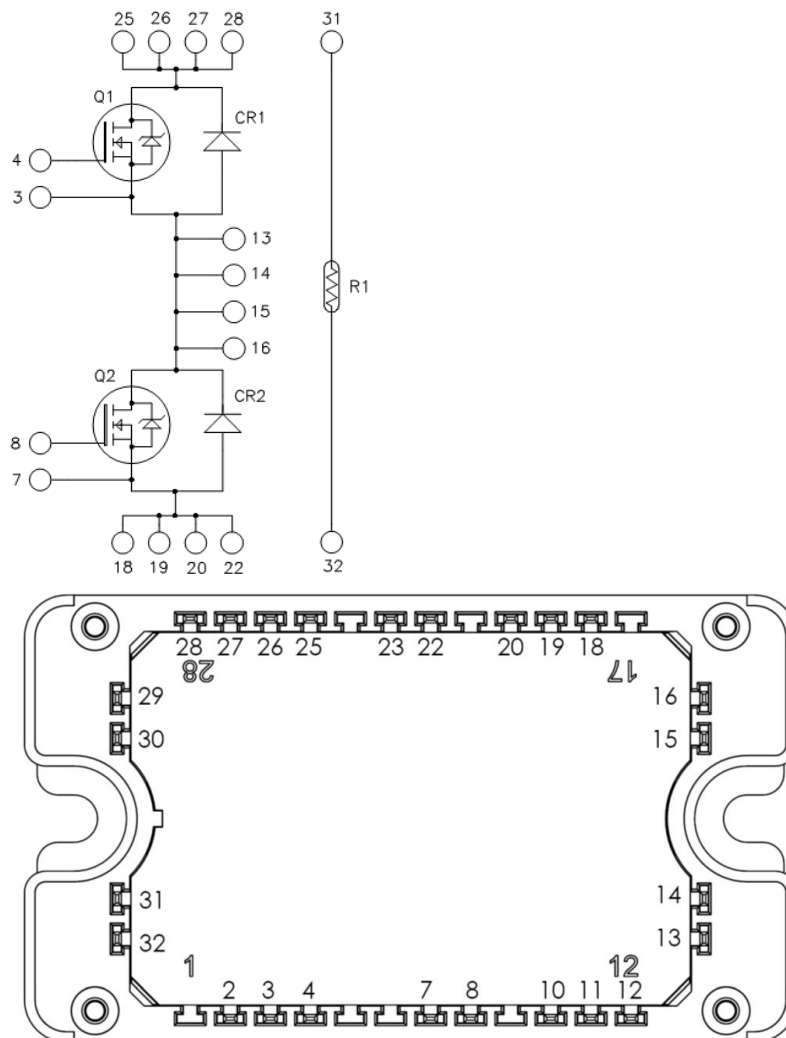


## Phase Leg SiC MOSFET Power Module

### Product Overview

The MSCSM170AM11CT3AG device is a phase leg 1700 V, 240 A silicon carbide (SiC) MOSFET power module.



Pins 25 to 28 must be shorted together.

Pins 13 to 16 must be shorted together.

Pins 18/19/20/22 must be shorted together.

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

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

## Features

The following are the key features of MSCSM170AM11CT3AG 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
- Low stray inductance
- Kelvin source for easy drive
- Internal thermistor for temperature monitoring
- Aluminum Nitride (AlN) substrate for improved thermal performance

## Benefits

The following are the benefits of MSCSM170AM11CT3AG device:

- High efficiency converter
- 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

## Applications

The following are the applications of MSCSM170AM11CT3AG device:

- Induction heating and welding
- Solar inverter
- EV motor and traction drive

## 1. Electrical Specifications

This section provides the electrical specifications of the MSCSM170AM11CT3AG device.

### 1.1 SiC MOSFET Characteristics (per SiC MOSFET)

The following table lists the absolute maximum ratings per SiC MOSFET of the MSCSM170AM11CT3AG device.

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

| Symbol       | Parameter                  |                                    | Maximum Ratings  | Unit       |
|--------------|----------------------------|------------------------------------|------------------|------------|
| $V_{DS}$     | Drain-Source voltage       |                                    | 1700             | V          |
| $I_D$        | Continuous drain current   | $T_C = 25\text{ }^{\circ}\text{C}$ | 240 <sup>1</sup> | A          |
|              |                            | $T_C = 80\text{ }^{\circ}\text{C}$ | 191 <sup>1</sup> |            |
| $I_{DM}$     | Pulsed drain current       |                                    | 480              |            |
| $V_{GS}$     | Gate-Source voltage        |                                    | –10/23           | V          |
| $R_{DS(on)}$ | Drain-Source ON resistance |                                    | 11.3             | m $\Omega$ |
| $P_D$        | Power dissipation          | $T_C = 25\text{ }^{\circ}\text{C}$ | 1140             | W          |

**Note:**

1. Specification of 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 MSCSM170AM11CT3AG device.

**Table 1-2. Electrical Characteristics**

| Symbol       | Characteristic                  | Test Conditions                                  |                                     | Min | Typ  | Max  | Unit          |
|--------------|---------------------------------|--------------------------------------------------|-------------------------------------|-----|------|------|---------------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 1700\text{ V}$ |                                     | —   | 40   | 400  | $\mu\text{A}$ |
| $R_{DS(on)}$ | Drain–Source on resistance      | $V_{GS} = 20\text{ V}$<br>$I_D = 120\text{ A}$   | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 8.8  | 11.3 | m $\Omega$    |
|              |                                 |                                                  | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 15.4 | —    |               |
| $V_{GS(th)}$ | Gate threshold voltage          | $V_{GS} = V_{DS}$ ; $I_D = 10\text{ mA}$         |                                     | 1.8 | 3.2  | —    | V             |
| $I_{GSS}$    | Gate–Source leakage current     | $V_{GS} = 20\text{ V}$ ; $V_{DS} = 0\text{ V}$   |                                     | —   | —    | 400  | nA            |

The following table lists the dynamic characteristics per SiC MOSFET of the MSCSM170AM11CT3AG device.

**Table 1-3. Dynamic Characteristics**

| Symbol              | Characteristic                      | Test Conditions                                                                                             |                         | Min | Typ   | Max   | Unit |
|---------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------|-----|-------|-------|------|
| C <sub>iss</sub>    | Input capacitance                   | V <sub>GS</sub> = 0 V                                                                                       |                         | —   | 13200 | —     | pF   |
| C <sub>oss</sub>    | Output capacitance                  | V <sub>DS</sub> = 1000 V                                                                                    |                         | —   | 600   | —     |      |
| C <sub>rss</sub>    | Reverse transfer capacitance        | f = 1 MHz                                                                                                   |                         | —   | 40    | —     |      |
| Q <sub>g</sub>      | Total gate charge                   | V <sub>GS</sub> = −5 V/20 V                                                                                 |                         | —   | 712   | —     | nC   |
| Q <sub>gs</sub>     | Gate-Source charge                  | V <sub>Bus</sub> = 850 V                                                                                    |                         | —   | 196   | —     |      |
| Q <sub>gd</sub>     | Gate-Drain charge                   | I <sub>D</sub> = 120 A                                                                                      |                         | —   | 108   | —     |      |
| T <sub>d(on)</sub>  | Turn-on delay time                  | T <sub>J</sub> = 150 °C                                                                                     |                         | —   | 24    | —     | ns   |
| T <sub>r</sub>      | Rise time                           | V <sub>GS</sub> = −5 V/20 V                                                                                 |                         | —   | 17    | —     |      |
| T <sub>d(off)</sub> | Turn-off delay time                 | V <sub>Bus</sub> = 900 V                                                                                    |                         | —   | 35    | —     |      |
| T <sub>f</sub>      | Fall time                           | I <sub>D</sub> = 200 A<br>R <sub>GON</sub> = 1.2 Ω<br>R <sub>GOFF</sub> = 0.7 Ω                             |                         | —   | 19    | —     |      |
| E <sub>on</sub>     | Turn-on energy                      | V <sub>GS</sub> = −5 V/20 V                                                                                 | T <sub>J</sub> = 150 °C | —   | 4.4   | —     | mJ   |
| E <sub>off</sub>    | Turn-off energy                     | V <sub>Bus</sub> = 900 V<br>I <sub>D</sub> = 200 A<br>R <sub>GON</sub> = 1.2 Ω<br>R <sub>GOFF</sub> = 0.7 Ω | T <sub>J</sub> = 150 °C | —   | 0.66  | —     |      |
| R <sub>Gint</sub>   | Internal gate resistance            |                                                                                                             |                         | —   | 1.46  | —     | Ω    |
| R <sub>thJC</sub>   | Junction-to-case thermal resistance |                                                                                                             |                         | —   | —     | 0.132 | °C/W |

The following table lists the body diode ratings and characteristics per SiC MOSFET of the MSCSM170AM11CT3AG device.

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

| Symbol   | Characteristic           | Test Conditions                                               | Min | Typ  | Max | Unit |
|----------|--------------------------|---------------------------------------------------------------|-----|------|-----|------|
| $V_{SD}$ | Diode forward voltage    | $V_{GS} = 0\text{ V}; I_{SD} = 120\text{ A}$                  | —   | 3.7  | —   | V    |
|          |                          | $V_{GS} = -5\text{ V}; I_{SD} = 120\text{ A}$                 | —   | 3.9  | —   |      |
| $t_{rr}$ | Reverse recovery time    | $I_{SD} = 120\text{ A}$                                       | —   | 27   | —   | ns   |
| $Q_{rr}$ | Reverse recovery charge  | $V_{GS} = -5\text{ V}$                                        | —   | 2600 | —   | nC   |
| $I_{rr}$ | Reverse recovery current | $V_R = 900\text{ V}$<br>$di_F/dt = 4000\text{ A}/\mu\text{s}$ | —   | 184  | —   | A    |

### 1.2 SiC Schottky Diode Characteristics (per SiC Diode)

The following table lists the SiC Schottky diode ratings and characteristics of the MSCSM170AM11CT3AG device.

**Table 1-5. SiC Diode Ratings and Characteristics (Per SiC Diode)**

| Symbol     | Characteristic                      | Test Conditions                        |                                     | Min | Typ | Max  | Unit                 |
|------------|-------------------------------------|----------------------------------------|-------------------------------------|-----|-----|------|----------------------|
| $V_{RRM}$  | Peak repetitive reverse voltage     |                                        |                                     | —   | —   | 1700 | V                    |
| $I_{RRM}$  | Reverse leakage current             | $V_R = 1700\text{ V}$                  | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 30  | 600  | $\mu\text{A}$        |
|            |                                     |                                        | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 450 | —    |                      |
| $I_F$      | DC forward current                  | —                                      | $T_C = 125\text{ }^{\circ}\text{C}$ | —   | 90  | —    | A                    |
| $V_F$      | Diode forward voltage               | $I_F = 90\text{ A}$                    | $T_J = 25\text{ }^{\circ}\text{C}$  | —   | 1.5 | 1.8  | V                    |
|            |                                     |                                        | $T_J = 175\text{ }^{\circ}\text{C}$ | —   | 2.3 | —    |                      |
| $Q_C$      | Total capacitive charge             | $V_R = 900\text{ V}$                   |                                     | —   | 690 | —    | nC                   |
| C          | Total capacitance                   | $f = 1\text{ MHz}, V_R = 600\text{ V}$ |                                     | —   | 501 | —    | pF                   |
|            |                                     | $f = 1\text{ MHz}, V_R = 900\text{ V}$ |                                     | —   | 414 | —    |                      |
| $R_{thJC}$ | Junction-to-case thermal resistance |                                        |                                     | —   | —   | 0.19 | $^{\circ}\text{C/W}$ |

### 1.3 Thermal and Package Characteristics

The following table lists the thermal and package characteristics of the MSCSM170AM11CT3AG device.

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

| Symbol     | Characteristic                                                               |             |    | 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 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                  |

The following table lists the temperature sensor NTC of the MSCSM170AM11CT3AG device.

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

| Symbol                 | Characteristics             | Min | Typ  | Max | Unit |
|------------------------|-----------------------------|-----|------|-----|------|
| $R_{25}$               | Resistance at 25 °C         | —   | 50   | —   | kΩ   |
| $\Delta R_{25}/R_{25}$ | —                           | —   | 5    | —   | %    |
| $B_{25/85}$            | $T_{25} = 298.15 \text{ K}$ | —   | 3952 | —   | K    |
| $\Delta B/B$           | — $T_C = 100^\circ\text{C}$ | —   | 4    | —   | %    |

$$R_T = \frac{R_{25}}{\exp\left[B_{25/85}\left(\frac{1}{T_{25}} - \frac{1}{T}\right)\right]}$$

T: Thermistor temperature  
 $R_T$ : Thermistor value at T

**Note:** See application note [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 MSCSM170AM11CT3AG device.

Figure 1-1. Maximum Thermal Impedance

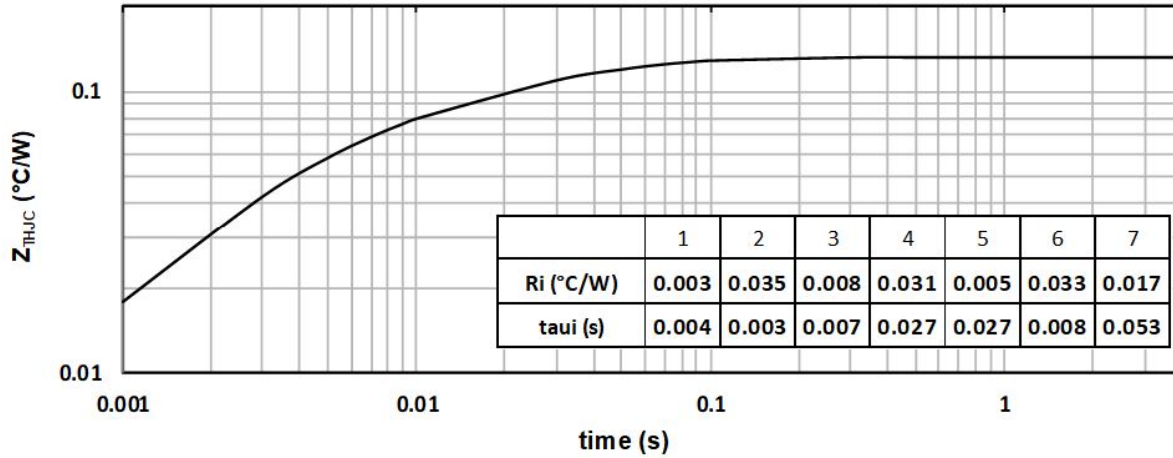


Figure 1-2. Output Characteristics,  $T_J = 25^\circ\text{C}$

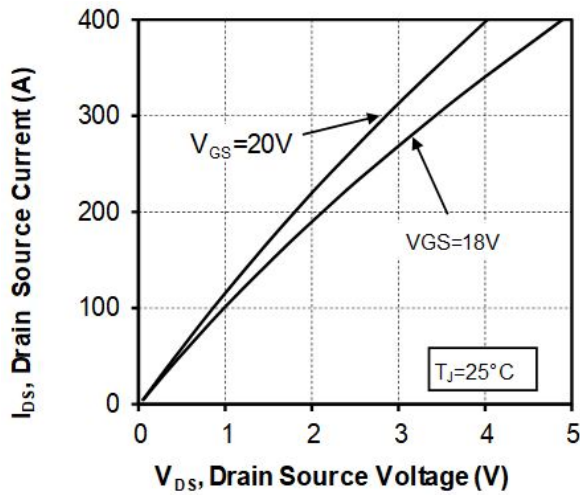
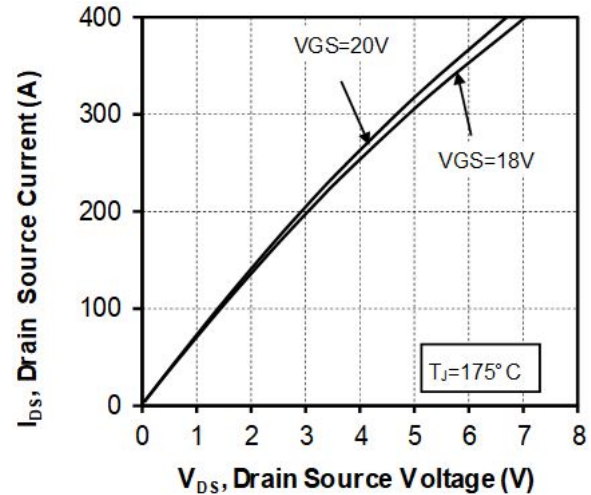


Figure 1-3. Output Characteristics,  $T_J = 175^\circ\text{C}$



# MSCSM170AM11CT3AG

## Electrical Specifications

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

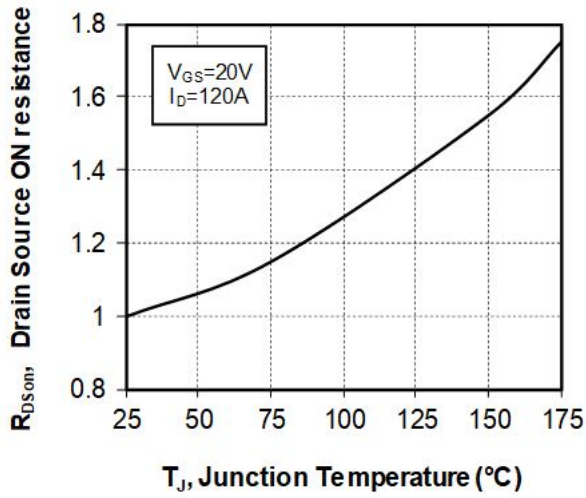


Figure 1-5. Transfer Characteristics

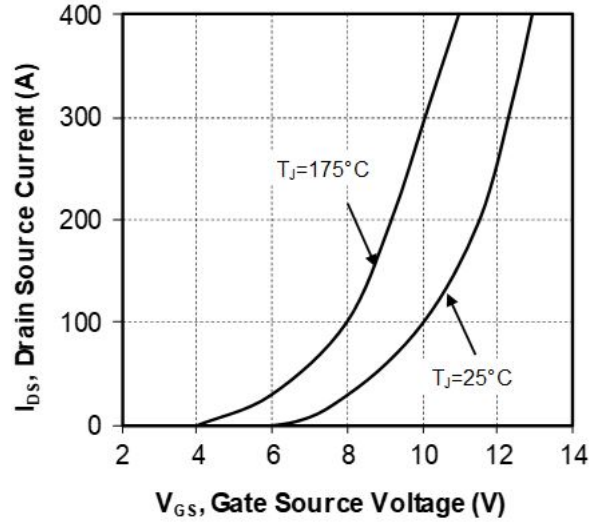


Figure 1-6. Switching Energy vs.  $R_g$

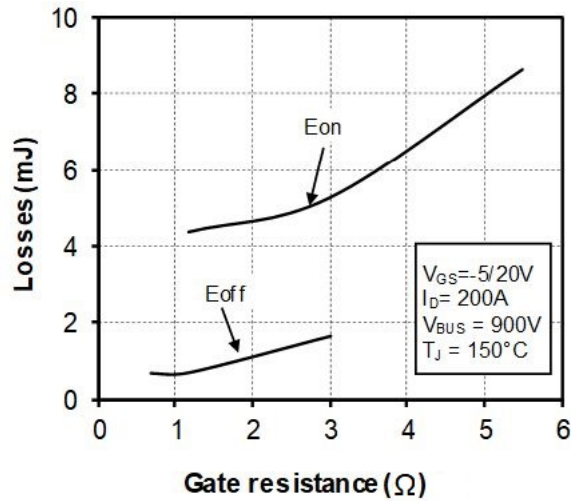


Figure 1-7. Switching Energy vs. Current

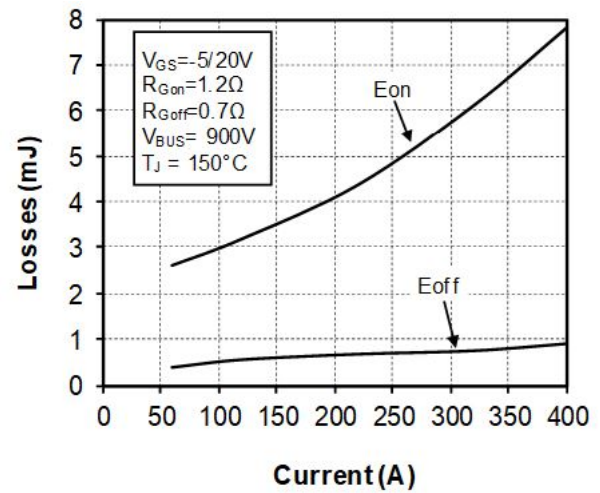


Figure 1-8. Capacitance vs. Drain Source Voltage

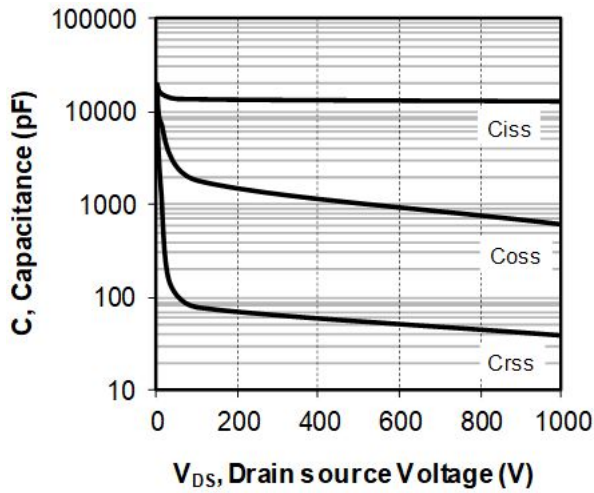


Figure 1-9. Gate Charge vs. Gate Source Voltage

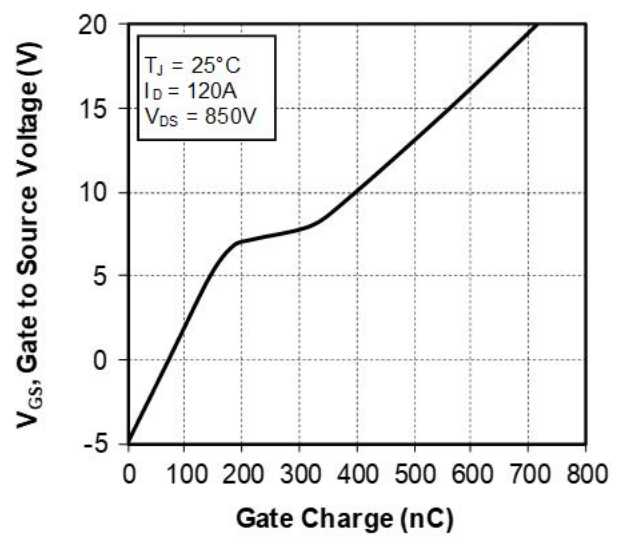


Figure 1-10. Body Diode Characteristics,  $T_J = 25^\circ\text{C}$

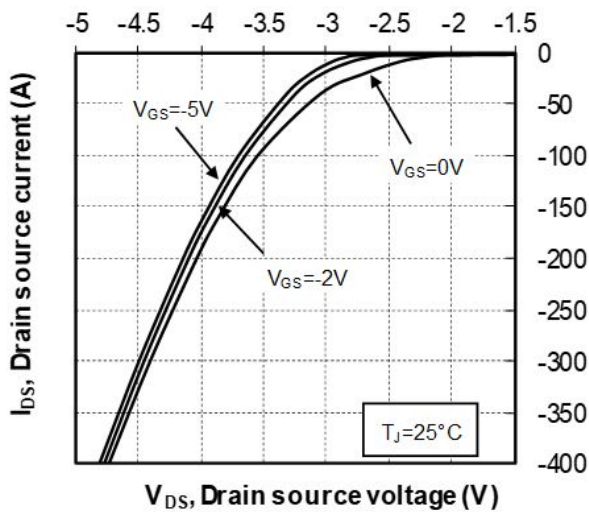


Figure 1-11. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$

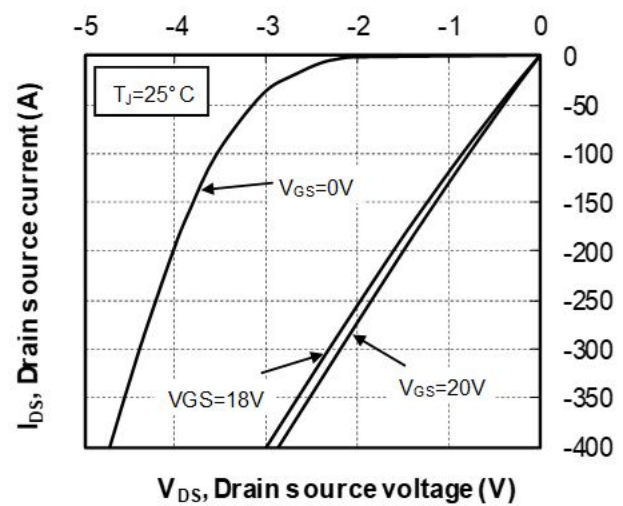


Figure 1-12. Body Diode Characteristics,  $T_J = 175^\circ\text{C}$

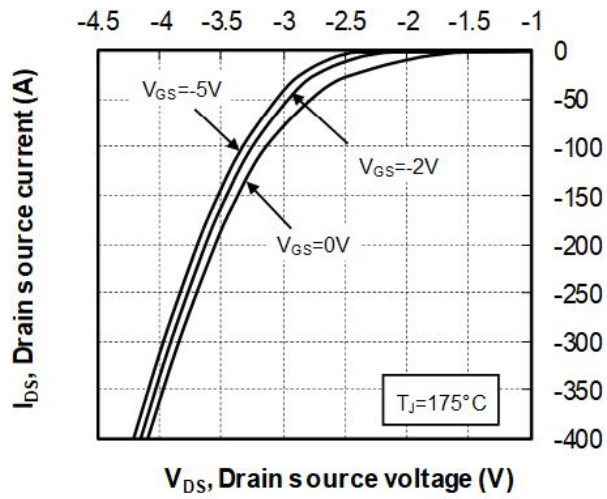


Figure 1-13. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$

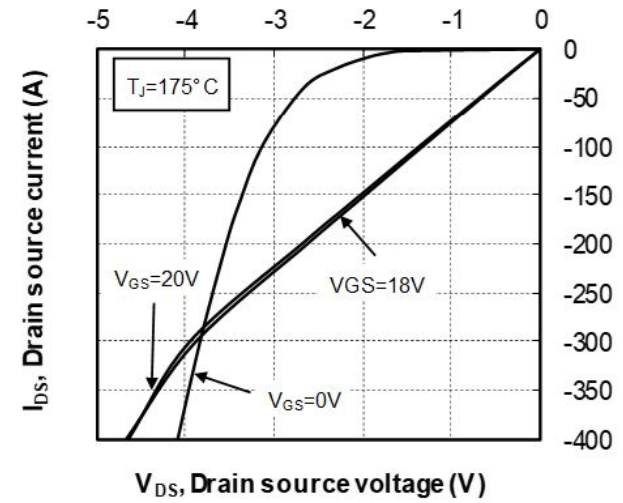
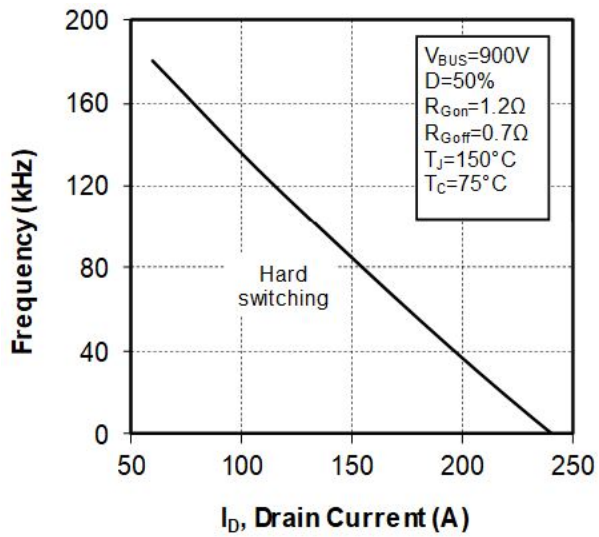


Figure 1-14. Operating Frequency vs. Drain Current



### 1.5 Typical SiC Diode Performance Curves

This section shows the typical SiC diode performance curves of the MSCSM170AM11CT3AG device.

Figure 1-15. Maximum Thermal Impedance

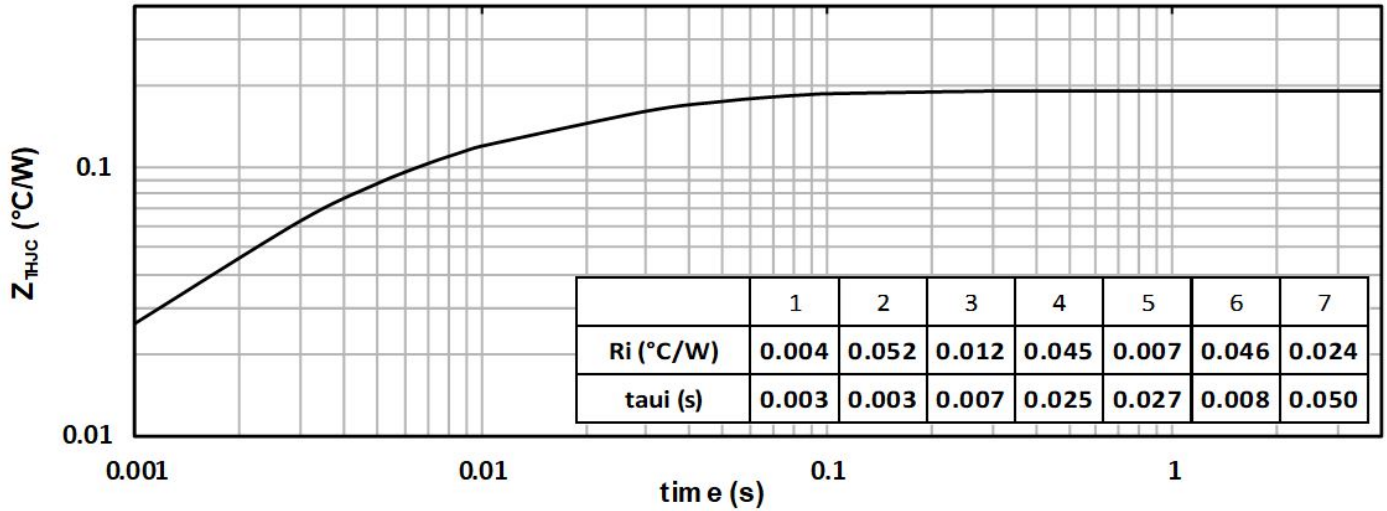


Figure 1-16. Forward Characteristics

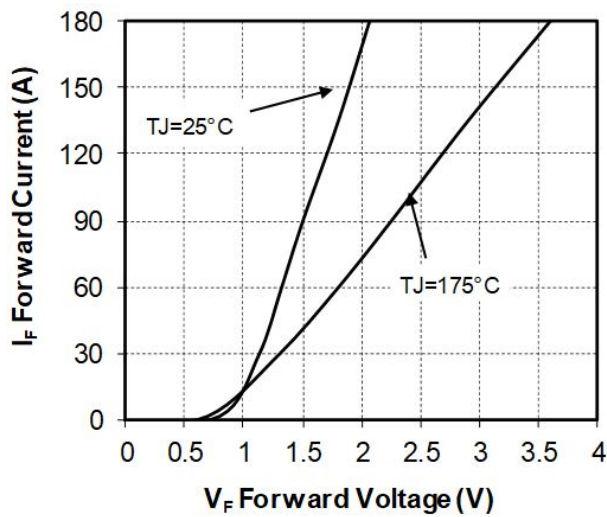
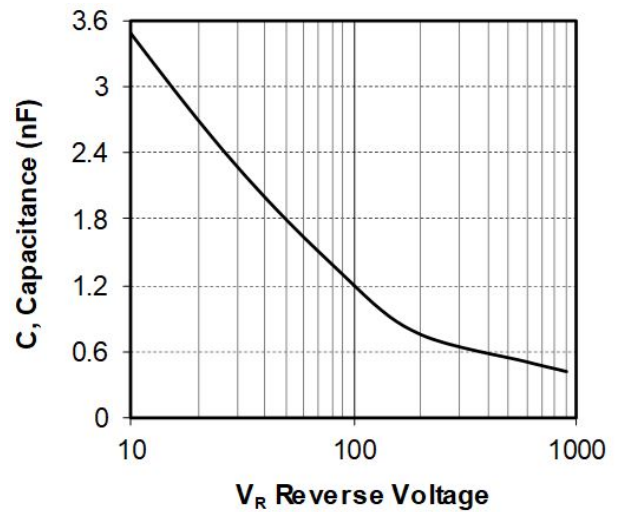


Figure 1-17. Capacitance vs. Reverse Voltage



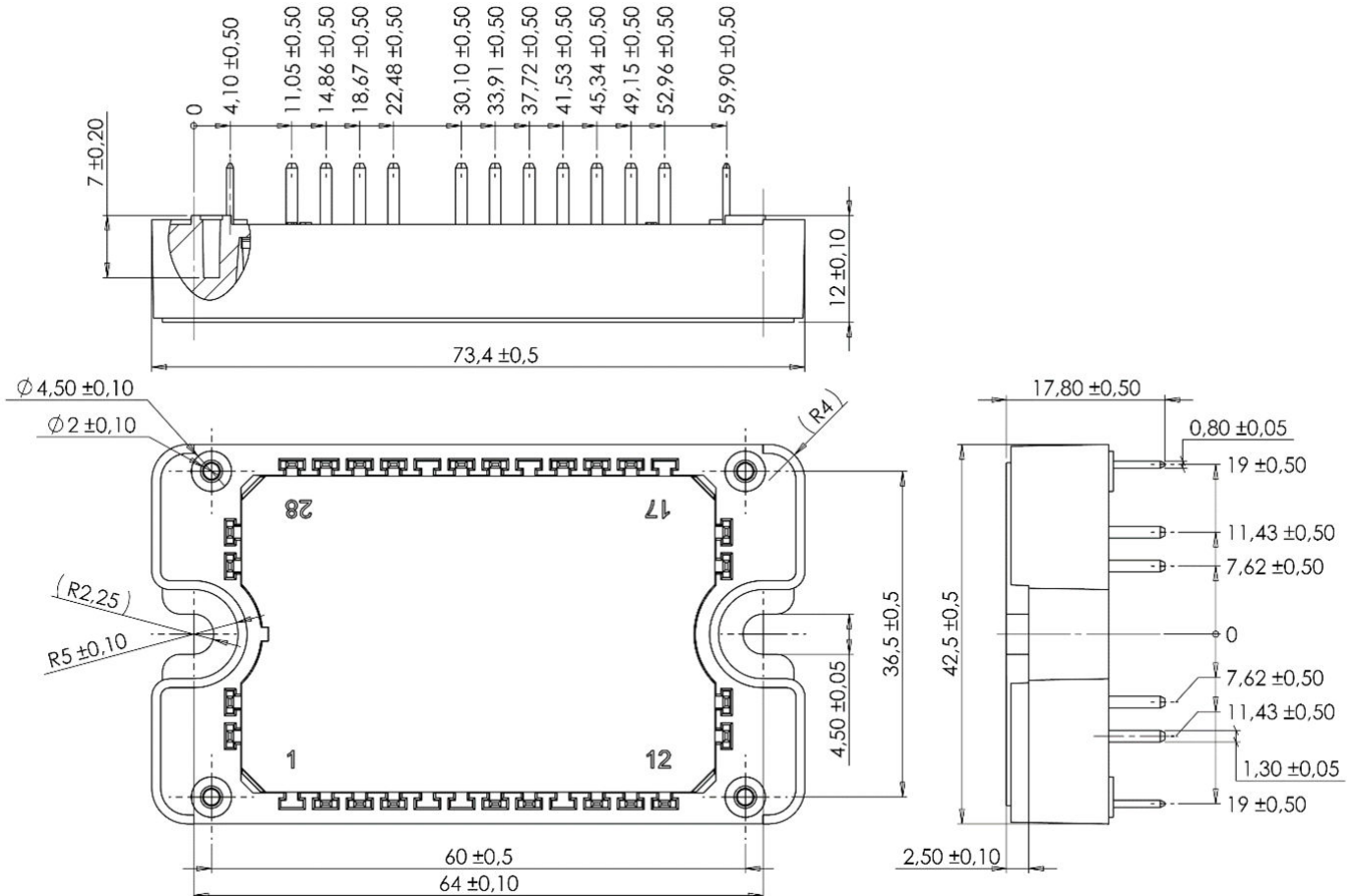
## 2. Package Specifications

The following section shows the package specification of the MSCSM170AM11CT3AG device.

### 2.1 Package Outline Drawing

The following figure shows the package outline drawing of the MSCSM170AM11CT3AG 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](#).

**3. Revision History**

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

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