

# Silicon Carbide (SiC) MOSFET – 32 mohm, 650 V, M2, TO-247-3L

## NVHL045N065SC1

### Features

- Typ.  $R_{DS(on)} = 32\text{ m}\Omega$  @  $V_{GS} = 18\text{ V}$   
Typ.  $R_{DS(on)} = 42\text{ m}\Omega$  @  $V_{GS} = 15\text{ V}$
- Ultra Low Gate Charge ( $Q_{G(tot)} = 105\text{ nC}$ )
- High Speed Switching with Low Capacitance ( $C_{oss} = 162\text{ pF}$ )
- 100% Avalanche Tested
- AEC-Q101 Qualified and PPAP Capable
- This Device is Halide Free and RoHS Compliant with exemption 7a, Pb-Free 2LI (on second level interconnection)

### Typical Applications

- Automotive On Board Charger
- Automotive DC-DC Converter for EV/HEV

### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

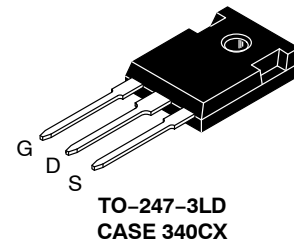
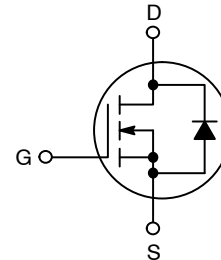
| Parameter                                                                                                |                                                                                        |                             | Symbol            | Value       | Unit               |
|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------|-------------------|-------------|--------------------|
| Drain-to-Source Voltage                                                                                  |                                                                                        |                             | $V_{DSS}$         | 650         | V                  |
| Gate-to-Source Voltage                                                                                   |                                                                                        |                             | $V_{GS}$          | -8/+22      | V                  |
| Recommended Operation Values of Gate-to-Source Voltage                                                   |                                                                                        | $T_C < 175^{\circ}\text{C}$ | $V_{GSop}$        | -5/+18      | V                  |
| Continuous Drain Current (Note 2)                                                                        | Steady State                                                                           | $T_C = 25^{\circ}\text{C}$  | $I_D$             | 66          | A                  |
| Power Dissipation (Note 2)                                                                               |                                                                                        |                             | $P_D$             | 291         | W                  |
| Continuous Drain Current (Notes 1, 2)                                                                    | Steady State                                                                           | $T_C = 100^{\circ}\text{C}$ | $I_D$             | 46          | A                  |
| Power Dissipation (Notes 1, 2)                                                                           |                                                                                        |                             | $P_D$             | 145         | W                  |
| Pulsed Drain Current (Note 3)                                                                            | $T_C = 25^{\circ}\text{C}$                                                             |                             | $I_{DM}$          | 191         | A                  |
| Single Pulse Surge Drain Current Capability                                                              | $T_A = 25^{\circ}\text{C}$ , $t_p = 10\text{ }\mu\text{s}$ , $R_G = 4.7\text{ }\Omega$ |                             | $I_{DSC}$         | 315         | A                  |
| Operating Junction and Storage Temperature Range                                                         |                                                                                        |                             | $T_J$ , $T_{stg}$ | -55 to +175 | $^{\circ}\text{C}$ |
| Source Current (Body Diode)                                                                              |                                                                                        |                             | $I_S$             | 75          | A                  |
| Single Pulse Drain-to-Source Avalanche Energy ( $I_{L(pk)} = 12\text{ A}$ , $L = 1\text{ mH}$ ) (Note 4) |                                                                                        |                             | $E_{AS}$          | 72          | mJ                 |
| Maximum Lead Temperature for Soldering (1/8" from case for 5 s)                                          |                                                                                        |                             | $T_L$             | 300         | $^{\circ}\text{C}$ |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

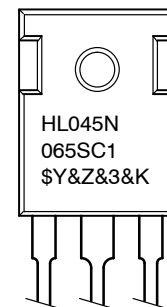
1. JA is constant value to follow guide table of LV/HV discrete final datasheet generation.
2. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.
3. Repetitive rating, limited by max junction temperature.
4. EAS of 72 mJ is based on starting  $T_J = 25^\circ\text{C}$ ;  $L = 1\text{ mH}$ ,  $I_{AS} = 12\text{ A}$ ,  $V_{DD} = 50\text{ V}$ ,  $V_{GS} = 18\text{ V}$ .

| $V_{(BR)DSS}$ | $R_{DS(on)}\text{ MAX}$ | $I_D\text{ MAX}$ |
|---------------|-------------------------|------------------|
| 650 V         | 50 m $\Omega$ @ 18 V    | 66 A             |

### N-CHANNEL MOSFET



### MARKING DIAGRAM



HL045N065SC1 = Specific Device Code  
 $\$Y$  = onsemi Logo  
 $\&Z$  = Assembly Plant Code  
 $\&3$  = Data Code (Year & Week)  
 $\&K$  = Lot

### ORDERING INFORMATION

| Device         | Package             | Shipping           |
|----------------|---------------------|--------------------|
| NVHL045N065SC1 | TO-247<br>Long Lead | 30 Units /<br>Tube |

**Table 1. THERMAL RESISTANCE MAXIMUM RATINGS**

| Parameter                                       | Symbol          | Max  | Unit |
|-------------------------------------------------|-----------------|------|------|
| Junction-to-Case – Steady State (Note 2)        | $R_{\theta JC}$ | 0.52 | °C/W |
| Junction-to-Ambient – Steady State (Notes 1, 2) | $R_{\theta JA}$ | 40   |      |

**Table 2. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------|--------|----------------|-----|-----|-----|------|
|-----------|--------|----------------|-----|-----|-----|------|

**OFF CHARACTERISTICS**

|                                                           |                   |                                                         |                           |      |     |                  |
|-----------------------------------------------------------|-------------------|---------------------------------------------------------|---------------------------|------|-----|------------------|
| Drain-to-Source Breakdown Voltage                         | $V_{(BR)DSS}$     | $V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$                | 650                       | –    | –   | V                |
| Drain-to-Source Breakdown Voltage Temperature Coefficient | $V_{(BR)DSS}/T_J$ | $I_D = 20\text{ mA}$ , referenced to $25^\circ\text{C}$ | –                         | 0.15 | –   | V/°C             |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$         | $V_{GS} = 0\text{ V}, V_{DS} = 650\text{ V}$            | $T_J = 25^\circ\text{C}$  | –    | –   | 10 $\mu\text{A}$ |
|                                                           |                   |                                                         | $T_J = 175^\circ\text{C}$ | –    | –   | 1 mA             |
| Gate-to-Source Leakage Current                            | $I_{GSS}$         | $V_{GS} = +22/-8\text{ V}, V_{DS} = 0\text{ V}$         | –                         | –    | 250 | nA               |

**ON CHARACTERISTICS** (Note 3)

|                               |              |                                                                    |     |     |     |            |
|-------------------------------|--------------|--------------------------------------------------------------------|-----|-----|-----|------------|
| Gate Threshold Voltage        | $V_{GS(TH)}$ | $V_{GS} = V_{DS}, I_D = 8\text{ mA}$                               | 1.8 | 2.8 | 4.3 | V          |
| Recommended Gate Voltage      | $V_{GOP}$    |                                                                    | –5  | –   | +18 | V          |
| Drain-to-Source On Resistance | $R_{DS(on)}$ | $V_{GS} = 15\text{ V}, I_D = 25\text{ A}, T_J = 25^\circ\text{C}$  | –   | 42  | –   | m $\Omega$ |
|                               |              | $V_{GS} = 18\text{ V}, I_D = 25\text{ A}, T_J = 25^\circ\text{C}$  | –   | 32  | 50  |            |
|                               |              | $V_{GS} = 18\text{ V}, I_D = 25\text{ A}, T_J = 175^\circ\text{C}$ | –   | 42  | –   |            |
| Forward Transconductance      | $g_{FS}$     | $V_{DS} = 10\text{ V}, I_D = 25\text{ A}$                          | –   | 16  | –   | S          |

**CHARGES, CAPACITANCES & GATE RESISTANCE**

|                              |              |                                                                     |   |      |   |          |
|------------------------------|--------------|---------------------------------------------------------------------|---|------|---|----------|
| Input Capacitance            | $C_{ISS}$    | $V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 325\text{ V}$      | – | 1870 | – | pF       |
| Output Capacitance           | $C_{OSS}$    |                                                                     | – | 162  | – |          |
| Reverse Transfer Capacitance | $C_{RSS}$    |                                                                     | – | 14   | – |          |
| Total Gate Charge            | $Q_{G(TOT)}$ | $V_{GS} = -5/18\text{ V}, V_{DS} = 520\text{ V}, I_D = 25\text{ A}$ | – | 105  | – | nC       |
| Gate-to-Source Charge        | $Q_{GS}$     |                                                                     | – | 27   | – |          |
| Gate-to-Drain Charge         | $Q_{GD}$     |                                                                     | – | 30   | – |          |
| Gate-Resistance              | $R_G$        | $f = 1\text{ MHz}$                                                  | – | 3.1  | – | $\Omega$ |

**SWITCHING CHARACTERISTICS**

|                         |              |                                                                                                                |   |     |   |               |
|-------------------------|--------------|----------------------------------------------------------------------------------------------------------------|---|-----|---|---------------|
| Turn-On Delay Time      | $t_{d(ON)}$  | $V_{GS} = -5/18\text{ V}, V_{DS} = 400\text{ V}, I_D = 25\text{ A}, R_G = 2.2\text{ }\Omega$<br>Inductive load | – | 14  | – | ns            |
| Rise Time               | $t_r$        |                                                                                                                | – | 30  | – |               |
| Turn-Off Delay Time     | $t_{d(OFF)}$ |                                                                                                                | – | 26  | – |               |
| Fall Time               | $t_f$        |                                                                                                                | – | 7   | – |               |
| Turn-On Switching Loss  | $E_{ON}$     |                                                                                                                | – | 198 | – | $\mu\text{J}$ |
| Turn-Off Switching Loss | $E_{OFF}$    |                                                                                                                | – | 28  | – |               |
| Total Switching Loss    | $E_{tot}$    |                                                                                                                | – | 226 | – |               |

**DRAIN-SOURCE DIODE CHARACTERISTICS**

|                                                    |           |                                                                      |   |     |     |   |
|----------------------------------------------------|-----------|----------------------------------------------------------------------|---|-----|-----|---|
| Continuous Drain-Source Diode Forward Current      | $I_{SD}$  | $V_{GS} = -5\text{ V}, T_J = 25^\circ\text{C}$                       | – | –   | 75  | A |
| Pulsed Drain-Source Diode Forward Current (Note 3) | $I_{SDM}$ |                                                                      | – | –   | 191 |   |
| Forward Diode Voltage                              | $V_{SD}$  | $V_{GS} = -5\text{ V}, I_{SD} = 25\text{ A}, T_J = 25^\circ\text{C}$ | – | 4.4 | –   | V |

**Table 2. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified) (continued)

| Parameter                                 | Symbol    | Test Condition                                                                                | Min | Typ | Max | Unit          |
|-------------------------------------------|-----------|-----------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| <b>DRAIN-SOURCE DIODE CHARACTERISTICS</b> |           |                                                                                               |     |     |     |               |
| Reverse Recovery Time                     | $t_{RR}$  | $V_{GS} = -5/18\text{ V}$ , $I_{SD} = 25\text{ A}$ ,<br>$dI_S/dt = 1000\text{ A}/\mu\text{s}$ | –   | 19  | –   | ns            |
| Reverse Recovery Charge                   | $Q_{RR}$  |                                                                                               | –   | 99  | –   | nC            |
| Reverse Recovery Energy                   | $E_{REC}$ |                                                                                               | –   | 3.5 | –   | $\mu\text{J}$ |
| Peak Reverse Recovery Current             | $I_{RRM}$ |                                                                                               | –   | 10  | –   | A             |
| Charge Time                               | $T_a$     |                                                                                               | –   | 11  | –   | ns            |
| Discharge Time                            | $T_b$     |                                                                                               | –   | 8.4 | –   | ns            |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL CHARACTERISTICS

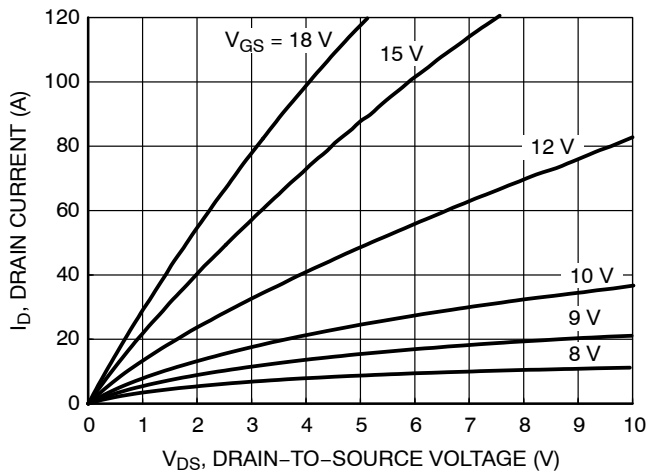


Figure 1. On-Region Characteristics

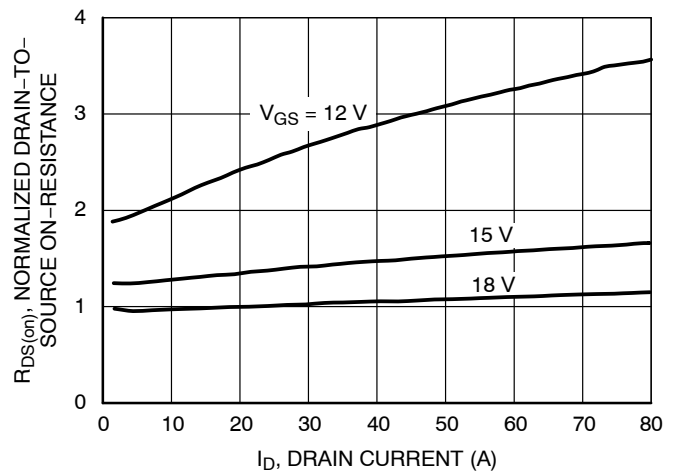


Figure 2. Normalized On-Resistance vs. Drain Current and Gate Voltage

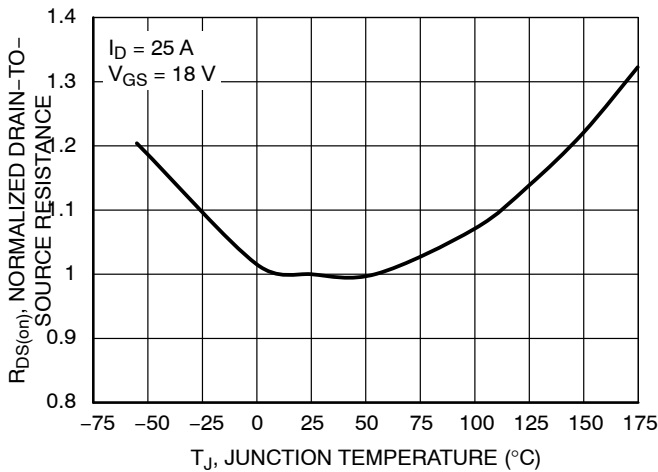


Figure 3. On-Resistance Variation with Temperature

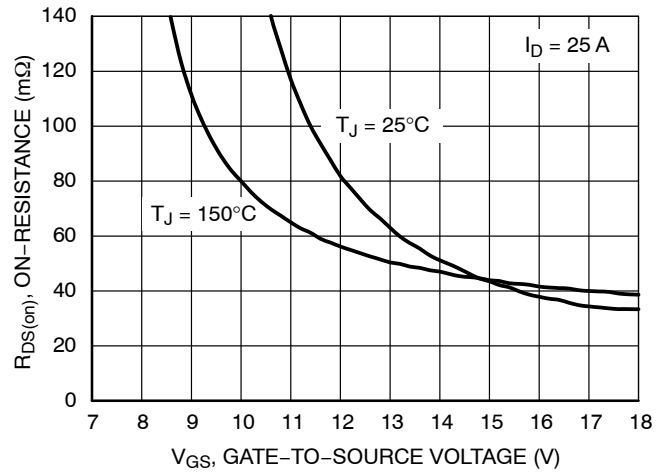


Figure 4. On-Resistance vs. Gate-to-Source Voltage

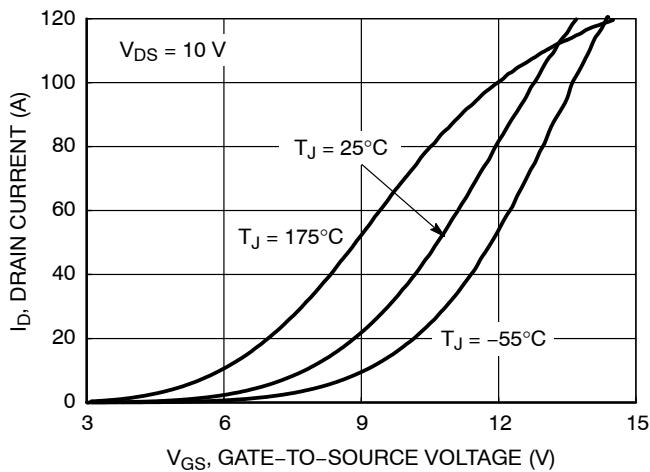


Figure 5. Transfer Characteristics

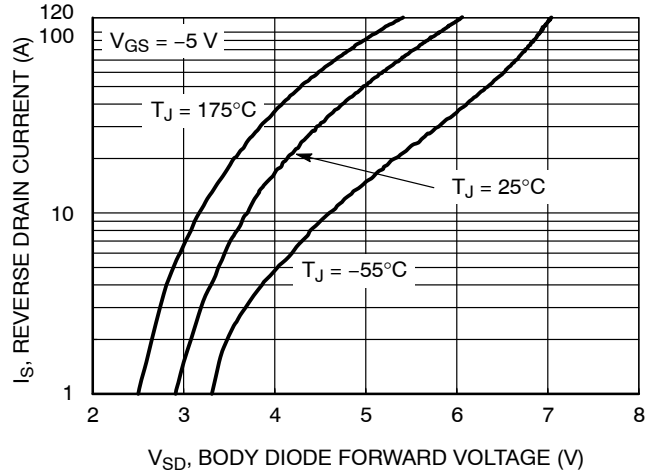


Figure 6. Diode Forward Voltage vs. Current

TYPICAL CHARACTERISTICS (continued)

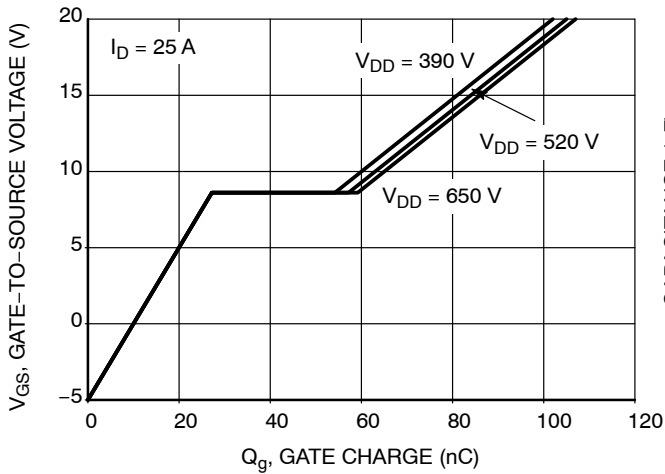


Figure 7. Gate-to-Source Voltage vs. Total Charge

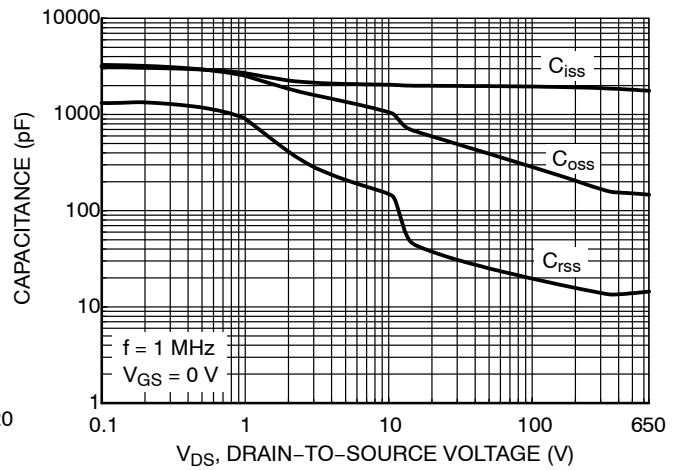


Figure 8. Capacitance vs. Drain-to-Source Voltage

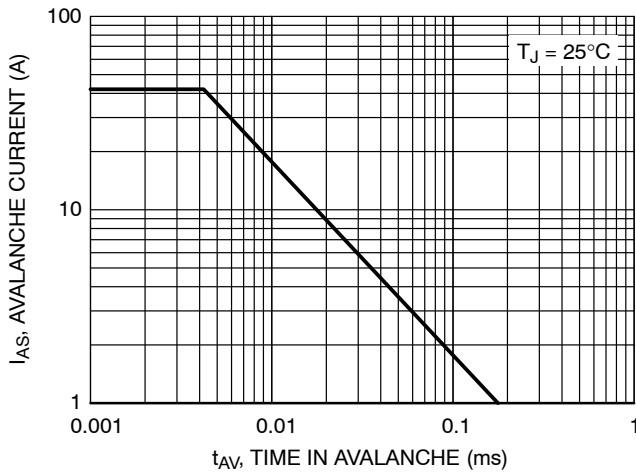


Figure 9. Unclamped Inductive Switching Capability

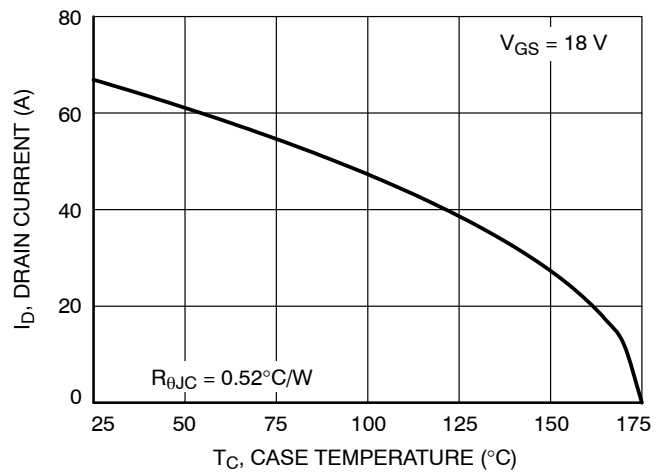


Figure 10. Maximum Continuous Drain Current vs. Case Temperature

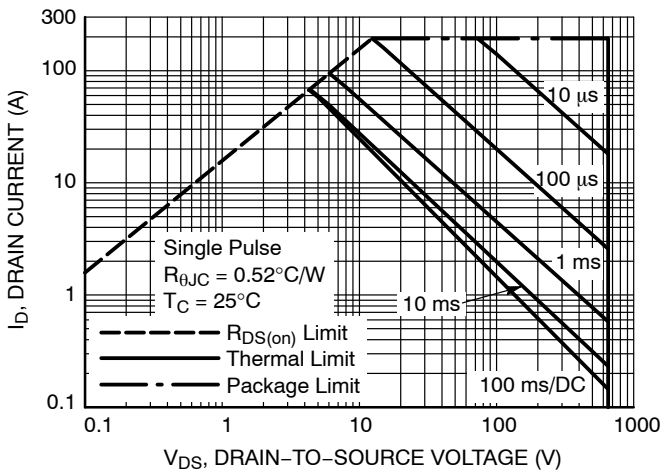


Figure 11. Safe Operating Area

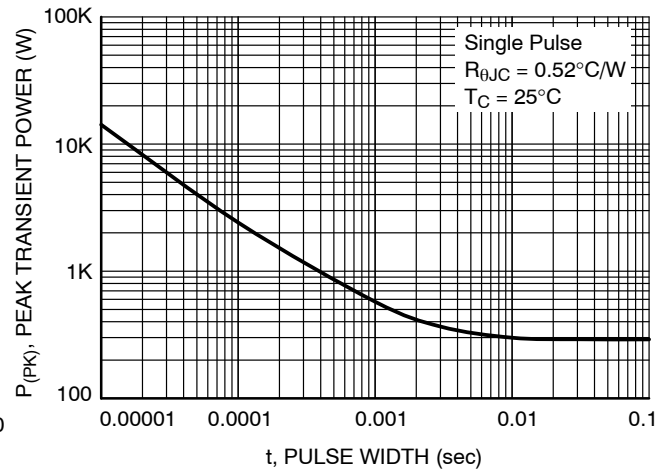


Figure 12. Single Pulse Maximum Power Dissipation

TYPICAL CHARACTERISTICS (continued)

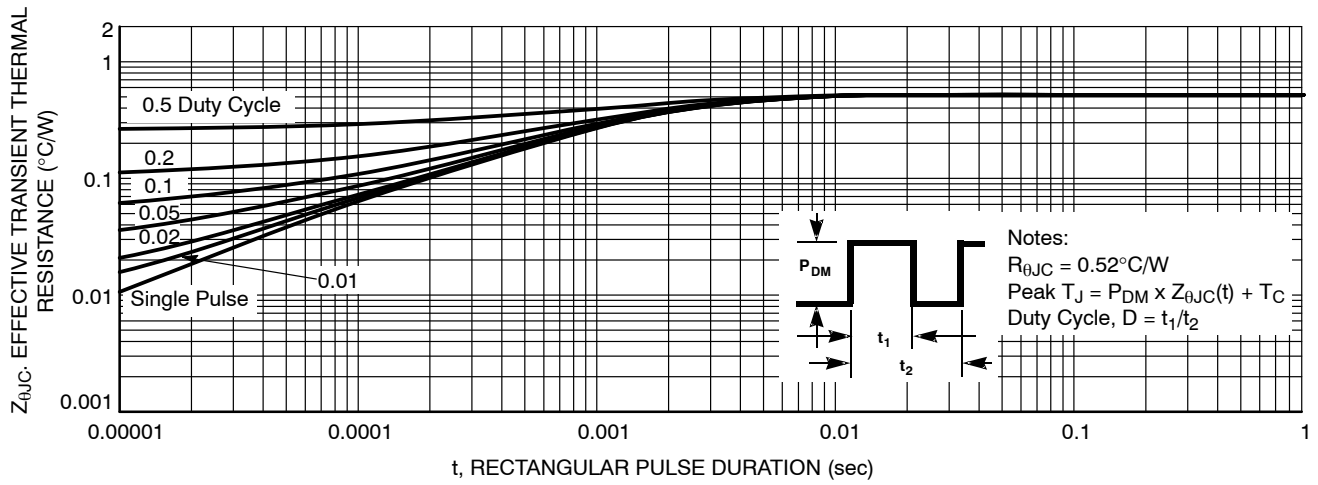


Figure 13. Junction-to-Case Thermal Response

**TO-247-3LD**  
**CASE 340CX**  
**ISSUE A**

DATE 06 JUL 2020



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.  
B. ALL DIMENSIONS ARE IN MILLIMETERS.  
C. DRAWING CONFORMS TO ASME Y14.5 - 2009.  
D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.  
E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC**  
**MARKING DIAGRAM\***


XXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.58        | 4.70  | 4.82  |
| A1  | 2.20        | 2.40  | 2.60  |
| A2  | 1.40        | 1.50  | 1.60  |
| D   | 20.32       | 20.57 | 20.82 |
| E   | 15.37       | 15.62 | 15.87 |
| E2  | 4.96        | 5.08  | 5.20  |
| e   | ~           | 5.56  | ~     |
| L   | 19.75       | 20.00 | 20.25 |
| L1  | 3.69        | 3.81  | 3.93  |
| ØP  | 3.51        | 3.58  | 3.65  |
| Q   | 5.34        | 5.46  | 5.58  |
| S   | 5.34        | 5.46  | 5.58  |
| b   | 1.17        | 1.26  | 1.35  |
| b2  | 1.53        | 1.65  | 1.77  |
| b4  | 2.42        | 2.54  | 2.66  |
| c   | 0.51        | 0.61  | 0.71  |
| D1  | 13.08       | ~     | ~     |
| D2  | 0.51        | 0.93  | 1.35  |
| E1  | 12.81       | ~     | ~     |
| ØP1 | 6.60        | 6.80  | 7.00  |

|                         |                    |                                                                                                                                                                                     |
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