

# Silicon Carbide (SiC) Module – EliteSiC Power Module for OBC, 80 mohm, 1200 V, 20 A, Vienna Rectifier, in APM32 Series NVXK2KR80WDT

## 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

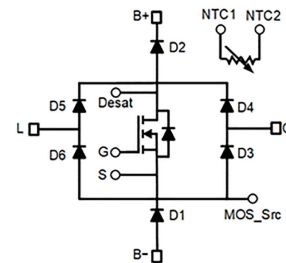
## MAXIMUM RATINGS MOSFET ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

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

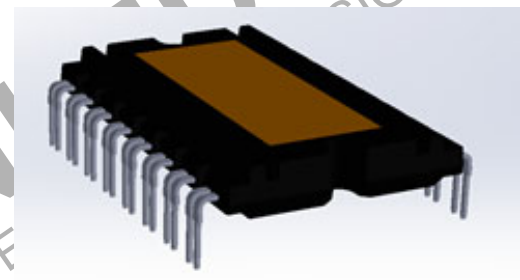
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Particular conditions specified determine thermal resistance values shown. Infinite heatsink with  $T_C = 100^\circ\text{C}$  for  $R_{\theta JC}$ . For  $R_{\psi JS}$  assembled to 3 mm thick aluminum heatsink with infinite cooling bottom surface at  $85^\circ\text{C}$ , through 80  $\mu\text{m}$  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  $T_J = 25^\circ\text{C}$ ,  $L = 1 \text{ mH}$ ,  $I_{AS} = 19 \text{ A}$ ,  $V_{DD} = 120 \text{ V}$ ,  $V_{GS} = 18 \text{ V}$ .

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



SiC MOSFET Vienna Rectifier Module



APM32

## ORDERING INFORMATION

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

# NVXK2KR80WDT

## 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 ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|-----------|--------|-----------------|-----|-----|-----|------|
|-----------|--------|-----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|                                                           |                     |                                                        |      |     |         |               |
|-----------------------------------------------------------|---------------------|--------------------------------------------------------|------|-----|---------|---------------|
| Drain-to-Source Breakdown Voltage                         | $V_{(BR)DSS}$       | $V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$               | 1200 |     |         | V             |
| Drain-to-Source Breakdown Voltage Temperature Coefficient | $V_{(BR)DSS} / T_J$ | $I_D = 1\text{ mA}$ , referenced to $25^\circ\text{C}$ |      | 500 |         | mV/°C         |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{GS} = 0\text{ V}$<br>$V_{DS} = 1200\text{ V}$      |      |     | 100     | $\mu\text{A}$ |
|                                                           |                     | $T_J = 175^\circ\text{C}$                              |      |     | 1       | mA            |
| Gate-to-Source Leakage Current                            | $I_{GSS}$           | $V_{GS} = +25/-15\text{ V}, V_{DS} = 0\text{ V}$       |      |     | $\pm 1$ | $\mu\text{A}$ |

### ON CHARACTERISTICS (Note 5)

|                               |              |                                                                    |     |     |     |            |
|-------------------------------|--------------|--------------------------------------------------------------------|-----|-----|-----|------------|
| Gate Threshold Voltage        | $V_{GS(TH)}$ | $V_{GS} = V_{DS}, I_D = 10\text{ mA}$                              | 1.8 | 3   | 4.3 | V          |
| Recommended Gate Voltage      | $V_{G0P}$    |                                                                    | -5  |     | +20 | V          |
| Drain-to-Source On Resistance | $R_{DS(on)}$ | $V_{GS} = 20\text{ V}, I_D = 20\text{ A}, T_J = 25^\circ\text{C}$  |     | 80  | 116 | m $\Omega$ |
| Drain-to-Source On Resistance | $R_{DS(on)}$ | $V_{GS} = 20\text{ V}, I_D = 20\text{ A}, T_J = 175^\circ\text{C}$ |     | 150 |     | m $\Omega$ |
| Forward Transconductance      | $g_{FS}$     | $V_{DS} = 20\text{ V}, I_D = 20\text{ A}$                          |     | 11  |     | S          |

### CHARGES, CAPACITANCES & GATE RESISTANCE

|                              |              |                                                                     |  |      |  |          |
|------------------------------|--------------|---------------------------------------------------------------------|--|------|--|----------|
| Input Capacitance            | $C_{ISS}$    | $V_{GS} = 0\text{ V}, f = 1\text{ MHz}, V_{DS} = 800\text{ V}$      |  | 1154 |  | pF       |
| Output Capacitance           | $C_{OSS}$    |                                                                     |  | 79   |  |          |
| Reverse Transfer Capacitance | $C_{RSS}$    |                                                                     |  | 7.9  |  |          |
| Total Gate Charge            | $Q_{G(TOT)}$ | $V_{GS} = -5/20\text{ V}, V_{DS} = 600\text{ V}, I_D = 20\text{ A}$ |  | 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              | $R_G$        | $V_{GS} = 0\text{ V}, f = 1\text{ MHz}$                             |  | 1.2  |  | $\Omega$ |

### INDUCTIVE SWITCHING CHARACTERISTICS

|                         |              |                                                                                                                        |  |     |  |               |
|-------------------------|--------------|------------------------------------------------------------------------------------------------------------------------|--|-----|--|---------------|
| Turn-On Delay Time      | $t_{d(ON)}$  | $V_{GS} = -5 / 20\text{ V}, V_{DS} = 800\text{ V},$<br>$I_D = 20\text{ A}, R_G = 4.7\text{ }\Omega,$<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 |  | $\mu\text{J}$ |
| Turn-Off Switching Loss | $E_{OFF}$    |                                                                                                                        |  | 46  |  | $\mu\text{J}$ |
| Total Switching Loss    | $E_{tot}$    |                                                                                                                        |  | 181 |  | $\mu\text{J}$ |

# NVXK2KR80WDT

## ELECTRICAL CHARACTERISTICS SiC MOSFET ( $T_J = 25^\circ\text{C}$ unless otherwise stated) (continued)

| Parameter                                                  | Symbol    | Test Conditions                                                                   | Min | Typ  | Max | Unit          |
|------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------|-----|------|-----|---------------|
| <b>DRAIN-SOURCE DIODE CHARACTERISTICS</b>                  |           |                                                                                   |     |      |     |               |
| Continuous Drain-Source Diode Forward Current (Notes 1, 2) | $I_{SD}$  | $V_{GS} = -5\text{ V}, T_J = 25^\circ\text{C}$                                    |     |      | 18  | A             |
| Pulsed Drain-Source Diode Forward Current (Note 3)         | $I_{SDM}$ | $V_{GS} = -5\text{ V}, T_J = 25^\circ\text{C}$                                    |     |      | 110 | A             |
| Forward Diode Voltage                                      | $V_{SD}$  | $V_{GS} = -5\text{ V}, I_{SD} = 10\text{ A}, T_J = 25^\circ\text{C}$              |     | 3.9  |     | V             |
| Reverse Recovery Time                                      | $t_{RR}$  | $V_{GS} = -5\text{ V}, dI_S/dt = 1000\text{ A}/\mu\text{s}, I_{SD} = 20\text{ A}$ |     | 16.2 |     | ns            |
| Peak Reverse Recovery Current                              | $I_{RRM}$ |                                                                                   |     | 7.6  |     | A             |
| Reverse Recovery Energy                                    | $E_{REC}$ |                                                                                   |     | 4.1  |     | $\mu\text{J}$ |
| 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  $\leq 300\text{ }\mu\text{s}$ , duty ratio  $\leq 2\%$ .

## MAXIMUM RATINGS SiC DIODE (D1-D2) ( $T_J = 25^\circ\text{C}$ 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 @ $T_C < 150^\circ\text{C}$ | $I_F$                     | 17                                               | A                |
| Continuous Rectified Forward Current @ $T_C < 75^\circ\text{C}$  |                           | 33                                               |                  |
| Non-Repetitive Peak Forward Surge Current                        | $I_{F, Max}$              | $T_C = 25^\circ\text{C}, 10\text{ }\mu\text{s}$  | A                |
|                                                                  |                           | $T_C = 150^\circ\text{C}, 10\text{ }\mu\text{s}$ |                  |
| Non-Repetitive Forward Surge Current (pk)                        | $I_{F, SM}$               | 78                                               | A                |
| Repetitive Forward Surge Current (pk)                            | $I_{F, RM}$               | 70                                               | A                |
| Power Dissipation                                                | $T_C = 25^\circ\text{C}$  | $P_{TOT}$                                        | W                |
|                                                                  | $T_C = 150^\circ\text{C}$ | $P_{TOT}$                                        |                  |
| Operating and Storage Temperature Range                          | $T_J, T_{STG}$            | -55 to +175                                      | $^\circ\text{C}$ |

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  $T_J = 25^\circ\text{C}$ ,  $L = 0.5\text{ mH}$ ,  $I_{AS} = 29\text{ A}$ ,  $V = 50\text{ V}$ .

## ELECTRICAL CHARACTERISTICS SiC DIODE (D1-D2) ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

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

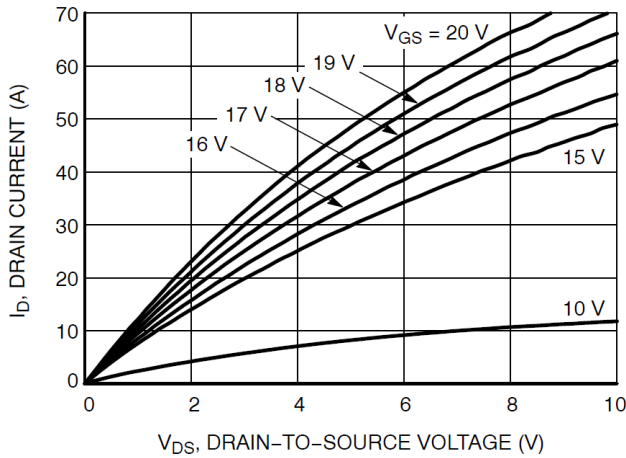


Figure 1. On-Region Characteristics

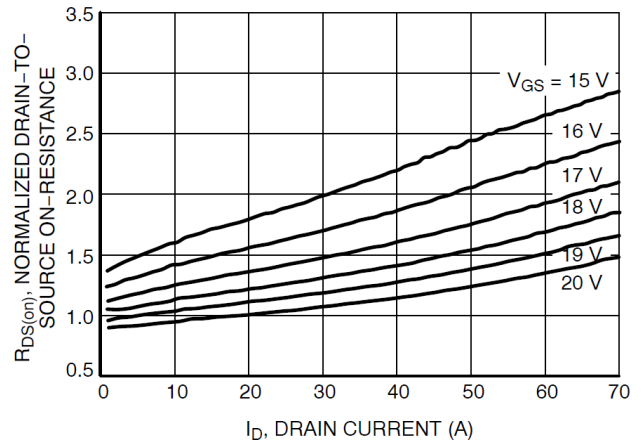


Figure 2. Normalized On-Resistance vs. Drain Current and Gate Voltage

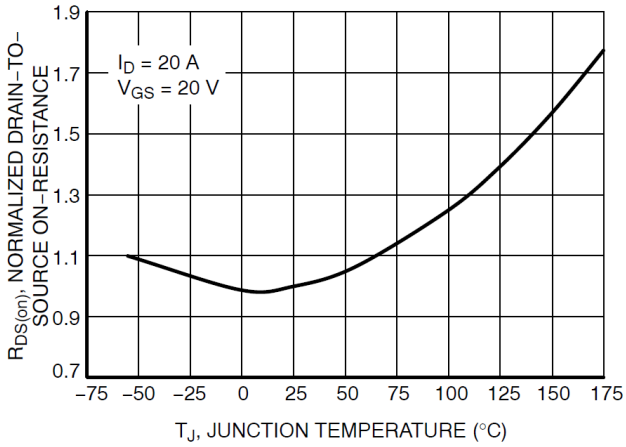


Figure 3. On-Resistance Variation with Temperature

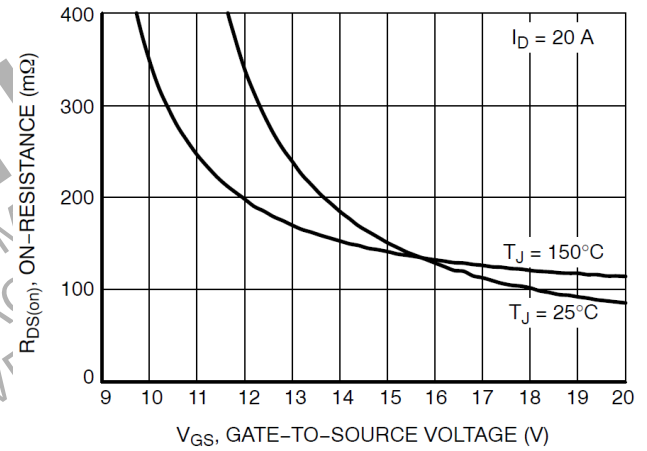


Figure 4. On-Resistance vs. Gate-to-Source Voltage

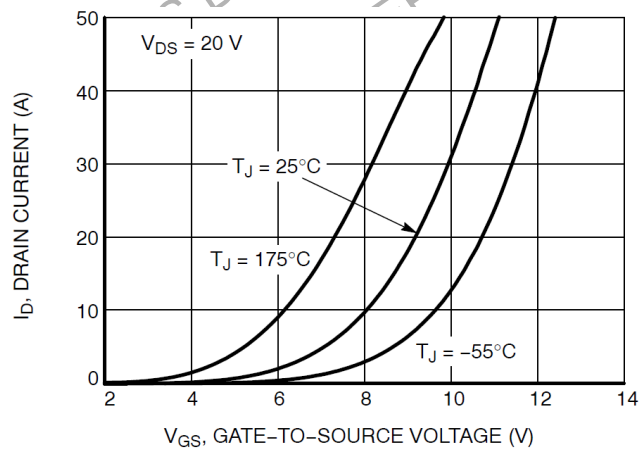


Figure 5. Transfer Characteristics

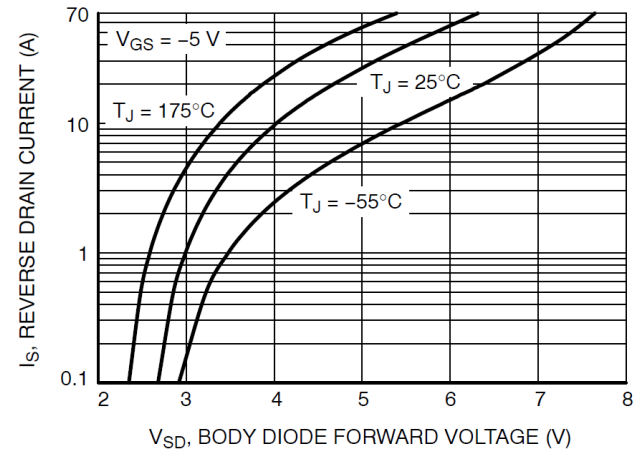


Figure 6. Diode Forward Voltage vs. Current

TYPICAL CHARACTERISTICS SIC MOSFET (CONTINUED)

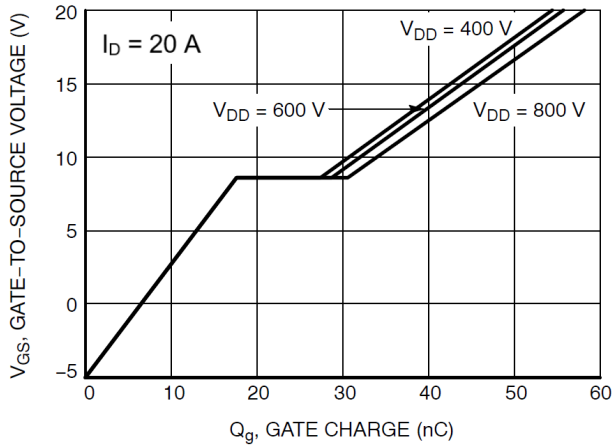


Figure 7. Gate-to-Source Voltage vs. Total Charge

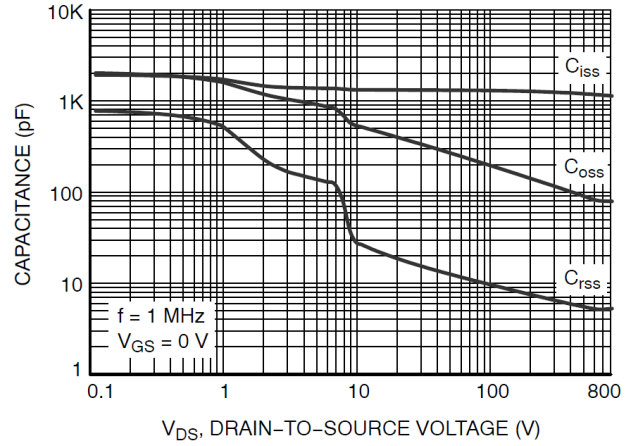


Figure 8. Capacitance vs. Drain-to-Source Voltage

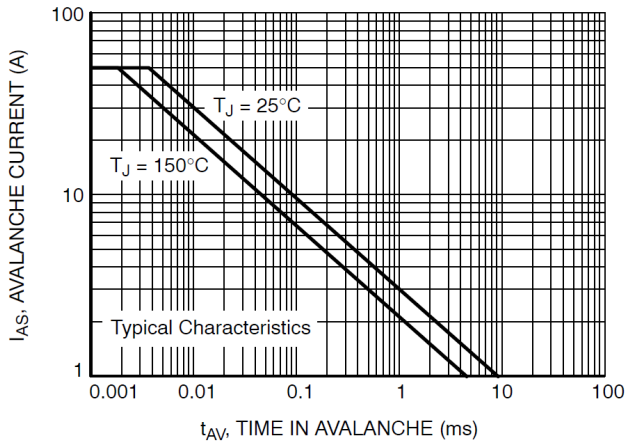


Figure 9. Unclamped Inductive Switching Capability

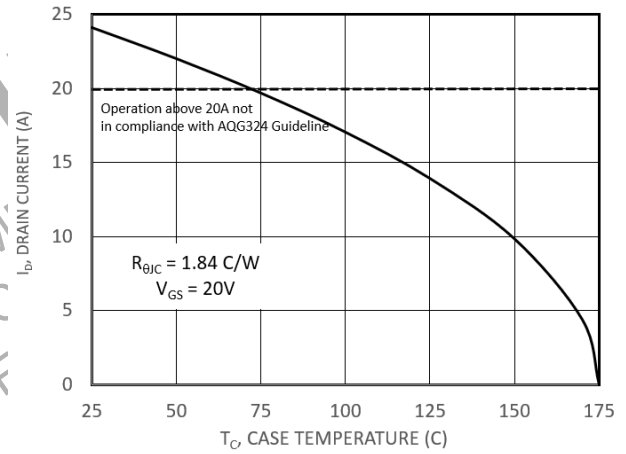


Figure 10. Maximum Continuous Drain Current vs. Case Temperature

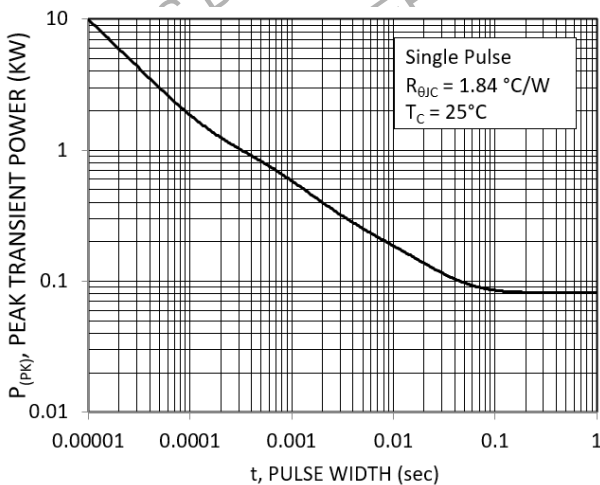


Figure 11. Single Pulse Maximum Power Dissipation

# NVXK2KR80WDT

## TYPICAL CHARACTERISTICS SIC MOSFET (CONTINUED)

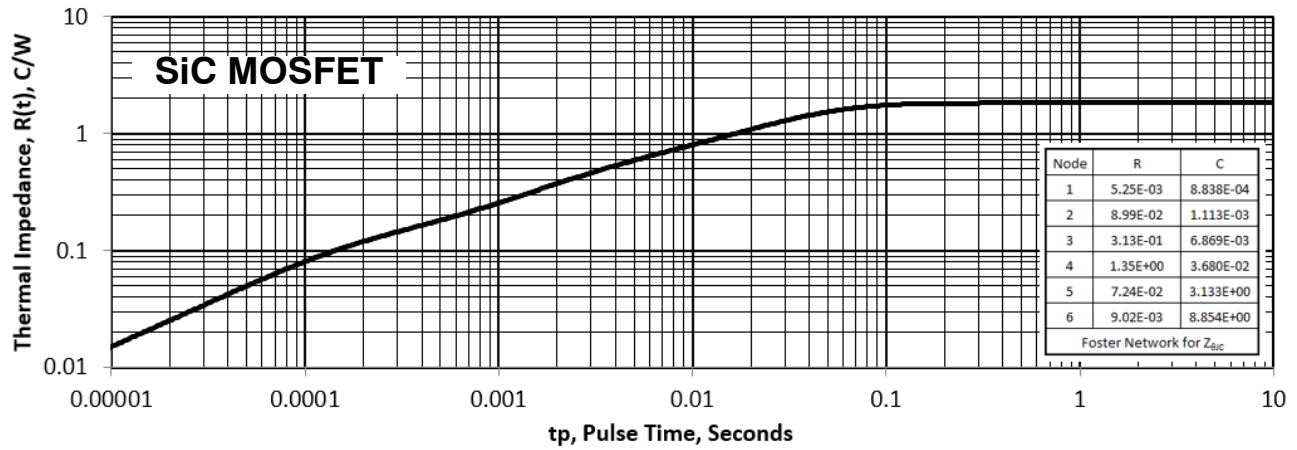


Figure 12. Thermal Response

**DISCONTINUED**  
 THIS DEVICE IS NOT RECOMMENDED FOR NEW DESIGN  
 PLEASE CONTACT YOUR onsemi  
 REPRESENTATIVE FOR INFORMATION

# NVXK2KR80WDT

## TYPICAL CHARACTERISTICS SIC DIODE

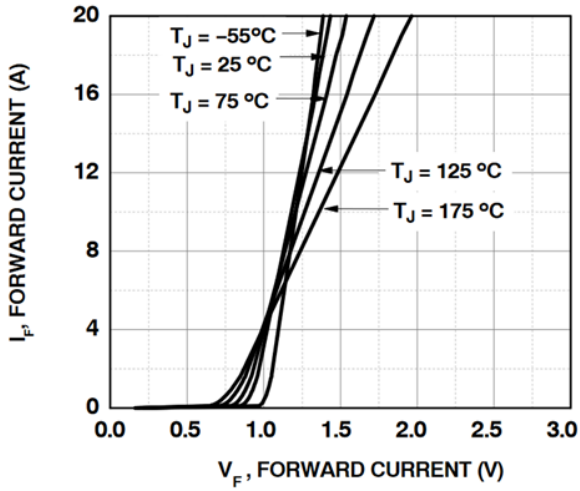


Figure 13. Forward Characteristics

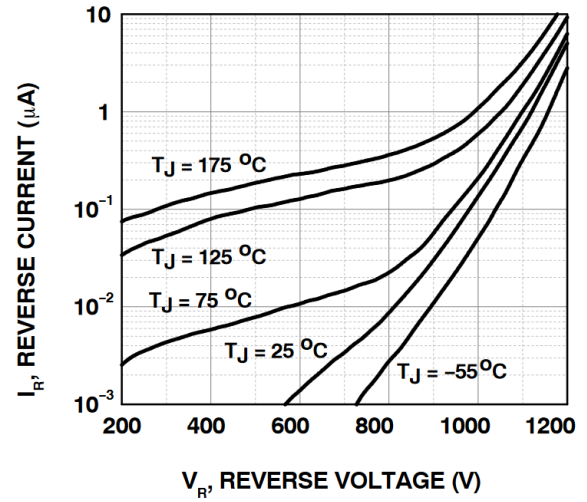


Figure 14. Reverse Characteristics

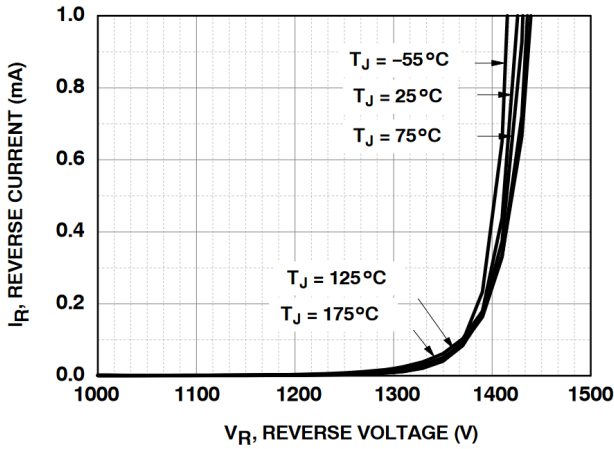


Figure 15. Reverse Characteristics

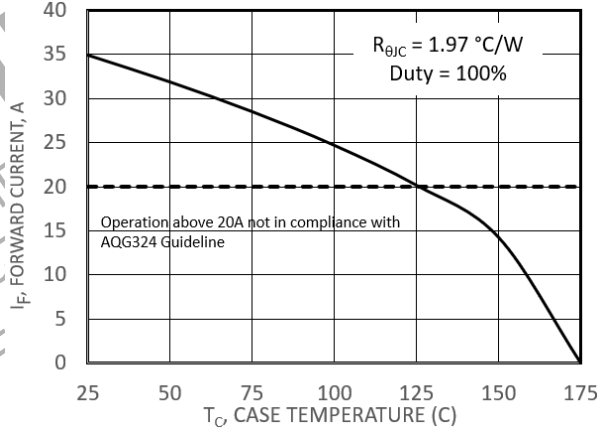


Figure 16. Current Derating

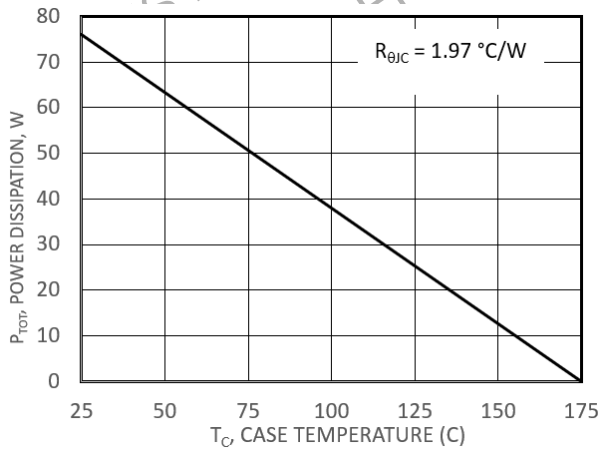


Figure 17. Power Derating

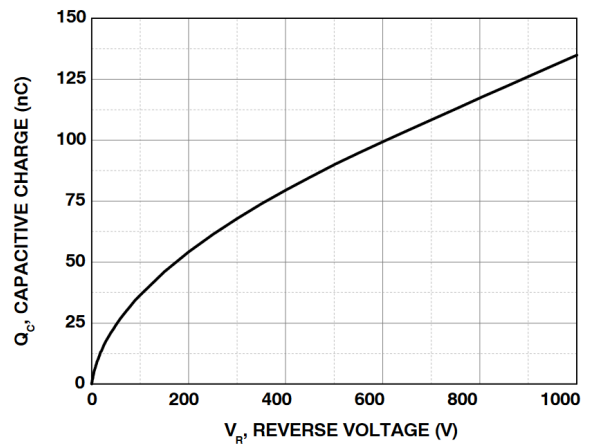


Figure 18. Capacitive Charge vs. Reverse Voltage

TYPICAL CHARACTERISTICS SIC DIODE (CONTINUED)

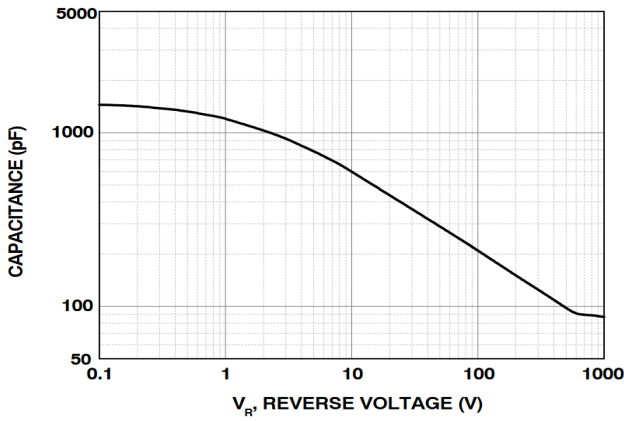


Figure 19. Capacitance vs. Reverse Voltage

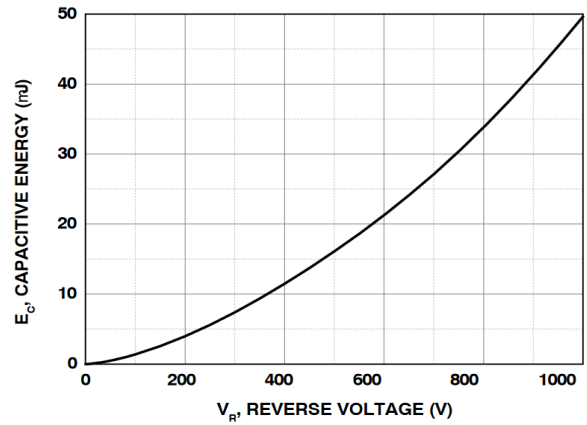


Figure 20. Capacitance Stored Energy

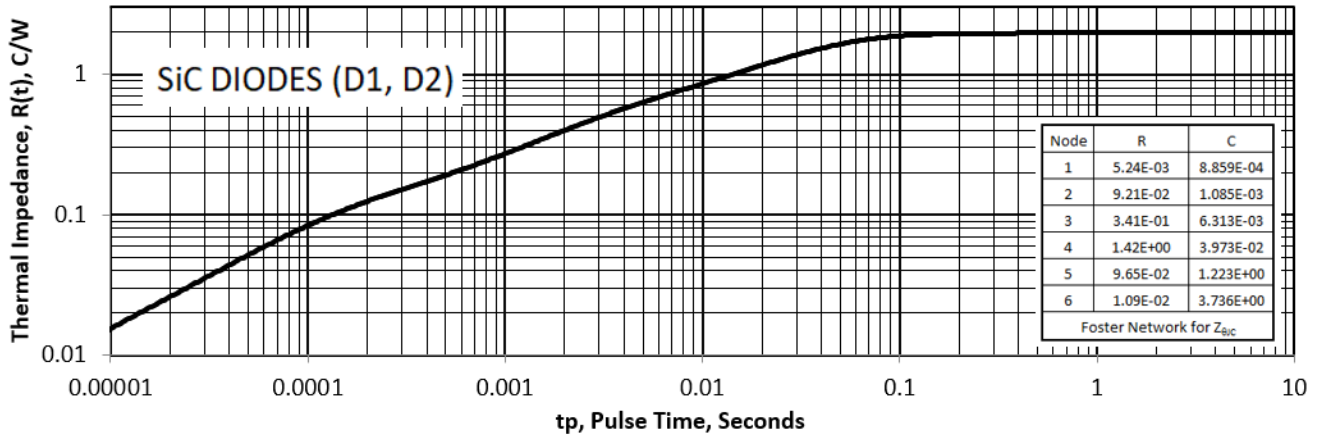


Figure 21. Junction-to-Case Transient Thermal Response Curve – SiC Diode

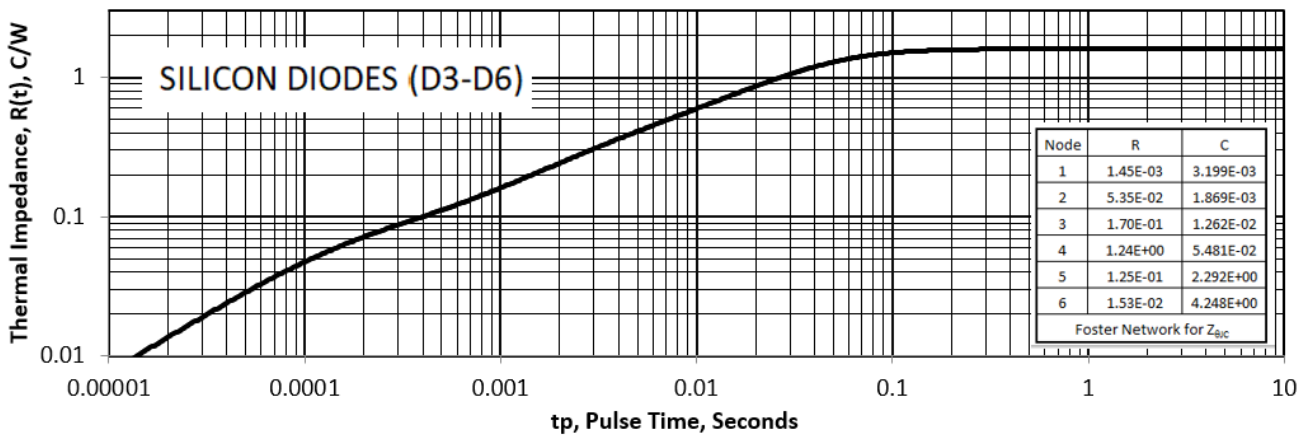
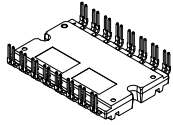
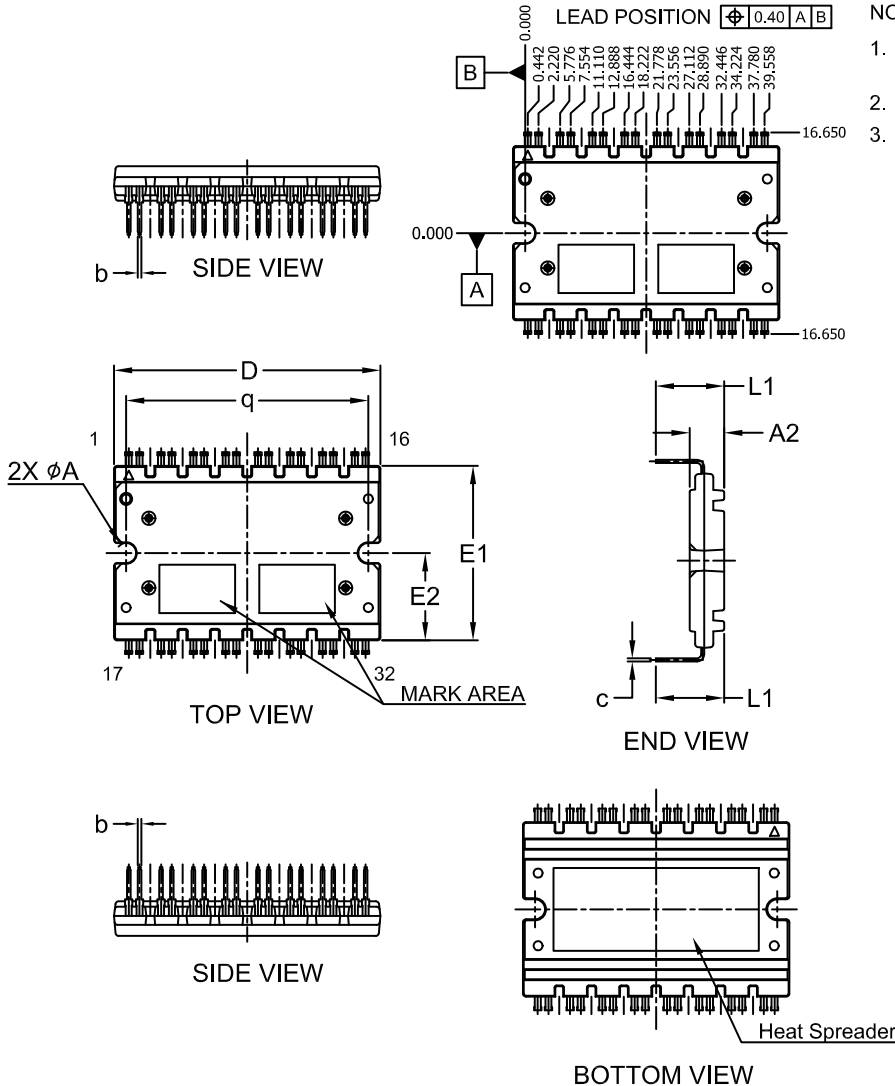


Figure 22. Junction-to-Case Transient Thermal Response Curve – Silicon Diode



**APM32 AUTOMOTIVE MODULE  
CASE MODHL  
ISSUE B**

DATE 05 APR 2022



**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.

| DIM      | MILLIMETERS |       |       |
|----------|-------------|-------|-------|
|          | MIN.        | NOM.  | MAX.  |
| A2       | 5.60        | 5.70  | 5.80  |
| b        | 0.50        | 0.60  | 0.70  |
| c        | 0.45        | 0.50  | 0.60  |
| D        | 43.80       | 44.00 | 44.20 |
| E1       | 28.60       | 28.80 | 29.00 |
| E2       | 14.25       | 14.40 | 14.55 |
| L1       | 11.00       | 11.30 | 11.60 |
| q        | 39.85       | 40.00 | 40.15 |
| $\phi A$ | 3.20        | 3.30  | 3.40  |

**GENERIC  
MARKING DIAGRAM\***

XXXXXXXXXXXXXXXXXX  
ZZZ ATYWW  
NNNNNNN

XXXX = Specific Device Code  
ZZZ = Lot ID  
AT = Assembly & Test Location  
Y = Year  
W = Work Week  
NNN = Serial Number

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

|                         |                                |                                                                                                                                                                                  |
|-------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>APM32 AUTOMOTIVE MODULE</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

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