching voltage and (b) the difference between the breakover current and the switching current. $R_S = (V_{(BO)} - V_S)/(I_{(BO)} - I_S)$	R_S	Fig. 2, 4, and 6

3.4 Thyristor surge protective device parameters (cont'd)

3.4.4 Additional parameters for negative-breakdown-resistance types (cont'd)

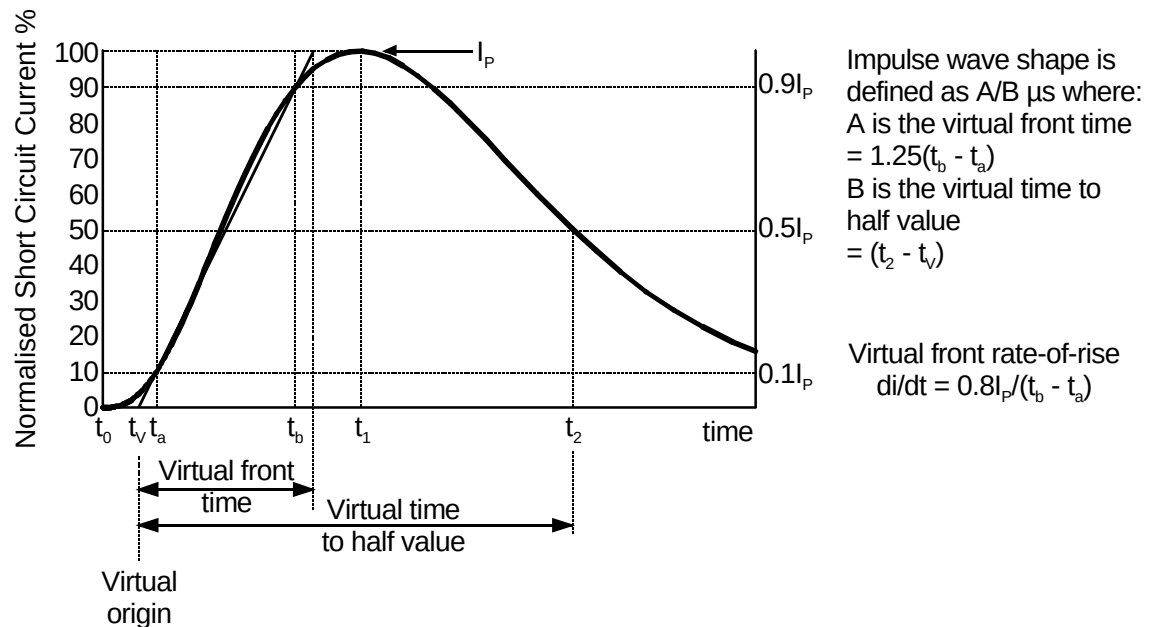


Figure 11 — Definition of double exponential impulse current waveshape

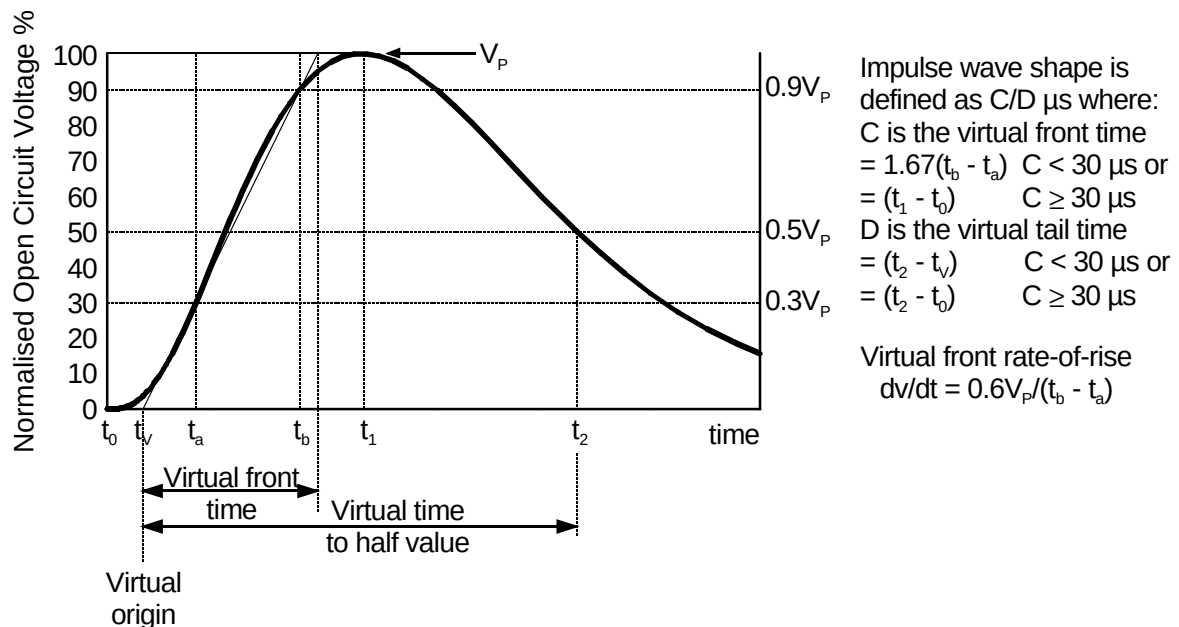


Figure 12 — Definition of double exponential impulse voltage waveshape