

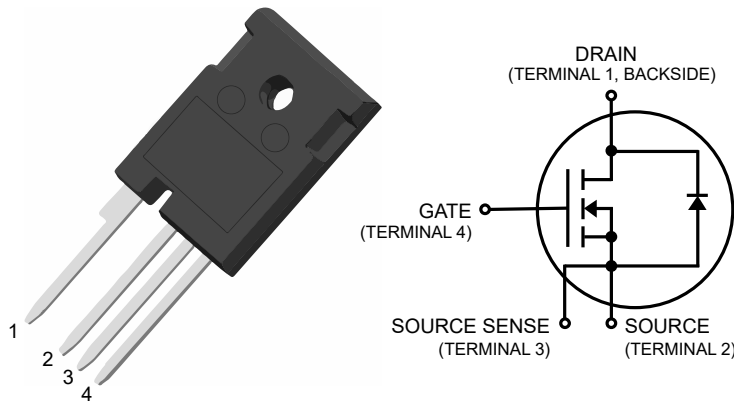
# 1200V, 25 mΩ N-Channel mSiC™ MOSFET

## MSC025SMA120B4N



## Product Overview

1200V, 25 mΩ typical at  $V_{GS} = 20V$ , 28 mΩ typical at  $V_{GS} = 18V$ , Silicon Carbide (SiC) N-Channel MOSFET, TO-247 notched 4-lead with a source sense.



## Features

- AEC-Q101 qualified option available
- Low capacitances and low gate charge
- Fast switching speed due to low internal gate resistance (ESR)
- Stable operation at high junction temperature,  $T_{J(max)} = 175\text{ }^{\circ}\text{C}$
- 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 |
|----------|-----------------------------------------------------------------|-----------|------|
| $V_{DS}$ | Drain source voltage                                            | 1200      | V    |
| $I_D$    | Continuous drain current at $T_C = 25\text{ }^{\circ}\text{C}$  | 113       | A    |
|          | Continuous drain current at $T_C = 100\text{ }^{\circ}\text{C}$ | 80        |      |
| $I_{DM}$ | Pulsed drain current <sup>1</sup>                               | 408       |      |
| $V_{GS}$ | Gate-source voltage                                             | 23 to -10 | V    |
|          | Transient gate-source voltage                                   | 25 to -12 |      |
| $P_D$    | Total power dissipation at $T_C = 25\text{ }^{\circ}\text{C}$   | 577       | W    |
|          | Linear derating factor                                          | 3.8       |      |

**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                                           | —    | 0.20 | 0.26 | $^{\circ}\text{C}/\text{W}$ |
| $T_J$           | Operating junction temperature                                                | -55  | —    | 175  | $^{\circ}\text{C}$          |
| $T_{STG}$       | Storage temperature                                                           | -55  | —    | 175  |                             |
| $T_L$           | Lead temperature for 10 seconds                                               | —    | —    | 300  | $^{\circ}\text{C}$          |
| $\tau_M$        | Mounting torque, M3 screw for heat sink attachment (requires 1, not included) | —    | 0.8  | —    | N-m                         |
| Wt              | Package weight                                                                | —    | 6.2  | —    | g                           |

ESD practices should comply with JESD-625.

## 1.2 Electrical Performance

The following table shows the static characteristics of this device.  $T_J = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

**Table 1-3.** Static Characteristics

| Symbol       | Characteristic                          | Test Conditions                                                                | Min. | Typ. | Max.      | Unit             |
|--------------|-----------------------------------------|--------------------------------------------------------------------------------|------|------|-----------|------------------|
| $V_{(BR)DS}$ | Drain-source breakdown voltage          | $V_{GS} = 0\text{V}, I_D = 100\text{ }\mu\text{A}$                             | 1200 | —    | —         | V                |
| $R_{DS(on)}$ | Drain-source on resistance <sup>1</sup> | $V_{GS} = 20\text{V}, I_D = 40\text{A}$                                        | —    | 25   | 31        | $\text{m}\Omega$ |
|              |                                         | $V_{GS} = 18\text{V}, I_D = 40\text{A}$                                        | —    | 28   | —         |                  |
| $V_{GS(th)}$ | Gate-source threshold voltage           | $V_{GS} = V_{DS}, I_D = 3\text{ mA}$                                           | 1.9  | 3.0  | 5.0       | V                |
| $I_{DSS}$    | Zero gate voltage drain current         | $V_{DS} = 1200\text{V}, V_{GS} = 0\text{V}$                                    | —    | 0.3  | 35        | $\mu\text{A}$    |
|              |                                         | $V_{DS} = 1200\text{V}, V_{GS} = 0\text{V}, T_J = 175\text{ }^{\circ}\text{C}$ | —    | 3.5  | —         |                  |
| $I_{GSS}$    | Gate-source leakage current             | $V_{GS} = 20\text{V}/-10\text{V}$                                              | —    | —    | $\pm 100$ | nA               |

**Note:**

1. Pulse test: pulse width < 380  $\mu$ s, duty cycle < 2%.

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

**Table 1-4. Dynamic Characteristics**

| Symbol       | Characteristic                    | Test Conditions                                                                                             | Min. | Typ. | Max. | Unit     |
|--------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{iss}$    | Input capacitance                 | $V_{GS} = 0\text{V}$                                                                                        | —    | 3633 | —    | pF       |
| $C_{rss}$    | Reverse transfer capacitance      | $V_{DD} = 1000\text{V}$                                                                                     | —    | 18   | —    |          |
| $C_{oss}$    | Output capacitance                | $V_{AC} = 25\text{ mV}$<br>$f = 200\text{ KHz}$                                                             | —    | 271  | —    |          |
| $Q_G$        | Total gate charge                 | $V_{GS} = -5\text{V}/20\text{V}$                                                                            | —    | 232  | —    | nC       |
| $Q_{GS}$     | Gate-source charge                | $V_{DD} = 800\text{V}$                                                                                      | —    | 41   | —    |          |
| $Q_{GD}$     | Gate-drain charge                 | $I_D = 40\text{A}$                                                                                          | —    | 50   | —    |          |
| $t_{d(on)}$  | Turn-on delay time                | $V_{DD} = 800\text{V}$                                                                                      | —    | 17   | —    | ns       |
| $t_r$        | Voltage rise time                 | $V_{GS} = -5\text{V}/20\text{V}$                                                                            | —    | 23   | —    |          |
| $t_{d(off)}$ | Turn-off delay time               | $I_D = 40\text{A}$                                                                                          | —    | 39   | —    |          |
| $t_f$        | Voltage fall time                 | $R_{G(ext)} = 4\Omega$                                                                                      | —    | 16   | —    |          |
| $E_{on}$     | Turn-on switching energy          | Freewheeling diode =<br>MSC025SMA120B4N ( $V_{GS} = -5\text{V}$ );<br>reference <a href="#">Figure 1-19</a> | —    | 716  | —    | $\mu$ J  |
| $E_{off}$    | Turn-off switching energy         |                                                                                                             | —    | 98   | —    |          |
| ESR          | Gate equivalent series resistance | $f = 1\text{ MHz}$ , 25 mV, drain short                                                                     | —    | 0.88 | —    | $\Omega$ |
| SCWT         | Short circuit withstand time      | $V_{DS} = 960\text{V}$ , $V_{GS} = 20\text{V}$                                                              | —    | 3    | —    | $\mu$ s  |
| $E_{AS}$     | Avalanche energy, single pulse    | $I_D = 40\text{A}$                                                                                          | —    | 3500 | —    | mJ       |

The following table shows the body diode characteristics of this device.  $T_J = 25\text{ }^{\circ}\text{C}$  unless otherwise specified. The body diode reverse recovery is characterized, not 100% tested.

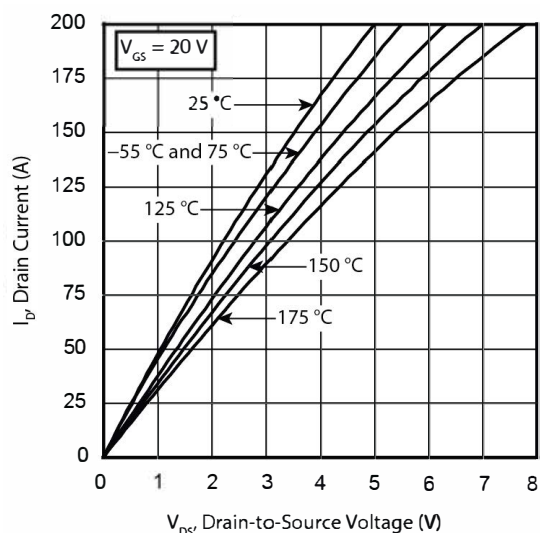
**Table 1-5. Body Diode Characteristics**

| Symbol    | Characteristic           | Test Conditions                                                                                                                        | Min. | Typ. | Max. | Unit |
|-----------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $V_{SD}$  | Diode forward voltage    | $I_{SD} = 40\text{A}$ , $V_{GS} = 0\text{V}$                                                                                           | —    | 3.6  | —    | V    |
|           |                          | $I_{SD} = 40\text{A}$ , $V_{GS} = -5\text{V}$                                                                                          | —    | 3.8  | 5.0  |      |
| $t_{rr}$  | Reverse recovery time    | $I_{SD} = 40\text{A}$ , $V_{GS} = -5\text{V}$ , Drive $R_G = 4\Omega$ , $V_{DD} = 800\text{V}$ , $dI/dt = -10000\text{ A}/\mu\text{s}$ | —    | 15   | —    | ns   |
| $Q_{rr}$  | Reverse recovery charge  |                                                                                                                                        | —    | 995  | —    | nC   |
| $I_{RRM}$ | Reverse recovery current |                                                                                                                                        | —    | 112  | —    | A    |

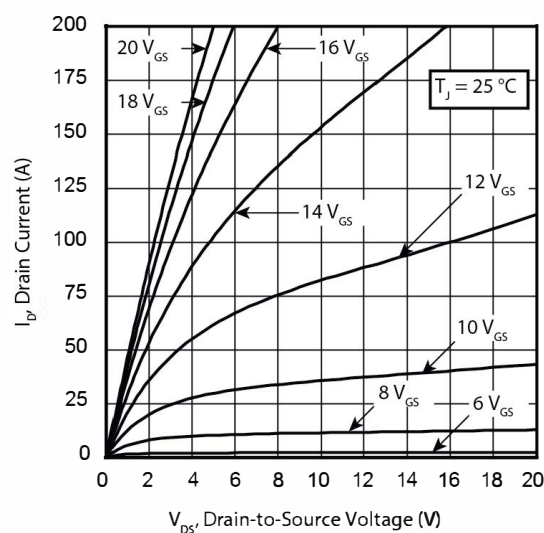
## 1.3 Typical Performance Curves

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

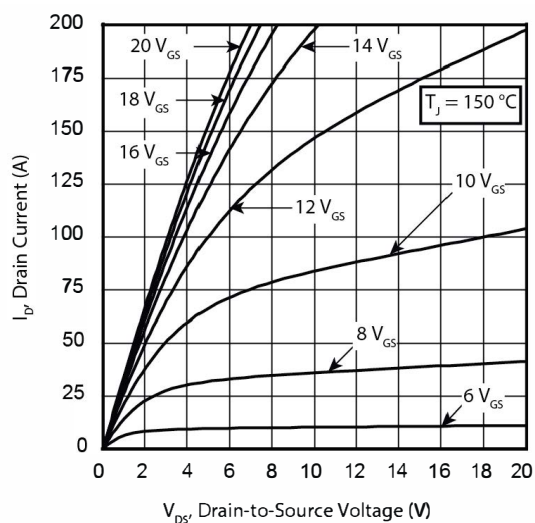
**Figure 1-1.** Drain Current vs.  $V_{DS}$  at  $T_J$



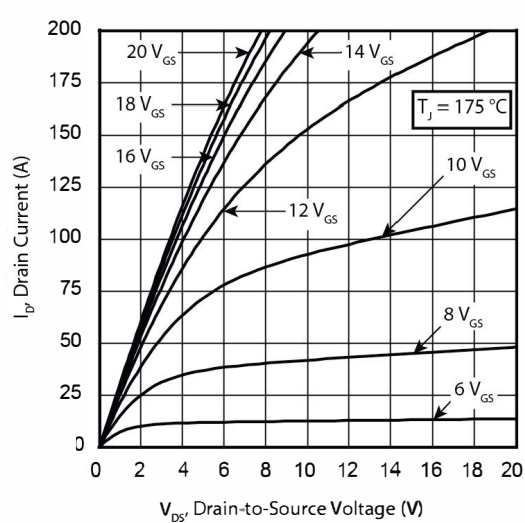
**Figure 1-2.** Drain Current vs.  $V_{DS}$  at  $V_{GS}$



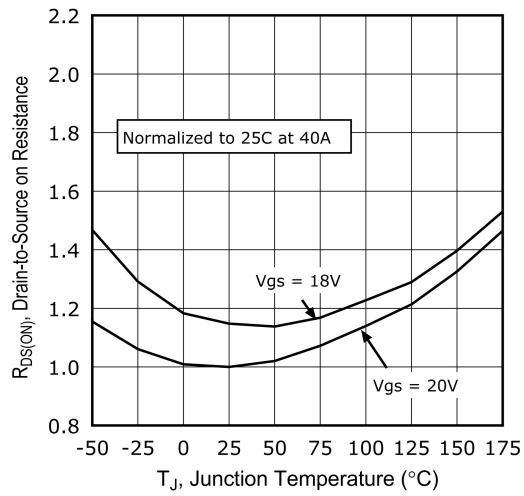
**Figure 1-3.** Drain Current vs.  $V_{DS}$  at  $V_{GS}$



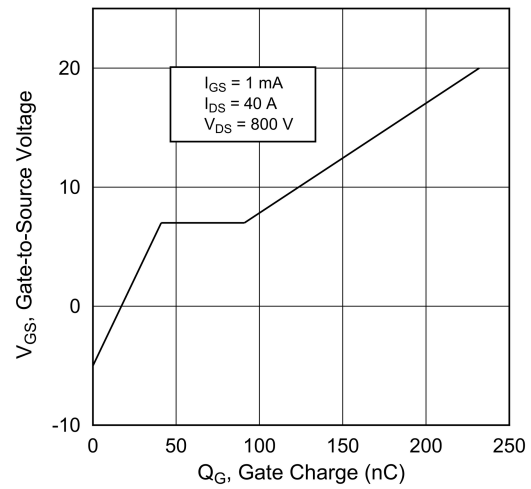
**Figure 1-4.** Drain Current vs.  $V_{DS}$  at  $V_{GS}$



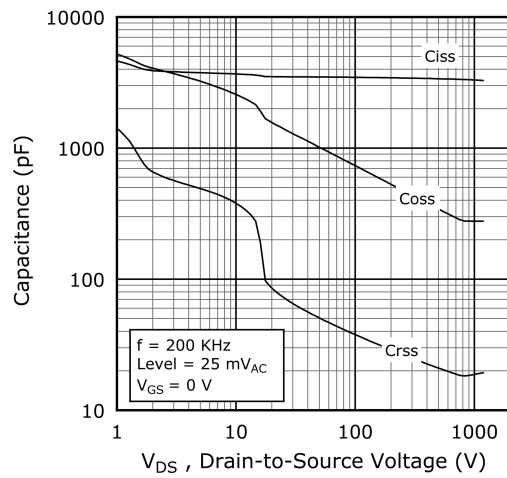
**Figure 1-5.**  $R_{DS(on)}$  vs. Junction Temperature



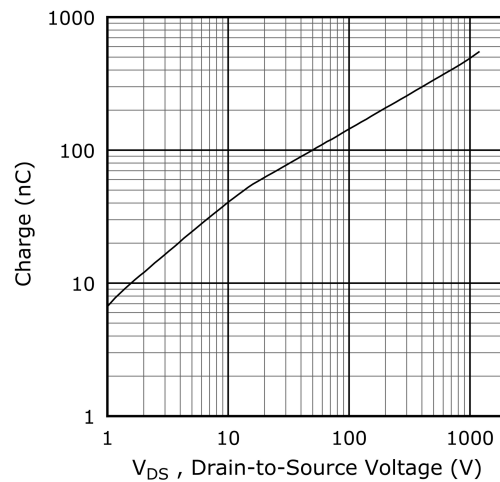
**Figure 1-6.** Gate Charge Characteristics



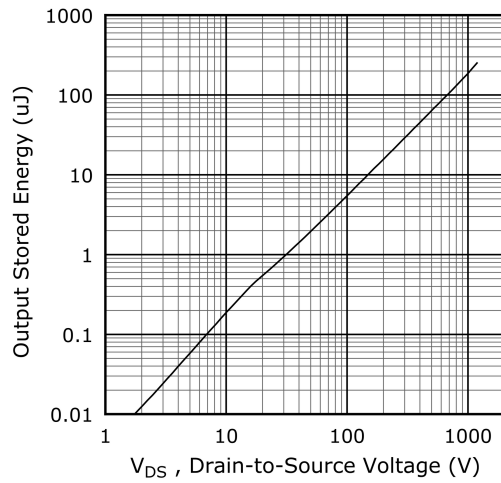
**Figure 1-7.** Capacitance vs. Drain-to-Source Voltage



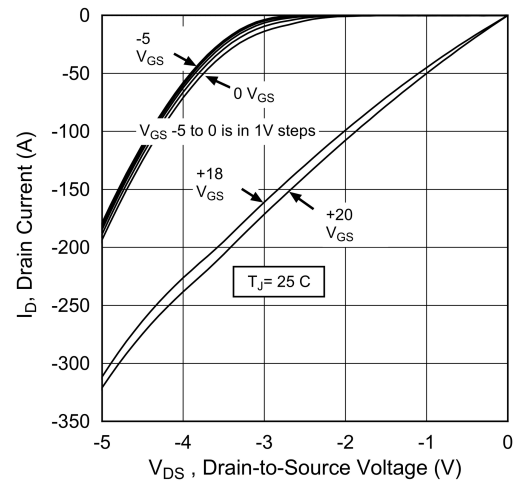
**Figure 1-8.** Output Charge vs. Drain-to-Source Voltage



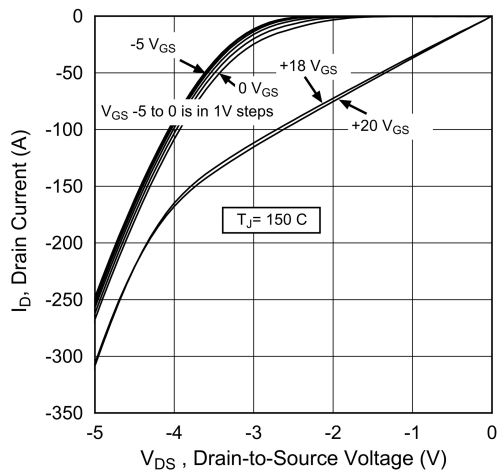
**Figure 1-9.** Output Stored Energy vs.  $V_{DS}$



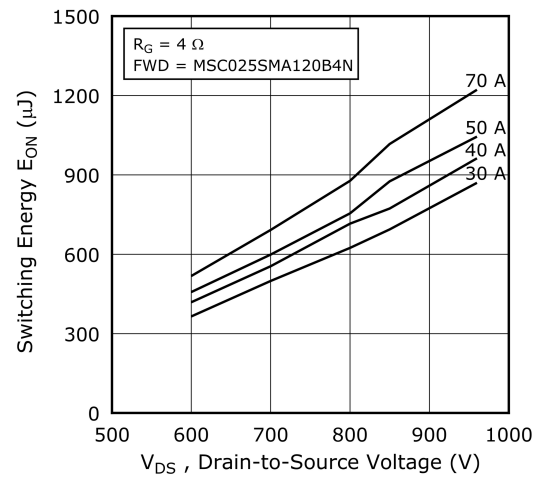
**Figure 1-10.**  $I_D$  vs.  $V_{DS}$  3<sup>rd</sup> Quadrant Conduction



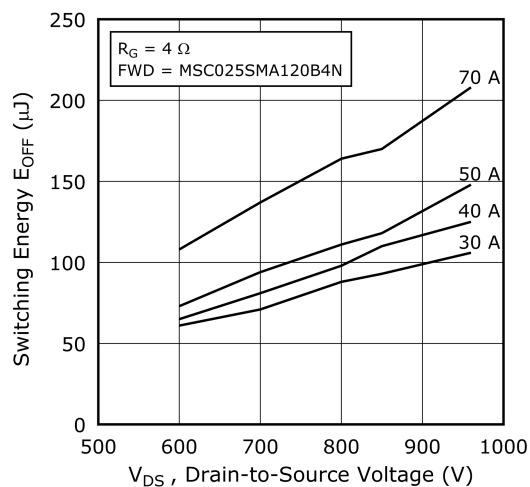
**Figure 1-11.**  $I_D$  vs.  $V_{DS}$  3<sup>rd</sup> Quadrant Conduction



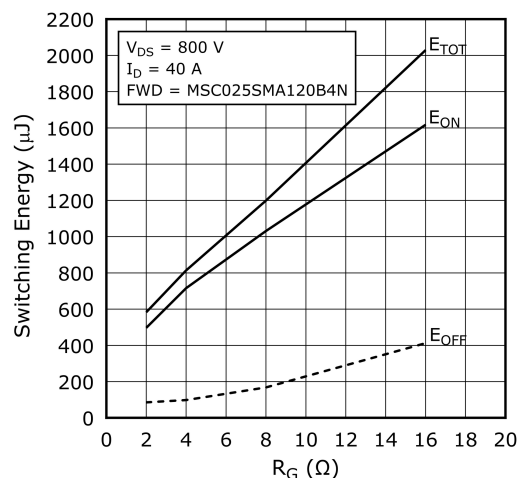
**Figure 1-12.** Switching Energy  $E_{ON}$  vs.  $V_{DS}$  &  $I_D$



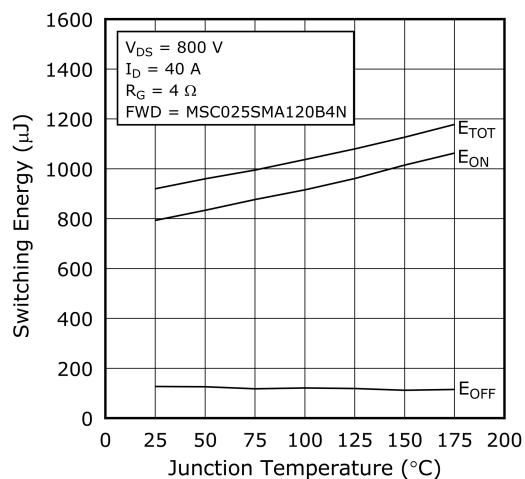
**Figure 1-13. Switching Energy  $E_{off}$  vs.  $V_{DS}$  &  $I_D$**



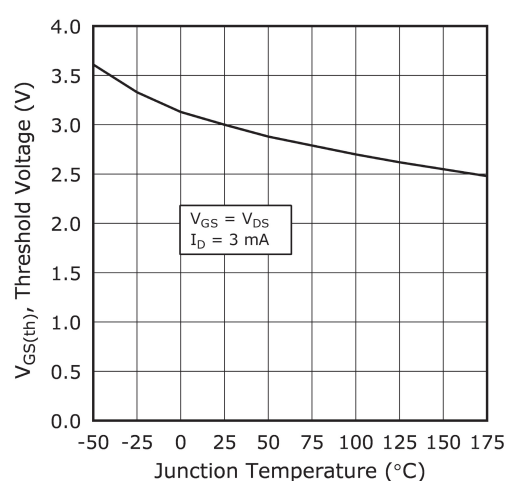
**Figure 1-14. Switching Energy vs.  $R_G$**



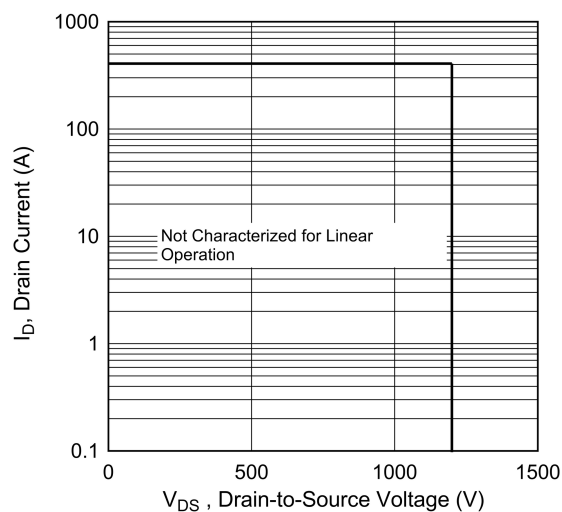
**Figure 1-15. Switching Energy vs. Junction Temperature**



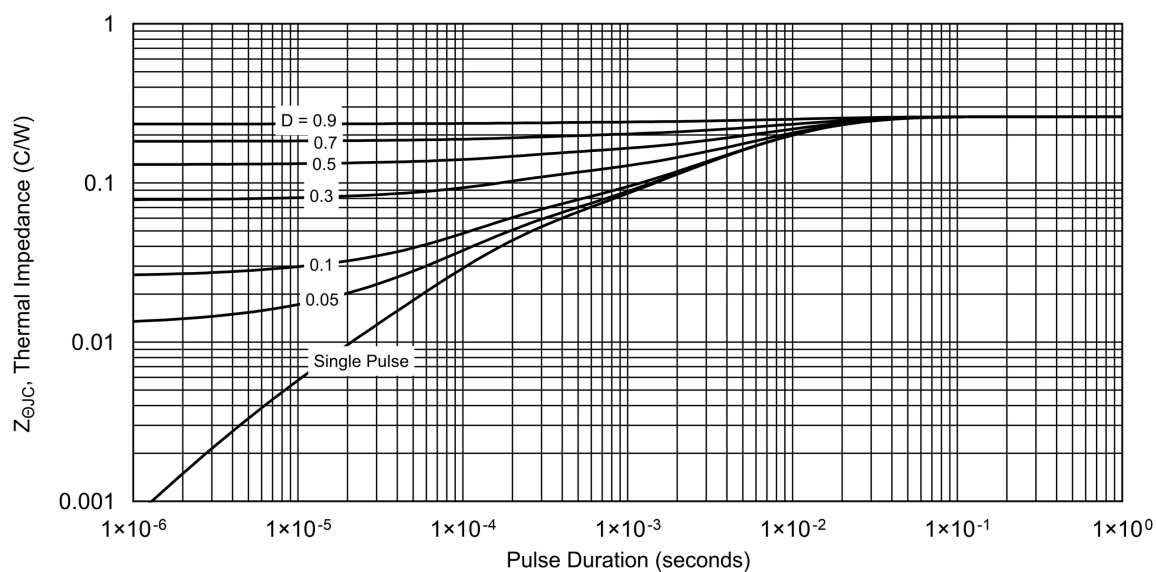
**Figure 1-16. Threshold Voltage vs. Junction Temperature**



**Figure 1-17. Forward Safe Operating Area**

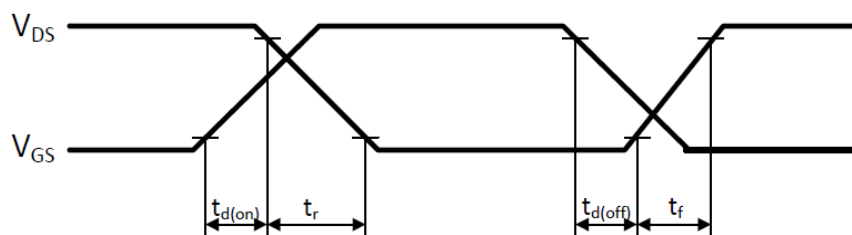


**Figure 1-18. Maximum Transient Thermal Impedance**



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

**Figure 1-19. Switching Waveform**



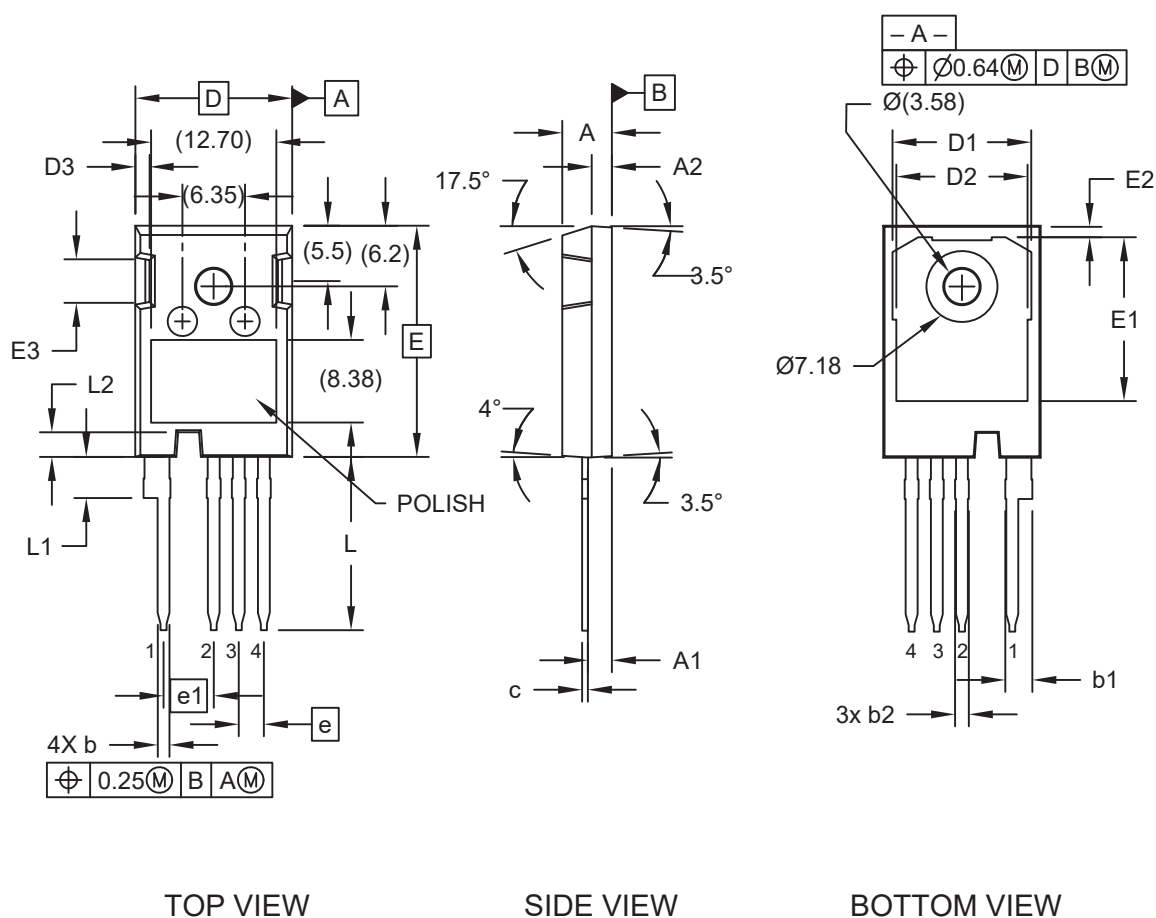
## 2. Package Specification

This section shows the package specification of this device.

### 2.1 Package Outline Drawing

The following figure illustrates the TO-247 notched-4L package outline of this device.

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



The following table shows the TO-247 notched-4L dimensions and should be used in conjunction with the package outline drawing.

**Table 2-1.** TO-247 Notched-4L Dimensions

| Symbol | Description           | Min. (mm) | Nom. (mm) | Max. (mm) |
|--------|-----------------------|-----------|-----------|-----------|
| N      | Number of terminals   | 4         |           |           |
| e      | Pitch                 | 2.54 BSC  |           |           |
| e1     |                       | 5.08 BSC  |           |           |
| A      | Overall height        | 4.83      | 5.02      | 5.21      |
| A1     | Standoff              | 2.29      | 2.41      | 2.54      |
| A2     | Exposed pad thickness | 1.91      | 2.03      | 2.16      |
| c      | Terminal thickness    | 0.55      | 0.60      | 0.68      |
| D      | Overall length        | 15.75     | 15.94     | 16.13     |

.....continued

| Symbol | Description                  | Min. (mm) | Nom. (mm) | Max. (mm) |
|--------|------------------------------|-----------|-----------|-----------|
| D1     | Exposed pad length           | 13.10     | 13.62     | 14.15     |
| D2     |                              | 12.38     | 12.90     | 13.43     |
| D3     | Cutout length                | 1.00      | 1.45      | 1.90      |
| E      | Overall width                | 23.30     | 23.45     | 23.60     |
| E1     | Exposed pad width            | 16.25     | 16.95     | 17.65     |
| E2     | Exposed pad gap to edge      | 0.95      | 1.10      | 1.25      |
| E3     | Cutout width                 | 3.68      | 4.39      | 5.10      |
| b      | Terminal width               | 1.07      | 1.20      | 1.33      |
| b1     | Terminal shoulder width (X1) | 2.39      | 2.66      | 2.94      |
| b2     | Terminal shoulder width (X3) | 1.07      | 1.33      | 1.60      |
| L      | Terminal length              | 17.31     | 17.56     | 17.82     |
| L1     | Terminal shoulder length     | 3.97      | 4.17      | 4.37      |
| L2     | Notch depth                  | 2.35      | 2.50      | 2.65      |

**Note:**

Dimensioning and tolerancing per ASME Y14.5M.

- BSC: Basic dimension. Theoretically exact value shown without tolerances.

### 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        | 07/2024 | The following changes are made in this revision of the document: <ul style="list-style-type: none"><li>• Added AEC feature in <a href="#">Product Overview</a>.</li><li>• Updated <math>T_{STG}</math> value in <a href="#">Table 1-2</a>.</li><li>• Updated mounting torque row in <a href="#">Table 1-2</a>.</li></ul> |
| A        | 02/2024 | Initial revision                                                                                                                                                                                                                                                                                                         |

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