

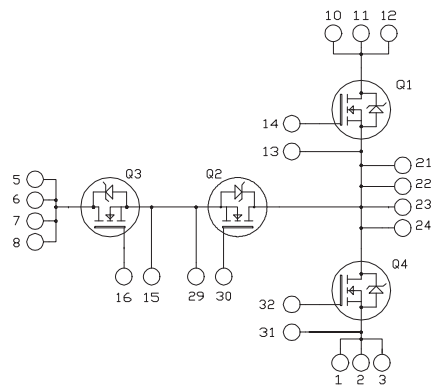
## T-Type SiC MOSFET Power Module

### Product Overview

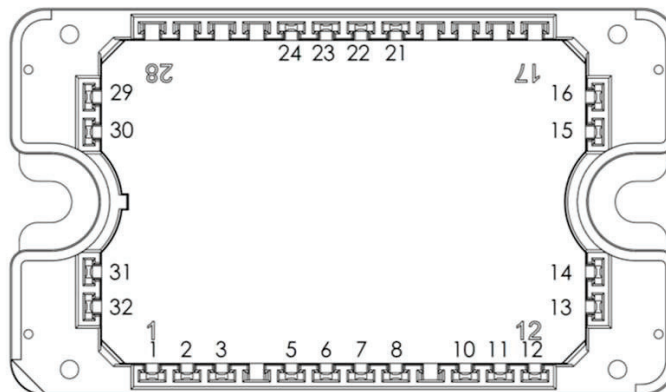
The MSCSM170HRM233AG device is a T-type Silicon Carbide (SiC) MOSFET power module with a phase leg 1700V, 124A and a dual common source 1200V, 89A.

The following figures show the electrical and pinout location diagrams of the device.

**Figure 1. Electrical Diagram**



**Figure 2. Pinout Location Diagram**



**Notes:**

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



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

## Features

The MSCSM170HRM233AG device has the following key features:

- SiC Power MOSFET
  - High-speed switching
  - Low  $R_{DS(on)}$
  - Ultra low loss
- Very low stray inductance
- AlN substrate for improved thermal performance

## Benefits

The MSCSM170HRM233AG device has the following benefits:

- Outstanding performance at high-frequency operation
- High-power and high-efficiency rectifiers and converters
- 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 MSCSM170HRM233AG device has the following applications:

- Solar inverter
- Three-level inverter
- Uninterruptible power supplies

### 1. Electrical Specifications

The following sections describe the electrical specifications of the MSCSM170HRM233AG device.

#### 1.1 Q1 and Q4 1700V Phase Leg SiC MOSFETs Characteristics (Per SiC MOSFET)

The following table lists the absolute maximum ratings (per SiC MOSFET) of the Q1 and Q4 1700V phase leg SiC MOSFETs.

**Table 1-1. Absolute Maximum Ratings: Q1 and Q4 1700V Phase Leg SiC MOSFETs**

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

The following table lists the electrical characteristics (per SiC MOSFET) of the Q1 and Q4 1700V Phase Leg SiC MOSFETs.

**Table 1-2. Electrical Characteristics: Q1 and Q4 1700V Phase Leg SiC MOSFETs**

| Symbol       | Characteristic                  | Test Conditions                         |                                     | Min. | Typ. | Max. | Unit       |
|--------------|---------------------------------|-----------------------------------------|-------------------------------------|------|------|------|------------|
| $I_{DSS}$    | Zero gate voltage drain current | $V_{GS} = 0V$ ; $V_{DS} = 1700V$        |                                     | —    | 20   | 200  | $\mu A$    |
| $R_{DS(on)}$ | Drain-source ON resistance      | $V_{GS} = 20V$<br>$I_D = 60A$           | $T_J = 25\text{ }^{\circ}\text{C}$  | —    | 17.5 | 22.5 | m $\Omega$ |
|              |                                 |                                         | $T_J = 175\text{ }^{\circ}\text{C}$ | —    | 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     | $V_{GS} = 20V$ ; $V_{DS} = 0V$          |                                     | —    | —    | 200  | nA         |

The following table lists the dynamic characteristics (per SiC MOSFET) of the Q1 and Q4 1700V phase leg SiC MOSFETs.

**Table 1-3. Dynamic Characteristics: Q1 and Q4 1700V Phase Leg SiC MOSFETs**

| Symbol       | Characteristic                      | Test Conditions                                                                     | Min.                         | Typ. | Max. | Unit          |
|--------------|-------------------------------------|-------------------------------------------------------------------------------------|------------------------------|------|------|---------------|
| $C_{iss}$    | Input capacitance                   | $V_{GS} = 0V$                                                                       | —                            | 6600 | —    | pF            |
| $C_{oss}$    | Output capacitance                  | $V_{DS} = 1000V$                                                                    | —                            | 300  | —    |               |
| $C_{rss}$    | Reverse transfer capacitance        | $f = 1\text{ MHz}$                                                                  | —                            | 20   | —    |               |
| $Q_g$        | Total gate charge                   | $V_{GS} = -5V/20V$                                                                  | —                            | 356  | —    | nC            |
| $Q_{gs}$     | Gate-source charge                  | $V_{Bus} = 850V$                                                                    | —                            | 98   | —    |               |
| $Q_{gd}$     | Gate-drain charge                   | $I_D = 60A$                                                                         | —                            | 54   | —    |               |
| $T_{d(on)}$  | Turn-on delay time                  | $V_{GS} = -5V/20V$                                                                  | $T_J = 150\text{ }^{\circ}C$ | 19   | —    | ns            |
| $T_r$        | Rise time                           | $V_{Bus} = 900V$                                                                    |                              | 23   | —    |               |
| $T_{d(off)}$ | Turn-off delay time                 | $I_D = 100A$                                                                        |                              | 30   | —    |               |
| $T_f$        | Fall time                           | $R_{GON} = 2.4\Omega$<br>$R_{GOFF} = 1.4\Omega$                                     |                              | 15   | —    |               |
| $E_{on}$     | Turn-on energy                      | $V_{GS} = -5V/20V$                                                                  | $T_J = 150\text{ }^{\circ}C$ | 3.4  | —    | mJ            |
| $E_{off}$    | Turn-off energy                     | $V_{Bus} = 900V$<br>$I_D = 100A$<br>$R_{GON} = 2.4\Omega$<br>$R_{GOFF} = 1.4\Omega$ |                              | 0.18 | —    |               |
| $R_{Gint}$   | Internal gate resistance            |                                                                                     | —                            | 2.93 | —    | $\Omega$      |
| $R_{thJC}$   | Junction-to-case thermal resistance |                                                                                     | —                            | —    | 0.25 | $^{\circ}C/W$ |

The following table lists the body diode ratings and characteristics (per SiC MOSFET) of the Q1 and Q4 1700V phase leg SiC MOSFETs.

**Table 1-4. Body Diode Ratings and Characteristics: Q1 and Q4 1700V Phase Leg SiC MOSFETs**

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

### 1.2 Q2 and Q3 1200V Dual Common Source SiC MOSFETs Characteristics (Per SiC MOSFET)

The following table lists the absolute maximum ratings (per SiC MOSFET) of the Q2 and Q3 1200V dual common source SiC MOSFETs.

**Table 1-5. Absolute Maximum Ratings: Q2 and Q3 1200V Dual Common Source SiC MOSFETs**

| Symbol       | Parameter                  |                                    | Maximum Ratings | Unit       |
|--------------|----------------------------|------------------------------------|-----------------|------------|
| $V_{DS}$     | Drain-source voltage       |                                    | 1200            | V          |
| $I_D$        | Continuous drain current   | $T_C = 25\text{ }^{\circ}\text{C}$ | 89              | A          |
|              |                            | $T_C = 80\text{ }^{\circ}\text{C}$ | 71              |            |
| $I_{DM}$     | Pulsed drain current       |                                    | 180             |            |
| $V_{GS}$     | Gate-source voltage        |                                    | -10/23          | V          |
| $R_{DS(on)}$ | Drain-source ON resistance |                                    | 31              | m $\Omega$ |
| $P_D$        | Power dissipation          | $T_C = 25\text{ }^{\circ}\text{C}$ | 395             | W          |

The following table lists the electrical characteristics (per SiC MOSFET) of the Q2 and Q3 1200V dual common source SiC MOSFETs.

**Table 1-6. Electrical Characteristics: Q2 and Q3 1200V Dual Common Source SiC MOSFETs**

| 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  | $\mu\text{A}$ |
| $R_{DS(on)}$ | Drain-source ON resistance      | $V_{GS} = 20\text{V}$<br>$I_D = 40\text{A}$ | $T_J = 25\text{ }^{\circ}\text{C}$  | —    | 25   | 31   | m $\Omega$    |
|              |                                 |                                             | $T_J = 175\text{ }^{\circ}\text{C}$ | —    | 40   | —    |               |
| $V_{GS(th)}$ | Gate threshold voltage          | $V_{GS} = V_{DS}; I_D = 3\text{ mA}$        |                                     | 1.8  | 2.8  | —    | V             |
| $I_{GSS}$    | Gate-source leakage current     | $V_{GS} = 20\text{V}; V_{DS} = 0\text{V}$   |                                     | —    | —    | 150  | nA            |

The following table lists the dynamic characteristics (per SiC MOSFET) of the Q2 and Q3 1200V dual common source SiC MOSFETs.

**Table 1-7. Dynamic Characteristics: Q2 and Q3 1200V Dual Common Source SiC MOSFETs**

| Symbol       | Characteristic                      | Test Conditions                                                                  | Min.                         | Typ. | Max. | Unit          |
|--------------|-------------------------------------|----------------------------------------------------------------------------------|------------------------------|------|------|---------------|
| $C_{iss}$    | Input capacitance                   | $V_{GS} = 0V$                                                                    | —                            | 3020 | —    | pF            |
| $C_{oss}$    | Output capacitance                  | $V_{DS} = 1000V$                                                                 | —                            | 270  | —    |               |
| $C_{rss}$    | Reverse transfer capacitance        | $f = 1\text{ MHz}$                                                               | —                            | 25   | —    |               |
| $Q_g$        | Total gate charge                   | $V_{GS} = -5V/20V$                                                               | —                            | 232  | —    | nC            |
| $Q_{gs}$     | Gate-source charge                  | $V_{Bus} = 800V$                                                                 | —                            | 41   | —    |               |
| $Q_{gd}$     | Gate-drain charge                   | $I_D = 40A$                                                                      | —                            | 50   | —    |               |
| $T_{d(on)}$  | Turn-on delay time                  | $V_{GS} = -5V/20V$                                                               | $T_J = 150\text{ }^{\circ}C$ | 30   | —    | ns            |
| $T_r$        | Rise time                           | $V_{Bus} = 800V$                                                                 |                              | 30   | —    |               |
| $T_{d(off)}$ | Turn-off delay time                 | $I_D = 50A$                                                                      |                              | 50   | —    |               |
| $T_f$        | Fall time                           | $R_{GON} = 8\Omega$<br>$R_{GOFF} = 4.7\Omega$                                    |                              | 25   | —    |               |
| $E_{on}$     | Turn-on energy                      | $V_{GS} = -5V/20V$                                                               | $T_J = 150\text{ }^{\circ}C$ | 1.2  | —    | mJ            |
| $E_{off}$    | Turn-off energy                     | $V_{Bus} = 600V$<br>$I_D = 50A$<br>$R_{GON} = 8\Omega$<br>$R_{GOFF} = 4.7\Omega$ |                              | 0.66 | —    |               |
| $R_{Gint}$   | Internal gate resistance            |                                                                                  | —                            | 0.88 | —    | $\Omega$      |
| $R_{thJC}$   | Junction-to-case thermal resistance |                                                                                  | —                            | —    | 0.38 | $^{\circ}C/W$ |

The following table lists the body diode ratings and characteristics (per SiC MOSFET) of the Q2 and Q3 1200V dual common source SiC MOSFETs.

**Table 1-8. Body Diode Ratings and Characteristics: Q2 and Q3 1200V Dual Common Source SiC MOSFETs**

| Symbol   | Characteristic           | Test Conditions                                 | Min. | Typ. | Max. | Unit |
|----------|--------------------------|-------------------------------------------------|------|------|------|------|
| $V_{SD}$ | Diode forward voltage    | $V_{GS} = 0V$ ; $I_{SD} = 40A$                  | —    | 4    | —    | V    |
|          |                          | $V_{GS} = -5V$ ; $I_{SD} = 40A$                 | —    | 4.2  | —    |      |
| $t_{rr}$ | Reverse recovery time    | $I_{SD} = 40A$                                  | —    | 90   | —    | ns   |
| $Q_{rr}$ | Reverse recovery charge  | $V_{GS} = -5V$                                  | —    | 550  | —    | nC   |
| $I_{rr}$ | Reverse recovery current | $V_R = 800V$<br>$di_F/dt = 1000\text{ A}/\mu s$ | —    | 13.5 | —    | A    |

### 1.3 Thermal and Package Characteristics

The following table lists the package characteristics of the MSCSM170HRM233AG device.

**Table 1-9. Thermal and Package Characteristics**

| Symbol            | Characteristic                                                     |             |    | Min. | Max.                  | Unit |
|-------------------|--------------------------------------------------------------------|-------------|----|------|-----------------------|------|
| V <sub>ISOL</sub> | RMS isolation voltage, any terminal to case t = 1 min, 50 Hz/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                                                    | To heatsink | M4 | 2    | 3                     | N.m  |
| Wt                | Package weight                                                     |             |    | —    | 110                   | g    |

1.4 Typical 1700V SiC MOSFET Performance Curve

The following figures show the SiC MOSFET performance curves of the Q1 and Q4 1700V phase leg SiC MOSFETs.

Figure 1-1. Maximum Thermal Impedance

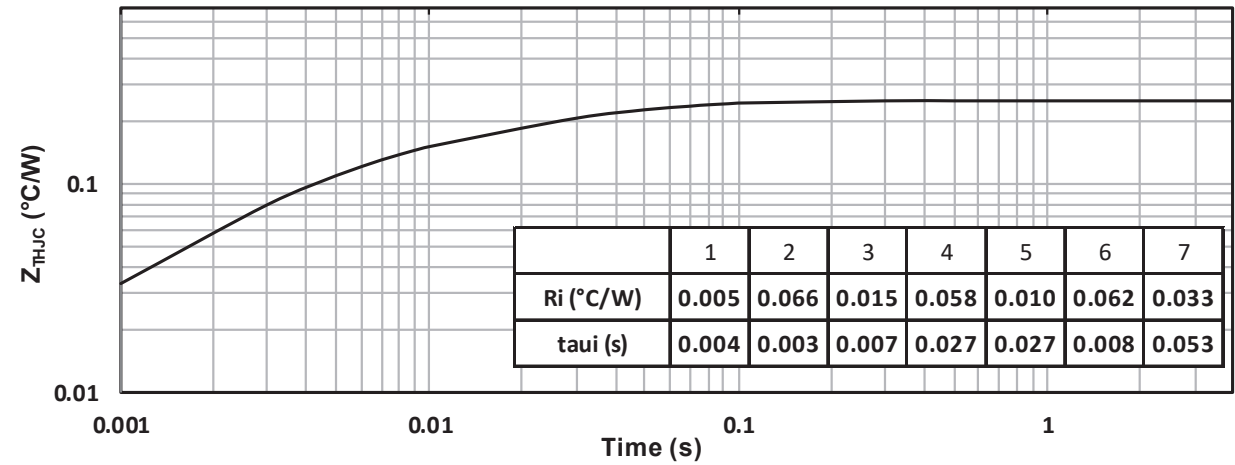


Figure 1-2. Output Characteristics, T<sub>J</sub> = 25 °C

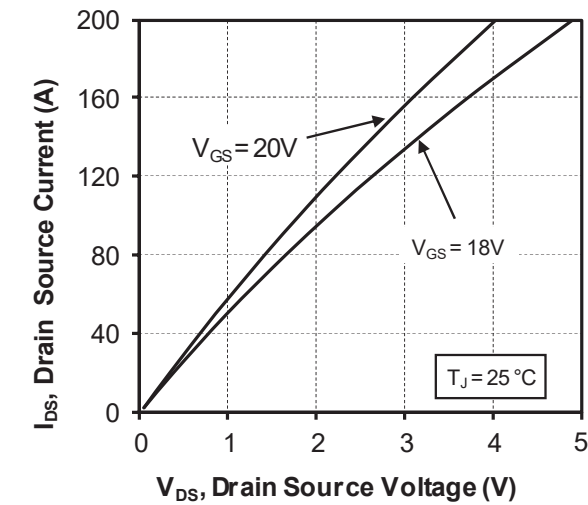


Figure 1-3. Output Characteristics, T<sub>J</sub> = 175 °C

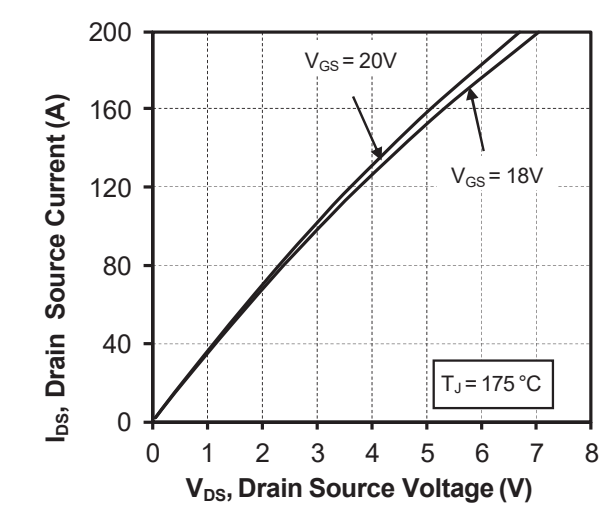


Figure 1-4. Normalized  $R_{DS(on)}$  vs. Temperature

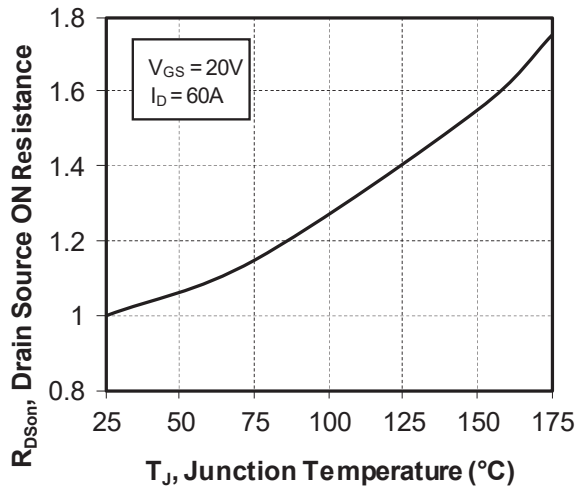


Figure 1-5. Transfer Characteristics

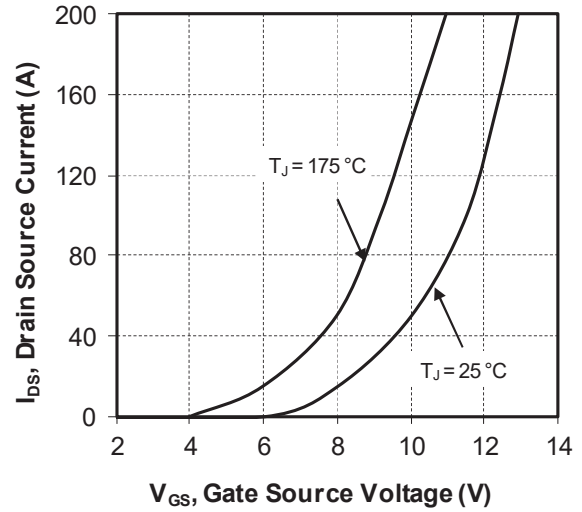


Figure 1-6. Switching Energy vs.  $R_g$

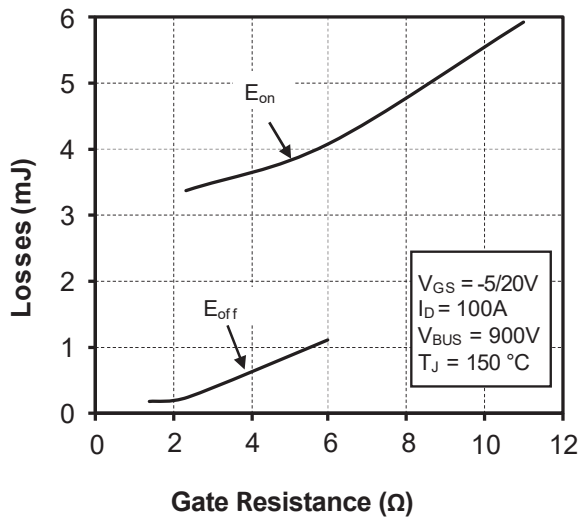


Figure 1-7. Switching Energy vs. Current

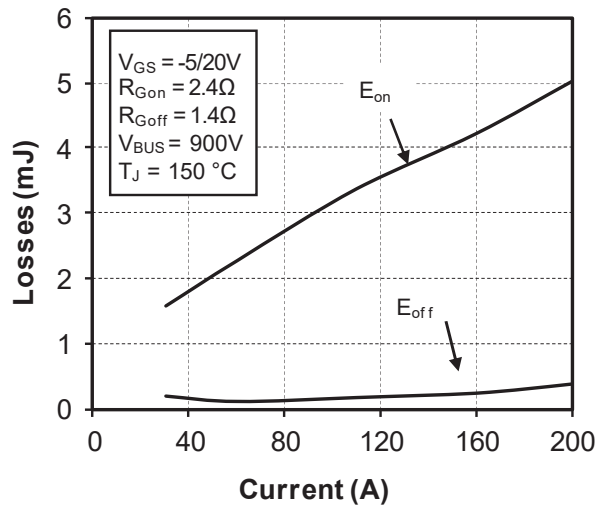


Figure 1-8. Capacitance vs. Drain Source Voltage

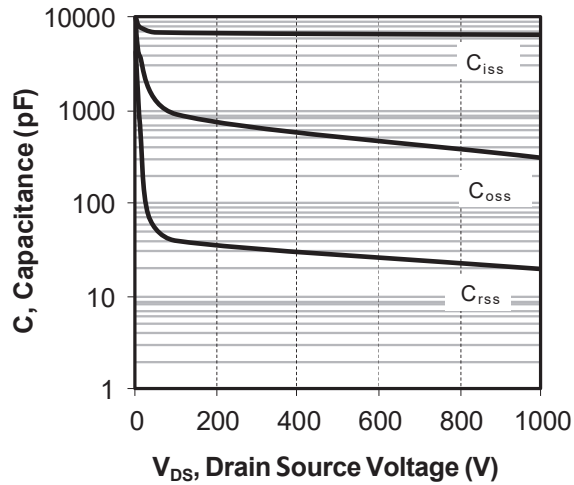


Figure 1-9. Gate Charge vs. Gate Source Voltage

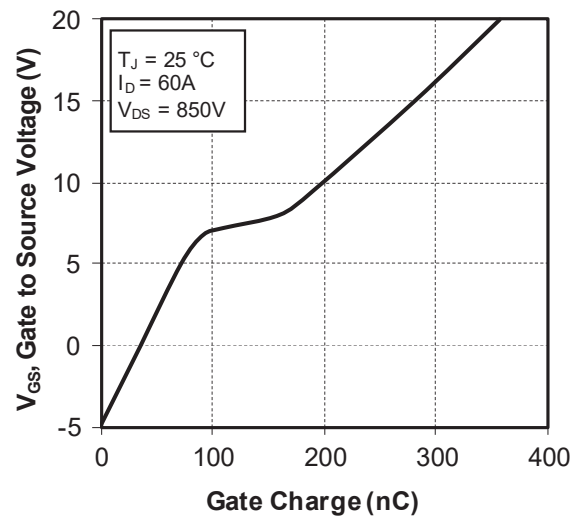


Figure 1-10. Body Diode Characteristics,  $T_J = 25^\circ\text{C}$

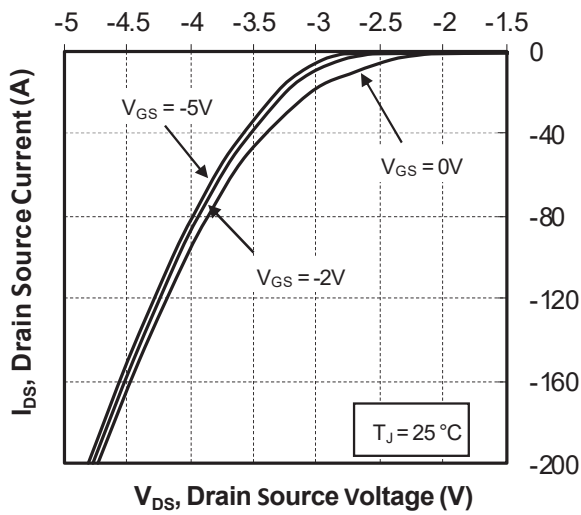


Figure 1-11. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$

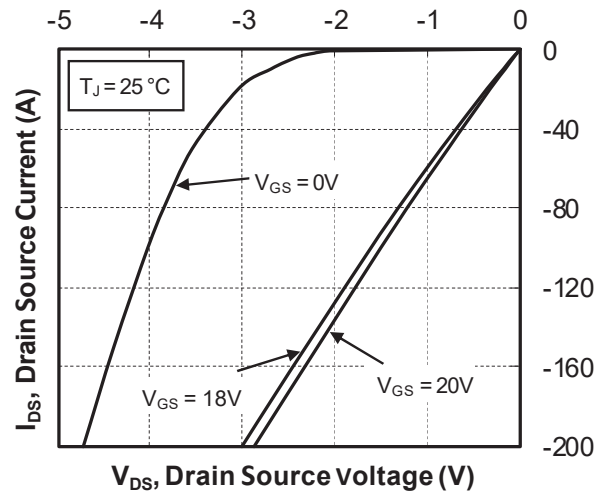


Figure 1-12. Body Diode Characteristics,  $T_J = 175\text{ }^\circ\text{C}$

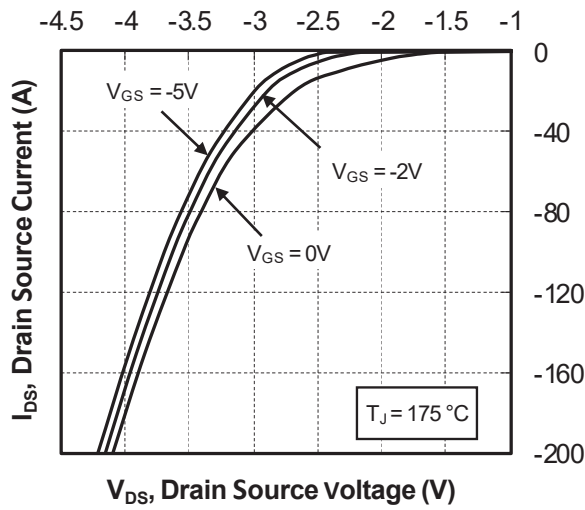


Figure 1-13. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175\text{ }^\circ\text{C}$

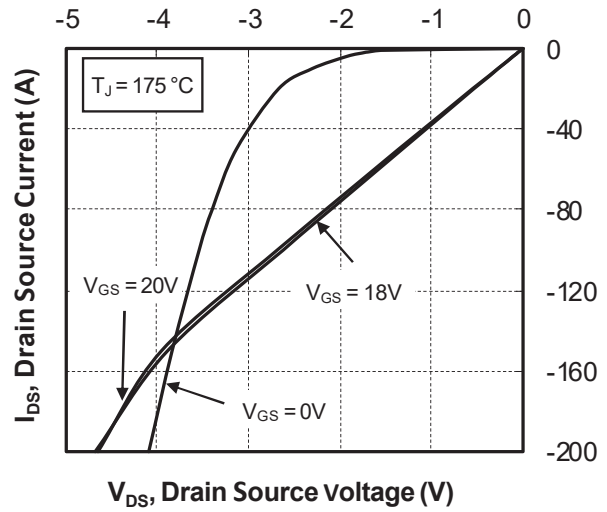
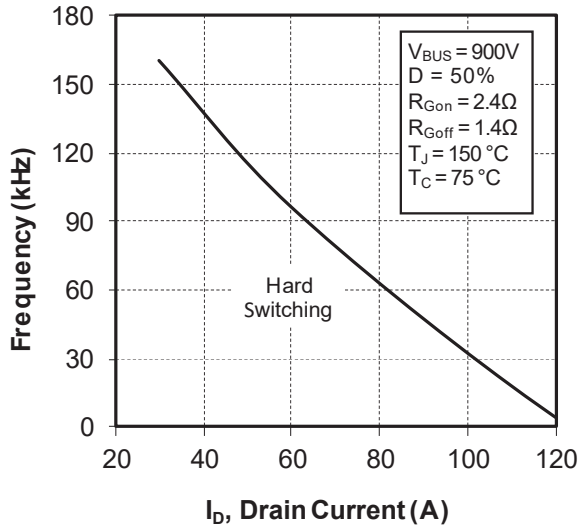


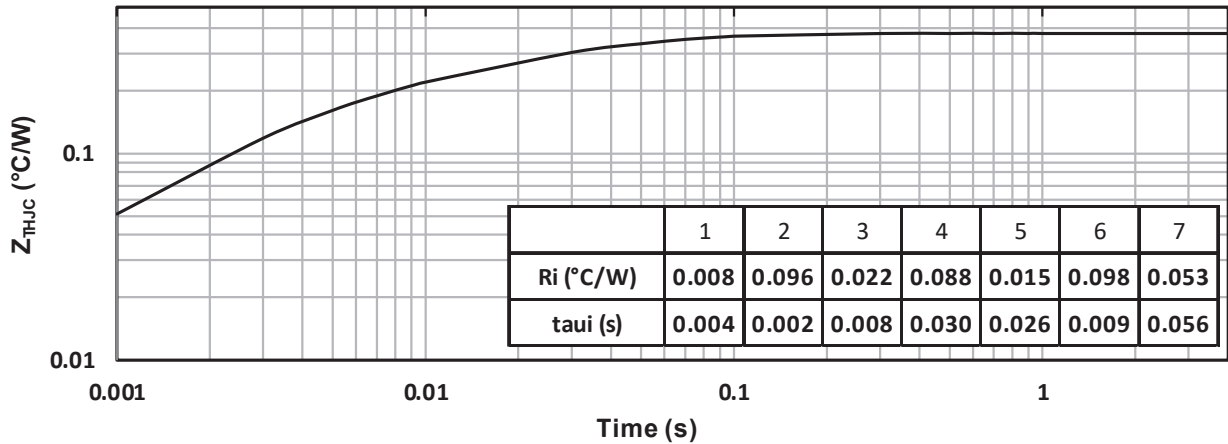
Figure 1-14. Operating Frequency vs. Drain Current



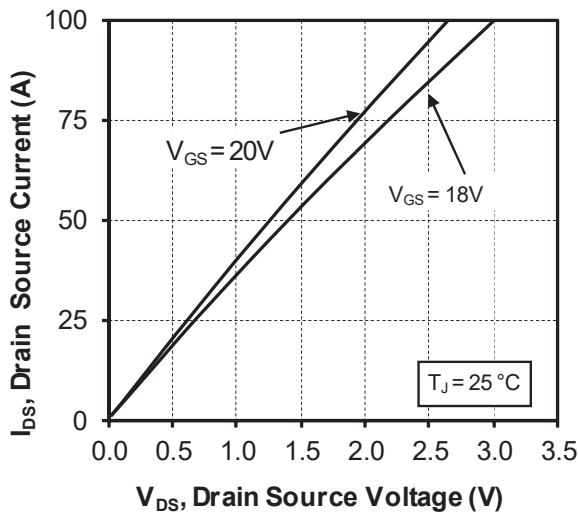
## 1.5 Typical 1200V SiC MOSFET Performance Curve

The following figures show the SiC MOSFET performance curves of the Q2 and Q3 1200V dual common source SiC MOSFETs.

**Figure 1-15. Maximum Thermal Impedance**



**Figure 1-16. Output Characteristics,  $T_J = 25^\circ\text{C}$**



**Figure 1-17. Output Characteristics,  $T_J = 175^\circ\text{C}$**

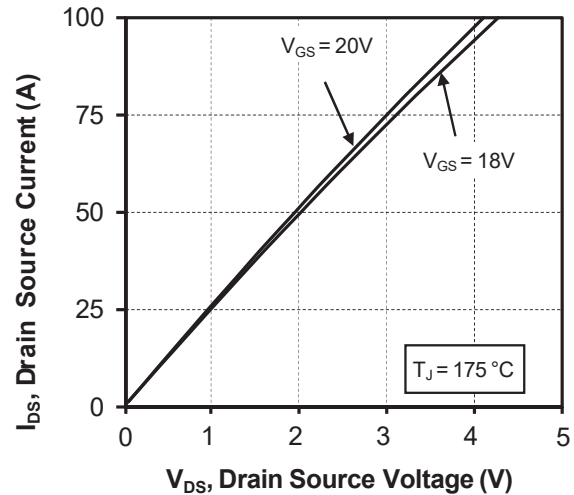


Figure 1-18. Normalized  $R_{DS(on)}$  vs. Temperature

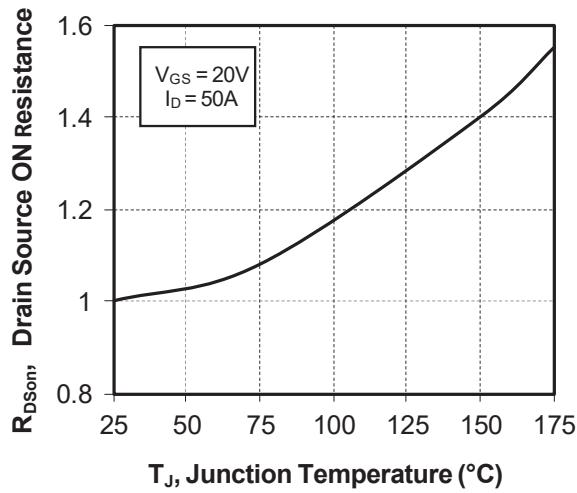


Figure 1-19. Transfer Characteristics

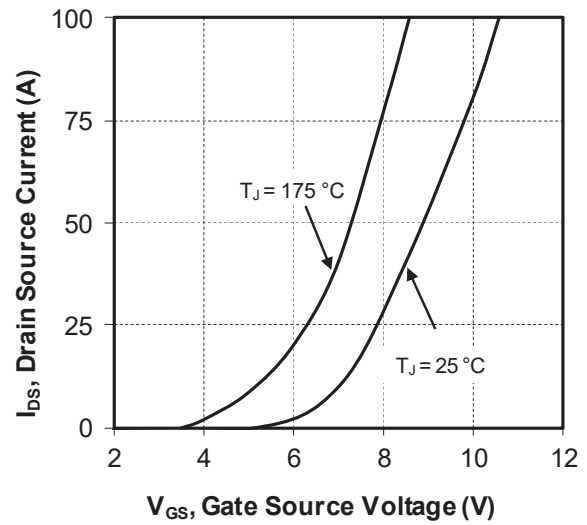


Figure 1-20. Switching Energy vs.  $R_g$

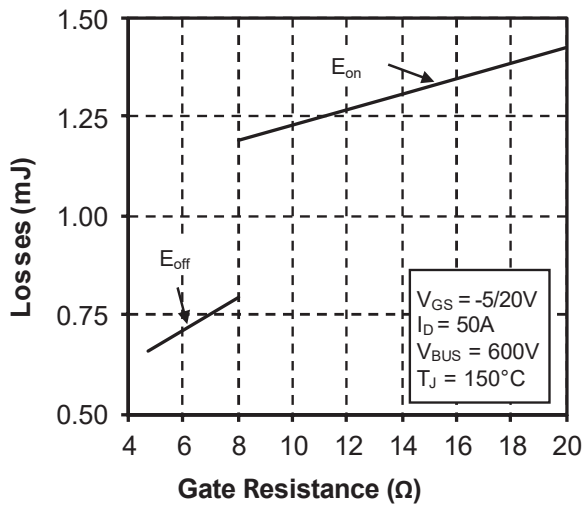


Figure 1-21. Switching Energy vs. Current

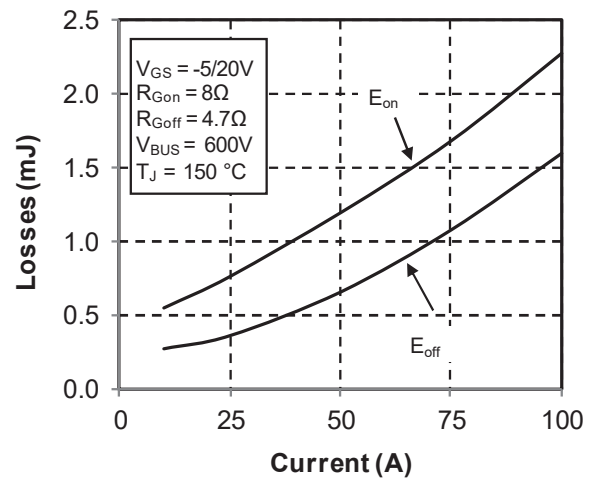


Figure 1-22. Capacitance vs. Drain Source Voltage

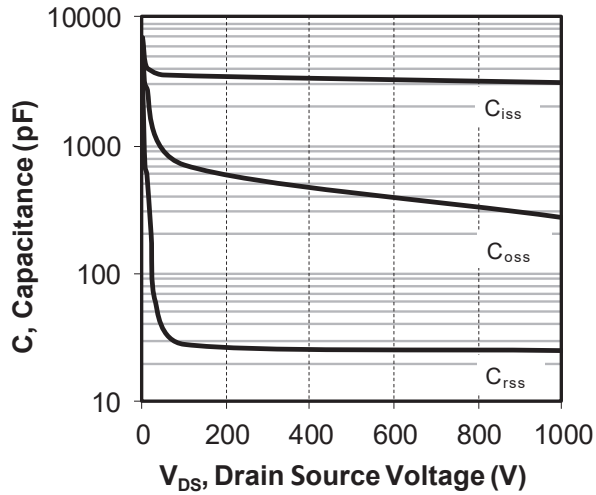


Figure 1-23. Gate Charge vs. Gate Source Voltage

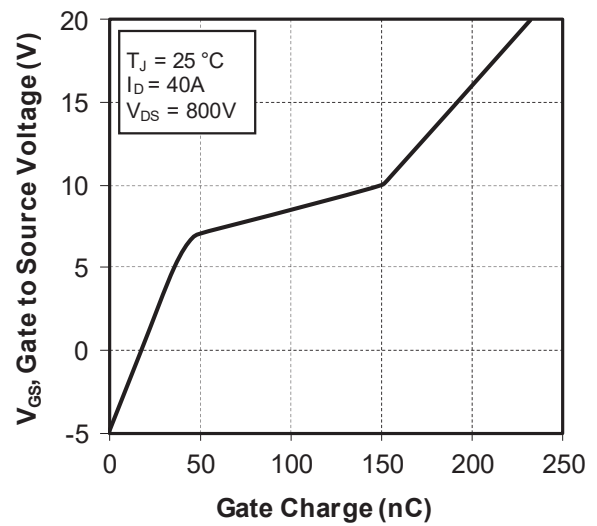


Figure 1-24. Body Diode Characteristics,  $T_J = 25^\circ\text{C}$

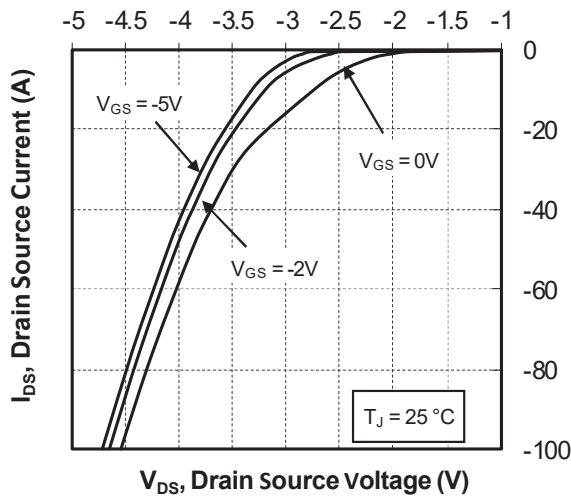


Figure 1-25. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 25^\circ\text{C}$

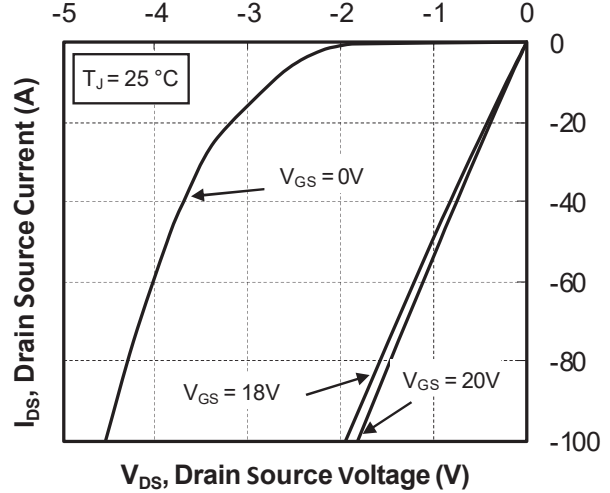


Figure 1-26. Body Diode Characteristics,  $T_J = 175^\circ\text{C}$

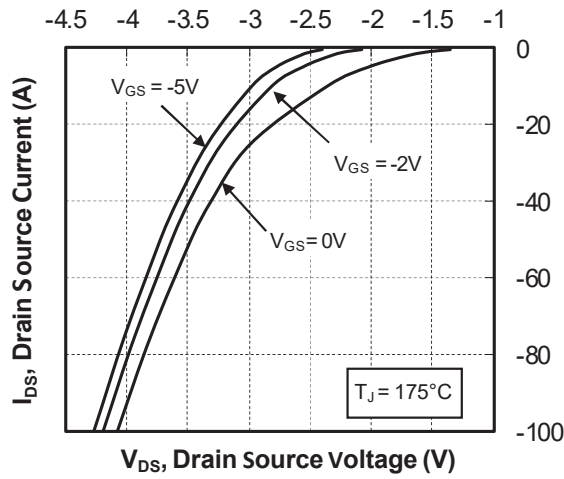


Figure 1-27. 3<sup>rd</sup> Quadrant Characteristics,  $T_J = 175^\circ\text{C}$

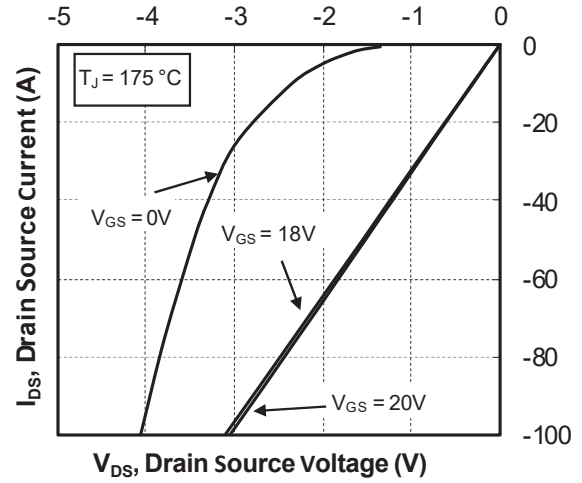
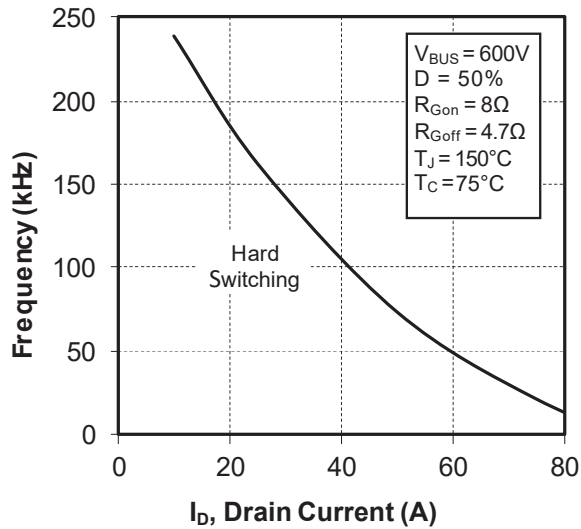


Figure 1-28. Operating Frequency vs. Drain Current



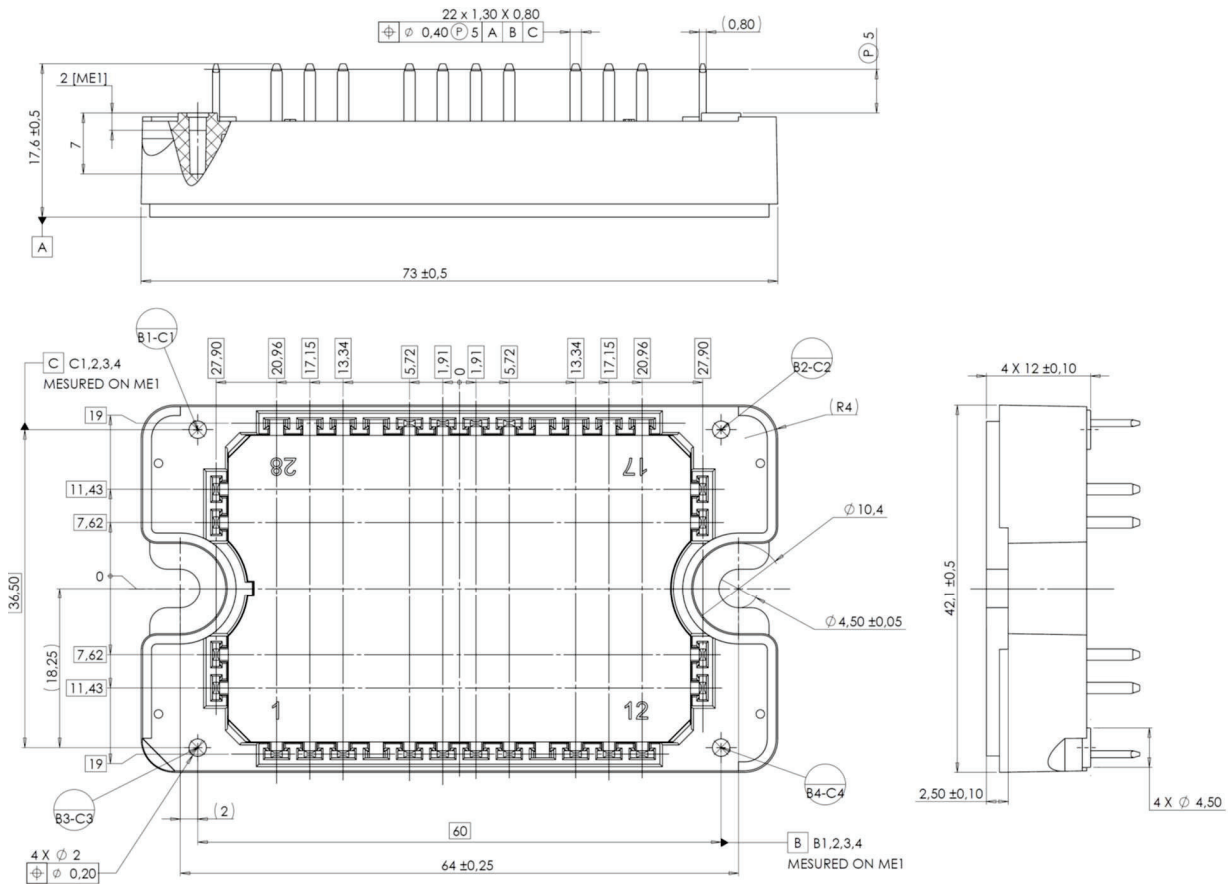
## 2. Package Specifications

The following section shows the package specification of the MSCSM170HRM233AG device.

### 2.1 Package Outline

The following figure shows the package outline drawing of the MSCSM170HRM233AG device. The dimensions in the following figure are in millimeters.

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



**Note:** For more information, see [AN3500—Mounting Instructions for SP1F and SP3F Power Modules](#).

### 3. 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.

| Revision | Date    | Description      |
|----------|---------|------------------|
| A        | 02/2023 | Initial revision |

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