# SOT-227 Power Module
# Low Side Chopper - Super Junction Power MOSFET and SiC Sky Diode, 50 A

SOT-227

## FEATURES

- Super junction power MOSFET
- SiC Sky diode
- Low $R_{DS(on)}$
- Low conduction losses and low switching losses
- Maximum 150 °C junction temperature
- UL approved file E78996
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

## APPLICATIONS

- DC/DC converter
- DC/AC inverter
- Power supplies
- UPS
- Charging stations
- Solar inverters

| PRIMARY CHARACTERISTICS | |
|---|---|
| $V_{DSS}$ | 1200 V |
| $R_{DS(on)}$ typical | 45 mΩ |
| $I_D$ | 42 A at 90 °C |
| $I_F$ | 21 A at 90 °C |
| Type | Low side chopper - super junction power MOSFET |
| Package | SOT-227 |

## ABSOLUTE MAXIMUM RATINGS

| PARAMETER | SYMBOL | TEST CONDITIONS | MAX. | UNITS |
|---|---|---|---|---|
| **MOSFET** | | | | |
| Drain to source voltage | $V_{DSS}$ | | 650 | V |
| Continuous drain current, $V_{GS}$ at 13 V | $I_D$ | $T_C$ = 25 °C | 58 | A |
| | | $T_C$ = 90 °C | 42 | |
| Pulsed drain current | $I_{DM}$ (1) | | 148 | |
| Diode continuous forward current | $I_F$ | $T_C$ = 25 °C | 33 | A |
| | | $T_C$ = 90 °C | 21 | |
| Single pulse foward current | $I_{FSM}$ | 10 ms sine or 6 ms rectangular pulse, $T_J$ = 25 °C | 105 | A |
| Power dissipation per MOSFET | $P_D$ | $T_C$ = 25 °C | 431 | W |
| Power dissipation per diode | $P_D$ | $T_C$ = 25 °C | 77 | W |
| Gate to source voltage | $V_{GS}$ | | ± 20 | V |
| Single pulse avalanche current | $E_{AS}$ | $T_C$ = 25 °C, L = 5 mH, $V_{DS}$ = 75 V | 408 | J |
| Avalanche current | $I_{AS}$ | | 12.8 | A |
| **MODULE** | | | | |
| Operating junction temperature range | $T_J$ | | -55 to +150 | °C |
| Operating storage temperature range | $T_{Stg}$ | | -40 to +150 | |
| Insulation voltage (RMS) | $V_{ISOL}$ | any terminal to case, t = 1 min | 2500 | V |

**Note**

(1) Limited at max. junction temperature

| **ELECTRICAL CHARACTERISTICS** ($T_J$ = 25 °C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| **MOSFET** | | | | | | |
| Drain to source breakdown voltage | $V_{(BR)DSS}$ | $V_{GS}$ = 0 V, $I_D$ = 0.25 mA | 650 | - | - | V |
| Breakdown voltage temperature coefficient | $\Delta V_{(BR)DSS}/\Delta T_J$ | $I_D$ = 0.25 mA (25 °C to 125 °C) | - | 0.41 | - | mV/°C |
| Static drain to source on-resistance | $R_{DS(on)}$ | $V_{GS}$ = 13 V, $I_D$ = 50 A | - | 45 | 54 | mΩ |
| | | $V_{GS}$ = 13 V, $I_D$ = 50 A, $T_J$ = 125 °C | - | 88 | - | |
| Gate threshold voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 0.25 mA | 2.9 | 4.0 | 5.1 | V |
| | | $V_{DS}$ = $V_{GS}$, $I_D$ = 0.25 mA, $T_J$ = 125 °C | - | 3.1 | - | |
| Temperature coefficient of threshold voltage | $\Delta V_{GS(th)}/\Delta T_J$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 0.25 mA (25 °C to 125 °C) | - | -9.0 | - | mV/°C |
| Forward transconductance | $g_{fs}$ | $V_{DS}$ = 20 V, $I_D$ = 50 A, $V_{GS}$ = 15 V | - | 48 | - | S |
| Drain to source leakage current | $I_{DSS}$ | $V_{DS}$ = 650 V, $V_{GS}$ = 0 V | - | 0.3 | 3.0 | μA |
| | | $V_{DS}$ = 650 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | - | 18 | - | |
| Gate to source leakage | $I_{GSS}$ | $V_{GS}$ = ± 20 V | - | - | ± 100 | nA |
| Total gate charge | $Q_g$ | $I_D$ = 46 A, $V_{DS}$ = 480 V, $V_{GS}$ = 0 V / 13 V | - | 167 | - | nC |
| Gate to source charge | $Q_{gs}$ | | - | 40 | - | |
| Gate to drain (“Miller”) charge | $Q_{gd}$ | | - | 60 | - | |
| Turn-on switching energy | $E_{on}$ | $V_{DD}$ = 400 V, $I_D$ = 50 A, $R_{g(on)}$ = 1.0 Ω, $V_{GS}$ = 13 V, $T_J$ = 125 °C | - | 0.5 | - | mJ |
| Turn-on delay time | $t_{d(on)}$ | | - | 51 | - | ns |
| Rise time | $t_r$ | | - | 10 | - | |
| Turn-off switching energy | $E_{off}$ | $V_{DD}$ = 400 V, $I_D$ = 50 A, $R_{g(off)}$ = 4.7 Ω, $V_{GS}$ = 13 V / -10 V, $T_J$ = 125 °C | - | 0.12 | - | mJ |
| Turn-off delay time | $t_{d(off)}$ | | - | 61 | - | ns |
| Fall time | $t_f$ | | - | 6 | - | |
| Input capacitance | $C_{iss}$ | $V_{GS}$ = 0 V, $V_{DS}$ = 400 V, f = 100 kHz | - | 6.2 | - | nF |
| Output capacitance | $C_{oss}$ | | - | 0.059 | - | |
| Reverse transfer capacitance | $C_{rss}$ | | - | 0.019 | - | |
| **SiC DIODE** | | | | | | |
| Cathode to anode breakdown voltage | $V_{BR}$ | $I_R$ = 100 μA | 650 | - | - | V |
| Forward voltage | $V_{FM}$ | $I_F$ = 20 A | - | 1.38 | 1.55 | |
| | | $I_F$ = 20 A, $T_J$ = 125 °C | - | 1.51 | - | |
| Reverse leakage current | $I_{RRM}$ | $V_R$ = 650 V | - | 0.7 | 40 | μA |
| | | $V_R$ = 650 V, $T_J$ = 125 °C | - | 2 | - | |
| Junction capacitance | $C_T$ | $V_R$ = 650 V, f = 1 MHz | - | 0.082 | - | nF |

| **DYNAMIC RECOVERY CHARACTERISTICS** ($T_J$ = 25 °C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| **DIODE** | | | | | | |
| Total capacitive charge | $Q_C$ | $V_R$ = 400 V | - | 56 | - | nC |

| **SOURCE-DRAIN RATINGS AND CHARACTERISTICS** ($T_J$ = 25 °C unless otherwise specified) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| Pulsed source current (body diode) | $I_{SM}$ | 6 ms rectangular pulse | - | - | 612 | A |
| Diode forward voltage | $V_{SD}$ | $I_S$ = 50 A, $V_{GS}$ = 0 V | - | 1.0 | 1.45 | V |
| Reverse recovery time | $t_{rr}$ | $T_J$ = 25 °C, $I_F$ = $I_S$ = 50 A, dI/dt = 100 A/μs, $V_R$ = 100 V | - | 145 | - | ns |
| Reverse recovery charge | $Q_{rr}$ | | - | 830 | - | nC |
| Reverse recovery current | $I_{RM}$ | | - | 11.5 | - | A |

| THERMAL AND MECHANICAL SPECIFICATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| PARAMETER | | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNITS |
| Operating junction temperature range | | $T_J$ | | -55 | - | 150 | °C |
| Operating storage temperature range | | $T_{Stg}$ | | -40 | - | 150 | |
| Junction to case | MOSFET | $R_{thJC}$ | | - | - | 0.29 | °C/W |
| | diode | $R_{thJC}$ | | - | - | 1.61 | |
| Case to heatsink | Module | $R_{thCS}$ | Flat, greased surface | - | 0.1 | - | |
| Weight | | | | - | 30 | - | g |
| Mounting torque | | | Torque to terminal | - | - | 1.1 (9.7) | Nm (lbf. in) |
| | | | Torque to heatsink | - | - | 1.8 (15.9) | Nm (lbf. in) |
| Case style | | | | SOT-227 | | | |

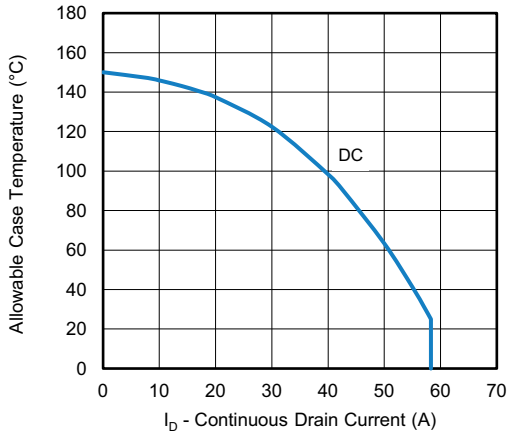



Fig. 1 - Maximum Continuous Drain Current vs. Case Temperature

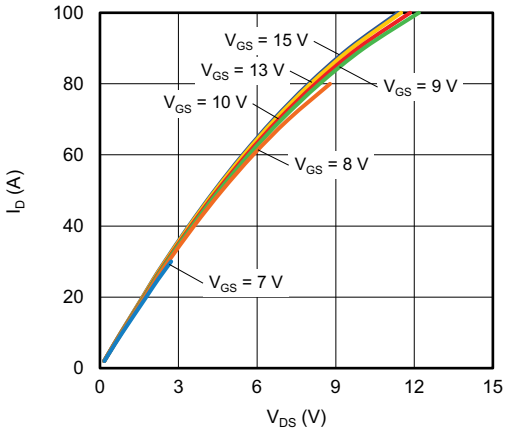



Fig. 3 - Typical Drain to Source Current Output Characteristics at $T_J$ = 125 °C

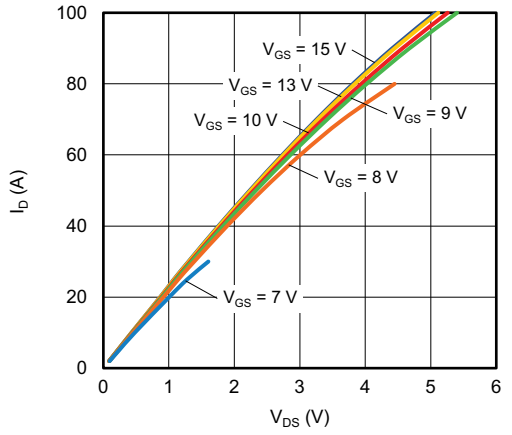



Fig. 2 - Typical Drain to Source Current Output Characteristics at $T_J$ = 25 °C

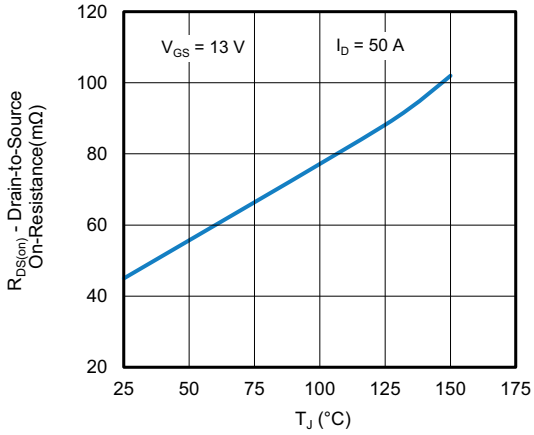



Fig. 4 - Typical Drain-to-Source On-Resistance vs. Temperature

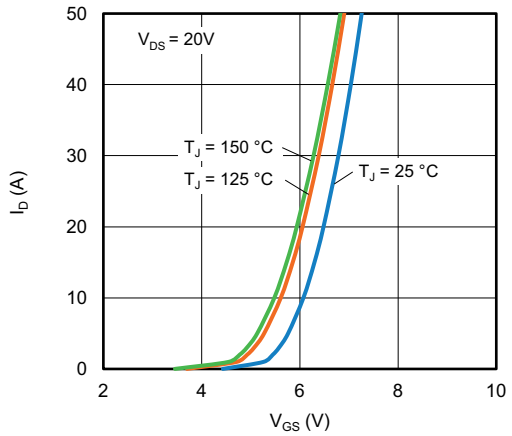



Fig. 5 - Typical Transfer Characteristics

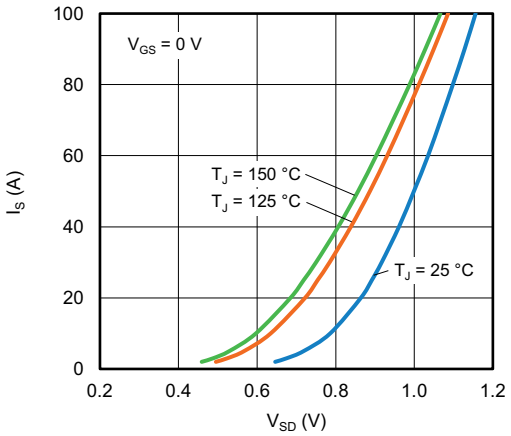



Fig. 8 - Typical Body Diode Source-to-Drain Current Characteristics

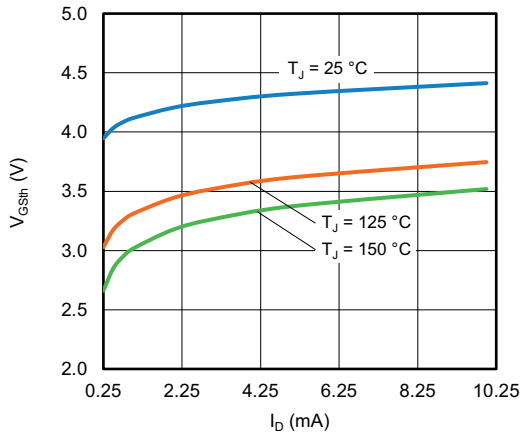



Fig. 6 - Typical Gate Threshold Voltage Characteristics

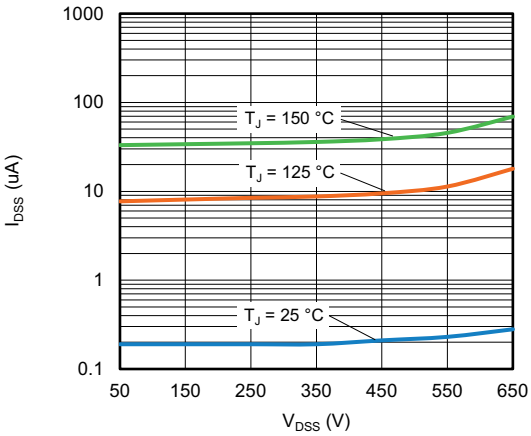



Fig. 9 - Typical Zero Gate Voltage Drain Current

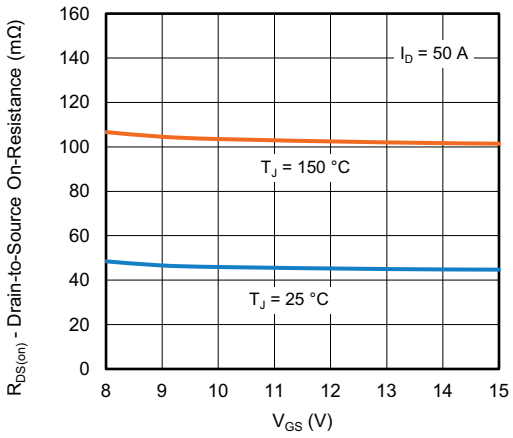



Fig. 7 - Typical Drain-to-Source On-Resistance vs. Gate to Source Voltage

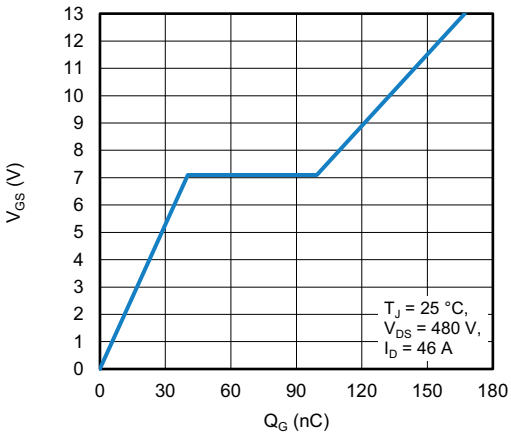



Fig. 10 - Typical Gate Charge vs. Gate to Source Voltage

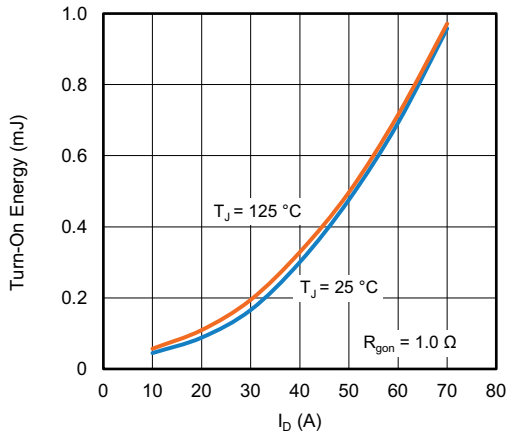



Fig. 11 - Typical Turn-On Energy Loss vs. $I_D$
($V_{GS}$ = 13 V)

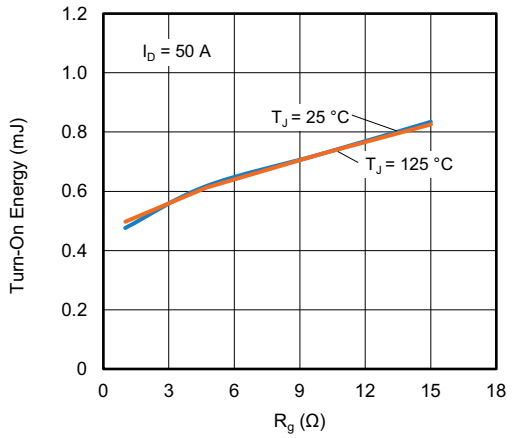



Fig. 12 - Typical Turn-On Energy Loss vs. $R_g$
($V_{GS}$ = 13 V)

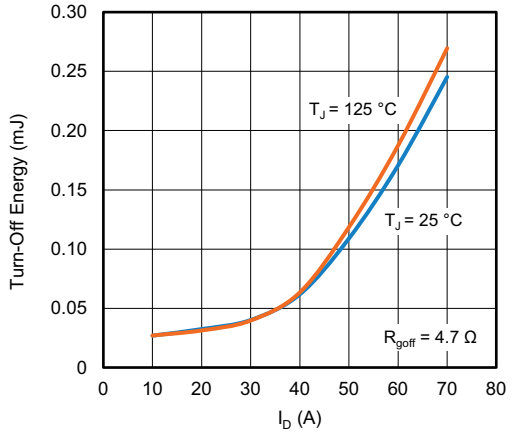



Fig. 13 - Typical Turn-Off Energy Loss vs. $I_D$
($V_{GS}$ = 13 V / -10 V)

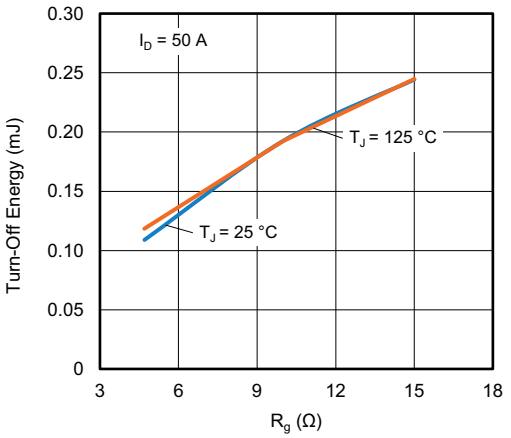



Fig. 14 - Typical Turn-Off Energy Loss vs. $R_g$
($V_{GS}$ = 13 V / -10 V)

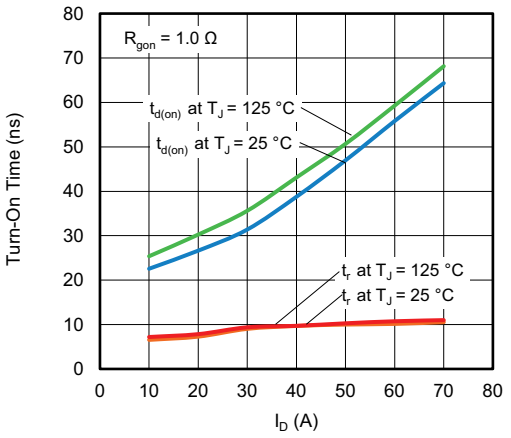



Fig. 15 - Typical Turn-On Switching Time vs. $I_D$
($V_{GS}$ = 13 V)

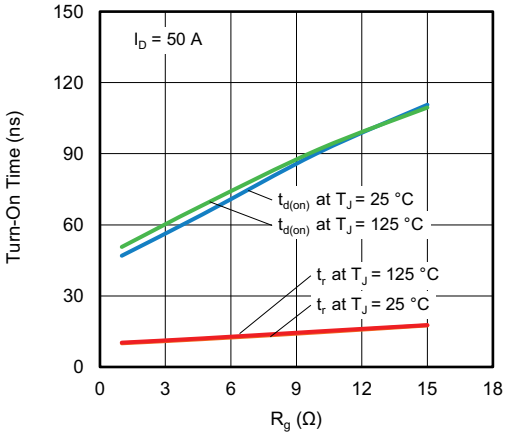



Fig. 16 - Typical Turn-On Switching Time vs. $R_g$
($V_{GS}$ = 13 V)

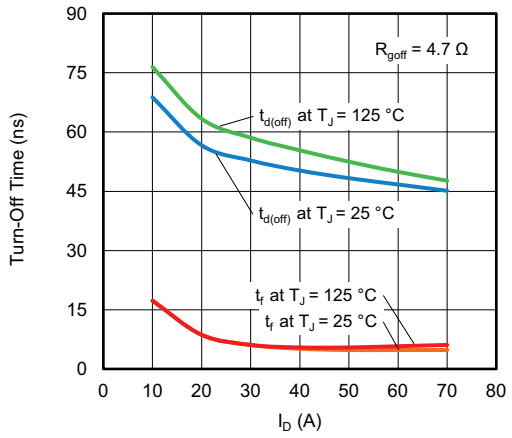



Fig. 17 - Typical Turn-Off Switching Time vs. $I_D$
($V_{GS}$ = 13 V / -10 V)

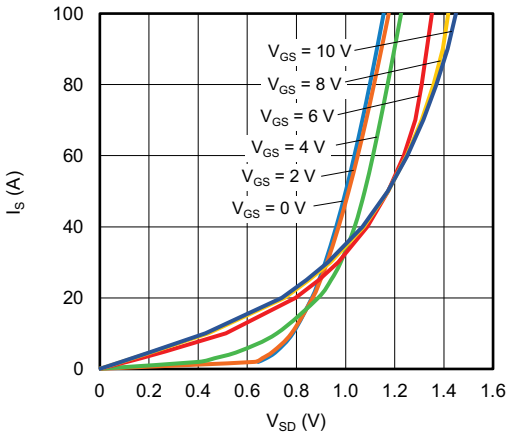



Fig. 20 - Typical Body Diode Source-to-Drain Current Characteristics $T_J$ = 25 °C

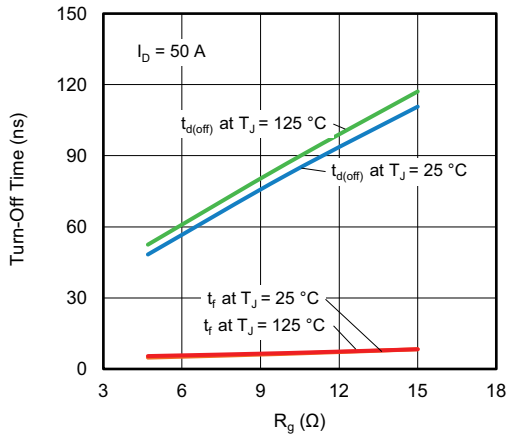



Fig. 18 - Typical Turn-Off Switching Time vs. $R_g$
($V_{GS}$ = 13 V / -10 V)

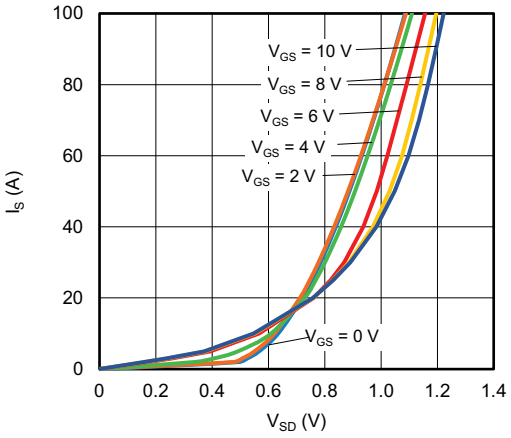



Fig. 21 - Typical Body Diode Source-to-Drain Current Characteristics $T_J$ = 125 °C

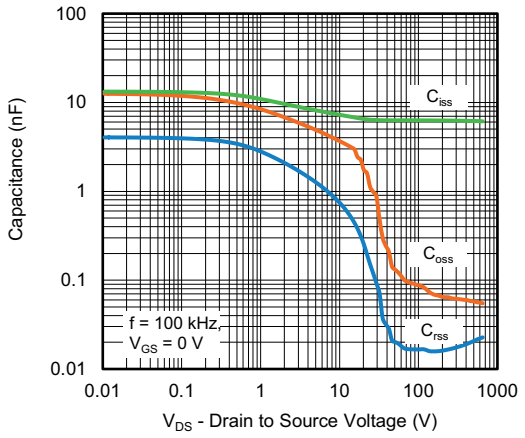



Fig. 19 - Typical Capacitance vs. Drain-to-Source Voltage

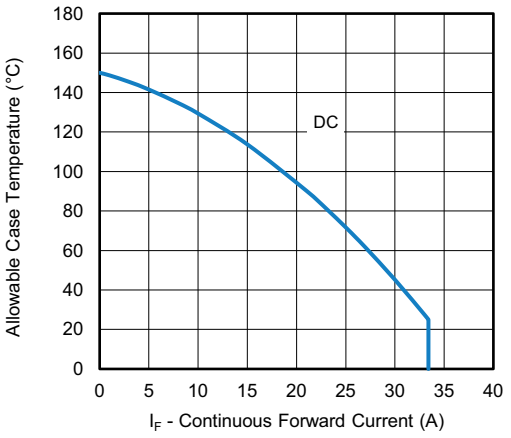



Fig. 22 - Allowable Case Temperature vs. Continuous Forward Current

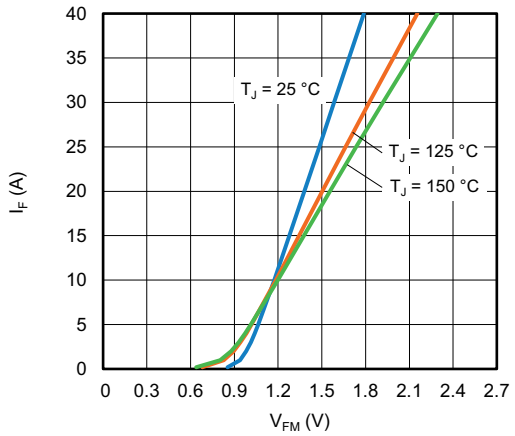



Fig. 23 - Diode Forward Characteristics

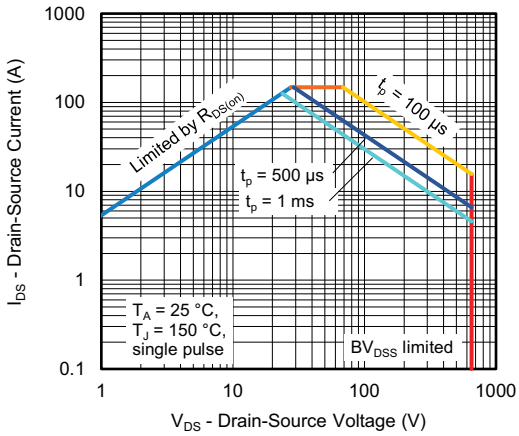



Fig. 24 - Safe Operating Area

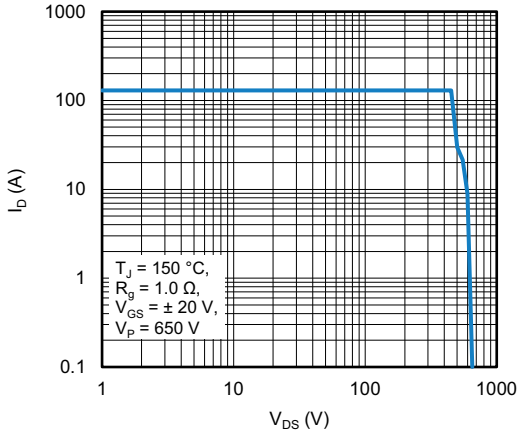



Fig. 25 - Reverse BIAS SOA

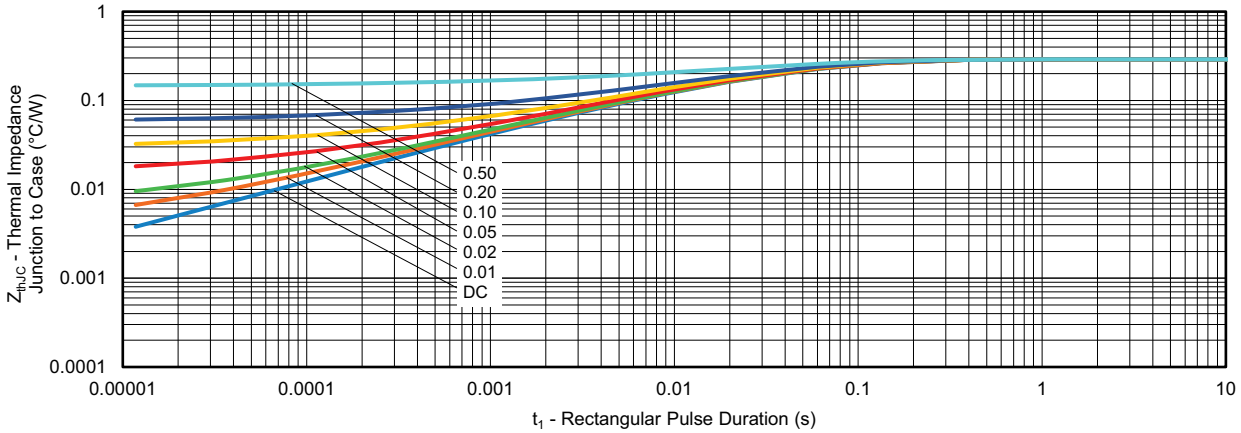



Fig. 26 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (MOSFET)

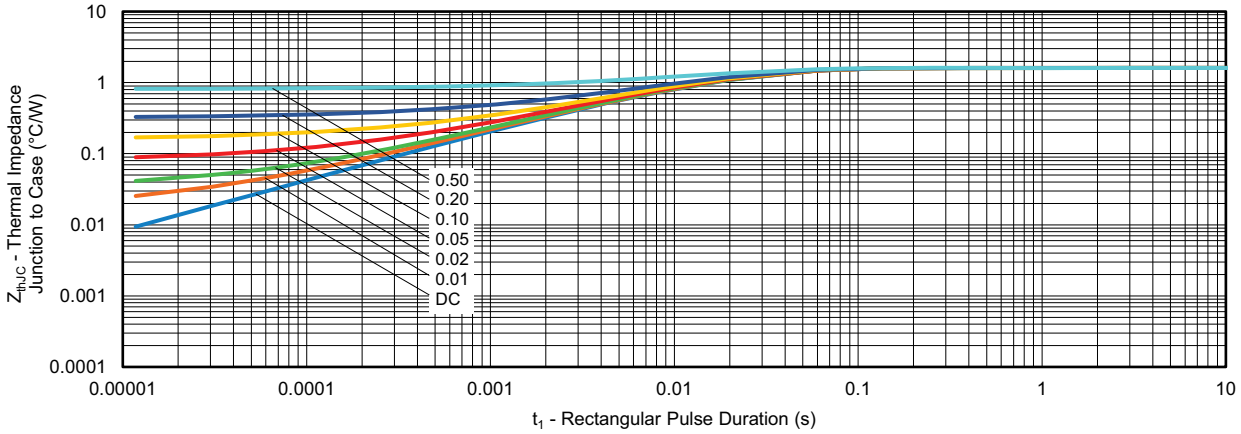


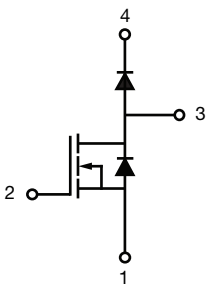
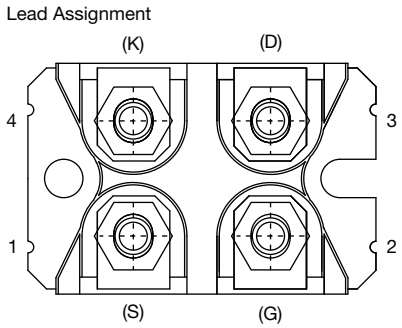

Fig. 27 - Maximum Thermal Impedance $Z_{thJC}$ Characteristics (Diode)

## ORDERING INFORMATION TABLE

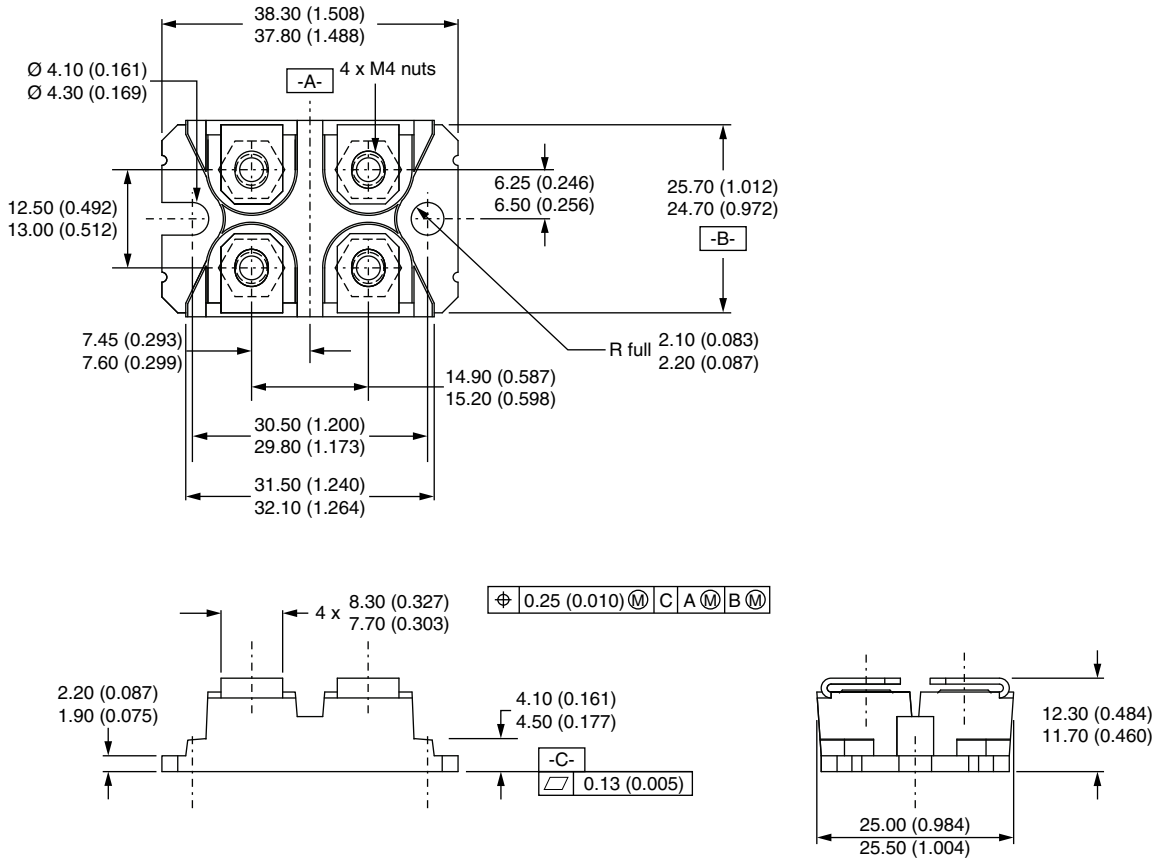
**Device code**

| VS- | F | C | 50 | L | A | 65 |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

- 1 - Vishay Semiconductors product
- 2 - F = MOSFET module
- 3 - C = MOSFET die generation
- 4 - Current rating (50 = 50 A)
- 5 - Circuit configuration (L = low side chopper)
- 6 - Package indicator (SOT-227)
- 7 - Voltage rating (65 = 650 V)

| CIRCUIT CONDIGURATION | | |
|---|---|---|
| **CIRCUIT** | **CIRCUIT CONFIGURATION CODE** | **CIRCUIT DRAWING** |
| Low side chopper | L |   |

**DIMENSIONS** in millimeters



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