

**MSCSM120AM03CT6LIAG**

**Datasheet**

**Very Low Stray Inductance Phase Leg SiC  
MOSFET 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 was published in January 2020. It is the first publication of this document.

## 2 Product Overview

The MSCSM120AM03CT6LIAG device is a 1200 V, 805 A full Silicon Carbide power module.

**Figure 1 • Electrical Schematic of MSCSM120AM03CT6LIAG Device**

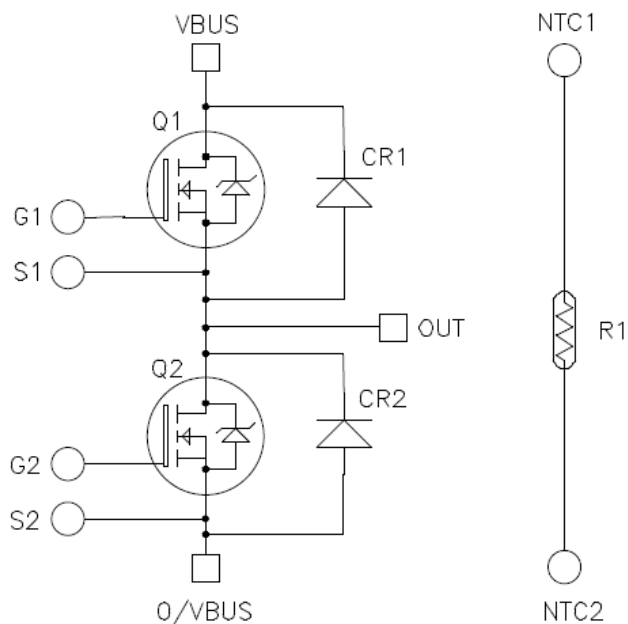
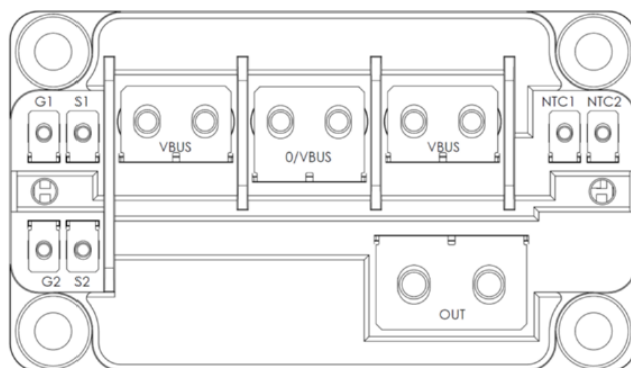


**Figure 2 • Pinout Location**



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 the features of MSCSM120AM03CT6LIAG 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
- M4 and M5 power connectors
- M2.5 signals connectors
- AlN substrate for improved thermal performance

## 2.2 Benefits

The following are the benefits of MSCSM120AM03CT6LIAG 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 MSCSM120AM03CT6LIAG 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 MSCSM120AM03CT6LIAG device.

### 3.1 SiC MOSFET Characteristics (Per MOSFET)

The following table shows the absolute maximum ratings of MSCSM120AM03CT6LIAG device.

**Table 1 • Absolute Maximum Ratings**

| Symbol       | Parameters                 |                          | Maximum Ratings  | Unit |
|--------------|----------------------------|--------------------------|------------------|------|
| $V_{DSS}$    | Drain–source voltage       |                          | 1200             | V    |
| $I_D$        | Continuous drain current   | $T_C = 25^\circ\text{C}$ | 805 <sup>1</sup> | A    |
|              |                            | $T_C = 80^\circ\text{C}$ | 640 <sup>1</sup> |      |
| $I_{DM}$     | Pulsed drain current       |                          | 1600             |      |
| $V_{GS}$     | Gate–source voltage        |                          | –10/25           | V    |
| $R_{DS(on)}$ | Drain–source ON resistance |                          | 3.1              | mΩ   |
| $P_D$        | Power dissipation          | $T_C = 25^\circ\text{C}$ | 3215             | 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 MSCSM120AM03CT6LIAG device.

**Table 2 • Electrical Characteristics**

| Symbol       | Characteristics                 | Test Conditions                                  |                           | Min | Typ | Max  | Unit |
|--------------|---------------------------------|--------------------------------------------------|---------------------------|-----|-----|------|------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 1200\text{ V}$ |                           |     | 150 | 1000 | μA   |
| $R_{DS(on)}$ | Drain–source on resistance      | $V_{GS} = 20\text{ V}$<br>$I_D = 400\text{ A}$   | $T_C = 25^\circ\text{C}$  |     | 2.5 | 3.1  | mΩ   |
|              |                                 |                                                  | $T_C = 175^\circ\text{C}$ |     | 4   |      |      |
| $V_{GS(th)}$ | Gate threshold voltage          | $V_{GS} = V_{DS}$ , $I_D = 10\text{ mA}$         |                           | 1.8 | 2.8 |      | V    |
| $I_{GSS}$    | Gate–source leakage current     | $V_{GS} = 20\text{ V}$ , $V_{DS} = 0\text{ V}$   |                           |     |     | 1    | μA   |

The following table shows the dynamic characteristics of MSCSM120AM03CT6LIAG device.

**Table 3 • Dynamic Characteristics**

| Symbol       | Characteristics                     | Test Conditions                                                                                                                                                        | Min | Typ  | Max   | Unit               |
|--------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-------|--------------------|
| $C_{iss}$    | Input capacitance                   | $V_{GS} = 0\text{ V}$<br>$V_{DS} = 1000\text{ V}$<br>$f = 1\text{ MHz}$                                                                                                |     | 30.2 |       | nF                 |
| $C_{oss}$    | Output capacitance                  |                                                                                                                                                                        |     | 2.7  |       |                    |
| $C_{rss}$    | Reverse transfer capacitance        |                                                                                                                                                                        |     | 0.25 |       |                    |
| $Q_g$        | Total gate charge                   | $V_{GS} = -5/20\text{ V}$<br>$V_{Bus} = 800\text{ V}$<br>$I_D = 400\text{ A}$                                                                                          |     | 2320 |       | nC                 |
| $Q_{gs}$     | Gate–source charge                  |                                                                                                                                                                        |     | 410  |       |                    |
| $Q_{gd}$     | Gate–drain charge                   |                                                                                                                                                                        |     | 500  |       |                    |
| $T_{d(on)}$  | Turn-on delay time                  | $V_{GS} = -5/20\text{ V}$<br>$T_J = 150\text{ }^\circ\text{C}$<br>$V_{Bus} = 600\text{ V}$<br>$I_D = 500\text{ A}$<br>$R_G = 0.3\text{ }\Omega$                        |     | 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>$T_J = 150\text{ }^\circ\text{C}$<br>$V_{GS} = -5/20\text{ V}$<br>$V_{Bus} = 600\text{ V}$<br>$I_D = 500\text{ A}$<br>$R_G = 0.3\text{ }\Omega$ |     | 9.2  |       | mJ                 |
| $E_{off}$    | Turn off energy                     |                                                                                                                                                                        |     | 8.3  |       |                    |
| $R_{Gint}$   | Internal gate resistance            |                                                                                                                                                                        |     | 0.98 |       | $\Omega$           |
| $R_{thJC}$   | Junction-to-case thermal resistance |                                                                                                                                                                        |     |      | 0.047 | $^\circ\text{C/W}$ |

The following table shows the body diode ratings and characteristics of MSCSM120AM03CT6LIAG device.

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

| Symbol   | Characteristics          | Test Conditions                                                                                                         | Min | Typ | Max | Unit          |
|----------|--------------------------|-------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| $V_{SD}$ | Diode forward voltage    | $V_{GS} = 0\text{ V}$ ;<br>$I_{SD} = 400\text{ A}$                                                                      |     | 4   |     | V             |
|          |                          | $V_{GS} = -5\text{ V}$ ;<br>$I_{SD} = 400\text{ A}$                                                                     |     | 4.2 |     |               |
| $t_{rr}$ | Reverse recovery time    | $I_{SD} = 400\text{ A}$ ;<br>$V_{GS} = -5\text{ V}$<br>$V_R = 800\text{ V}$ ;<br>$di_F/dt = 10000\text{ A}/\mu\text{s}$ |     | 90  |     | ns            |
| $Q_{rr}$ | Reverse recovery charge  |                                                                                                                         |     | 5.5 |     | $\mu\text{C}$ |
| $I_{rr}$ | Reverse recovery current |                                                                                                                         |     | 135 |     | A             |

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

The following table shows the SiC diode characteristics (per SiC diode) of MSCSM120AM03CT6LIAG device.

**Table 5 • SiC Diode Characteristics (Per SiC Diode)**

| Symbol     | Characteristics                     | Test Conditions                        |                       | Min | Typ  | Max   | Unit |
|------------|-------------------------------------|----------------------------------------|-----------------------|-----|------|-------|------|
| $V_{RRM}$  | Peak repetitive reverse voltage     |                                        |                       |     |      | 1200  | V    |
| $I_{RM}$   | Reverse leakage current             | $V_R = 1200\text{ V}$                  | $T_J = 25\text{ °C}$  |     | 0.08 | 1     | mA   |
|            |                                     |                                        | $T_J = 175\text{ °C}$ |     | 1.25 |       |      |
| $I_F$      | DC forward current                  |                                        | $T_C = 95\text{ °C}$  |     | 250  |       | A    |
| $V_F$      | Diode forward voltage               | $I_F = 250\text{ A}$                   | $T_J = 25\text{ °C}$  |     | 1.5  | 1.8   | V    |
|            |                                     |                                        | $T_J = 175\text{ °C}$ |     | 2.1  |       |      |
| $Q_C$      | Total capacitive charge             | $V_R = 600\text{ V}$                   |                       |     | 1120 |       | nC   |
| C          | Total capacitance                   | $f = 1\text{ MHz}, V_R = 400\text{ V}$ |                       |     | 1230 |       | pF   |
|            |                                     | $f = 1\text{ MHz}, V_R = 800\text{ V}$ |                       |     | 910  |       |      |
| $R_{thJC}$ | Junction-to-case thermal resistance |                                        |                       |     |      | 0.126 | °C/W |

### 3.3 Thermal and Package Characteristics

The following table shows the package characteristics of MSCSM120AM03CT6LIAG device.

**Table 6 • Package Characteristics**

| Symbol            | Characteristics                                                         |               |      | Min  | Max                   | Unit |
|-------------------|-------------------------------------------------------------------------|---------------|------|------|-----------------------|------|
| V <sub>ISOL</sub> | RMS isolation voltage, any terminal to case t =1 min, 50/60 Hz          |               |      | 4000 |                       | V    |
| T <sub>J</sub>    | Operating junction temperature range                                    |               |      | −40  | 175                   | °C   |
| T <sub>JOP</sub>  | Recommended junction temperature under switching 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 <sub>BUS</sub> and 0/V <sub>BUS</sub> |               |      |      | 3                     | nH   |
| Wt                | Package weight                                                          |               |      |      | 320                   | g    |

The following table shows the temperature sensor NTC of MSCSM120AM03CT6LIAG device.

**Table 7 • Temperature Sensor NTC**

| Symbol                            | Characteristics            |                        | 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

### 3.4 SiC MOSFET Performance Curves

The following images show the SiC MOSFET performance curves of the MSCSM120AM03CT6LIAG device.

**Figure 3 • Maximum Thermal Impedance**

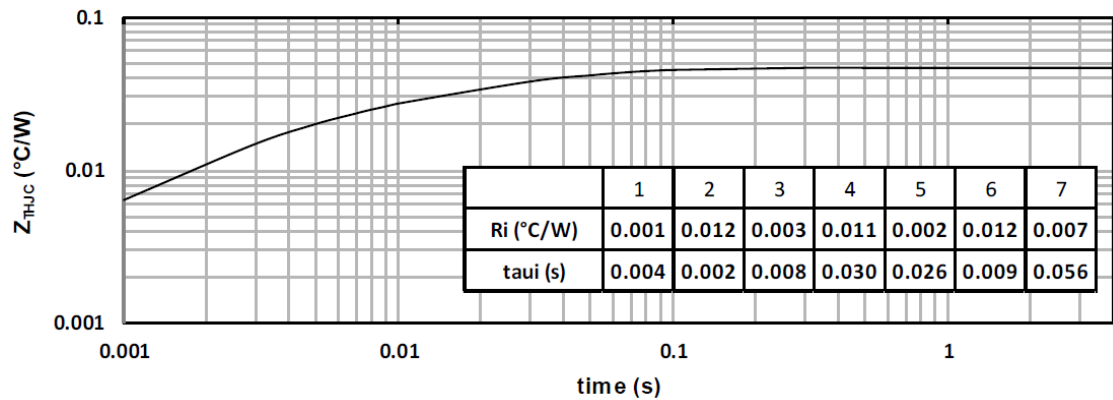


**Figure 4 • Output Characteristics,  $T_J = 25^\circ\text{C}$**

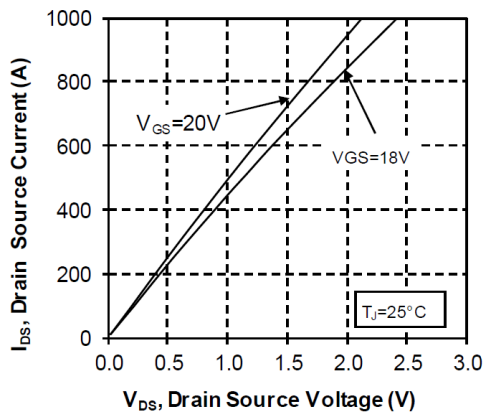


**Figure 5 • Output Characteristics,  $T_J = 175^\circ\text{C}$**

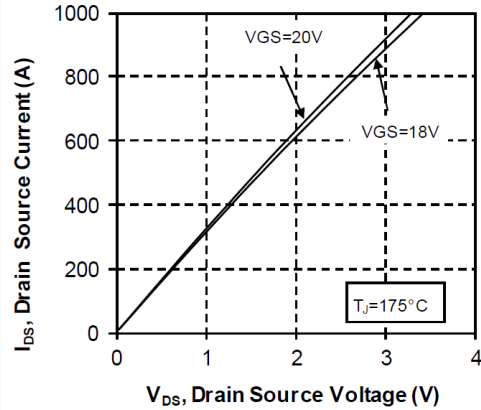


**Figure 6 • Normalized  $R_{DS(on)}$  vs. Temperature**

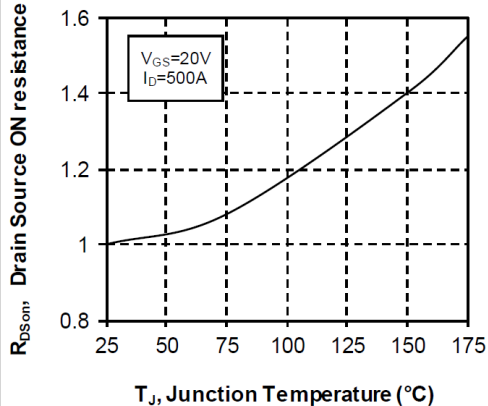


**Figure 7 • Transfer Characteristics**

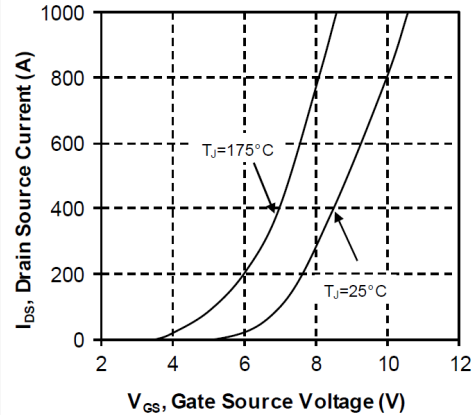


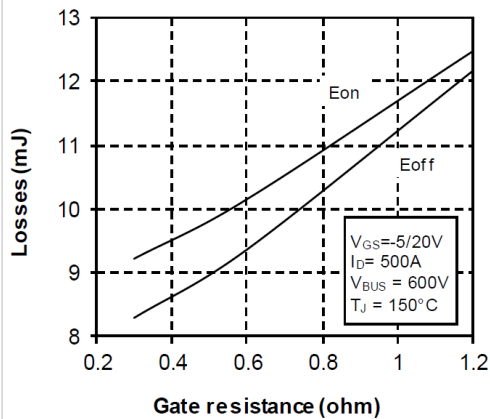
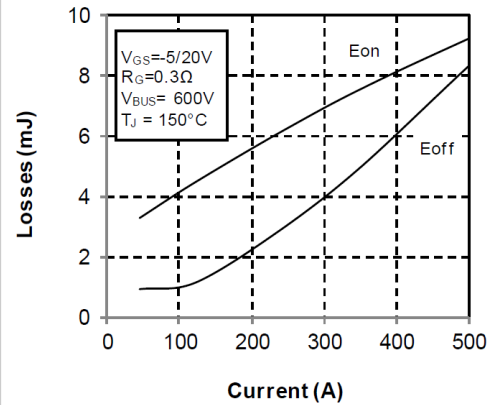
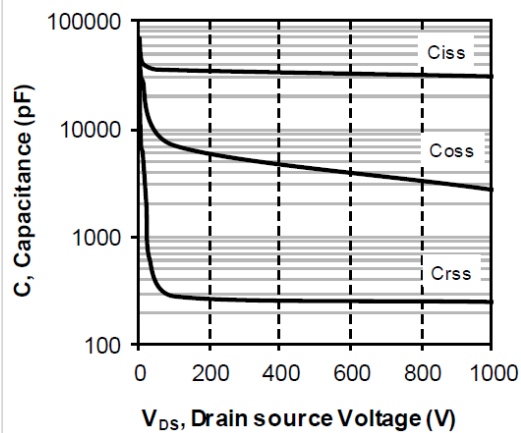
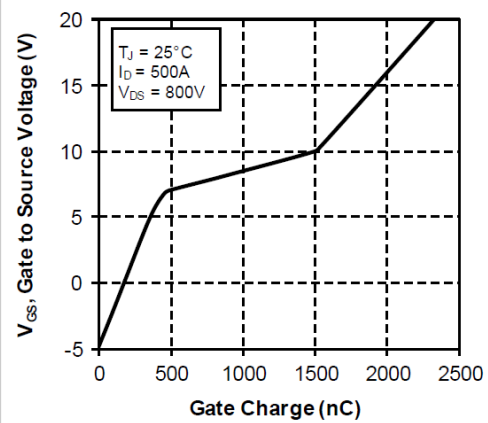
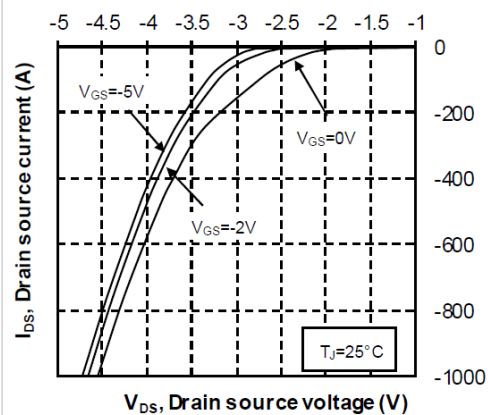
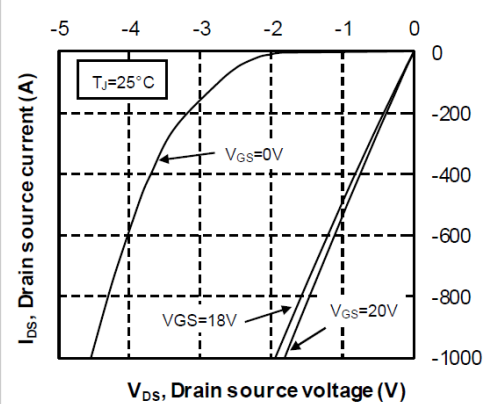
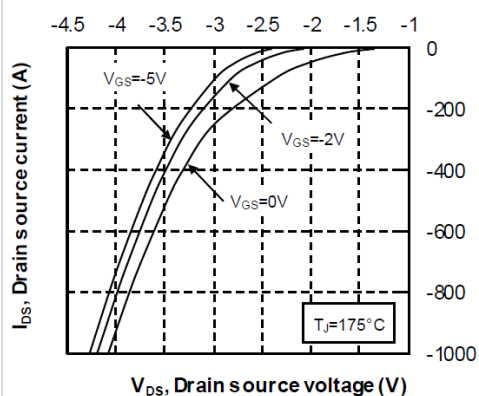
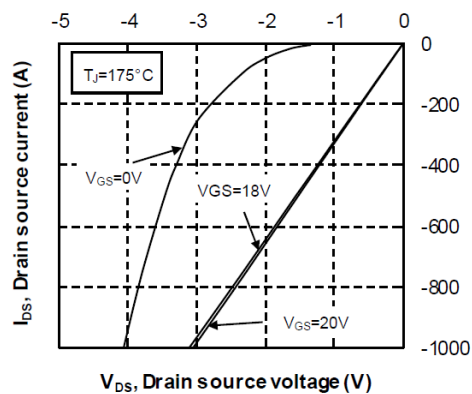
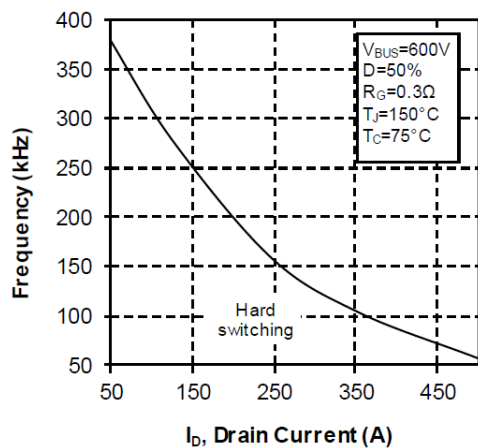
**Figure 8 • Switching Energy vs.  $R_g$** **Figure 9 • Switching Energy vs. Current****Figure 10 • Capacitance vs. Drain Source Voltage****Figure 11 • Gate Charge vs. Gate Source Voltage****Figure 12 • Body Diode Characteristics,  $T_J = 25^\circ C$** **Figure 13 • 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ C$** 

**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 SiC Diode Performance Curves

The following images show the SiC diode performance curves of MSCSM120AM03CT6LIAG device.

**Figure 17 • Maximum Thermal Impedance**

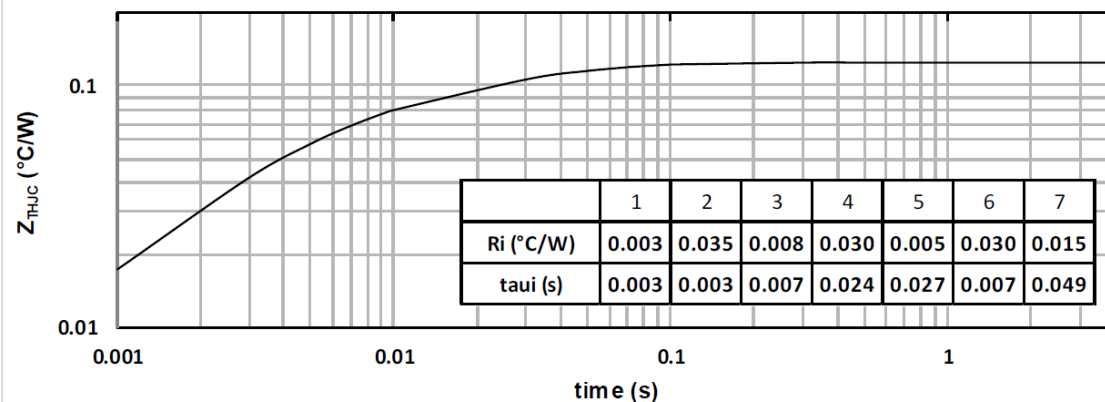


**Figure 18 • Forward Characteristics**

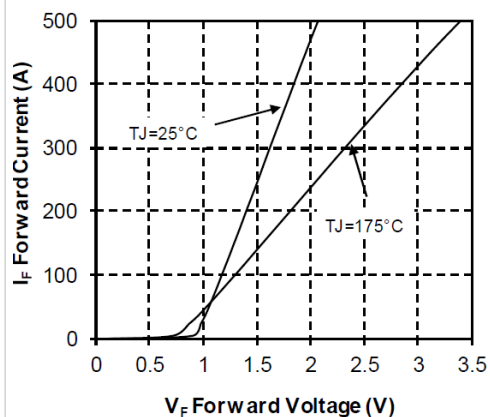
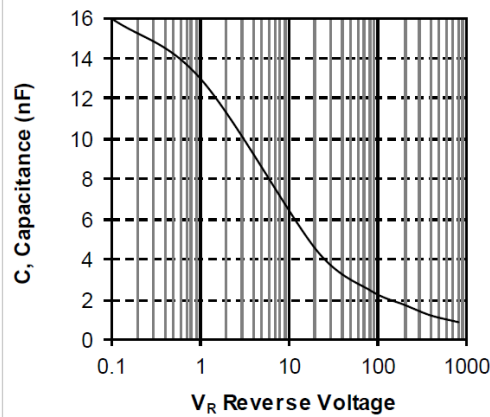


**Figure 19 • Capacitance vs. Reverse Voltage**



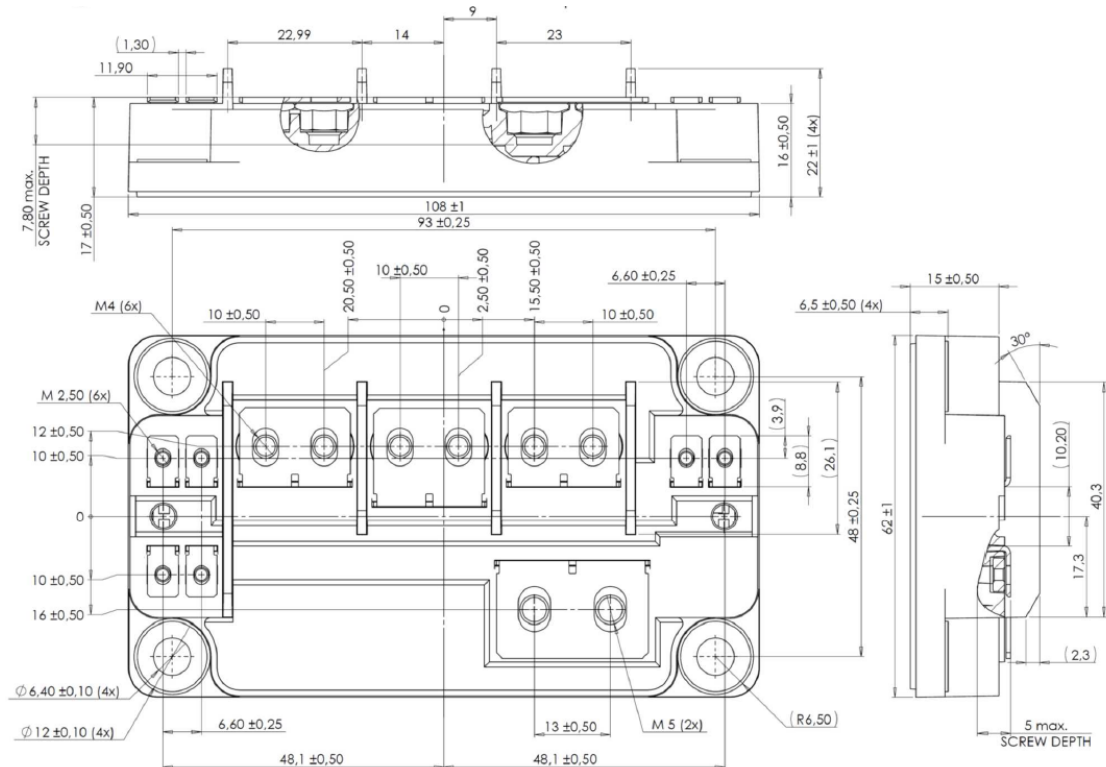
## 4 Package Specification

The following section shows the package specification of MSCSM120AM03CT6LIAG device.

## 4.1 Package Outline Drawing

The following image illustrates the package outline drawing of MSCSM120AM03CT6LIAG 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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