

**MSCSM120AM042CT6AG**  
**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.

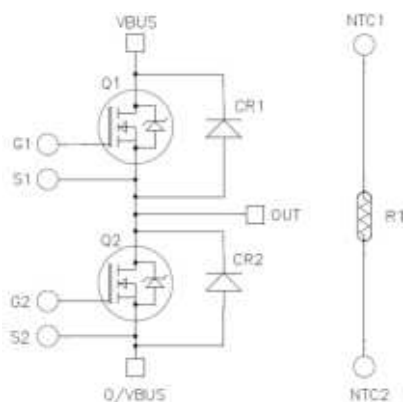
## 1.1 Revision 1.0

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

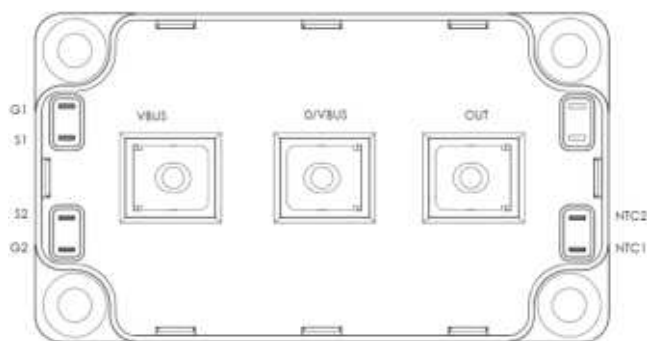
## 2 Product Overview

The MSCSM120AM042CT6AG is a phase leg 1200 V/495 A Silicon Carbide power module.

**Figure 1 • MSCSM120AM042CT6AG Electrical Schematic**



**Figure 2 • MSCSM120AM042CT6AG 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 MSCSM120AM042CT6AG 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 source for easy drive
- Low stray inductance
- M5 power connectors
- Internal thermistor for temperature monitoring
- Aluminum nitride (AlN) substrate for improved thermal performance

## 2.2 Benefits

The following are benefits of the MSCSM120AM042CT6AG device:

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

## 2.3 Applications

The MSCSM120AM042CT6AG 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 MSCSM120AM042CT6AG device.

### 3.1 SiC MOSFET Characteristics (Per MOSFET)

This section describes the electrical characteristics of the MSCSM120AM042CT6AG 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**

| Symbol       | Characteristic                  | Test Conditions                                                                      | Min | Typ | Max | Unit          |
|--------------|---------------------------------|--------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0\text{ V}; V_{DS} = 1200\text{ V}$                                        |     | 60  | 600 | $\mu\text{A}$ |
| $R_{DSon}$   | Drain–source on resistance      | $V_{GS} = 20\text{ V}$<br>$I_D = 240\text{ A}$<br>$T_J = 25\text{ }^{\circ}\text{C}$ |     | 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                   | $V_{GS} = 0\text{ V}$<br>$V_{DS} = 1000\text{ V}$<br>$f = 1\text{ MHz}$                                                                                              |                                   |     | 18.1 |       | pF                 |
| $C_{oss}$    | Output capacitance                  |                                                                                                                                                                      |                                   |     | 1.6  |       |                    |
| $C_{rss}$    | Reverse transfer capacitance        |                                                                                                                                                                      |                                   |     | 0.15 |       |                    |
| $Q_g$        | Total gate charge                   | $V_{GS} = -5/20\text{ V}$<br>$V_{Bus} = 800\text{ V}$<br>$I_D = 240\text{ A}$                                                                                        |                                   |     | 1392 |       | nC                 |
| $Q_{gs}$     | Gate-source charge                  |                                                                                                                                                                      |                                   |     | 246  |       |                    |
| $Q_{gd}$     | Gate-drain charge                   |                                                                                                                                                                      |                                   |     | 300  |       |                    |
| $T_{d(on)}$  | Turn-on delay time                  | $V_{GS} = -5/20\text{ V}$<br>$V_{Bus} = 600\text{ V}$<br>$I_D = 300\text{ A}$<br>$T_J = 150\text{ }^\circ\text{C}$<br>$R_{Gon} = 1.3\Omega$ ; $R_{Goff} = 0.8\Omega$ |                                   |     | 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<br>$V_{GS} = -5/20\text{ V}$                                                                                                                     | $T_J = 150\text{ }^\circ\text{C}$ |     | 6.1  |       | mJ                 |
| $E_{off}$    | Turn off energy                     | $V_{Bus} = 600\text{ V}$<br><br>$I_D = 300\text{ A}$<br>$R_{Gon} = 1.3\Omega$<br>$R_{Goff} = 0.8\Omega$                                                              | $T_J = 150\text{ }^\circ\text{C}$ |     | 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 |       | pF                   |
|            |                                     | $f = 1\text{ MHz}, V_R = 800\text{ V}$ |                                     |     | 630 |       |                      |
| $R_{thJC}$ | Junction-to-case thermal resistance |                                        |                                     |     |     | 0.175 | $^{\circ}\text{C/W}$ |

### 3.3 Thermal and 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 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   | M5 | 2    | 3.5             |                    |
| Wt         | Package weight                                                            |               |    |      | 300             | g                  |

**Table 7 • Temperature Sensor NTC<sup>1</sup>**

| Symbol                            | Characteristic             | Min | Typ  | Max | Unit |
|-----------------------------------|----------------------------|-----|------|-----|------|
| R <sub>25</sub>                   | Resistance at 25 °C        |     | 50   |     | kΩ   |
| ΔR <sub>25</sub> /R <sub>25</sub> |                            |     | 5    |     | %    |
| B <sub>25/85</sub>                | T <sub>25</sub> = 298.15 K |     | 3952 |     | K    |
| ΔB/B                              | 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

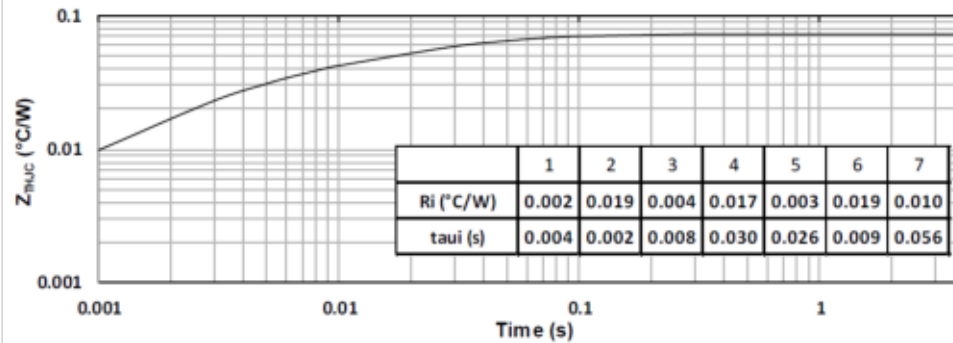
**Note:**

1. See the application note APT0406 on [www.microsemi.com](http://www.microsemi.com).

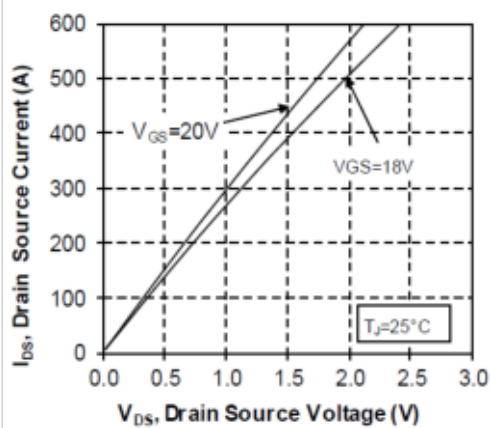
### 3.4 Typical SiC MOSFET Performance Curves

This section shows the typical performance curves of the MSCSM120AM042CT6AG SiC MOSFET.

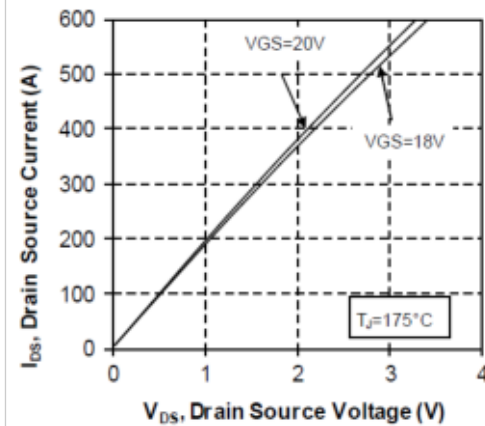
**Figure 3 • Maximum Thermal Impedance**



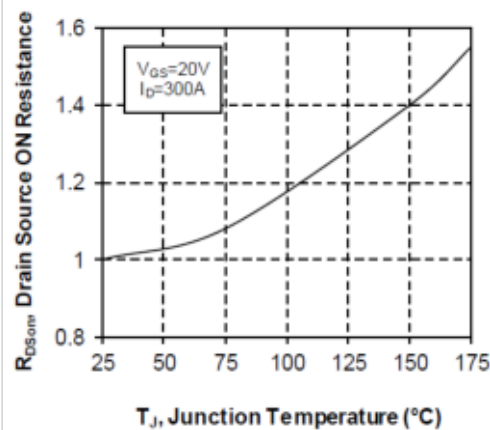
**Figure 4 • Output Characteristics at  $T_J = 25^\circ\text{C}$**



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



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



**Figure 7 • Transfer Characteristics**

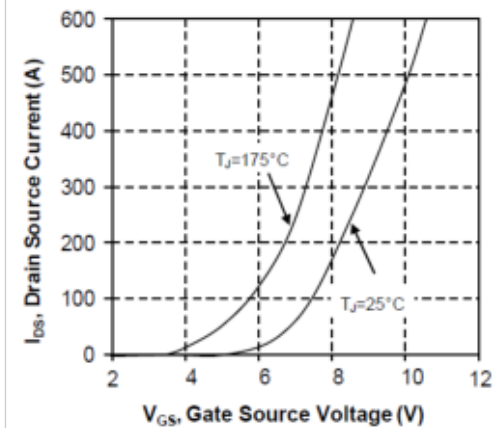


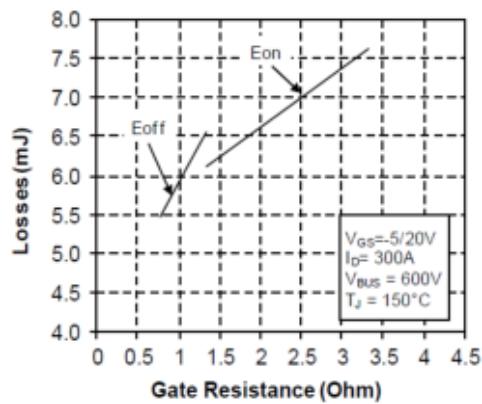
Figure 8 • Switching Energy vs.  $R_g$ 

Figure 9 • Switching Energy vs. Current

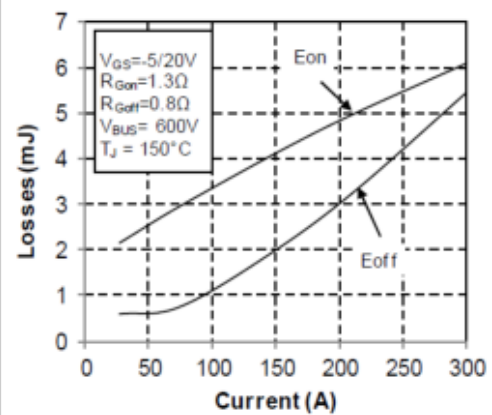


Figure 10 • Capacitance vs. Drain Source Voltage

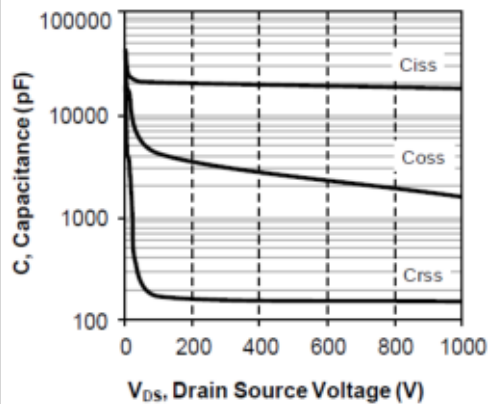


Figure 11 • Gate Charge vs. Gate Source Voltage

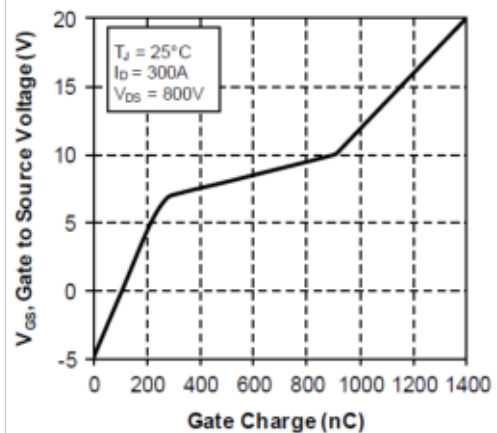
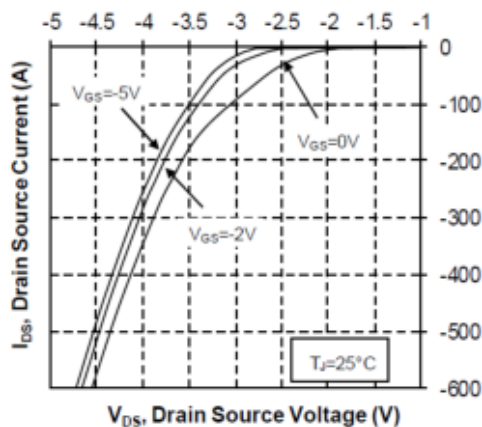
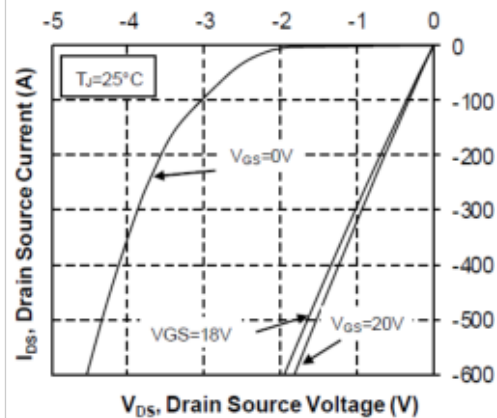
Figure 12 • Body Diode Characteristics,  $T_J = 25^\circ\text{C}$ Figure 13 • 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$ 

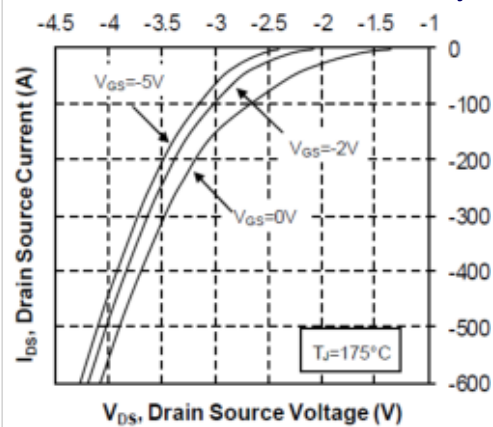
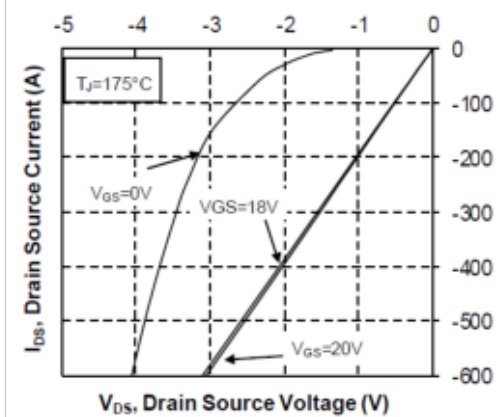
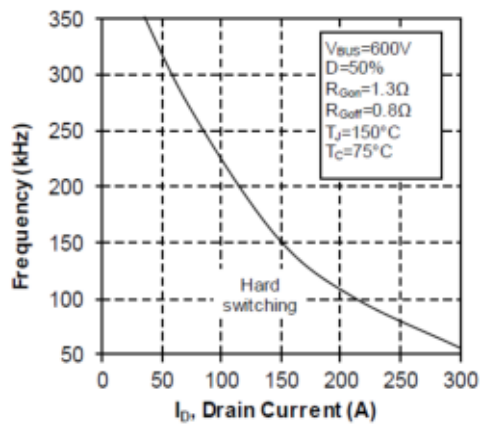
Figure 14 • Body Diode Characteristics,  $T_J = 175^\circ\text{C}$ Figure 15 • 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$ 

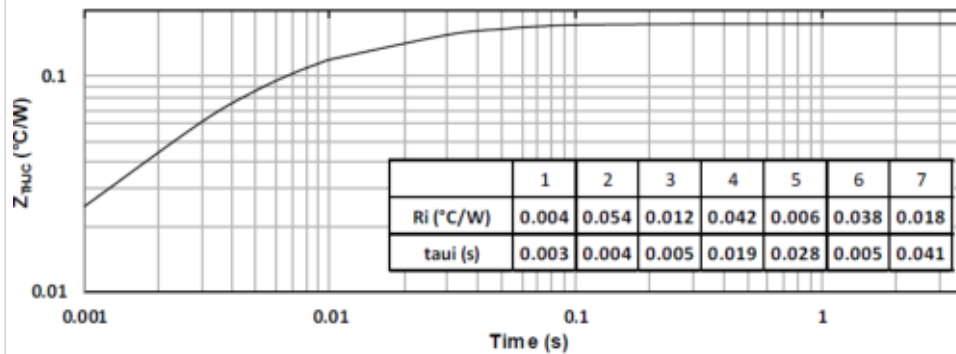
Figure 16 • Operating Frequency vs. Drain Current



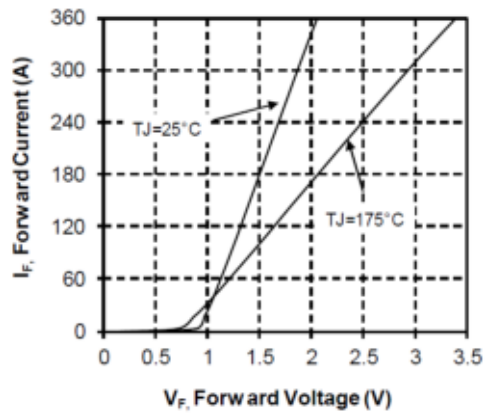
### 3.5 Typical SiC Diode Performance Curves

This section shows the typical performance curves of the MSCSM120AM042CT6AG SiC diode.

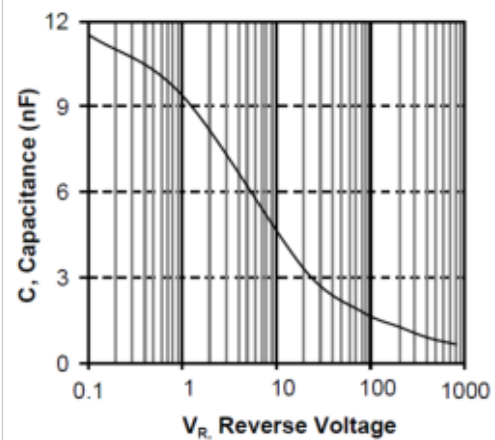
**Figure 17 • Maximum Thermal Impedance**



**Figure 18 • Forward Characteristics**



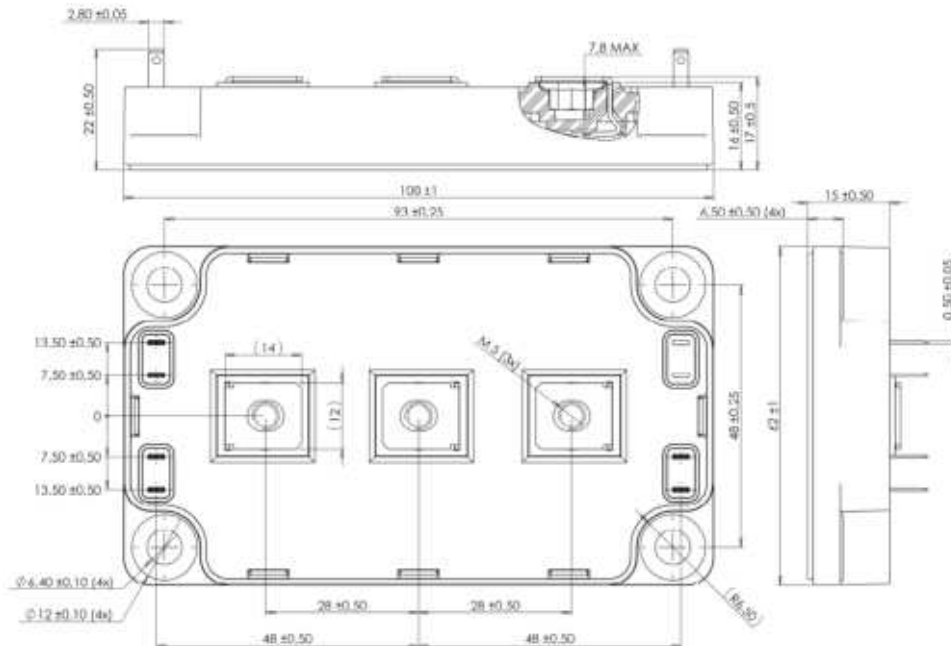
**Figure 19 • Capacitance vs. Reverse Voltage**



## 4 Package Specification

This section shows the package outline of the MSCSM120AM042CT6AG device. All dimensions are in millimeters.

**Figure 20 • Package Outline**



See application note APT0601 - Mounting Instructions for SP6 Power Modules on [www.microsemi.com](http://www.microsemi.com).

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