

MSCSM70VM19C3AG
Datasheet
Vienna Rectifier Phase Leg SiC Power
Module

April 2020



a  **MICROCHIP** company

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1 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.

1.1 Revision 1.0

Revision 1.0 is the first publication of this document, published in April 2020.

2 Product Overview

The MSCSM70VM19C3AG is Vienna Rectifier phase leg 700 V/124 A full Silicon Carbide power module.

Figure 1 • MSCSM70VM19C3AG Electrical Schematic

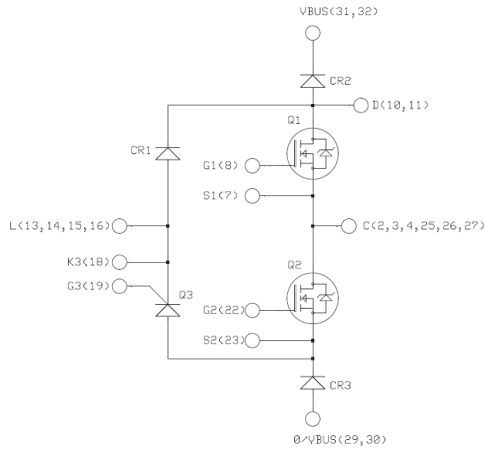
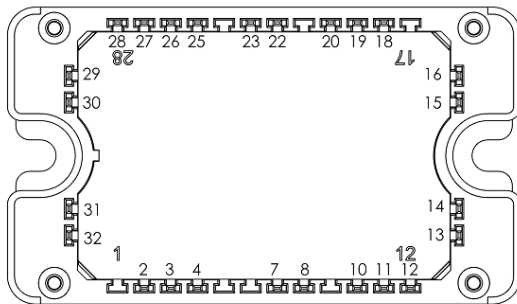


Figure 2 • MSCSM70VM19C3AG Pinout Location



All multiple inputs and outputs must be shorted together

All ratings at $T_j = 25\text{ }^\circ\text{C}$ unless otherwise specified.

Caution: These devices are sensitive to electrostatic discharge. Proper handling procedures should be followed.

2.1 Features

The following are key features of the MSCSM70VM19C3AG device:

- SiC Power MOSFET
 - Low RDS(on)
 - High temperature performance
- Silicon carbide (SiC) Schottky diode (CR2 and CR3)
 - Zero reverse recovery
 - Zero forward recovery
 - Temperature-independent switching behavior
 - Positive temperature coefficient on VF
- Kelvin emitter for easy drive
- Very low stray inductance
- High level of integration
- Aluminum nitride (AlN) substrate for improved thermal performance

2.2 Benefits

The following are benefits of the MSCSM70VM19C3AG device:

- Outstanding performance at high frequency operation
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- Solderable terminals both for power and signal for easy PCB mounting
- Low profile
- RoHS compliant

2.3 Applications

The MSCSM70VM19C3AG device is designed for the following applications:

- Plasma and induction heating
- Uninterruptible power supplies

3 Electrical Specifications

This section shows the electrical specifications of the MSCSM70VM19C3AG device.

3.1 SiC MOSFET Characteristics (per SiC MOSFET)

This section describes the electrical characteristics of the MSCSM70VM19C3AG (Q1 and Q2) device.

Table 1 • Absolute Maximum Ratings

| Symbol | Parameter | Maximum Ratings | Unit |
|------------|----------------------------|---|------------|
| V_{DSS} | Drain-source voltage | 700 | V |
| I_D | Continuous drain current | $T_C = 25\text{ }^\circ\text{C}$ 124 ¹ | A |
| | | $T_C = 80\text{ }^\circ\text{C}$ 98 ¹ | |
| I_{DM} | Pulsed drain current | 250 | |
| V_{GS} | Gate-source voltage | -10/25 | V |
| R_{Dson} | Drain-source ON resistance | 19 | m Ω |
| P_D | Power dissipation | $T_C = 25\text{ }^\circ\text{C}$ 365 | W |

Note:

1. Specification of SiC MOSFET device but output current must be limited due to size of power connectors.

Table 2 • Electrical Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|--------------|---------------------------------|---|-----------------------------------|-----|------|---------------|
| I_{DSS} | Zero gate voltage drain current | $V_{GS} = 0\text{ V}; V_{DS} = 700\text{ V}$ | | | 100 | μA |
| R_{Dson} | Drain-source on resistance | $V_{GS} = 20\text{ V}$ $I_D = 40\text{ A}$ | $T_J = 25\text{ }^\circ\text{C}$ | 15 | 19 | m Ω |
| | | | $T_J = 175\text{ }^\circ\text{C}$ | | 18.8 | |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{GS} = V_{DS}, I_D = 4\text{ mA}$ | 1.9 | 2.4 | | V |
| I_{GSS} | Gate-source leakage current | $V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$ | | | 150 | nA |

Table 3 • Dynamic Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|--------------|-------------------------------------|---|-----------------------------------|------|------|--------------------|
| C_{iss} | Input capacitance | $V_{GS} = 0\text{ V}$ | | 4500 | | pF |
| C_{oss} | Output capacitance | $V_{DS} = 700\text{ V}$ $f = 1\text{ MHz}$ | | 510 | | |
| C_{riss} | Reverse transfer capacitance | | | 29 | | |
| Q_g | Total gate charge | $V_{GS} = -5/20\text{ V}$ | | 215 | | nC |
| Q_{gs} | Gate-source charge | $V_{Bus} = 470\text{ V}$ $I_D = 40\text{ A}$ | | 58 | | |
| Q_{gd} | Gate-drain charge | | | 35 | | |
| $T_{d(on)}$ | Turn-on delay time | $V_{GS} = -5/20\text{ V}$ | | 40 | | ns |
| T_r | Rise time | $V_{Bus} = 400\text{ V}$ $I_D = 80\text{ A}$ | | 35 | | |
| $T_{d(off)}$ | Turn-off delay time | $T_J = 150\text{ }^\circ\text{C}$ $R_{Gon} = 27\text{ }\Omega$; $R_{Goff} = 4.7\text{ }\Omega$ | | 50 | | |
| T_f | Fall time | | | 20 | | |
| E_{on} | Turn on energy | $V_{GS} = -5/20\text{ V}$ | $T_J = 150\text{ }^\circ\text{C}$ | 545 | | μJ |
| E_{off} | Turn off energy | $V_{Bus} = 400\text{ V}$ $I_D = 80\text{ A}$ $R_{Gon} = 27\text{ }\Omega$ $R_{Goff} = 4.7\text{ }\Omega$ | $T_J = 150\text{ }^\circ\text{C}$ | 186 | | μJ |
| R_{Gint} | Internal gate resistance | | | 0.69 | | Ω |
| R_{thJC} | Junction-to-case thermal resistance | | | | 0.41 | $^\circ\text{C/W}$ |

Table 4 • Body Diode Ratings and Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|----------|--------------------------|--|-----|------|-----|------|
| V_{SD} | Diode forward voltage | $V_{GS} = 0\text{ V}$; $I_{SD} = 40\text{ A}$ | | 3.4 | | V |
| | | $V_{GS} = -5\text{ V}$; $I_{SD} = 40\text{ A}$ | | 3.8 | | |
| t_{rr} | Reverse recovery time | $I_{SD} = 40\text{ A}$; $V_{GS} = -5\text{ V}$ | | 38 | | ns |
| Q_{rr} | Reverse recovery charge | $V_R = 400\text{ V}$; $di_F/dt = 1000\text{ A}/\mu\text{s}$ | | 318 | | nC |
| I_{rr} | Reverse recovery current | | | 14.8 | | A |

3.2 SiC Schottky Diode Ratings Characteristics

This section shows the SiC Schottky diode (CR2 and CR3) ratings and characteristics of the device.

Table 5 • Absolute Maximum Ratings

| Symbol | Parameter | Max Ratings | Unit | |
|-----------|---------------------------------|----------------------------------|------|---|
| V_{RRM} | Peak repetitive reverse voltage | 700 | V | |
| I_F | DC forward current | $T_C = 80\text{ }^\circ\text{C}$ | 50 | A |
| P_D | Power dissipation | $T_C = 25\text{ }^\circ\text{C}$ | 174 | W |

Table 6 • SiC Schottky Diode Ratings and Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|------------|-------------------------------------|--|-----------------------------------|-----|------|--------------------|
| V_{RRM} | Peak repetitive reverse voltage | | | | 700 | V |
| I_{RRM} | Reverse leakage current | $V_R = 700\text{ V}$ | $T_J = 25\text{ }^\circ\text{C}$ | 15 | 200 | μA |
| | | | $T_J = 175\text{ }^\circ\text{C}$ | 250 | | |
| V_F | Diode forward voltage | $I_F = 50\text{ A}$ | $T_J = 25\text{ }^\circ\text{C}$ | 1.5 | 1.8 | V |
| | | | $T_J = 175\text{ }^\circ\text{C}$ | 1.9 | | |
| Q_C | Total capacitive charge | $V_R = 400\text{ V}$ | | 133 | | nC |
| C | Total capacitance | $f = 1\text{ MHz}, V_R = 200\text{ V}$ | | 248 | | pF |
| | | $f = 1\text{ MHz}, V_R = 400\text{ V}$ | | 216 | | |
| R_{thJC} | Junction-to-case thermal resistance | | | | 0.86 | $^\circ\text{C/W}$ |

3.3 Diode Characteristics

This section shows the electrical characteristics and ratings of the CR1 diode.

Table 7 • Absolute Maximum Ratings

| Symbol | Parameter | | Max Ratings | Unit | |
|-----------|--------------------------------------|--|----------------------------------|------|---|
| V_{RRM} | Peak repetitive reverse voltage | | 1600 | V | |
| I_F | DC forward current | $T_C = 80\text{ }^\circ\text{C}$ | 200 | A | |
| I_{FSM} | Non-repetitive forward surge current | $t = 10\text{ ms}$ $T_J = 25\text{ }^\circ\text{C}$ | 1600 | | |
| P_D | Power dissipation | | $T_C = 25\text{ }^\circ\text{C}$ | 400 | W |

Table 8 • Electrical Characteristics

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|------------|-------------------------------------|-----------------------|-----------------------------------|-----|-----|------|---------------------------|
| I_R | Reverse current | $V_R = 1600\text{ V}$ | | | | 50 | μA |
| V_F | Forward voltage | $I_F = 77\text{ A}$ | $T_J = 25\text{ }^\circ\text{C}$ | | 1 | 1.21 | V |
| | | | $T_J = 125\text{ }^\circ\text{C}$ | | 0.9 | 1.1 | |
| V_T | On-state voltage | | | | | 0.83 | V |
| r_T | On-state slope resistance | | | | | 2.2 | $\text{m}\Omega$ |
| R_{thJC} | Junction-to-case thermal resistance | | | | | 0.31 | $^\circ\text{C}/\text{W}$ |

3.4 Thyristor Characteristics

This section shows the electrical characteristics and ratings of the thyristor (Q3).

Table 9 • Absolute Maximum Ratings

| Symbol | Parameter | | Max Ratings | Unit | |
|------------|---------------------------------|--|----------------------------------|------|---|
| V_{DRM} | Repetitive peak reverse voltage | | 1600 | V | |
| I_{DRM} | Repetitive peak reverse current | | 3 | mA | |
| I_{TRMS} | RMS on-state current | $T_C = 90\text{ }^\circ\text{C}$ | 60 | A | |
| I_{TSM} | Surge on-state current | $t = 10\text{ ms}$ $T_J = 45\text{ }^\circ\text{C}$ | 520 | | |
| V_{RGM} | Peak reverse gate voltage | | 10 | V | |
| P_D | Power dissipation | | $T_C = 25\text{ }^\circ\text{C}$ | 357 | W |

Table 10 • Electrical Characteristics

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|------------|-------------------------------------|---------------------|-----------------------|-----|------|------|------|
| V_T | On-state Voltage | $I_T = 60\text{ A}$ | $T_J = 25\text{ °C}$ | | 1.41 | | V |
| V_{TO} | Direct on state threshold voltage | | $T_J = 125\text{ °C}$ | | 0.85 | | |
| r_T | On-state Slope resistance | | $T_J = 125\text{ °C}$ | | 10 | | mΩ |
| V_{GT} | Gate trigger voltage | | $T_J = 25\text{ °C}$ | | 1.5 | | V |
| I_{GT} | Gate trigger current | | | | 50 | | mA |
| R_{thJC} | Junction-to-case thermal resistance | | | | | 0.35 | °C/W |

3.5 Thermal and Package Characteristics

This section shows the thermal and package characteristics of the device.

Table 11 • Package Characteristics

| Symbol | Characteristic | | Min | Max | Unit |
|------------|---|------------------|------|-----------------|------|
| V_{ISOL} | RMS Isolation Voltage, any terminal to case $t = 1\text{ min}$, 50/60 Hz | | 4000 | | V |
| T_J | Operating junction temperature range | Q3, CR1 | -40 | 150 | °C |
| | | Q1, Q2, CR2, CR3 | -40 | 175 | |
| T_{JOP} | Recommended junction temperature under switching conditions | | -40 | $T_{Jmax} - 25$ | |
| T_{STG} | Storage temperature range | | -40 | 125 | |
| T_C | Operating case temperature | | -40 | 125 | |
| Torque | Mounting torque | To Heatsink M4 | 2 | 3 | N.m |
| Weight | Package weight | | | 110 | g |

3.6 Typical SiC MOSFET Performance Curve

This section shows the typical performance curves of the MSCSM70VM19C3AG SiC MOSFET.

Figure 3 • Maximum Thermal Impedance

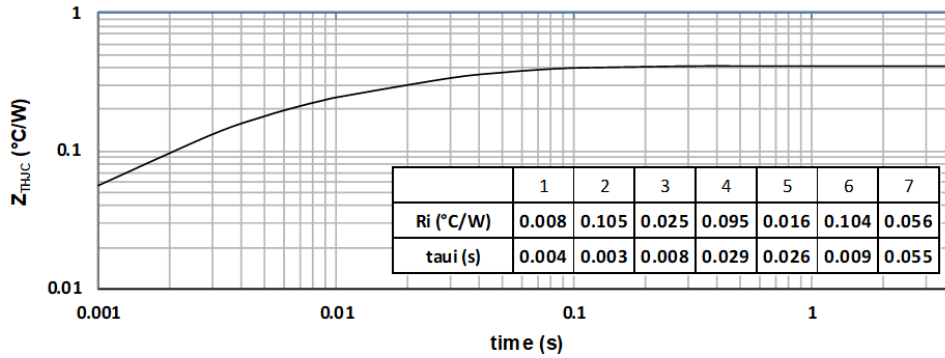


Figure 4 • Output Characteristics at T_J = 25 °C

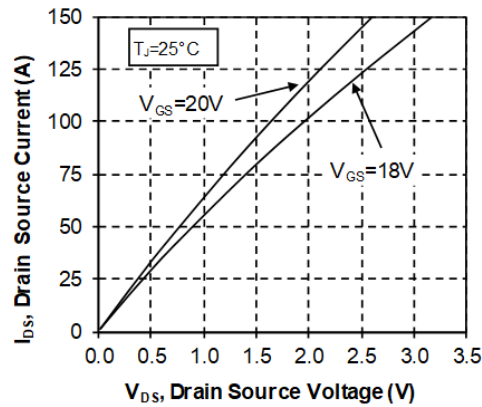


Figure 5 • Output Characteristics at T_J = 175 °C

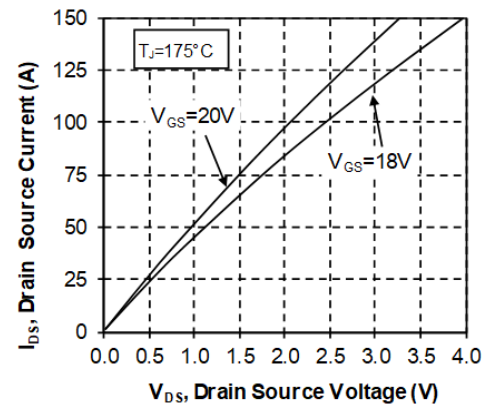


Figure 6 • Normalized RDS(on) vs. Temperature

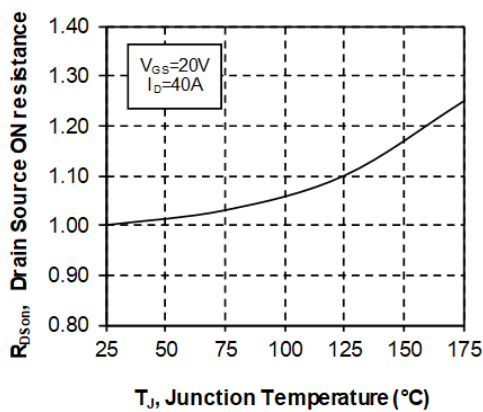


Figure 7 • Transfer Characteristics

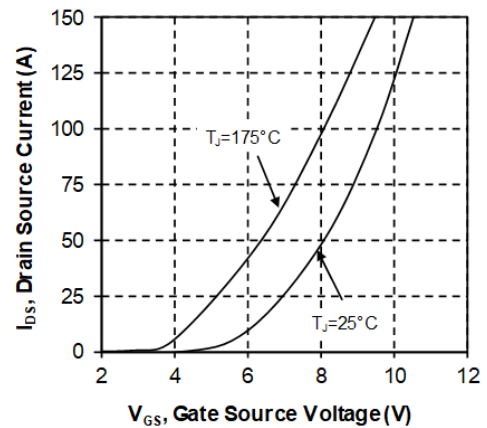


Figure 8 • Capacitance vs. Drain Source Voltage

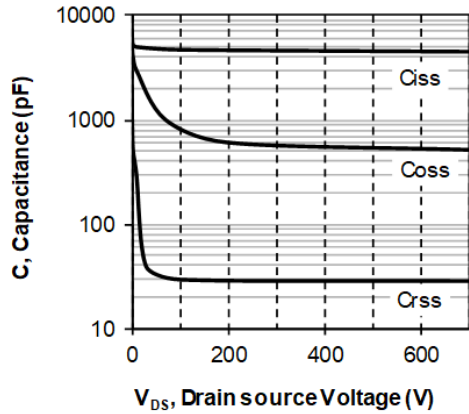


Figure 9 • Gate Charge vs. Gate Source Voltage

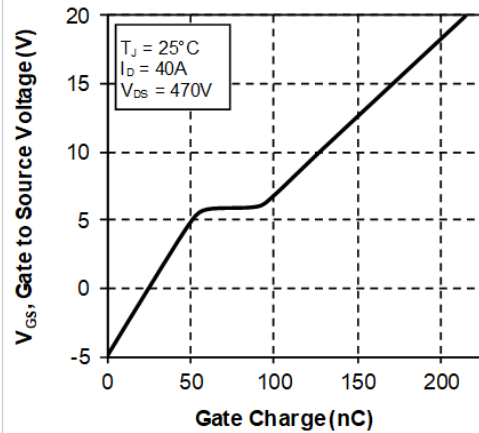


Figure 10 • Body Diode Char, T_J = 25 °C

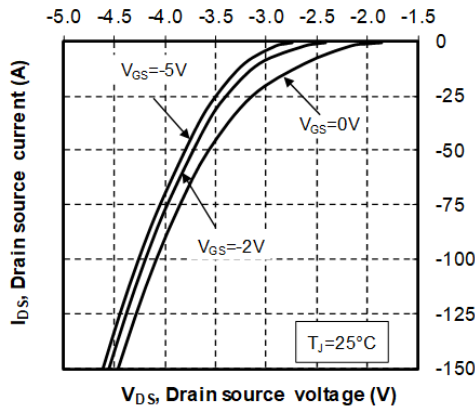


Figure 11 • 3rd Quadrant Char, T_J = 25 °C

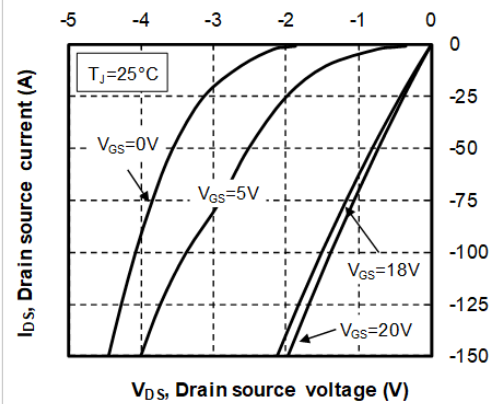


Figure 12 • Body Diode Char, T_J = 175 °C

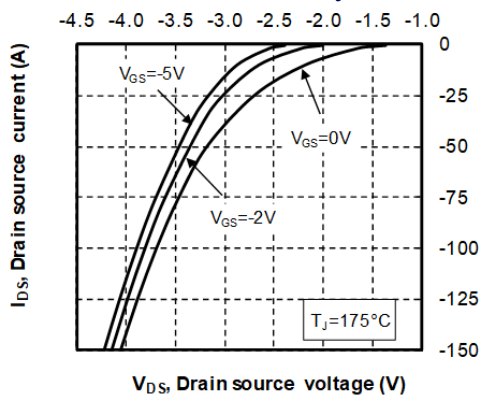


Figure 13 • 3rd Quadrant Char, T_J = 175 °C

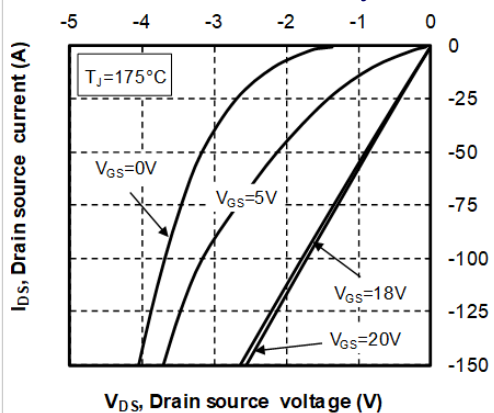


Figure 14 • Switching Energy vs. Current

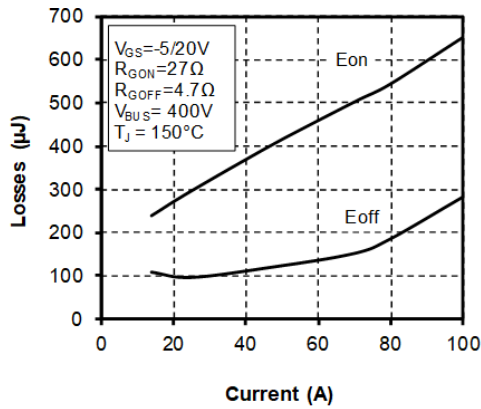


Figure 15 • Turn-on Energy vs. Rg

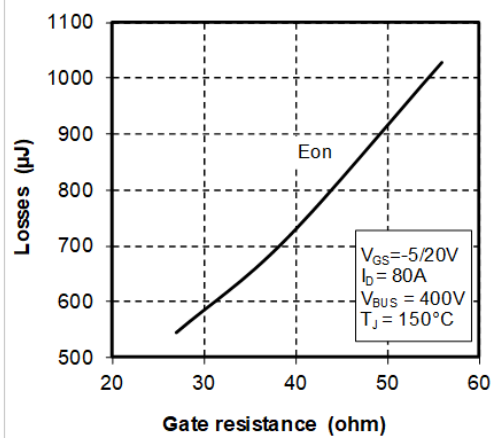


Figure 16 • Operating Frequency vs. Drain Current

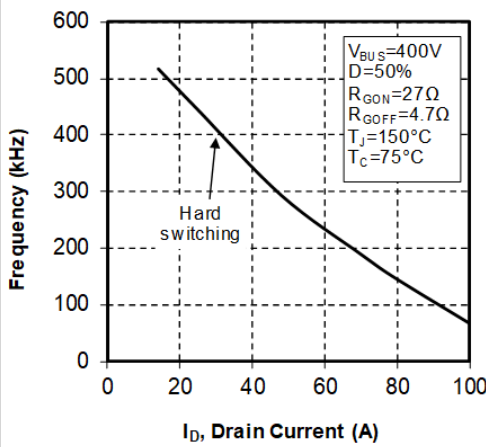
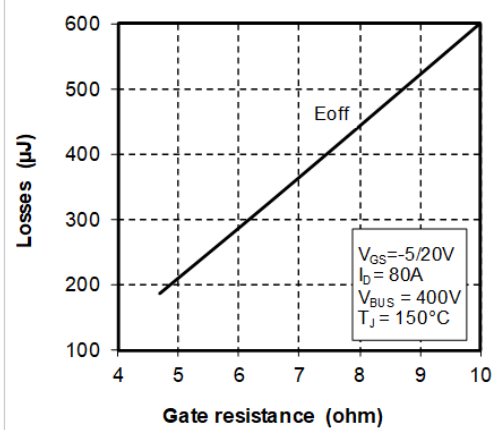


Figure 17 • Turn-off Energy vs. Rg



3.7 Typical SiC Diode Performance

This section shows the typical performance curves of the MSCSM70VM19C3AG SiC diodes (CR2 and CR3).

Figure 18 • Maximum Thermal Impedance

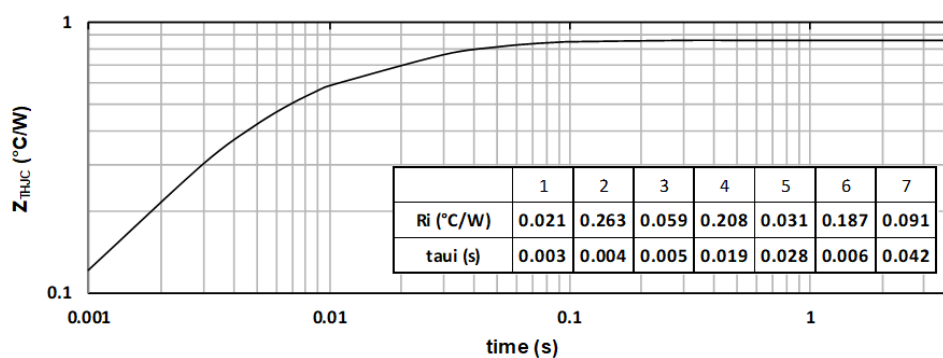


Figure 19 • Forward Characteristics

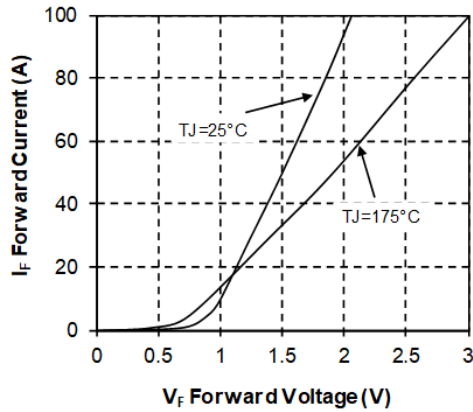
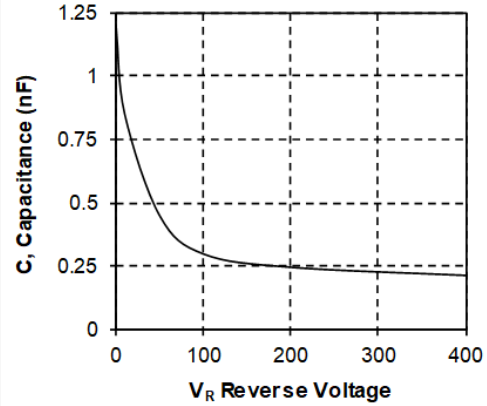


Figure 20 • Capacitance vs. Reverse Voltage



3.8 Typical Diode Curves

This section shows the typical performance curves of the MSCSM70VM19C3AG CR1 diode.

Figure 21 • Maximum Thermal Impedance

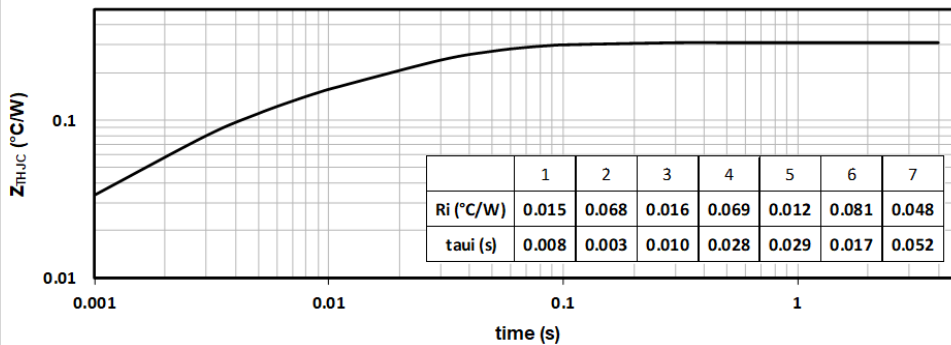
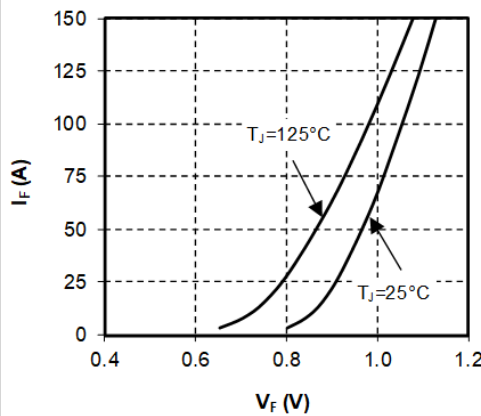


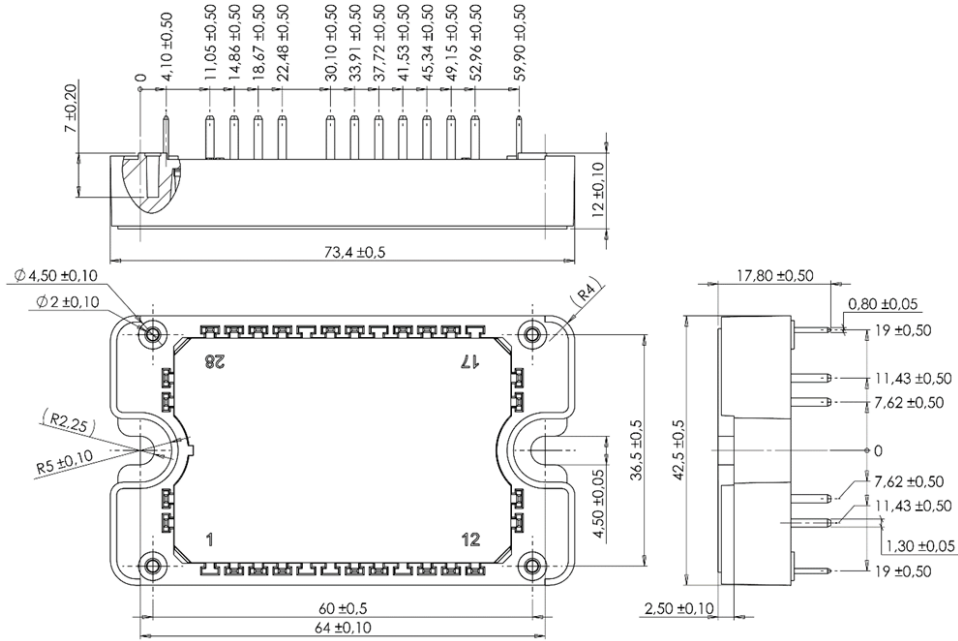
Figure 22 • Forward Characteristics



4 Package Specification

This section shows the package outline of the MSCSM70VM19C3AG device. All dimensions are in millimeters.

Figure 23 • Package Outline



See application note 1906 - Mounting Instructions for SP3F Power Modules on www.microsemi.com

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