

**MSCSM120AM042CD3AG**  
**Datasheet**  
**Phase Leg SiC Power Module**

January 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.

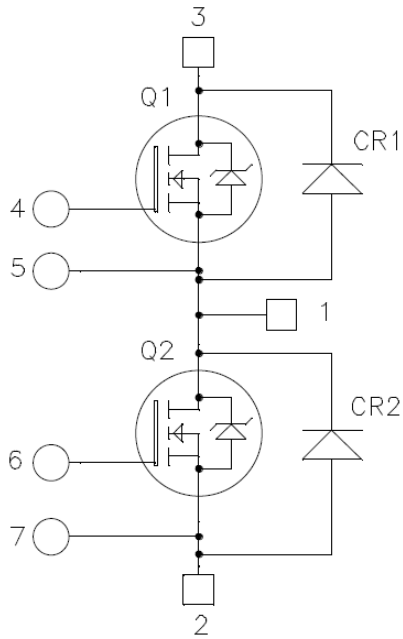
## 1.1 Revision 1.0

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

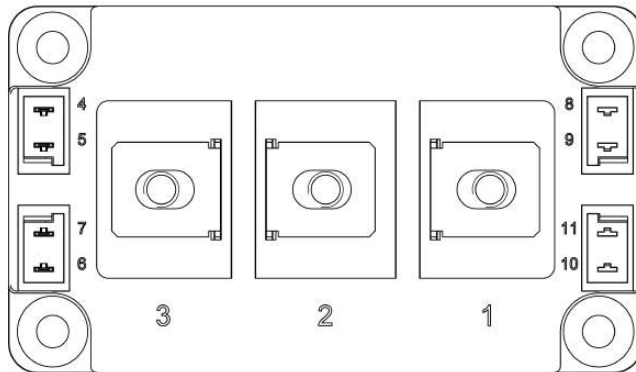
## 2 Product Overview

The MSCSM120AM042CD3AG is a phase leg 1200 V/495 A silicon carbide power module.

**Figure 1 • MSCSM120AM042CD3AG Electrical Schematic**



**Figure 2 • MSCSM120AM042CD3AG 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 MSCSM120AM042CD3AG device:

- SiC Power MOSFET
  - Low RDS(on)
  - High temperature performance
- Silicon carbide (SiC) Schottky diode
  - Zero reverse recovery
  - Zero forward recovery
  - Temperature-independent switching behavior
  - Positive temperature coefficient on VF
- Kelvin emitter for easy drive
- High level of integration
- Aluminum nitride (AlN) substrate for improved thermal performance
- M6 power connectors

## 2.2 Benefits

The following are benefits of the MSCSM120AM042CD3AG device:

- High efficiency converters
- Stable temperature behavior
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- RoHS Compliant

## 2.3 Applications

The MSCSM120AM042CD3AG device is designed for the following applications:

- Welding converters
- Switched Mode Power Supplies
- Uninterruptible Power Supplies
- EV motor and traction drive

## 3 Electrical Specifications

This section shows the electrical specifications of the MSCSM120AM042CD3AG device.

### 3.1 SiC MOSFET Characteristics (Per MOSFET)

This section describes the electrical characteristics of the MSCSM120AM042CD3AG device.

**Table 1 • Absolute Maximum Ratings**

Symbol	Parameter	Maximum Ratings	Unit
$V_{DSS}$	Drain-source voltage	1200	V
$I_D$	Continuous drain current	$T_C = 25\text{ }^\circ\text{C}$ 495 <sup>1</sup>	A
		$T_C = 80\text{ }^\circ\text{C}$ 395 <sup>1</sup>	
$I_{DM}$	Pulsed drain current	990	
$V_{GS}$	Gate-source voltage	-10/25	V
$R_{Dson}$	Drain-source ON resistance	5.2	m $\Omega$
$P_D$	Power dissipation	$T_C = 25\text{ }^\circ\text{C}$ 2031	W

**Note:**

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

**Table 2 • Electrical Characteristics**

Sym- bol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}; V_{DS} = 1200\text{ V}$		60	600	$\mu\text{A}$
$R_{Dson}$	Drain-source on resistance	$V_{GS} = 20\text{ V}$ $I_D = 240\text{ A}$	$T_J = 25\text{ }^\circ\text{C}$	4.2	5.2	m $\Omega$
			$T_J = 175\text{ }^\circ\text{C}$	6.7		
$V_{GS(th)}$	Gate threshold voltage	$V_{GS} = V_{DS}, I_D = 6\text{ mA}$	1.8	2.8		V
$I_{GSS}$	Gate-source leakage current	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$			600	nA



**Table 3 • Dynamic Characteristics**

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$C_{iss}$	Input capacitance	$V_{GS} = 0\text{ V}$ $V_{DS} = 1000\text{ V}$ $f = 1\text{ MHz}$		18.1		pF
$C_{oss}$	Output capacitance			1.6		
$C_{rss}$	Reverse transfer capacitance			0.15		
$Q_g$	Total gate charge	$V_{GS} = -5/20\text{ V}$ $V_{Bus} = 800\text{ V}$ $I_D = 240\text{ A}$		1392		nC
$Q_{gs}$	Gate–source charge			246		
$Q_{gd}$	Gate–drain charge			300		
$T_{d(on)}$	Turn-on delay time	$V_{GS} = -5/20\text{ V}$ $V_{Bus} = 600\text{ V}$ $I_D = 300\text{ A}$ $R_{Gon} = 1.3\Omega$ ; $R_{Goff} = 0.8\Omega$ $T_J = 150\text{ }^\circ\text{C}$		56		ns
$T_r$	Rise time			55		
$T_{d(off)}$	Turn-off delay time			166		
$T_f$	Fall time			67		
$E_{on}$	Turn on energy	Inductive Switching $V_{GS} = -5/20\text{ V}$ $V_{Bus} = 600\text{ V}$ $I_D = 300\text{ A}$ $R_{Gon} = 1.3\Omega$ $R_{Goff} = 0.8\Omega$	$T_J = 150\text{ }^\circ\text{C}$	6.1		mJ
$E_{off}$	Turn off energy		$T_J = 150\text{ }^\circ\text{C}$	5.5		mJ
$R_{Gint}$	Internal gate resistance			1		$\Omega$
$R_{thJC}$	Junction-to-case thermal resistance				0.074	$^\circ\text{C/W}$

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

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
$V_{SD}$	Diode forward voltage	$V_{GS} = 0\text{ V}$ ; $I_{SD} = 240\text{ A}$		4		V
		$V_{GS} = -5\text{ V}$ ; $I_{SD} = 240\text{ A}$		4.2		
$t_{rr}$	Reverse recovery time	$I_{SD} = 240\text{ A}$ ; $V_{GS} = -5\text{ V}$ ; $V_R = 800\text{ V}$ ; $diF/dt = 6000\text{ A}/\mu\text{s}$		90		ns
$Q_{rr}$	Reverse recovery charge			3300		nC
$I_{rr}$	Reverse recovery current			81		A

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

This section shows the SiC Schottky diode ratings and characteristics of the 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
$I_{RRM}$	Reverse leakage current	$V_R = 1200\text{ V}$	$T_J = 25\text{ }^\circ\text{C}$	60	1200	$\mu\text{A}$
			$T_J = 175\text{ }^\circ\text{C}$	900		
$I_F$	Forward current		$T_C = 100\text{ }^\circ\text{C}$	180		A
$V_F$	Diode forward voltage	$I_F = 180\text{ A}$	$T_J = 25\text{ }^\circ\text{C}$	1.5	1.8	V
			$T_J = 175\text{ }^\circ\text{C}$	2.1		
$Q_C$	Total capacitive charge	$V_R = 600\text{ V}$		780		nC
C	Total capacitance	$f = 1\text{ MHz}, V_R = 400\text{ V}$		846		$\mu\text{F}$
		$f = 1\text{ MHz}, V_R = 800\text{ V}$		630		
$R_{thJC}$	Junction-to-case thermal resistance				0.175	$^\circ\text{C/W}$

### 3.3 Thermal Package Characteristics

This section shows the thermal and package characteristics of the device.

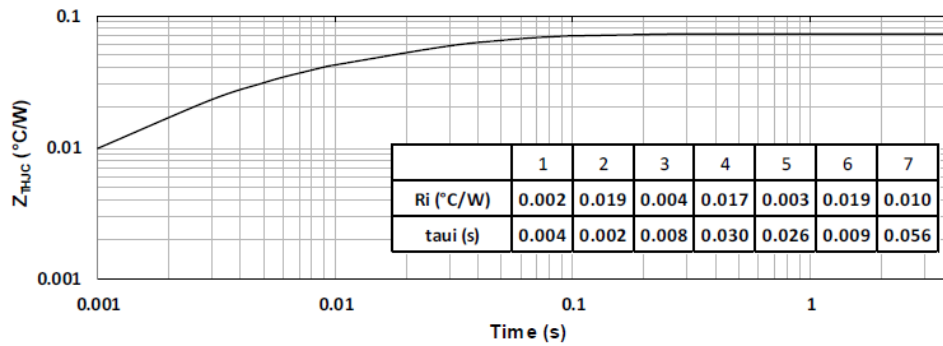
**Table 6 • Package Characteristics**

Symbol	Characteristic	Min	Max	Unit		
$V_{ISOL}$	RMS isolation voltage, any terminal to case $t = 1\text{ min}, 50/60\text{ Hz}$	4000		V		
$T_J$	Operating junction temperature range	-40	175	$^\circ\text{C}$		
$T_{JOP}$	Recommended junction temperature under switching conditions	-40	$T_{Jmax} - 25$	$^\circ\text{C}$		
$T_{STG}$	Storage temperature range	-40	125	$^\circ\text{C}$		
$T_C$	Operating case temperature	-40	125	$^\circ\text{C}$		
Torque	Mounting torque	For terminals	M6	3	5	N.m
		To heatsink	M6	3	5	
Wt	Package weight			350	g	

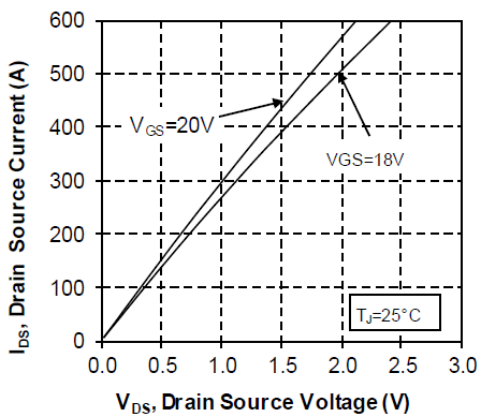
### 3.4 Typical SiC MOSFET Performance Curves

This section shows the typical performance curves of the MSCSM120AM042CD3AG SiC MOSFET.

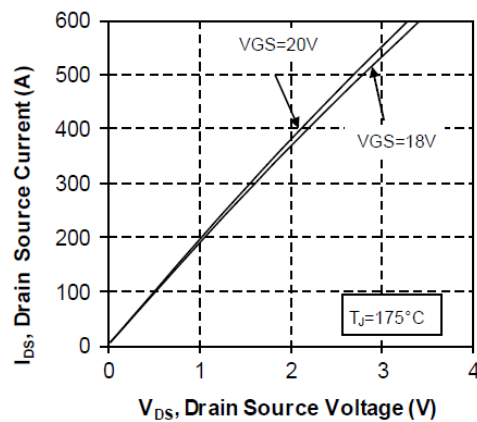
**Figure 3 • Maximum Thermal Impedance**



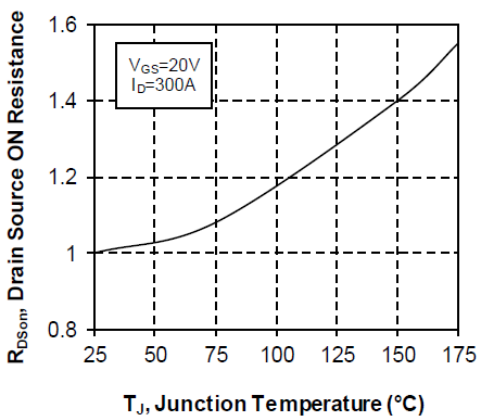
**Figure 4 • Output Characteristics, T<sub>J</sub> = 25 °C**



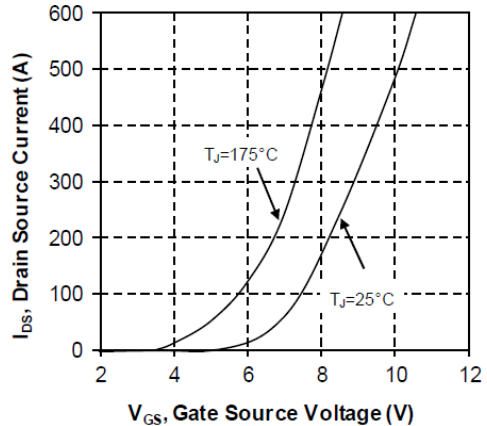
**Figure 5 • Output Characteristics, T<sub>J</sub> = 175 °C**



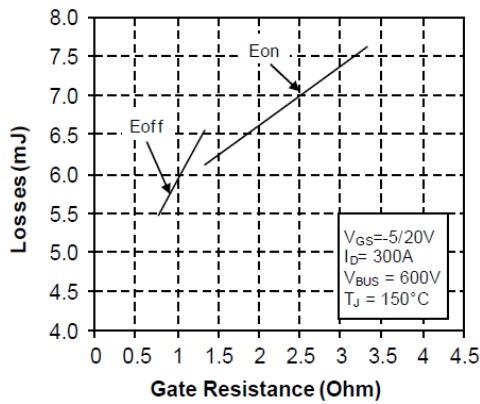
**Figure 6 • Normalized RDS(on) vs. Temperature**



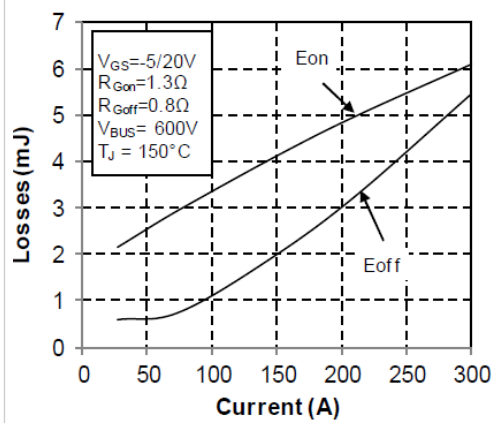
**Figure 7 • Transfer Characteristics**



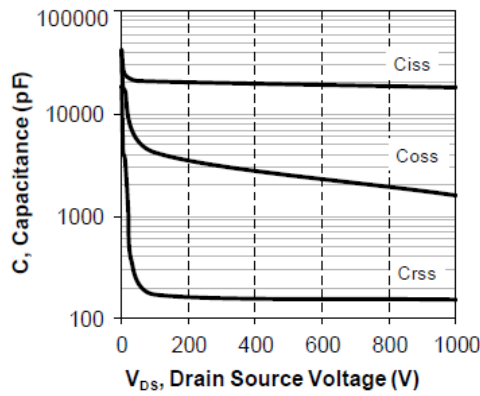
**Figure 8 • Switching Energy vs. Rg**



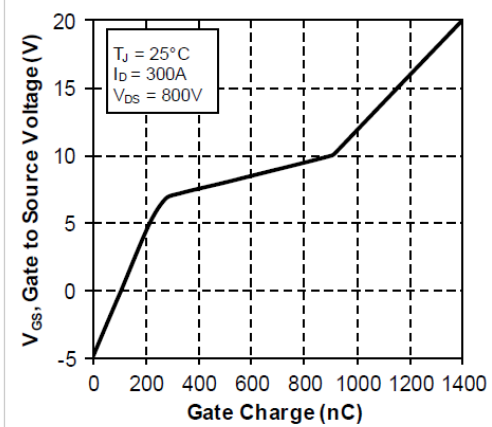
**Figure 9 • Switching Energy vs. Current**



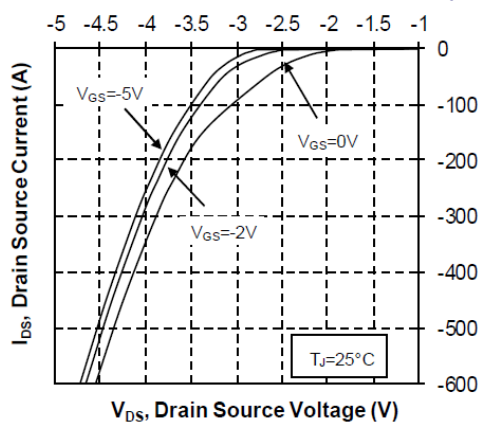
**Figure 10 • Capacitance vs. Drain Source Voltage**



**Figure 11 • Gate Charge vs. Gate Source Voltage**



**Figure 12 • Body Diode Characteristics, TJ = 25 °C**



**Figure 13 • 3<sup>rd</sup> Quadrant Characteristics, TJ = 25 °C**

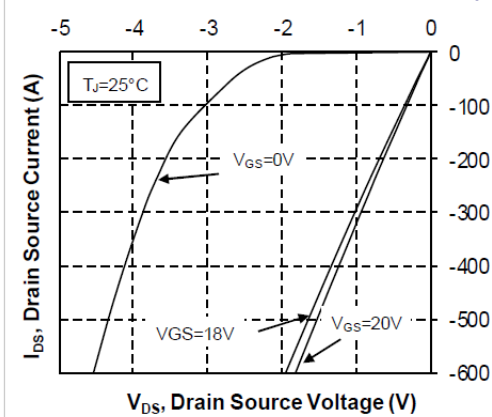


Figure 14 • Body Diode Characteristics,  $T_J = 175^\circ\text{C}$

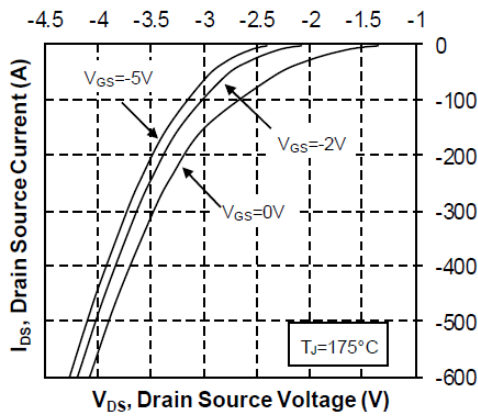


Figure 15 • 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$

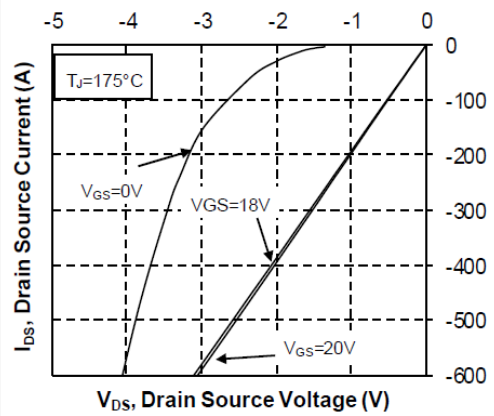
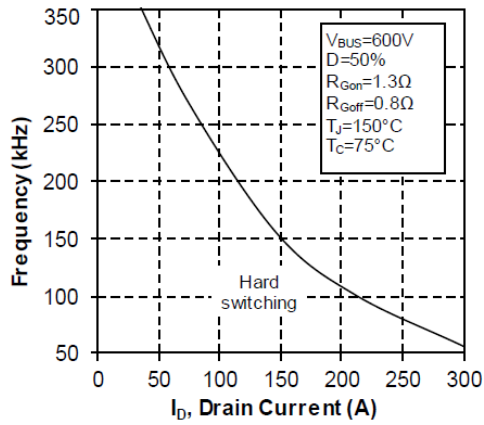


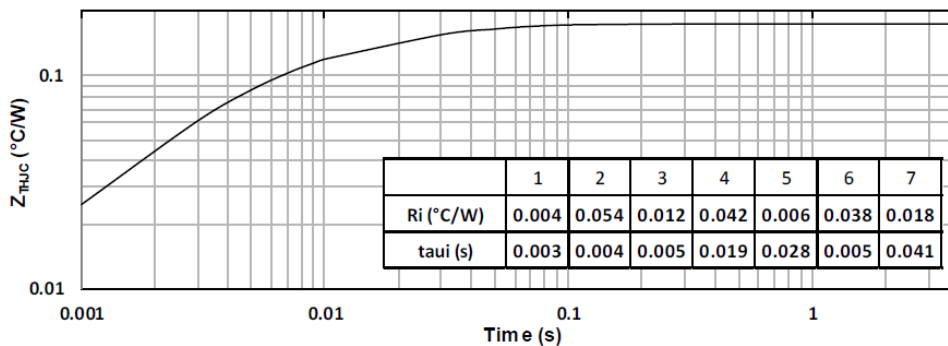
Figure 16 • Operating Frequency vs. Drain Current



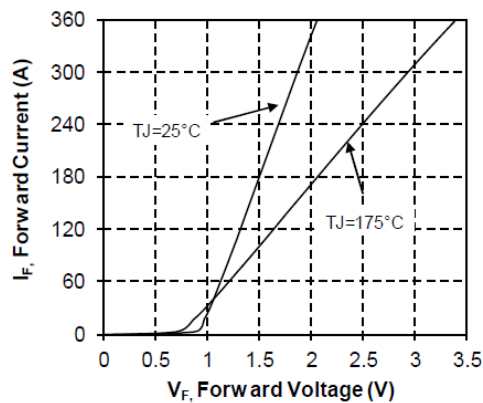
### 3.5 Typical SiC Diode Performance Curves

This section shows the typical performance curves of the MSCSM120AM042CD3AG SiC diode.

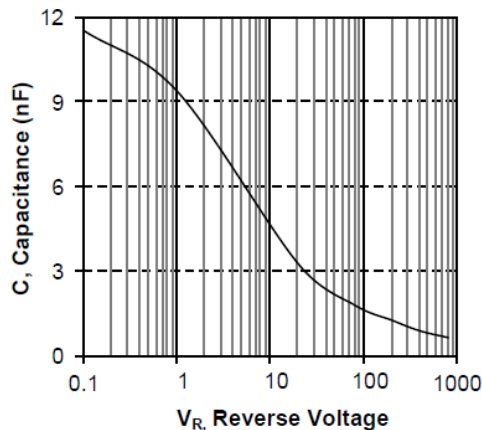
**Figure 17 • Maximum Thermal Impedance**



**Figure 18 • Forward Characteristics**



**Figure 19 • Capacitance vs. Reverse Voltage**





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