TISP® Terms and Letter Symbols

Introduction

Thyristor-based overvoltage protectors for telecom systems were first introduced in the late 1970s. The characteristics of thyristor SPDs (Surge Protective Devices) are very different than the normal SCR (Silicon Controlled Rectifier) and TRIAC (Triode for AC Control) type thyristors. In many cases the standard thyristor terms, definitions and test circuits were inadequate for thyristor SPDs.

This situation led to many manufacturers and users "inventing" terms or using terms from other device types for the description of the thyristor SPD parameters. Manufacturers of avalanche or zener breakdown diodes used for TVS (Transient Voltage Suppression) applications adopted TVS terms. Manufacturers of SIDAC® (Silicon Diode for AC, in Japan a registered trademark of Shindengen) type thyristor devices which are typically used for discharge lamp ignition, often used SIDAC® terms. Manufacturing testing was another problem area; standard thyristor testers could not cope with thyristor SPD measurement and manufacturers had to either commission special test equipment or build it themselves.

The lack of a common nomenclature and test conditions caused frustration for designers and users who wanted to compare and evaluate products. The first comprehensive standard on thyristor SPD terms, letter symbols, definitions and test circuits was the result of the IEEE Surge Protective Devices Committee (SPDC) authorizing the development of C62.37 - 1996 (IEEE Standard Test Specification for Thyristor Diode Surge Protective Devices), which was published in August 1997. To further the understanding of how thyristor SPD parameters are used in the design of protection systems, the IEEE SDPC has now released a companion publication called C62.37.1 (IEEE Guide for the Application of Thyristor Surge Protective Devices).

The purpose of this review is to provide a cross-reference between some of the common non-standard parameter sets and the C62.37 parameters. This review is not intended to replace or summarize the IEEE C62.37 publications, and interested parties are encouraged to study these comprehensive standards.

Letter Symbols

The letter symbol, read right to left, usually gives the parameter term. The first part of the symbol is the prime quantity. Some examples are:

V = voltage
I = current
P = power
C = capacitance

The first subscripted letter indicates the operating condition of the thyristor. Some examples are:

D = off state
(BR) = breakdown
T = on state
R = reverse

Note that the breakdown condition has parenthesis around the two letters, BR. This is to ensure that the two letters are read together rather than separately. In addition, the first subscripted letter can also indicate a specific point. Some examples are:

(BO) = breakover
S = switching
H = holding

For ratings, the second subscript letter indicates the type of rating. These letters are:

R = repetitive
S = non-repetitive (surge)

The final subscript letter(s) may indicate a limit value, e.g. M = peak (maximum). In addition, there are some alternative subscript letters and some subscript letters which have been established through historical use. Examples are:

o = off state as an alternative to "D" in capacitance symbols
PP = Peak (im) Pulse current

The above list is not comprehensive and readers are referred to C62.37. Only fixed voltage thyristor SPDs are covered here. Gated thyristor SPDs are also available and the additional parameters needed for this type of protector are covered by C62.37.

Letter Symbols (continued)

To deduce a letter symbol term, the convention is to read the symbol from right to left as in the following examples:

V_D = Off-state, $_D$, voltage, V
I_D = Off-state, $_D$, current, I
V_{DRM} = Peak, $_M$, repetitive, $_R$, off-state, $_D$, voltage, V
$V_{(BO)}$ = Breakover, $_{(BO)}$, voltage, V
I_{PPS} = Non-repetitive, $_S$, peak pulse, $_{PP}$, current, I
I_{TSM} = Peak, $_M$, non-repetitive, $_S$, on-state, $_T$, current, I
I_T = On-state, $_T$, current, I

Electrical Characteristic Curves

Thyristor SPD current parameters cover a range from a few nanoamps to hundreds of amps. To represent this on a linear scale is impossible, so the current scale used for the characteristic voltage-current curves is non-linear. The distorted scale is chosen to illustrate specific regions: very low current parameters in the nanoamp to milliamp area for the off-state condition, hundreds of milliamps for breakover, switching and holding points, amps for on-state voltage measurements, tens of amps for a.c. ratings and hundreds of amps for impulse ratings.

A similar situation exists for thyristor SPD voltages. This is a simpler situation with volts to tens of volts for the on-state region, a specific region for any d.c. off-state current test and a specific voltage band for the breakdown region. Figure 1 shows the result for one voltage-current quadrant. There are four regions to the switching characteristic; off-state, breakdown, switching (from breakdown region, from on-state region) and on-state. The breakdown region is often re-entrant (reduces in voltage with increasing current, then increases in voltage) as it is the breakdown of an internal open-base transistor structure. Higher voltage Thyristor SPDs, e.g., 300 V breakdown, can show re-entrant levels of 20 V. The high current end of the breakdown region terminates at the switching point. The peak voltage point in the breakdown region will always be higher in voltage than the switching point.

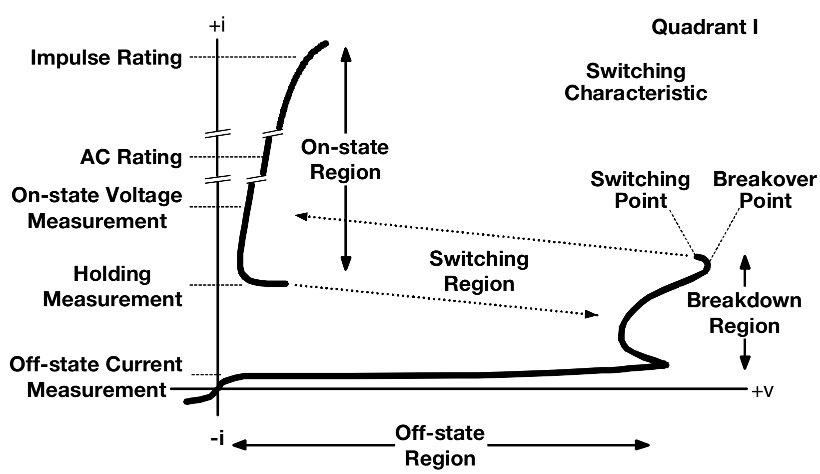

Figure 1. Thyristor SPD Switching Quadrant Regions

Several manufacturers approximate the characteristic curve by three straight lines, Figure 2. In working with this reduced form, there are several points to be remembered. First, the variation of off-state current is not resistive as shown, but tends to be independent of off-state voltage until the breakdown region is approached. Second, with a straight line for the breakdown region, the re-entrant voltage reduction is not obvious. Third, at the high current termination of the breakdown region, there isn't any differentiation between the breakover and switching points. Fourth, the increase of on-state voltage as the holding point is approached is not shown.

Electrical Characteristic Curves (continued)

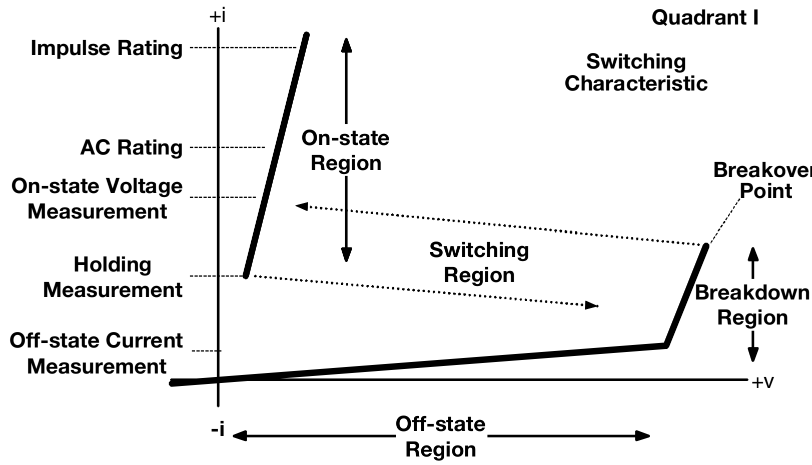

Figure 2. Straight Line Approximation of Thyristor SPD Switching Quadrant Regions

Figure 3 shows the essential ratings and characteristic values for the voltage current characteristic from C62.37. One C62.37 rating, the peak repetitive on-state current, I_{TRM}, is not shown in Figure 3 as this would be normally covered by the long term, 1000 s, I_{TSM} value. Most data sheets will give two breakover voltage values ($V_{(BO)}$); one for a.c. conditions and the other for impulse conditions. The impulse $V_{(BO)}$ test conditions may be a specific waveshape of given peak current, I_{PP}, or an equivalent di/dt ramp (See M. J. Maytum, K. Rutgers & D. Unterweger "Lightning surge voltage limiting and survival properties of telecommunication thyristor-based protectors", IEEE/ESD Association, *1994 Electrical Overstress/Electrostatic Discharge Symposium Proceedings*., ISBN 1-878303-51-1, EOS-16, pp 4.6.1-4.6.11, Las Vegas, Nevada).

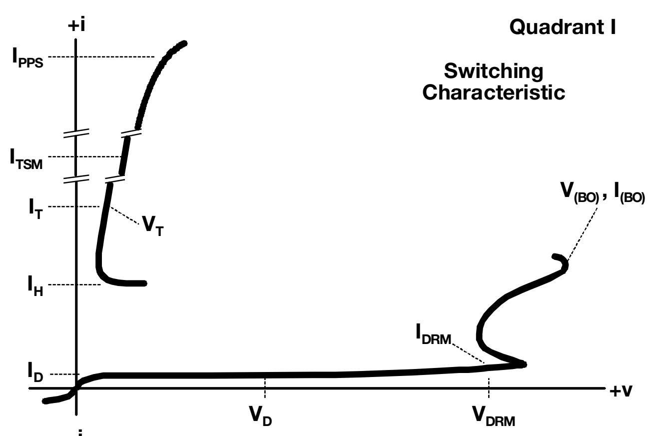

Figure 3. Thyristor SPD Switching Quadrant Regions with Letter Symbols

Comparison of TISP® and C62.37 Parameters

Bourns TISP® (Totally Integrated Surge Protector) thyristor SPDs are designed and manufactured at its Power Innovations facility. Production of these devices started in 1982 and today, both fixed voltage and gated products are produced. The standard TISP® parameters align with C62.37 apart from the impulse current rating parameter. The characteristic curves are shown in Figure 4 and the table below lists the single parameter difference.

Comparison of TISP® and C62.37 Parameters (continued)

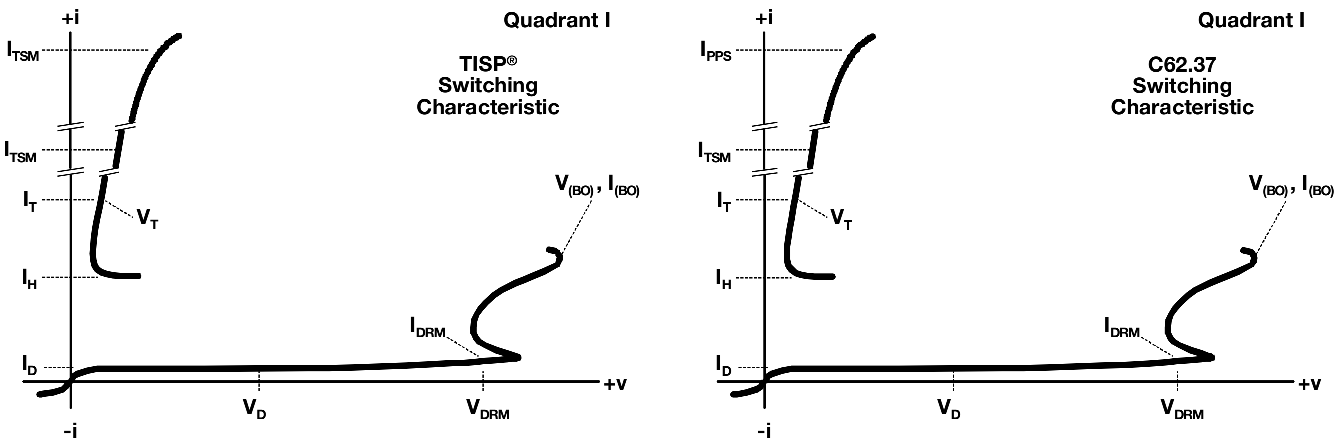

Figure 4. Comparison of TISP® and C62.37 Switching Quadrant Parameters

Differences between TISP® and C62.37 Terms and Letter Symbols

TISP®		C62.37	
TERM	**SYMBOL**	**TERM**	**SYMBOL**
Non-repetitive peak on-state pulse current	I_{TSP}	Non-repetitive peak pulse current	I_{PPS}

Comparison of Manufacturer A and C62.37 Parameters

The fixed voltage products from this manufacturer originally were negative breakdown slope devices, but now the majority are positive breakdown slope devices like the Bourns TISP®. A straight line characteristic approximation is used and there are several term and symbol differences from the C62.37 standard. The characteristic curves are shown in Figure 5 and the table below lists the parameter differences.

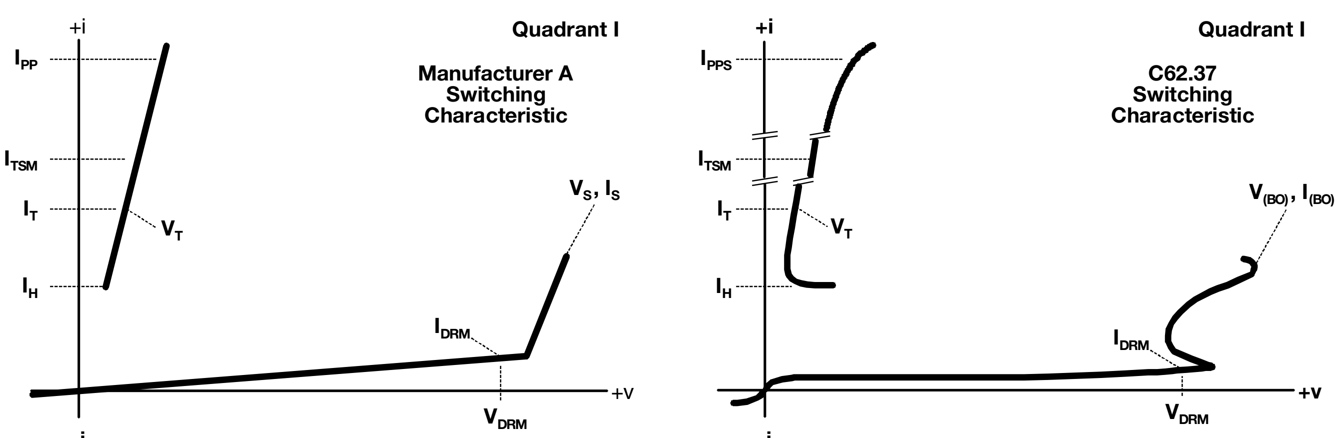

Figure 5. Comparison of Manufacturer A and C62.37 Switching Quadrant Parameters

Differences between Manufacturer A and C62.37 Terms and Letter Symbols

Manufacturer A		C62.37		TISP®
TERM	SYMBOL	TERM	SYMBOL	SYMBOL
Peak pulse current	I_{PP}	Non-repetitive peak pulse current	I_{PPS}	I_{TSP}
Peak one cycle surge current	I_{TSM}	Non-repetitive peak on-state current	I_{TSM}	I_{TSM}
Peak off-state voltage	V_{DRM}	Repetitive peak off-state voltage	V_{DRM}	V_{DRM}
Leakage current	I_{DRM}	Repetitive peak off-state current	I_{DRM}	I_{DRM}
Switching voltage	V_S	Breakover voltage	$V_{(BO)}$	$V_{(BO)}$
Switching current	I_S	Breakover current	$I_{(BO)}$	$I_{(BO)}$

Users are advised to carefully check parameter test conditions and measurement technique to confirm the equivalence of the above.

Comparison of Manufacturer B and C62.37 Parameters

The use of V_R type letter symbols and terms like stand-off are a heritage from TVS diodes. Where a V_{BR} value is quoted, in most cases the TISP® V_{DRM} value is equivalent. A combination of two straight lines and a curved line are used for the characteristic curve. There are several term and symbol differences from the C62.37 standard. The characteristic curves are shown in Figure 6 and the table below lists the parameter differences.

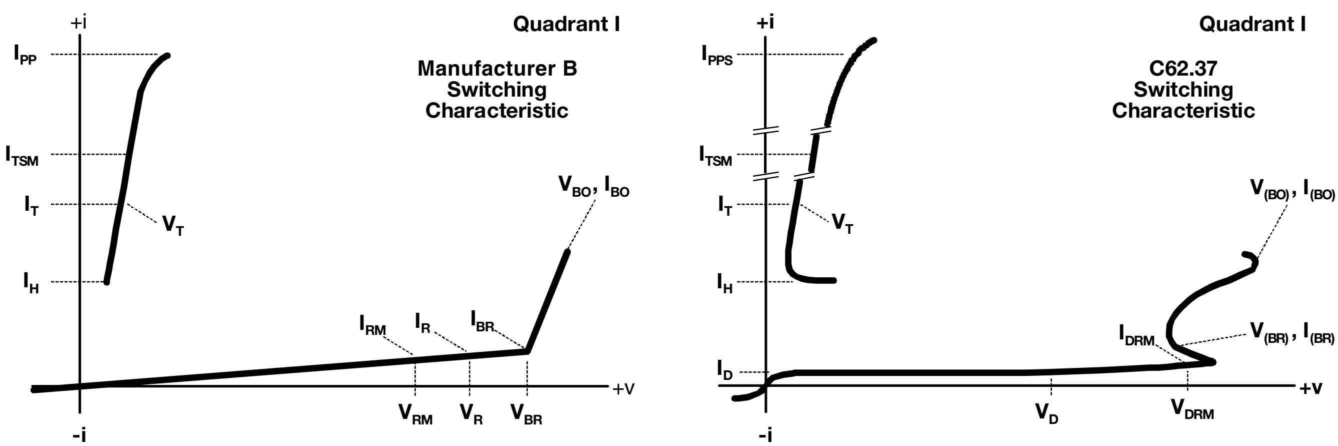

Figure 6. Comparison of Manufacturer B and C62.37 Switching Quadrant Parameters

Differences between Manufacturer B and C62.37 Terms and Letter Symbols

Manufacturer B		C62.37		TISP®
TERM	SYMBOL	TERM	SYMBOL	SYMBOL
Peak pulse current	I_{PP}	Non-repetitive peak pulse current	I_{PPS}	I_{TSP}
Non repetitive surge peak on-state current	I_{TSM}	Non-repetitive peak on-state current	I_{TSM}	I_{TSM}
Leakage current at stand-off voltage	I_{RM}	Off-state current	I_D	I_D
Stand-off voltage	V_{RM}	Off-state voltage	V_D	V_D
Continuous reverse current	I_R	Repetitive peak off-state current	I_{DRM}	I_{DRM}
Continuous reverse voltage	V_R	Repetitive peak off-state voltage	V_{DRM}	V_{DRM}
Breakdown current	I_{BR}	Breakdown current	$I_{(BR)}$	$I_{(BR)}$
Breakdown voltage	V_{BR}	Breakdown voltage	$V_{(BR)}$	$V_{(BR)}$
Breakover current	I_{BO}	Breakover current	$I_{(BO)}$	$I_{(BO)}$
Breakover voltage	V_{BO}	Breakover voltage	$V_{(BO)}$	$V_{(BO)}$

Users are advised to carefully check parameter test conditions and measurement technique to confirm the equivalence of the above.

Comparison of Manufacturer C and C62.37 Parameters

A combination of a straight line and a curved line are used for the characteristic curve. There are several term and symbol differences from the C62.37 standard. The characteristic curves are shown in Figure 7 and the table below lists the parameter differences.

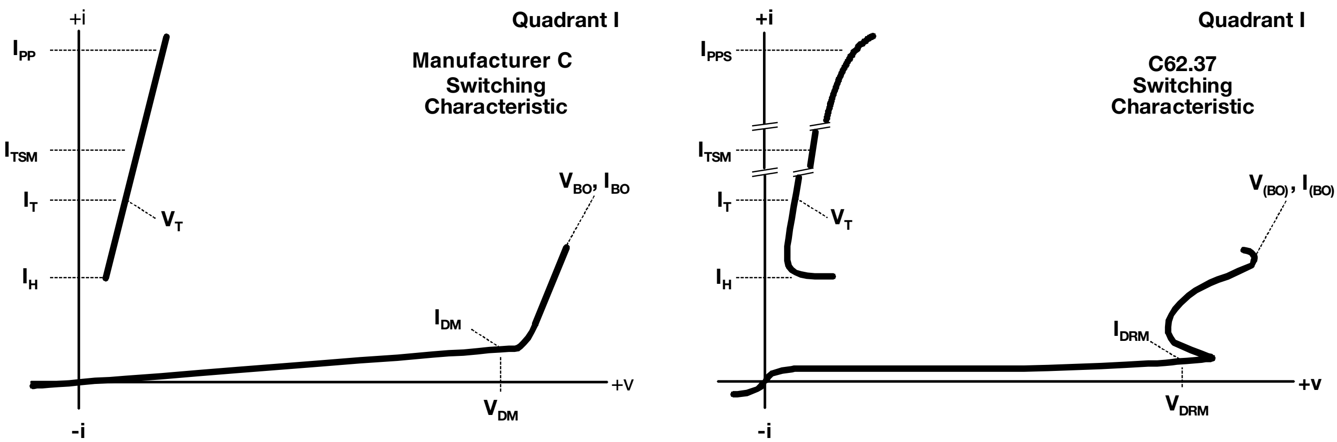

Figure 7. Comparison of Manufacturer C and C62.37 Switching Quadrant Parameters

Comparison of Manufacturer C and C62.37 Parameters

Manufacturer C		C62.37		TISP®
TERM	SYMBOL	TERM	SYMBOL	SYMBOL
Peak pulse current	I_{pp}	Non-repetitive peak pulse current	I_{PPS}	I_{TSP}
Peak on-state surge current	I_{TSM}	Non-repetitive peak on-state current	I_{TSM}	I_{TSM}
Off-state current	I_{DM}	Repetitive peak off-state current	I_{DRM}	I_{DRM}
Maximum off-state voltage	V_{DM}	Repetitive peak off-state voltage	V_{DRM}	V_{DRM}
Breakover current	I_{BO}	Breakover current	$I_{(BO)}$	$I_{(BO)}$
Breakover voltage	V_{BO}	Breakover voltage	$V_{(BO)}$	$V_{(BO)}$
Hold current	I_H	Holding current	I_H	I_H

Users are advised to carefully check parameter test conditions and measurement technique to confirm the equivalence of the above.