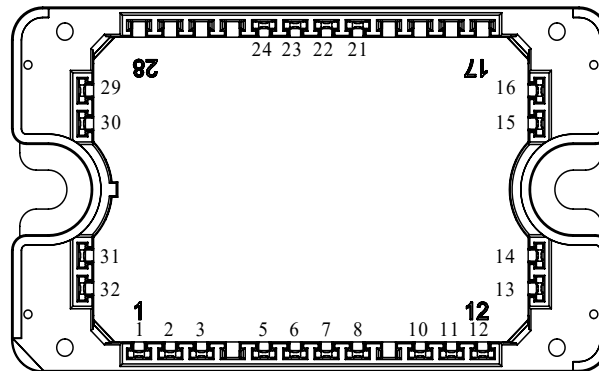
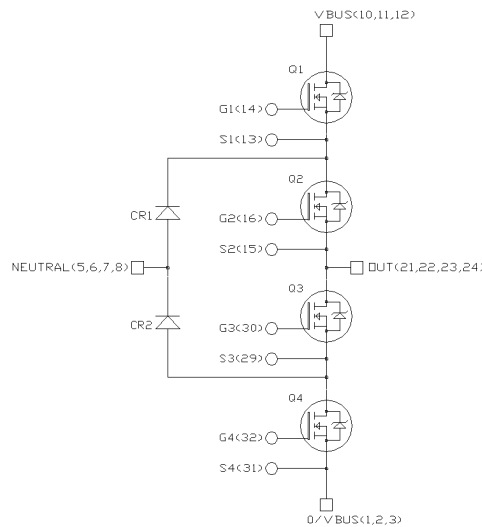


## Three Level Inverter SiC MOSFET Power Module

### Product Overview

The MSCSM120TLM31C3AG device is a 1200V/89A three level inverter silicon carbide (SiC) MOSFET power module.



**Note:**

1. All ratings at  $T_j = 25\text{ }^\circ\text{C}$ , unless otherwise specified.
2. All multiple inputs and outputs must be shorted together: 1/2/3 ; 10/11/12 ; 5/6/7/8 ; 21/22/23/24



These devices are sensitive to electrostatic discharge. Proper handling procedures must be followed.

## Features

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The following are the key features of MSCSM120TLM31C3AG device:

- SiC Power MOSFET
  - Low  $R_{DS(on)}$
  - High temperature performance
- SiC Schottky Diode (CR1 and CR2)
  - Zero reverse recovery
  - Zero forward recovery
  - Temperature independent switching behavior
  - Positive temperature coefficient on VF
- Kelvin source for easy drive
- Low stray inductance
- High level of integration
- AlN substrate for improved thermal performance

## Benefits

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The following are the benefits of MSCSM120TLM31C3AG device:

- Outstanding performance at high frequency operation
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- Solderable terminals both for power and signal for easy PCB mounting
- Low profile
- RoHS compliant

## Application

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The following are the applications of MSCSM120TLM31C3AG device:

- Uninterruptible power supplies

## 1. Electrical Specifications

This section provides the electrical specifications of the MSCSM120TLM31C3AG device.

### 1.1 SiC MOSFET Characteristics (Per SiC MOSFET)

The following table lists the absolute maximum ratings of MSCSM120TLM31C3AG device.

**Table 1-1. Absolute Maximum Ratings**

| Symbol       | Parameter                  | Maximum Ratings                  | Unit       |
|--------------|----------------------------|----------------------------------|------------|
| $V_{DSS}$    | Drain-Source voltage       | 1200                             | V          |
| $I_D$        | Continuous drain current   | $T_C = 25\text{ }^\circ\text{C}$ | 89         |
|              |                            | $T_C = 80\text{ }^\circ\text{C}$ | 71         |
| $I_{DM}$     | Pulsed drain current       | 180                              |            |
| $V_{GSmax}$  | Gate-Source voltage        | -10/25                           | V          |
| $R_{DS(on)}$ | Drain-Source ON resistance | 31                               | m $\Omega$ |
| $P_D$        | Power dissipation          | $T_C = 25\text{ }^\circ\text{C}$ | 395        |

The following table lists the electrical characteristics of MSCSM120TLM31C3AG device.

**Table 1-2. Electrical Characteristics**

| Symbol       | Characteristic                  | Test Conditions                          | Min.                              | Typ. | Max. | Unit    |            |
|--------------|---------------------------------|--|-----------------------------------|------|------|---------|------------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0V$<br>$V_{DS} = 1200V$        | —                                 | 10   | 100  | $\mu A$ |            |
| $R_{DS(on)}$ | Drain-Source on resistance      | $V_{GS} = 20V$<br>$I_D = 40A$            | $T_J = 25\text{ }^\circ\text{C}$  | —    | 25   | 31      | m $\Omega$ |
|              |                                 |  | $T_J = 175\text{ }^\circ\text{C}$ | —    | 40   | —       |            |
| $V_{GS(th)}$ | Gate threshold voltage          | $V_{GS} = V_{DS}$<br>$I_D = 1\text{ mA}$ | 1.8                               | 2.8  | —    | V       |            |
| $I_{GSS}$    | Gate-Source leakage current     | $V_{GS} = 20V$<br>$V_{DS} = 0V$          | —                                 | —    | 150  | nA      |            |

# MSCSM120TLM31C3AG

## Electrical Specifications

The following table lists the dynamic characteristics of MSCSM120TLM31C3AG device.

**Table 1-3. Dynamic Characteristics**

| Symbol              | Characteristic                      | Test Conditions  | Min.                    | Typ. | Max. | Unit |
|---------------------|-------------------------------------|--|-------------------------|------|------|------|
| C <sub>iss</sub>    | Input capacitance                   | V <sub>GS</sub> = 0V   | —                       | 3020 | —    | pF   |
| C <sub>oss</sub>    | Output capacitance                  | V <sub>DS</sub> = 1000V  | —                       | 270  | —    |      |
| C <sub>rss</sub>    | Reverse transfer capacitance        | f = 1 MHz  | —                       | 25   | —    |      |
| Q <sub>g</sub>      | Total gate charge                   | V <sub>GS</sub> = -5V/20V  | —                       | 232  | —    | nC   |
| Q <sub>gs</sub>     | Gate-Source charge                  | V <sub>Bus</sub> = 800V  | —                       | 41   | —    |      |
| Q <sub>gd</sub>     | Gate-Drain charge                   | I <sub>D</sub> = 40A   | —                       | 50   | —    |      |
| T <sub>d(on)</sub>  | Turn-on delay time                  | V <sub>GS</sub> = -5V/20V  | —                       | 30   | —    | ns   |
| T <sub>r</sub>      | Rise time                           | V <sub>Bus</sub> = 800V  | —                       | 30   | —    |      |
| T <sub>d(off)</sub> | Turn-off delay time                 | I <sub>D</sub> = 50A   | —                       | 50   | —    |      |
| T <sub>f</sub>      | Fall time                           | R <sub>Gon</sub> = 8Ω<br>R <sub>Goff</sub> = 4.7Ω  | —                       | 25   | —    |      |
| E <sub>on</sub>     | Turn-on energy                      | V <sub>GS</sub> = -5V/20V  | T <sub>J</sub> = 150 °C | —    | 0.99 | mJ   |
| E <sub>off</sub>    | Turn-off energy                     | V <sub>Bus</sub> = 600V<br>I <sub>D</sub> = 50A<br>R <sub>Gon</sub> = 8Ω<br>R <sub>Goff</sub> = 4.7Ω | T <sub>J</sub> = 150 °C | —    | 0.66 |      |
| R <sub>Gint</sub>   | Internal gate resistance            |  | —                       | 0.88 | —    | Ω    |
| R <sub>thJC</sub>   | Junction-to-case thermal resistance |  | —                       | —    | 0.38 | °C/W |

The following table lists the body diode ratings and characteristics of MSCSM120TLM31C3AG device.

**Table 1-4. Body Diode Ratings and Characteristics**

| Symbol          | Characteristic           | Test Conditions  | Min. | Typ. | Max. | Unit |
|-----------------|--------------------------|--|------|------|------|------|
| V <sub>SD</sub> | Diode forward voltage    | V <sub>GS</sub> = 0V<br>I <sub>SD</sub> = 40A            | —    | 4    | —    | V    |
|                 |                          | V <sub>GS</sub> = -5V<br>I <sub>SD</sub> = 40A           | —    | 4.2  | —    |      |
| t <sub>rr</sub> | Reverse recovery time    | I <sub>SD</sub> = 40A                                    | —    | 90   | —    | ns   |
| Q <sub>rr</sub> | Reverse recovery charge  | V <sub>GS</sub> = -5V                                    | —    | 550  | —    | nC   |
| I <sub>rr</sub> | Reverse recovery current | V <sub>R</sub> = 800V<br>di <sub>F</sub> /dt = 1000 A/μs | —    | 13.5 | —    | A    |

### 1.2 CR1 and CR2 SiC Diode Ratings and Characteristics (Per SiC Diode)

The following table lists the CR1 and CR2 SiC diode ratings and characteristics (per SiC diode) of MSCSM120TLM31C3AG device.

**Table 1-5. CR1 and CR2 SiC 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                 | $V_R = 1200\text{ V}$                      | $T_J = 25\text{ }^\circ\text{C}$  | —    | 15   | 200                | $\mu\text{A}$ |
|            |   |  | $T_J = 175\text{ }^\circ\text{C}$ | —    | 250  | —                  |               |
| $I_F$      | DC forward current                      |  |                                   |      |      |                    |               |
| $V_F$      | Diode forward voltage                   | $I_F = 50\text{ A}$                        | $T_J = 25\text{ }^\circ\text{C}$  | —    | 1.5  | 1.8                | V             |
|            |   |  | $T_J = 175\text{ }^\circ\text{C}$ | —    | 2.1  | —                  |               |
| $Q_C$      | Total capacitive charge                 | $V_R = 600\text{ V}$                       | —                                 | 224  | —    | nC                 |               |
| C          | Total capacitance                       | $f = 1\text{ MHz}$<br>$V_R = 400\text{ V}$ | —                                 | 246  | —    | pF                 |               |
|            |   | $f = 1\text{ MHz}$<br>$V_R = 800\text{ V}$ | —                                 | 182  | —    |                    |               |
| $R_{thJH}$ | Junction-to-heatsink thermal resistance |  | —                                 | —    | 0.56 | $^\circ\text{C/W}$ |               |

### 1.3 Thermal and Package Characteristics

The following table lists the thermal and package characteristics of the MSCSM120TLM31C3AG device.

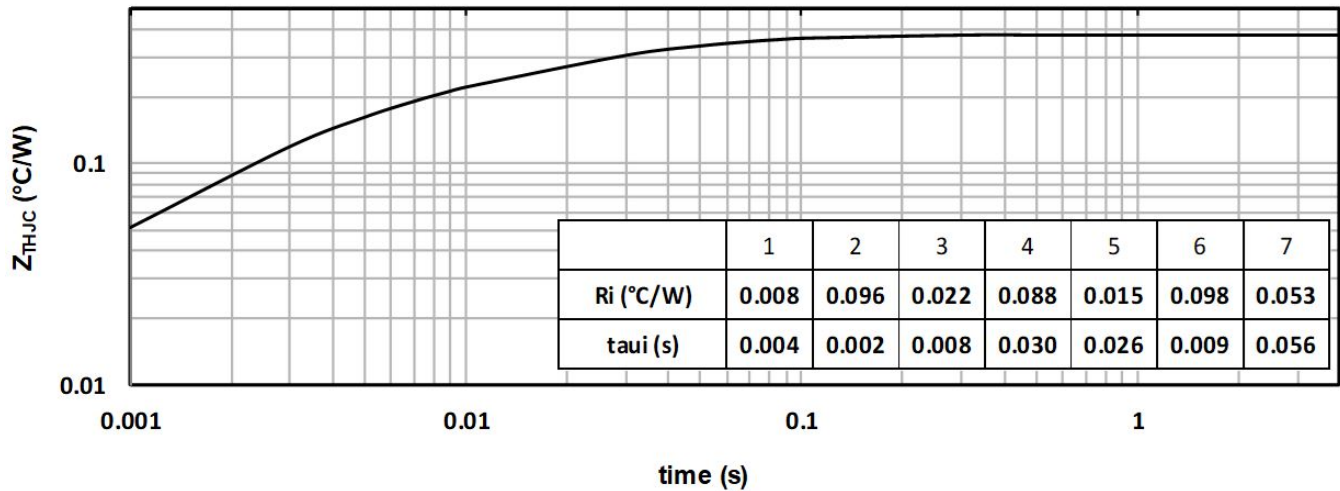
**Table 1-6. Thermal and Package Characteristics**

| 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 case temperature   | -40         | 125           |      |   |     |
| $T_C$      | Operating case temperature   | -40         | 125           |      |   |     |
| Torque     | Mounting torque  | To heatsink | M4            | 2    | 3 | N.m |
| Wt         | Package weight   | —           | 110           | g    |   |     |

### 1.4 Typical SiC MOSFET Performance Curve (Per SiC MOSFET)

This section shows the typical SiC MOSFET performance curves of the MSCSM120TLM31C3AG device.

**Figure 1-1. Junction-to-Heatsink Thermal Impedance**



# MSCSM120TLM31C3AG

## Electrical Specifications

Figure 1-2. Output Characteristics,  $T_J = 25^\circ\text{C}$

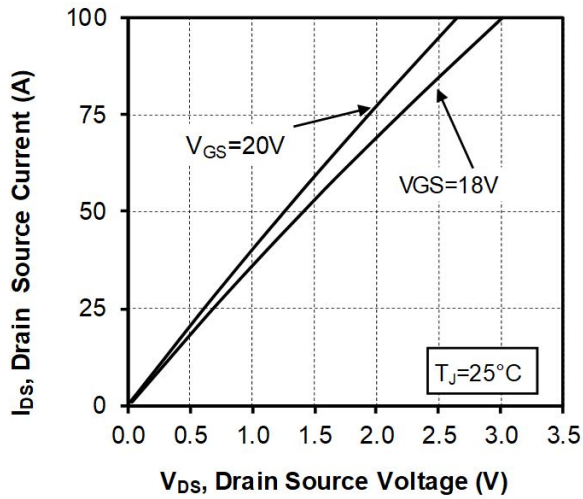


Figure 1-3. Output Characteristics,  $T_J = 175^\circ\text{C}$

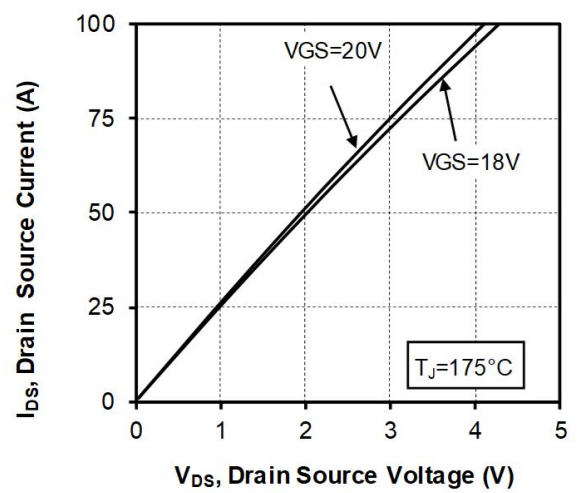


Figure 1-4. Normalized  $R_{DS(on)}$  vs. Temperature

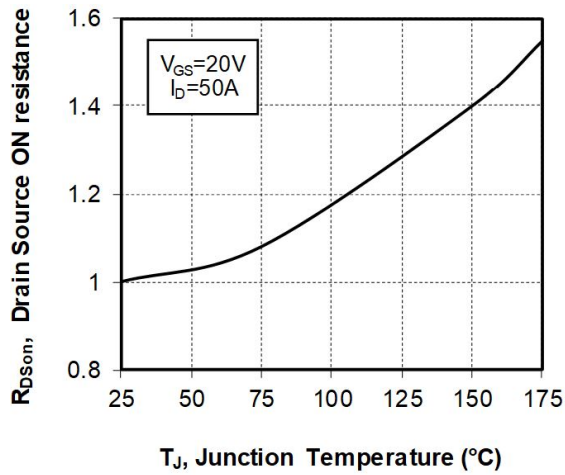


Figure 1-5. Transfer Characteristics

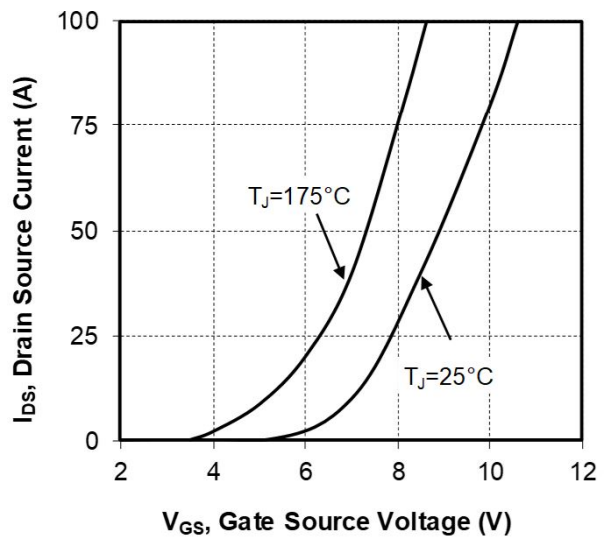


Figure 1-6. Switching Energy vs. Rg

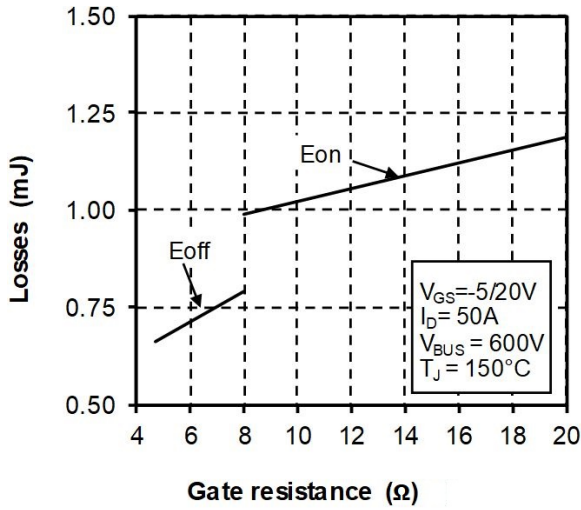


Figure 1-7. Switching Energy vs. Current

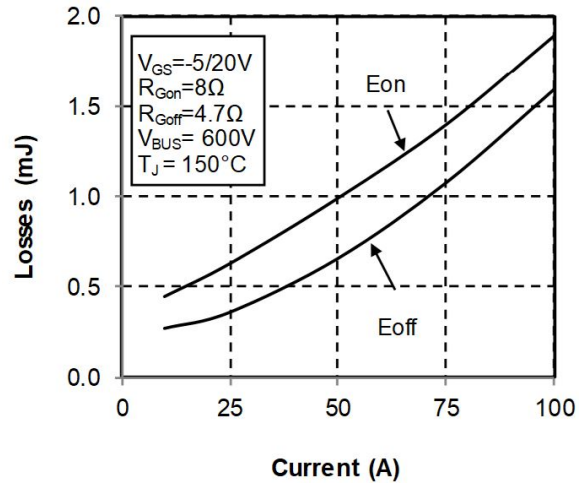


Figure 1-8. Capacitance vs. Drain Source Voltage

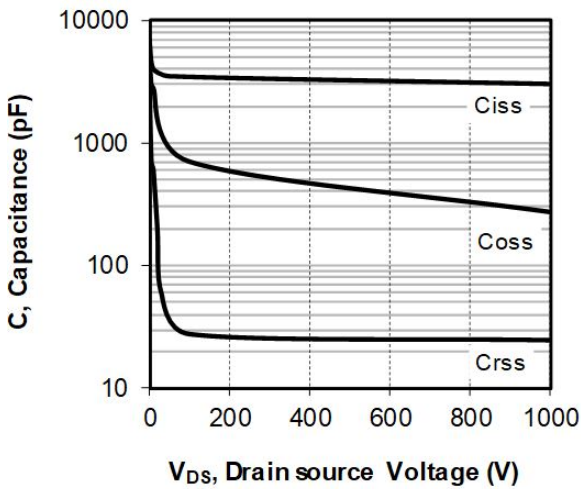


Figure 1-9. Gate Charge vs. Gate Source Voltage

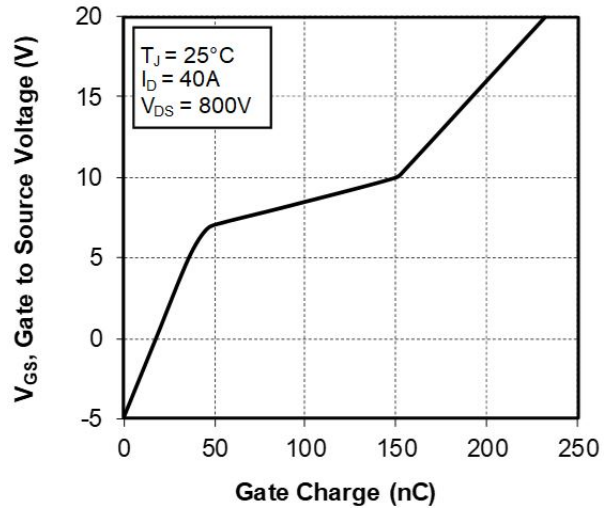




Figure 1-10. Body Diode Characteristics,  $T_J = 25^\circ\text{C}$

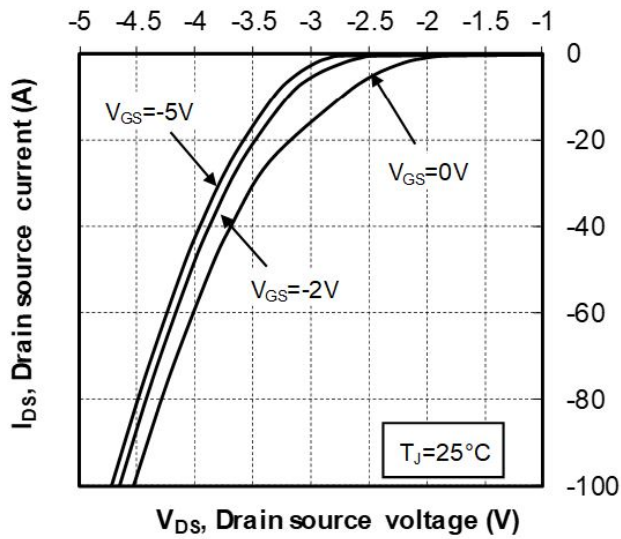


Figure 1-11. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$

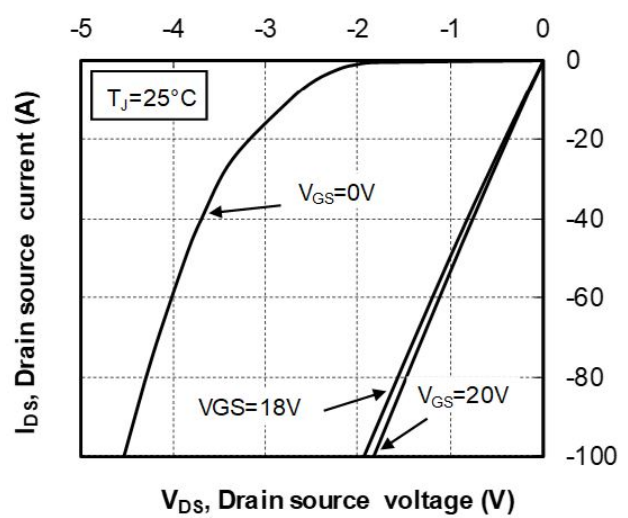


Figure 1-12. Body Diode Characteristics,  $T_J = 175^\circ\text{C}$

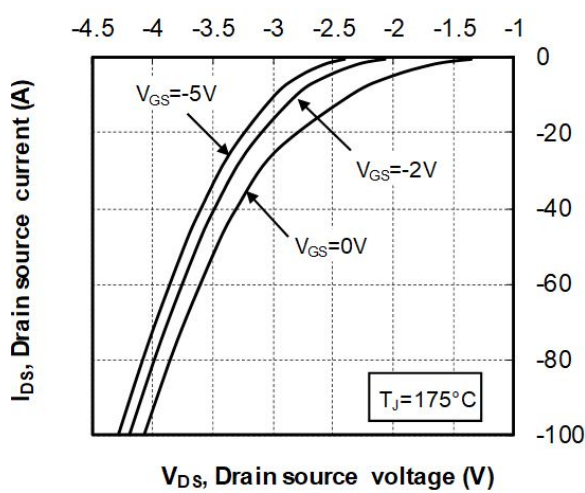


Figure 1-13. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$

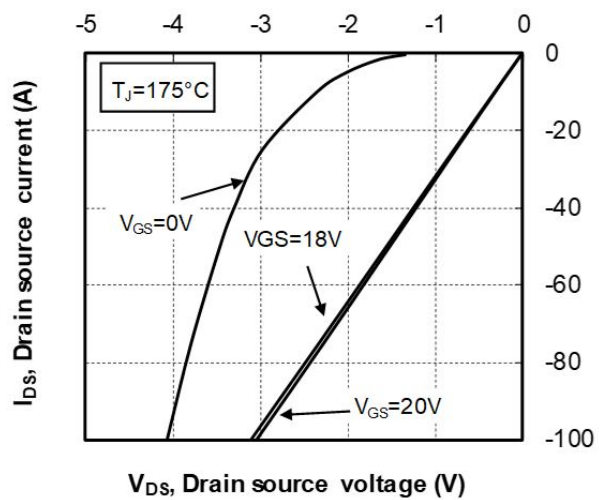
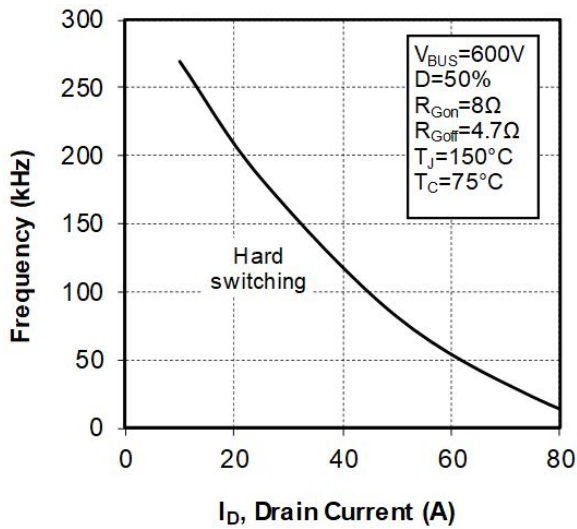


Figure 1-14. Operating Frequency vs. Drain Current



### 1.5 Typical SiC Diode Performance Curves (Per SiC Diode)

This section shows the typical SiC diode performance curves of the MSCSM120TLM31C3AG device.

Figure 1-15. Junction-to-Heatsink Thermal Impedance

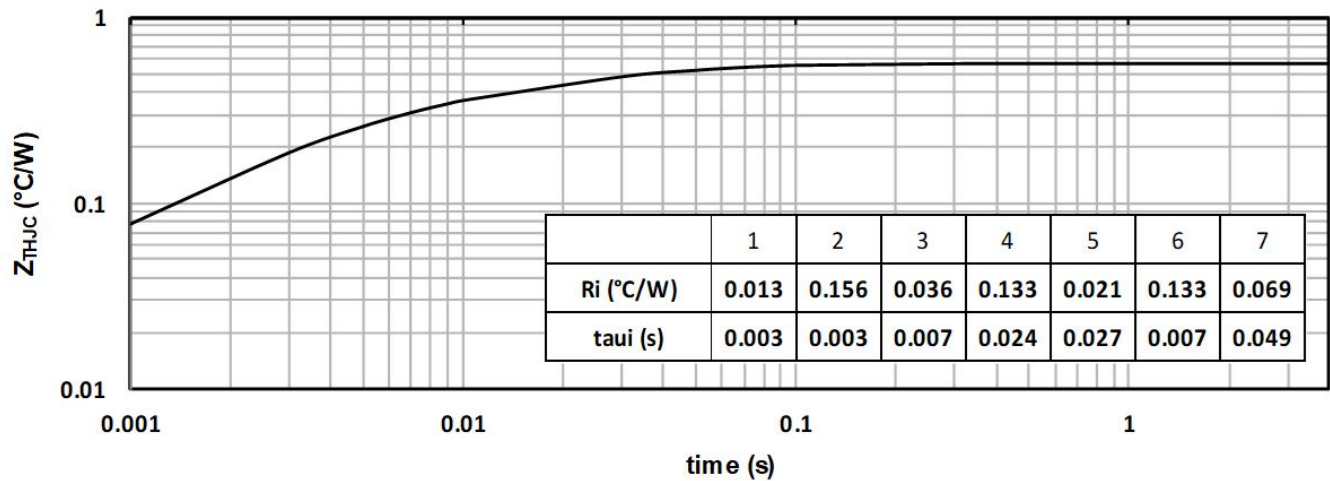


Figure 1-16. Forward Characteristics

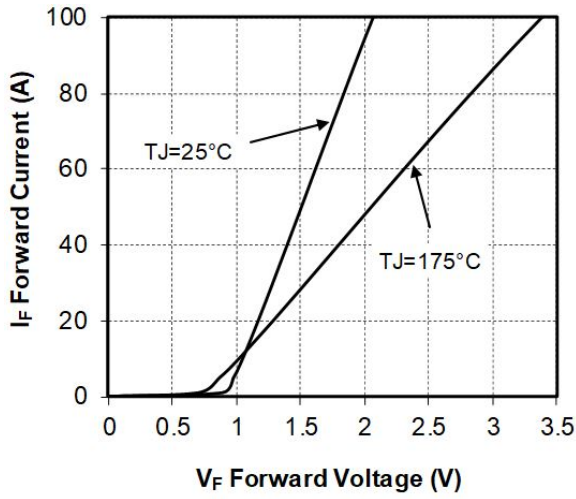
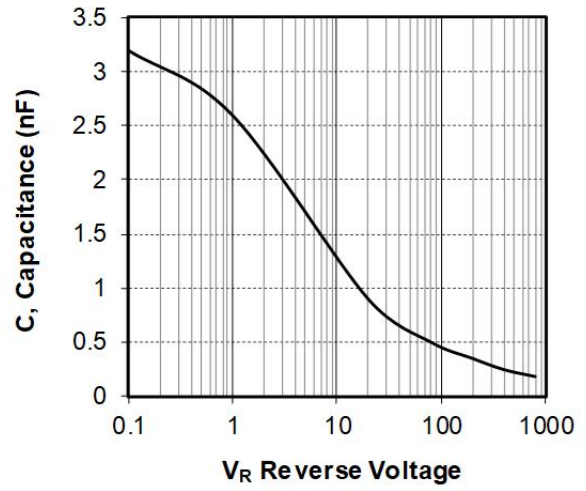


Figure 1-17. Capacitance vs. Reverse Voltage



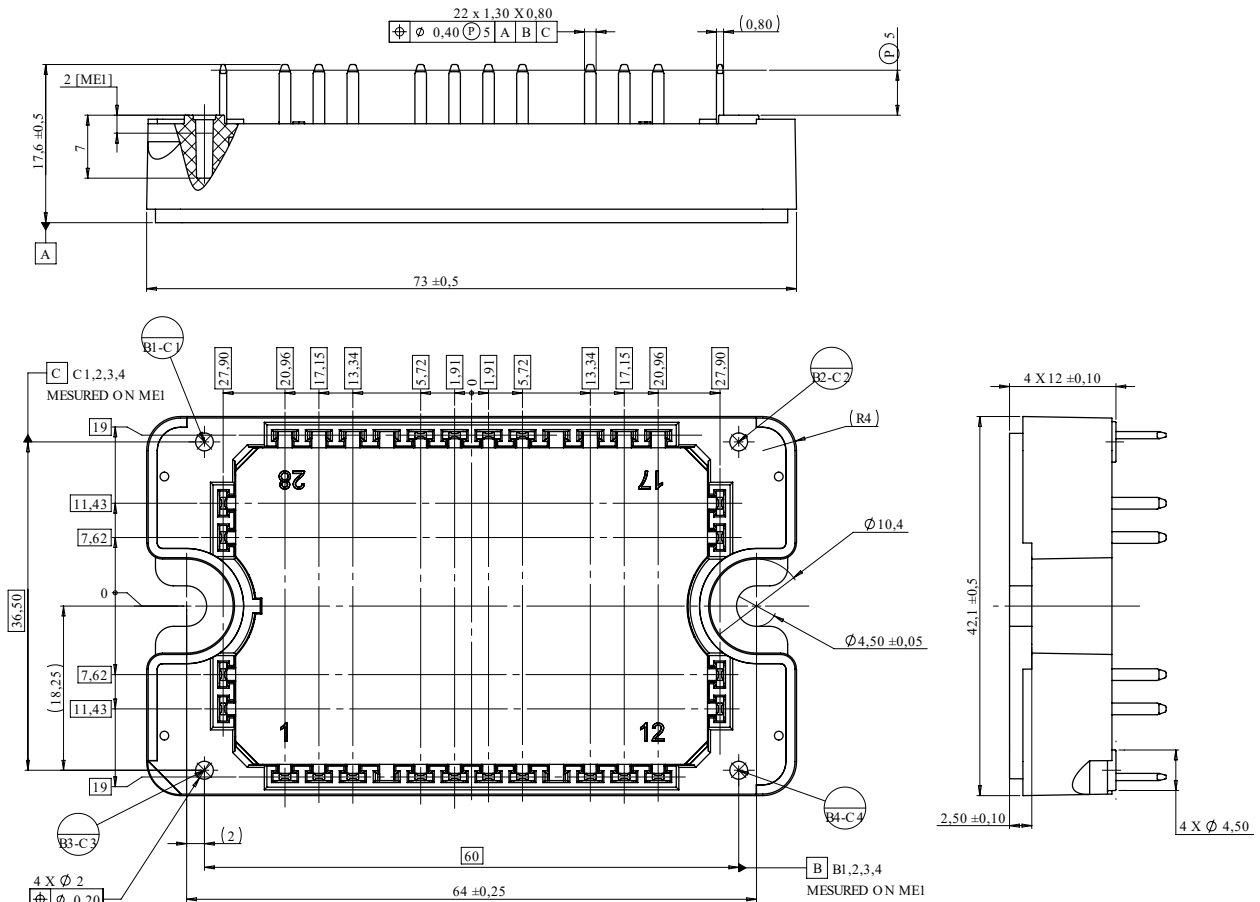
## 2. Package Specifications

The following section shows the package specification of the device.

### 2.1 Package Outline

The following figure shows the package outline drawing of the MSCSM120TLM31C3AG device. The dimensions in the following figure are in millimeters.

**Figure 2-1. Package Outline Drawing**



**Note:** See application note [AN3500A—Mounting instructions for SP1F and SP3F power modules](#).

### 3. Revision History

| Revision | Date    | Description      |
|----------|---------|------------------|
| A        | 12/2021 | Initial Revision |

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