MSCSM70VM10C4AG

Datasheet

Vienna Rectifier Phase Leg SiC Power Module

April 2020

Microsemi

a Microchip company

Contents

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

Figure 1 • MSCSM70VM10C4AG Electrical Schematic

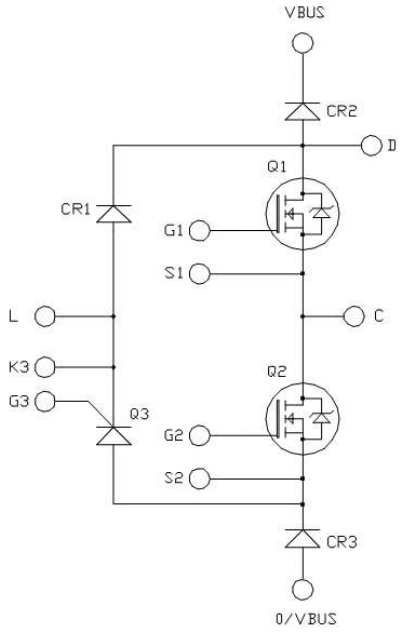
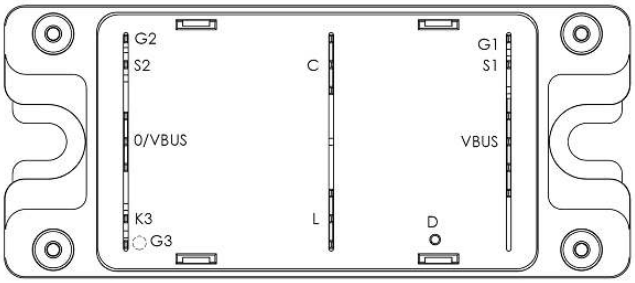


Figure 2 • MSCSM70VM10C4AG Pinout Location



All ratings at T_J = 25 °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 °C	238	A
		T_C = 80 °C	189	
I_{DM}	Pulsed drain current		476	
V_{GS}	Gate-source voltage		–10/25	V
R_{DSon}	Drain-source ON resistance		9.5	mΩ
P_D	Power dissipation	T_C = 25 °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 V; V_{DS} = 700 V				200	µA
R_{DSon}	Drain–source on resistance	V_{GS} = 20 V I_D = 80 A	T_J = 25 °C		7.5	9.5	mΩ
			T_J = 175 °C		9.5		
$V_{GS(th)}$	Gate threshold voltage	V_{GS} = V_{DS}, I_D = 8 mA		1.9	2.4		V
I_{GSS}	Gate–source leakage current	V_{GS} = 20 V, V_{DS} = 0 V				200	nA

Table 3 • Dynamic Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
C_{iss}	Input capacitance	V_{GS} = 0 V V_{DS} = 700 V f = 1 MHz			9000		pF
C_{oss}	Output capacitance				1020		
C_{rss}	Reverse transfer capacitance				58		
Q_g	Total gate charge	V_{GS}= –5/20 V V_{Bus} = 470 V I_D = 80 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 V V_{Bus} = 400 V I_D = 160 A T_J = 150 °C R_{Gon} = 13.5 Ω; R_{Goff} = 2.4 Ω			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 V V_{Bus} = 400 V I_D = 160 A R_{Gon} = 13.5 Ω R_{Goff} = 2.4 Ω	T_J = 150 °C		1090		µJ
E_{off}	Turn off energy		T_J = 150 °C		372		µJ
R_{Gint}	Internal gate resistance				2.8		Ω
R_{thJC}	Junction-to-case thermal resistance					0.222	°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 V ; I_{SD} = 80 A		3.4		V
		V_{GS} = –5 V ; I_{SD} = 80 A		3.8		
t_{rr}	Reverse recovery time	I_{SD} = 80 A ; V_{GS} = –5 V V_R = 400 V ; di_F/dt = 2000 A/µs		38		ns
Q_{rr}	Reverse recovery charge			636		nC
I_{rr}	Reverse recovery current			29.6		A

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 °C	100	A
P_D	Power dissipation	T_C = 25 °C	322	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 V	T_J = 25 °C		30	400	µA
			T_J = 175 °C		500		
V_F	Diode forward voltage	I_F = 100 A	T_J = 25 °C		1.5	1.8	V
			T_J = 175 °C		1.9		
Q_C	Total capacitive charge	V_R = 400 V			266		nC
C	Total capacitance	f = 1 MHz, V_R = 200 V			496		pF
		f = 1 MHz, V_R = 400 V			432		
R_{thJC}	Junction-to-case thermal resistance					0.466	°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 °C	200	A
I_{FSM}	Non-repetitive forward surge current	t = 10 ms	T_J = 25 °C	1600	
P_D	Power dissipation		T_C = 25 °C	400	W

Table 8 • Electrical Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
I_R	Reverse current	V_R = 1600 V				50	µA
V_F	Forward voltage	I_F = 77 A	T_J = 25 °C		1	1.21	V
			T_J = 125 °C		0.9	1.1	
V_T	On–state voltage					0.83	V
r_T	On–state slope resistance					2.2	mΩ
R_{thJC}	Junction-to-case thermal resistance					0.32	°C/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 °C	60	A
I_{TSM}	Surge on–state current	t = 10 ms	T_J = 45 °C	520	
V_{RGM}	Peak reverse gate voltage			10	V
P_D	Power dissipation		T_C = 25 °C	357	W

Table 10 • Electrical Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
V_T	On–state Voltage	I_T = 60 A	T_J = 25 °C		1.41		V
V_{TO}	Direct on state threshold voltage		T_J = 125 °C		0.85		
r_T	On–state Slope resistance		T_J = 125 °C		10		mΩ
V_{GT}	Gate trigger voltage		T_J = 25 °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.

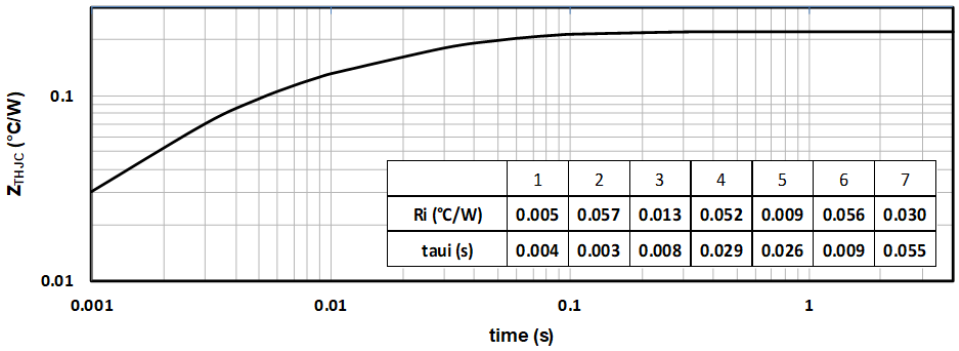
Table 11 • Package Characteristics

Symbol	Characteristic			Min	Max	Unit
V_{ISOL}	RMS Isolation Voltage, any terminal to case t =1 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



	1	2	3	4	5	6	7
Ri (°C/W)	0.005	0.057	0.013	0.052	0.009	0.056	0.030
taui (s)	0.004	0.003	0.008	0.029	0.026	0.009	0.055

Figure 4 • Output Characteristics at T_J = 25 °C

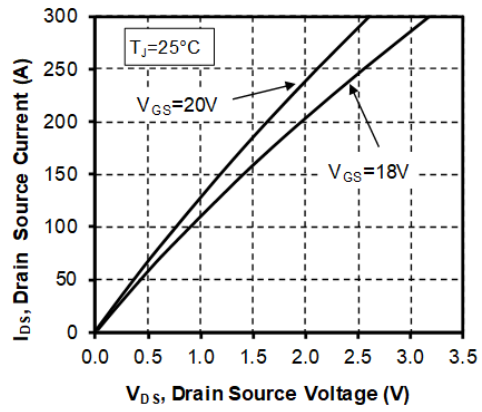


Figure 5 • Output Characteristics at T_J = 175 °C

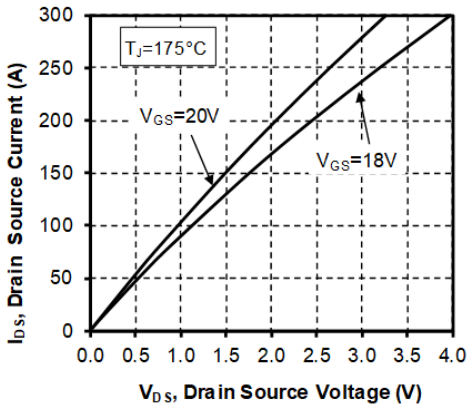


Figure 6 • Normalized RDS(on) vs. Temperature

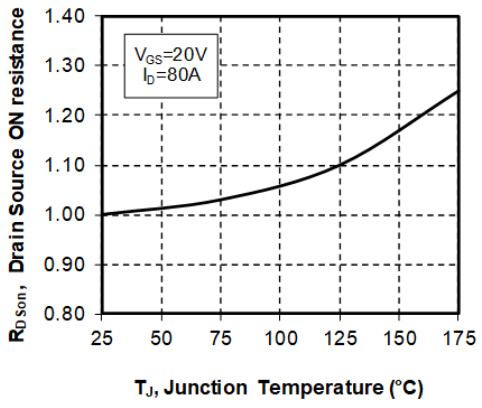


Figure 7 • Transfer Characteristics

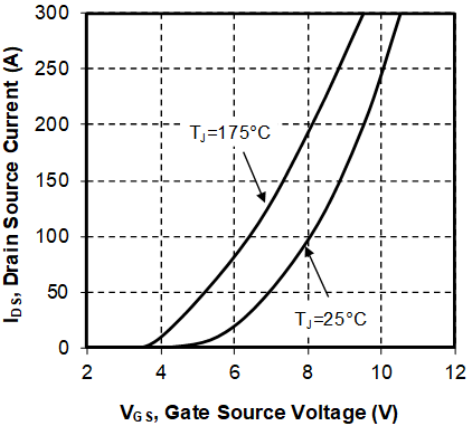


Figure 8 • Capacitance vs. Drain Source Voltage

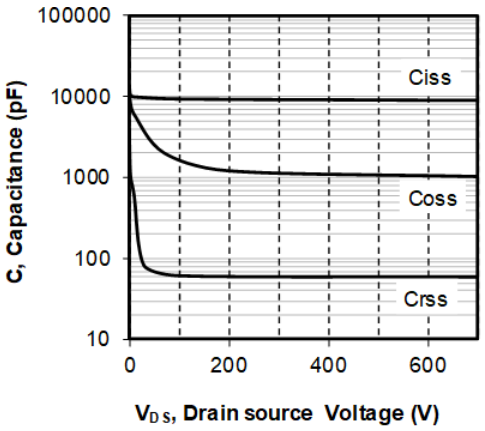


Figure 9 • Gate Charge vs. Gate Source Voltage

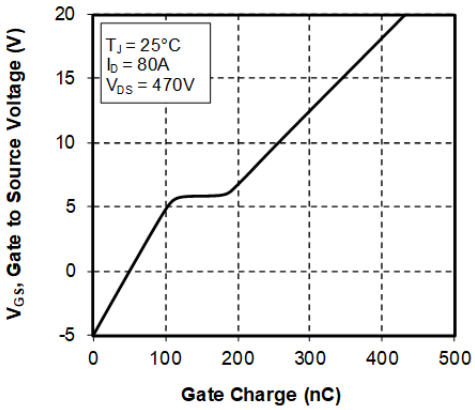


Figure 10 • Body Diode Char, T_J = 25 °C

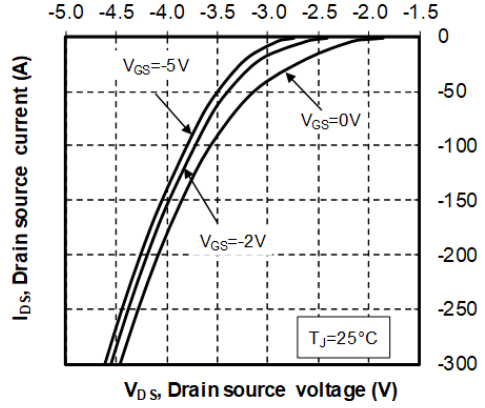


Figure 11 • 3rd Quadrant Char, T_J = 25 °C

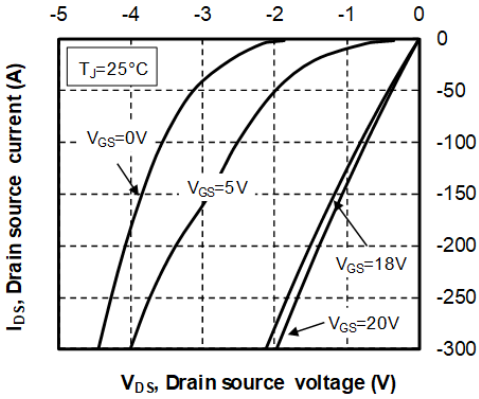


Figure 12 • Body Diode Char, T_J = 175 °C

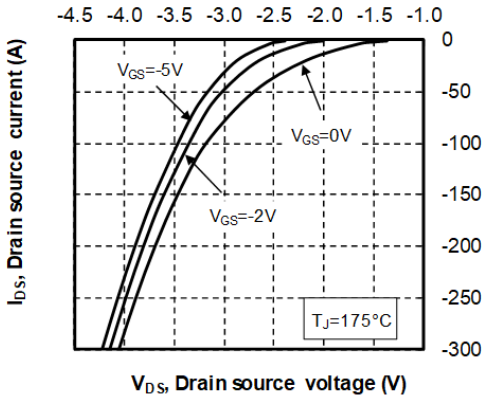


Figure 13 • 3rd Quadrant Char, T_J = 175 °C

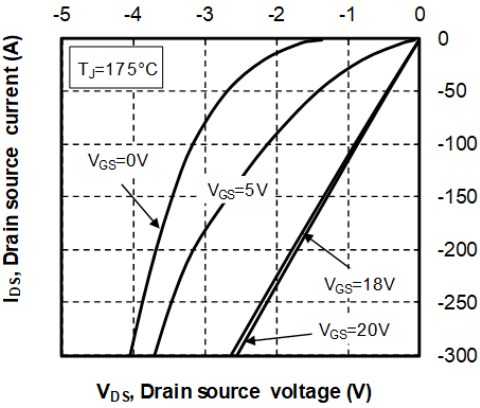


Figure 14 • Switching Energy vs. Current

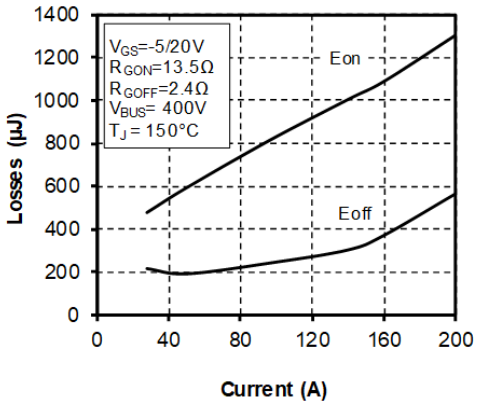


Figure 15 • Turn-on Energy vs. Rg

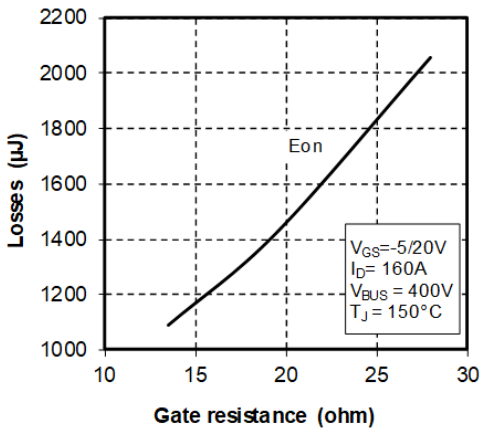


Figure 16 • Operating Frequency vs. Drain Current

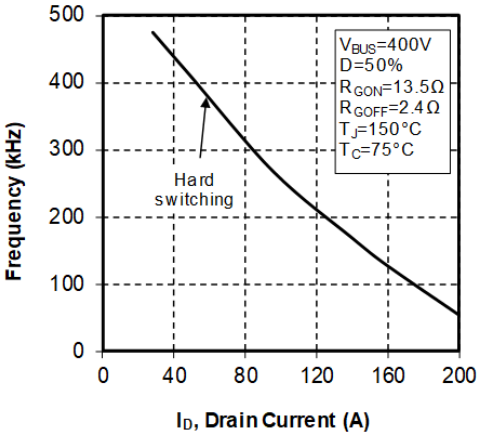
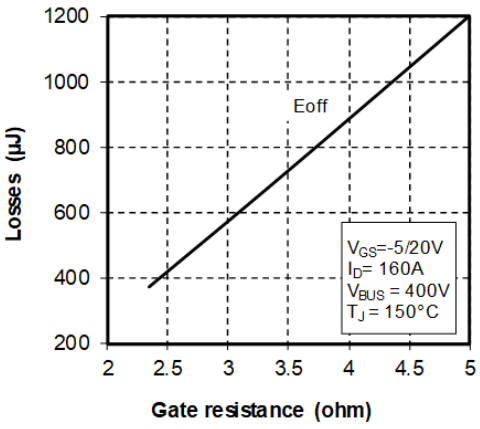


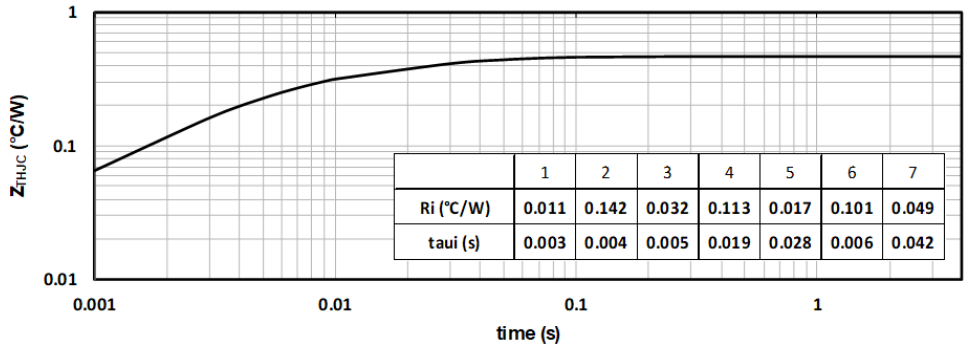
Figure 17 • Turn-off Energy vs. Rg



3.7 Typical SiC Diode Performance Curves

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

Figure 18 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.011	0.142	0.032	0.113	0.017	0.101	0.049
taui (s)	0.003	0.004	0.005	0.019	0.028	0.006	0.042

Figure 19 • Forward Characteristics

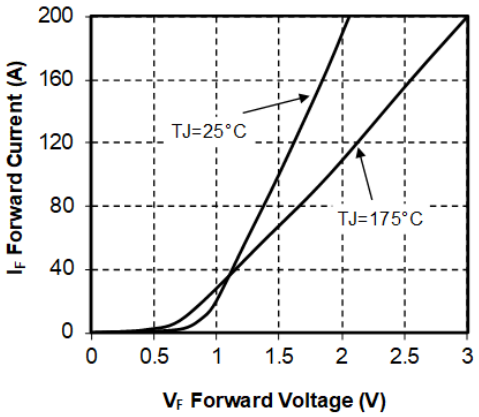
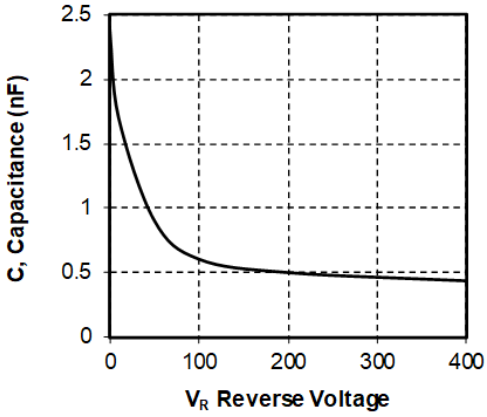


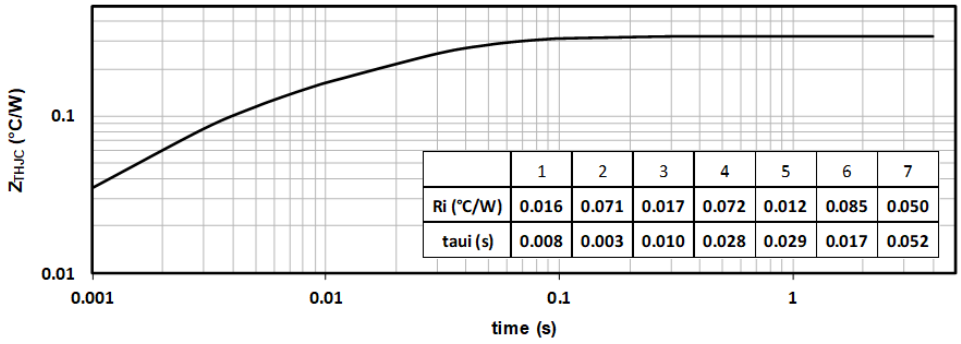
Figure 20 • Capacitance vs. Reverse Voltage



3.8 Typical CR1 Diode Curves

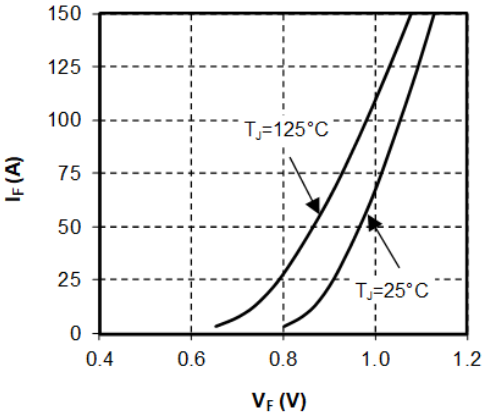
This section shows the typical performance curves of the MSCSM70VM10C4AG CR1 diode.

Figure 21 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.016	0.071	0.017	0.072	0.012	0.085	0.050
taui (s)	0.008	0.003	0.010	0.028	0.029	0.017	0.052

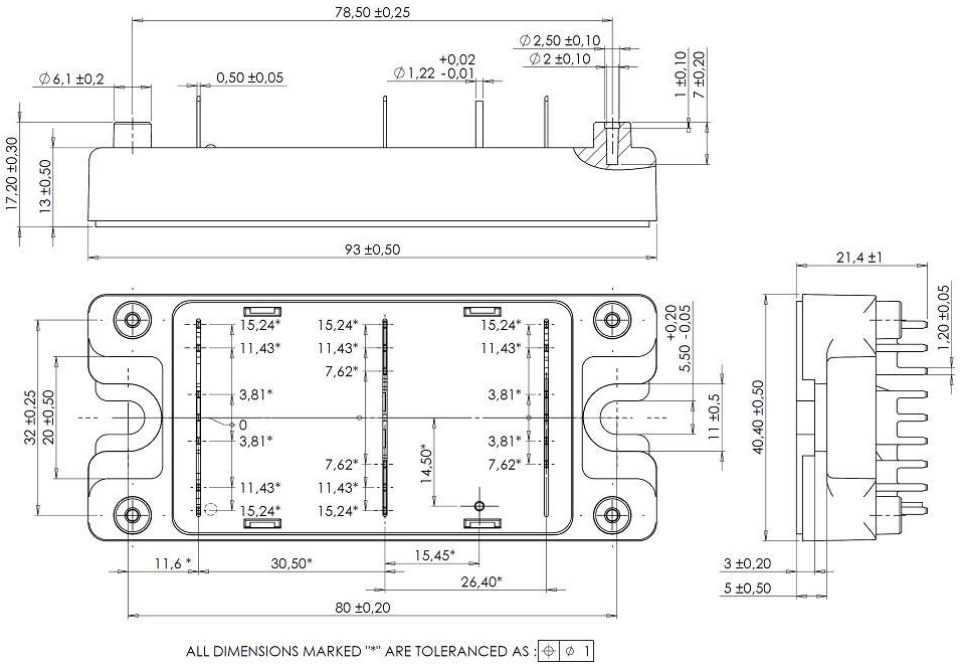
Figure 22 • Forward Characteristics



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.*

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