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Parameters of fixed-voltage thyristor overvoltage protector components used for the protection of telecommunication installations

Recommendation ITU-T K.102

ITU-T

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Parameters of fixed-voltage thyristor overvoltage protector components used for the protection of telecommunication installations

Summary

Recommendation ITU-T K.102 defines the basic electrical parameters to be met by fixed-voltage thyristor overvoltage protector components used for the protection of telecommunications equipment or lines from surges. Examples of equipment include those located either within a telecommunications centre [b-ITU-T K.20], customer premises [b-ITU-T K.21], in access or in trunk networks [b-ITU-T K.45]. It is intended that this Recommendation be used for the harmonization of existing or future specifications issued by thyristor surge protective component manufacturers, telecommunication equipment manufacturers, administrations or network operators.

History

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Recommendation ITU-T K.102

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1 Scope

Thyristor surge protective components (SPCs) are specially formulated thyristors designed to limit overvoltages and divert surge currents by clamping and switching actions. This Recommendation applies to fixed-voltage thyristor overvoltage SPCs used in surge protective devices (SPDs) and telecommunications equipment ports to provide overvoltage protection for installations during lightning surges and AC power faults, in accordance with [b-ITU-T K.11]. Telecommunications equipment port test levels and criterion are defined by [b-ITU-T K.20], [b-ITU-T K.21] and [b-ITU-T K.45], as appropriate and are supported by [b-ITU-T K.44] with test circuit details and application guidance.

This Recommendation covers fixed-voltage thyristor SPCs with a switching characteristic in the first quadrant and a switching or blocking or conducting characteristic in the third quadrant.

This Recommendation contains information on:

- a) terminology;
- b) letter and circuit symbols;
- c) essential electrical ratings and characteristics;
- d) rating verification and characteristic measurement;
- e) environmental tests on packaging;
- f) identification and ordering information.

It does not deal with:

- a) mountings and their effect on thyristor performance, the test results only apply for the mounting method used for that test;
- b) system signal performance such as insertion loss, see [b-ITU-T G.117];
- c) mechanical dimensions;
- d) RoHS requirements;
- e) electrical overload;
- f) quality assurance requirements, see [b-IEC 60738-1];
- g) specific cases of user agreed and regional values;
- h) conventional thyristors as covered by [b-IEC 60747-6];
- i) gated thyristor SPCs.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T K.96] Recommendation ITU-T K.96 (02/2014), *Surge protective components: Overview of surge mitigation functions and technologies.*
- [IEC 60068-1] IEC 60068-1 ed5.0 (1988), *Environmental testing – Part 1: General and guidance, plus Amendment 1 (1992).*
- [IEC 60068-2-1] IEC 60068-2-1 ed6.0 (2007), *Environmental testing – Part 2-1: Tests – Test A: Cold.*
- [IEC 60068-2-2] IEC 60068-2-2 ed5.0 (2007), *Environmental testing – Part 2-2: Tests – Test B: Dry heat.*
- [IEC 60068-2-6] IEC 60068-2-6 ed7.0 (2007), *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal).*
- [IEC 60068-2-13] IEC 60068-2-13 ed4.0 (1983), *Environmental testing – Part 2-13: Tests – Test M: Low air pressure.*
- [IEC 60068-2-14] IEC 60068-2-14 ed6.0 (2009), *Environmental testing – Part 2-14: Tests – Test N: Change of temperature.*
- [IEC 60068-2-20] IEC 60068-2-20 ed5.0 (2008), *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads.*
- [IEC 60068-2-21] IEC 60068-2-21 ed6.0 (2006), *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices.*
- [IEC 60068-2-27] IEC 60068-2-27 ed4.0 (2008), *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock.*
- [IEC 60068-2-29] IEC 60068-2-29 ed2.0 (1987), *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump.*
- [IEC 60068-2-30] IEC 60068-2-30 ed3.0 (2005), *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h+12 h cycle).*
- [IEC 60068-2-45] IEC 60068-2-45 ed1.0 (1980), *Environmental testing – Part 2-45: Tests – Test XA and guidance: Immersion in cleaning solvents.*
- [IEC 60068-2-54] IEC 60068-2-54 ed2.0 (2006), *Environmental testing – Part 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method.*
- [IEC 60068-2-58] IEC 60068-2-58 ed3.0 (2004), *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD).*
- [IEC 60068-2-69] IEC 60068-2-69 ed2.0 (2007), *Environmental testing – Part 2-69: Tests – Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method.*
- [IEC 60068-2-78] IEC 60068-2-78 ed1.0 (2001), *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state.*
- [IEC 60695-11-5] IEC 60695-11-5 ed1.0 (2004), *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance.*

3 Definitions

Where possible, terms, definitions, letter symbols and circuit diagram symbols are used from conventional thyristor [b-IEC 60747-6] and rectifier diode [b-IEC 60747-2] standards.

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Types of semiconductor component

3.1.1.1 bidirectional diode thyristor [b-IEC 60050-521]: Two-terminal thyristor having substantially the same switching behaviour in the first and third quadrants of the current-voltage characteristic.

3.1.1.2 reverse conducting diode thyristor [b-IEC 60050-521]: Two-terminal thyristor which for negative anode voltage does not switch and conducts large currents at voltages comparable in magnitude to the forward on-state voltage.

3.1.1.3 reverse blocking diode thyristor [b-IEC 60050-521]: Two-terminal thyristor which for negative anode voltage does not switch, but exhibits reverse blocking state.

3.1.1.4 (semiconductor) rectifier diode [b-IEC 60050-521]: Semiconductor diode designed for rectification and including its associated mounting and cooling attachments if integral with it.

3.1.1.5 thyristor [b-IEC 60050-521]: Bi-stable semiconductor device comprising three or more junctions which can be switched from the off-state to the on-state or vice versa.

3.1.2 General terms for semiconductor components

3.1.2.1 avalanche breakdown (of a PN junction) [b-IEC 60050-521]: Breakdown that is caused by the cumulative multiplication of charge carriers in a semi-conductor under the action of a strong electric field which causes some carriers to gain enough energy to liberate new hole-electron pairs by ionization.

3.1.2.2 breakdown (of a reverse-biased PN junction) [b-IEC 60050-521]: Phenomenon, the initiation of which is observed as a transition from a state of high dynamic resistance to a state of substantially lower dynamic resistance for increasing magnitude of reverse current.

3.1.2.3 forward direction (of a PN junction) [b-IEC 60050-521]: Direction of current that results when the P-type semiconductor region is at a positive voltage relative to the N-type region.

3.1.2.4 reverse direction (of a PN junction) [b-IEC 60050-521]: Direction of current that results when the N-type semiconductor region is at a positive voltage relative to the P-type region.

3.1.2.5 Zener breakdown (of a PN junction) [b-IEC 60050-521]: Breakdown caused by the transition of electrons from the valence band to the conduction band due to tunnel action under the influence of a strong electric field in a PN junction.

3.1.3 Component packaging

3.1.3.1 dual in-line package (DIP) [b-IEC 61188-5-1]: Rectangular component package that has a row of leads extending from each of the longer sides of its body that are formed at right angles to a plane that is parallel to the base of its body.

3.1.3.2 guarded measurement (three terminal network) [b-ITU-T K.95]: Measurement technique that allows the direct impedance between two terminals to be measured correctly by applying a compensating voltage to the third terminal that removes the shunting effects of any impedances to the third terminal.

3.1.3.3 package [b-IEC 60050-521]: Enclosure for one or more chips, film elements or other components, that allows electrical connection and provides mechanical and environmental protection.

3.1.3.4 single in-line package (SIP) [b-IEC 61188-5-1]: Component package with one straight row of pins or wire leads.

3.1.3.5 surface mounting component [b-IEC 61760-1]: Electronic component designed for mounting on to terminal pads or conducting tracks on the surface of substrate.

3.1.3.6 surface-mount device, SMD [b-IEC 60749-20-1]: Plastic-encapsulated surface-mount devices made with moisture-permeable materials.

3.1.3.7 surface-mount technology (SMT) [b-IEC 61188-5-1]: Technology where electrical connection of components is made to the surface of a conductive pattern of a printed board and does not utilize component lead holes.

3.1.3.8 surge protective component (SPC) [ITU-T K.96]: Component specifically included in a device or equipment for the mitigation of the onward propagation of overvoltages or overcurrents or both.

3.1.3.9 surge protective device (SPD) [ITU-T K.96]: Device that mitigates the onward propagation of overvoltages or overcurrents or both.

3.1.3.10 terminal (of a semiconductor device) [b-IEC 60050-521]: Conductive element provided for external connection.

3.1.3.11 through-hole technology (THT) [b-IEC 61188-5-1]: Assembly process for mounting component packages where leads are passed through supported (plated-through) or unsupported (bare) holes in an interconnection substrate.

3.1.4 Specific terms for thyristors

3.1.4.1 anode-to-cathode (voltage-current) characteristic [b-IEC 60050-521]: Function, usually represented graphically, relating the anode voltage to the principal current, with the gate current, where applicable, as a parameter.

3.1.4.2 breakover point [b-IEC 60050-521]: Any point on the principal characteristic for which the differential resistance is zero and where the principal voltage reaches a maximum value.

3.1.4.3 critical rate of rise of off-state voltage [b-IEC 60050-521]: Lowest value of the rate of rise of principal voltage that will cause switching from the off-state to the on-state.

3.1.4.4 critical rate of rise of on-state current [b-IEC 60050-521]: Highest value of the rate of rise of on-state current which a thyristor can withstand without deleterious effect.

3.1.4.5 main terminal [b-IEC 60050-521]: Terminal through which the main current flows.

3.1.4.6 off-state [b-IEC 60050-521]: Condition of a thyristor corresponding to the portion of the principal characteristic between the origin and the breakover point or points.

3.1.4.7 on-state [b-IEC 60050-521]: Condition of a thyristor corresponding to the low-resistance low-voltage portion of the principal characteristic.

3.1.4.8 principal (voltage-current) characteristic [b-IEC 60050-521]: Function, usually represented graphically, relating the principal voltage to the principal current, with the gate current, where applicable, as a parameter.

3.1.4.9 principal current [b-IEC 60050-521]: Current which flows through the device excluding gate current.

3.1.4.10 principal voltage [b-IEC 60050-521]: Voltage between the main terminals.

3.1.4.11 reverse blocking state (of a reverse blocking thyristor) [b-IEC 60050-521]: Condition of a reverse blocking thyristor corresponding to reverse currents of lower magnitude than the current at the reverse breakdown voltage.

3.1.5 Thyristor characteristic terms and symbols

3.1.5.1 breakover voltage, V_{BO} [b-IEC 60747-6]: Voltage at the breakover point.

3.1.5.2 breakover current, I_{BO} [b-IEC 60747-6]: Anode, principal, or thyristor current at the breakover point.

3.1.5.3 forward current (diode), I_F [b-IEC 60747-6]: Current through the device in the forward conducting state.

3.1.5.4 forward recovery voltage (diode), V_{FRM} [b-IEC 60747-2]: Varying voltage occurring during the forward recovery time after instantaneous switching from zero or a specified reverse voltage to a specified forward current.

3.1.5.5 forward voltage (diode), V_F [b-IEC 60747-6]: Voltage across the terminals which results from the flow of current in the forward direction.

3.1.5.6 holding current, I_H [b-IEC 60747-6]: Minimum anode, principal, or thyristor current that will maintain the thyristor in the on state.

3.1.5.7 on-state current, I_T [b-IEC 60747-6]: Anode, principal, or thyristor current when the thyristor is in the on state.

3.1.5.8 on-state voltage, V_T [b-IEC 60747-6]: Anode, principal, or thyristor voltage when the thyristor is in the on state.

3.1.5.9 off-state capacitance, C_o , C_J [b-IEC 61643-341]: Differential capacitance at the specified terminals in the off-state measured at specified frequency, f , amplitude, V_d and d.c. bias, V_D .

3.1.5.10 off-state current, I_D [b-IEC 60747-6]: Anode, principal, or thyristor current when the thyristor is in the off state.

3.1.5.11 off-state voltage, V_D [b-IEC 60747-6]: Anode, principal, or thyristor voltage when the thyristor is in the off state.

3.1.5.12 repetitive peak off-state current, I_{DRM} [b-IEC 61643-341]: Maximum (peak) value of off-state current that results from the application of the repetitive peak off-state voltage, V_{DRM} .

3.1.5.13 repetitive peak reverse current, I_{RRM} [b-IEC 61643-341]: Maximum (peak) value of reverse current that results from the application of the repetitive peak reverse voltage, V_{RRM} .

3.1.5.14 reverse current I_R [b-IEC 60747-2]: Total conductive current flowing through the diode when specified reverse voltage is applied.

3.1.5.15 reverse voltage (of a unidirectional thyristor), V_R [b-IEC 60747-6]: Negative anode voltage.

3.1.6 Thyristor rating terms and symbols

3.1.6.1 critical rate of rise of on-state current, $(di_T/dt)_{cr}$ [b-IEC 60747-6]: Highest value of the rate of rise of on-state current that a thyristor can withstand without deleterious effect.

3.1.6.2 non-repetitive peak impulse current, I_{PP} [b-IEC 61643-341]: Rated maximum value of peak impulse current of specified amplitude and waveshape that may be applied.

3.1.6.3 peak sinusoidal on-state current, I_{TM} [b-IEC 60747-6]: Peak value of a sinusoidal on-state current, excluding any transient currents.

3.1.6.4 repetitive peak forward current (diode), I_{FRM} [b-IEC 60747-2]: Peak value of the forward current including all repetitive transient currents.

3.1.6.5 repetitive peak off-state voltage, V_{DRM} [b-IEC 60747-6]: Highest instantaneous value of the off-state voltage, including all repetitive transient voltages, but excluding all non-repetitive transient voltages.

3.1.6.6 repetitive peak on-state current, I_{TRM} [b-IEC 60747-6]: Peak value of the on-state current, including all repetitive transient currents.

3.1.6.7 repetitive peak reverse voltage (of a unidirectional thyristor), V_{RRM} [b-IEC 60747-6]: Highest instantaneous value of the reverse voltage, including all repetitive transient voltages, but excluding all non-repetitive transient voltages.

3.1.6.8 surge forward current (diode), I_{FSM} [b-IEC 60747-2]: Peak value of the forward current including all repetitive transient currents.

3.1.6.9 surge on-state current, I_{TSM} [b-IEC 60747-6]: On-state current pulse of short duration and specified waveshape, whose application 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.

3.1.7 Temperature related parameters

3.1.7.1 maximum junction temperature, T_{JM} [b-IEC 61643-341]: Maximum value of permissible junction temperature, due to self-heating, which a thyristor surge suppressor can withstand without degradation.

3.1.7.2 storage temperature range, T_{stgmin} to T_{stgmax} [b-IEC 61643-341]: Temperature range over which the device can be stored without any voltage applied.

3.1.7.3 temperature derating [b-IEC 61643-341]: Derating with temperature above a specified base temperature, expressed as a percentage, such as may be applied to peak pulse current.

3.1.7.4 thermal resistance, R_{th} [b-IEC 62590]: Quotient of the temperature difference between two specified points or regions and the heat flow between these two points or regions under conditions of thermal equilibrium.

3.1.7.5 transient thermal impedance, Z_{th} [b-IEC 62590]: Quotient of the variation of the temperature difference, reached at the end of a time interval between the virtual junction temperature and the temperature at a specified external reference point and the step function change of power dissipation at the beginning of the same time interval causing the change of temperature.

3.1.7.6 virtual temperature, T_{vj} , T_j [b-IEC 60747-1]: The temperature of the theoretical point or region in a simplified model of the thermal and electrical behaviour of a semiconductor device at or in which all the power dissipation within the device is assumed to occur.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSL	Asymmetric Digital Subscriber Line
DFN	Dual Flat No leads
GDT	Gas Discharge Tube
JEDEC	Joint Electronic Device Engineering Council
POTS	Plain Old Telephone Service
QFN	Quad Flat No leads
SIP	Single In-line Package
SMD	Surface Mounting Device

SPC	Surge Protective Component
SPD	Surge Protective Device
VDSL	Very high speed Digital Subscriber Line

5 Conventions

This Recommendation uses the following circuit symbols, Figure 1, based on [b-IEC 60617] for fixed voltage thyristor SPC types:

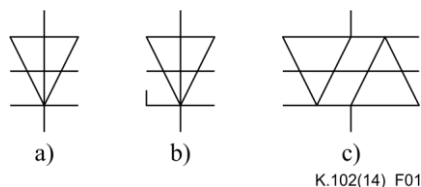


Figure 1 – Symbols for a) Reverse blocking diode thyristor (S00650), b) Reverse conducting diode thyristor (S00651) and c) Bidirectional diode thyristor (S00652)

The characteristics of the three types of fixed-voltage thyristor SPC are shown in Figures 2, 3 and 4. These figures show key component parameters.

Voltage-Current Quadrant 1 characteristics of Figure 2, Figure 3 and Figure 4 are measured with a positive voltage applied to the top terminal of the Figure 1 circuit symbols. Quadrant 3 characteristics are measured with a negative voltage applied to the top terminal.

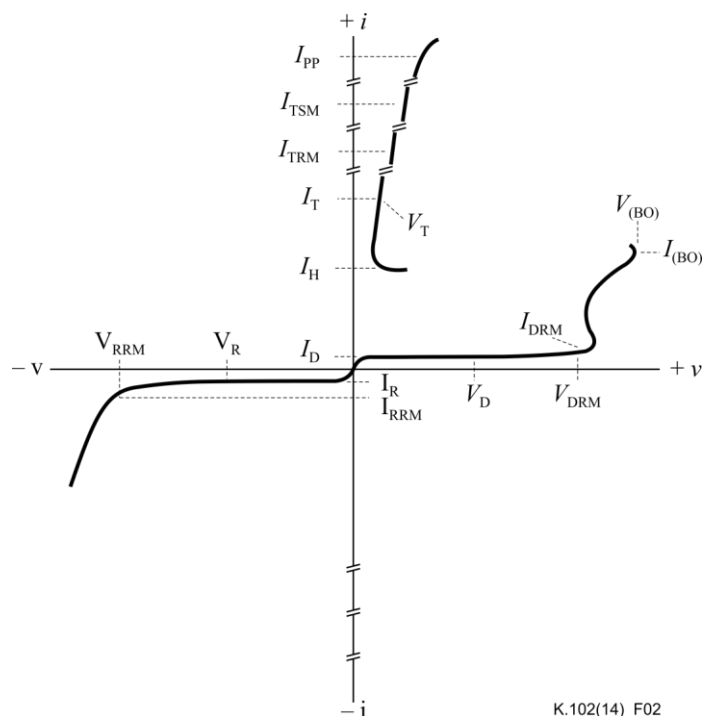


Figure 2 – Reverse blocking diode thyristor characteristic

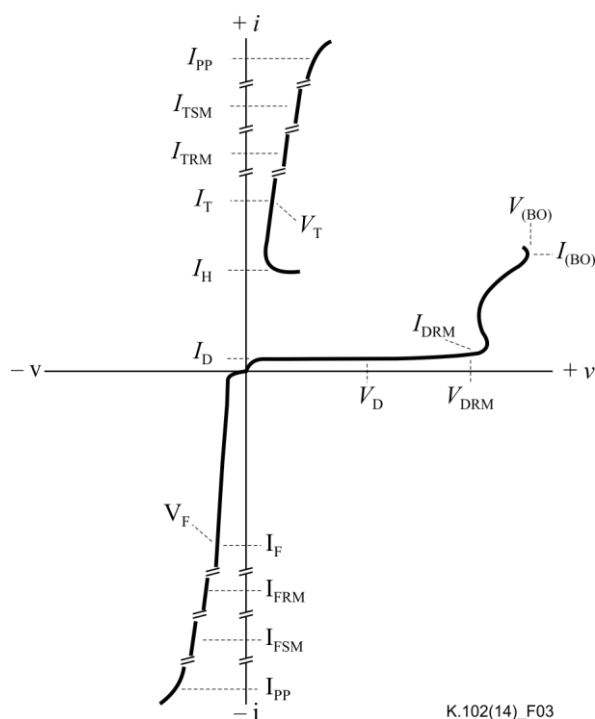


Figure 3 – Reverse conducting diode thyristor characteristic

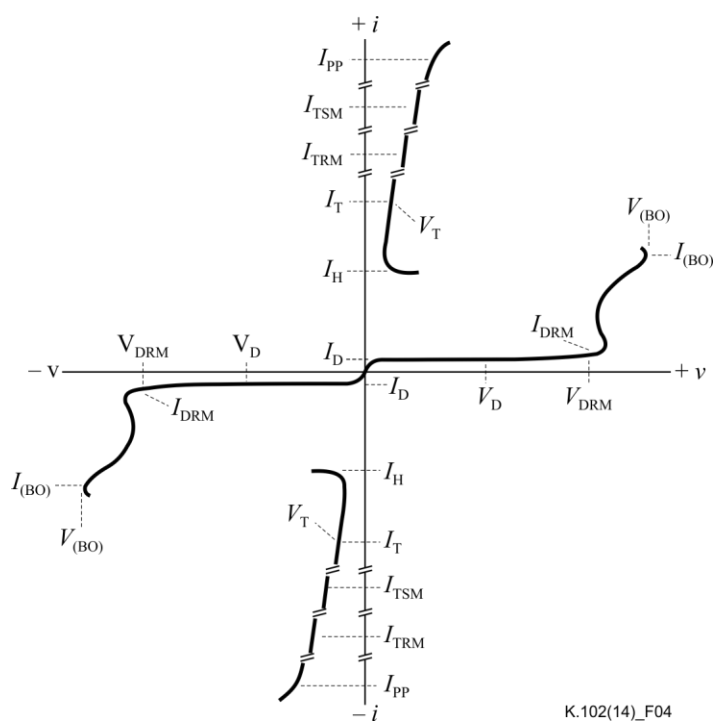


Figure 4 – Bidirectional diode thyristor characteristic

6 Service conditions

6.1 Normal service conditions

This Recommendation is for stationary telecommunications installations that are weather-protected [b-IEC 60721-3-3]. Two equipment microclimates [b-IEC 60721-3-9] defined:

a) Normal microclimate

- 1) ambient air temperature within the range of 0°C to 70°C