# MSCSM120AM042CT6LIAG Datasheet Very Low Stray Inductance Phase Leg SiC MOSFET Power Module

January 2020





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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 MSCSM120AM042CT6LIAG device is a 1200 V, 495 A full Silicon Carbide power module.

Figure 1 • Electrical Schematic of MSCSM120AM042CT6LIAG Device

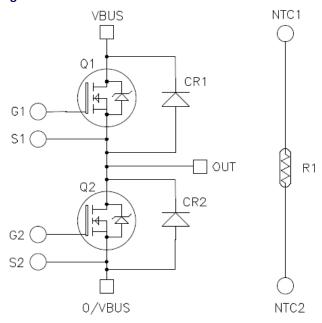
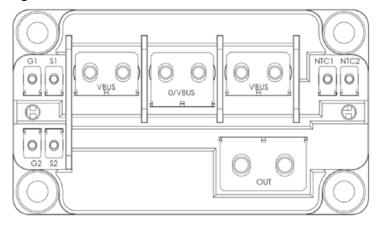


Figure 2 • Pinout Location



All ratings at Tj = 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 the features of MSCSM120AM042CT6LIAG device:

- SiC power MOSFET
  - Low R<sub>DS(on)</sub>
  - 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
- M4 and M5 power connectors
- M2.5 signals connectors
- AlN substrate for improved thermal performance

## 2.2 Benefits

The following are the benefits of MSCSM120AM042CT6LIAG device:

- High efficiency converter
- Outstanding performance at high frequency operation
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- Low profile
- RoHS compliant

## 2.3 Applications

The following are the applications of MSCSM120AM042CT6LIAG device:

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



# **3** Electrical Specifications

This section provides the electrical specifications for the MSCSM120AM042CT6LIAG device.

#### 3.1 SiC MOSFET Characteristics

The following table shows the absolute maximum ratings of MSCSM120AM042CT6LIAG device.

**Table 1 • Absolute Maximum Ratings** 

Symbol	Parameters	Maximum Ratings	Unit	
V <sub>DSS</sub>	Drain-source voltage	1200	V	
I <sub>D</sub>	Continuous drain current	T <sub>C</sub> = 25°C	495 <sup>1</sup>	А
		T <sub>C</sub> = 80°C	395 <sup>1</sup>	
I <sub>DM</sub>	Pulsed drain current		990	
V <sub>GS</sub>	Gate-source voltage		-10/25	V
R <sub>DSon</sub>	Drain–source ON resistance	5.2	mΩ	
P <sub>D</sub>	Power dissipation	T <sub>C</sub> = 25°C	2031	w

#### Note:

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

The following table shows the electrical characteristics of MSCSM120AM042CT6LIAG device.

**Table 2 • Electrical Characteristics** 

Symbol	Characteristics	Test Conditions		Min	Тур	Max	Unit
I <sub>DSS</sub>	Zero gate voltage drain current	V <sub>GS</sub> = 0 V ; V <sub>DS</sub> = 1200 V			60	600	μΑ
R <sub>DS(on)</sub>	Drain-source on resistance	V <sub>GS</sub> = 20 V	T <sub>C</sub> = 25°C		4.2	5.2	mΩ
	I <sub>D</sub> = 240 A	I <sub>D</sub> = 240 A	T <sub>C</sub> = 175°C		6.7		
V <sub>GS(th)</sub>	Gate threshold voltage	$V_{GS} = V_{DS}$ , $I_D = 6 \text{ mA}$		1.8	2.8		V
I <sub>GSS</sub>	Gate-source leakage current	V <sub>GS</sub> = 20 V, V <sub>DS</sub> = 0	V			0.6	μΑ



The following table shows the dynamic characteristics of MSCSM120AM042CT6LIAG device.

**Table 3 • Dynamic Characteristics** 

Symbol	Characteristics	<b>Test Conditions</b>	Min	Тур	Max	Unit
C <sub>iss</sub>	Input capacitance	V <sub>GS</sub> = 0 V		18.1		nF
C <sub>oss</sub>	Output capacitance	V <sub>DS</sub> = 1000 V f = 1 MHz		1.6		
C <sub>rss</sub>	Reverse transfer capacitance			0.15		
Qg	Total gate charge	V <sub>GS</sub> = -5/20 V		1392		nC
$Q_{gs}$	Gate-source charge	V <sub>Bus</sub> = 800 V I <sub>D</sub> = 240 A		246		
$Q_{gd}$	Gate-drain charge			300		
T <sub>d(on)</sub>	Turn-on delay time	V <sub>GS</sub> = -5/20 V		56		ns
T <sub>r</sub>	Rise time	$T_{J}$ = 150 °C $V_{Bus}$ = 600 V $I_{D}$ = 300 A $R_{G}$ = 0.5 $\Omega$		55		
T <sub>d(off)</sub>	Turn-off delay time			166		
T <sub>f</sub>	Fall time			67		
E <sub>on</sub>	Turn on energy	Inductive switching  T <sub>i</sub> = 150 °C		5.5		mJ
E <sub>off</sub>	Turn off energy	$V_{GS} = -5/20 \text{ V}$ $V_{Bus} = 600 \text{ V}$ $I_D = 300 \text{ A}$ $R_G = 0.5 \Omega$		4.97		
R <sub>Gint</sub>	Internal gate resistance			1.6		Ω
$R_{thJC}$	Junction-to-case thermal resistance				0.074	°C/W

The following table shows the body diode ratings and characteristics of MSCSM120AM042CT6LIAG device.

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

Symbol	Characteristics	Test Conditions	Min	Тур	Max	Unit
V <sub>SD</sub>	Diode forward voltage	V <sub>GS</sub> = 0 V ; I <sub>SD</sub> = 240 A		4		V
		V <sub>GS</sub> = -5 V ; I <sub>SD</sub> = 240 A		4.2		
t <sub>rr</sub>	Reverse recovery time	I <sub>SD</sub> = 240 A;		90		ns
Q <sub>rr</sub>	Reverse recovery charge	$V_{GS} = -5 \text{ V}$ $V_{R} = 800 \text{ V}$ ;		3.3		μС
I <sub>rr</sub>	Reverse recovery current	di <sub>F</sub> /dt = 6000 A/μs		81		А



# 3.2 SiC Diode Characteristics (Per SiC Diode)

The following table shows the SiC diode characteristics (per SiC diode) of MSCSM120AM042CT6LIAG device.

Table 5 • SiC Diode Characteristics (Per SiC Diode)

Symbol	Characteristics	Test Conditions		Min	Тур	Max	Unit
V <sub>RRM</sub>	Peak repetitive reverse voltage					1200	V
I <sub>RM</sub>	Reverse leakage current	V <sub>R</sub> = 1200 V	T <sub>J</sub> = 25°C		0.06	1.2	mA
			T <sub>J</sub> = 175°C		0.9		
I <sub>F</sub>	DC forward current		T <sub>C</sub> = 95°C		180		А
V <sub>F</sub>	Diode forward voltage	I <sub>F</sub> = 180 A	T <sub>J</sub> = 25°C		1.5	1.8	V
			T <sub>J</sub> = 175°C		2.1		
$Q_{C}$	Total capacitive charge	V <sub>R</sub> = 600 V			780		nC
С	Total capacitance	f = 1 MHz, V <sub>R</sub> = 400 V			846		pF
		f = 1 MHz, V <sub>R</sub> = 800 V			630		
R <sub>thJC</sub>	Junction-to-case thermal	resistance				0.175	°C/W



## 3.3 Thermal and Package Characteristics

The following table shows the package characteristics of MSCSM120AM042CT6LIAG device.

**Table 6 • Package Characteristics** 

Symbol	Characteristics			Min	Max	Unit
V <sub>ISOL</sub>	RMS isolation voltage, any term	inal to case t =1 m	4000		V	
Тյ	Operating junction temperature	e range		-40	175	°C
T <sub>JOP</sub>	Recommended junction temper	rature under switc	hing conditions	-40	T <sub>Jmax</sub> -25	
T <sub>STG</sub>	Storage temperature range	-40	125			
T <sub>C</sub>	Operating case temperature	-40	125			
Torque	Mounting torque	For terminals	M2.5	0.4	0.6	N.m
			M4	2	3	
			M5	2	3.5	
		To heatsink	M6	3	5	
L <sub>DC</sub>	Module stray inductance between $V_{BUS}$ and $0/V_{BUS}$				3	nH
Wt	Package weight				320	g

The following table shows the temperature sensor NTC of MSCSM120AM042CT6LIAG device.

**Table 7 • Temperature Sensor NTC** 

Symbol	Characteristics	Min	Тур	Max	Unit	
R <sub>25</sub>	Resistance at 25°C		50		kΩ	
$\Delta R_{25}/R_{25}$				5		%
B <sub>25/85</sub>	T <sub>25</sub> = 298.15 K		3952		K	
ΔΒ/Β		T <sub>C</sub> = 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<sub>T</sub>: Thermistor value at T



#### 3.4 SiC MOSFET Performance Curves

The following images show the SiC MOSFET performance curves of the MSCSM120AM042CT6LIAG device.

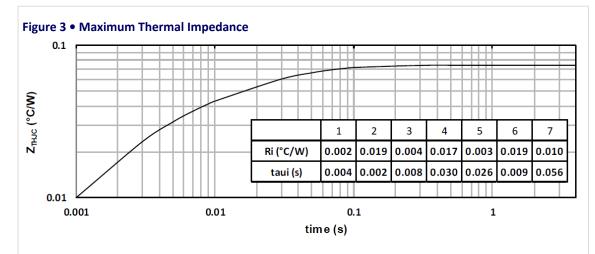
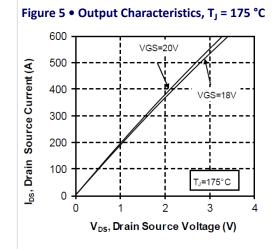
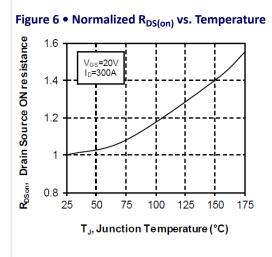


Figure 4 • Output Characteristics, T<sub>1</sub> = 25 °C 600 I<sub>DS</sub>, Drain Source Current (A) 500 V<sub>GS</sub>=20V 400 VGS=18V 300 200 100 T<sub>J</sub>=25°C 0 2.0 0.5 1.0 1.5 2.5 V<sub>DS</sub>, Drain Source Voltage (V)





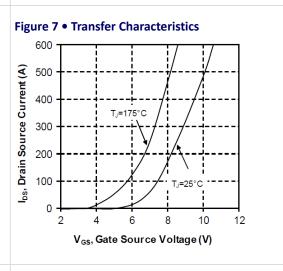




Figure 8 • Switching Energy vs. Rg

8
7
Eon
V<sub>GS</sub>=-5/20V
I<sub>D</sub>= 300A
V<sub>BUS</sub> = 600V
T<sub>J</sub> = 150°C

Gate resistance (ohm)

Figure 9 • Switching Energy vs. Current <sub>GS</sub>=-5/20V 5 R<sub>G</sub>=0.5Ω V<sub>BUS</sub>= 600V T<sub>J</sub> = 150°C Losses (mJ) Eoff 3 50 200 250 300 0 100 150 Current (A)

Figure 10 • Capacitance vs. Drain Source Voltage

100000

Ciss

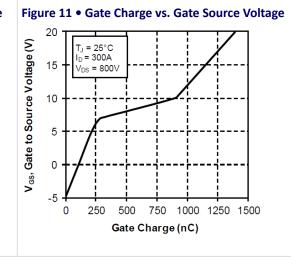
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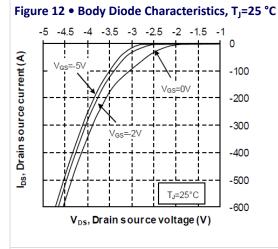
1000

Coss

Crss

VDS, Drain source Voltage (V)





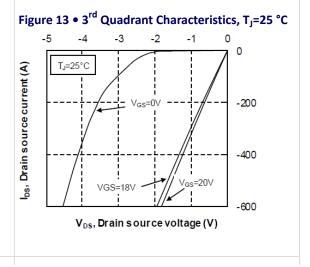




Figure 14 • Body Diode Characteristics, T<sub>J</sub>=175 °C

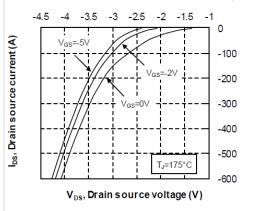


Figure 15 • 3<sup>rd</sup> Quadrant Characteristics, T<sub>j</sub>=175 °C

-5 -4 -3 -2 -1 0

-100

-100

-200

V<sub>GS</sub>=0V

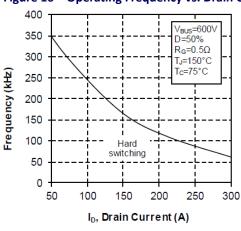
V<sub>GS</sub>=18V

-500

-600

 $V_{DS}$ , Drain source voltage (V)

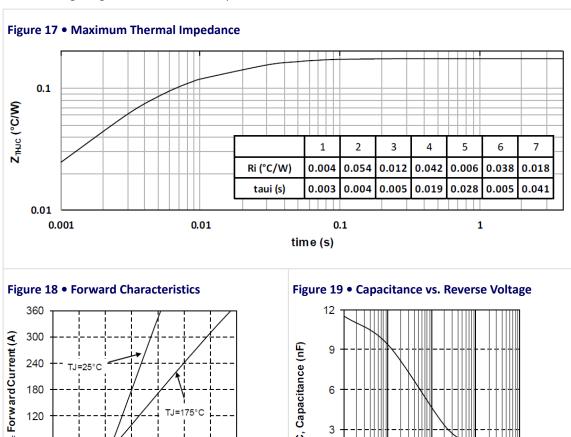
Figure 16 • Operating Frequency vs. Drain Current

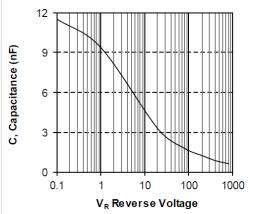




#### 3.5 **SiC Diode Performance Curves**

The following images show the SiC diode performance curves of MSCSM120AM042CT6LIAG device.







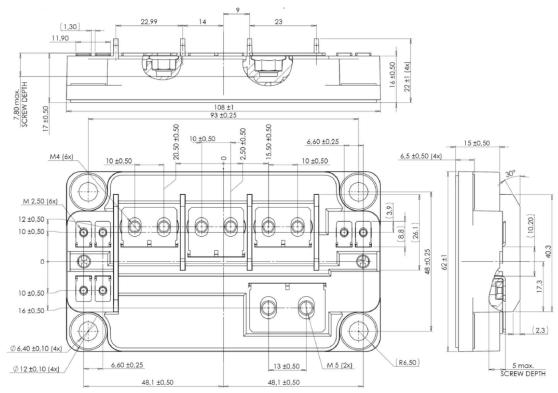
# 4 Package Specification

The following section shows the package specification of MSCSM120AM042CT6LIAG device.

## 4.1 Package Outline Drawing

The following image illustrates the package outline drawing of MSCSM120AM042CT6LIAG device. The dimensions are in millimeters.

Figure 20 • Package Outline Drawing



#### Note:

See AN1911—Mounting instructions for SP6 Low inductance Power Module application note.





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25.163.2453.	0 25.163.4253.0	25.190.2053.0	25.194.3453.0	25.320.4853.1	25.320.5253.1	25.326.3253.1	25.326.3553.1	25.330.1653.1
25.330.4753.	1 25.330.5253.1	25.334.3253.1	25.334.3353.1	25.350.2053.0	25.352.4753.1	25.522.3253.0	<u>T483C</u> <u>T484C</u>	<u>T485F</u> <u>T485H</u>
<u>T512F-YEB</u>	<u>T513F</u> <u>T514F</u>	T554 T612FSE	25.161.3453.0	25.179.2253.0	25.194.3253.0	25.325.1253.1	25.326.4253.1	25.330.0953.1
25.332.4353.	1 25.350.1653.0	25.350.2453.0	25.352.1453.0	25.352.1653.0	25.352.2453.0	25.352.5453.1	25.522.3353.0	25.602.4053.0
25.640.5053.	0							