Wolfspeed®

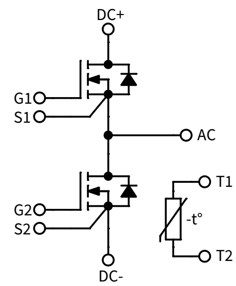
# CAB006A12GM3, CAB006A12GM3T

## 1200 V, 6 mΩ, Silicon Carbide, Half-Bridge Module

| | |
|---|---|
| $V_{DS}$ | **1200 V** |
| $R_{DS(on)}$ | **6 mΩ** |

### Technical Features

- Ultra-Low Loss
- High Frequency Operation
- Zero Turn-Off Tail Current from MOSFET
- Normally-Off, Fail-Safe Device Operation
- Aluminum Nitride Ceramic Substrate
- Optional Pre-Applied Thermal Interface Material


### Typical Applications

- DC-DC Converters
- EV Chargers
- High-Efficiency Converters / Inverters
- Renewable Energy
- Smart-Grid / Grid-Tied Distributed Generation

### System Benefits

- Enables Compact, Lightweight Systems
- Increased System Efficiency, due to Low Switching & Conduction Losses of SiC
- Reduced Thermal Requirements and System Cost

### Key Parameters

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|---|---|---|---|---|---|---|---|
| Drain-Source Voltage | $V_{DS}$ | | | 1200 | V | | |
| Maximum Gate-Source Voltage | $V_{GS(max)}$ | -10 | | +23 | | Transient | Fig. 33<br>Note 1 |
| Operational Gate-Source Voltage | $V_{GS(op)}$ | | -4/15 | | | Static | |
| DC Continuous Drain Current ($T_{VJ}$ ≤ 150 °C) | $I_D$ | | | 200 | A | $V_{GS}$ = 15 V, $T_{HS}$ = 75 °C, $T_{VJ}$ ≤ 150 °C | Notes 2,3,4<br>Fig. 20 |
| DC Continuous Drain Current ($T_{VJ}$ ≤ 175 °C) | | | | 200 | | $V_{GS}$ = 15 V, $T_{HS}$ = 75 °C, $T_{VJ}$ ≤ 175 °C | |
| DC Source-Drain Current (Body Diode) | $I_{SD\ BD}$ | | 166 | | | $V_{GS}$ = -4 V, $T_{HS}$ = 75 °C, $T_{VJ}$ ≤ 175 °C | |
| Pulsed Drain Current | $I_{D\ (pulsed)}$ | | | 400 | | $t_{Pmax}$ limited by $T_{VJmax}$<br>$V_{GS}$ = 15 V, $T_{HS}$ = 50 °C | |
| Power Dissipation | $P_D$ | | 568 | | W | $T_{HS}$ = 75 °C, $T_{VJ}$ ≤ 150 °C | Note 5<br>Fig. 21 |
| Virtual Junction Temperature | $T_{VJ(op)}$ | -40 | | 150 | °C | Operation | |
| | | -40 | | 175 | | Intermittent with Reduced Life | |

Note (1): Recommended turn-on gate voltage is 15 V with ±5% regulation tolerance. Not for use in linear region.
Note (2): DC continuous drain current limits are imposed by package.
Note (3): See Figure 22 for implementable AC current.
Note (4): Verified by design.
Note (5): $P_D = (T_{VJ} - T_{HS})/R_{TH(JH,typ)}$

## MOSFET Characteristics (Per Position) ($T_{VJ}$ = 25 °C unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions | Note |
|---|---|---|---|---|---|---|---|
| Drain-Source Breakdown Voltage | $V_{(BR)DSS}$ | 1200 | | | V | $V_{GS}$ = 0 V, $T_{VJ}$ = -40 °C | |
| Gate Threshold Voltage | $V_{GS(th)}$ | 1.8 | 2.5 | 3.9 | V | $V_{DS} = V_{GS}$, $I_D$ = 69 mA | |
| | | | 2.1 | | | $V_{DS} = V_{GS}$, $I_D$ = 69 mA, $T_{VJ}$ = 150 °C | |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | | 6 | 600 | µA | $V_{GS}$ = 0 V, $V_{DS}$ = 1200 V | |
| Gate-Source Leakage Current | $I_{GSS}$ | | 0.06 | 1.5 | | $V_{GS}$ = 15 V, $V_{DS}$ = 0 V | |
| Drain-Source On-State Resistance (Devices Only) | $R_{DS(on)}$ | | 5.3 | 7.2 | mΩ | $V_{GS}$ = 15 V, $I_D$ = 200 A | Fig. 2<br>Fig. 3 |
| | | | 8.5 | | | $V_{GS}$ = 15 V, $I_D$ = 200 A, $T_{VJ}$ = 150 °C | |
| | | | 9.6 | | | $V_{GS}$ = 15 V, $I_D$ = 200 A, $T_{VJ}$ = 175 °C | |
| Transconductance | $g_{fs}$ | | 162 | | S | $V_{DS}$ = 20 V, $I_D$ = 200 A | Fig. 4 |
| | | | 145 | | | $V_{DS}$ = 20 V, $I_D$ = 200 A, $T_{VJ}$ = 150 °C | |
| Turn-On Switching Energy, $T_{VJ}$ = 25 °C<br>$T_{VJ}$ = 125 °C<br>$T_{VJ}$ = 150 °C | $E_{On}$ | | 4.76<br>5.12<br>5.41 | | mJ | $V_{DD}$ = 600 V,<br>$I_D$ = 200 A,<br>$V_{GS}$ = -4 V/15 V,<br>$R_{G(OFF)}$ = 0.0 Ω, $R_{G(ON)}$ = 1.5 Ω,<br>L = 40 µH | Fig. 11<br>Fig. 13 |
| Turn-Off Switching Energy, $T_{VJ}$ = 25 °C<br>$T_{VJ}$ = 125 °C<br>$T_{VJ}$ = 150 °C | $E_{Off}$ | | 0.44<br>0.45<br>0.46 | | | | |
| Internal Gate Resistance | $R_{G(int)}$ | | 1.12 | | Ω | f = 100 kHz, $V_{AC}$ = 25 mV | |
| Input Capacitance | $C_{iss}$ | | 20.4 | | nF | $V_{GS}$ = 0 V, $V_{DS}$ = 800 V,<br>$V_{AC}$ = 25 mV, f = 100 kHz | Fig. 9 |
| Output Capacitance | $C_{oss}$ | | 0.79 | | | | |
| Reverse Transfer Capacitance | $C_{rss}$ | | 43 | | pF | | |
| Gate to Source Charge | $Q_{GS}$ | | 240 | | nC | $V_{DS}$ = 800 V, $V_{GS}$ = -4 V/15 V,<br>$I_D$ = 200 A,<br>Per IEC60747-8-4 pg 21 | |
| Gate to Drain Charge | $Q_{GD}$ | | 204 | | | | |
| Total Gate Charge | $Q_G$ | | 708 | | | | |
| FET Thermal Resistance, Junction to Heatsink | $R_{th\ JHS}$ | | 0.132 | | °C/W | Measured with Pre-Applied TIM | Fig. 17 |

## Diode Characteristics (Per Position) ($T_{VJ}$ = 25 °C unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions | Notes |
|---|---|---|---|---|---|---|---|
| Body Diode Forward Voltage | $V_{SD}$ | | 4.9 | | V | $V_{GS}$ = -4 V, $I_{SD}$ = 200 A | Fig. 7 |
| | | | 4.4 | | | $V_{GS}$ = -4 V, $I_{SD}$ = 200 A, $T_{VJ}$ = 150 °C | |
| Reverse Recovery Time | $t_{RR}$ | | 29 | | ns | $V_{GS}$ = -4 V, $I_{SD}$ = 200 A, $V_R$ = 600 V,<br>di/dt = 20.0 A/ns, $T_{VJ}$ = 150 °C | Fig. 32 |
| Reverse Recovery Charge | $Q_{RR}$ | | 4.8 | | µC | | |
| Peak Reverse Recovery Current | $I_{RRM}$ | | 275 | | A | | |
| Reverse Recovery Energy, $T_{VJ}$ = 25 °C<br>$T_{VJ}$ = 125 °C<br>$T_{VJ}$ = 150 °C | $E_{RR}$ | | 0.14<br>0.45<br>0.63 | | mJ | $V_{DD}$ = 600 V, $I_D$ = 200 A,<br>$V_{GS}$ = -4 V/15 V, $R_{G(ON)}$ = 1.5 Ω,<br>L = 40 µH | Fig. 14 |

## Module Physical Characteristics

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Package Resistance, M1 (High-Side) | $R_{HS}$ | | 1.37 | | mΩ | $T_C$ = 125°C, $I_D$ = 200 A, Note 6 |
| Package Resistance, M2 (Low-Side) | $R_{LS}$ | | 1.25 | | | $T_C$ = 125°C, $I_D$ = 200 A, Note 6 |
| Stray Inductance | $L_{Stray}$ | | 7.1 | | nH | Between DC- and DC+, f = 10 MHz |
| Case Temperature | $T_C$ | -40 | | 125 | °C | |
| Mounting Torque | $M_S$ | | 2.0 | 2.3 | N-m | M4 bolts |
| Weight | W | | 39 | | g | |
| Case Isolation Voltage | $V_{isol}$ | 3 | | | kV | AC, 50 Hz, 1 minute |
| Comparative Tracking Index | CTI | 200 | | | | |
| Clearance Distance | | | 5.0 | | mm | Terminal to Terminal |
| | | | 10.0 | | | Terminal to Heatsink |
| Creepage Distance | | | 6.3 | | | Terminal to Terminal |
| | | | 11.5 | | | Terminal to Heatsink |

Note (6): Total Effective Resistance (Per Switch Position) = MOSFET $R_{DS(on)}$ + Switch Position Package Resistance.

## NTC Thermistor Characterization

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Rated Resistance | $R_{NTC}$ | | 5.0 | | kΩ | $T_{NTC}$ = 25°C |
| Resistance Tolerance at 25 °C | ΔR/R | -5 | | 5 | % | |
| Beta Value ($T_2$ = 50 °C) | $\beta_{25/50}$ | | 3380 | | K | |
| Beta Value ($T_2$ = 80 °C) | $\beta_{25/80}$ | | 3468 | | K | |
| Beta Value ($T_2$ = 100 °C) | $\beta_{25/100}$ | | 3523 | | K | |
| Power Dissipation | $P_{Max}$ | | | 10 | mW | $T_{NTC}$ = 25°C |

## Typical Performance

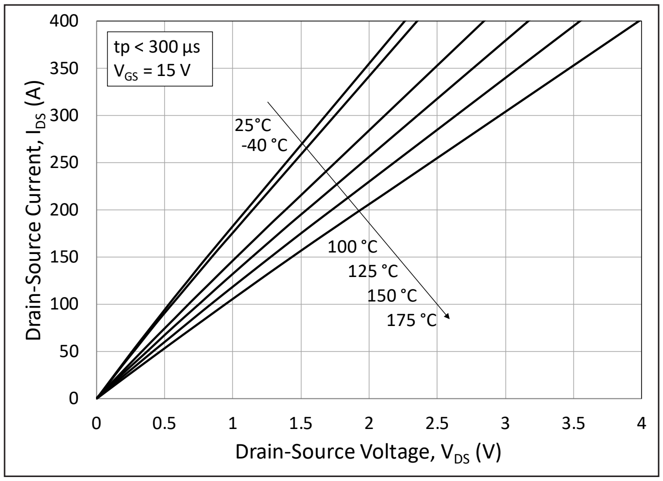



**Figure 1.** Output Characteristics for Various Junction Temperatures

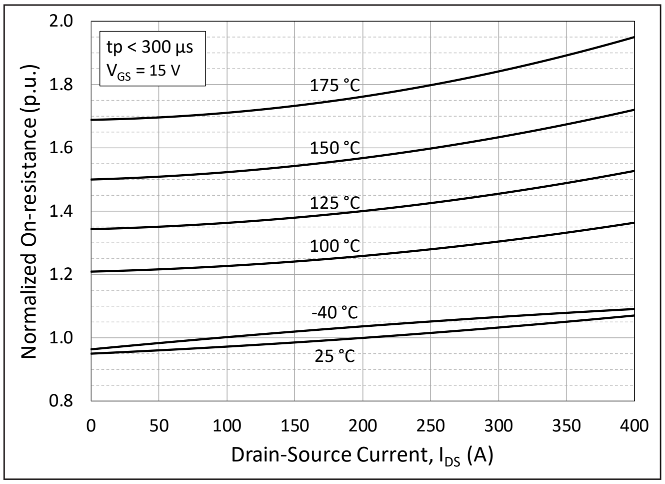



**Figure 2.** Normalized On-State Resistance vs. Drain Current for Various Junction Temperatures

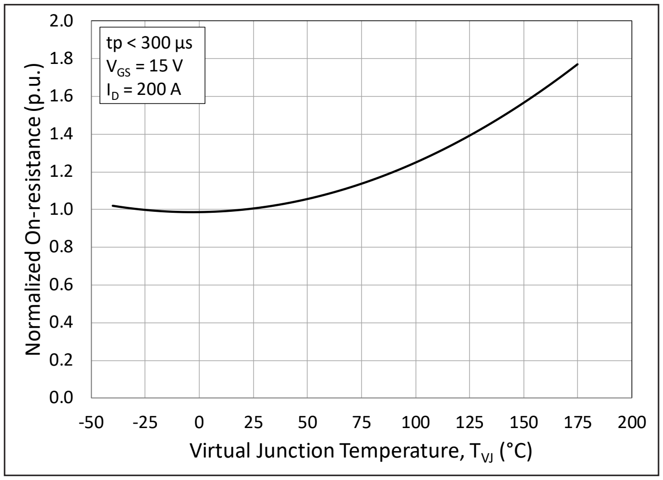



**Figure 3.** Normalized On-State Resistance vs. Junction Temperature

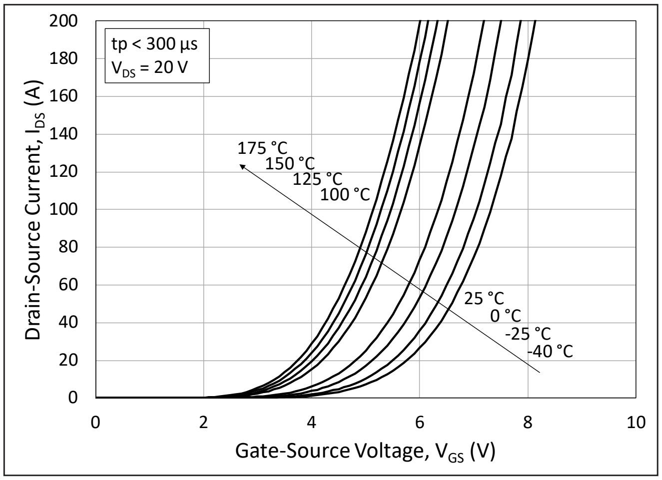



**Figure 4.** Transfer Characteristic for Various Junction Temperatures

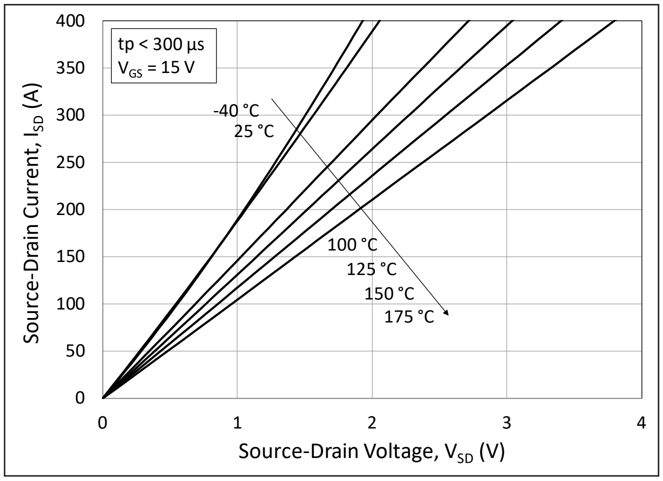



**Figure 5.** 3rd Quadrant Characteristic vs. Junction Temperatures at $V_{GS}$ = 15 V

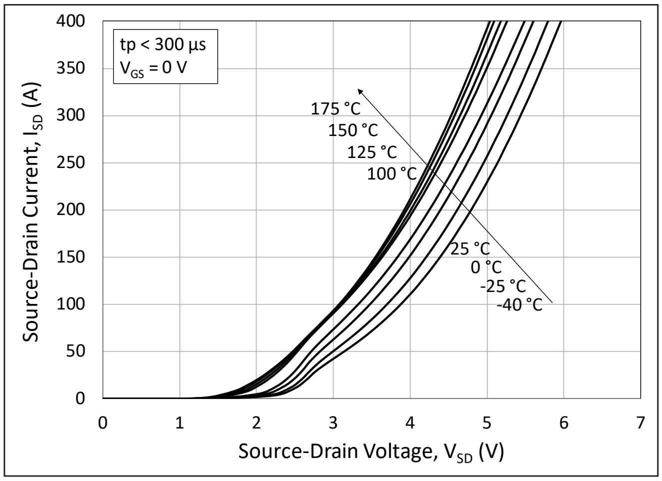



**Figure 6.** 3rd Quadrant Characteristic vs. Junction Temperatures at $V_{GS}$ = 0 V

## Typical Performance

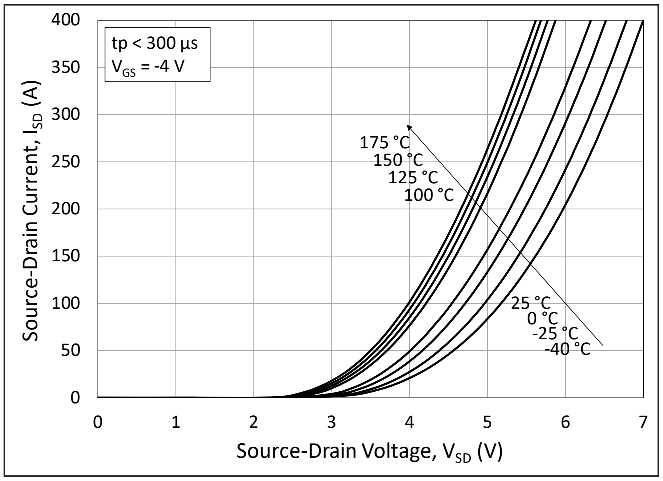



**Figure 7.** 3rd Quadrant Characteristic vs. Junction Temperatures at $V_{GS}$ = -4 V (Body Diode)

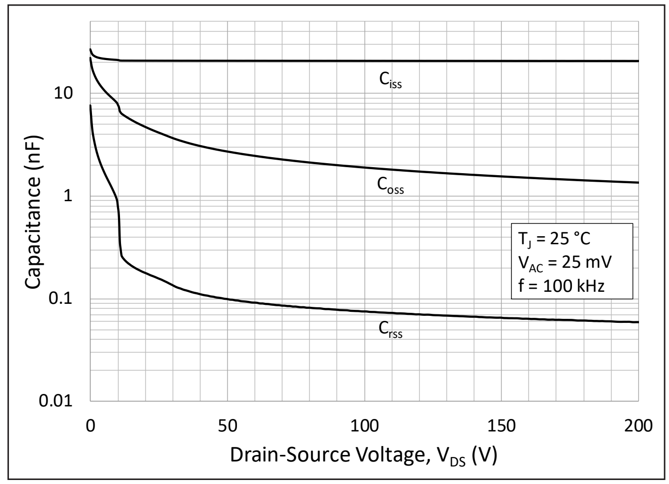



**Figure 8.** Typical Capacitances vs. Drain to Source Voltage (0 - 200 V)

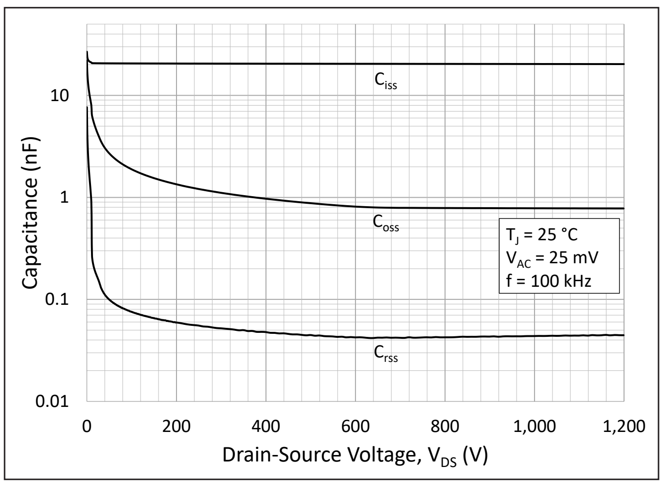



**Figure 9.** Typical Capacitances vs. Drain to Source Voltage (0 - 1200 V)

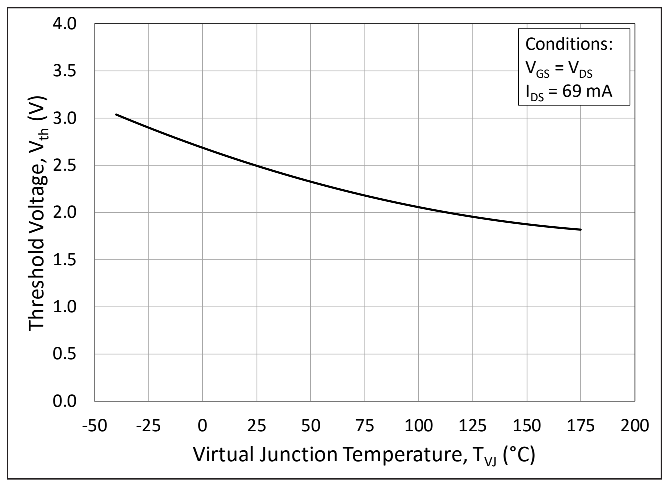



**Figure 10.** Threshold Voltage vs. Junction Temperature

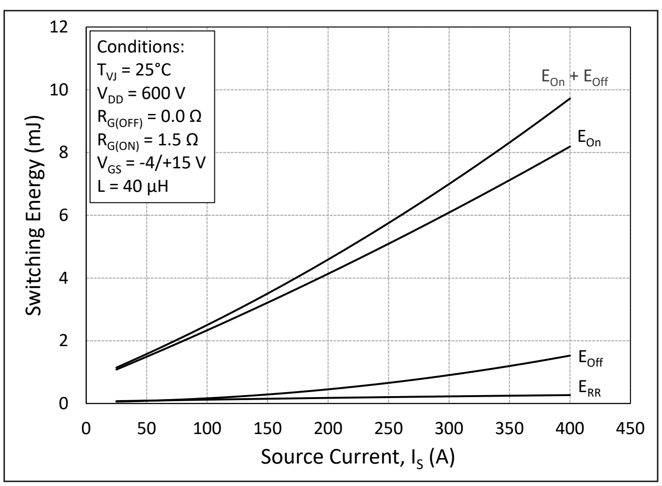



**Figure 11.** Switching Energy vs. Drain Current ($V_{DD}$ = 600 V)

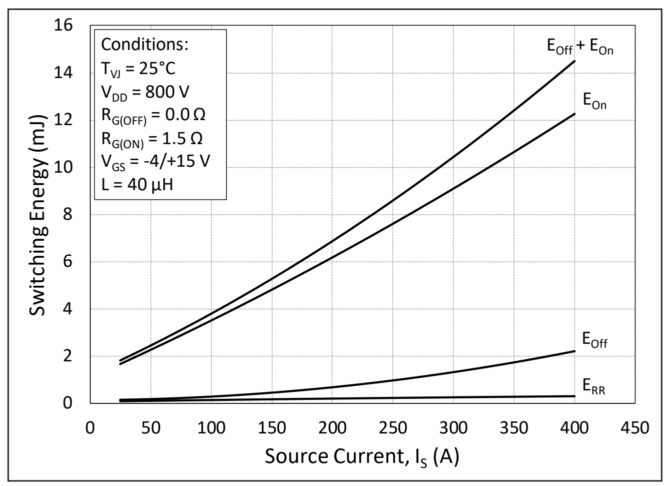



**Figure 12.** Switching Energy vs. Drain Current ($V_{DD}$ = 800 V)

## Typical Performance

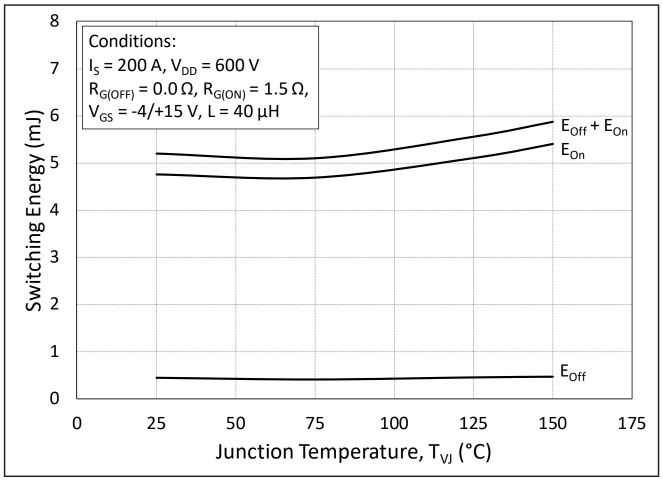



**Figure 13.** MOSFET Switching Energy vs. Junction Temperature

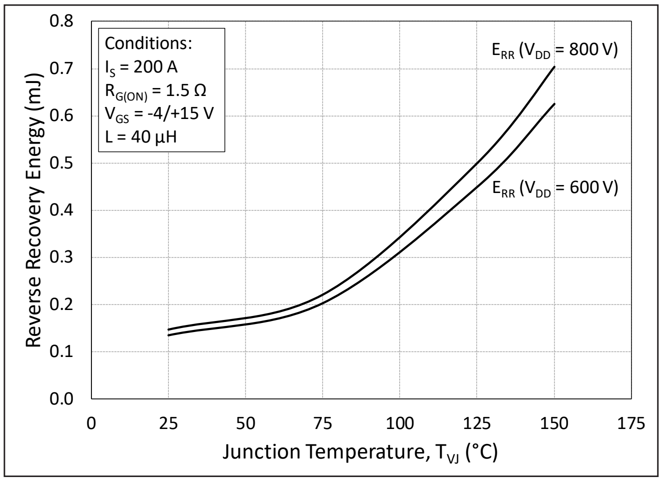



**Figure 14.** Reverse Recovery Energy vs. Junction Temperature

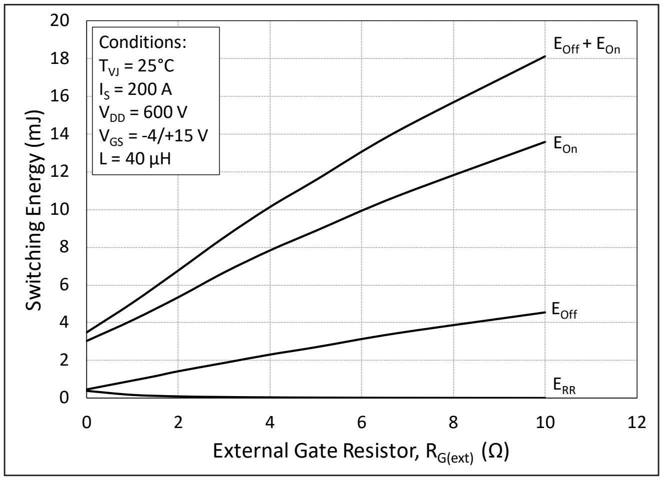



**Figure 15.** MOSFET Switching Energy vs. External Gate Resistance

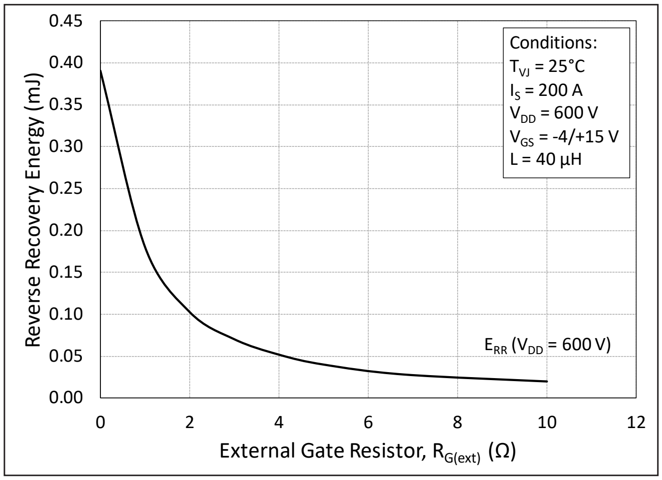



**Figure 16.** Reverse Recovery Energy vs. External Gate Resistance

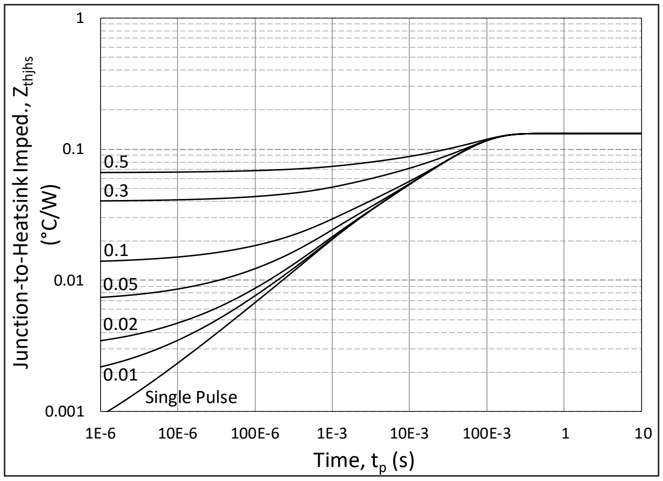



**Figure 17.** MOSFET Junction to Heatsink Transient Thermal Impedance, $Z_{th\ JHS}$ (°C/W)

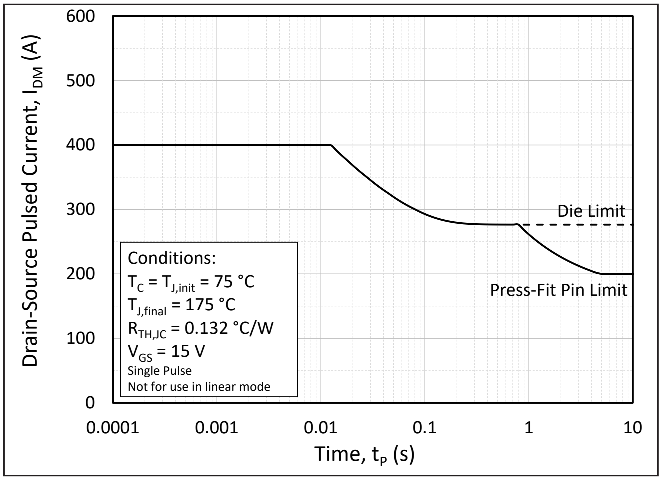



**Figure 18.** Pulsed Current Safe Operating Area

## Typical Performance

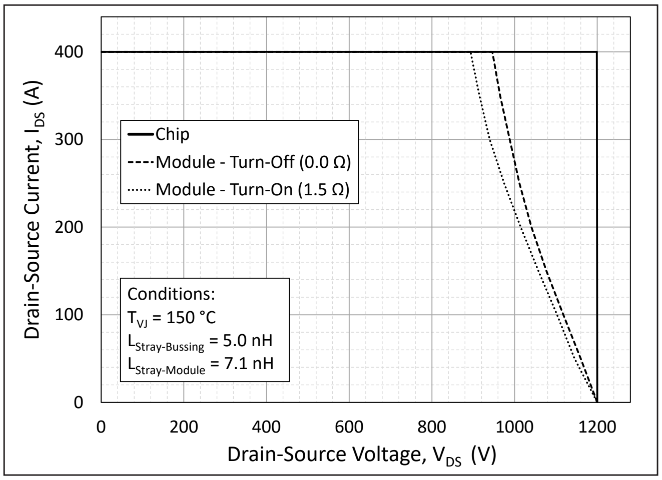



**Figure 19.** Switching Safe Operating Area

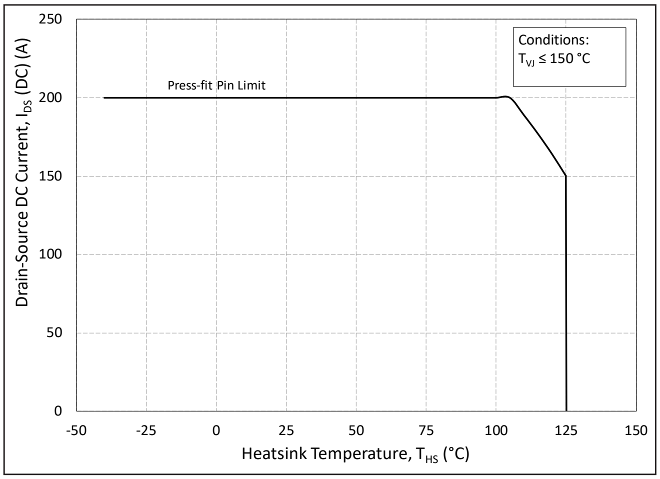



**Figure 20.** Continuous Drain Current Derating vs. Heatsink Temperature

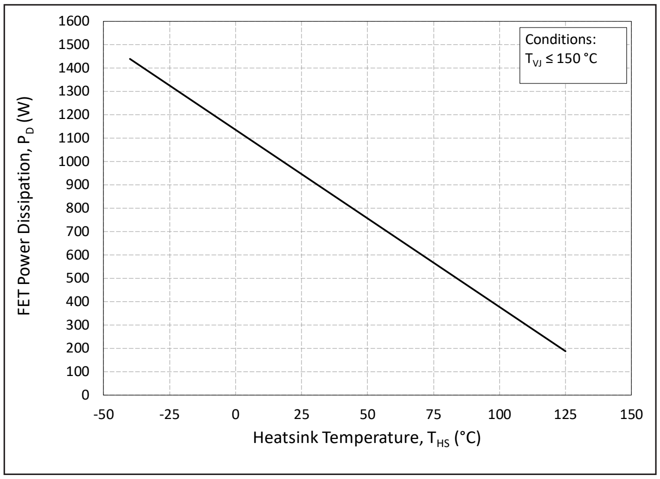



**Figure 21.** Maximum Power Dissipation Derating vs. Heatsink Temperature

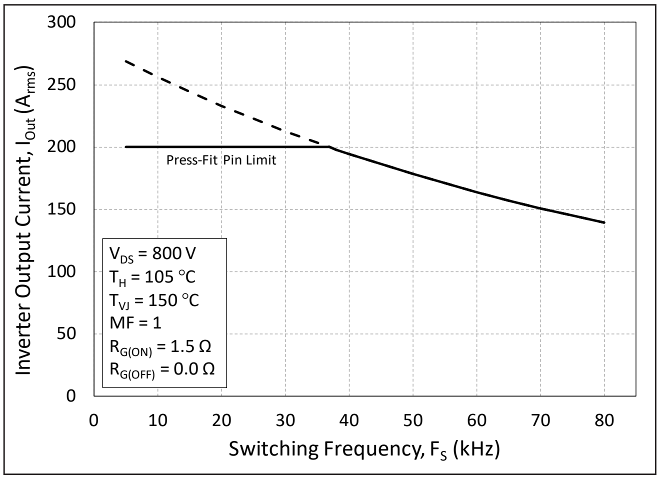



**Figure 22.** Typical Output Current Capability vs. Switching Frequency (Inverter Application)

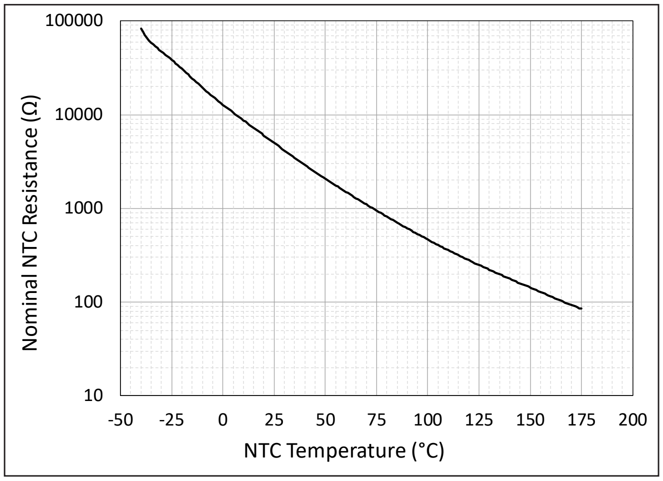



**Figure 23.** Nominal NTC Resistance vs. NTC Temperature

## Timing Characteristics

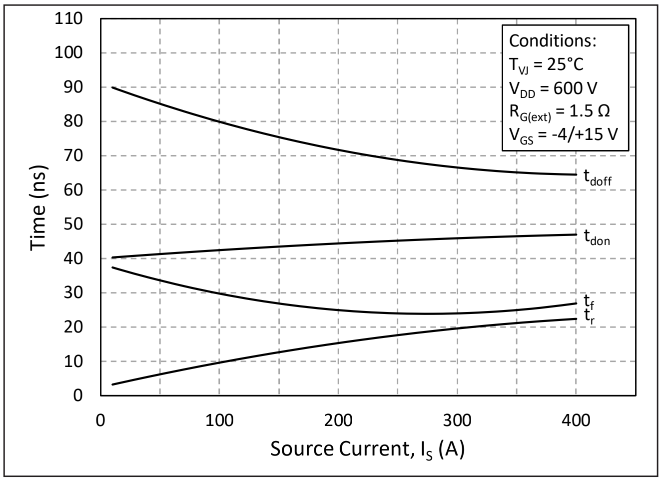



**Figure 24.** Timing vs. Source Current

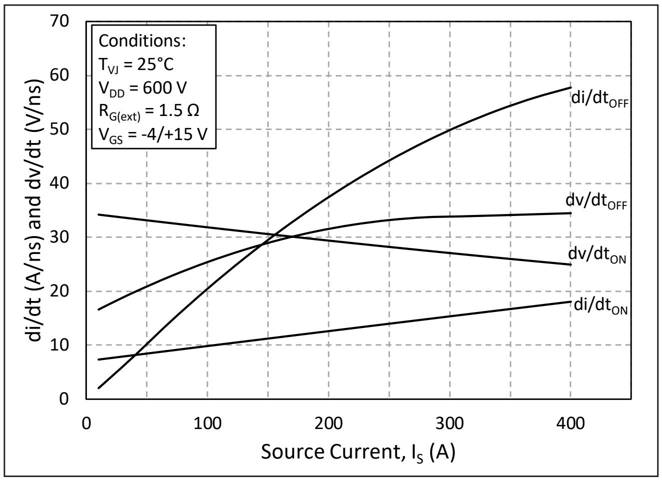



**Figure 25.** dv/dt and di/dt vs. Source Current

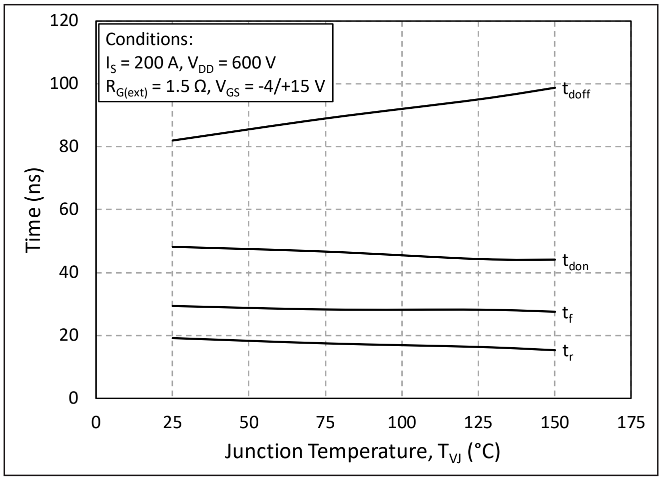



**Figure 26.** Timing vs. Junction Temperature

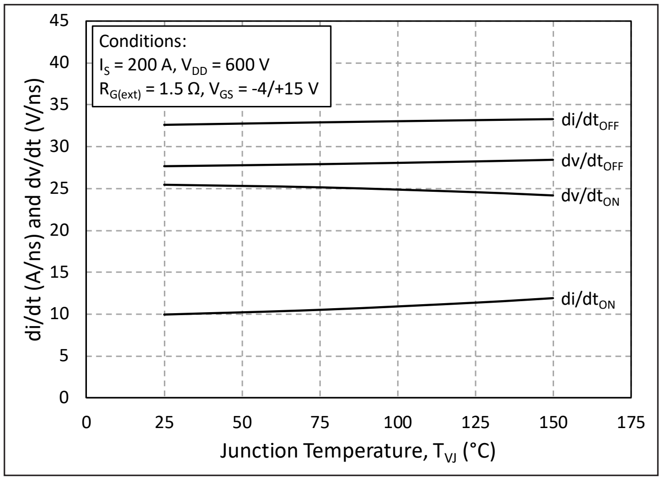



**Figure 27.** dv/dt and di/dt vs. Junction Temperature

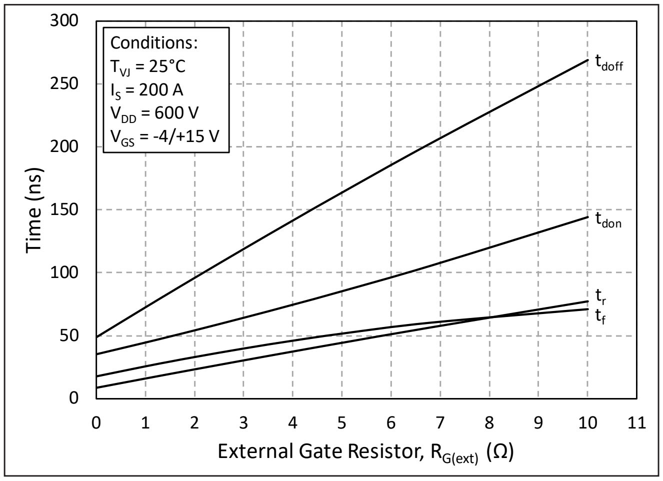



**Figure 28.** Timing vs. External Gate Resistance

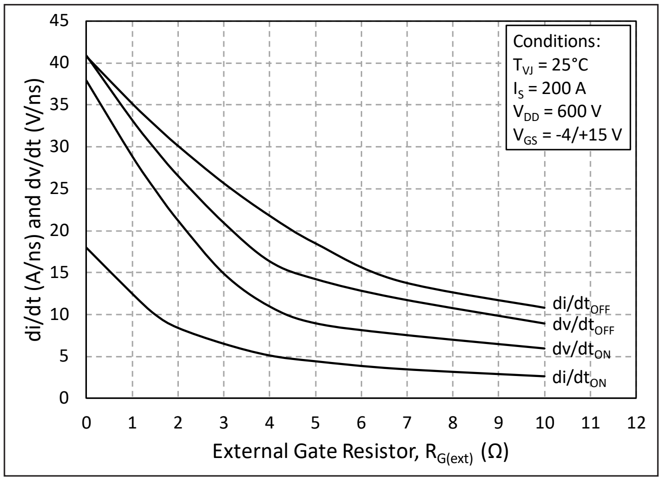



**Figure 29.** dv/dt and di/dt vs. External Gate Resistance

## Definitions

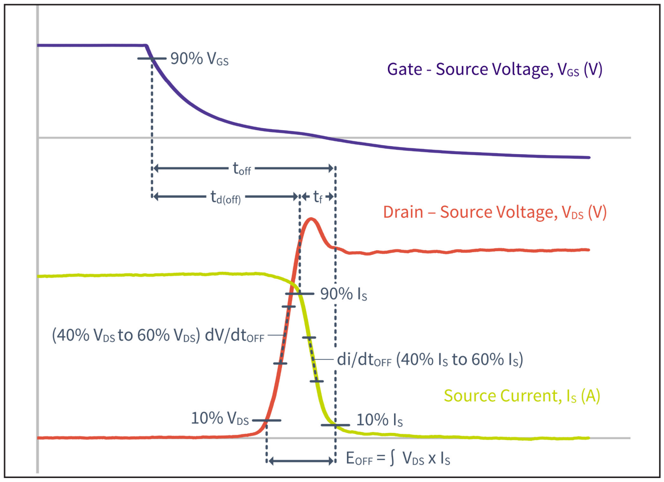



**Figure 30.** Turn-off Transient Definitions

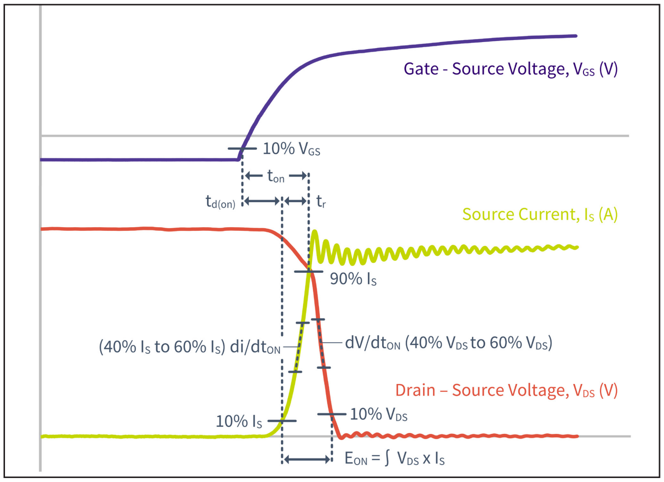



**Figure 31.** Turn-on Transient Definitions

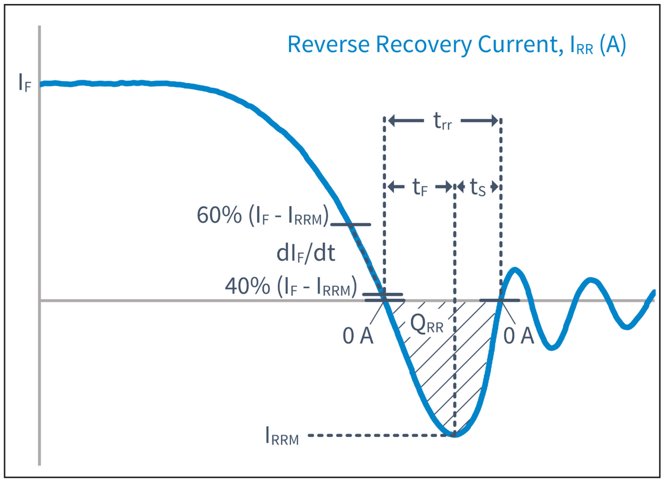



**Figure 32.** Reverse Recovery Definitions

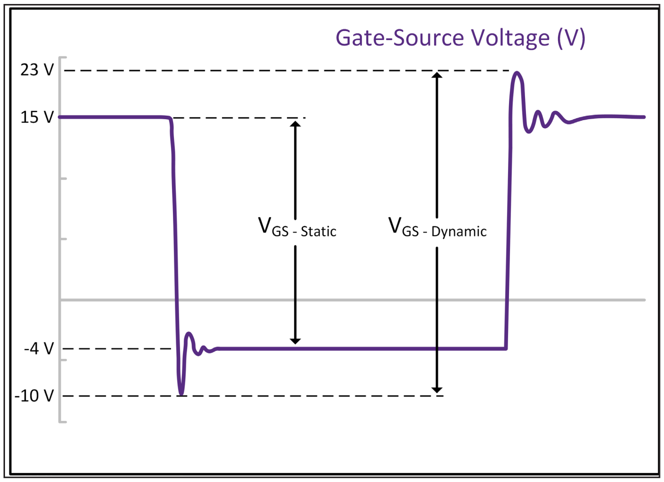
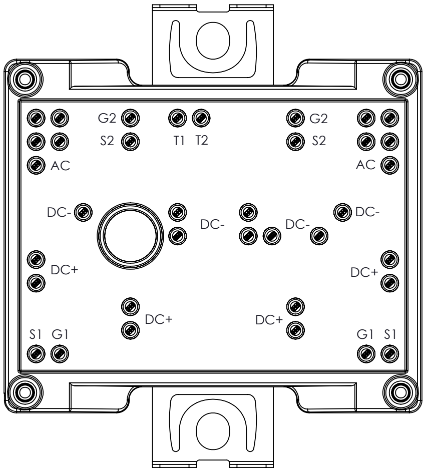
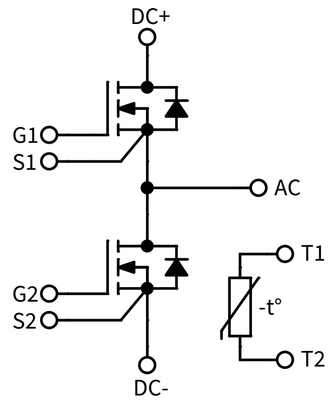



**Figure 33.** $V_{GS}$ Transient Definitions

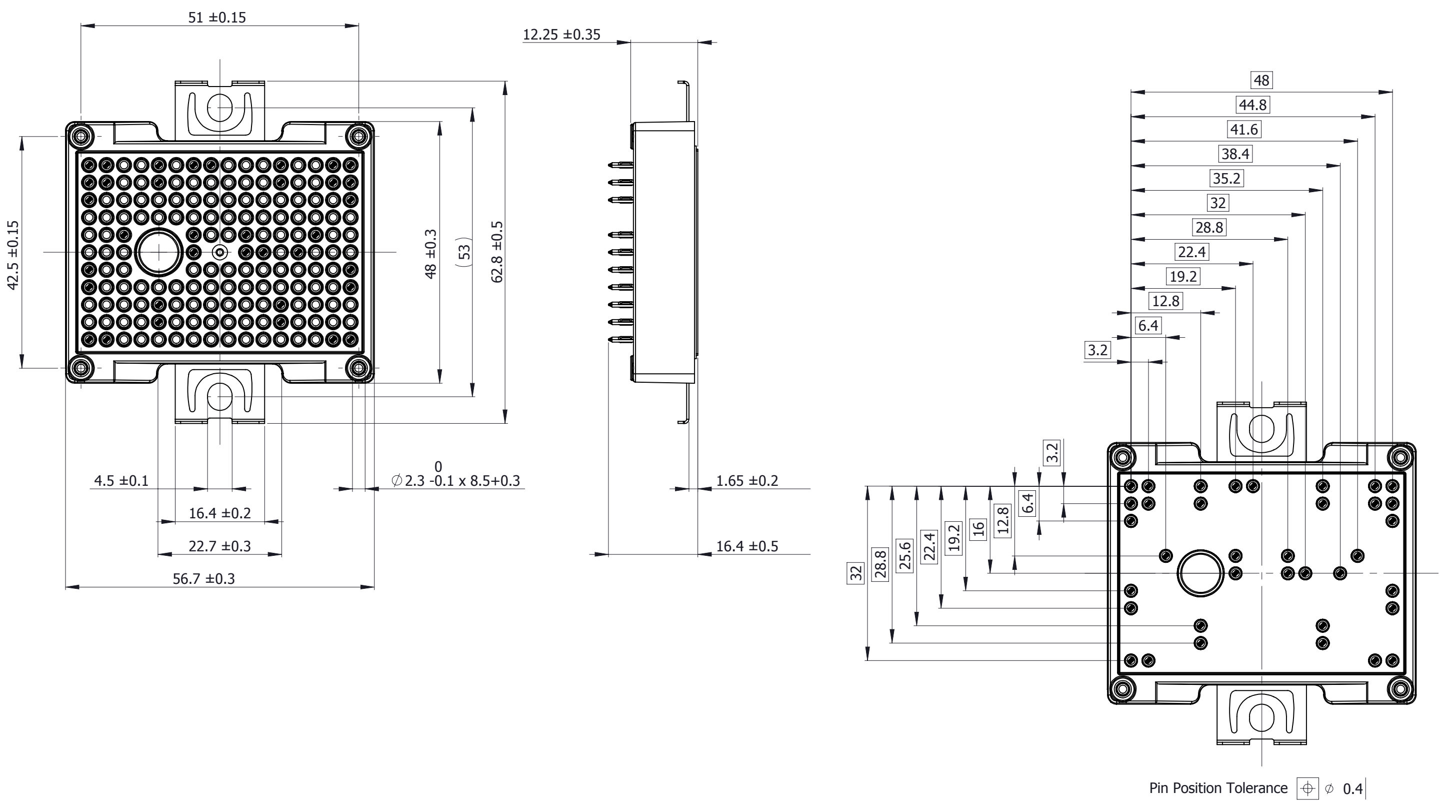
Note (7): The CGD1700HB2M-UNA, which features the UCC21710 gate driver IC, was used to evaluate dynamic performance. The typical driver high-state output resistance of 2.5 Ω and low-state output resistance of 0.3 Ω are not included in the $R_{G(ext)}$ values on this datasheet.

## Pinout




## Package Dimension (mm)



## Product Ordering Code

| Part Number | Description |
|---|---|
| CAB006A12GM3 | Without Pre-Applied Phase Change Thermal Interface Material |
| CAB006A12GM3T | With Pre-Applied Phase Change Thermal Interface Material |

## Supporting Links & Tools

### Simulation Tools & Support

- All LTSpice Models
- All PLECS Models
- SpeedFit 2.0 Design Simulator™
- Technical Support Forum

### Compatible Evaluation Hardware

- EVAL-ADUM4146WHB1Z: Analog Devices® Gate Driver Board
- UCC21710QDWEVM-054: Texas Instruments® Gate Driver Board
- Si823H-AxWA-KIT: Skyworks® Gate Driver Board
- ACPL-355JC: Broadcom® Gate Driver Board
- CGD1700HB2M-UNA: Wolfspeed Gate Driver Board
- CGD12HB00D: Differential Transceiver Daughter Board Companion Tool for Differential Gate Drivers

### Application Notes

- PRD-02302: Wolfpack Mounting Instructions and PCB Requirements
- PRD-06379: Environmental Considerations for Power Electronics
- PRD-07845: Power Module Baseplate Capacitance and Electromagnetic Compatibility
- PRD-07933: Wolfspeed Power Module Thermal Interface Material Application User Guide
- PRD-07968: Wolfspeed WolfPACK™ Dynamic Performance
- PRD-08376: Thermal Characterization Methods and Applications
- PRD-08710: Measuring Stray Inductance in Power Electronics Systems

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