

# TISP4xxxM3BJ Overvoltage Protector Series

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## Description (Continued)

The TISP4xxxM3BJ range consists of nineteen voltage variants to meet various maximum system voltage levels (58 V to 320 V). They are guaranteed to voltage limit and withstand the listed international lightning surges in both polarities. These medium (M) current protection devices are in a plastic package SMBJ (JEDEC DO-214AA with J-bend leads) and supplied in embossed tape reel pack. For alternative voltage and holding current values, consult the factory. For higher rated impulse currents in the SMB package, the 100 A 10/1000 TISP4xxxH3BJ series is available.

## Absolute Maximum Ratings, $T_A = 25^\circ\text{C}$ (Unless Otherwise Noted)

| Rating                                                                                         | Symbol              | Value       | Unit |
|------------------------------------------------------------------------------------------------|---------------------|-------------|------|
| Repetitive peak off-state voltage, (see Note 1)                                                | V <sub>DRM</sub>    | ±58         | V    |
|                                                                                                |                     | ±65         |      |
|                                                                                                |                     | ±75         |      |
|                                                                                                |                     | ±90         |      |
|                                                                                                |                     | ±100        |      |
|                                                                                                |                     | ±120        |      |
|                                                                                                |                     | ±135        |      |
|                                                                                                |                     | ±145        |      |
|                                                                                                |                     | ±155        |      |
|                                                                                                |                     | ±160        |      |
|                                                                                                |                     | ±180        |      |
|                                                                                                |                     | ±190        |      |
|                                                                                                |                     | ±200        |      |
|                                                                                                |                     | ±220        |      |
|                                                                                                |                     | ±230        |      |
|                                                                                                |                     | ±275        |      |
|                                                                                                |                     | ±290        |      |
| ±320                                                                                           |                     |             |      |
| ±300                                                                                           |                     |             |      |
| Non-repetitive peak on-state pulse current (see Notes 2, 3 and 4)                              | I <sub>TSP</sub>    | 300         | A    |
| 2/10 μs (GR-1089-CORE, 2/10 μs voltage wave shape)                                             |                     | 220         |      |
| 8/20 μs (IEC 61000-4-5,combination wave generator, 1.2/50 voltage, 8/20 current)               |                     | 120         |      |
| 10/160 μs (FCC Part 68, 10/160 μs voltage wave shape)                                          |                     | 110         |      |
| 5/200 μs (VDE 0433, 10/700 μs voltage wave shape)                                              |                     | 100         |      |
| 0.2/310 μs (I3124, 0.5/700 μs voltage wave shape)                                              |                     | 100         |      |
| 5/310 μ (ITU-T K.20/21/45, K.44 10/700 μs voltage wave shape)                                  |                     | 100         |      |
| 5/310 μs (FTZ R12, 10/700 μs voltage wave shape)                                               |                     | 75          |      |
| 10/560 μs (FCC Part 68, 10/560 μs voltage wave shape)                                          |                     | 50          |      |
| 10/1000 μs (GR-1089-CORE, 10/1000 μs voltage wave shape)                                       |                     |             |      |
| Non-repetitive peak on-state current (see Notes 2, 3 and 5)                                    | I <sub>TSM</sub>    | 30          | A    |
| 20 ms (50 Hz) full sine wave                                                                   |                     | 32          |      |
| 16.7 ms (60 Hz) full sine wave                                                                 |                     | 2.1         |      |
| 1000 s 50 Hz/60 Hz a.c.                                                                        |                     |             |      |
| Initial rate of rise of on-state current, Exponential current ramp, Maximum ramp value < 100 A | di <sub>T</sub> /dt | 300         | A/μs |
| Junction temperature                                                                           | T <sub>J</sub>      | -40 to +150 | °C   |
| Storage temperature range                                                                      | T <sub>stg</sub>    | -65 to +150 | °C   |

- NOTES: 1. See Applications Information and Figure 11 for voltage values at lower temperatures.  
2. Initially, the TISP4xxxM3BJ must be in thermal equilibrium with  $T_J = 25^\circ\text{C}$ .  
3. The surge may be repeated after the TISP4xxxM3BJ returns to its initial conditions.  
4. See Applications Information and Figure 12 for current ratings at other temperatures.  
5. EIA/JESD51-2 environment and EIA/JESD51-3 PCB with standard footprint dimensions connected with 5 A rated printed wiring track widths. See Figure 9 for the current ratings at other durations. Derate current values at -0.61 %/ $^\circ\text{C}$  for ambient temperatures above  $25^\circ\text{C}$ .

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# TISP4xxxM3BJ Overvoltage Protector Series

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## Electrical Characteristics, $T_A = 25^\circ\text{C}$ (Unless Otherwise Noted)

| Parameter                                          | Test Conditions                                                                                                                                                                                                            | Min        | Typ | Max                                                                                                                                                                                                                                               | Unit                    |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| $I_{\text{DRM}}$ Repetitive peak off-state current | $V_D = V_{\text{DRM}}$<br>$T_A = 25^\circ\text{C}$<br>$T_A = 85^\circ\text{C}$                                                                                                                                             |            |     | $\pm 5$<br>$\pm 10$                                                                                                                                                                                                                               | $\mu\text{A}$           |
| $V_{(\text{BO})}$ Breakover voltage                | $dv/dt = \pm 250 \text{ V/ms}$ , $R_{\text{SOURCE}} = 300 \Omega$                                                                                                                                                          |            |     | $\pm 70$<br>$\pm 80$<br>$\pm 95$<br>$\pm 115$<br>$\pm 125$<br>$\pm 145$<br>$\pm 165$<br>$\pm 180$<br>$\pm 200$<br>$\pm 220$<br>$\pm 240$<br>$\pm 250$<br>$\pm 265$<br>$\pm 290$<br>$\pm 300$<br>$\pm 350$<br>$\pm 360$<br>$\pm 395$<br>$\pm 400$  | V                       |
| $V_{(\text{BO})}$ Impulse breakover voltage        | $dv/dt \leq \pm 1000 \text{ V}/\mu\text{s}$ , Linear voltage ramp,<br>Maximum ramp value = $\pm 500 \text{ V}$<br>$di/dt = \pm 20 \text{ A}/\mu\text{s}$ , Linear current ramp,<br>Maximum ramp value = $\pm 10 \text{ A}$ |            |     | $\pm 78$<br>$\pm 88$<br>$\pm 102$<br>$\pm 122$<br>$\pm 132$<br>$\pm 151$<br>$\pm 171$<br>$\pm 186$<br>$\pm 207$<br>$\pm 227$<br>$\pm 247$<br>$\pm 257$<br>$\pm 272$<br>$\pm 298$<br>$\pm 308$<br>$\pm 359$<br>$\pm 370$<br>$\pm 405$<br>$\pm 410$ | V                       |
| $I_{(\text{BO})}$ Breakover current                | $dv/dt = \pm 250 \text{ V/ms}$ , $R_{\text{SOURCE}} = 300 \Omega$                                                                                                                                                          | $\pm 0.15$ |     | $\pm 0.6$                                                                                                                                                                                                                                         | A                       |
| $V_T$ On-state voltage                             | $I_T = \pm 5 \text{ A}$ , $t_W = 100 \mu\text{s}$                                                                                                                                                                          |            |     | $\pm 3$                                                                                                                                                                                                                                           | V                       |
| $I_H$ Holding current                              | $I_T = \pm 5 \text{ A}$ , $di/dt = \pm 30 \text{ mA/ms}$                                                                                                                                                                   | $\pm 0.15$ |     | $\pm 0.35$                                                                                                                                                                                                                                        | A                       |
| $dv/dt$ Critical rate of rise of off-state voltage | Linear voltage ramp, Maximum ramp value $< 0.85 V_{\text{DRM}}$                                                                                                                                                            | $\pm 5$    |     |                                                                                                                                                                                                                                                   | $\text{kV}/\mu\text{s}$ |
| $I_D$ Off-state current                            | $V_D = \pm 50 \text{ V}$<br>$T_A = 85^\circ\text{C}$                                                                                                                                                                       |            |     | $\pm 10$                                                                                                                                                                                                                                          | $\mu\text{A}$           |

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# TISP4xxxM3BJ Overvoltage Protector Series

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## Electrical Characteristics, $T_A = 25\text{ }^{\circ}\text{C}$ (Unless Otherwise Noted)

| Parameter                       | Test Conditions                                                                     | Min              | Typ | Max | Unit |
|---------------------------------|-------------------------------------------------------------------------------------|------------------|-----|-----|------|
| $C_{off}$ Off-state capacitance | $f = 1\text{ MHz}$ , $V_d = 1\text{ V rms}$ , $V_D = 0$                             | 4070 thru '4115  | 83  | 100 | pF   |
|                                 |                                                                                     | '4125 thru '4220 | 62  | 74  |      |
|                                 |                                                                                     | '4240 thru '4400 | 50  | 60  |      |
|                                 | $f = 1\text{ MHz}$ , $V_d = 1\text{ V rms}$ , $V_D = -1\text{ V}$                   | '4070 thru '4115 | 78  | 94  |      |
|                                 |                                                                                     | '4125 thru '4220 | 56  | 67  |      |
|                                 |                                                                                     | '4240 thru '4400 | 45  | 54  |      |
|                                 | $f = 1\text{ MHz}$ , $V_d = 1\text{ V rms}$ , $V_D = -2\text{ V}$                   | '4070 thru '4115 | 72  | 87  |      |
|                                 |                                                                                     | '4125 thru '4220 | 52  | 62  |      |
|                                 |                                                                                     | '4240 thru '4400 | 42  | 50  |      |
|                                 | $f = 1\text{ MHz}$ , $V_d = 1\text{ V rms}$ , $V_D = -50\text{ V}$                  | '4070 thru '4115 | 36  | 44  |      |
|                                 |                                                                                     | '4125 thru '4220 | 26  | 31  |      |
|                                 |                                                                                     | '4240 thru '4400 | 19  | 22  |      |
|                                 | $f = 1\text{ MHz}$ , $V_d = 1\text{ V rms}$ , $V_D = -100\text{ V}$<br>(see Note 6) | '4125 thru '4220 | 21  | 25  |      |
|                                 |                                                                                     | '4240 thru '4400 | 15  | 18  |      |

NOTE 6: To avoid possible voltage clipping, the '4125 is tested with  $V_D = -98\text{ V}$ .

## Thermal Characteristics

| Parameter                                               | Test Conditions                                                                                                 | Min | Typ | Max | Unit                 |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----|-----|-----|----------------------|
| $R_{\theta JA}$ Junction to free air thermal resistance | EIA/JESD51-3 PCB, $I_T = I_{TSM(1000)}$ ,<br>$T_A = 25\text{ }^{\circ}\text{C}$ , (see Note 7)                  |     |     | 115 | $^{\circ}\text{C/W}$ |
|                                                         | 265 mm x 210 mm populated line card,<br>4-layer PCB, $I_T = I_{TSM(1000)}$ , $T_A = 25\text{ }^{\circ}\text{C}$ |     | 52  |     |                      |

NOTE 7: EIA/JESD51-2 environment and PCB has standard footprint dimensions connected with 5 A rated printed wiring track widths.

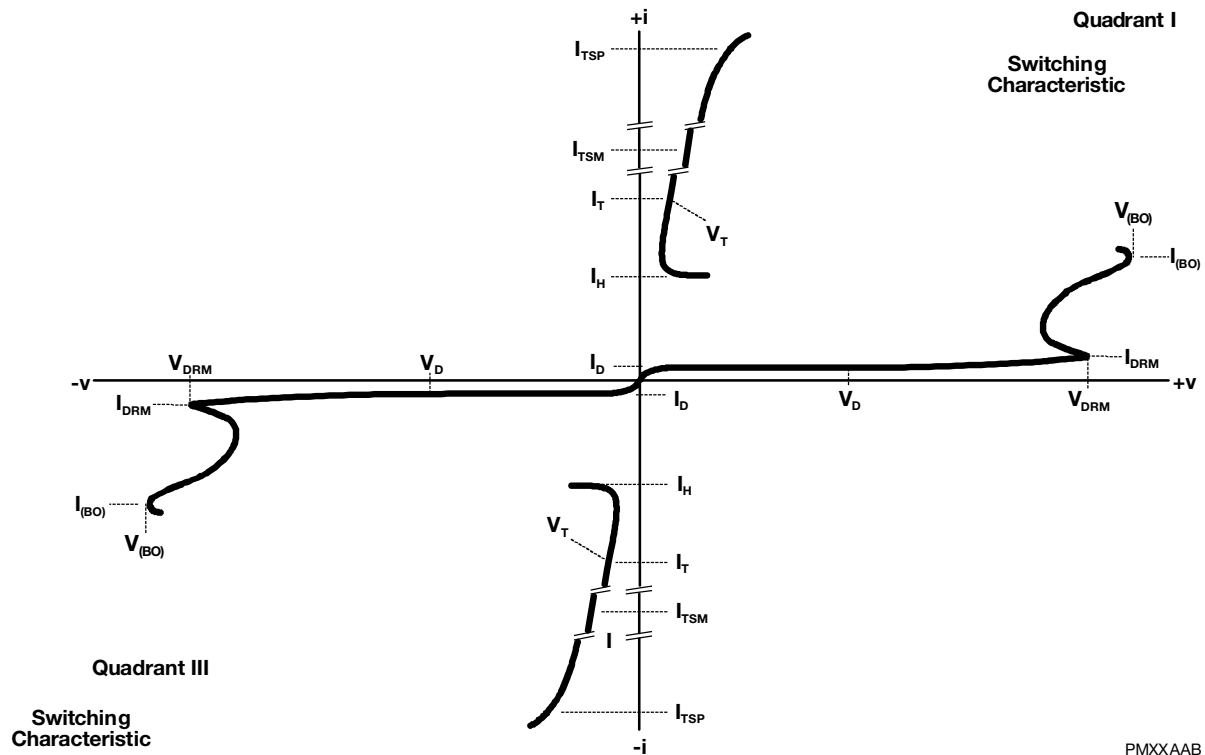
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## Parameter Measurement Information



**Figure 1. Voltage-Current Characteristic for T and R Terminals**  
**All Measurements are Referenced to the R Terminal**

PMXXAAB

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## Typical Characteristics

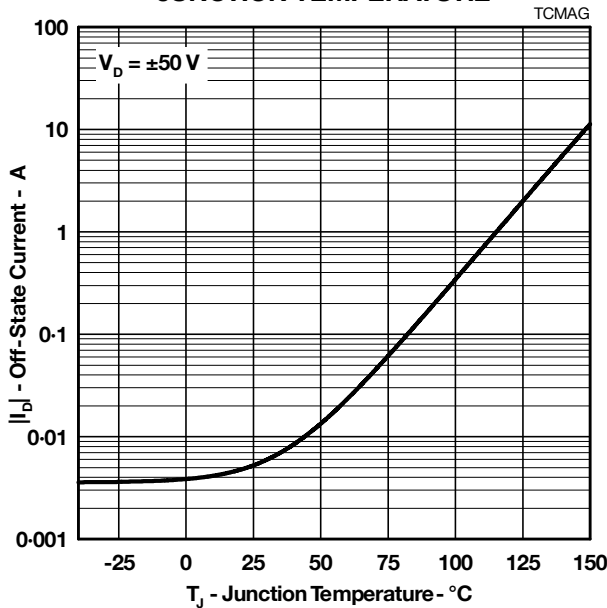
OFF-STATE CURRENT  
vs  
JUNCTION TEMPERATURE

Figure 2.

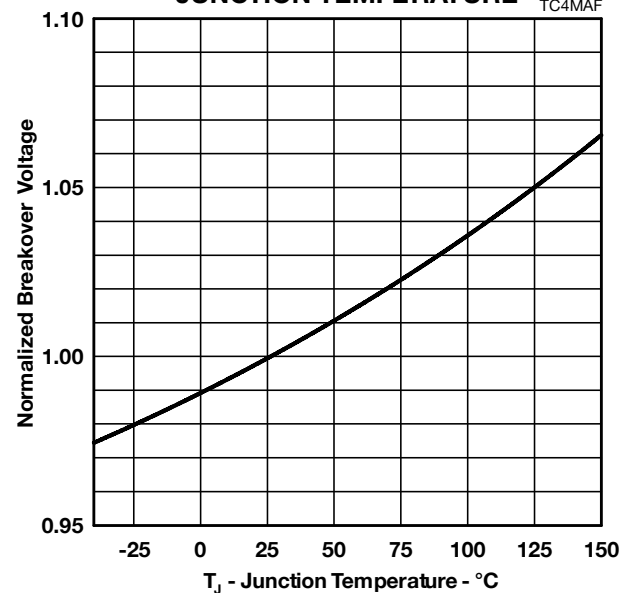
NORMALIZED BREAKOVER VOLTAGE  
vs  
JUNCTION TEMPERATURE

Figure 3.

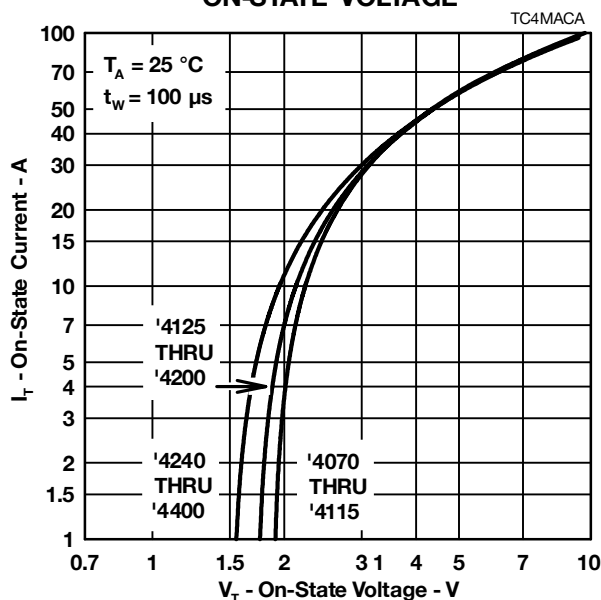
ON-STATE CURRENT  
vs  
ON-STATE VOLTAGE

Figure 4.

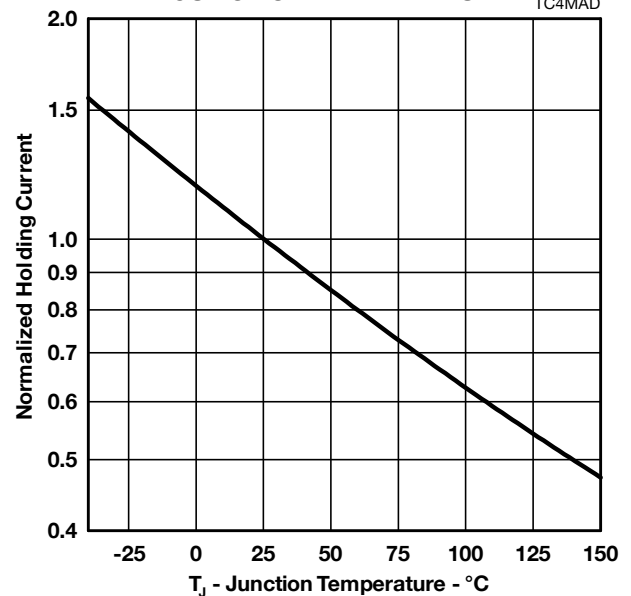
NORMALIZED HOLDING CURRENT  
vs  
JUNCTION TEMPERATURE

Figure 5.

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## Typical Characteristics

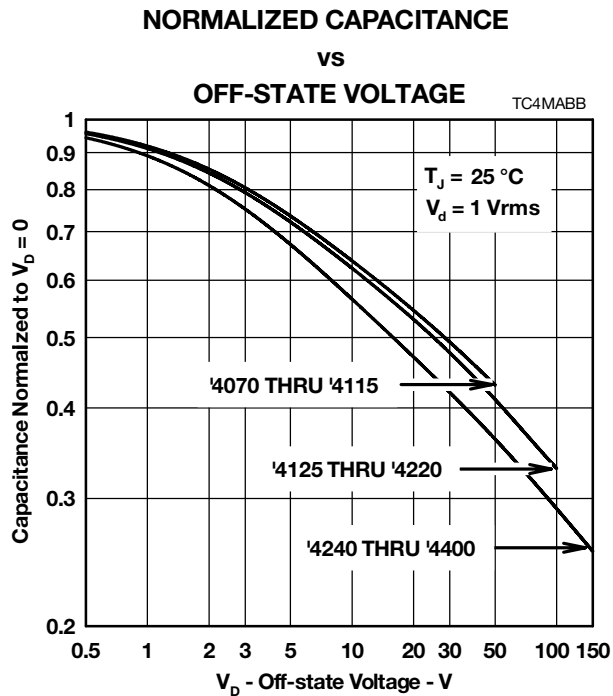


Figure 6.

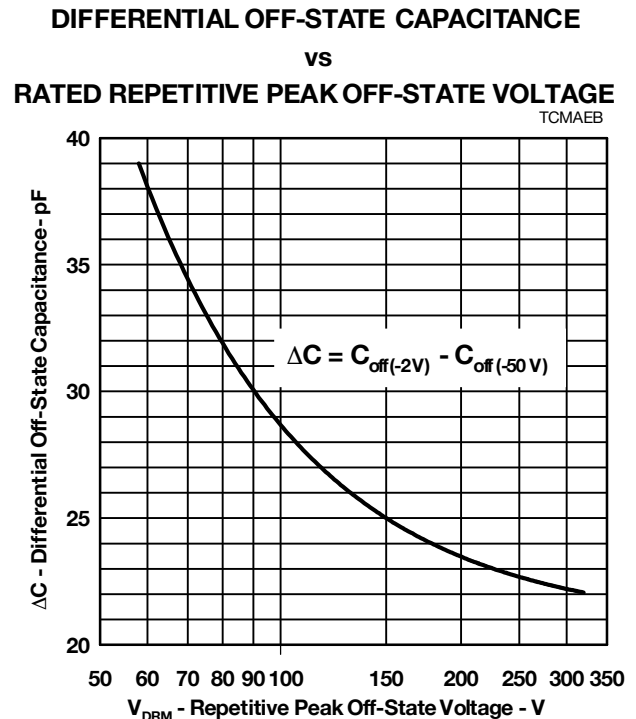


Figure 7.

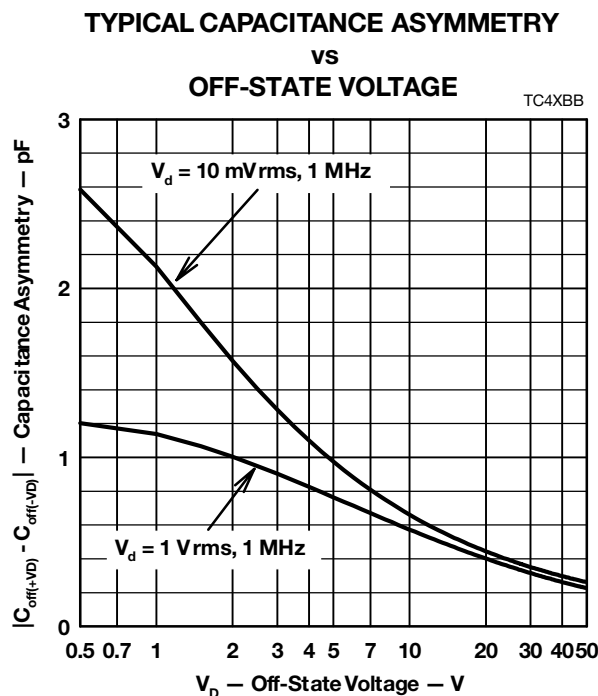


Figure 8.

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## Rating and Thermal Information

### NON-REPETITIVE PEAK ON-STATE CURRENT VS CURRENT DURATION

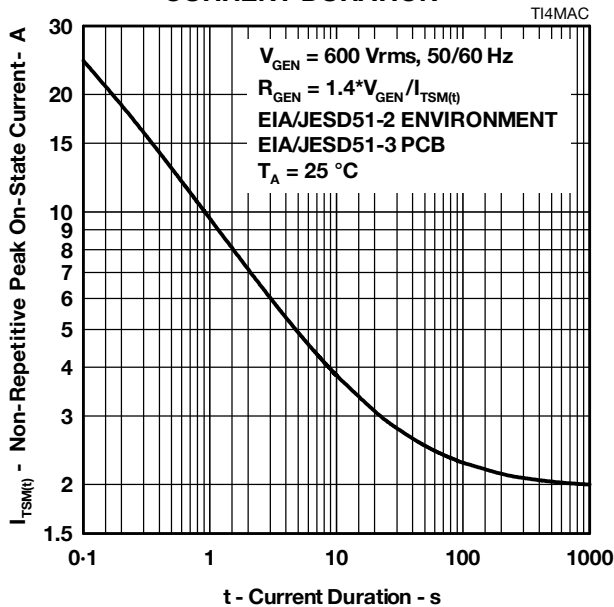


Figure 9.

### THERMAL IMPEDANCE VS POWER DURATION

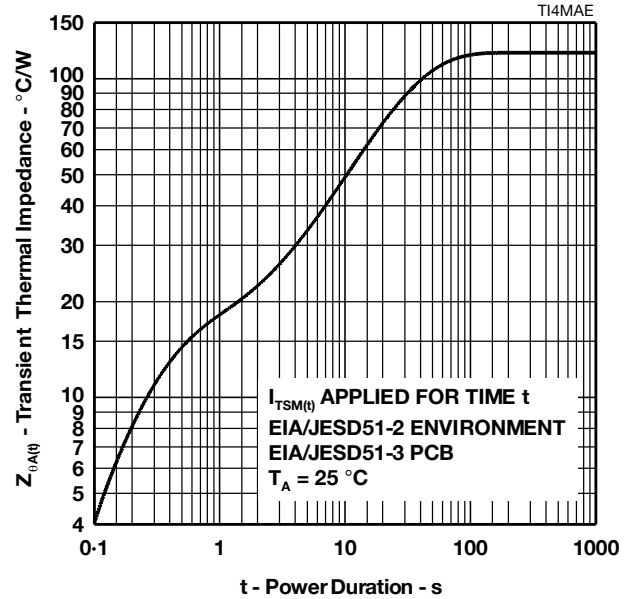


Figure 10.

### V\_DRM DERATING FACTOR VS MINIMUM AMBIENT TEMPERATURE

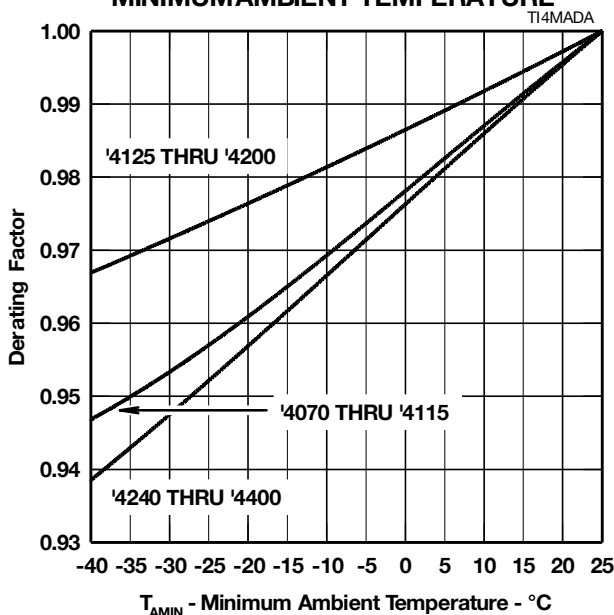


Figure 11.

### IMPULSE RATING VS AMBIENT TEMPERATURE

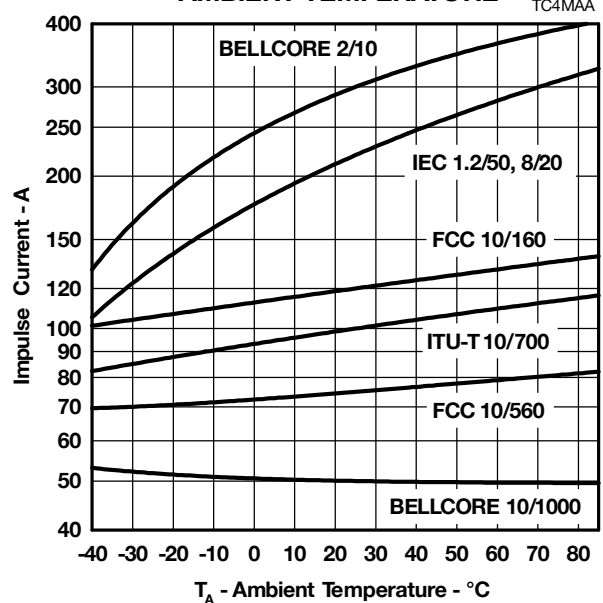


Figure 12.

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## APPLICATIONS INFORMATION

## Deployment

These devices are two terminal overvoltage protectors. They may be used either singly to limit the voltage between two conductors (Figure 13) or in multiples to limit the voltage at several points in a circuit (Figure 14).

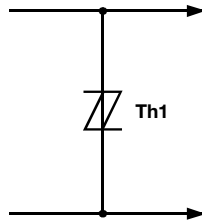


Figure 13. Two Point Protection

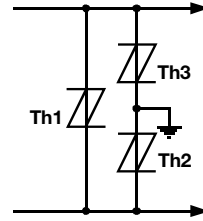


Figure 14. Multi-Point Protection

In Figure 13, protector Th1 limits the maximum voltage between the two conductors to  $\pm V(BO)$ . This configuration is normally used to protect circuits without a ground reference, such as modems. In Figure 14, protectors Th2 and Th3 limit the maximum voltage between each conductor and ground to the  $\pm V(BO)$  of the individual protector. Protector Th1 limits the maximum voltage between the two conductors to its  $\pm V(BO)$  value. If the equipment being protected has all its vulnerable components connected between the conductors and ground, then protector Th1 is not required.

## Impulse Testing

To verify the withstand capability and safety of the equipment, standards require that the equipment is tested with various impulse wave forms. The table below shows some common values.

| Standard                    | Peak Voltage<br>Setting<br>V | Voltage<br>Wave Shape<br>$\mu s$ | Peak Current<br>Value<br>A | Current<br>Wave Shape<br>$\mu s$ | TISP4XXXM3<br>25 °C Rating<br>A | Series<br>Resistance<br>$\Omega$ |
|-----------------------------|------------------------------|----------------------------------|----------------------------|----------------------------------|---------------------------------|----------------------------------|
| GR-1089-CORE                | 2500                         | 2/10                             | 500                        | 2/10                             | 300                             | 11                               |
|                             | 1000                         | 10/1000                          | 100                        | 10/1000                          | 50                              |                                  |
| FCC Part 68<br>(March 1998) | 1500                         | 10/160                           | 200                        | 10/160                           | 120                             | 2x5.6                            |
|                             | 800                          | 10/560                           | 100                        | 10/560                           | 75                              | 3                                |
|                             | 1500                         | 9/720 †                          | 37.5                       | 5/320 †                          | 100                             | 0                                |
|                             | 1000                         | 9/720 †                          | 25                         | 5/320 †                          | 100                             | 0                                |
| I3124                       | 1500                         | 0.5/700                          | 37.5                       | 0.2/310                          | 100                             | 0                                |
| ITU-T K.20/K.21             | 1500                         | 10/700                           | 37.5                       | 5/310                            | 100                             | 0                                |
|                             | 4000                         |                                  | 100                        |                                  |                                 |                                  |

† FCC Part 68 terminology for the waveforms produced by the ITU-T recommendation K.21 10/700 impulse generator

If the impulse generator current exceeds the protector's current rating, then a series resistance can be used to reduce the current to the protector's rated value to prevent possible failure. The required value of series resistance for a given waveform is given by the following calculations. First, the minimum total circuit impedance is found by dividing the impulse generator's peak voltage by the protector's rated current. The impulse generator's fictive impedance (generator's peak voltage divided by peak short circuit current) is then subtracted from the minimum total circuit impedance to give the required value of series resistance.

For the FCC Part 68 10/560 waveform, the following values result. The minimum total circuit impedance is  $800/75 = 10.7 \Omega$  and the generator's fictive impedance is  $800/100 = 8 \Omega$ . This gives a minimum series resistance value of  $10.7 - 8 = 2.7 \Omega$ . After allowing for tolerance, a  $3 \Omega \pm 10\%$  resistor would be suitable. The 10/160 waveform needs a standard resistor value of  $5.6 \Omega$  per conductor. These would be R1a and R1b in Figure 16 and Figure 17. FCC Part 68 allows the equipment to be non-operational after the 10/160 (conductor to ground) and 10/560 (inter-conductor) impulses. The series resistor value may be reduced to zero to pass FCC Part 68 in a non-operational mode, e.g. Figure 15. For this type of design, the series fuse must open before the TISP4xxxM3 fails. For Figure 15, the maximum fuse  $i^2t$  is  $2.3 A^2s$ . In some cases, the equipment will require verification over a temperature range. By using the rated waveform values from Figure 12, the appropriate series resistor value can be calculated for ambient temperatures in the range of  $-40^\circ C$  to  $85^\circ C$ .

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## AC Power Testing

The protector can withstand currents applied for times not exceeding those shown in Figure 9. Currents that exceed these times must be terminated or reduced to avoid protector failure. Fuses, PTC (Positive Temperature Coefficient) thermistors and fusible resistors are overcurrent protection devices which can be used to reduce the current flow. Protective fuses may range from a few hundred milliamperes to one ampere. In some cases, it may be necessary to add some extra series resistance to prevent the fuse opening during impulse testing. The current versus time characteristic of the overcurrent protector must be below the line shown in Figure 9. In some cases, there may be a further time limit imposed by the test standard (e.g. UL 1459 wiring simulator failure).

## Capacitance

The protector characteristic off-state capacitance values are given for d.c. bias voltage,  $V_D$ , values of 0, -1 V, -2 V and -50 V. Where possible values are also given for -100 V. Values for other voltages may be calculated by multiplying the  $V_D = 0$  capacitance value by the factor given in Figure 6. Up to 10 MHz, the capacitance is essentially independent of frequency. Above 10 MHz, the effective capacitance is strongly dependent on connection inductance. In many applications, such as Figure 16 and Figure 18, the typical conductor bias voltages will be about -2 V and -50 V. Figure 7 shows the differential (line unbalance) capacitance caused by biasing one protector at -2 V and the other at -50 V.

Figure 8 shows the typical capacitance asymmetry; the difference between the capacitance measured with a positive value of  $V_D$  and the capacitance value when the polarity of  $V_D$  is reversed. Capacitance asymmetry is an important parameter in ADSL systems where the protector often has no d.c. bias and the signal level is in the region of  $\pm 10$  V.

## Normal System Voltage Levels

The protector should not clip or limit the voltages that occur in normal system operation. For unusual conditions, such as ringing without the line connected, some degree of clipping is permissible. Under this condition, about 10 V of clipping is normally possible without activating the ring trip circuit.

Figure 11 allows the calculation of the protector  $V_{DRM}$  value at temperatures below 25 °C. The calculated value should not be less than the maximum normal system voltages. The TISP4265M3BJ, with a  $V_{DRM}$  of 200 V, can be used for the protection of ring generators producing 100 V rms of ring on a battery voltage of -58 V (Th2 and Th3 in Figure 18). The peak ring voltage will be  $58 + 1.414 \times 100 = 199.4$  V. However, this is the open circuit voltage and the connection of the line and its equipment will reduce the peak voltage. In the extreme case of an unconnected line, clipping the peak voltage to 190 V should not activate the ring trip. This level of clipping would occur at the temperature when the  $V_{DRM}$  has reduced to  $190/200 = 0.95$  of its 25 °C value. Figure 11 shows that this condition will occur at an ambient temperature of -28 °C. In this example, the TISP4265M3BJ will allow normal equipment operation provided that the minimum expected ambient temperature does not fall below -28 °C.

## JESD51 Thermal Measurement Method

To standardize thermal measurements, the EIA (Electronic Industries Alliance) has created the JESD51 standard. Part 2 of the standard (JESD51-2, 1995) describes the test environment. This is a  $0.0283 \text{ m}^3$  ( $1 \text{ ft}^3$ ) cube which contains the test PCB (Printed Circuit Board) horizontally mounted at the center. Part 3 of the standard (JESD51-3, 1996) defines two test PCBs for surface mount components; one for packages smaller than 27 mm on a side and the other for packages up to 48 mm. The SMBJ measurements used the smaller  $76.2 \text{ mm} \times 114.3 \text{ mm}$  ( $3.0 \text{ "} \times 4.5 \text{ "}$ ) PCB. The JESD51-3 PCBs are designed to have low effective thermal conductivity (high thermal resistance) and represent a worst case condition. The PCBs used in the majority of applications will achieve lower values of thermal resistance, and can dissipate higher power levels than indicated by the JESD51 values.

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## Typical Circuits

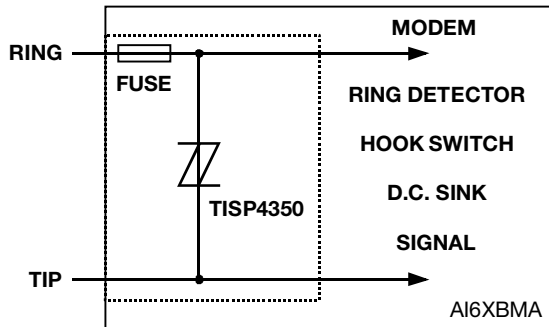


Figure 15. Modem Inter-Wire Protection

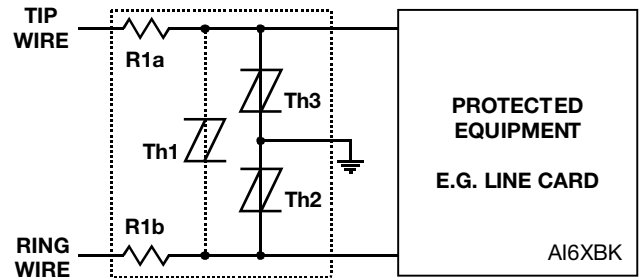


Figure 16. PROTECTION MODULE

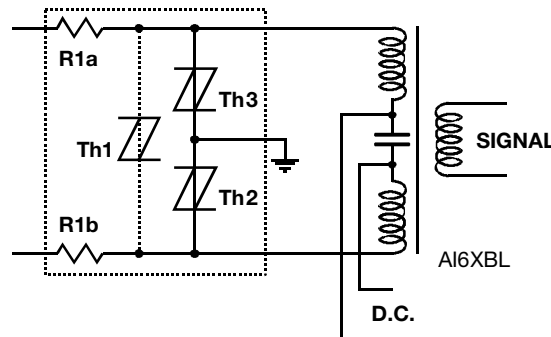


Figure 17. ISDN Protection

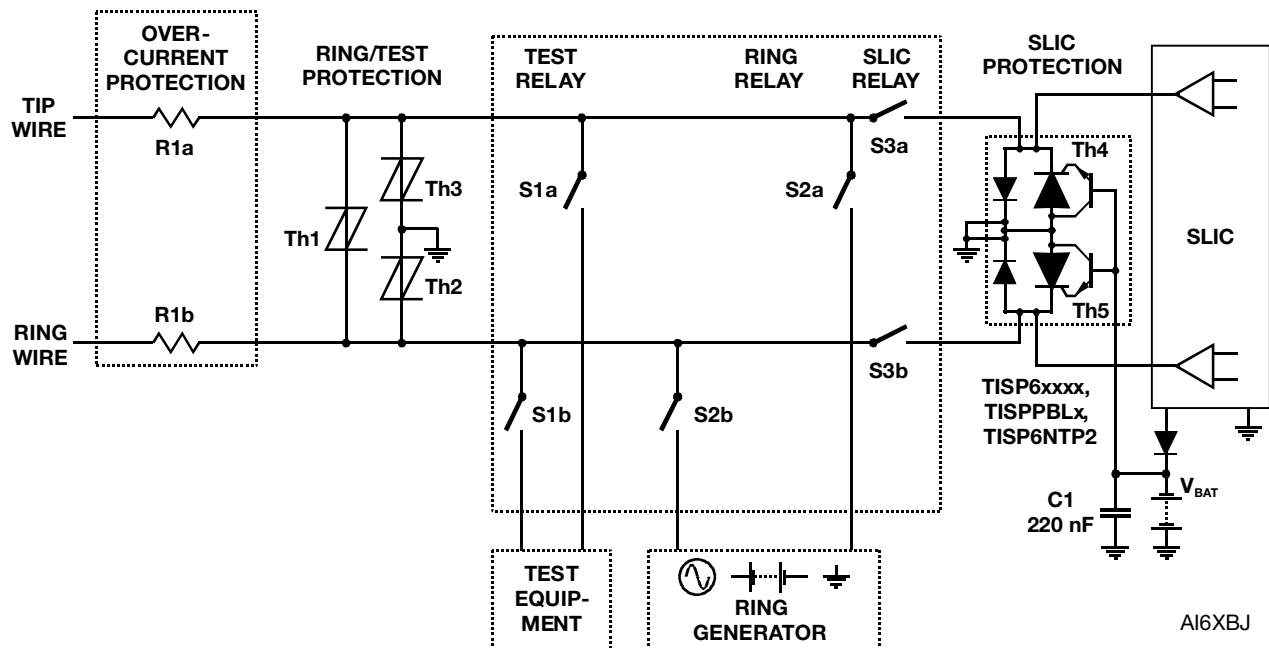


Figure 18. Line Card Ring/Test Protection

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## TISP4xxxM3BJ Overvoltage Protector Series

**BOURNS®**

### Device Symbolization Code

Devices will be coded as below. As the device parameters are symmetrical, terminal 1 is not identified.

| Device       | Symbolization Code |
|--------------|--------------------|
| TISP4070M3BJ | 4070M3             |
| TISP4080M3BJ | 4080M3             |
| TISP4095M3BJ | 4095M3             |
| TISP4115M3BJ | 4115M3             |
| TISP4125M3BJ | 4125M3             |
| TISP4145M3BJ | 4145M3             |
| TISP4165M3BJ | 4165M3             |
| TISP4180M3BJ | 4180M3             |
| TISP4200M3BJ | 4200M3             |
| TISP4220M3BJ | 4220M3             |
| TISP4240M3BJ | 4240M3             |
| TISP4250M3BJ | 4250M3             |
| TISP4265M3BJ | 4265M3             |
| TISP4290M3BJ | 4290M3             |
| TISP4300M3BJ | 4300M3             |
| TISP4350M3BJ | 4350M3             |
| TISP4360M3BJ | 4360M3             |
| TISP4395M3BJ | 4395M3             |
| TISP4400M3BJ | 4400M3             |

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NOVEMBER 1997 – REVISED JULY 2019

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