MSCSM120TAM31CT3AG

Datasheet

3 Phase Bridge SiC MOSFET Power Module

January 2020

Microsemi

a Microchip company

Contents

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 MSCSM120TAM31CT3AG device is a 3 phase leg 1200 V/89 A full Silicon Carbide (SiC) power module.

Figure 1 • MSCSM120TAM31CT3AG Electrical Schematic

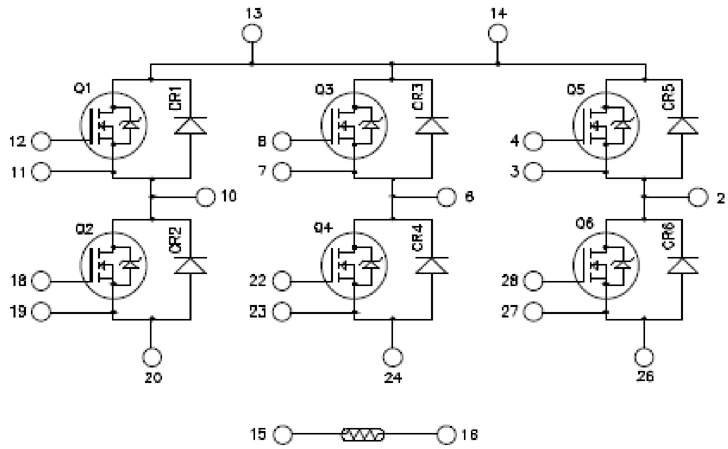
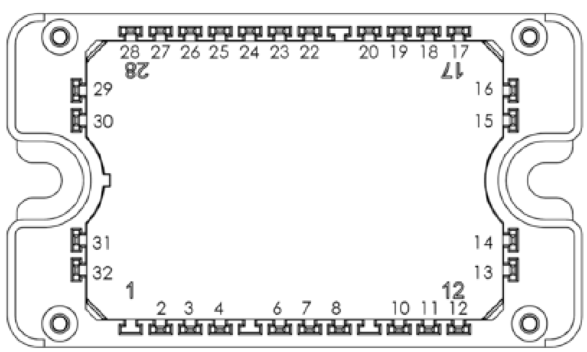


Figure 2 • MSCSM120TAM31CT3AG Pinout Location



Pins 20, 24, and 26 must be shorted together to perform a 3 phase bridge.

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 MSCSM120TAM31CT3AG device:

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

2.2 Benefits

The following are benefits of the MSCSM120TAM31CT3AG device:

- High efficiency converter
- 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 MSCSM120TAM31CT3AG 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 MSCSM120TAM31CT3AG device.

3.1 SiC MOSFET Characteristics (Per SiC MOSFET)

The following table shows the absolute maximum ratings per SiC MOSFET of the MSCSM120TAM31CT3AG 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 °C	89	A
		T_C = 80 °C	71	
I_{DM}	Pulsed drain current		180	
V_{GS}	Gate-source voltage		–10/25	V
R_{DSon}	Drain-source ON resistance		31	mΩ
P_D	Power dissipation	T_C = 25 °C	395	W

The following table shows the electrical characteristics per SiC MOSFET of the MSCSM120TAM31CT3AG device.

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} = 1200 V			10	100	µA
$R_{DS(on)}$	Drain-source on resistance	V_{GS} = 20 V I_D = 40 A	T_J = 25 °C		25	31	mΩ
			T_J = 175 °C		40		
$V_{GS(th)}$	Gate threshold voltage	V_{GS} = V_{DS}, I_D = 1 mA		1.8	2.8		V
I_{GSS}	Gate-source leakage current	V_{GS} = 20 V, V_{DS} = 0 V				150	nA

The following table shows the dynamic characteristics per SiC MOSFET of the MSCSM120TAM31CT3AG device.

Table 3 • Dynamic Characteristics

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
C_{iss}	Input capacitance	V_{GS} = 0 V V_{DS} = 1000 V f = 1 MHz			3020		pF
C_{oss}	Output capacitance				270		
C_{rss}	Reverse transfer capacitance				25		
Q_g	Total gate charge	V_{GS} = –5 V/20 V V_{Bus} = 800 V I_D = 40 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 V/20 V V_{Bus} = 800 V I_D = 50 A R_{Gon} = 8 Ω; R_{Goff} = 4.7 Ω			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 V_{GS} = –5 V/20 V V_{Bus} = 600 V I_D = 50 A R_{Gon} = 8 Ω R_{Goff} = 4.7 Ω	T_J = 150 °C		0.99		mJ
E_{off}	Turn off energy		T_J = 150 °C		0.66		mJ
R_{Gint}	Internal gate resistance				0.88		Ω
R_{thJC}	Junction-to-case thermal resistance					0.38	°C/W

The following table shows the body diode ratings and characteristics per SiC MOSFET of the MSCSM120TAM31CT3AG device.

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} = 40 A		4.0		V
		V_{GS} = –5V ; I_{SD} = 40 A		4.2		
t_{rr}	Reverse recovery time	I_{SD} = 40 A; V_{GS} = –5 V V_R = 800 V; d_{iF}/dt = 1000 A/µs		90		ns
Q_{rr}	Reverse recovery charge			550		nC
I_{rr}	Reverse recovery current			13.5		A

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

The following table shows the SiC diode ratings and characteristics per SiC diode of the MSCSM120TAM31CT3AG device.

Table 5 • SiC Schottky Diode Ratings and Characteristics

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

3.3 Thermal and Package Characteristics

The following table shows the package characteristics of the MSCSM120TAM31CT3AG device.

Table 6 • Package Characteristics

Symbol	Characteristic			Min	Max	Unit
V_{ISOL}	RMS isolation voltage, any terminal to case t = 1 min, 50 Hz/60 Hz			4000		V
T_J	Operating junction temperature range			–40	175	°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 MSCSM120TAM31CT3AG device.

Table 7 • Temperature Sensor NTC

Symbol	Characteristic		Min	Typ	Max	Unit
R_{25}	Resistance at 25 °C			50		kΩ
$\Delta R_{25}/R_{25}$				5		%
$B_{25/85}$	T_{25} = 298.15 K			3952		K
ΔB/B		T_C = 100 °C		4		%

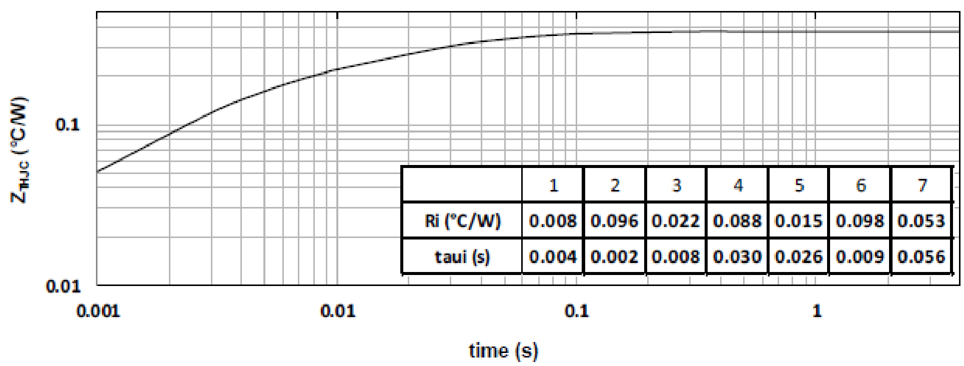
$$R_T = \frac{R_{25}}{\exp\left[B_{25/85}\left(\frac{1}{T_{25}} - \frac{1}{T}\right)\right]}$$

T: Thermistor temperature
R_T: Thermistor value at T

3.4 Typical SiC MOSFET Performance Curves

This section shows the typical SiC MOSFET performance curves of the MSCSM120TAM31CT3AG device.

Figure 3 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.008	0.096	0.022	0.088	0.015	0.098	0.053
taui (s)	0.004	0.002	0.008	0.030	0.026	0.009	0.056

Figure 4 • Output Characteristics, T_J = 25 °C

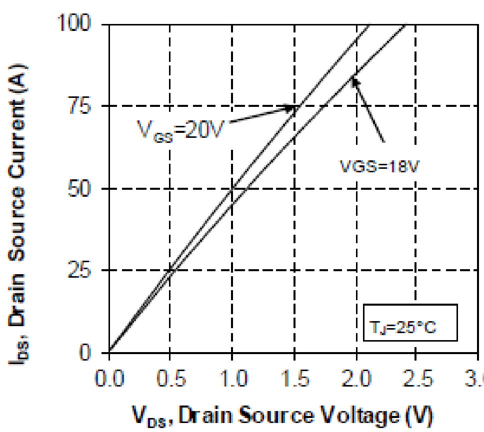


Figure 5 • Output Characteristics, T_J = 175 °C

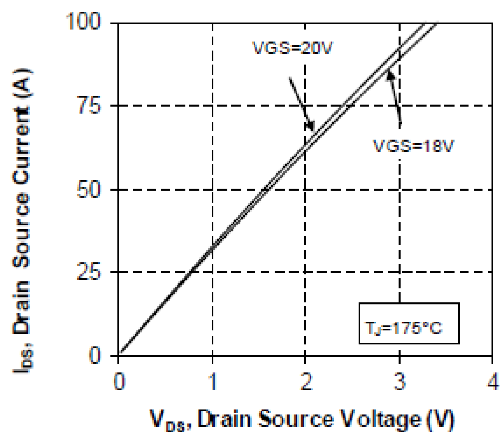


Figure 6 • Normalized $R_{DS(on)}$ vs. Temperature

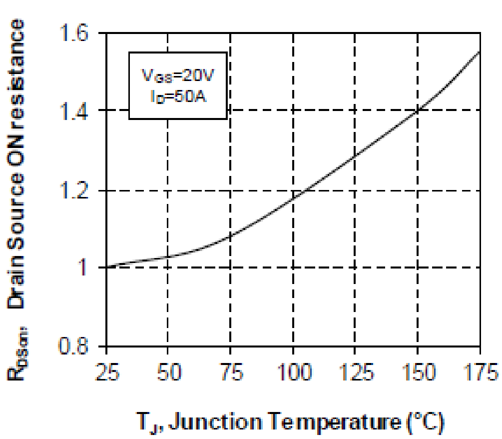


Figure 7 • Transfer Characteristics

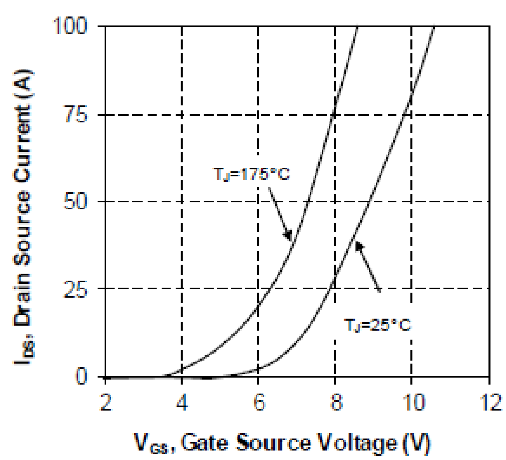


Figure 8 • Switching Energy vs. Rg

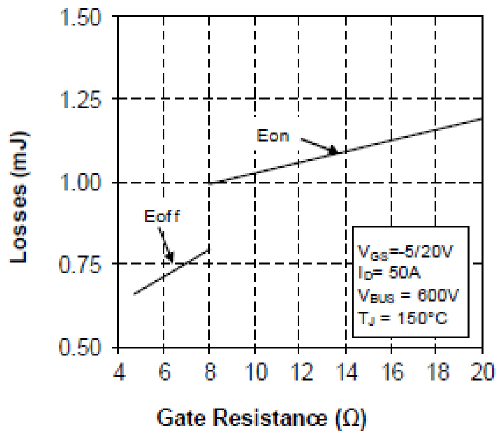


Figure 9 • Switching Energy vs. Current

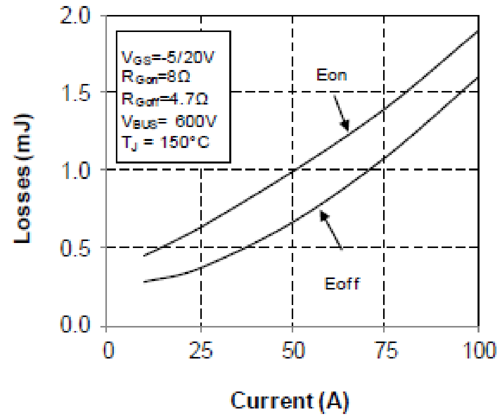


Figure 10 • Capacitance vs. Drain Source Voltage

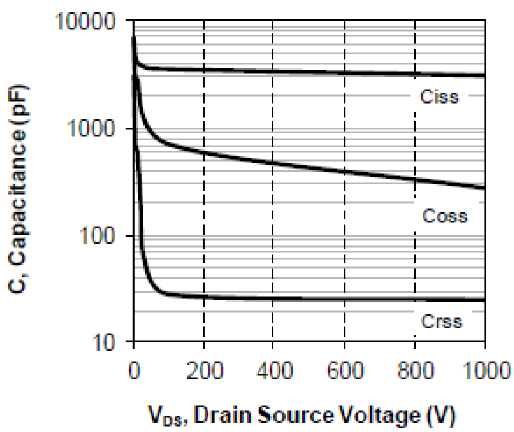


Figure 11 • Gate Charge vs. Gate Source Voltage

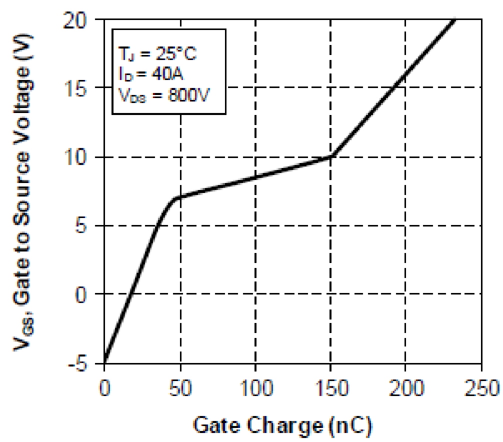


Figure 12 • Body Diode Characteristics, T_J = 25 °C

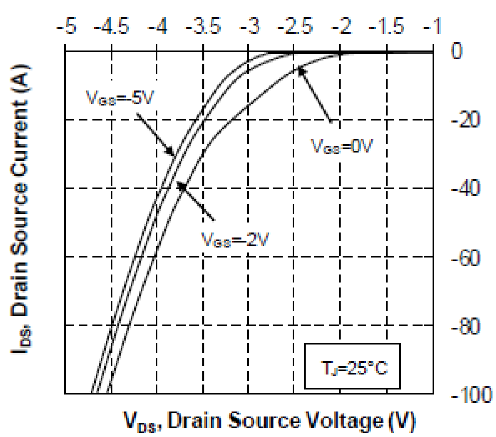


Figure 13 • 3rd Quadrant Characteristics, T_J = 25 °C

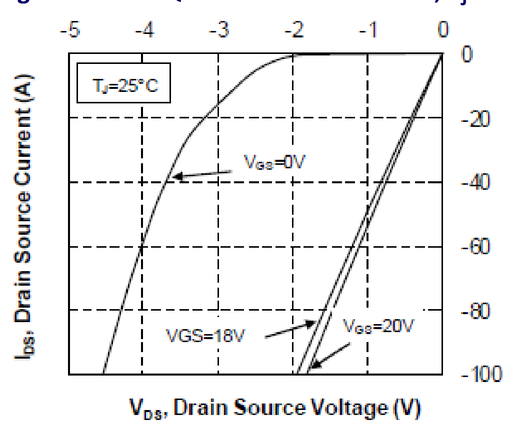


Figure 14 • Body Diode Characteristics, T_J = 175 °C

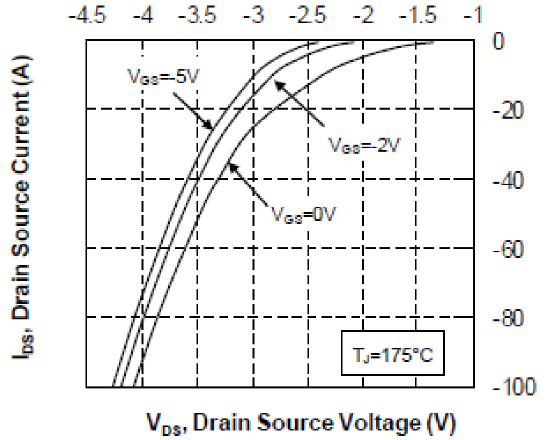


Figure 15 • 3rd Quadrant Characteristics, T_J = 175 °C

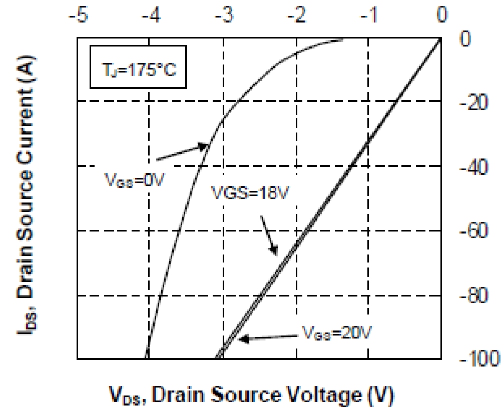
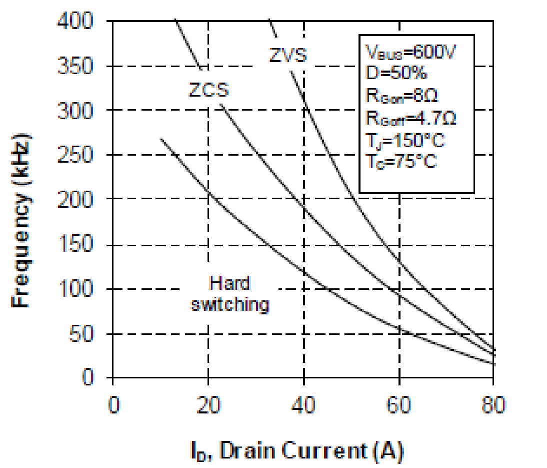


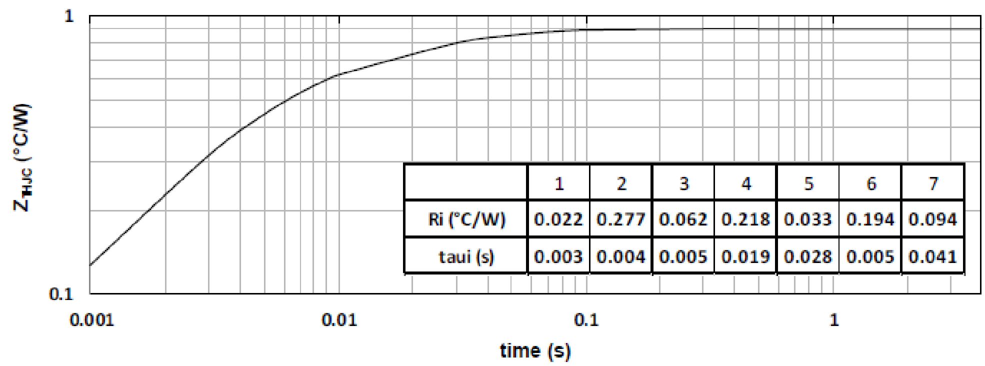
Figure 16 • Operating Frequency vs. Drain Current



3.5 Typical SiC Diode Performance Curves

This sections shows the typical SiC diode performance curves of the MSCSM120TAM31CT3AG device.

Figure 17 • Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.022	0.277	0.062	0.218	0.033	0.194	0.094
taui (s)	0.003	0.004	0.005	0.019	0.028	0.005	0.041

Figure 18 • Forward Characteristics

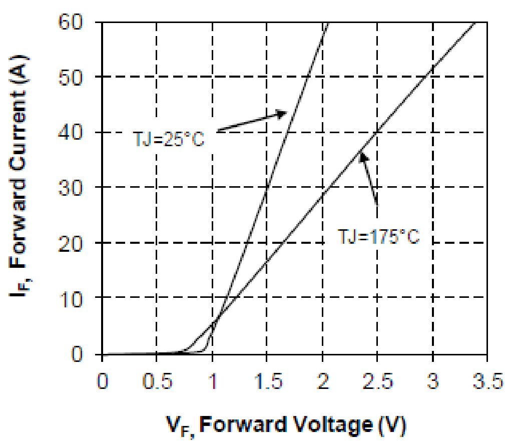
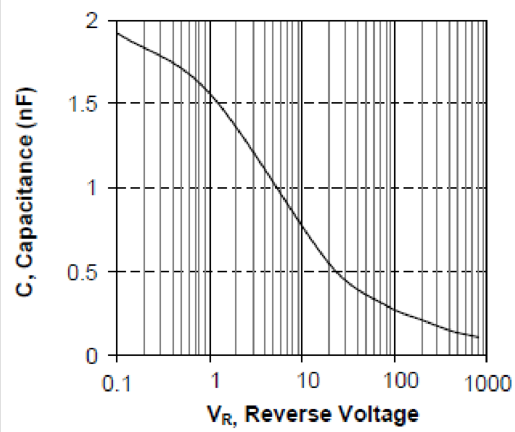


Figure 19 • Capacitance vs. Reverse Voltage



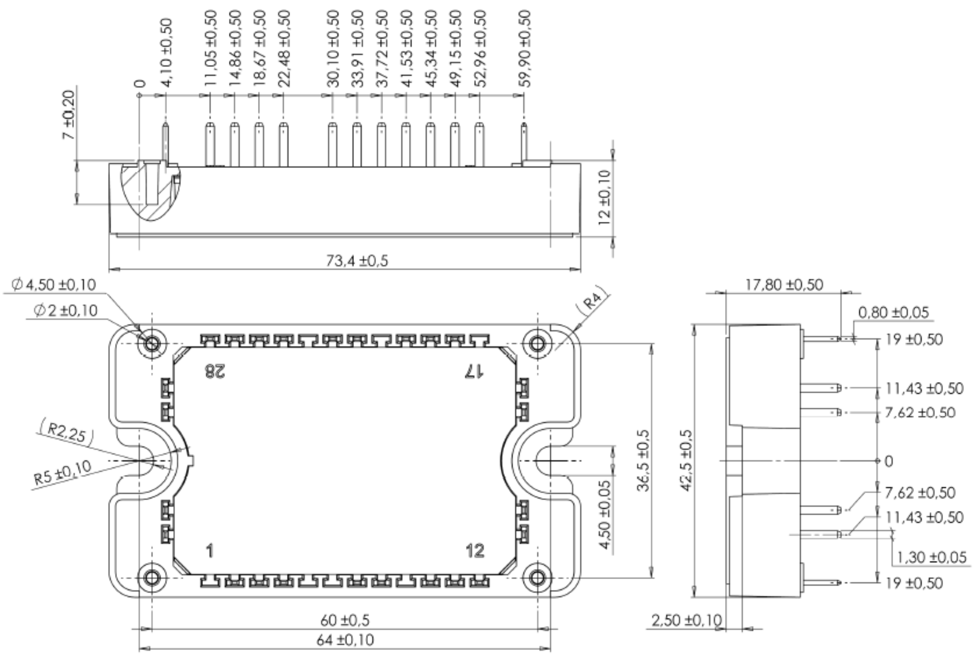
4 Package Specifications

This section shows the package specification of the MSCSM120TAM31CT3AG device.

4.1 Package Outline Drawing

The following figure illustrates the package outline of the MSCSM120TAM31CT3AG device. The dimensions in the following figure are in millimeters.

Figure 20 • Package Outline Drawing



Note: See application note *1906—Mounting Instructions for SP3F Power Modules* at www.microsemi.com.