

MSCSM120HM31CT3AG
Datasheet
Full Bridge SiC MOSFET Power Module

January 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 was published in January 2020. It is the first publication of this document.

2 Product Overview

The MSCSM120HM31CT3AG device is a full bridge 1200 V/89 A full Silicon Carbide (SiC) power module.

Figure 1 • MSCSM120HM31CT3AG Electrical Schematic

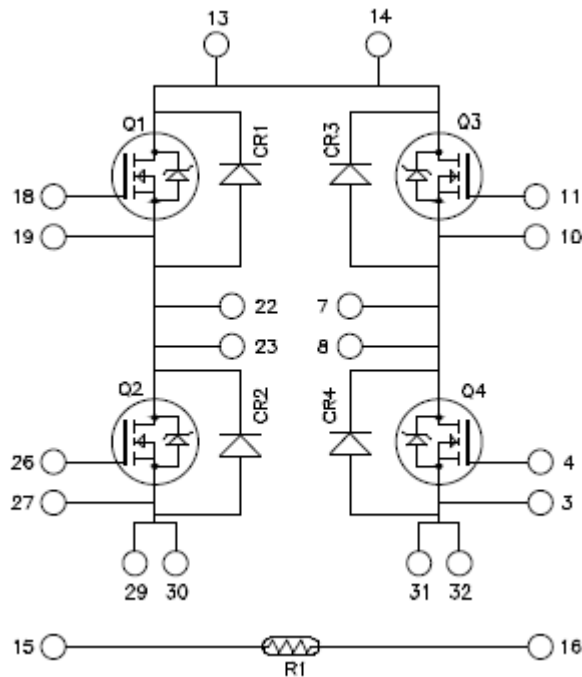
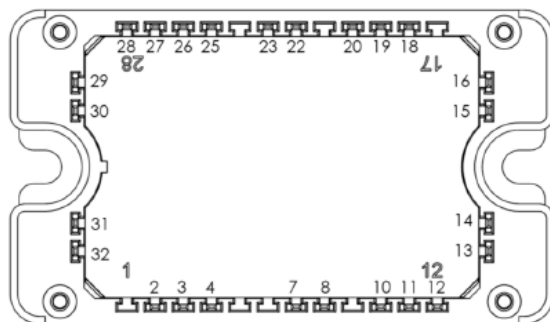


Figure 2 • MSCSM120HM31CT3AG Pinout Location



All multiple inputs and outputs must be shorted together. Example: 13/14; 29/30; 22/23, and so on.

All ratings at $T_j = 25^\circ\text{C}$, 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 MSCSM120HM31CT3AG device:

- SiC Power MOSFET
 - Low $R_{DS(on)}$
 - High temperature performance
- SiC Schottky Diode
 - Zero reverse recovery
 - Zero forward recovery
 - Temperature independent switching behavior
 - Positive temperature coefficient on VF
- Very low stray inductance
- Internal thermistor for temperature monitoring
- Aluminum nitride (AlN) substrate for improved thermal performance

2.2 Benefits

The following are benefits of the MSCSM120HM31CT3AG device:

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

2.3 Applications

The MSCSM120HM31CT3AG device is designed for the following applications:

- Uninterruptible power supplies
- Switched mode power supplies
- EV motor and traction drive
- Welding converters

3 Electrical Specifications

This section shows the electrical specifications of the MSCSM120HM31CT3AG device.

3.1 SiC MOSFET Characteristics (Per MOSFET)

The following table shows the absolute maximum ratings per MOSFET of the MSCSM120HM31CT3AG device.

Table 1 • Absolute Maximum Ratings

Symbol	Parameter		Max Ratings	Unit
V_{DSS}	Drain-source voltage		1200	V
I_D	Continuous drain current	$T_C = 25\text{ }^{\circ}\text{C}$	89	A
		$T_C = 80\text{ }^{\circ}\text{C}$	71	
I_{DM}	Pulsed drain current		180	
V_{GS}	Gate-source voltage		-10/25	V
$R_{DS(on)}$	Drain source ON resistance		31	m Ω
P_D	Power dissipation	$T_C = 25\text{ }^{\circ}\text{C}$	395	W

The following table shows the electrical characteristics per MOSFET of the MSCSM120HM31CT3AG device.

Table 2 • Electrical Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
I_{DSS}	Zero gate voltage drain current	$V_{GS} = 0\text{ V}; V_{DS} = 1200\text{ V}$			10	100	μA
$R_{DS(on)}$	Drain-source on resistance	$V_{GS} = 20\text{ V}$ $I_D = 40\text{ A}$	$T_J = 25\text{ }^{\circ}\text{C}$		25	31	m Ω
			$T_J = 175\text{ }^{\circ}\text{C}$		40		
$V_{GS(th)}$	Gate threshold voltage	$V_{GS} = V_{DS}, I_D = 1\text{ mA}$		1.8	2.8		V
I_{GSS}	Gate-source leakage current	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$				150	nA

The following table shows the dynamic characteristics per MOSFET of the MSCSM120HM31CT3AG device.

Table 3 • Dynamic Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
C_{iss}	Input capacitance	$V_{GS} = 0\text{ V}$ $V_{DS} = 1000\text{ V}$ $f = 1\text{ MHz}$			3020		pF
C_{oss}	Output capacitance				270		
C_{rss}	Reverse transfer capacitance				25		
Q_g	Total gate charge	$V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 800\text{ V}$ $I_D = 40\text{ A}$			232		nC
Q_{gs}	Gate–source charge				41		
Q_{gd}	Gate–drain charge				50		
$T_{d(on)}$	Turn-on delay time	$V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 800\text{ V}$ $I_D = 50\text{ A}$ $R_{Gon} = 8\text{ }\Omega$; $R_{Goff} = 4.7\text{ }\Omega$			30		ns
T_r	Rise time				30		
$T_{d(off)}$	Turn-off delay time				50		
T_f	Fall time				25		
E_{on}	Turn on energy	Inductive switching	$T_J = 150\text{ }^\circ\text{C}$		0.99		mJ
E_{off}	Turn off energy	$V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 600\text{ V}$ $I_D = 50\text{ A}$ $R_{Gon} = 8\text{ }\Omega$ $R_{Goff} = 4.7\text{ }\Omega$	$T_J = 150\text{ }^\circ\text{C}$		0.66		mJ
R_{Gint}	Internal gate resistance				0.88		Ω
R_{thJC}	Junction-to-case thermal resistance					0.38	$^\circ\text{C}/\text{W}$

The following table shows the body diode ratings and characteristics per MOSFET of the MSCSM120HM31CT3AG device.

Table 4 • Body Diode Ratings and Characteristics

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
V_{SD}	Diode forward voltage	$V_{GS} = 0\text{ V}$; $I_{SD} = 40\text{ A}$		4.0		V
		$V_{GS} = -5\text{ V}$; $I_{SD} = 40\text{ A}$		4.2		
t_{rr}	Reverse recovery time	$I_{SD} = 40\text{ A}$; $V_{GS} = -5\text{ V}$ $V_R = 800\text{ V}$; $dI_F/dt = 1000\text{ A}/\mu\text{s}$		90		ns
Q_{rr}	Reverse recovery charge			550		nC
I_{rr}	Reverse recovery current			13.5		A

3.2 Reverse SiC Diode Ratings and Characteristics (Per SiC Diode)

The following table shows the reverse SiC diode ratings and characteristics per SiC diode of the MSCSM120HM31CT3AG device.

Table 5 • Reverse SiC Diode Ratings and Characteristics (Per SiC Diode)

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
V_{RRM}	Peak repetitive reverse voltage					1200	V
I_{RM}	Reverse leakage current	$V_R = 1200\text{ V}$	$T_J = 25\text{ }^{\circ}\text{C}$		10	200	μA
			$T_J = 175\text{ }^{\circ}\text{C}$		150		
I_F	DC forward current		$T_C = 100\text{ }^{\circ}\text{C}$		30		A
V_F	Diode forward voltage	$I_F = 30\text{ A}$	$T_J = 25\text{ }^{\circ}\text{C}$		1.5	1.8	V
			$T_J = 175\text{ }^{\circ}\text{C}$		2.1		
QC	Total capacitive charge	$V_R = 600\text{ V}$			130		nC
C	Total capacitance	$f = 1\text{ MHz}, V_R = 400\text{ V}$			141		pF
		$f = 1\text{ MHz}, V_R = 800\text{ V}$			105		
R_{thJC}	Junction-to-case thermal resistance					0.9	$^{\circ}\text{C/W}$

3.3 Thermal and Package Characteristics

The following table shows the package characteristics of the MSCSM120HM31CT3AG device.

Table 6 • Package Characteristics

Symbol	Characteristic			Min	Max	Unit
V_{ISOL}	RMS isolation voltage, any terminal to case $t = 1\text{ min}$, 50 Hz/60 Hz			4000		V
T_J	Operating junction temperature range			-40	175	$^{\circ}\text{C}$
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
Wt	Package weight				110	g

The following table shows the temperature sensor NTC (see application note [APT0406](#) on www.microsemi.com) of the MSCSM120HM31CT3AG device.

Table 7 • Temperature Sensor NTC

Symbol	Characteristic	Min	Typ	Max	Unit
R ₂₅	Resistance at 25 °C		50		kΩ
ΔR ₂₅ /R ₂₅			5		%
B _{25/85}	T ₂₅ = 298.15 K		3952		K
ΔB/B	T _C = 100 °C		4		%

$$R_T = \frac{R_{25}}{\exp \left[B_{25/85} \left(\frac{1}{T_{25}} - \frac{1}{T} \right) \right]}$$

T: Thermistor temperature
R_T: Thermistor value at T

3.4 Typical SiC MOSFET Performance Curves

This sections shows the typical SiC MOSFET performance curves of the MSCSM120HM31CT3AG device.

Figure 3 • Maximum Thermal Impedance

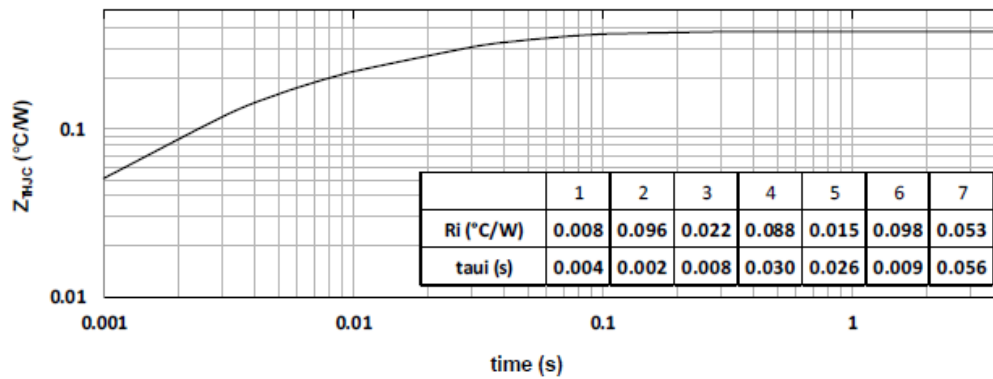


Figure 4 • Output Characteristics, $T_J = 25^\circ\text{C}$

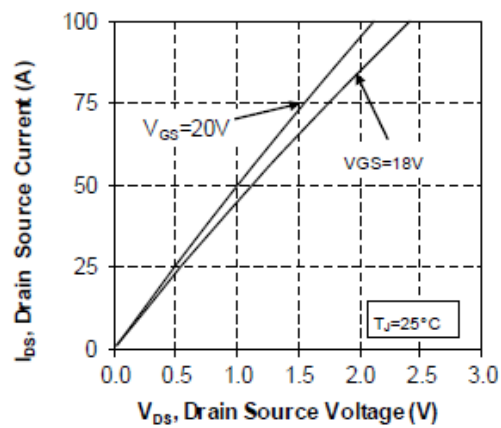


Figure 5 • Output Characteristics, $T_J = 175^\circ\text{C}$

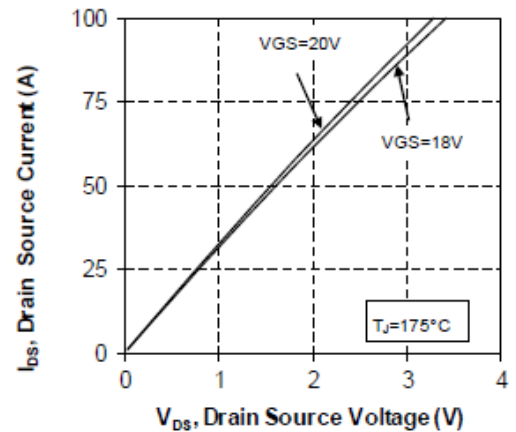


Figure 6 • Normalized $R_{DS(on)}$ vs. Temperature

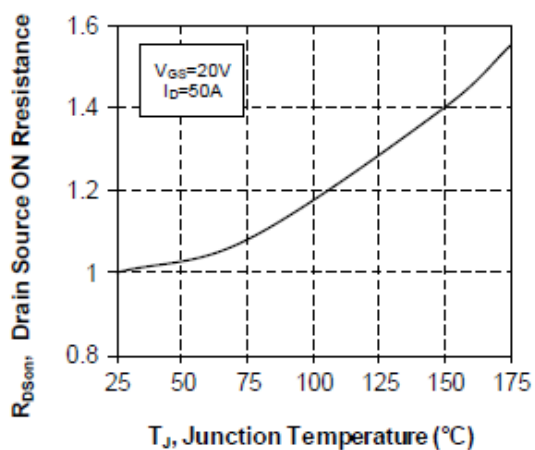


Figure 7 • Transfer Characteristics

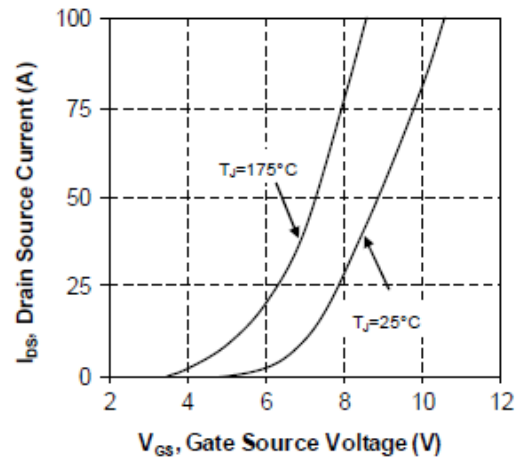


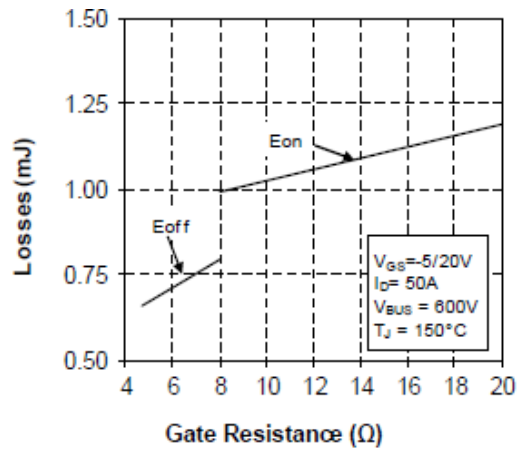
Figure 8 • Switching Energy vs. R_g 

Figure 9 • Switching Energy vs. Current

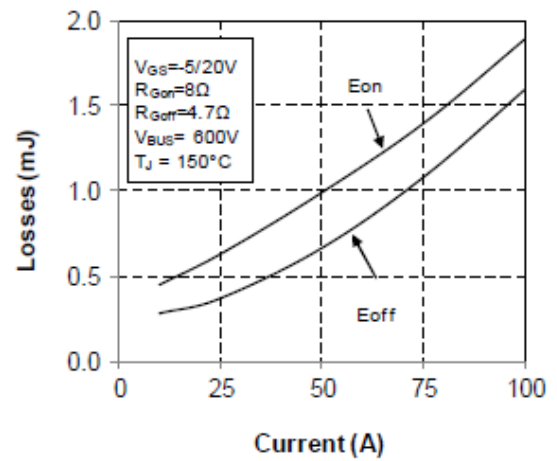


Figure 10 • Capacitance vs. Drain Source Voltage

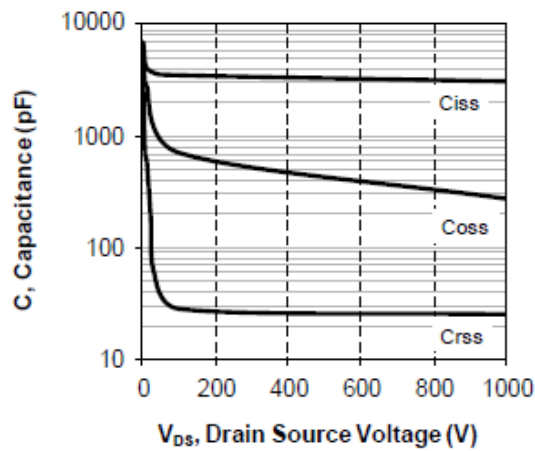


Figure 11 • Gate Charge vs. Gate Source Voltage

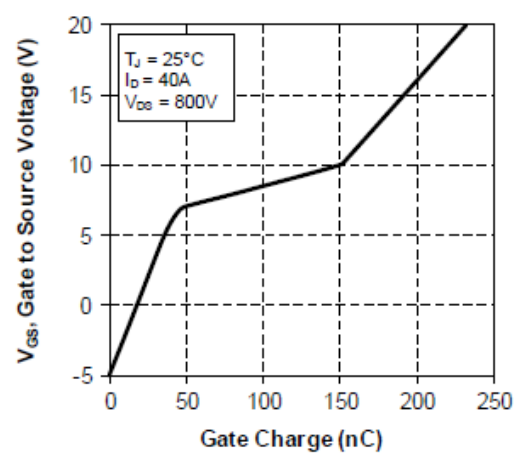
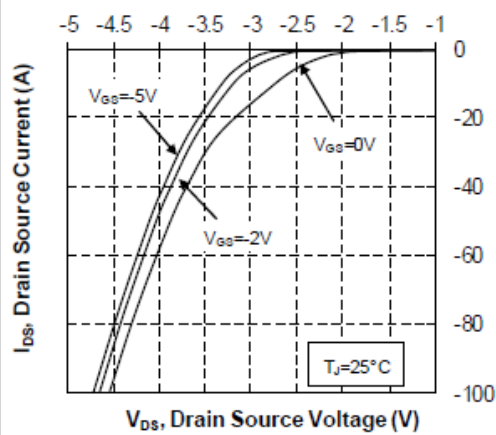
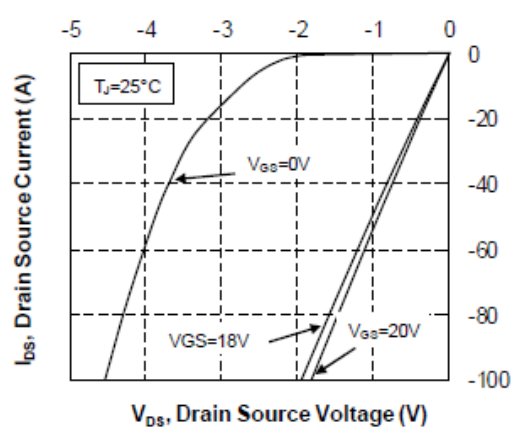
Figure 12 • Body Diode Characteristics, $T_J = 25^\circ C$ Figure 13 • 3rd Quadrant Characteristics, $T_J = 25^\circ C$ 

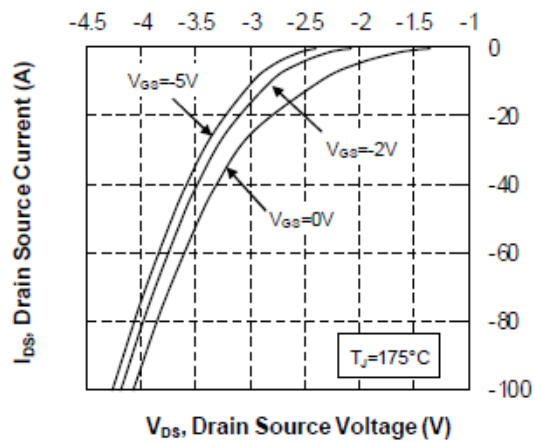
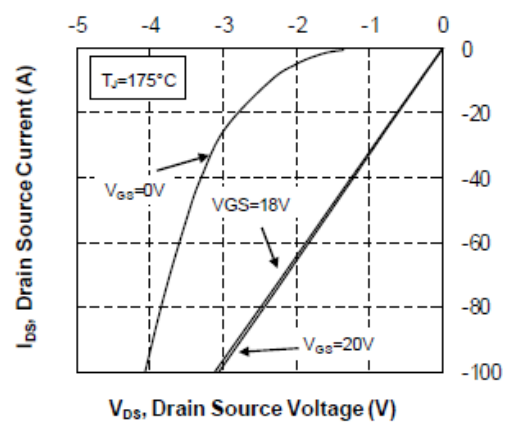
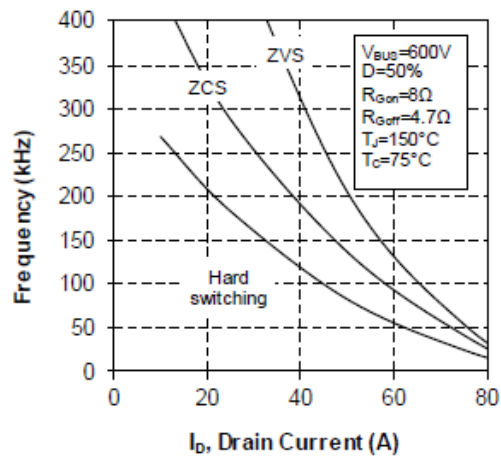
Figure 14 • Body Diode Characteristics, $T_J = 175^\circ\text{C}$ Figure 15 • 3rd Quadrant Characteristics, $T_J = 175^\circ\text{C}$ 

Figure 16 • Operating Frequency vs. Drain Current



3.5 Typical SiC Diode Performance Curves

This sections shows the typical SiC diode performance curves of the MSCSM120HM31CT3AG device.

Figure 17 • Maximum Thermal Impedance

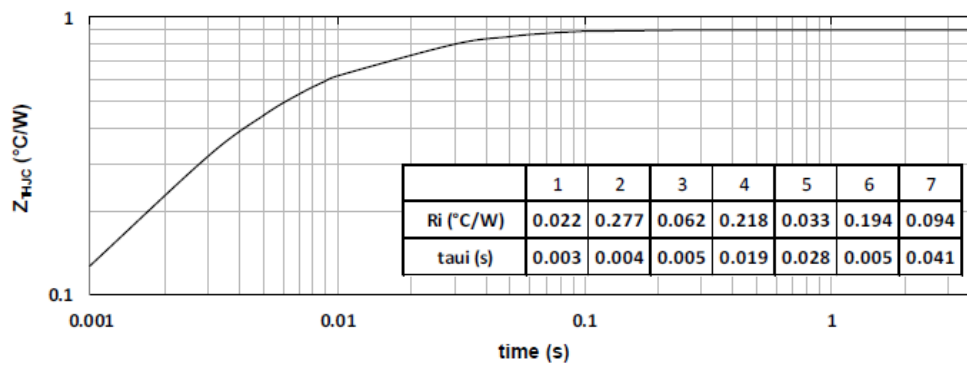


Figure 18 • Forward Characteristics

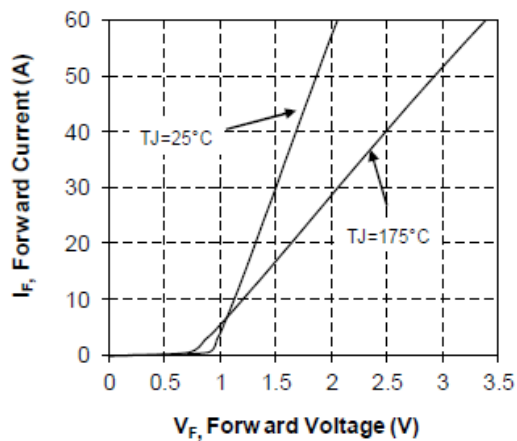
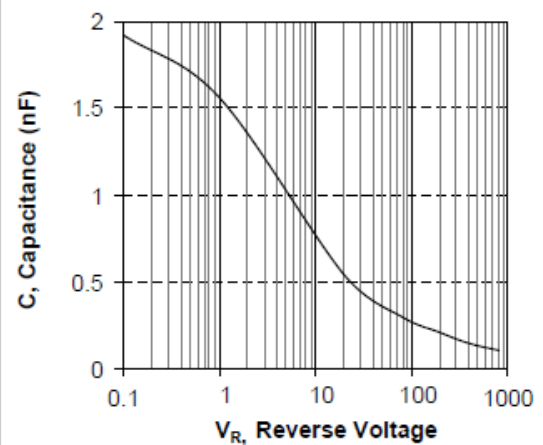


Figure 19 • Capacitance vs. Reverse Voltage



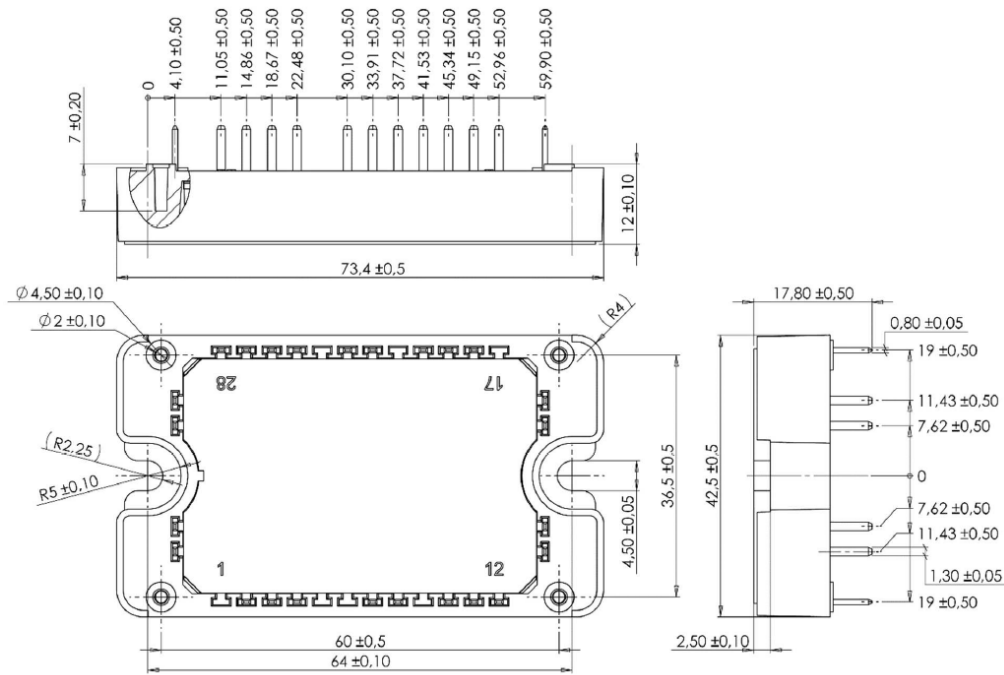
4 Package Specifications

This section shows the package specification of the MSCSM120HM31CT3AG device.

4.1 Package Outline Drawing

The following figure illustrates the package outline of the MSCSM120HM31CT3AG device. The dimensions are in millimeters.

Figure 20 • Package Outline Drawing



Note: See application note [1906—Mounting Instructions for SP3F Power Modules](#) on www.microsemi.com.

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