

# NPMC Series

## Ultra Low Capacitance TSPD

The NPMC series of Low Capacitance Thyristor Surge Protection Devices (TSPD) protect sensitive electronic equipment from transient overvoltage conditions. Due to their ultra low off-state capacitance ( $C_o$ ), they offer minimal signal distortion for high speed equipment such as DSL and T1/E1 circuits. The low nominal offstate capacitance translates into the extremely low differential capacitance offering superb linearity with applied voltage or frequency.

The NPMC Series helps designers to comply with the various regulatory standards and recommendations including: GR-1089-CORE, IEC 61000-4-5, ITU K.20/K.21/K.45, IEC 60950, TIA-968-A, FCC Part 68, EN 60950, UL 1950.

### Features

- Ultra Low – Micro Capacitance
- Low Leakage (Transparent)
- High Surge Current Capabilities
- Precise Turn on Voltages
- Low Voltage Overshoot
- These are Pb-Free Devices

### Typical Applications

- xDSL Central Office and Customer Premise
- T1/E1
- Other Broadband High Speed Data Transmission Equipment

### ELECTRICAL PARAMETERS

| Device        | $V_{DRM}$ | $V_{(BO)}$ | $V_T$ | $I_{DRM}$ | $I_{(BO)}$ | $I_T$ | $I_H$ |
|---------------|-----------|------------|-------|-----------|------------|-------|-------|
|               | V         | V          | V     | $\mu A$   | mA         | A     | mA    |
| NP0640SxMCT3G | 58        | 77         | 4     | 5         | 800        | 2.2   | 150   |
| NP0720SxMCT3G | 65        | 88         | 4     | 5         | 800        | 2.2   | 150   |
| NP0900SxMCT3G | 75        | 98         | 4     | 5         | 800        | 2.2   | 150   |
| NP1100SxMCT3G | 90        | 130        | 4     | 5         | 800        | 2.2   | 150   |
| NP1300SxMCT3G | 120       | 160        | 4     | 5         | 800        | 2.2   | 150   |
| NP1500SxMCT3G | 140       | 180        | 4     | 5         | 800        | 2.2   | 150   |
| NP1800SxMCT3G | 170       | 220        | 4     | 5         | 800        | 2.2   | 150   |
| NP2100SxMCT3G | 180       | 240        | 4     | 5         | 800        | 2.2   | 150   |
| NP2300SxMCT3G | 190       | 260        | 4     | 5         | 800        | 2.2   | 150   |
| NP2600SxMCT3G | 220       | 300        | 4     | 5         | 800        | 2.2   | 150   |
| NP3100SxMCT3G | 275       | 350        | 4     | 5         | 800        | 2.2   | 150   |
| NP3500SxMCT3G | 320       | 400        | 4     | 5         | 800        | 2.2   | 150   |

G = indicates leadfree, RoHS compliant

\* Recognized Components



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## ULTRA LOW CAPACITANCE BIDIRECTIONAL SURFACE MOUNT THYRISTOR 64 – 350 VOLTS



**SMB**  
**JEDEC DO-214AA**  
**CASE 403C**

### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
xxxx = Specific Device Code (NPxxx0SxMC)  
▪ = Pb-Free Package  
(Note: Microdot may be in either location)

### ORDERING INFORMATION

| Device        | Package          | Shipping <sup>†</sup> |
|---------------|------------------|-----------------------|
| NPxxx0SxMCT3G | SMB<br>(Pb-Free) | 2500 Tape &<br>Reel   |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# NPMC Series

## TEL-COM STANDARDS

| Specification | Waveform           |                    | x = series ratings |     |     | Unit  |
|---------------|--------------------|--------------------|--------------------|-----|-----|-------|
|               | Voltage ( $\mu$ s) | Current ( $\mu$ s) | A                  | B   | C   |       |
| GR-1089-CORE  | 2x10               | 2x10               | 150                | 250 | 500 | A(pk) |
| TIA-968-A     | 10x160             | 10x160             | 90                 | 150 | 200 |       |
| GR-1089-CORE  | 10x360             | 10x360             | 75                 | 125 | 175 |       |
| TIA-968-A     | 10x560             | 10x560             | 50                 | 100 | 150 |       |
| ITU-T K.20/21 | 10x700             | 5x310              | 75                 | 100 | 200 |       |
| GR-1089-CORE  | 10x1000            | 10x1000            | 50                 | 80  | 100 |       |

## SURGE RATINGS

| Characteristics                                                                                                       | Symbol            | A   | B   | C   | Unit  |
|-----------------------------------------------------------------------------------------------------------------------|-------------------|-----|-----|-----|-------|
| Nominal Pulse<br>Surge Short Circuit Current Non – Repetitive<br>Double Exponential Decay Waveform (Notes 1, 2 and 3) |                   |     |     |     | A(pk) |
| 2 x 10 $\mu$ Sec                                                                                                      | I <sub>PPS1</sub> | 150 | 250 | 500 |       |
| 8 x 20 $\mu$ Sec                                                                                                      | I <sub>PPS2</sub> | 150 | 250 | 400 |       |
| 10 x 160 $\mu$ Sec                                                                                                    | I <sub>PPS3</sub> | 90  | 150 | 200 |       |
| 10 x 360 $\mu$ Sec                                                                                                    | I <sub>PPS4</sub> | 75  | 125 | 150 |       |
| 10 x 560 $\mu$ Sec                                                                                                    | I <sub>PPS5</sub> | 50  | 100 | 150 |       |
| 10 x 700 $\mu$ Sec                                                                                                    | I <sub>PPS6</sub> | 75  | 100 | 200 |       |
| 10 x 1000 $\mu$ Sec                                                                                                   | I <sub>PPS7</sub> | 50  | 80  | 100 |       |

1. Allow cooling before testing second polarity.
2. Measured under pulse conditions to reduce heating.
3. Nominal values may not represent the maximum capability of a device.

## CAPACITANCE

| Characteristics                                                                   | Symbol         | Max |    |    | Unit |
|-----------------------------------------------------------------------------------|----------------|-----|----|----|------|
|                                                                                   |                | A   | B  | C  |      |
| (f=1.0 MHz, 1.0 V <sub>rms</sub> , 2 Vdc bias)<br>(C <sub>o</sub> Apx 45% @ 50 V) | C <sub>o</sub> |     |    |    | pF   |
| NP0640SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP0720SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP0900SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP1100SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP1300SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP1500SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP1800SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP2100SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP2300SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP2600SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP3100SxMCT3G                                                                     |                | 23  | 29 | 33 |      |
| NP3500SxMCT3G                                                                     |                | 23  | 29 | 33 |      |

## MAXIMUM RATINGS (T<sub>A</sub> = 25°C unless otherwise noted)

| Symbol           | Rating                                                                                                                                                                                                                                                                                       | Value | Unit |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|
| V <sub>DRM</sub> | Repetitive peak off-state voltage: Rated maximum (peak) continuous voltage that may be applied in the off-state conditions including all dc and repetitive alternating voltage components.                                                                                                   | ±58   | V    |
|                  |                                                                                                                                                                                                                                                                                              | ±65   |      |
|                  |                                                                                                                                                                                                                                                                                              | ±75   |      |
|                  |                                                                                                                                                                                                                                                                                              | ±90   |      |
|                  |                                                                                                                                                                                                                                                                                              | ±120  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±140  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±170  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±180  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±190  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±220  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±275  |      |
|                  |                                                                                                                                                                                                                                                                                              | ±320  |      |
|                  | (Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.) |       |      |

## NPMC Series

**ELECTRICAL CHARACTERISTICS TABLE** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

| Symbol     | Rating                                                                                                                                         | Min                 | Typ | Max       | Unit             |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----|-----------|------------------|
| $V_{(BO)}$ | Breakover voltage: The maximum voltage across the device in or at the breakdown region. (Note 4)<br>VDC = 1000 V, dv/dt = 100 V/ $\mu\text{s}$ | NP0640SxMCT3G       |     | $\pm 77$  | V                |
|            |                                                                                                                                                | NP0720SxMCT3G       |     | $\pm 88$  |                  |
|            |                                                                                                                                                | NP0900SxMCT3G       |     | $\pm 98$  |                  |
|            |                                                                                                                                                | NP1100SxMCT3G       |     | $\pm 130$ |                  |
|            |                                                                                                                                                | NP1300SxMCT3G       |     | $\pm 160$ |                  |
|            |                                                                                                                                                | NP1500SxMCT3G       |     | $\pm 180$ |                  |
|            |                                                                                                                                                | NP1800SxMCT3G       |     | $\pm 220$ |                  |
|            |                                                                                                                                                | NP2100SxMCT3G       |     | $\pm 240$ |                  |
|            |                                                                                                                                                | NP2300SxMCT3G       |     | $\pm 260$ |                  |
|            |                                                                                                                                                | NP2600SxMCT3G       |     | $\pm 300$ |                  |
|            |                                                                                                                                                | NP3100SxMCT3G       |     | $\pm 350$ |                  |
|            |                                                                                                                                                | NP3500SxMCT3G       |     | $\pm 400$ |                  |
| $I_{(BO)}$ | Breakover Current: The instantaneous current flowing at the breakover voltage.                                                                 |                     |     | 800       | mA               |
| $I_H$      | Holding Current: Minimum current required to maintain the device in the on-state. (Notes 5, 6)                                                 | 150                 |     |           | mA               |
| $I_{DRM}$  | Off-state Current: The dc value of current that results from the application of the off-state voltage                                          | $V_D = 50\text{ V}$ |     | 2         | $\mu\text{A}$    |
|            |                                                                                                                                                | $V_D = V_{DRM}$     |     | 5         |                  |
| $V_T$      | On-state Voltage: The voltage across the device in the on-state condition.<br>$I_T = 2.2\text{ A}$ (pk), PW = 300 $\mu\text{s}$ , DC = 2%      |                     |     | 4         | V                |
| di/dt      | Critical rate of rise of on-state current: rated value of the rate of rise of current which the device can withstand without damage.           |                     |     | $\pm 500$ | A/ $\mu\text{s}$ |

4. Electrical parameters are based on pulsed test methods.  
 5. Measured under pulsed conditions to reduce heating  
 6. Allow cooling before testing second polarity.

### THERMAL CHARACTERISTICS

| Symbol          | Rating                                                                                                                                 | Value       | Unit               |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------|
| $T_{STG}$       | Storage Temperature Range                                                                                                              | -65 to +150 | $^\circ\text{C}$   |
| $T_J$           | Junction Temperature                                                                                                                   | -40 to +150 | $^\circ\text{C}$   |
| $R_{\theta JA}$ | Thermal Resistance: Junction-to-Ambient Per EIA/JESD51-3, PCB = FR4 3"x4.5"x0.06"<br>Fan out in a 3x3 inch pattern, 2 oz copper track. | 90          | $^\circ\text{C/W}$ |

# NPMC Series

## ELECTRICAL PARAMETER/RATINGS DEFINITIONS

| Symbol     | Parameter                           |
|------------|-------------------------------------|
| $V_{DRM}$  | Repetitive Peak Off-state Voltage   |
| $V_{(BO)}$ | Breakover Voltage                   |
| $I_{DRM}$  | Off-state Current                   |
| $I_{(BO)}$ | Breakover Current                   |
| $I_H$      | Holding Current                     |
| $V_T$      | On-state Voltage                    |
| $I_T$      | On-state Current                    |
| $I_{TSM}$  | Nonrepetitive Peak On-state Current |
| $I_{PPS}$  | Nonrepetitive Peak Impulse Current  |
| $V_D$      | Off-state Voltage                   |
| $I_D$      | Off-state Current                   |

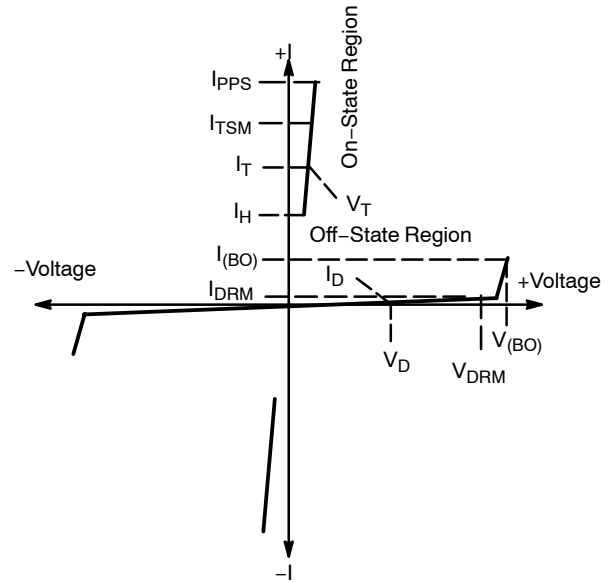


Figure 1. Voltage Current Characteristics of TSPD

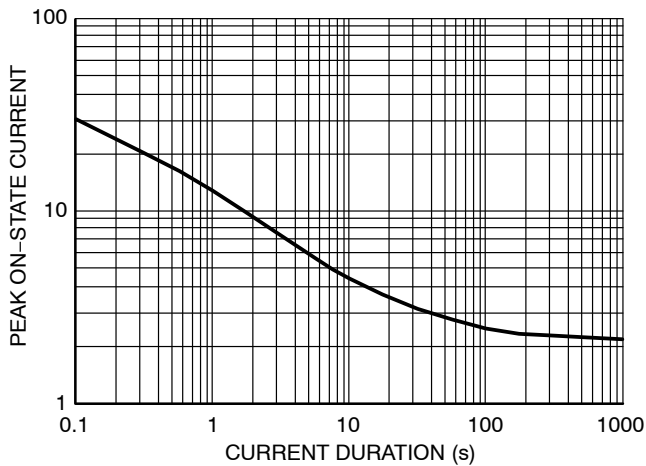


Figure 2. Nonrepetitive On-State Current vs. Time ( $I_{TSM}$ )

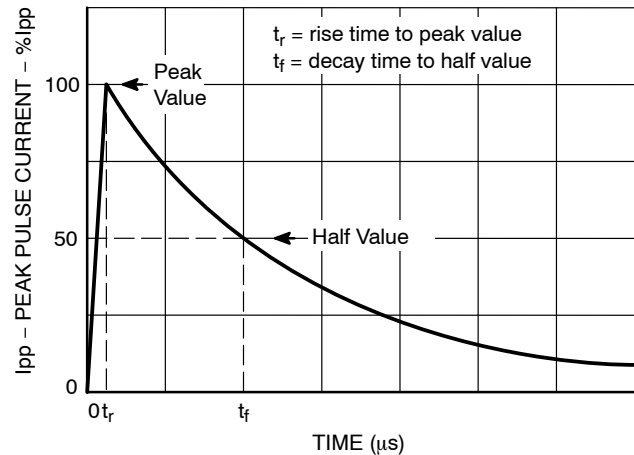


Figure 3. Nonrepetitive On-State Impulse vs. Waveform ( $I_{PPS}$ )

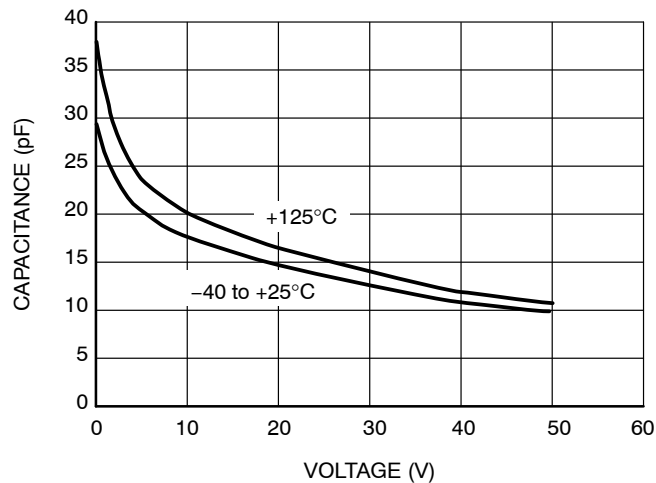


Figure 4. Capacitance vs. Off-State Voltage

## Detailed Operating Description

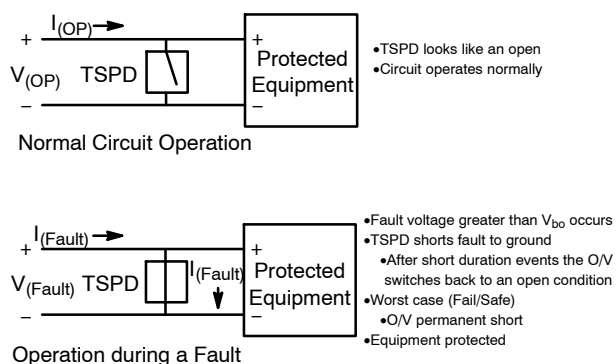
The TSPD or Thyristor Surge Protection Device are specialized silicon based overvoltage protectors, used to protect sensitive electronic circuits from damaging overvoltage transient surges caused by induced lightning and powercross conditions.

The TSPD protects by switching to a low on state voltage when the specified protection voltage is exceeded. This is known as a “crowbar” effect. When an overvoltage occurs, the crowbar device changes from a high-impedance to a low-impedance state. This low-impedance state then offers a path to ground, shunting unwanted surges away from the sensitive circuits.

This crowbar action defines the TSPD’s two states of functionality: Open Circuit and Short Circuit.

**Open Circuit** – The TSPD must remain transparent during normal circuit operation. The device looks like an open across the two wire line.

**Short Circuit** – When a transient surge fault exceeds the TSPD protection voltage threshold, the devices switches on, and shorts the transient to ground, safely protecting the circuit.

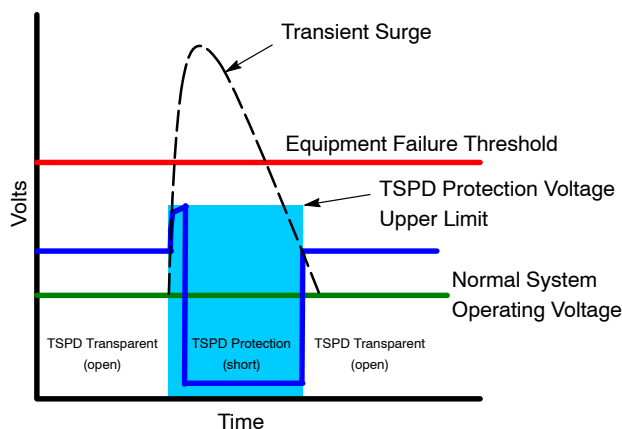


**Figure 5. Normal and Fault Conditions**

The electrical characteristics of the TSPD help the user to define the protection threshold for the circuit. During the open circuit condition the device must remain transparent; this is defined by the  $I_{DRM}$ . The  $I_{DRM}$  should be as low as possible. The typical value is less than 5  $\mu A$ .

The circuit operating voltage and protection voltage must be understood and considered during circuit design. The  $V_{(BO)}$  is the guaranteed maximum voltage that the protected circuit will see, this is also known as the protection voltage. The  $V_{DRM}$  is the guaranteed maximum voltage that will keep the TSPD in its normal open circuit state. The TSPD  $V_{(BO)}$  is typically a 20–30% higher than the  $V_{DRM}$ . Based on these characteristics it is critical to choose devices which have a  $V_{DRM}$  higher than the normal circuit operating voltage, and a  $V_{(BO)}$  which is less than the failure threshold of the protected equipment circuit. A low on-state voltage  $V_t$  allows the TSPD to conduct large amounts of surge current (500 A) in a small package size.

Once a transient surge has passed and the operating voltage and currents have dropped to their normal level the TSPD changes back to its open circuit state.



**Figure 6. Protection During a Transient Surge**

TSPD’s are useful in helping designers meet safety and regulatory standards in Telecom equipment including GR–1089–CORE, ITU–K.20, ITU–K.21, ITU–K.45, FCC Part 68, UL1950, and EN 60950.

ON Semiconductor offers a full range of these products in the NP series product line.

## DEVICE SELECTION

When selecting a TSPD use the following key selection parameters.

### Off-State Voltage $V_{DRM}$

Choose a TSPD that has an Off-State Voltage greater than the normal system operating voltage. The protector should not operate under these conditions:

Example:

$$V_{bat} = 48 \text{ Vmax}$$

$$V_{ring} = 150 \text{ Vrms} = 150 \times 1.414 = 212 \text{ V peak}$$

$V_{DRM}$  should be greater than the peak value of these two components:

$$V_{DRM} > 212 + 48 = 260 \text{ V}_{DRM}$$

### Breakover Voltage $V_{(BO)}$

Verify that the TSPD Breakover Voltage is a value less than the peak voltage rating of the circuit it is protecting.

Example: Relay breakdown voltage, SLIC maximum voltage, or coupling capacitor maximum rated voltage.

### Peak Pulse Current $I_{pps}$

Choose a Peak Pulse current value which will exceed the anticipated surge currents in testing. In some cases the 100 A “C” series device may be needed when little or no series resistance is used. When a series current limiter is used in the circuit a lower current level of “A” or “B” may be used. To determine the peak current divide the maximum surge current by the series resistance.

### Hold Current ( $I_H$ )

The Hold Current must be greater than the maximum system generated current. If it is not then the TSPD will remain in a shorted condition, even after a transient event has passed.

## NPMC Series

### TYPICAL APPLICATIONS

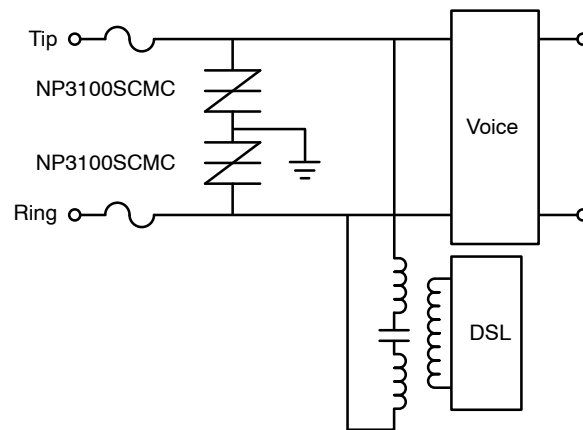


Figure 7. ADSL

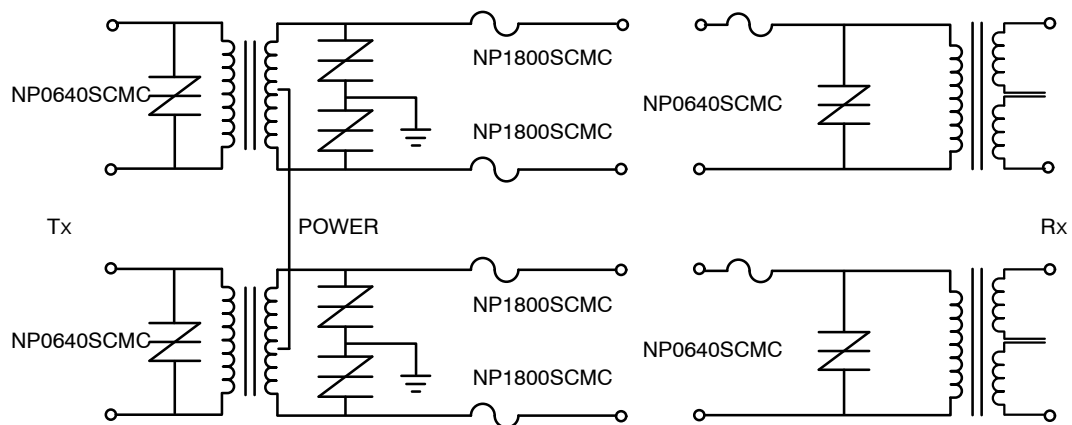
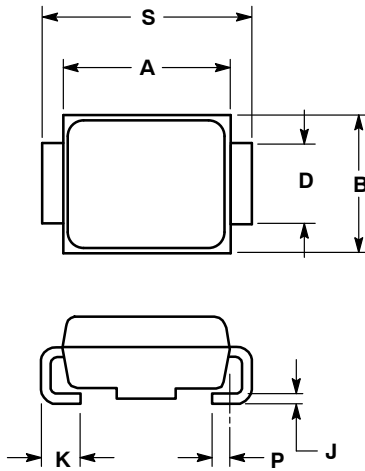


Figure 8. T1/E1

# NPMC Series

## PACKAGE DIMENSIONS

### SMB CASE 403C-01 ISSUE A

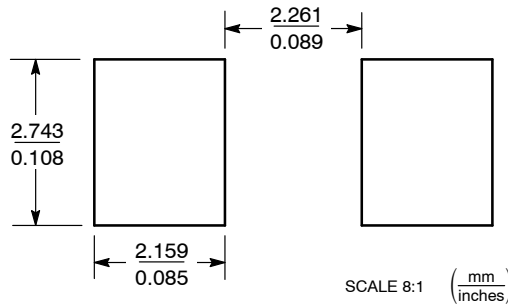


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. D DIMENSION SHALL BE MEASURED WITHIN DIMENSION P.

| DIM | INCHES    |        | MILLIMETERS |       |
|-----|-----------|--------|-------------|-------|
|     | MIN       | MAX    | MIN         | MAX   |
| A   | 0.160     | 0.180  | 4.06        | 4.57  |
| B   | 0.130     | 0.150  | 3.30        | 3.81  |
| C   | 0.075     | 0.095  | 1.90        | 2.41  |
| D   | 0.077     | 0.083  | 1.96        | 2.11  |
| H   | 0.0020    | 0.0060 | 0.051       | 0.152 |
| J   | 0.006     | 0.012  | 0.15        | 0.30  |
| K   | 0.030     | 0.050  | 0.76        | 1.27  |
| P   | 0.020 REF |        | 0.51 REF    |       |
| S   | 0.205     | 0.220  | 5.21        | 5.59  |

### SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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