

**MSCSM70VM10C4AG**  
**Datasheet**  
**Vienna Rectifier Phase Leg SiC Power**  
**Module**

April 2020



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a  **MICROCHIP** company

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# 1 Revision History

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The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

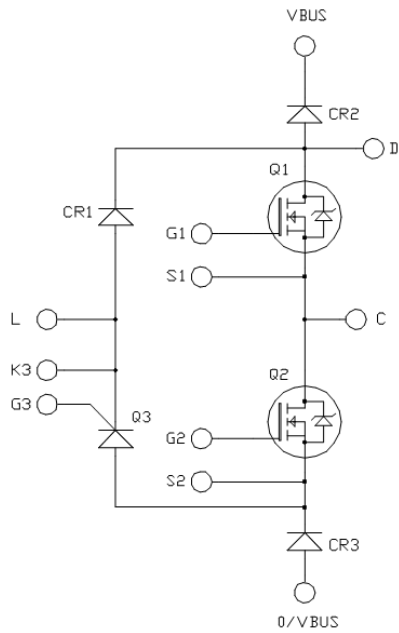
## 1.1 Revision 1.0

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

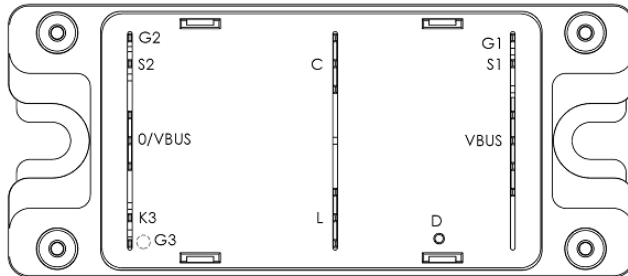
## 2 Product Overview

The MSCSM70VM10C4AG is Vienna Rectifier phase leg 700 V/241 A full Silicon Carbide power module.

**Figure 1 • MSCSM70VM10C4AG Electrical Schematic**



**Figure 2 • MSCSM70VM10C4AG Pinout Location**



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 MSCSM70VM10C4AG 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 MSCSM70VM10C4AG 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 MSCSM70VM10C4AG 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 MSCSM70VM10C4AG device.

### 3.1 SiC MOSFET Characteristics (per SiC MOSFET)

This section describes the electrical characteristics of the MSCSM70VM10C4AG (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	$T_C = 25\text{ }^\circ\text{C}$	238	A
		$T_C = 80\text{ }^\circ\text{C}$	189	
$I_{DM}$	Pulsed drain current	476		
$V_{GS}$	Gate-source voltage	-10/25	V	
$R_{Dson}$	Drain-source ON resistance	9.5	m $\Omega$	
$P_D$	Power dissipation	$T_C = 25\text{ }^\circ\text{C}$	674	W

**Table 2 • Electrical Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit	
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}; V_{DS} = 700\text{ V}$			200	$\mu\text{A}$	
$R_{Dson}$	Drain-source on resistance	$V_{GS} = 20\text{ V}$ $I_D = 80\text{ A}$	$T_J = 25\text{ }^\circ\text{C}$		7.5	9.5	m $\Omega$
			$T_J = 175\text{ }^\circ\text{C}$		9.5		
$V_{GS(th)}$	Gate threshold voltage	$V_{GS} = V_{DS}, I_D = 8\text{ mA}$	1.9	2.4		V	
$I_{GSS}$	Gate-source leakage current	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$			200	nA	



**Table 3 • Dynamic Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$C_{iss}$	Input capacitance	$V_{GS} = 0\text{ V}$ $V_{DS} = 700\text{ V}$ $f = 1\text{ MHz}$		9000		pF
$C_{oss}$	Output capacitance			1020		
$C_{riss}$	Reverse transfer capacitance			58		
$Q_g$	Total gate charge	$V_{GS} = -5/20\text{ V}$ $V_{Bus} = 470\text{ V}$ $I_D = 80\text{ A}$		430		nC
$Q_{gs}$	Gate-source charge			116		
$Q_{gd}$	Gate-drain charge			70		
$T_{d(on)}$	Turn-on delay time	$V_{GS} = -5/20\text{ V}$ $V_{Bus} = 400\text{ V}$ $I_D = 160\text{ A}$ $T_J = 150\text{ }^\circ\text{C}$ $R_{Gon} = 13.5\text{ }\Omega$ ; $R_{Goff} = 2.4\text{ }\Omega$		40		ns
$T_r$	Rise time			35		
$T_{d(off)}$	Turn-off delay time			50		
$T_f$	Fall time			20		
$E_{on}$	Turn on energy	$V_{GS} = -5/20\text{ V}$		$T_J = 150\text{ }^\circ\text{C}$	1090	$\mu\text{J}$
$E_{off}$	Turn off energy	$V_{Bus} = 400\text{ V}$ $I_D = 160\text{ A}$ $R_{Gon} = 13.5\text{ }\Omega$ $R_{Goff} = 2.4\text{ }\Omega$		$T_J = 150\text{ }^\circ\text{C}$	372	$\mu\text{J}$
$R_{Gint}$	Internal gate resistance			2.8		$\Omega$
$R_{thJC}$	Junction-to-case thermal resistance				0.222	$^\circ\text{C/W}$

**Table 4 • Body Diode Ratings and Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$V_{SD}$	Diode forward voltage	$V_{GS} = 0\text{ V}$ ; $I_{SD} = 80\text{ A}$		3.4		V
		$V_{GS} = -5\text{ V}$ ; $I_{SD} = 80\text{ A}$		3.8		
$t_{rr}$	Reverse recovery time	$I_{SD} = 80\text{ A}$ ; $V_{GS} = -5\text{ V}$ $V_R = 400\text{ V}$ ; $di_F/dt = 2000\text{ A}/\mu\text{s}$		38		ns
$Q_{rr}$	Reverse recovery charge			636		nC
$I_{rr}$	Reverse recovery current				29.6	

### 3.2 SiC Schottky Diode Ratings Characteristics (per SiC Diode)

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	$T_C = 70\text{ }^\circ\text{C}$	A
$P_D$	Power dissipation	$T_C = 25\text{ }^\circ\text{C}$	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	$V_R = 700\text{ V}$	$T_J = 25\text{ }^\circ\text{C}$	30	400	$\mu\text{A}$
			$T_J = 175\text{ }^\circ\text{C}$	500		
$V_F$	Diode forward voltage	$I_F = 100\text{ A}$	$T_J = 25\text{ }^\circ\text{C}$	1.5	1.8	V
			$T_J = 175\text{ }^\circ\text{C}$	1.9		
$Q_C$	Total capacitive charge	$V_R = 400\text{ V}$		266		nC
C	Total capacitance	$f = 1\text{ MHz}, V_R = 200\text{ V}$		496		pF
		$f = 1\text{ MHz}, V_R = 400\text{ V}$		432		
$R_{thJC}$	Junction-to-case thermal resistance				0.466	$^\circ\text{C/W}$

### 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	$\mu\text{A}$
$V_F$	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					0.32	$^\circ\text{C}/\text{W}$

### 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	$T_C = 100\text{ }^\circ\text{C}$	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.

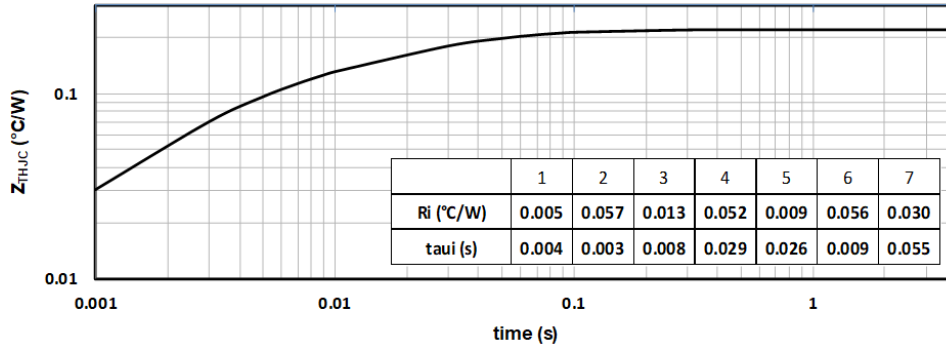
**Table 11 • Package Characteristics**

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	M5	2.5	4.7	N.m
Weight	Package weight			160		g

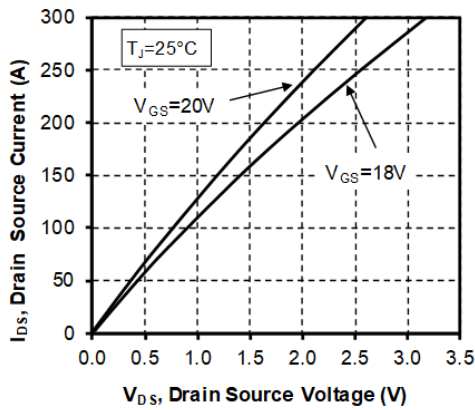
### 3.6 Typical SiC MOSFET Performance Curves

This section shows the typical performance curves of the MSCSM70VM10C4AG SiC MOSFET.

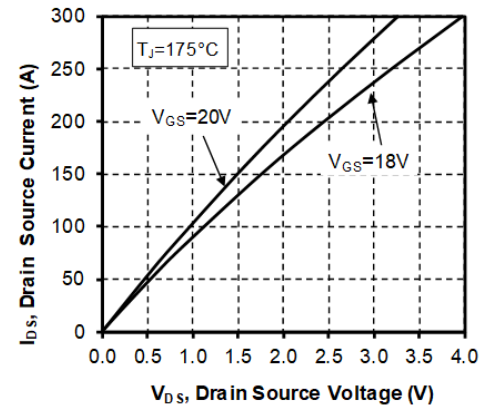
**Figure 3 • Maximum Thermal Impedance**



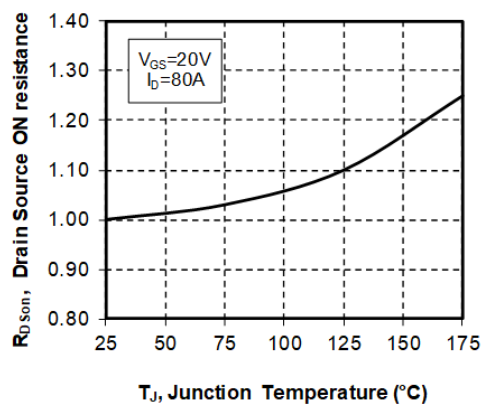
**Figure 4 • Output Characteristics at T<sub>J</sub> = 25 °C**



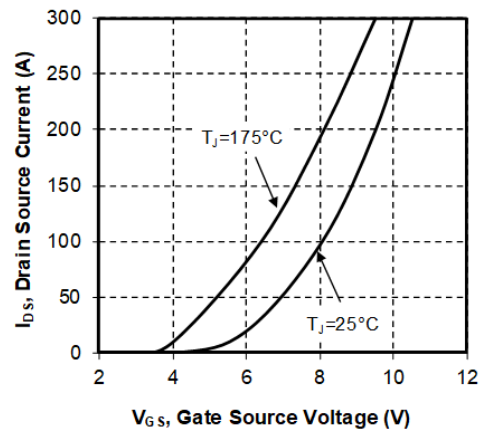
**Figure 5 • Output Characteristics at T<sub>J</sub> = 175 °C**



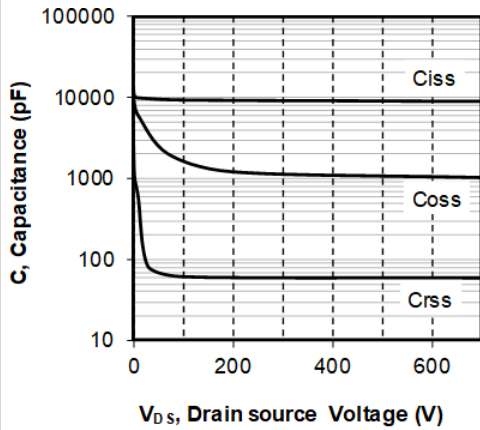
**Figure 6 • Normalized RDS(on) vs. Temperature**



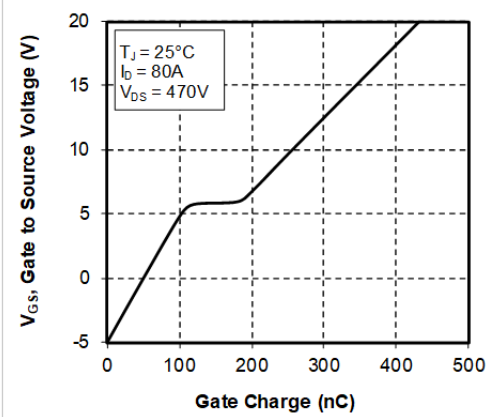
**Figure 7 • Transfer Characteristics**



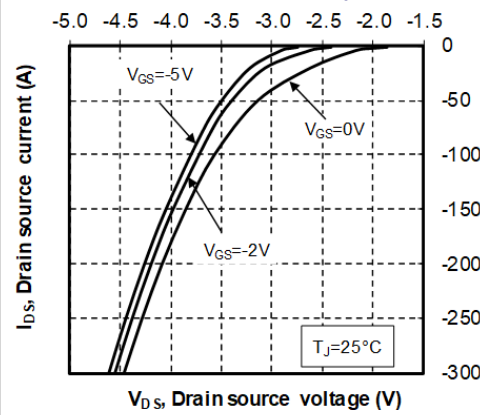
**Figure 8 • Capacitance vs. Drain Source Voltage**



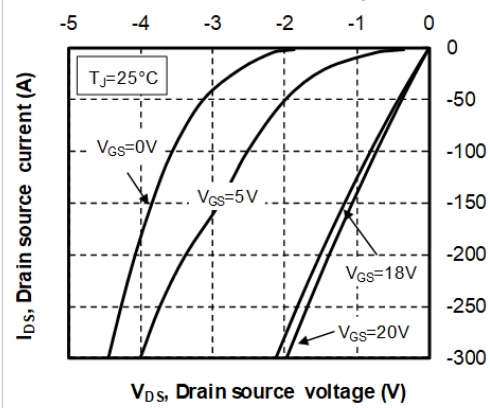
**Figure 9 • Gate Charge vs. Gate Source Voltage**



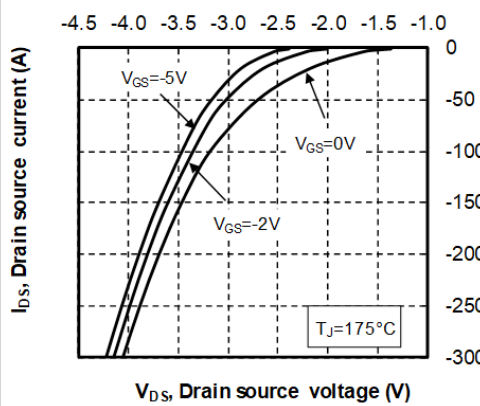
**Figure 10 • Body Diode Char,  $T_J = 25^\circ\text{C}$**



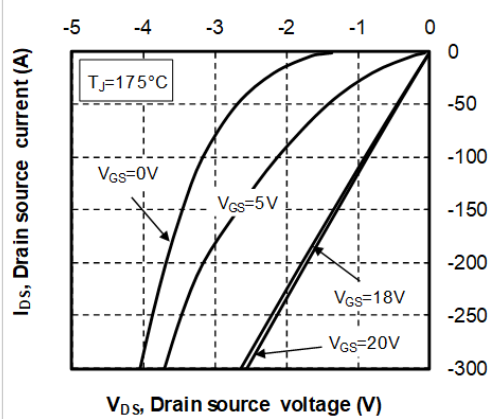
**Figure 11 • 3<sup>rd</sup> Quadrant Char,  $T_J = 25^\circ\text{C}$**



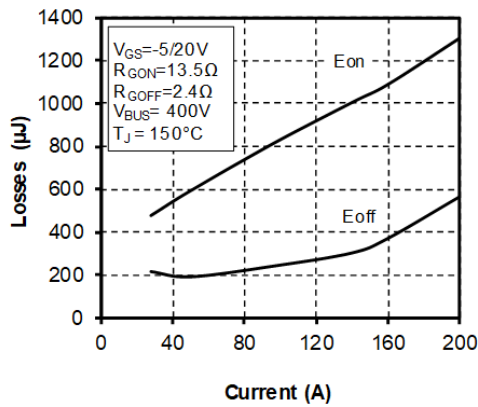
**Figure 12 • Body Diode Char,  $T_J = 175^\circ\text{C}$**



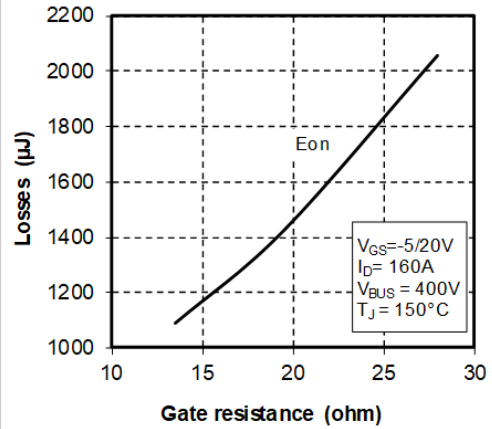
**Figure 13 • 3<sup>rd</sup> Quadrant Char,  $T_J = 175^\circ\text{C}$**



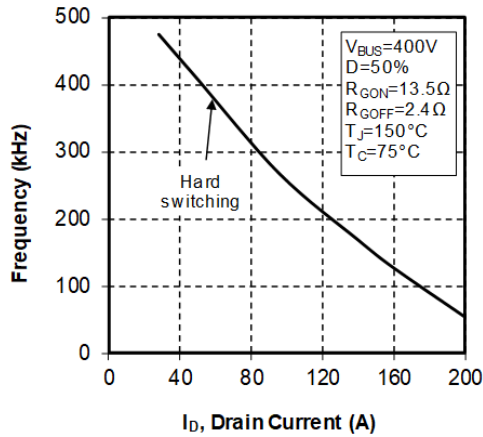
**Figure 14 • Switching Energy vs. Current**



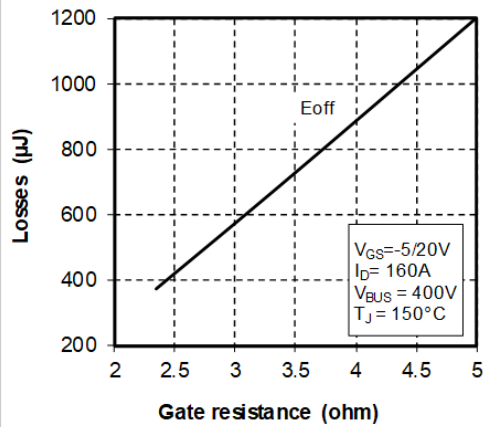
**Figure 15 • Turn-on Energy vs. Rg**



**Figure 16 • Operating Frequency vs. Drain Current**



**Figure 17 • Turn-off Energy vs. Rg**



### 3.7 Typical SiC Diode Performance Curves

This section shows the typical performance curves of the MSCSM70VM10C4AG SiC diodes (CR2 and CR3).

**Figure 18 • Maximum Thermal Impedance**

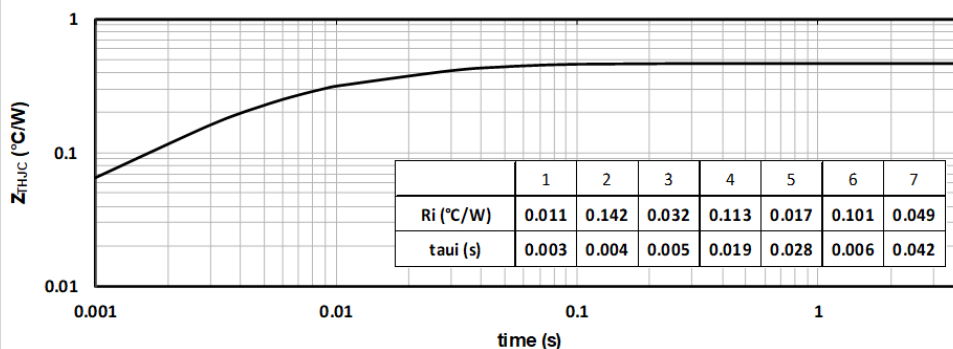


Figure 19 • Forward Characteristics

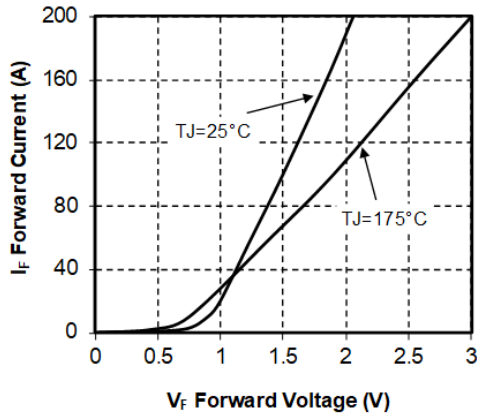
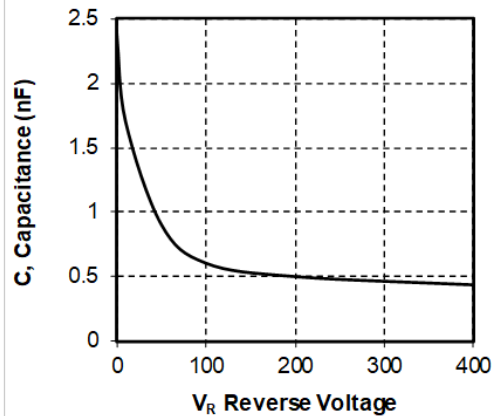


Figure 20 • Capacitance vs. Reverse Voltage



### 3.8 Typical CR1 Diode Curves

This section shows the typical performance curves of the MSCSM70VM10C4AG CR1 diode.

Figure 21 • Maximum Thermal Impedance

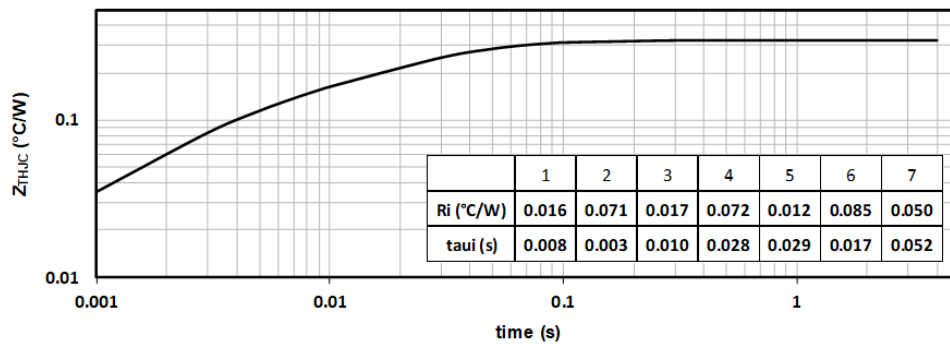
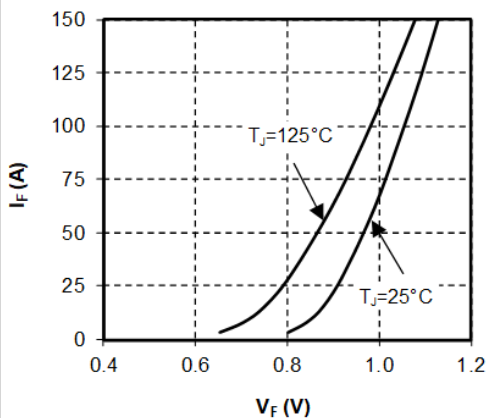


Figure 22 • Forward Characteristics

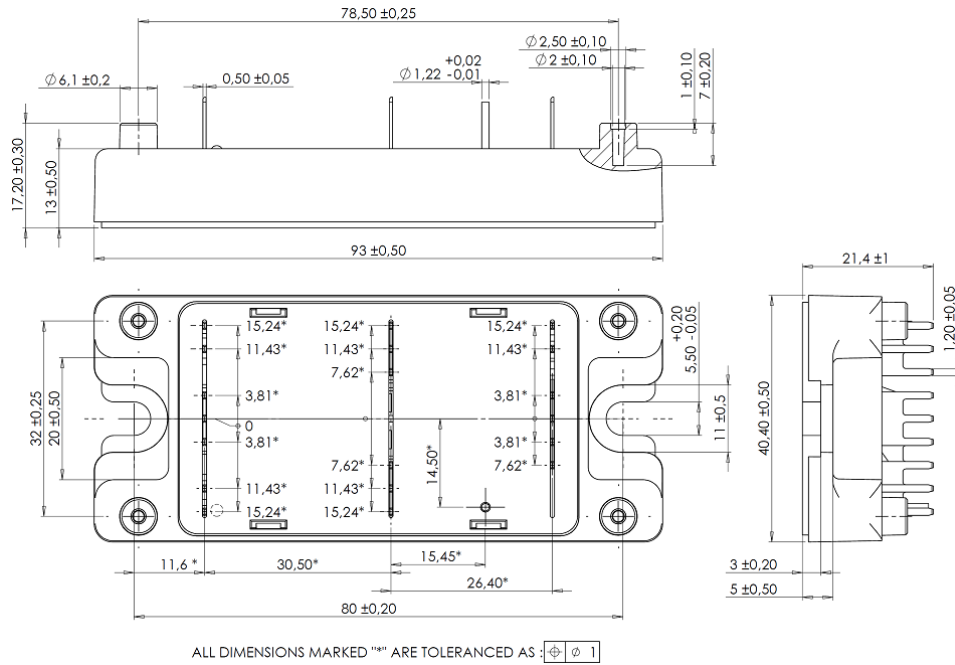




## 4 Package Specification

This section shows the package outline of the MSCSM70VM10C4AG device. All dimensions are in millimeters.

**Figure 23 • Package Outline**



See application note APT0501 - Mounting Instructions for SP4 Power Modules on [www.microsemi.com](http://www.microsemi.com).

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