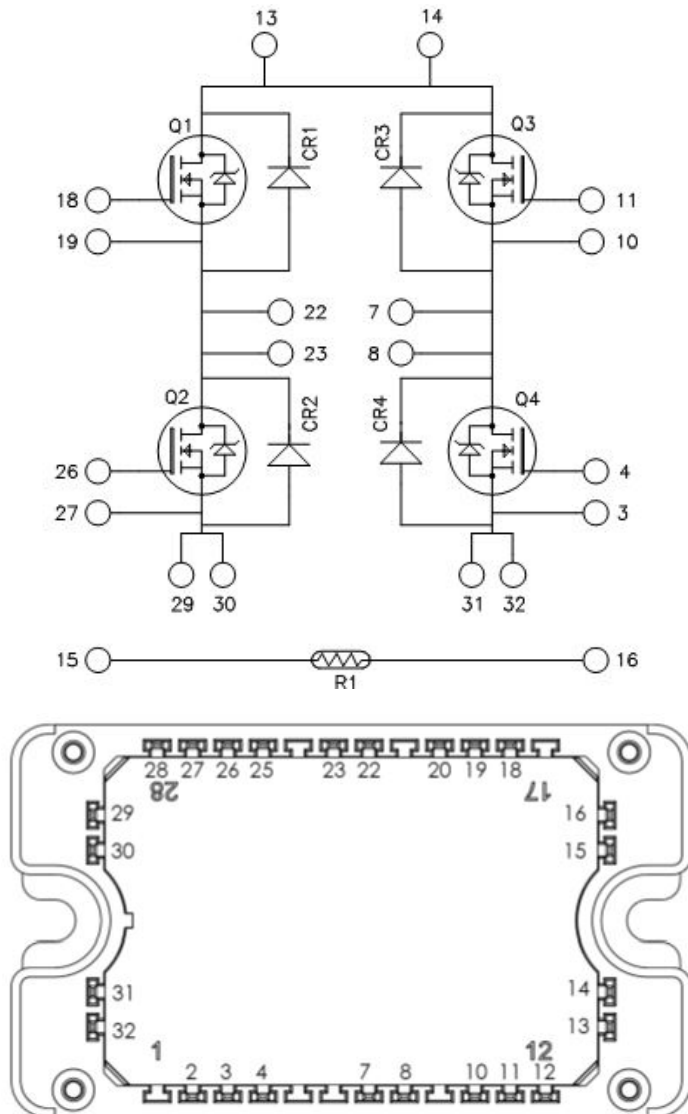


## Full Bridge SiC MOSFET Power Module

### Product Overview

The MSCSM170HM23CT3AG device is a full bridge 1700 V, 124 A silicon carbide (SiC) MOSFET power module.



**Note:** All multiple inputs and outputs, such as pins 13/14, 29/30, 22/23 and so on, must be shorted together.

All ratings at  $T_J = 25^\circ\text{C}$ , unless otherwise specified.

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

## Features

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The following are key features of the MSCSM170HM23CT3AG device:

- SiC Power MOSFET
  - High speed switching
  - Low  $R_{DS(on)}$
  - Ultra low loss
- SiC Schottky Diode
  - Zero reverse recovery
  - Zero forward recovery
  - Temperature independent switching behavior
  - Positive temperature coefficient on VF
- Very low stray inductance
- Kelvin source for easy drive
- Internal thermistor for temperature monitoring
- Aluminum nitride (AlN) substrate for improved thermal performance

## Benefits

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The following are the benefits of MSCSM170HM23CT3AG device:

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

## Application

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The MSCSM170HM23CT3AG device is designed for the following applications:

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

## 1. Electrical Specifications

This section provides the electrical specifications of the MSCSM170HM23CT3AG device.

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

The following table lists the absolute maximum ratings per SiC MOSFET of the MSCSM170HM23CT3AG device.

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

| Symbol       | Parameter                  |                                    | Maximum Ratings  | Unit |
|--------------|----------------------------|------------------------------------|------------------|------|
| $V_{DS}$     | Drain-Source voltage       |                                    | 1700             | V    |
| $I_D$        | Continuous drain current   | $T_C = 25\text{ }^{\circ}\text{C}$ | 124 <sup>1</sup> | A    |
|              |                            | $T_C = 80\text{ }^{\circ}\text{C}$ | 98 <sup>1</sup>  |      |
| $I_{DM}$     | Pulsed drain current       |                                    | 240              |      |
| $V_{GS}$     | Gate-Source voltage        |                                    | –10/23           | V    |
| $R_{DS(on)}$ | Drain-Source ON resistance |                                    | 22.5             | mΩ   |
| $P_D$        | Power dissipation          | $T_C = 25\text{ }^{\circ}\text{C}$ | 602              | W    |

**Note:**

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

The following table lists the electrical characteristics per SiC MOSFET of the MSCSM170HM23CT3AG device.

**Table 1-2. Electrical Characteristics**

| Symbol       | Characteristic                  | Test Conditions                               |                                     | Min | Typ  | Max  | Unit |
|--------------|---------------------------------|-----------------------------------------------|-------------------------------------|-----|------|------|------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0\text{ V}; V_{DS} = 1700\text{ V}$ |                                     | —   | 20   | 200  | μA   |
| $R_{DS(on)}$ | Drain–Source on resistance      | $V_{GS} = 20\text{ V}$<br>$I_D = 60\text{ A}$ | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 17.5 | 22.5 | mΩ   |
|              |                                 |                                               | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 31   | —    |      |
| $V_{GS(th)}$ | Gate threshold voltage          | $V_{GS} = V_{DS}; I_D = 5\text{ mA}$          |                                     | 1.8 | 3.2  | —    | V    |
| $I_{GSS}$    | Gate–Source leakage current     | $V_{GS} = 20\text{ V}; V_{DS} = 0\text{ V}$   |                                     | —   | —    | 200  | nA   |

The following table lists the dynamic characteristics per SiC MOSFET of the MSCSM170HM23CT3AG device.

**Table 1-3. Dynamic Characteristics**

| Symbol       | Characteristic                      | Test Conditions                                                                                                         | Min                   | Typ  | Max  | Unit                        |
|--------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------|------|------|-----------------------------|
| $C_{iss}$    | Input capacitance                   | $V_{GS} = 0\text{ V}$                                                                                                   | —                     | 6600 | —    | pF                          |
| $C_{oss}$    | Output capacitance                  | $V_{DS} = 1000\text{ V}$                                                                                                | —                     | 300  | —    |                             |
| $C_{rss}$    | Reverse transfer capacitance        | $f = 1\text{ MHz}$                                                                                                      | —                     | 20   | —    |                             |
| $Q_g$        | Total gate charge                   | $V_{GS} = -5\text{ V}/20\text{ V}$                                                                                      | —                     | 356  | —    | nC                          |
| $Q_{gs}$     | Gate-Source charge                  | $V_{Bus} = 850\text{ V}$                                                                                                | —                     | 98   | —    |                             |
| $Q_{gd}$     | Gate-Drain charge                   | $I_D = 60\text{ A}$                                                                                                     | —                     | 54   | —    |                             |
| $T_{d(on)}$  | Turn-on delay time                  | $T_J = 150\text{ °C}$                                                                                                   | —                     | 24   | —    | ns                          |
| $T_r$        | Rise time                           | $V_{GS} = -5\text{ V}/20\text{ V}$                                                                                      | —                     | 17   | —    |                             |
| $T_{d(off)}$ | Turn-off delay time                 | $V_{Bus} = 900\text{ V}$                                                                                                | —                     | 35   | —    |                             |
| $T_f$        | Fall time                           | $I_D = 100\text{ A}$<br>$R_{G(on)} = 2.4\text{ }\Omega$<br>$R_{G(off)} = 1.4\text{ }\Omega$                             | —                     | 19   | —    |                             |
| $E_{on}$     | Turn-on energy                      | $V_{GS} = -5\text{ V}/20\text{ V}$                                                                                      | $T_J = 150\text{ °C}$ | —    | 2.2  | mJ                          |
| $E_{off}$    | Turn-off energy                     | $V_{Bus} = 900\text{ V}$<br>$I_D = 100\text{ A}$<br>$R_{G(on)} = 2.4\text{ }\Omega$<br>$R_{G(off)} = 1.4\text{ }\Omega$ | $T_J = 150\text{ °C}$ | —    | 0.33 |                             |
| $R_{Gint}$   | Internal gate resistance            |                                                                                                                         | —                     | 2.93 | —    | $\Omega$                    |
| $R_{thJC}$   | Junction-to-case thermal resistance |                                                                                                                         | —                     | —    | 0.25 | $^{\circ}\text{C}/\text{W}$ |

The following table lists the body diode ratings and characteristics per SiC MOSFET of the MSCSM170HM23CT3AG device.

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

| Symbol   | Characteristic           | Test Conditions                                           | Min | Typ  | Max | Unit |
|----------|--------------------------|-----------------------------------------------------------|-----|------|-----|------|
| $V_{SD}$ | Diode forward voltage    | $V_{GS} = 0\text{ V}; I_{SD} = 60\text{ A}$               | —   | 3.7  | —   | V    |
|          |                          | $V_{GS} = -5\text{ V}; I_{SD} = 60\text{ A}$              | —   | 3.9  | —   |      |
| $t_{rr}$ | Reverse recovery time    | $I_{SD} = 60\text{ A}; V_{GS} = -5\text{ V}$              | —   | 27   | —   | ns   |
| $Q_{rr}$ | Reverse recovery charge  | $V_R = 900\text{ V}; di_F/dt = 2000\text{ A}/\mu\text{s}$ | —   | 1300 | —   | nC   |
| $I_{rr}$ | Reverse recovery current |                                                           | —   | 92   | —   | A    |

### 1.2 SiC Schottky Diode Ratings and Characteristics (Per SiC Diode)

The following table lists the SiC diode ratings and characteristics per SiC diode of MSCSM170HM23CT3AG device.

**Table 1-5. SiC Schottky Diode Ratings and Characteristics**

| Symbol     | Characteristic                      | Test Conditions                        |                                     | Min | Typ | Max   | Unit                 |
|------------|-------------------------------------|----------------------------------------|-------------------------------------|-----|-----|-------|----------------------|
| $V_{RRM}$  | Peak repetitive reverse voltage     |                                        |                                     | —   | —   | 1700  | V                    |
| $I_{RRM}$  | Reverse leakage current             | $V_R = 1700\text{ V}$                  | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 20  | 400   | $\mu\text{A}$        |
|            |                                     |                                        | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 300 | —     |                      |
| $I_F$      | DC forward current                  | —                                      | $T_C = 125\text{ }^{\circ}\text{C}$ | —   | 60  | —     | A                    |
| $V_F$      | Diode forward voltage               | $I_F = 60\text{ A}$                    | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 1.5 | 1.8   | V                    |
|            |                                     |                                        | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 2.3 | —     |                      |
| $Q_C$      | Total capacitive charge             | $V_R = 900\text{ V}$                   |                                     | —   | 460 | —     | nC                   |
| C          | Total capacitance                   | $f = 1\text{ MHz}, V_R = 600\text{ V}$ |                                     | —   | 334 | —     | pF                   |
|            |                                     | $f = 1\text{ MHz}, V_R = 900\text{ V}$ |                                     | —   | 276 | —     |                      |
| $R_{thJC}$ | Junction-to-case thermal resistance |                                        |                                     | —   | —   | 0.276 | $^{\circ}\text{C/W}$ |

### 1.3 Thermal and Package Characteristics

The following table lists the thermal and package characteristics of the MSCSM170HM23CT3AG device.

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

| Symbol     | Characteristics                                                              |             |    | Min  | Max             | Unit               |
|------------|------------------------------------------------------------------------------|-------------|----|------|-----------------|--------------------|
| $V_{ISOL}$ | RMS isolation voltage, any terminal to case $t = 1\text{ min}$ , 50 Hz/60 Hz |             |    | 4000 | —               | V                  |
| $T_J$      | Operating junction temperature range                                         |             |    | −40  | 175             | $^{\circ}\text{C}$ |
| $T_{JOP}$  | Recommended junction temperature under switching conditions                  |             |    | −40  | $T_{Jmax} - 25$ |                    |
| $T_{STG}$  | Storage temperature range                                                    |             |    | −40  | 125             |                    |
| $T_C$      | Operating case temperature                                                   |             |    | −40  | 125             |                    |
| Torque     | Mounting torque                                                              | To heatsink | M4 | 2    | 3               | N.m                |
| Wt         | Package weight                                                               |             |    | —    | 110             | g                  |

# MSCSM170HM23CT3AG

## Electrical Specifications

The following table lists the temperature sensor NTC of the MSCSM170HM23CT3AG device.

**Table 1-7. Temperature Sensor NTC**

| 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:** See [APT0406—Using NTC Temperature Sensor Integrated into Power Module](#) for more information.

## 1.4 Typical SiC MOSFET Performance Curve

This section shows the typical SiC MOSFET performance curves of the MSCSM170HM23CT3AG device.

**Figure 1-1. Maximum Thermal Impedance**

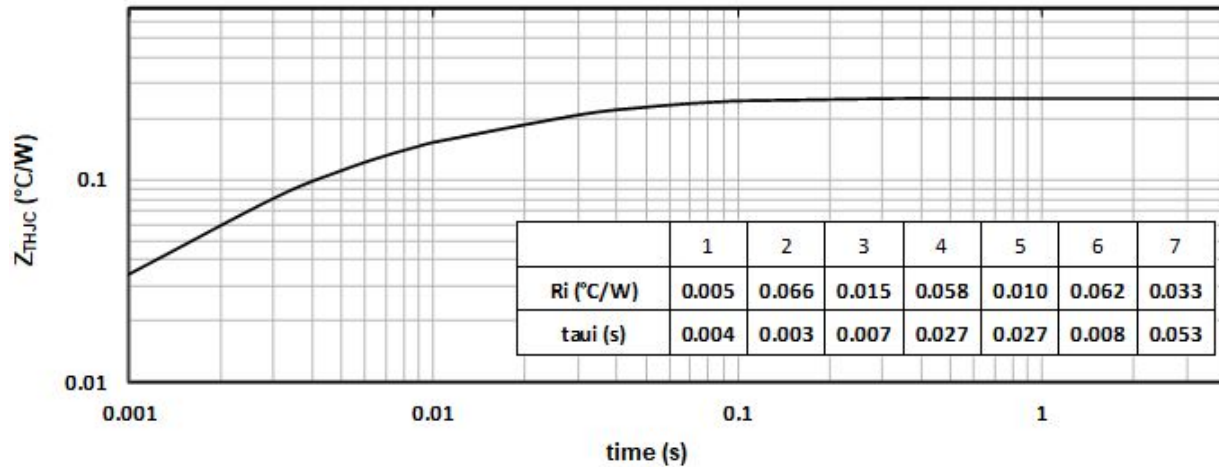


Figure 1-2. Output Characteristics,  $T_J = 25^\circ\text{C}$

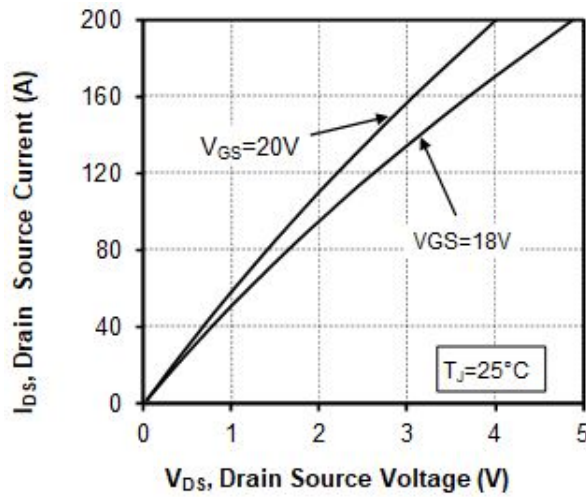


Figure 1-3. Output Characteristics,  $T_J = 175^\circ\text{C}$

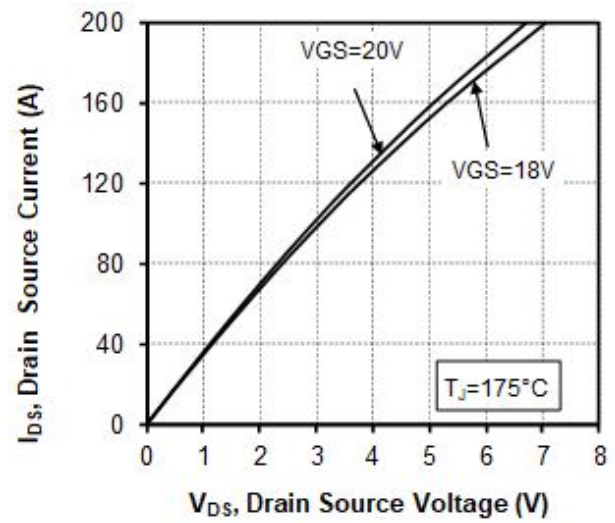


Figure 1-4. Normalized  $R_{DS(on)}$  vs. Temperature

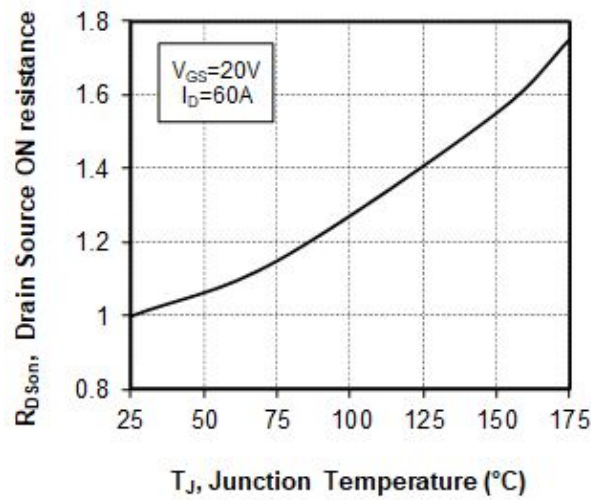


Figure 1-5. Transfer Characteristics

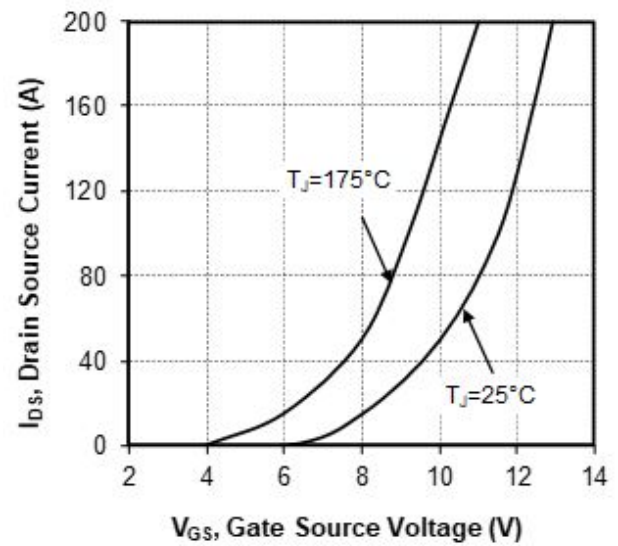


Figure 1-6. Switching Energy vs. R<sub>g</sub>

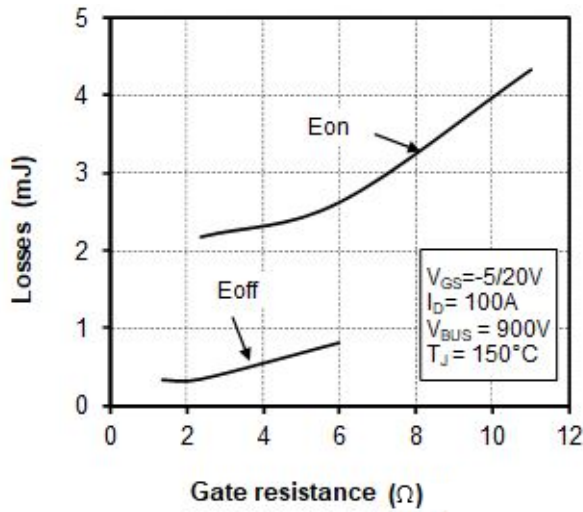


Figure 1-7. Switching Energy vs. Current

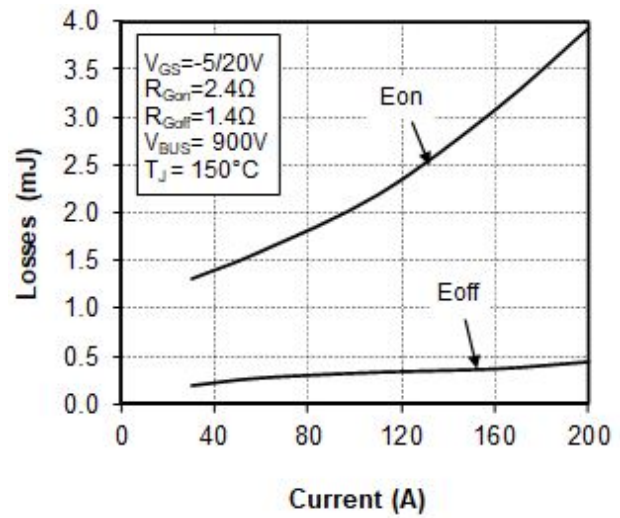


Figure 1-8. Capacitance vs. Drain Source Voltage

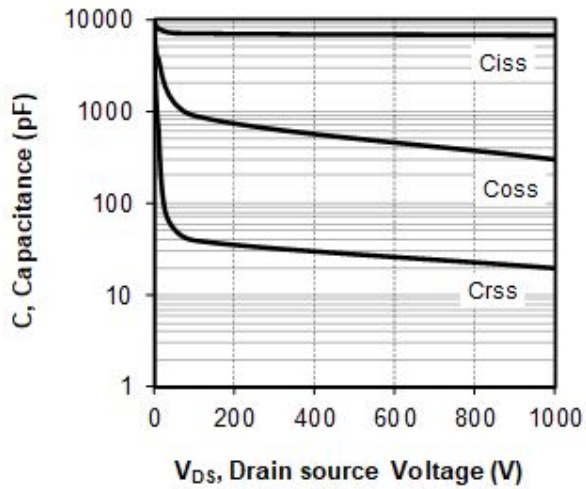


Figure 1-9. Gate Charge vs. Gate Source Voltage

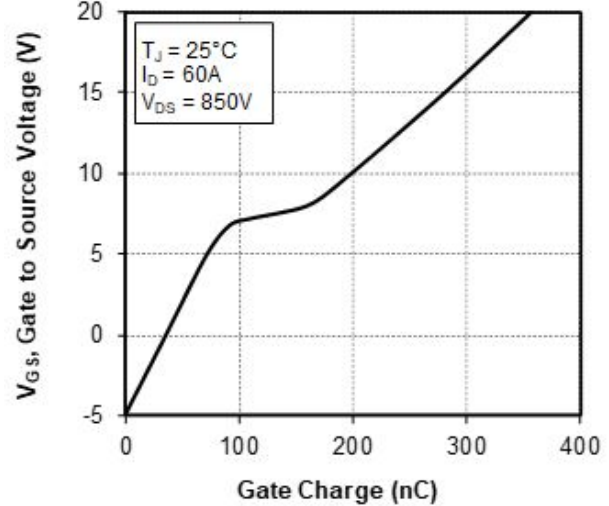


Figure 1-10. Body Diode Characteristics,  $T_J = 25^\circ\text{C}$

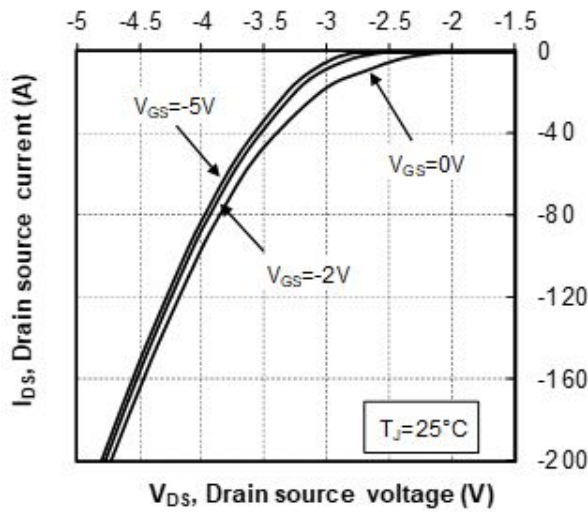


Figure 1-11. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$

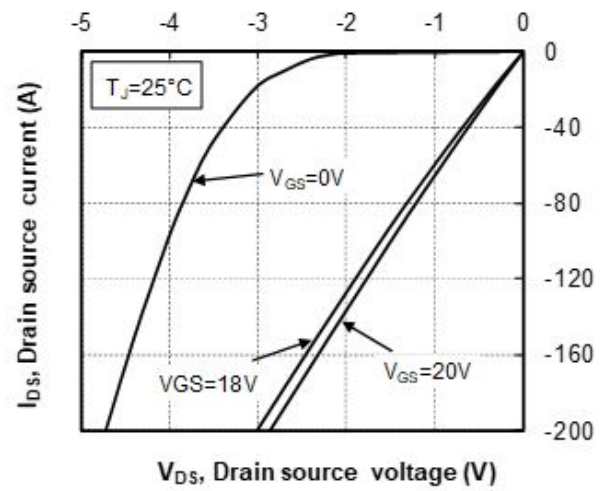


Figure 1-12. Body Diode Characteristics,  $T_J = 175^\circ\text{C}$

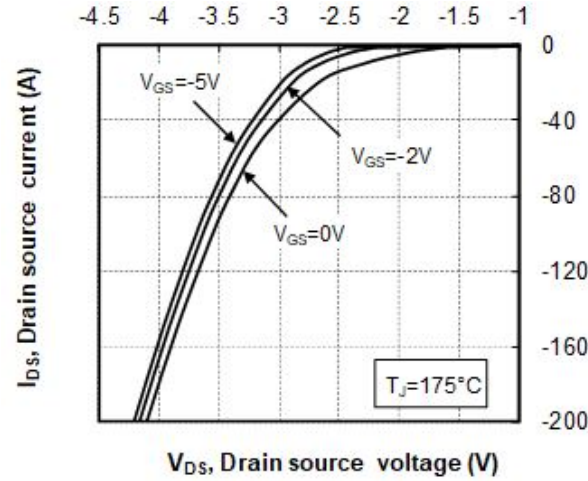


Figure 1-13. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$

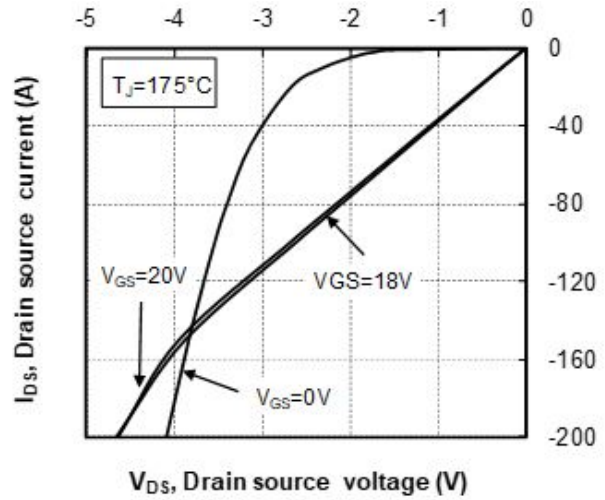
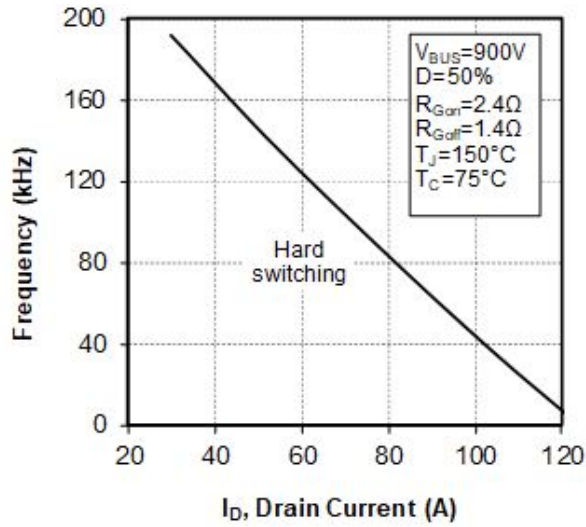


Figure 1-14. Operating Frequency vs Drain Current



## 1.5 Typical SiC Diode Performance Curves

This section shows the typical SiC diode performance curves of the MSCSM170HM23CT3AG device.

Figure 1-15. Maximum Thermal Impedance

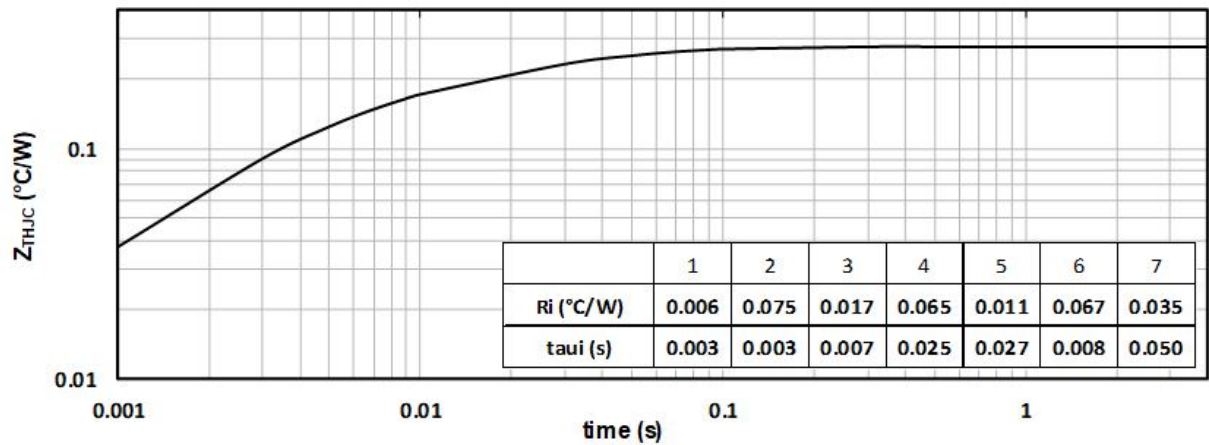


Figure 1-16. Forward Characteristics

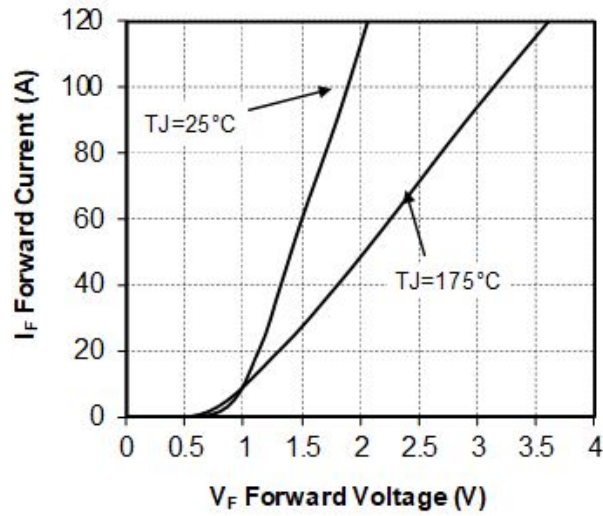
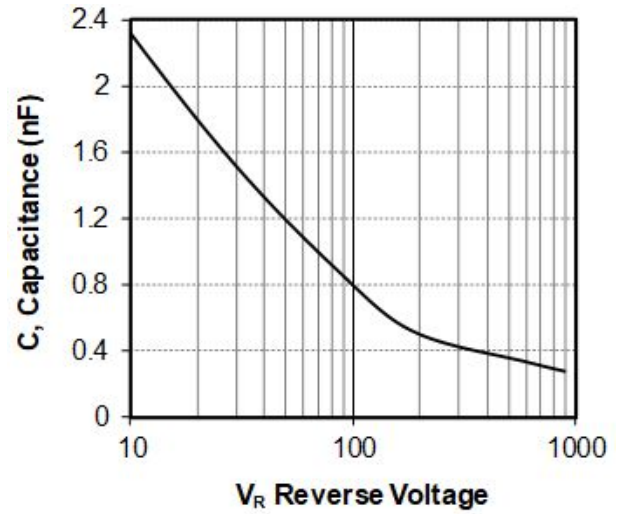


Figure 1-17. Capacitance vs. Reverse Voltage



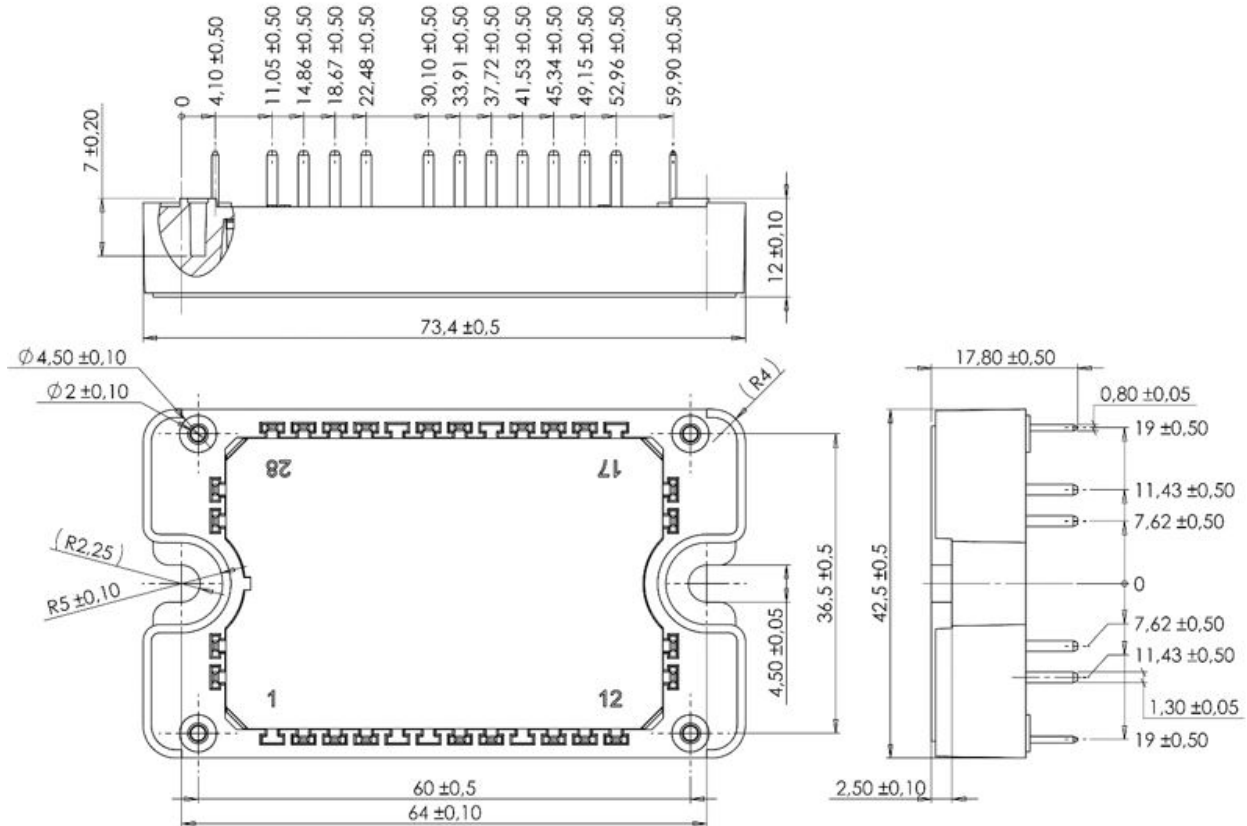
## 2. Package Specifications

The following section shows the package specification of the MSCSM170HM23CT3AG device.

### 2.1 Package Outline

The following figure shows the package outline drawing of the MSCSM170HM23CT3AG device. The dimensions in the following figure are in millimeters.

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



**Note:** See [AN3500A—Mounting Instructions for SP1F and SP3F Power Modules](#) for more information.

**3. Revision History**

| Revision | Date    | Description                                     |
|----------|---------|-------------------------------------------------|
| A        | 04/2021 | This is the first publication of this document. |

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