

MSCSM120AM50CT1AG
Datasheet
Phase Leg SiC MOSFET Power Module

January 2020



a  **MICROCHIP** company

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1 Revision History

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 MSCSM120AM50CT1AG device is a phase leg 1200 V/55 A full Silicon Carbide (SiC) power module.

Figure 1 • MSCSM120AM50CT1AG Electric Schematic

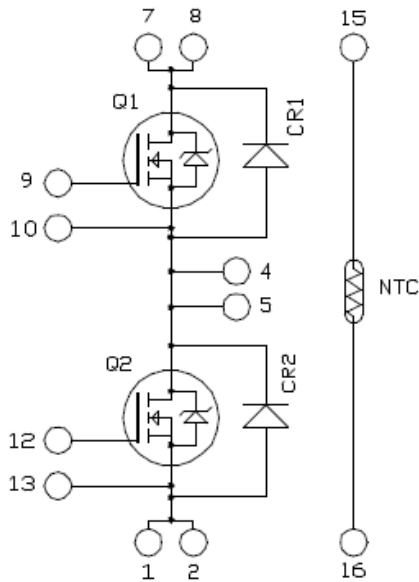
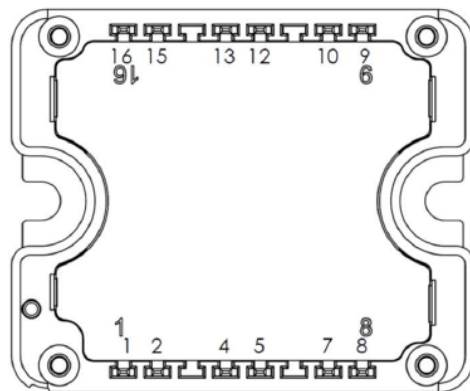


Figure 2 • MSCSM120AM50CT1AG Pinout Location



Pins 1/2 ; 4/5 ; 7/8 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 should be followed.

2.1 Features

The following are key features of the MSCSM120AM50CT1AG 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
- Aluminum nitride (AlN) substrate for improved thermal performance

2.2 Benefits

The following are benefits of the MSCSM120AM50CT1AG device:

- High power and efficiency converters and inverters
- 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 PCB mounting
- Low profile
- RoHS compliant

2.3 Applications

The MSCSM120AM50CT1AG device is designed for the following applications:

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

3 Electrical Specifications

This section shows the electrical specifications of the MSCSM120AM50CT1AG device.

3.1 SiC MOSFET Characteristics (Per MOSFET)

The following table shows the absolute maximum ratings per MOSFET of the MSCSM120AM50CT1AG device.

Table 1 • Absolute Maximum Ratings

| Symbol | Parameter | Max Ratings | Unit | |
|--------------|----------------------------|----------------------------------|------------|---|
| V_{DSS} | Drain-source voltage | 1200 | V | |
| I_D | Continuous drain current | $T_C = 25\text{ }^\circ\text{C}$ | 55 | A |
| | | $T_C = 80\text{ }^\circ\text{C}$ | 44 | |
| I_{DM} | Pulsed drain current | 110 | | |
| V_{GS} | Gate-source voltage | -10/25 | V | |
| $R_{DS(on)}$ | Drain-source ON resistance | 50 | m Ω | |
| P_D | Power dissipation | $T_C = 25\text{ }^\circ\text{C}$ | 245 | W |

The following table shows the electrical characteristics per MOSFET of the MSCSM120AM50CT1AG device.

Table 2 • Electrical Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit | |
|--------------|---------------------------------|---|-----------------------------------|-----|-----|---------------|------------|
| I_{DSS} | Zero gate voltage drain current | $V_{GS} = 0\text{ V}; V_{DS} = 1200\text{ V}$ | | 10 | 100 | μA | |
| $R_{DS(on)}$ | Drain-source on resistance | $V_{GS} = 20\text{ V}$ $I_D = 40\text{ A}$ | $T_J = 25\text{ }^\circ\text{C}$ | | 40 | 50 | m Ω |
| | | | $T_J = 175\text{ }^\circ\text{C}$ | | 64 | | |
| $V_{GS(th)}$ | Gate threshold voltage | $V_{GS} = V_{DS}, I_D = 1\text{ mA}$ | 1.8 | 2.7 | | V | |
| I_{GSS} | Gate-source leakage current | $V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$ | | | 150 | nA | |

The following table shows the dynamic characteristics per MOSFET of the MSCSM120AM50CT1AG device.

Table 3 • Dynamic Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|--------------|-------------------------------------|---|-----------------------------------|------|------|---------------------------|
| C_{iss} | Input capacitance | $V_{GS} = 0\text{ V}$ $V_{DS} = 1000\text{ V}$ $f = 1\text{ MHz}$ | | 1990 | | pF |
| C_{oss} | Output capacitance | | | 156 | | |
| C_{rss} | Reverse transfer capacitance | | | 17 | | |
| Q_g | Total gate charge | $V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 800\text{ V}$ $I_D = 40\text{ A}$ | | 137 | | nC |
| Q_{gs} | Gate-source charge | | | 29 | | |
| Q_{gd} | Gate-drain charge | | | 31 | | |
| $T_{d(on)}$ | Turn-on delay time | $V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 600\text{ V}$ $I_D = 40\text{ A}$ $R_{Gon} = 10\ \Omega$; $R_{Goff} = 5.8\ \Omega$ | | 30 | | ns |
| T_r | Rise time | | | 30 | | |
| $T_{d(off)}$ | Turn-off delay time | | | 50 | | |
| T_f | Fall time | | | 25 | | |
| E_{on} | Turn on energy | Inductive switching | $T_j = 150\text{ }^\circ\text{C}$ | 0.79 | | mJ |
| E_{off} | Turn off energy | $V_{GS} = -5\text{ V}/20\text{ V}$ $V_{Bus} = 600\text{ V}$ $I_D = 40\text{ A}$ $R_{Gon} = 10\ \Omega$ $R_{Goff} = 5.8\ \Omega$ | $T_j = 150\text{ }^\circ\text{C}$ | 0.53 | | mJ |
| R_{Gint} | Internal gate resistance | | | 1.2 | | Ω |
| R_{thJC} | Junction-to-case thermal resistance | | | | 0.61 | $^\circ\text{C}/\text{W}$ |

The following table shows the body diode ratings and characteristics per MOSFET of the MSCSM120AM50CT1AG device.

Table 4 • Body Diode Ratings and Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|----------|--------------------------|---|-----|-----|-----|------|
| V_{SD} | Diode forward voltage | $V_{GS} = 0\text{ V}$; $I_{SD} = 40\text{ A}$ | | 5.4 | | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 40\text{ A}$; $V_{GS} = -5\text{ V}$ $V_R = 800\text{ V}$; $dI_F/dt = 1800\text{ A}/\mu\text{s}$ | | 31 | | ns |
| Q_{rr} | Reverse recovery charge | | | 610 | | nC |
| I_{rr} | Reverse recovery current | | | 40 | | A |

3.2 Reverse SiC Diode Ratings and Characteristics (Per SiC Diode)

The following table shows the reverse SiC diode ratings and characteristics per SiC diode of the MSCSM120AM50CT1AG device.

Table 5 • Reverse SiC Diode Ratings and Characteristics (Per SiC Diode)

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|------------|-------------------------------------|--|-----------------------|-----|-----|------|----------------------|
| V_{RRM} | Peak repetitive reverse voltage | | | | | 1200 | V |
| I_{RM} | Reverse leakage current | $V_R = 1200\text{ V}$ | $T_J = 25\text{ °C}$ | 10 | 200 | | μA |
| | | | $T_J = 175\text{ °C}$ | 50 | | | |
| I_F | DC forward current | | | | 15 | | A |
| V_F | Diode forward voltage | $I_F = 15\text{ A}$ | $T_J = 25\text{ °C}$ | 1.5 | 1.8 | | V |
| | | | $T_J = 175\text{ °C}$ | 2 | | | |
| QC | Total capacitive charge | $V_R = 600\text{ V}$ | | | 73 | | nC |
| C | Total capacitance | $f = 1\text{ MHz}, V_R = 400\text{ V}$ | | | 80 | | μF |
| | | $f = 1\text{ MHz}, V_R = 800\text{ V}$ | | | 59 | | |
| R_{thJC} | Junction-to-case thermal resistance | | | | | 1.55 | $^{\circ}\text{C/W}$ |

3.3 Thermal and Package Characteristics

The following table shows the package characteristics of the MSCSM120AM50CT1AG device.

Table 6 • 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 temperature range | | | -40 | 125 | |
| T_C | Operating case temperature | | | -40 | 125 | |
| Torque | Mounting torque | To heatsink | M4 | 2 | 3 | N.m |
| Wt | Package weight | | | | 80 | g |

The following table shows the temperature sensor NTC (see application note [APT0406](#) on www.microsemi.com) of the MSCSM120AM50CT1AG device.

Table 7 • Temperature Sensor NTC

| Symbol | Characteristic | Min | Typ | Max | Unit |
|-----------------------------------|----------------------------|-----|------|-----|------|
| R ₂₅ | Resistance at 25 °C | | 50 | | kΩ |
| ΔR ₂₅ /R ₂₅ | | | 5 | | % |
| B _{25/85} | T ₂₅ = 298.15 K | | 3952 | | K |
| ΔB/B | | | 4 | | % |
| | T _C = 100 °C | | | | |

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

T: Thermistor temperature
 R_T: Thermistor value at T

3.4 Typical SiC MOSFET Performance Curves

This sections shows the typical SiC MOSFET performance curves of the MSCSM120AM50CT1AG device.

Figure 3 • Maximum Thermal Impedance

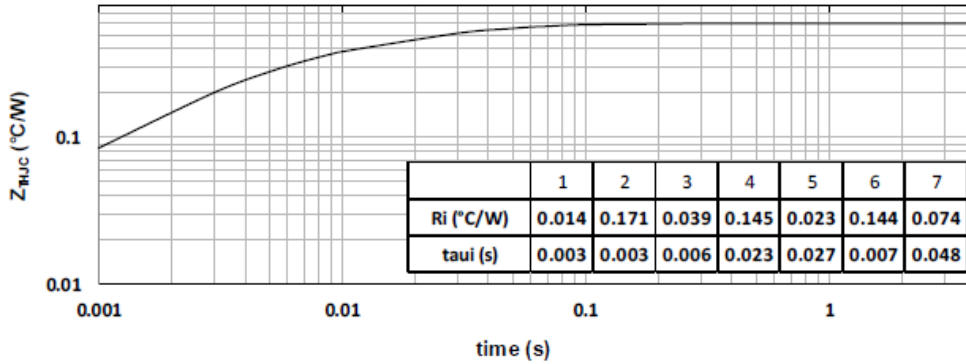


Figure 4 • Output Characteristics, $T_J = 25^\circ\text{C}$

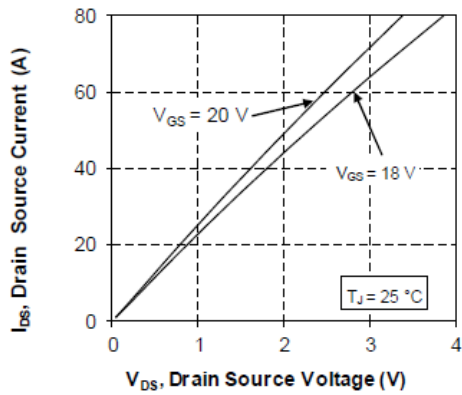


Figure 5 • Output Characteristics, $T_J = 175^\circ\text{C}$

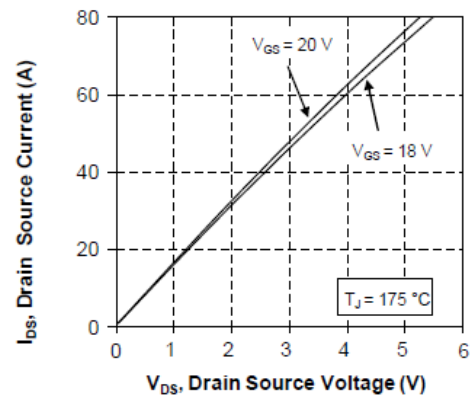


Figure 6 • Normalized $R_{DS(on)}$ vs. Temperature

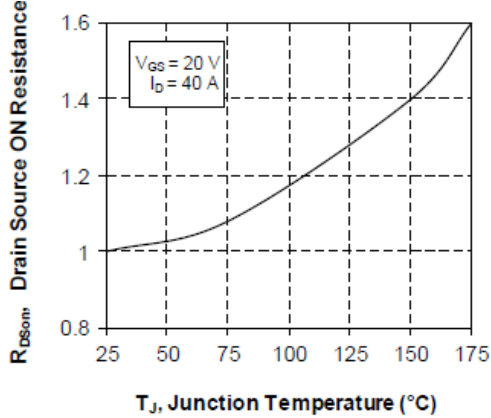


Figure 7 • Transfer Characteristics

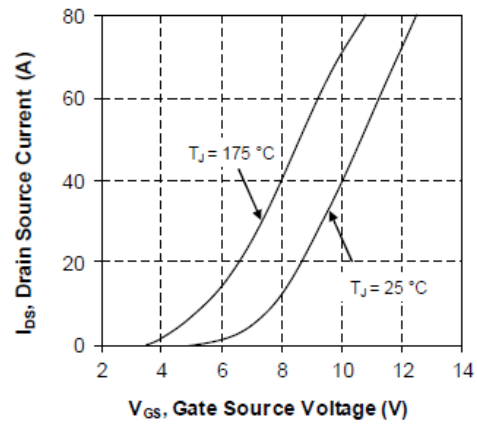


Figure 8 • Switching Energy vs. Rg

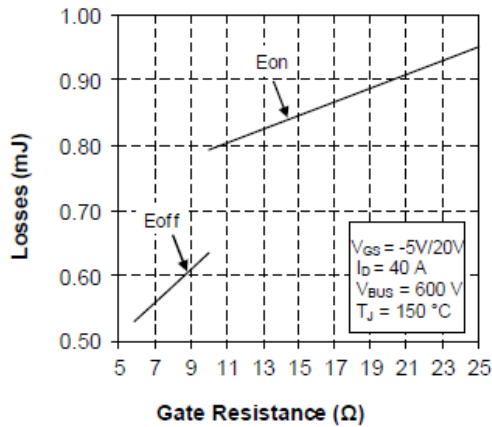


Figure 9 • Switching Energy vs. Current

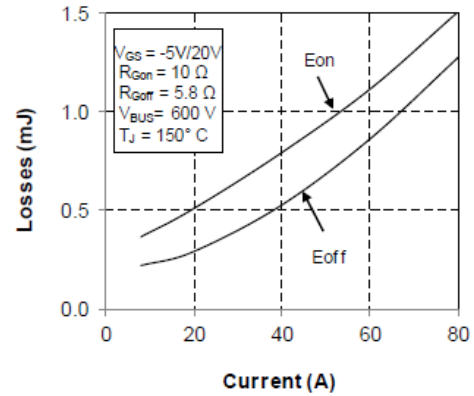


Figure 10 • Capacitance vs. Drain Source Voltage

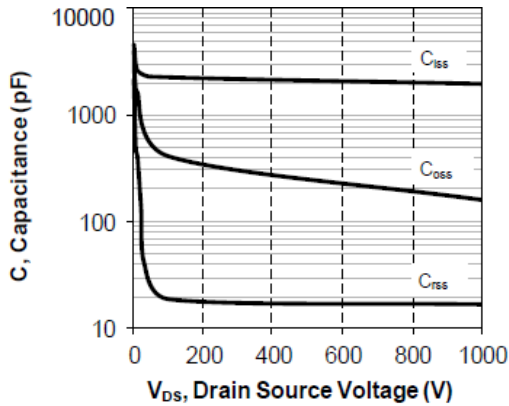


Figure 11 • Gate Charge vs. Gate Source Voltage

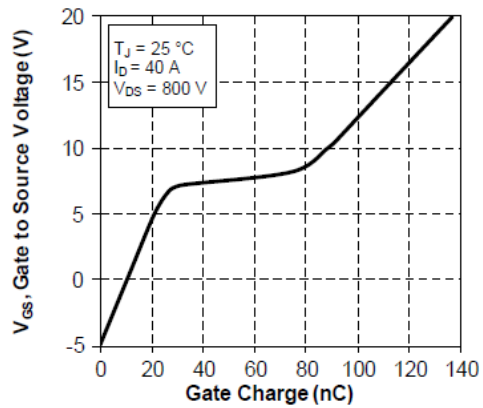


Figure 12 • Body Diode Characteristics, TJ = 25 °C

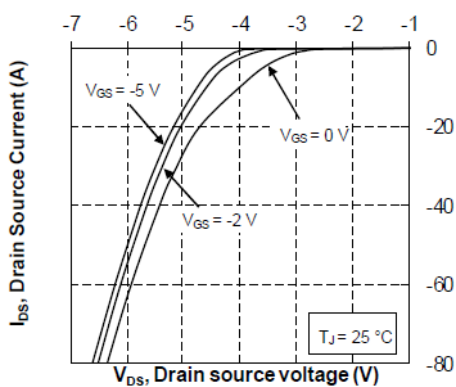


Figure 13 • 3rd Quadrant Characteristics, TJ = 25 °C

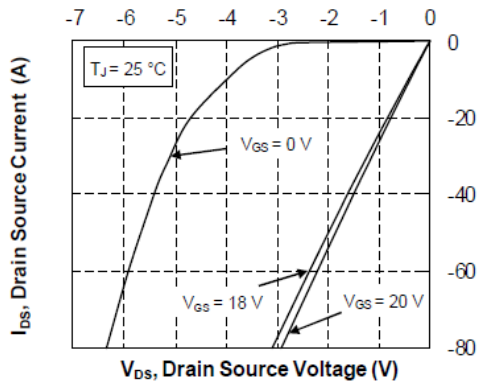


Figure 14 • Body Diode Characteristics, $T_J = 175^\circ\text{C}$

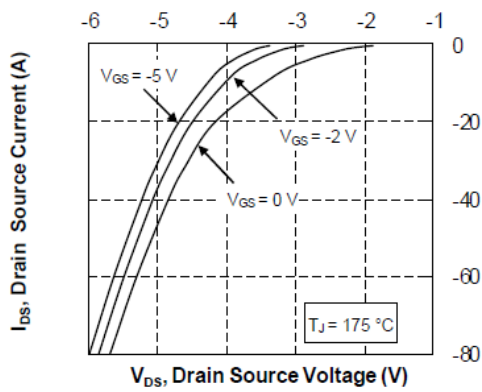


Figure 15 • 3rd Quadrant Characteristics, $T_J = 175^\circ\text{C}$

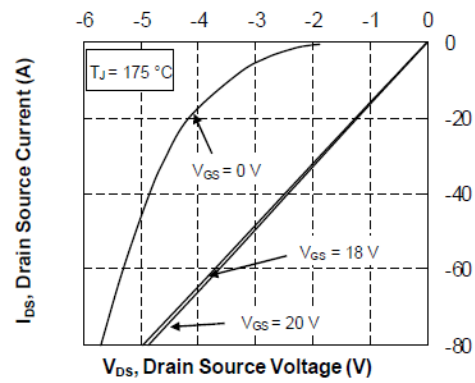
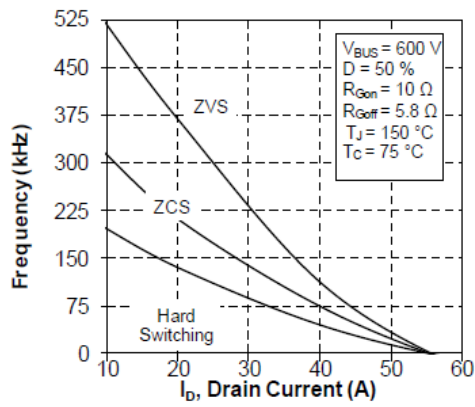


Figure 16 • Operating Frequency vs. Drain Current



3.5 Typical SiC Diode Performance Curves

This sections shows the typical SiC diode performance curves of the MSCSM120AM50CT1AG device.

Figure 17 • Maximum Thermal Impedance

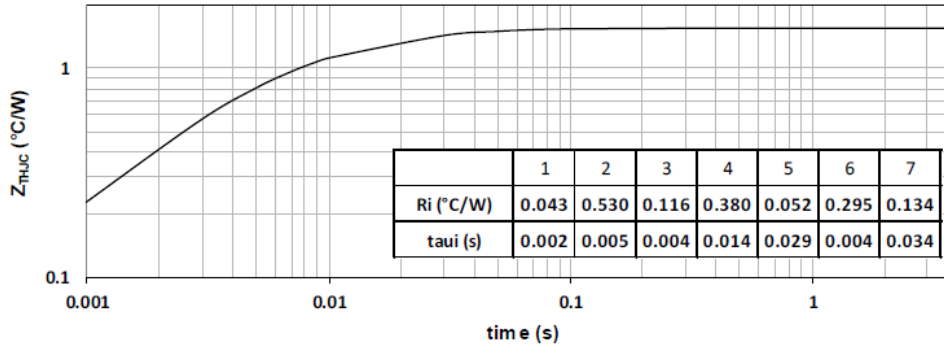


Figure 18 • Forward Characteristics

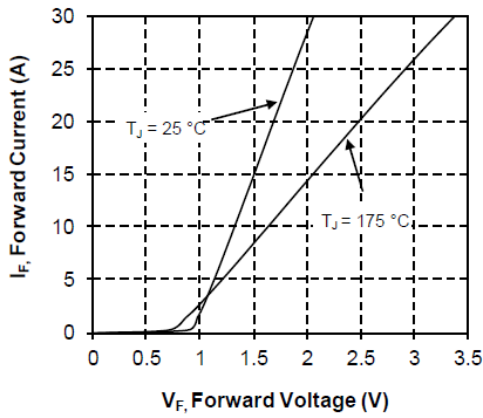
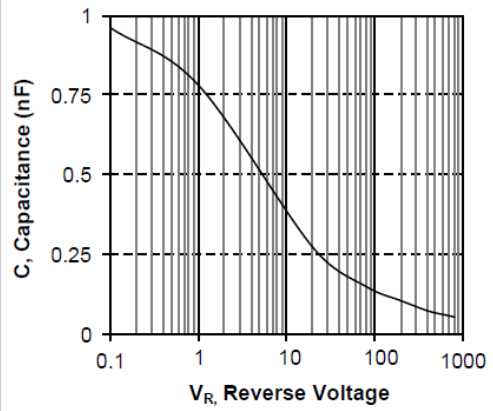


Figure 19 • Capacitance vs. Reverse Voltage



4 Package Specifications

This section shows the package specification of the MSCSM120AM50CT1AG device.

4.1 Package Outline Drawing

This section shows the package outline drawing of the MSCSM120AM50CT1AG device. The dimensions in the following figure are in millimeters.

Figure 20 • Package Outline Drawing

