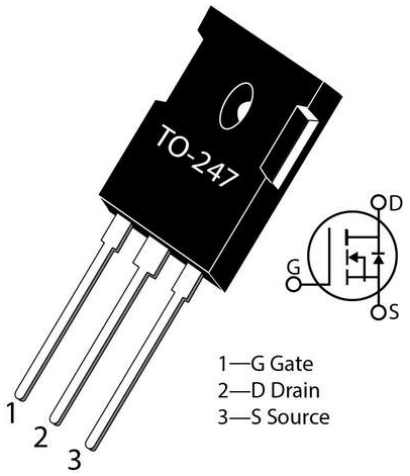
# 700V, 15 mΩ N-Channel mSiC™ MOSFET

## MSC015SMA070B

## Product Overview

700V, 15 mΩ typical at 20 $V_{GS}$, 18 mΩ typical at 18 $V_{GS}$, Silicon Carbide (SiC) N-Channel MOSFET, TO-247.




### Features

- Low capacitances and low gate charge
- Fast switching speed due to low internal gate resistance (ESR)
- Stable operation at high junction temperature, $T_{J(max)}$ = 175 °C
- Fast and reliable body diode
- Superior avalanche ruggedness
- RoHS compliant

### Benefits

- High efficiency to enable lighter and more compact system
- Simple to drive and easy to parallel
- Improved thermal capabilities and lower switching losses
- Eliminates the need for external freewheeling diode
- Lower system cost of ownership

### Applications

- Photovoltaic (PV) inverter, converter, and industrial motor drives
- Smart grid transmission and distribution
- Induction heating and welding
- Hybrid Electric Vehicle (HEV) powertrain and Electric Vehicle (EV) charger
- Power supply and distribution

# 1. Device Specifications

This section shows the specifications of this device.

## 1.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings of this device.

**Table 1-1.** Absolute Maximum Ratings

| Symbol | Parameter | Ratings | Unit |
|---|---|---|---|
| $V_{DSS}$ | Drain source voltage | 700 | V |
| $I_D$ | Continuous drain current at $T_C$ = 25 °C | 149 | A |
| | Continuous drain current at $T_C$ = 100 °C | 106 | |
| $I_{DM}$ | Pulsed drain current[1] | 350 | |
| $V_{GS}$ | Gate-source voltage | 23 to –10 | V |
| | Transient gate-source voltage | 25 to –12 | |
| $P_D$ | Total power dissipation at $T_C$ = 25 °C | 524 | W |
| | Linear derating factor | 3.5 | W/°C |

**Note:**

1. Repetitive rating: pulse width and case temperature are limited by the maximum junction temperature.

The following table shows the thermal and mechanical characteristics of this device.

**Table 1-2.** Thermal and Mechanical Characteristics

| Symbol | Characteristic/Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-case thermal resistance | — | 0.22 | 0.29 | °C/W |
| $T_J$ | Operating junction temperature | –55 | — | 175 | °C |
| $T_{STG}$ | Storage temperature | –55 | — | 150 | °C |
| $T_L$ | Lead temperature for 10 seconds | — | — | 300 | °C |
| — | Mounting torque, 6-32 or M3 screw | — | — | 10 | lbf.in |
| | | — | — | 1.1 | N.m |
| Wt | Package weight | — | 0.22 | — | oz |
| | | — | 6.2 | — | g |

ESD practices should comply with JESD-625.

## 1.2 Electrical Performance

The following table shows the static characteristics of this device. $T_J$ = 25 °C unless otherwise specified.

**Table 1-3.** Static Characteristics

| Symbol | Characteristic | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage | $V_{GS}$ = 0V, $I_D$ = 100 µA | 700 | — | — | V |
| $R_{DS(on)}$ | Drain-source on resistance[1] | $V_{GS}$ = 20V, $I_D$ = 40A | — | 15 | 19 | mΩ |
| | | $V_{GS}$ = 18V, $I_D$ = 40A | — | 18 | — | |
| $V_{GS(th)}$ | Gate-source threshold voltage | $V_{GS}$ = $V_{DS}$, $I_D$ = 4 mA | 1.9 | 3.0 | — | V |
| $I_{DSS}$ | Zero gate voltage drain current | $V_{DS}$ = 700V, $V_{GS}$ = 0V | — | 0.3 | 40 | µA |
| | | $V_{DS}$ = 700V, $V_{GS}$ = 0V, $T_J$ = 175 °C | — | 3.5 | — | |
| $I_{GSS}$ | Gate-source leakage current | $V_{GS}$ = 20V/–10V | — | — | ±100 | nA |

**Note:**

1. Pulse test: pulse width < 380 µs, duty cycle < 2%.

The following table shows the dynamic characteristics of this device. $T_J$ = 25 °C unless otherwise specified. The dynamic characteristics are characterized, not 100% tested, at the recommended operating $V_{GS}$ = 20V/–5V.

**Table 1-4.** Dynamic Characteristics

| Symbol | Characteristic | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input capacitance | $V_{GS}$ = 0V<br>$V_{DD}$ = 700V<br>$V_{AC}$ = 25 mV<br>ƒ = 200 kHz | — | 4500 | — | pF |
| $C_{rss}$ | Reverse transfer capacitance | | — | 44 | — | |
| $C_{oss}$ | Output capacitance | | — | 510 | — | |
| $Q_g$ | Total gate charge | $V_{GS}$ = –5V/20V<br>$V_{DD}$ = 470V<br>$I_D$ = 40A | — | 215 | — | nC |
| $Q_{gs}$ | Gate-source charge | | — | 58 | — | |
| $Q_{gd}$ | Gate-drain charge | | — | 35 | — | |
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 470V<br>$V_{GS}$ = –5V/20V<br>$I_D$ = 40A<br>$R_{g(ext)}$ = 4Ω<br>Freewheeling diode = MSC015SMA070B ($V_{GS}$ = –5V); reference Figure 1-18 | — | 25 | — | ns |
| $t_r$ | Voltage rise time | | — | 34 | — | |
| $t_{d(off)}$ | Turn-off delay time | | — | 53 | — | |
| $t_f$ | Voltage fall time | | — | 20 | — | |
| $E_{on}$ | Turn-on switching energy | | — | 856 | — | µJ |
| $E_{off}$ | Turn-off switching energy | | — | 129 | — | |
| ESR | Gate equivalent series resistance | f = 1 MHz, 25 mV, drain short | — | 0.69 | — | Ω |
| SCWT | Short circuit withstand time | $V_{DS}$ = 560V, $V_{GS}$ = 20V | — | 3 | — | µs |
| $E_{AS}$ | Avalanche energy, single pulse | $I_D$ = 40A | — | 4400 | — | mJ |

The following table shows the body diode characteristics of this device. $T_J$ = 25 °C unless otherwise specified.

**Table 1-5.** Body Diode Characteristics

| Symbol | Characteristic | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{SD}$ | Diode forward voltage | $I_{SD}$ = 40A, $V_{GS}$ = 0V | — | 3.4 | — | V |
| | | $I_{SD}$ = 40A, $V_{GS}$ = –5V | — | 3.8 | — | |
| $t_{rr}$ | Reverse recovery time | $I_{SD}$ = 40A, $V_{GS}$ = –5V, $V_{DD}$ = 470V, dI/dt = –1200 A/µs | — | 40 | — | ns |
| $Q_{rr}$ | Reverse recovery charge | | — | 495 | — | nC |
| $I_{RRM}$ | Reverse recovery current | | — | 19 | — | A |

## 1.3 Typical Performance Curves

Data for performance curves are characterized, not 100% tested.

**Figure 1-1.** Drain Current vs. $V_{DS}$ at $T_J$

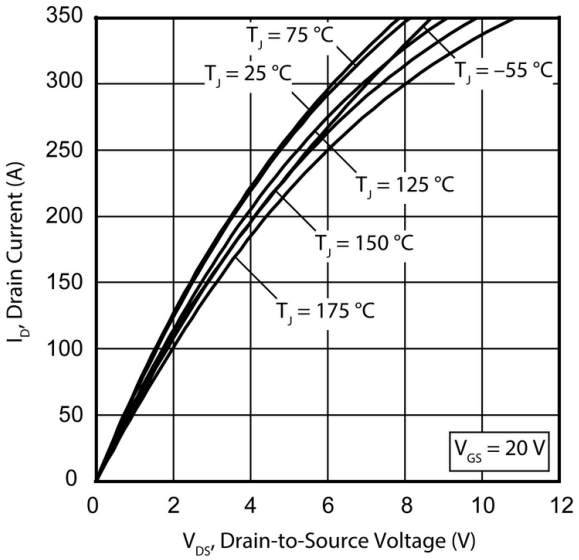



**Figure 1-2.** Drain Current vs. $V_{DS}$ at $V_{GS}$

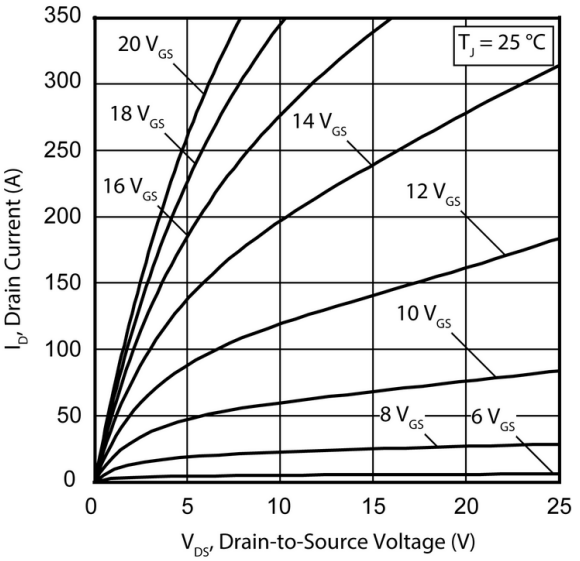



**Figure 1-3.** Drain Current vs. $V_{DS}$ at $V_{GS}$

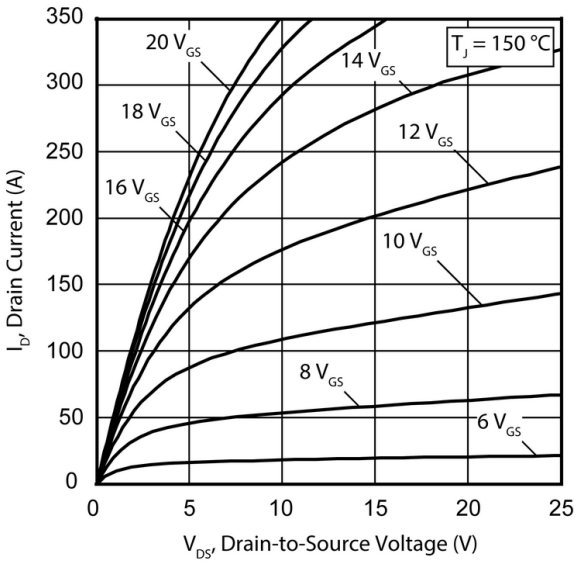



**Figure 1-4.** Drain Current vs. $V_{DS}$ at $V_{GS}$

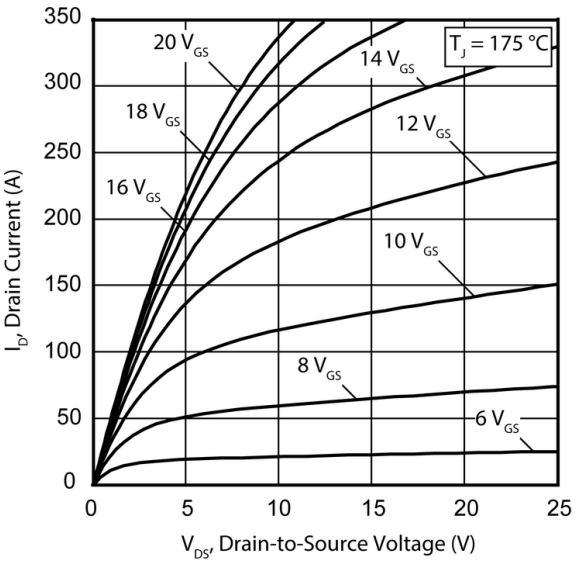


**Figure 1-5.** $R_{DS(on)}$ vs. Junction Temperature

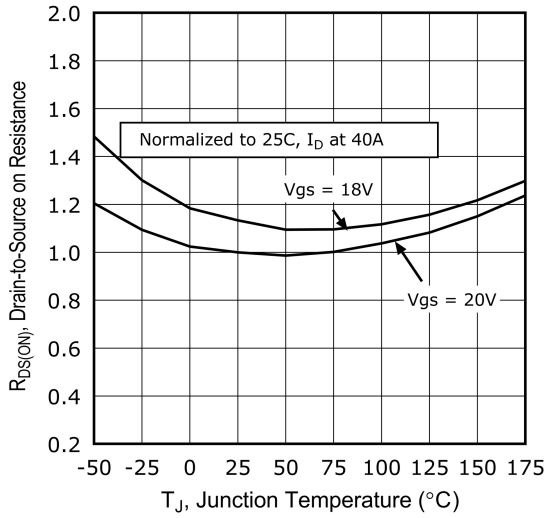



**Figure 1-6.** Gate Charge Characteristics

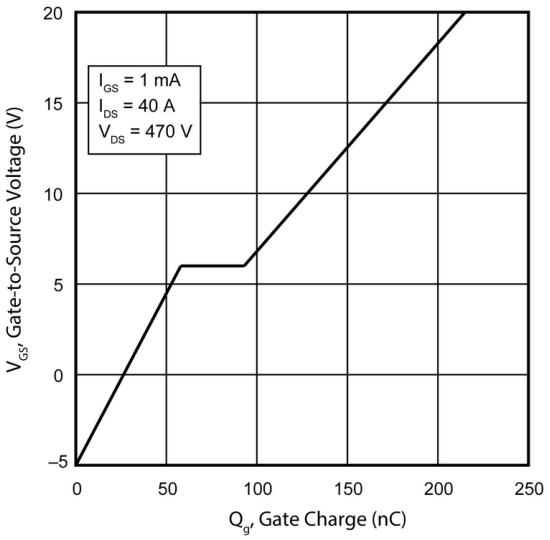



**Figure 1-7.** Capacitance vs. Drain-to-Source Voltage

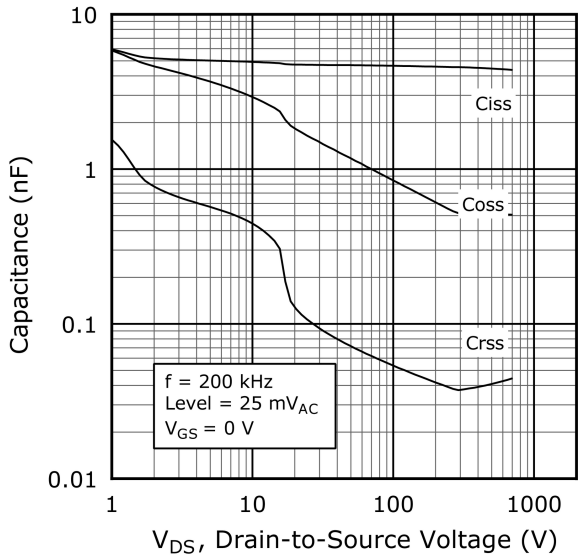



**Figure 1-8.** Output Charge vs. Drain-to-Source Voltage

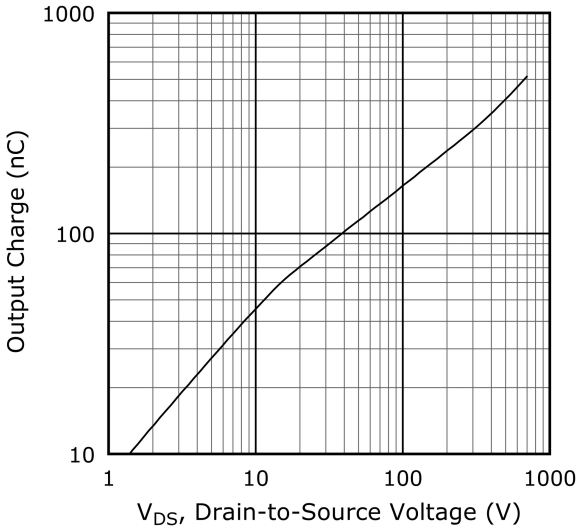


**Figure 1-9.** $I_D$ vs. $V_{DS}$ 3rd Quadrant Conduction

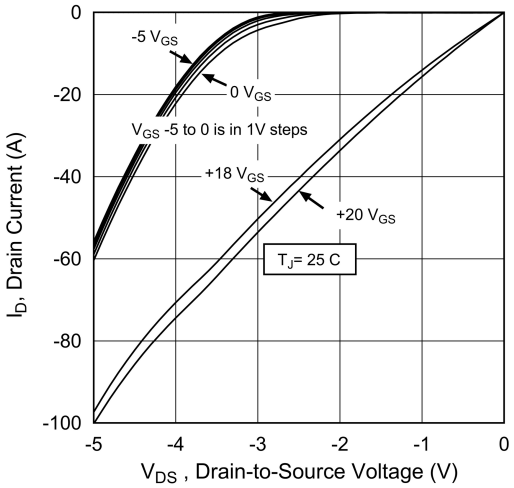



**Figure 1-10.** $I_D$ vs. $V_{DS}$ 3rd Quadrant Conduction

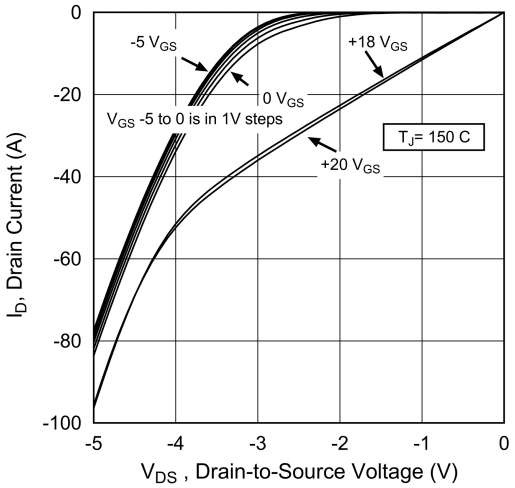



**Figure 1-11.** Switching Energy Eon vs. $V_{DS}$ & $I_D$

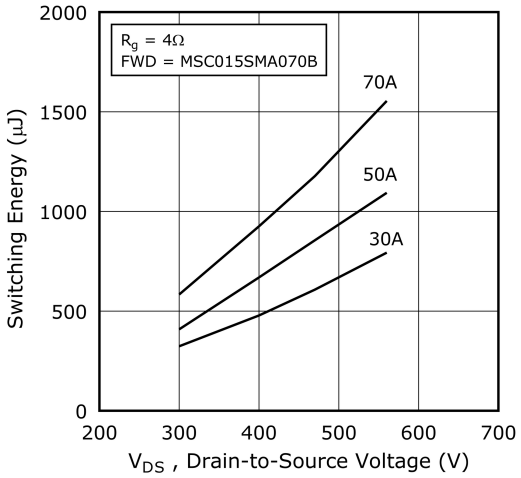



**Figure 1-12.** Switching Energy Eoff vs. $V_{DS}$ & $I_D$

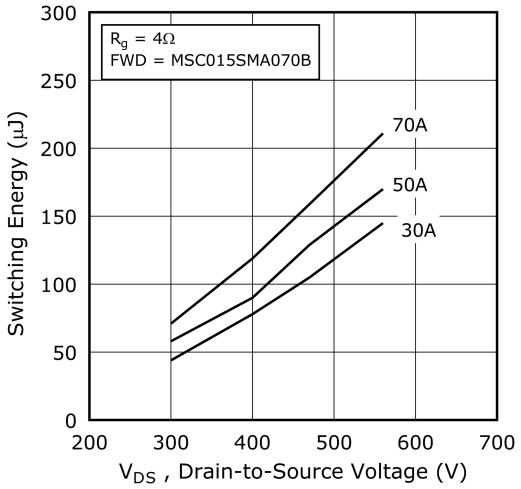


**Figure 1-13.** Switching Energy vs. $R_g$

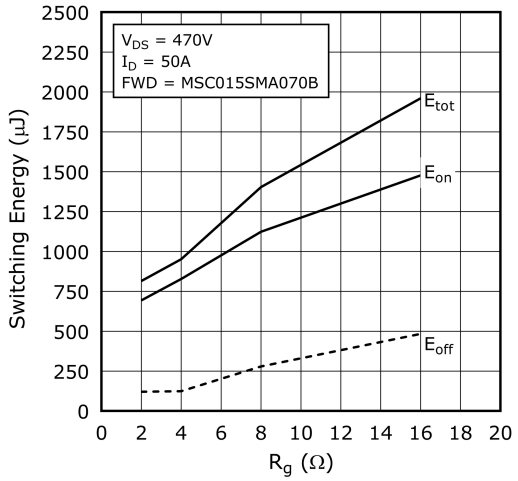



**Figure 1-14.** Switching Energy vs. Junction Temperature

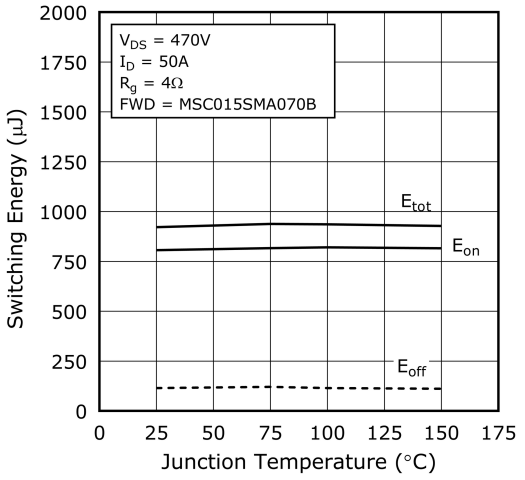



**Figure 1-15.** Threshold Voltage vs. Junction Temperature

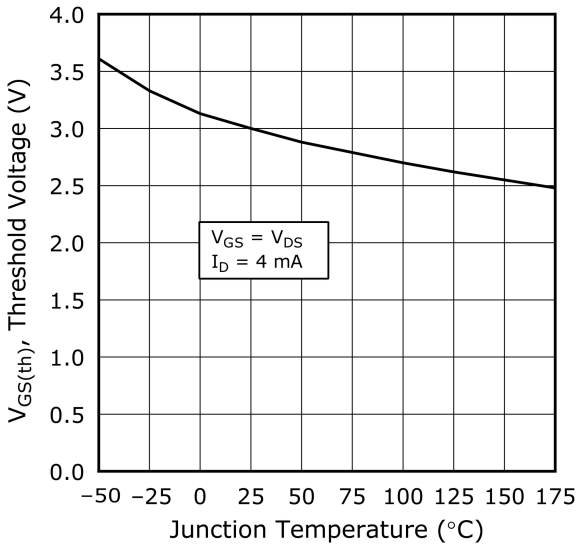



**Figure 1-16.** Forward Safe Operating Area

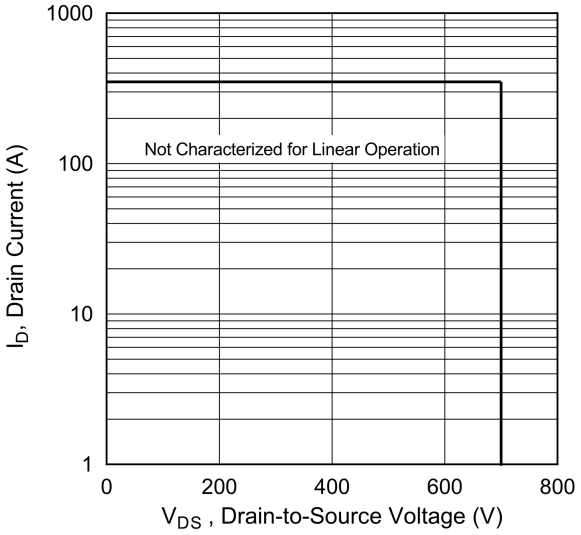
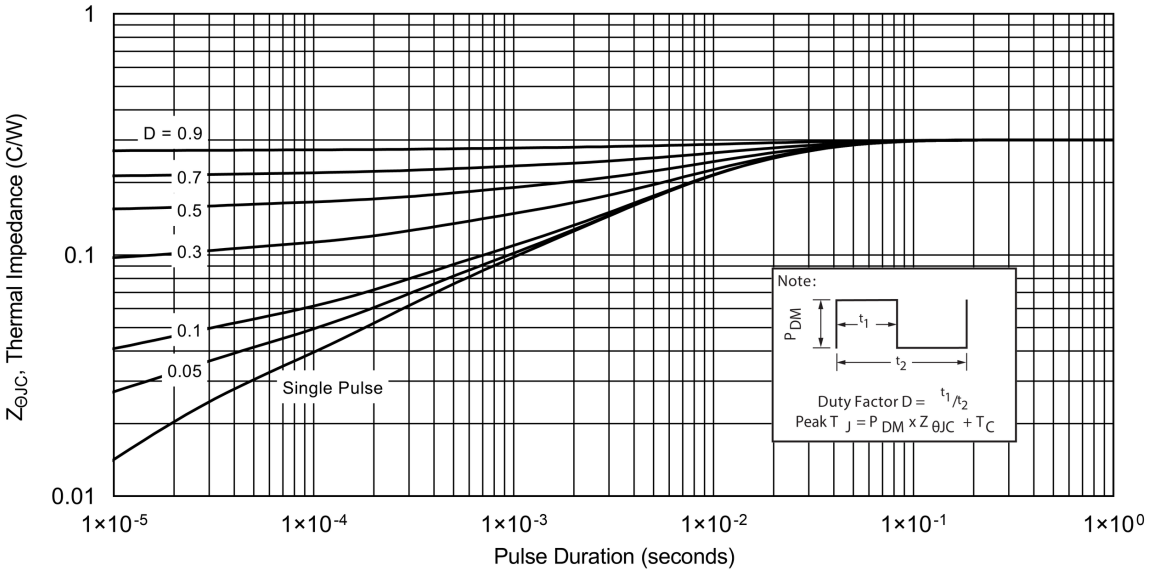
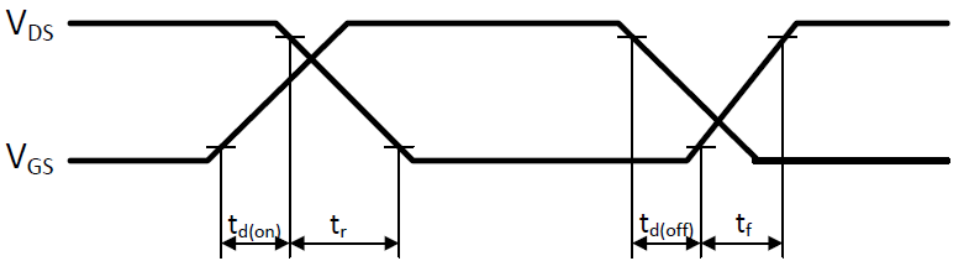


**Figure 1-17.** Maximum Transient Thermal Impedance




The following figure shows the switching waveform diagram of this device.

**Figure 1-18.** Switching Waveform



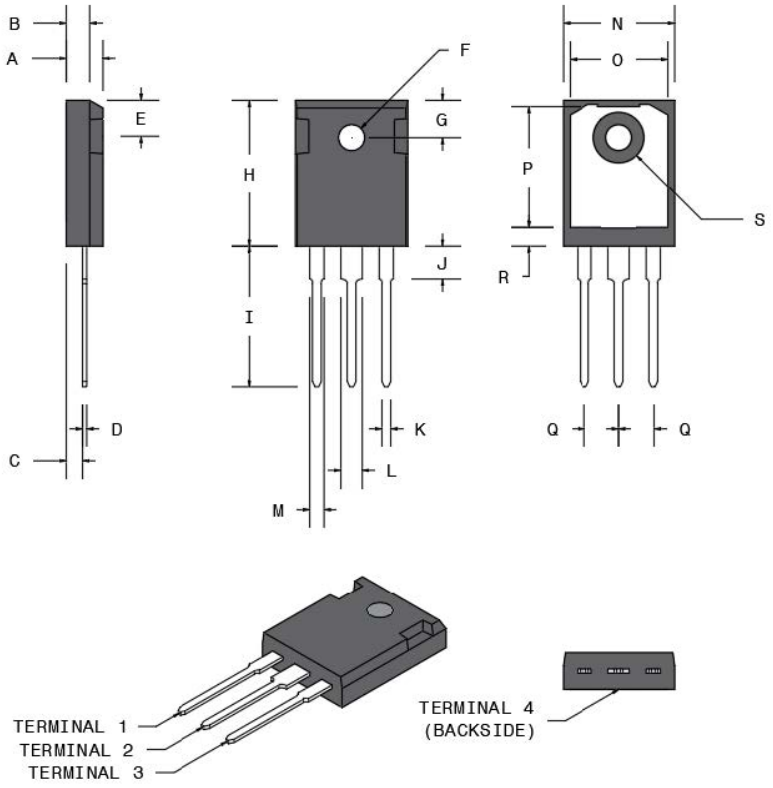
# 2. Package Specification

This section shows the package specification of this device.

## 2.1 Package Outline Drawing

The following figure illustrates the TO-247 package outline of this device.

**Figure 2-1.** Package Outline Drawing




The following table shows the TO-247 dimensions and must be used in conjunction with the package outline drawing.

**Table 2-1.** TO-247 Dimensions

| Symbol | Min. (mm) | Max. (mm) | Min. (in.) | Max. (in.) |
|---|---|---|---|---|
| A | 4.69 | 5.31 | 0.185 | 0.209 |
| B | 1.49 | 2.49 | 0.059 | 0.098 |
| C | 2.21 | 2.59 | 0.087 | 0.102 |
| D | 0.40 | 0.79 | 0.016 | 0.031 |
| E | 5.38 | 6.20 | 0.212 | 0.244 |
| F | 3.50 | 3.81 | 0.138 | 0.150 |
| G | 6.15 BSC | | 0.242 BSC | |
| H | 20.80 | 21.46 | 0.819 | 0.845 |
| I | 19.81 | 20.32 | 0.780 | 0.800 |
| J | 4.00 | 4.50 | 0.157 | 0.177 |
| K | 1.01 | 1.40 | 0.040 | 0.055 |
| L | 2.87 | 3.12 | 0.113 | 0.123 |

| .....continued | | | | |
|---|---|---|---|---|
| Symbol | Min. (mm) | Max. (mm) | Min. (in.) | Max. (in.) |
| M | 1.65 | 2.13 | 0.065 | 0.084 |
| N | 15.49 | 16.26 | 0.610 | 0.640 |
| O | 13.50 | 14.50 | 0.531 | 0.571 |
| P | 16.50 | 17.50 | 0.650 | 0.689 |
| Q | 5.45 BSC | | 0.215 BSC | |
| R | 2.00 | 2.75 | 0.079 | 0.108 |
| S | 7.10 | 7.50 | 0.280 | 0.295 |
| Terminal 1 | Gate | | | |
| Terminal 2 | Drain | | | |
| Terminal 3 | Source | | | |
| Terminal 4 | Drain | | | |

# 3. Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

**Table 3-1.** Revision History

| Revision | Date | Description |
|---|---|---|
| B | 09/2023 | The following changes are made in this revision of the document:<br>• Updated the maximum value for the lead temperature in the Table 1-2.<br>• Added Figure 1-8, Figure 1-9, Figure 1-10, and Figure 1-18.<br>• Updated Figure 1-5 and Figure 1-16.<br>• Corrected the initial releases row of the revision history table to show accurate revisions and release dates of Microsemi versions of this data sheet. |
| A | 05/2023 | Document migrated from Microsemi template to Microchip template; Assigned Microchip literature number DS-00004985A, which replaces the previous Microsemi literature number 050-7746. |
| Initial releases (Microsemi Revisions A, B, and C) | 03/2019–09/2020 | Initial releases. |

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