DATA SHEET
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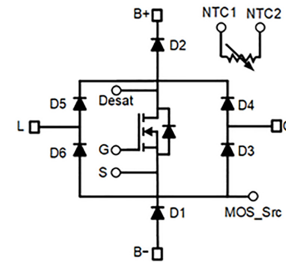
# SiC Power MOSFET Module

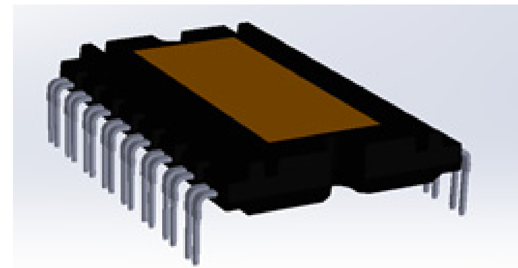
## 1200 V, 80 mΩ, 20 A
## Vienna Rectifier Power Module

# NVXK2KR80WDT

| $V_{(BR)DSS}$ | $R_{DS(on)}$ Max | $I_D$ Max |
|---|---|---|
| 1200 V | 116 mΩ @ 20 V | 20 A |




SiC MOSFET Vienna Rectifier Module



APM32

### Features

- DIP Silicon Carbide Vienna Rectifier Power Module for On−board Charger (OBC) for xEV Applications
- Creepage and Clearance per IEC60664−1, IEC 60950−1
- Compact Design for Low Total Module Resistance
- Module Serialization for Full Traceability
- Lead Free, ROHS and UL94V−0 Compliant
- Automotive Qualified per AEC−Q101 and AQG324

### Typical Applications

- Vienna PFC for On−Board Charger in xEV Applications

**MAXIMUM RATINGS MOSFET** ($T_J$ = 25°C unless otherwise noted)

| Parameter | | Symbol | Value | Unit |
|---|---|---|---|---|
| Drain−to−Source Voltage | | $V_{DSS}$ | 1200 | V |
| Gate−to−Source Voltage | | $V_{GS}$ | +25/−15 | V |
| Recommended Operation Values of Gate−to−Source Voltage, $T_J \le 175°C$ | | $V_{GSop}$ | +20/−5 | V |
| Continuous Drain Current (Notes1, 2) | $T_C$ = 25°C | $I_D$ | 20 | A |
| Power Dissipation (Note 1) | | $P_D$ | 82 | W |
| Pulsed Drain Current (Note 3) | $T_C$ = 25°C | $I_{DM}$ | 110 | A |
| Single Pulse Surge Drain Current Capability | $T_C$ = 25°C, $t_p$ = 10 μs, $R_G$ = 4.7 Ω | $I_{DSC}$ | 266 | A |
| Operating Junction and Storage Temperature | | $T_J$, $T_{stg}$ | −55 to 175 | °C |
| Source Current (Body Diode) | | $I_S$ | 18 | A |
| Single Pulse Drain−to−Source Avalanche Energy (Note 4) | | $E_{AS}$ | 180 | mJ |

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. Particular conditions specified determine thermal resistance values shown. Infinite heatsink with $T_C$ = 100°C for $R_{\theta JC}$. For $R_{\Psi JS}$ assembled to 3 mm thick aluminum heatsink with infinite cooling bottom surface at 85°C, through 80 μm thick TIM with 3 W/mK thermal conductivity.
2. Qualified per ECPE Guideline AQG 324.
3. Repetitive rating limited by maximum junction temperature and transconductance.
4. $E_{AS}$ based on initial $T_J$ = 25°C, L = 1 mH, $I_{AS}$ = 19 A, $V_{DD}$ = 120 V, $V_{GS}$ = 18 V.

### ORDERING INFORMATION

| Device | Package | Shipping |
|---|---|---|
| NVXK2KR80WDT | APM32 (Pb−Free) | 10 ea / Tube |

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### THERMAL CHARACTERISTICS SiC MOSFET (Note 1)

| Parameter | Symbol | Typ | Max | Unit |
|---|---|---|---|---|
| Thermal Resistance Junction−to−Case (Note 1) | $R_{\theta JC\ (MOS)}$ | 1.41 | 1.84 | °C/W |
| Thermal Resistance Junction−to−Sink (Note 1) | $R_{\Psi JS\ (MOS)}$ | 1.84 | 2.26 | °C/W |

### THERMAL CHARACTERISTICS DIODES (Note 1)

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| SiC Diode (D1−D2) Thermal Resistance Junction−to−Case (Note 1) | $R_{\theta JC\ (SiC\ Diode)}$ | 1.97 | °C/W |
| SiC Diode (D1−D2) Thermal Resistance Junction−to−Sink (Note 1) | $R_{\Psi JS\ (SiC\ Diode)}$ | 2.51 | °C/W |
| SiC Diode (D3−D6) Thermal Resistance Junction−to−Case (Note 1) | $R_{\theta JC\ (Si\ Diode)}$ | 1.61 | °C/W |
| SiC Diode (D3−D6) Thermal Resistance Junction−to−Sink (Note 1) | $R_{\Psi JS\ (Si\ Diode)}$ | 2.54 | °C/W |

### ELECTRICAL CHARACTERISTICS SiC MOSFET ($T_J$ = 25°C unless otherwise stated)

| Parameter | Symbol | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | | |
| Drain−to−Source Breakdown Voltage | $V_{(BR)DSS}$ | $V_{GS}$ = 0 V, $I_D$ = 1 mA | | 1200 | | | V |
| Drain−to−Source Breakdown Voltage Temperature Coefficient | $V_{(BR)DSS} / T_J$ | $I_D$ = 1 mA, referenced to 25°C | | | 500 | | mV/°C |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{GS}$ = 0 V<br>$V_{DS}$ = 1200 V | $T_J$ = 25°C | | | 100 | μA |
| | | | $T_J$ = 175°C | | | 1 | mA |
| Gate−to−Source Leakage Current | $I_{GSS}$ | $V_{GS}$ = +25/−15 V, $V_{DS}$ = 0 V | | | | ±1 | μA |
| **ON CHARACTERISTICS** (Note 5) | | | | | | | |
| Gate Threshold Voltage | $V_{GS(TH)}$ | $V_{GS}$ = $V_{DS}$ , $I_D$ = 10 mA | | 1.8 | 3 | 4.3 | V |
| Recommended Gate Voltage | $V_{GOP}$ | | | −5 | | +20 | V |
| Drain−to−Source On Resistance | $R_{DS(on)}$ | $V_{GS}$ = 20 V, $I_D$ = 20 A, $T_J$ = 25°C | | | 80 | 116 | mΩ |
| Drain−to−Source On Resistance | $R_{DS(on)}$ | $V_{GS}$ = 20 V, $I_D$ = 20 A, $T_J$ = 175°C | | | 150 | | mΩ |
| Forward Transconductance | $g_{FS}$ | $V_{DS}$ = 20 V, $I_D$ = 20 A | | | 11 | | S |
| **CHARGES, CAPACITANCES & GATE RESISTANCE** | | | | | | | |
| Input Capacitance | $C_{ISS}$ | $V_{GS}$ = 0 V, f = 1 MHz, $V_{DS}$ = 800 V | | | 1154 | | pF |
| Output Capacitance | $C_{OSS}$ | | | | 79 | | |
| Reverse Transfer Capacitance | $C_{RSS}$ | | | | 7.9 | | |
| Total Gate Charge | $Q_{G(TOT)}$ | $V_{GS}$ = −5/20 V, $V_{DS}$ = 600 V, $I_D$ = 20 A | | | 56 | | nC |
| Threshold Gate Charge | $Q_{G(TH)}$ | | | | 10 | | |
| Gate−to−Source Charge | $Q_{GS}$ | | | | 18 | | |
| Gate−to−Drain Charge | $Q_{GD}$ | | | | 11 | | |
| Gate−Resistance | $R_G$ | $V_{GS}$ = 0 V, f = 1 MHz | | | 1.2 | | Ω |
| **INDUCTIVE SWITCHING CHARACTERISTICS** | | | | | | | |
| Turn−On Delay Time | $t_{d(ON)}$ | $V_{GS}$ = −5 / 20 V, $V_{DS}$ = 800 V,<br>$I_D$ = 20 A, $R_G$ = 4.7 Ω,<br>Inductive load | | | 12 | | ns |
| Rise Time | $t_r$ | | | | 12 | | |
| Turn−Off Delay Time | $t_{d(OFF)}$ | | | | 21 | | |
| Fall Time | $t_f$ | | | | 9 | | |
| Turn−On Switching Loss | $E_{ON}$ | | | | 135 | | μJ |
| Turn−Off Switching Loss | $E_{OFF}$ | | | | 46 | | μJ |
| Total Switching Loss | $E_{tot}$ | | | | 181 | | μJ |

### ELECTRICAL CHARACTERISTICS SiC MOSFET ($T_J$ = 25°C unless otherwise stated) (continued)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **DRAIN−SOURCE DIODE CHARACTERISTICS** | | | | | | |
| Continuous Drain−Source Diode Forward Current (Notes 1, 2) | $I_{SD}$ | $V_{GS}$ = −5 V, $T_J$ = 25°C | | | 18 | A |
| Pulsed Drain−Source Diode Forward Current (Note 3) | $I_{SDM}$ | $V_{GS}$ = −5 V, $T_J$ = 25°C | | | 110 | A |
| Forward Diode Voltage | $V_{SD}$ | $V_{GS}$ = −5 V, $I_{SD}$ = 10 A, $T_J$ = 25°C | | 3.9 | | V |
| Reverse Recovery Time | $t_{RR}$ | $V_{GS}$ = −5 V, $dI_S/dt$ = 1000 A/µs, $I_{SD}$ = 20 A | | 16.2 | | ns |
| Peak Reverse Recovery Current | $I_{RRM}$ | | | 7.6 | | A |
| Reverse Recovery Energy | $E_{REC}$ | | | 4.1 | | µJ |
| Reverse Recovery Charge | $Q_{RR}$ | | | 61.6 | | nC |

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.

5. Pulse test: pulse width ≤300 µs, duty ratio ≤2%.

### MAXIMUM RATINGS SiC DIODE (D1−D2) ($T_J$ = 25°C unless otherwise noted)

| Parameter | | Symbol | Value | Unit |
|---|---|---|---|---|
| Peak Repetitive Reverse Voltage | | $V_{RRM}$ | 1200 | V |
| Single Pulse Avalanche Energy (Note 6) | | $E_{AS}$ | 210 | mJ |
| Continuous Rectified Forward Current @ $T_C$ < 150°C | | $I_F$ | 17 | A |
| Continuous Rectified Forward Current @ $T_C$ < 75°C | | | 33 | |
| Non−Repetitive Peak Forward Surge Current | $T_C$ = 25°C, 10 µs | $I_{F, Max}$ | 394 | A |
| | $T_C$ = 150°C, 10 µs | | 161 | |
| Non−Repetitive Forward Surge Current (pk) | Half−Sine Pulse, $t_p$ = 8.3 ms | $I_{F, SM}$ | 78 | A |
| Repetitive Forward Surge Current (pk) | Half−Sine Pulse, $t_p$ = 8.3 ms | $I_{F, RM}$ | 70 | A |
| Power Dissipation | $T_C$ = 25°C | $P_{TOT}$ | 76 | W |
| | $T_C$ = 150°C | $P_{TOT}$ | 13 | |
| Operating and Storage Temperature Range | | $T_J$, $T_{STG}$ | −55 to +175 | °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.

6. $E_{AS}$ of 210 mJ is based on starting $T_J$ = 25°C, L = 0.5 mH, $I_{AS}$ = 29 A, V = 50 V.

### ELECTRICAL CHARACTERISTICS SiC DIODE (D1−D2) ($T_J$ = 25°C unless otherwise stated)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Forward Voltage | $V_F$ | $I_F$ = 20 A, $T_J$ = 25°C | | 1.45 | 1.75 | V |
| | | $I_F$ = 20 A, $T_J$ = 125°C | | 1.70 | | |
| | | $I_F$ = 20 A, $T_J$ = 175°C | | 2.00 | | |
| Reverse Current | $I_R$ | $V_R$ = 1200 V, $T_J$ = 25°C | | | 200 | µA |
| | | $V_R$ = 1200 V, $T_J$ = 125°C | | | 300 | |
| | | $V_R$ = 1200 V, $T_J$ = 175°C | | | 400 | |
| Total Capacitive Charge | $Q_C$ | V = 800 V | | 120 | | nC |
| Total Capacitance | C | $V_R$ = 1 V, f = 100 kHz | | 1220 | | pF |
| | | $V_R$ = 400 V, f = 100 kHz | | 111 | | |
| | | $V_R$ = 800 V, f = 100 kHz | | 88 | | |

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.

### MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS Si DIODE (D3−D6)

Maximum ratings and electrical characteristics are found in Vishay Data Sheet VS207DM..CCB, Document Number 93888, Revision: 04−Aug−13. Refer herein for thermal performance only (Figure 22 & Thermal Characteristics Table, p. 2).

## TYPICAL CHARACTERISTICS SIC MOSFET

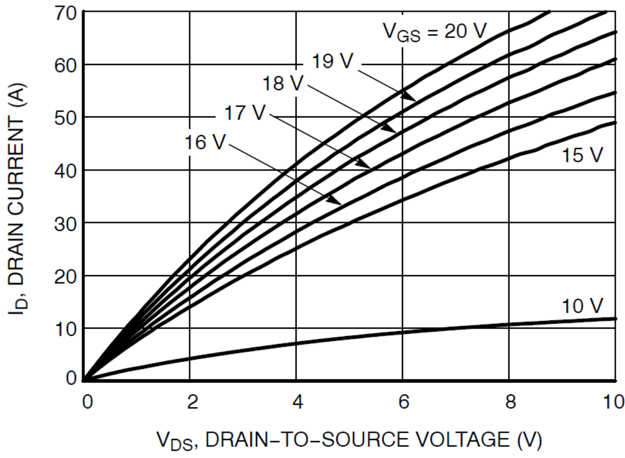



**Figure 1. On−Region Characteristics**

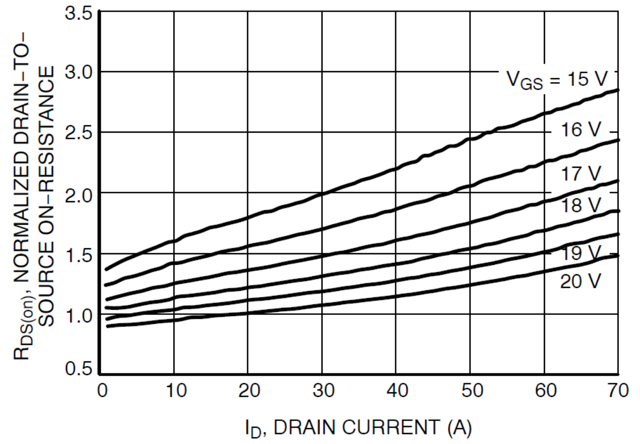



**Figure 2. Normalized On−Resistance vs. Drain Current and Gate Voltage**

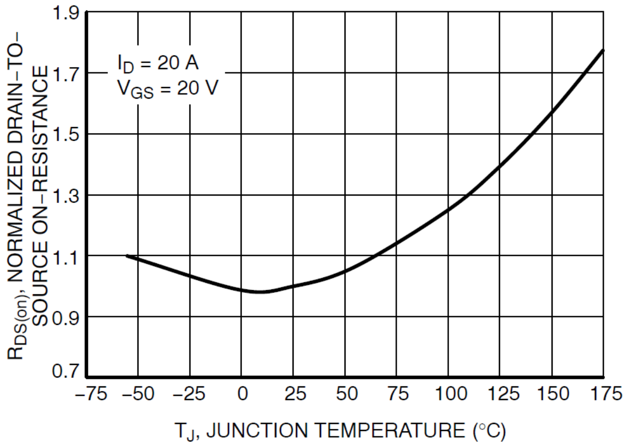



**Figure 3. On−Resistance Variation with Temperature**

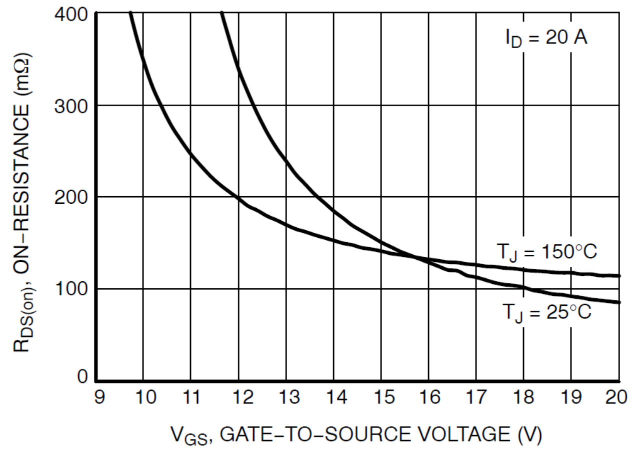



**Figure 4. On−Resistance vs. Gate−to−Source Voltage**

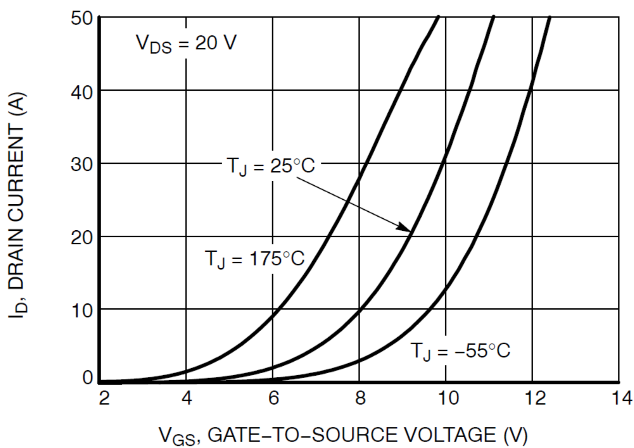



**Figure 5. Transfer Characteristics**

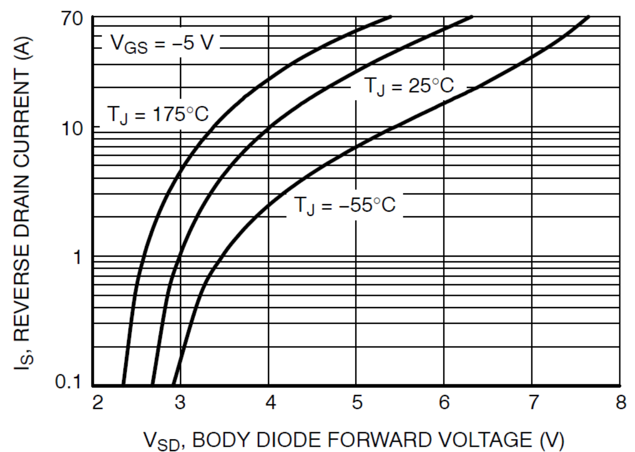



**Figure 6. Diode Forward Voltage vs. Current**

## TYPICAL CHARACTERISTICS SIC MOSFET (CONTINUED)

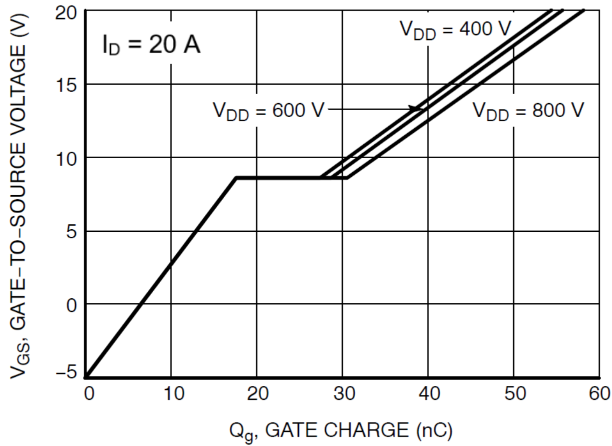



**Figure 7. Gate−to−Source Voltage vs. Total Charge**

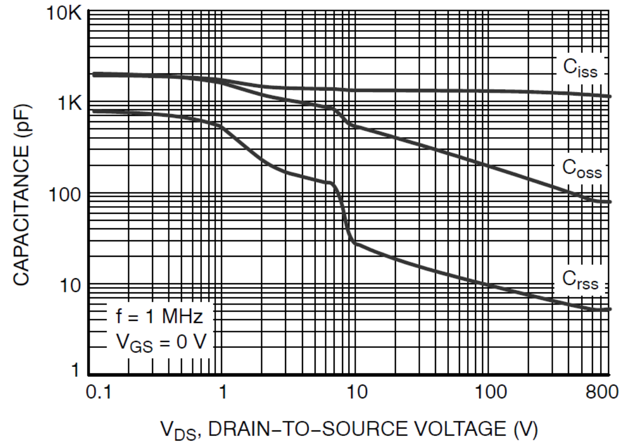



**Figure 8. Capacitance vs. Drain−to−Source Voltage**

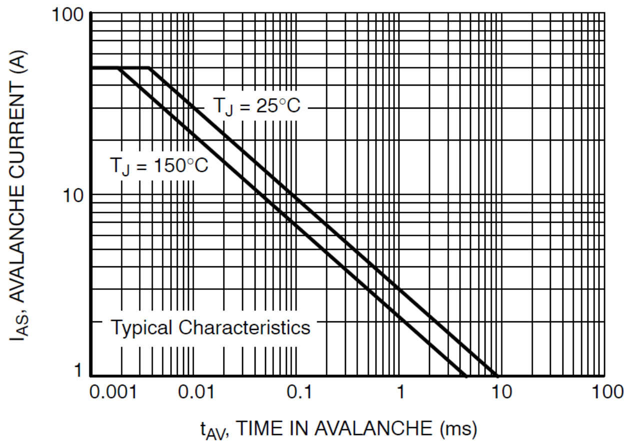



**Figure 9. Unclamped Inductive Switching Capability**

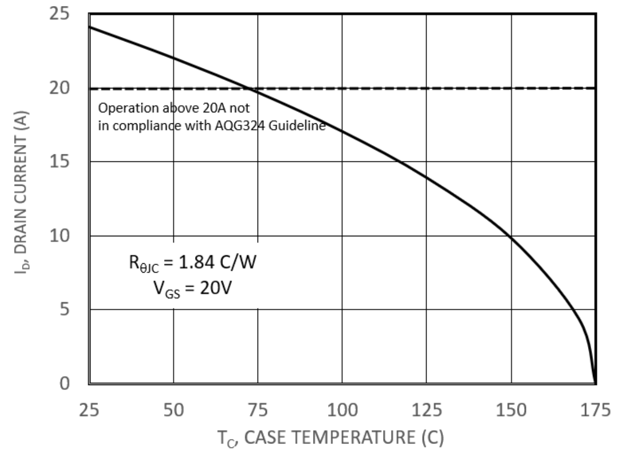



**Figure 10. Maximum Continuous Drain Current vs. Case Temperature**

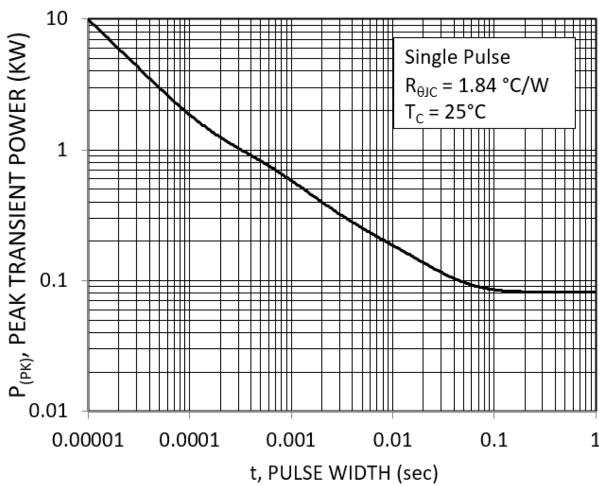
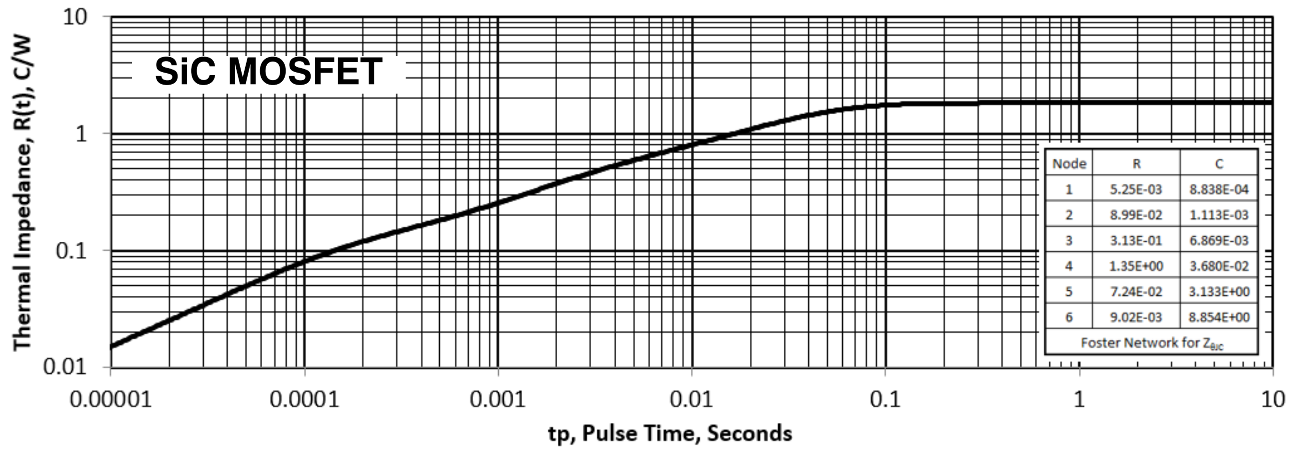



**Figure 11. Single Pulse Maximum Power Dissipation**

## TYPICAL CHARACTERISTICS SIC MOSFET (CONTINUED)




| Node | R | C |
|---|---|---|
| 1 | 5.25E-03 | 8.838E-04 |
| 2 | 8.99E-02 | 1.113E-03 |
| 3 | 3.13E-01 | 6.869E-03 |
| 4 | 1.35E+00 | 3.680E-02 |
| 5 | 7.24E-02 | 3.133E+00 |
| 6 | 9.02E-03 | 8.854E+00 |
| Foster Network for $Z_{\theta JC}$ | | |

**Figure 12. Thermal Response**

## TYPICAL CHARACTERISTICS SIC DIODE

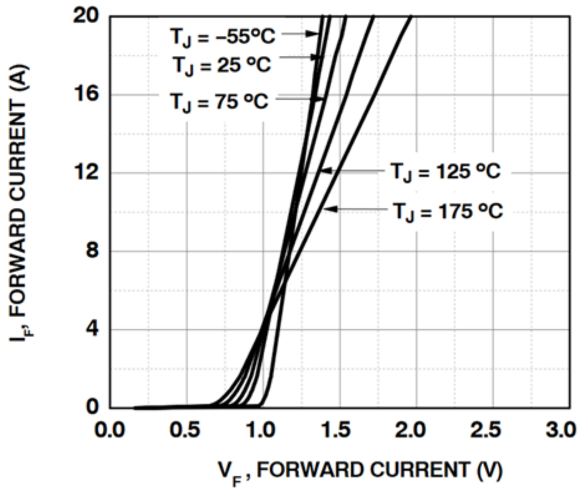



**Figure 13. Forward Characteristics**

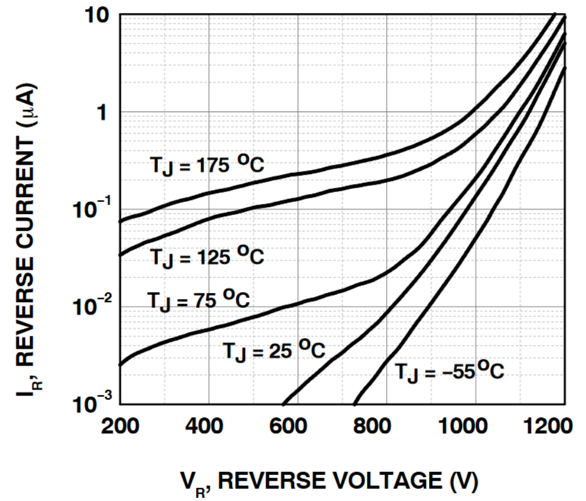



**Figure 14. Reverse Characteristics**

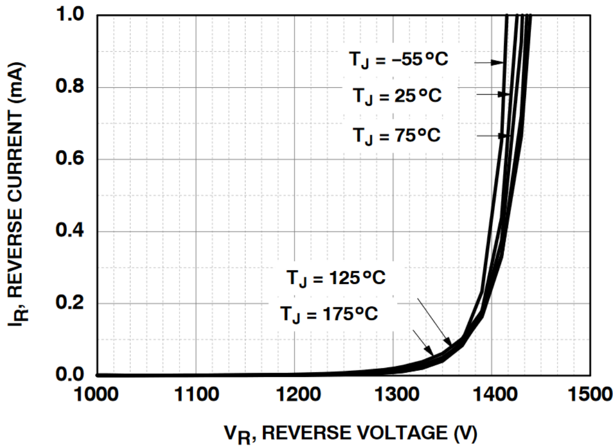



**Figure 15. Reverse Characteristics**

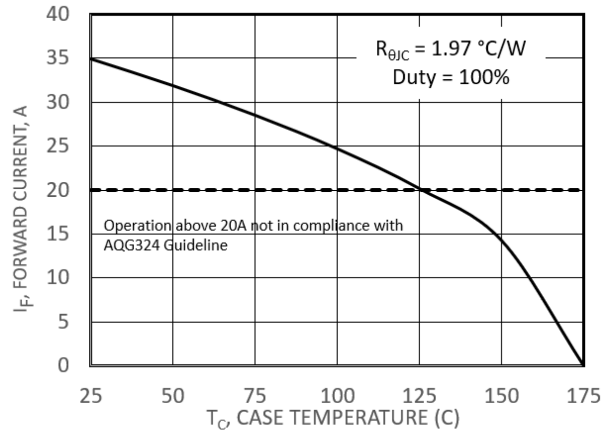



**Figure 16. Current Derating**

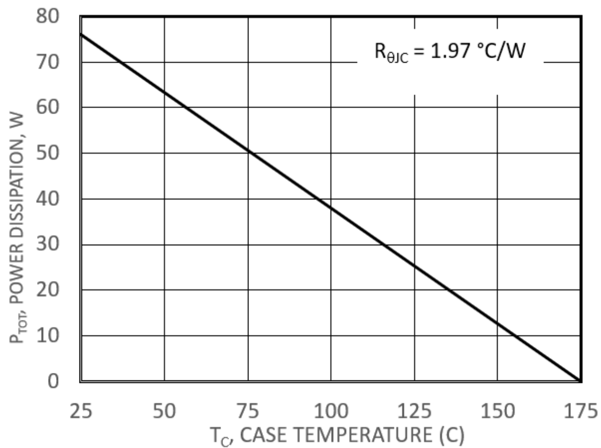



**Figure 17. Power Derating**

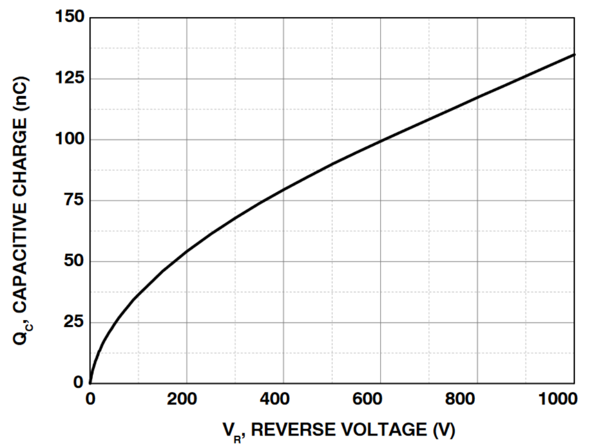



**Figure 18. Capacitive Charge vs. Reverse Voltage**

## TYPICAL CHARACTERISTICS SIC DIODE (CONTINUED)

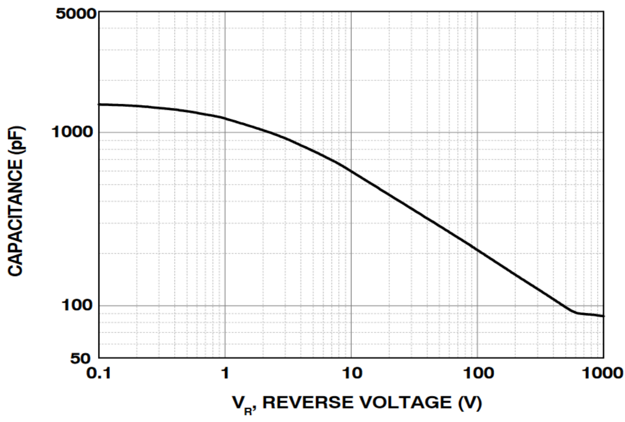



**Figure 19. Capacitance vs. Reverse Voltage**

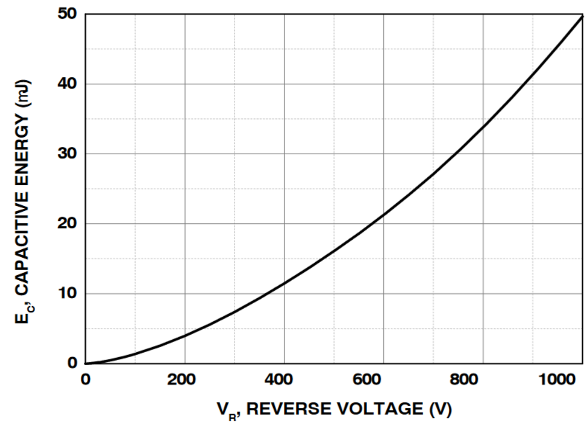
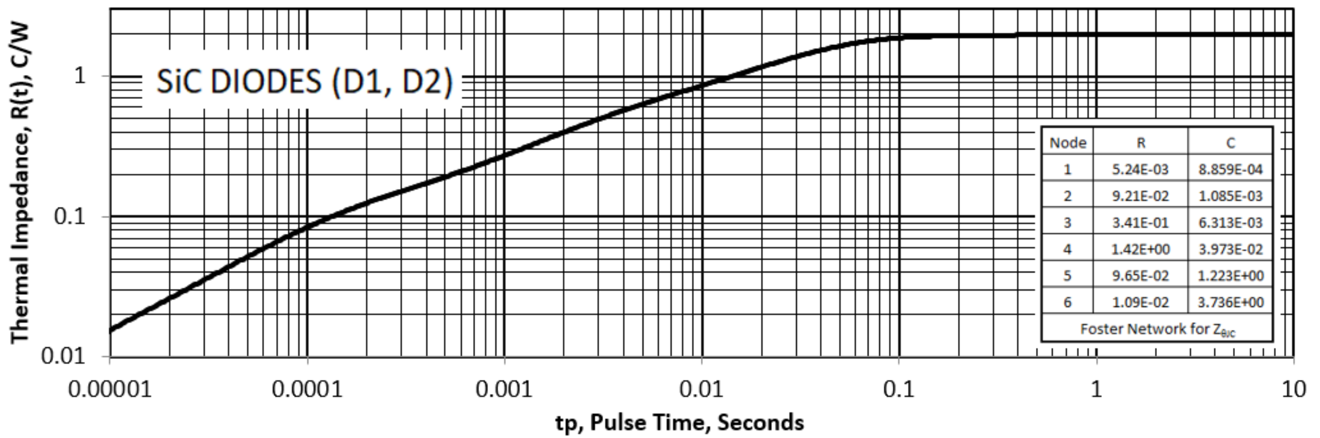
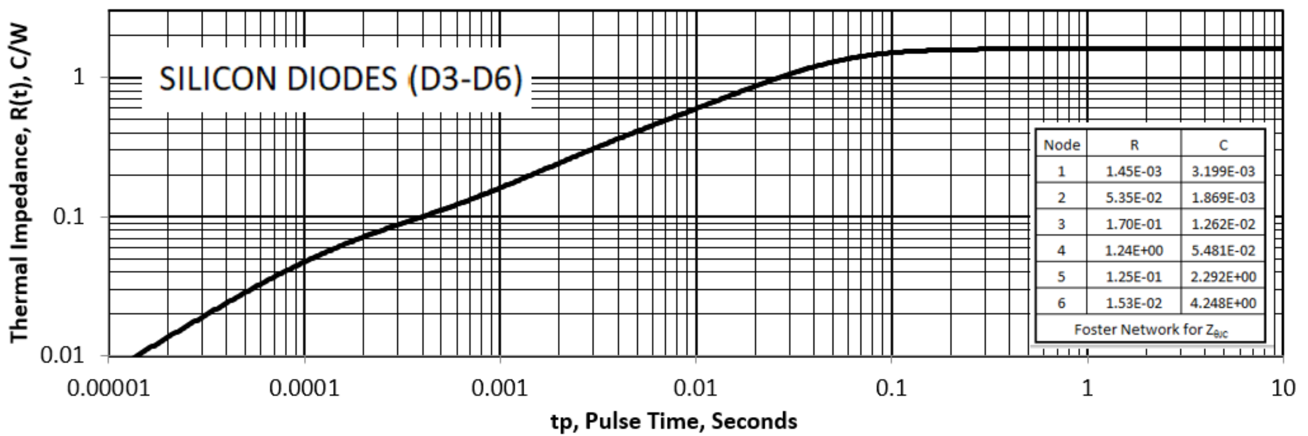



**Figure 20. Capacitance Stored Energy**




| Node | R | C |
|---|---|---|
| 1 | 5.24E-03 | 8.859E-04 |
| 2 | 9.21E-02 | 1.085E-03 |
| 3 | 3.41E-01 | 6.313E-03 |
| 4 | 1.42E+00 | 3.973E-02 |
| 5 | 9.65E-02 | 1.223E+00 |
| 6 | 1.09E-02 | 3.736E+00 |

**Figure 21. Junction−to−Case Transient Thermal Response Curve − SiC Diode**




| Node | R | C |
|---|---|---|
| 1 | 1.45E-03 | 3.199E-03 |
| 2 | 5.35E-02 | 1.869E-03 |
| 3 | 1.70E-01 | 1.262E-02 |
| 4 | 1.24E+00 | 5.481E-02 |
| 5 | 1.25E-01 | 2.292E+00 |
| 6 | 1.53E-02 | 4.248E+00 |

**Figure 22. Junction−to−Case Transient Thermal Response Curve − Silicon Diode**

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