

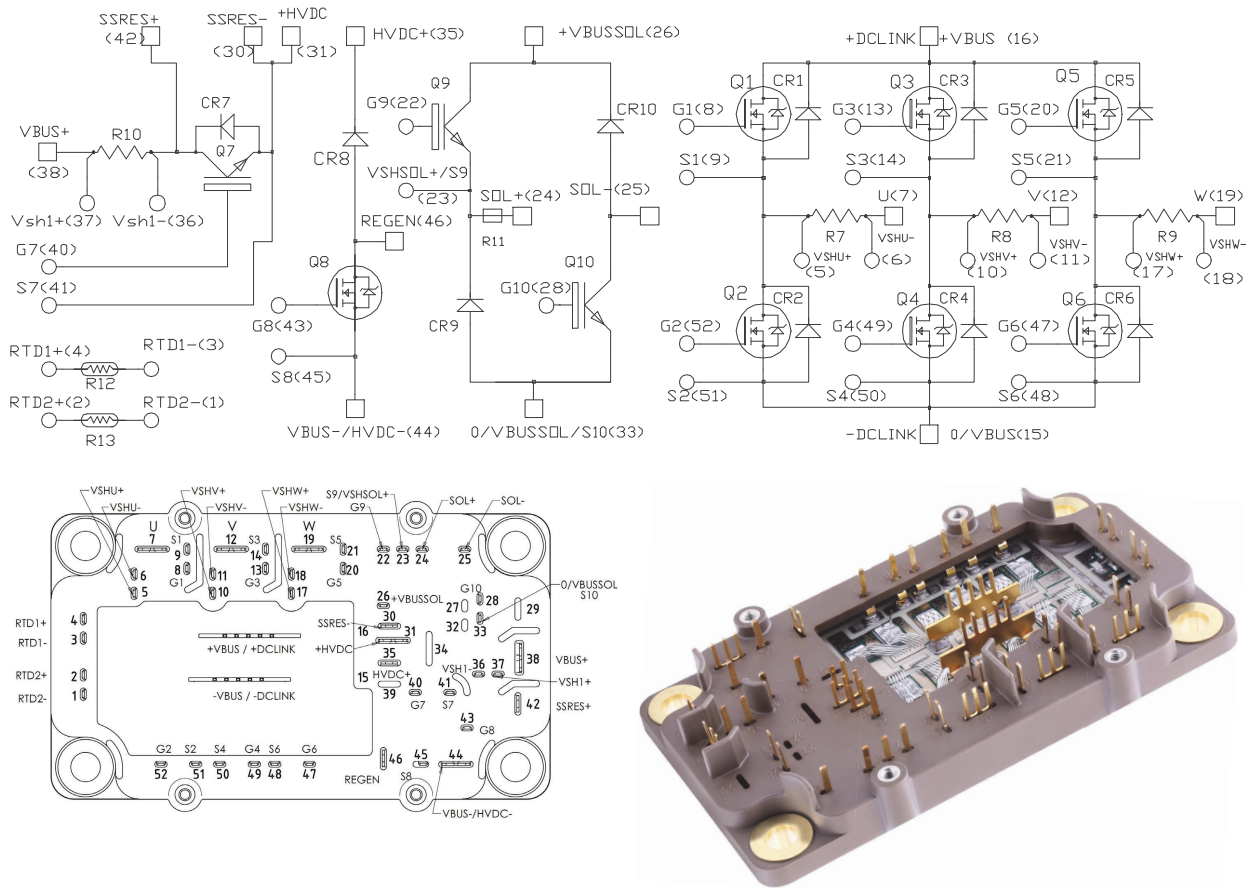


MSCSM120XM31CTYZBNMG

Three-Phase Bridge, Brake, Soft Start, and Solenoid Power Module

Product Overview

The MSCSM120XM31CTYZBNMG device is a three-phase bridge, brake, soft start, and solenoid power module.



Note: 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 MSCSM120XM31CTYZBNMG device has the following key features:

- Silicon Carbide (SiC) MOSFET
- SiC Schottky Diode
- Low stray inductance
- Lead frames for power connections
- Si₃N₄ substrate for improved thermal performance
- AlSiC base plate for extended reliability and reduced weight
- Extended storage temperature range
- Internal thermistor for temperature monitoring

Benefits

The MSCSM120XM31CTYZBNMG device has the following benefits:

- Stable temperature behavior
- Very rugged
- Solderable terminals for easy PCB mounting
- Direct mounting to heatsink (isolated package)
- Low junction-to-case thermal resistance
- RoHS Compliant

Application

The MSCSM120XM31CTYZBNMG device has the following applications:

- Hybrid Power Device (HPD) for Electro-Mechanical Actuator (EMA) and Electro-Hydrostatic Actuator (EHA) systems
- High reliability Power Core Module (PCM)
- Modular power module for Power Drive Electronic (PDE)

1. Electrical Specification

The following sections describe the electrical specifications of the MSCSM120XM31CTYZBNMG device.

1.1 Q1 to Q6 and Q8 SiC MOSFETs (Per SiC MOSFET): Three-Phase Bridge and Brake

The following table lists the absolute maximum ratings (per SiC MOSFET) of the Q1 to Q6 and Q8 SiC MOSFETs.

Table 1-1. Absolute Maximum Ratings: Q1 to Q6 and Q8 SiC MOSFETs

Symbol	Parameter		Maximum Ratings	Unit
V_{DS}	Drain-source voltage		1200	V
I_D	Continuous drain current	$T_C = 25\text{ }^{\circ}\text{C}$	80	A
		$T_C = 80\text{ }^{\circ}\text{C}$	63	
I_{DM}	Pulsed drain current		160	
V_{GS}	Gate-source voltage		–10/23	V
$R_{DS(on)}$	Drain-source on resistance		31	m Ω
P_D	Power dissipation	$T_C = 25\text{ }^{\circ}\text{C}$	315	W

The following table lists the electrical characteristics (per SiC MOSFET) of the Q1 to Q6 and Q8 SiC MOSFETs.

Table 1-2. Electrical Characteristics: Q1 to Q6 and Q8 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	μA
$R_{DS(on)}$	Drain-source on resistance	$V_{GS} = 20\text{V}$ $I_D = 40\text{A}$	$T_J = 25\text{ }^{\circ}\text{C}$	—	25	31	m Ω
			$T_J = 175\text{ }^{\circ}\text{C}$	—	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 Q1 to Q6 and Q8 SiC MOSFETs.

Table 1-3. Dynamic Characteristics: Q1 to Q6 and Q8 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	$V_{GS} = -5V/20V$	—	30	—	ns
T_r	Rise time	$V_{Bus} = 600V$	—	30	—	
$T_{d(off)}$	Turn-off delay time	$I_D = 50A$	—	50	—	
T_f	Fall time	$R_{G(on)} = 8\Omega$ $R_{G(off)} = 4.7\Omega$	—	25	—	
E_{on}	Turn-on energy	$V_{GS} = -5V/20V$	—	1	—	mJ
E_{off}	Turn-off energy	$V_{Bus} = 600V$ $I_D = 50A$ $R_{G(on)} = 8\Omega$ $R_{G(off)} = 4.7\Omega$		0.66	—	
R_{Gint}	Internal gate resistance		—	5.88	—	Ω
R_{thJC}	Junction-to-case thermal resistance		—	—	0.48	$^{\circ}C/W$

The following table lists the body diode ratings and characteristics (per SiC MOSFET) of the Q1 to Q6 and Q8 SiC MOSFETs.

Table 1-4. Body Diode Ratings and Characteristics: Q1 to Q6 and Q8 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	$V_R = 800V$ $di_F/dt = 1000\text{ A}/\mu s$	—	13.5	—	A

1.2 CR1 to CR6 SiC Diodes (Per SiC Diode): Three-Phase Bridge

The following table lists the ratings and characteristics (per SiC diode) of the CR1 to CR6 SiC diodes.

Table 1-5. Ratings and Characteristics: CR1 to CR6 SiC Diodes

Symbol	Characteristic	Test Conditions		Min.	Typ.	Max.	Unit
V_{RRM}	Peak repetitive reverse voltage			—	—	1200	V
I_{RM}	Reverse leakage current	$V_R = 1200V$	$T_J = 25\text{ }^{\circ}C$	—	10	200	μA
			$T_J = 175\text{ }^{\circ}C$	—	150	—	
I_F	DC forward current	$T_J = 175\text{ }^{\circ}C$	$T_C = 80\text{ }^{\circ}C$	—	30	—	A
V_F	Diode forward voltage	$I_F = 30A$	$T_J = 25\text{ }^{\circ}C$	—	1.5	1.8	V
			$T_J = 175\text{ }^{\circ}C$	—	2.1	—	
Q_C	Total capacitive charge	$V_R = 600V$		—	130	—	nC
C	Total capacitance	f = 1 MHz, $V_R = 400V$		—	141	—	pF
		f = 1 MHz, $V_R = 800V$		—	105	—	
R_{thJC}	Junction-to-case thermal resistance			—	—	1.125	$^{\circ}C/W$

1.3 Q7 IGBT: Soft Start

The following table lists the absolute maximum ratings of the Q7 IGBT.

Table 1-6. Absolute Maximum Ratings: Q7 IGBT

Symbol	Parameter		Maximum Ratings	Unit
V_{CES}	Collector-emitter voltage		1200	V
I_C	Continuous collector current	$T_C = 25\text{ }^{\circ}C$	180	A
		$T_C = 80\text{ }^{\circ}C$	114	
I_{CM}	Pulsed collector current	$T_C = 25\text{ }^{\circ}C$	300	
V_{GE}	Gate-emitter voltage		± 20	V
P_D	Power dissipation	$T_C = 25\text{ }^{\circ}C$	452	W

The following table lists the electrical characteristics of the Q7 IGBT.

Table 1-7. Electrical Characteristics: Q7 IGBT

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Zero gate voltage collector current	$V_{GE} = 0V$ $V_{CE} = 1200V$	—	—	50	μA
$V_{CE(sat)}$	Collector emitter saturation voltage	$V_{GE} = 15V$ $I_C = 75A$	—	1.85	2.25	V
		$T_J = 150\text{ }^{\circ}C$	—	2.25	—	
$V_{GE(th)}$	Gate threshold voltage	$V_{GE} = V_{CE}$ $I_C = 2.6\text{ mA}$	5.3	5.8	6.5	
I_{GES}	Gate-emitter leakage current	$V_{GE} = 20V$ $V_{CE} = 0V$	—	—	150	nA

The following table lists the dynamic characteristics of the Q7 IGBT.

Table 1-8. Dynamic Characteristics: Q7 IGBT

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
C_{ies}	Input capacitance	$V_{GE} = 0V$	—	4.4	—	nF
C_{oes}	Output capacitance	$V_{CE} = 25V$	—	0.29	—	
C_{res}	Reverse transfer capacitance	$f = 1\text{ MHz}$	—	0.24	—	
Q_G	Gate charge	$V_{GE} = \pm 15V$ $V_{CE} = 600V$ $I_C = 75A$	—	0.57	—	μC
$T_{d(on)}$	Turn-on delay time	$V_{GE} = \pm 15V$	$T_J = 150\text{ }^{\circ}C$	—	150	ns
T_r	Rise time	$V_{Bus} = 600V$		—	35	
$T_{d(off)}$	Turn-off delay time	$I_C = 75A$		—	350	
T_f	Fall time	$R_G = 2.2\Omega$		—	80	
E_{on}	Turn-on switching energy	$V_{GE} = \pm 15V$ $V_{Bus} = 600V$	$T_J = 150\text{ }^{\circ}C$	—	5.1	mJ
E_{off}	Turn-off switching energy	$I_C = 75A$ $R_G = 2.2\Omega$		—	7.2	
R_{Gint}	Internal gate resistor		—	10	—	Ω
I_{sc}	Short circuit data	$V_{GE} \leq 15V$ $V_{Bus} = 900V$ $t_p \leq 10\text{ }\mu s$	$T_J = 150\text{ }^{\circ}C$	—	300	A
R_{thJC}	Junction-to-case thermal resistance		—	—	0.332	$^{\circ}C/W$

1.4 CR7 and CR8 SiC Diodes (Per SiC diode): Brake and Soft Start

The following table lists the ratings and characteristics (per SiC diode) of the CR7 and CR8 SiC diodes.

Table 1-9. Ratings and Characteristics: CR7 and CR8 SiC Diodes

Symbol	Characteristic	Test Conditions		Min.	Typ.	Max.	Unit
V_{RRM}	Peak repetitive reverse voltage			—	—	1200	V
I_{RM}	Reverse leakage current	$V_R = 1200V$	$T_J = 25\text{ }^{\circ}C$	—	15	200	μA
			$T_J = 175\text{ }^{\circ}C$	—	250	—	
I_F	DC forward current	$T_J = 175\text{ }^{\circ}C$	$T_C = 80\text{ }^{\circ}C$	—	50	—	A
V_F	Diode forward voltage	$I_F = 50A$	$T_J = 25\text{ }^{\circ}C$	—	1.5	1.8	V
			$T_J = 175\text{ }^{\circ}C$	—	2.1	—	
Q_C	Total capacitive charge	$V_R = 600V$		—	224	—	nC
C	Total capacitance	$f = 1\text{ MHz}, V_R = 400V$		—	246	—	pF
		$f = 1\text{ MHz}, V_R = 800V$		—	182	—	
R_{thJC}	Junction-to-case thermal resistance			—	—	0.7	$^{\circ}C/W$

1.5 Q9 and Q10 IGBTs (Per IGBT): Solenoid

The following table lists the absolute maximum ratings (per IGBT) of the Q9 and Q10 IGBTs.

Table 1-10. Absolute Maximum Ratings: Q9 and Q10 IGBTs

Symbol	Parameter		Maximum Ratings	Unit
V_{CES}	Collector-emitter voltage		1200	V
I_C	Continuous collector current	$T_C = 25\text{ }^{\circ}C$	27	A
		$T_C = 80\text{ }^{\circ}C$	15	
I_{CM}	Pulsed collector current	$T_C = 25\text{ }^{\circ}C$	30	
V_{GE}	Gate-emitter voltage		± 20	V
P_D	Power dissipation	$T_C = 25\text{ }^{\circ}C$	80	W

The following table lists the electrical characteristics (per IGBT) of the Q9 and Q10 IGBTs.

Table 1-11. Electrical Characteristics: Q9 and Q10 IGBTs

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Zero gate voltage collector current	$V_{GE} = 0V$ $V_{CE} = 1200V$	—	—	100	μA
$V_{CE(sat)}$	Collector emitter saturation voltage	$V_{GE} = 15V$ $I_C = 8A$	$T_J = 25\text{ }^{\circ}C$ 1.6	1.85	2.1	V
			$T_J = 150\text{ }^{\circ}C$ —	2.25	—	
$V_{GE(th)}$	Gate threshold voltage	$V_{GE} = V_{CE}$ $I_C = 0.3\text{ mA}$	5.3	5.8	6.3	
I_{GES}	Gate-emitter leakage current	$V_{GE} = 15V$ $V_{CE} = 0V$	—	—	150	nA
C_{ies}	Input capacitance	$V_{GE} = 0V$	—	490	—	pF
C_{res}	Reverse transfer capacitance	$V_{CE} = 25V$ $f = 1\text{ MHz}$	—	30	—	
R_{thJC}	Junction-to-case thermal resistance		—	—	1.85	$^{\circ}C/W$

1.6 CR9 and CR10 SiC Diodes (Per SiC diode): Solenoid

The following table lists the ratings and characteristics (per SiC diode) of the CR9 and CR10 SiC diodes.

Table 1-12. Ratings and Characteristics: CR9 and CR10 SiC Diodes

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
V_{RRM}	Peak repetitive reverse voltage		—	—	1200	V
I_{RM}	Reverse leakage current	$V_R = 1200V$	$T_J = 25\text{ }^{\circ}C$	—	15	μA
			$T_J = 175\text{ }^{\circ}C$	—	50	
I_F	DC forward current	$T_J = 175\text{ }^{\circ}C$ $T_C = 80\text{ }^{\circ}C$	—	10	—	A
V_F	Diode forward voltage	$I_F = 10A$ $T_J = 25\text{ }^{\circ}C$	—	1.5	1.8	V
		$T_J = 175\text{ }^{\circ}C$	—	2.1	—	
Q_C	Total capacitive charge	$V_R = 600V$	—	48	—	nC
C	Total capacitance	$f = 1\text{ MHz}, V_R = 400V$	—	55	—	pF
		$f = 1\text{ MHz}, V_R = 800V$	—	43	—	
R_{thJC}	Junction-to-case thermal resistance		—	—	3	$^{\circ}C/W$

1.7 Electrical Shunt Characteristics

The following tables list the electrical shunt characteristics of the MSCSM120XM31CTYZBNMG device.

Table 1-13. Shunt (R7 to R9)

Symbol	Characteristic		Min.	Typ.	Max.	Unit
R_i	Resistance value	$i = 7, 8, \text{ and } 9$	—	0.7	—	mΩ
T_{Ri}	Tolerance	TCR Max 20 ppm/°C (from 20 °C to 60 °C)	—	1	1.5	%
P_{Ri}	Load capacity		—	—	4	W
I_{Ri}	Current capacity		—	—	75	A

Table 1-14. Shunt (R10)

Symbol	Characteristic		Min.	Typ.	Max.	Unit
R_i	Resistance value	$i = 10$	—	0.5	—	mΩ
T_{Ri}	Tolerance	TCR Max 20 ppm/°C (from 20 °C to 60 °C)	—	1	1.5	%
P_{Ri}	Load capacity		—	—	5	W
I_{Ri}	Current capacity		—	—	100	A

Table 1-15. Shunt (R11)

Symbol	Characteristic		Min.	Typ.	Max.	Unit
R_i	Resistance value	$i = 11$	—	15	—	mΩ
$RSoli$	Resistance value with SOL+ connector ¹	TCR Max 50 ppm/°C (from 20 °C to 60 °C)	—	15.25	—	
T_{Ri}	Tolerance		—	1	1.5	%
P_{Ri}	Load capacity		—	—	3	W
I_{Ri}	Current capacity		—	—	14	A

Note:

1. Value that integrates the resistivity of the SOL+ connector considering the user PCB mounted on the spacers and soldered on the power module according with the IPC A610, class 3.

1.8 Temperature Sensor PTC

The following table lists the temperature sensor PTC of the MSCSM120XM31CTYZBNMG device.

Table 1-16. Temperature Sensor PTC

Symbol	Characteristic	Typ.	Unit
R_0	Resistance at 0 °C	1000	Ω
A	—	3.9083×10^{-3}	$^{\circ}\text{C}^{-1}$
B	—	-5.775×10^{-7}	$^{\circ}\text{C}^{-2}$
C	—	-4.183×10^{-12}	$^{\circ}\text{C}^{-4}$
ΔT	—	$\pm(0.3 + 0.005 \times T)$	$^{\circ}\text{C}$

For temperature range of 0 °C up to 175 °C, $R_T = R_0 (1 + A \times T + B \times T^2)$

For temperature range of -55 °C up to 0 °C, $R_T = R_0 (1 + A \times T + B \times T^2 + C (T - 100) T^3)$

Where:

T: Temperature in °C

R_T : Thermistor value at T

Note: For more information, see [APT0406—Using NTC Temperature Sensor Integrated into Power Module](#).

1.9 Thermal and Package Characteristics

The following table lists the thermal and package characteristics of the MSCSM120XM31CTYZBNMG device.

Table 1-17. Thermal and Package Characteristics

Symbol	Characteristic			Min.	Max.	Unit
V_{ISOL}	RMS isolation voltage, any terminal to case, t = 1 min, at 1 bar			4000	—	V
$V_{\text{ISOL}}^{\text{PTC}}$	RMS isolation voltage, PTC to any other electrical terminals, t = 1 min at 1 bar, 50/60 Hz			1500	—	
T_J	Operating junction temperature range			-55	175	$^{\circ}\text{C}$
T_{JOP}	Recommended junction temperature under switching conditions			-55	$T_{\text{Jmax}}-25$	
T_{STG}	Storage temperature range			-60	125	
T_C	Operating case temperature			-55	125	
Torque	Mounting torque	Insert	M2.5	—	0.3	N.m
		To heatsink	M6	3	5	
Wt	Package weight			—	150	g

1.10 Typical SiC MOSFET Performance Curve (Q1 to Q6 and Q8)

The following figures show the performance curves of the Q1 to Q6 and Q8 SiC MOSFETs.

Figure 1-1. Maximum Thermal Impedance

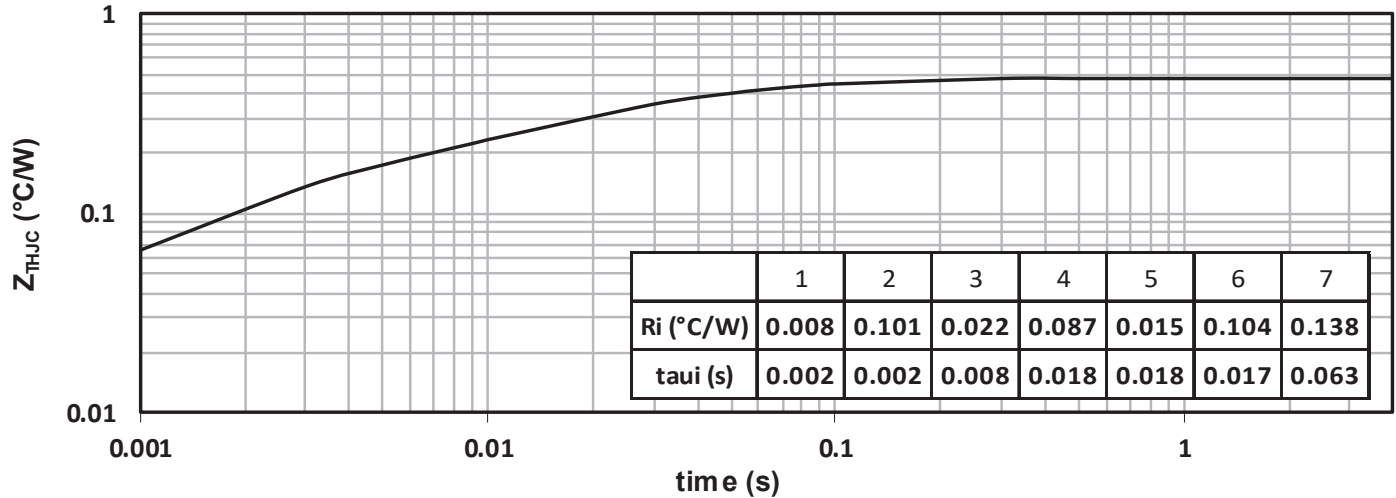


Figure 1-2. Output Characteristics, $T_J = 25^\circ\text{C}$

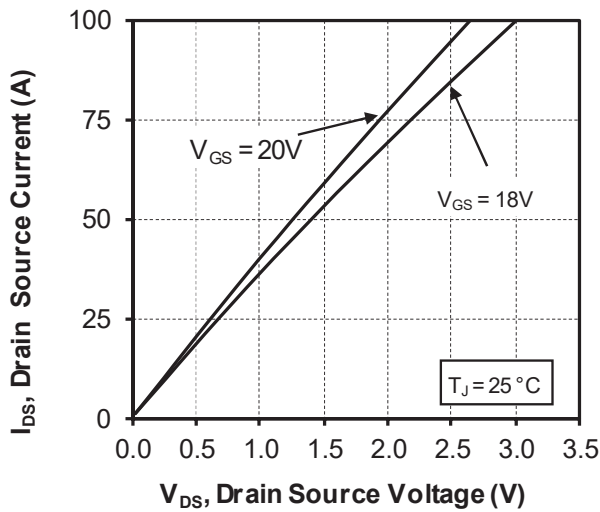
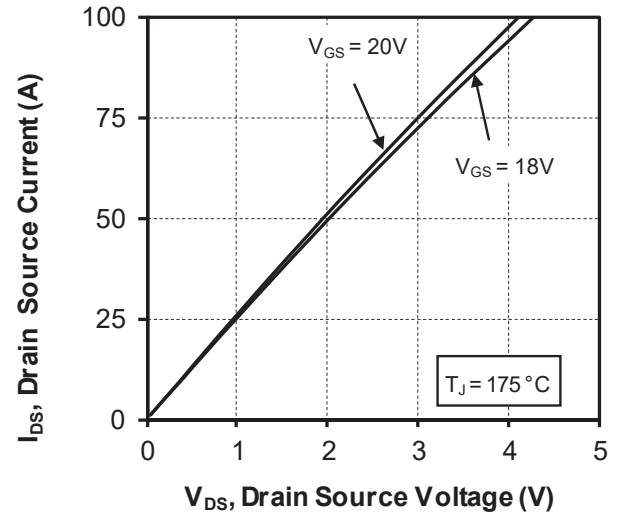


Figure 1-3. Output Characteristics, $T_J = 175^\circ\text{C}$



MSCSM120XM31CTYZBNMG

Electrical Specification

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

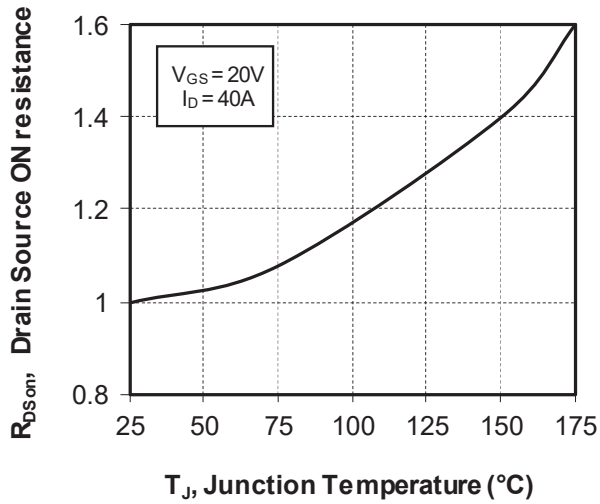


Figure 1-5. Transfer Characteristics

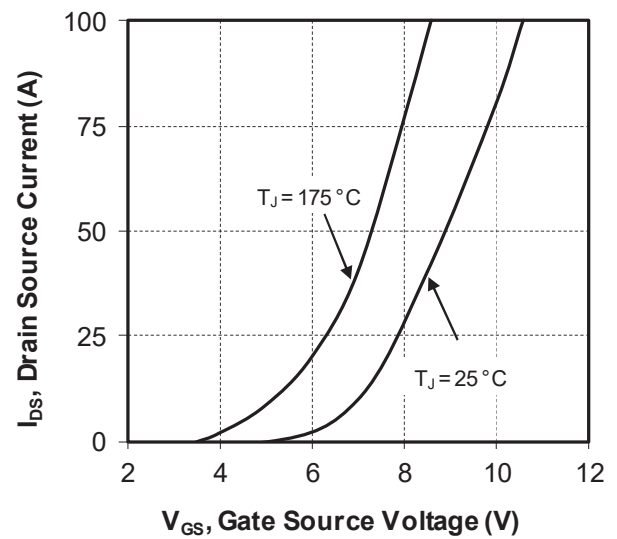


Figure 1-6. Switching Energy vs. R_g

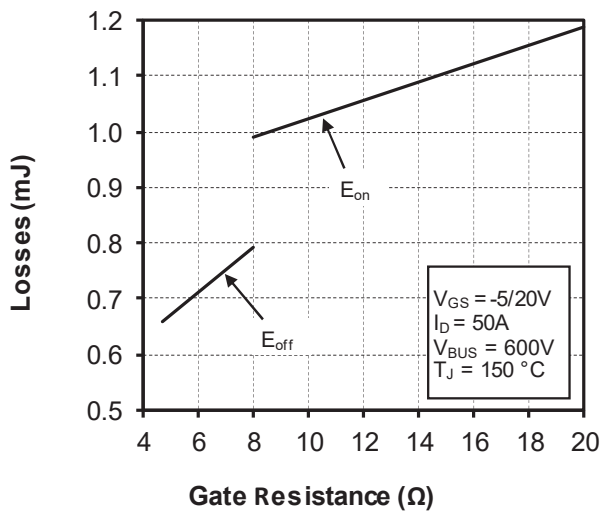


Figure 1-7. Switching Energy vs. Current

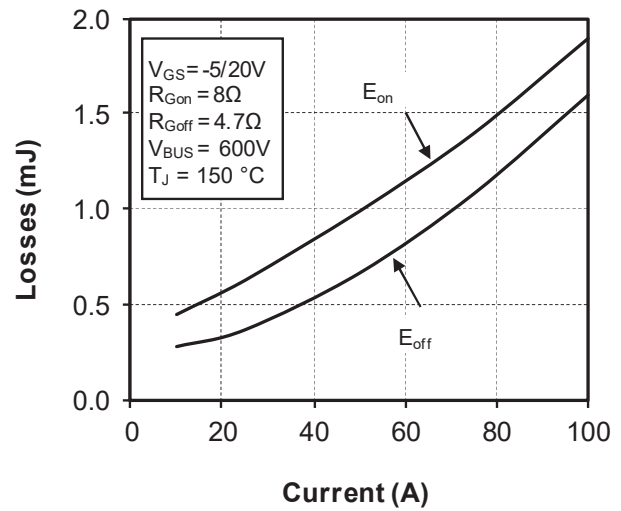


Figure 1-8. Capacitance vs. Drain Source Voltage

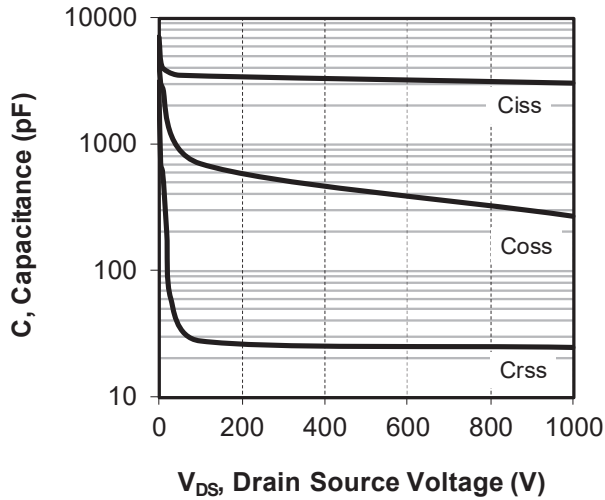


Figure 1-9. Gate Charge vs. Gate Source Voltage

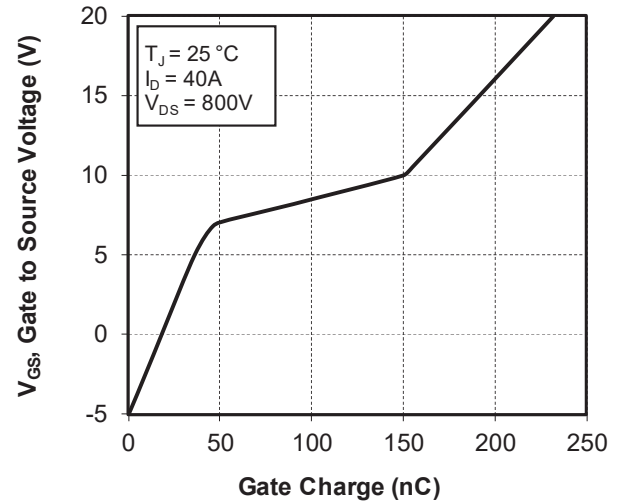


Figure 1-10. Body Diode Characteristics, $T_J = 25\text{ }^{\circ}\text{C}$

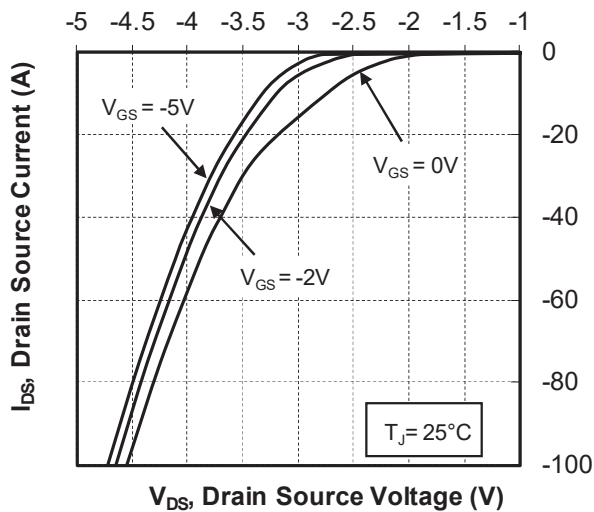


Figure 1-11. 3rd Quadrant Characteristics, $T_J = 25\text{ }^{\circ}\text{C}$

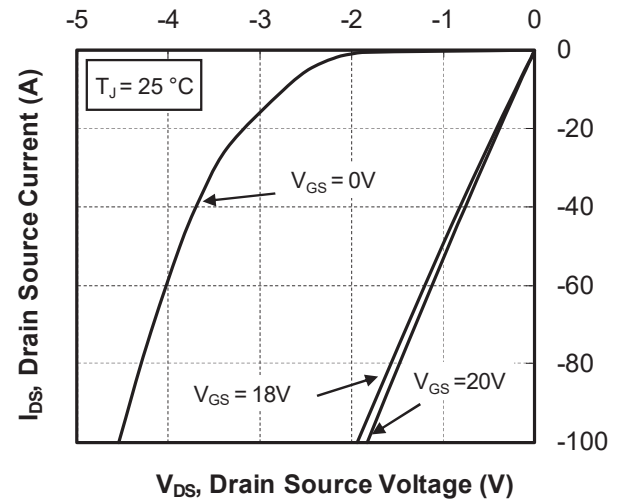


Figure 1-12. Body Diode Characteristics, $T_J = 175\text{ }^{\circ}\text{C}$

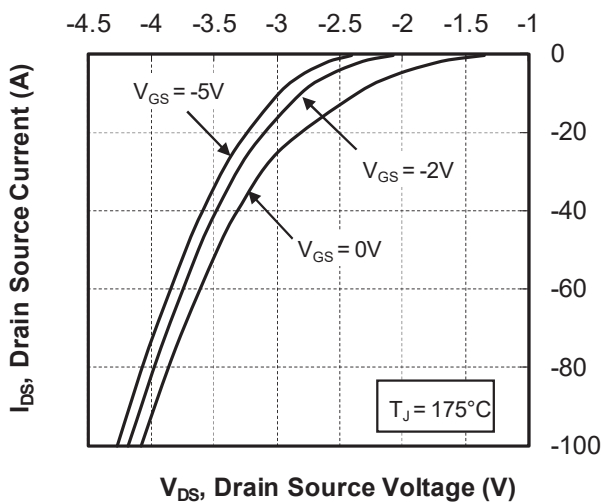


Figure 1-13. 3rd Quadrant Characteristics, $T_J = 175\text{ }^{\circ}\text{C}$

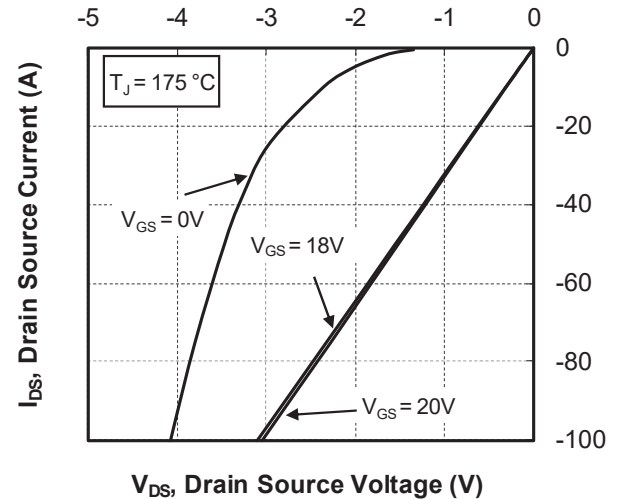
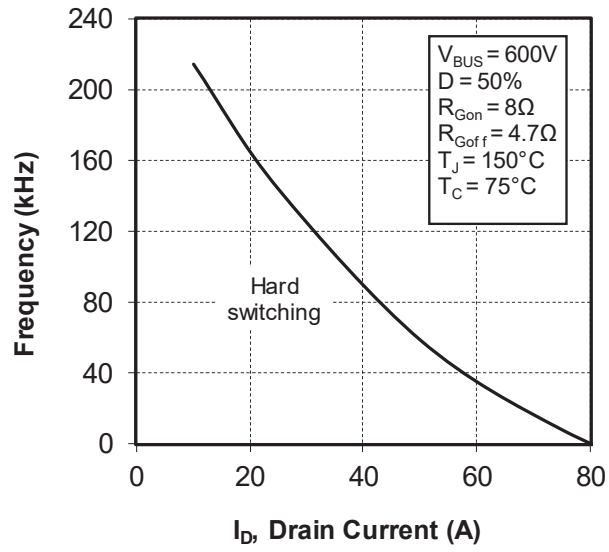


Figure 1-14. Operating Frequency vs. Drain Current



1.11 Typical SiC Diode Performance Curve (CR1 to CR6)

The following figures show the performance curves of the CR1 to CR6 SiC diodes.

Figure 1-15. Maximum Thermal Impedance

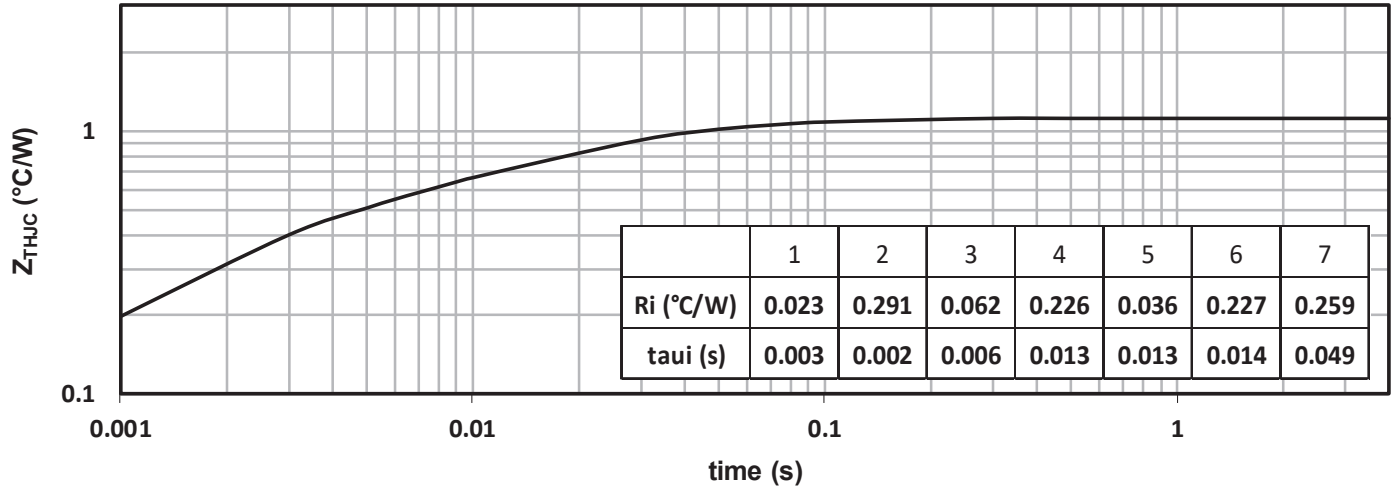


Figure 1-16. Forward Characteristics

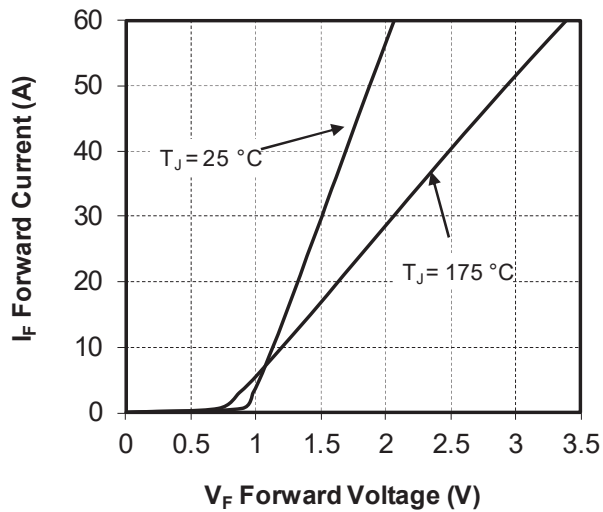
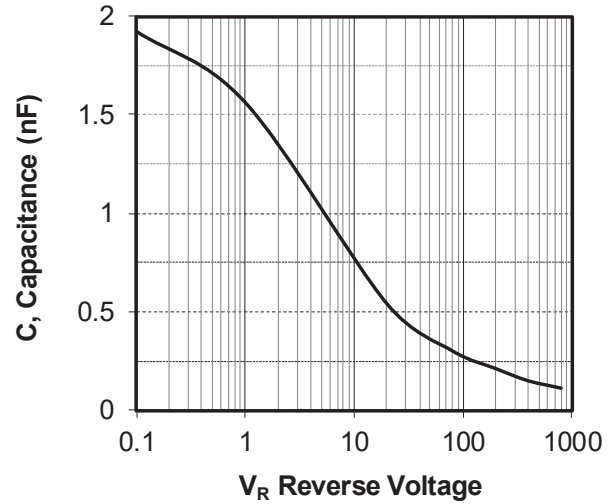


Figure 1-17. Capacitance vs. Reverse Voltage



1.12 Typical SiC Diode Performance Curve (CR7 and CR8)

The following figures show the performance curves of the CR7 and CR8 SiC diodes.

Figure 1-18. Maximum Thermal Impedance

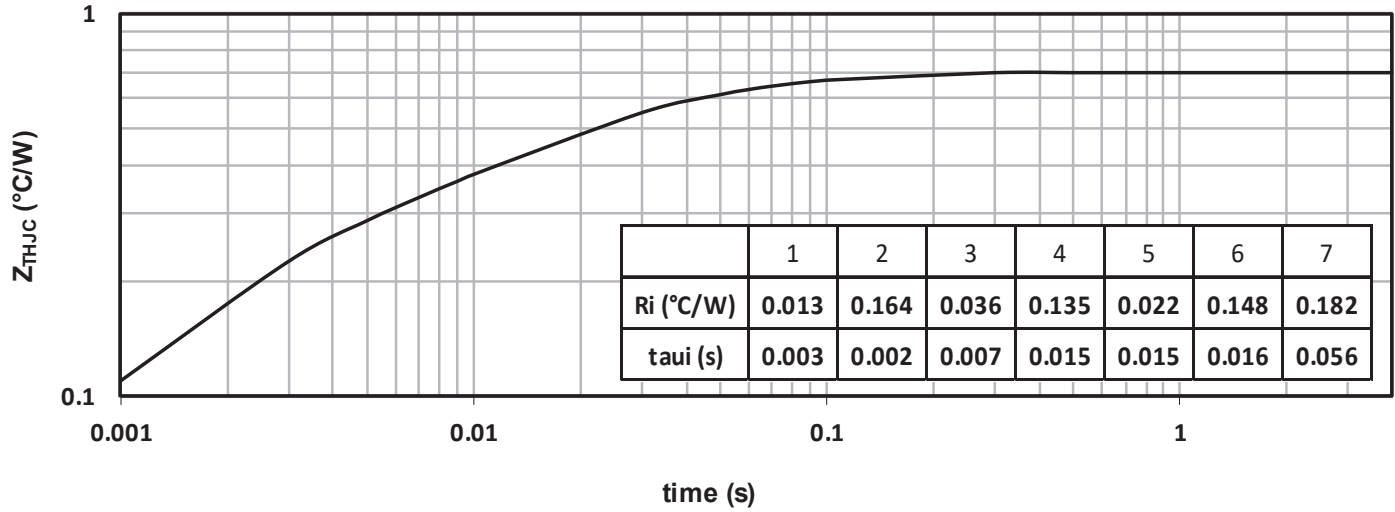


Figure 1-19. Forward Characteristics

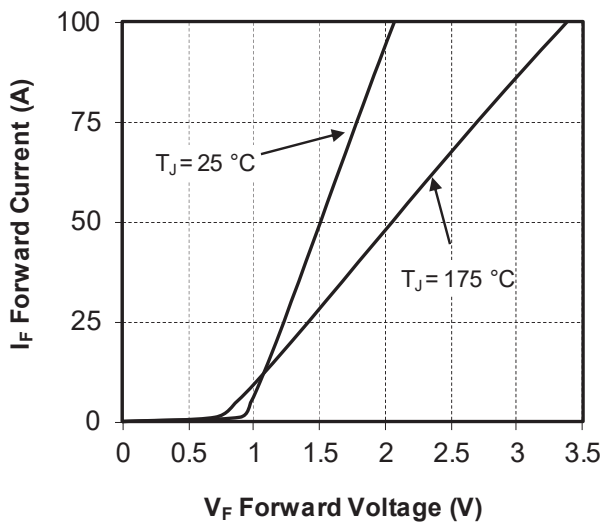
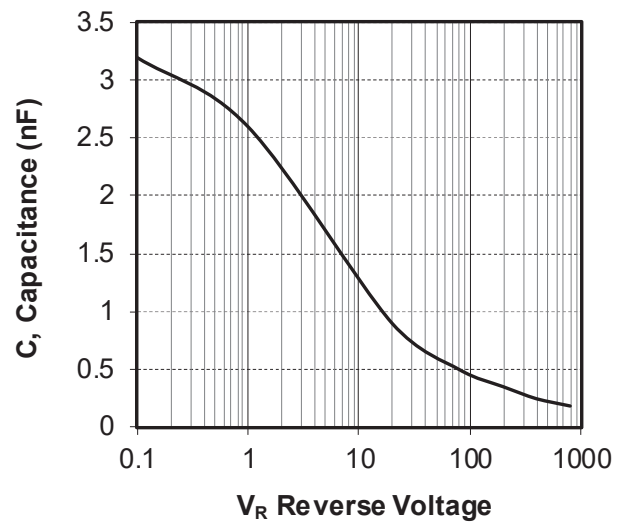


Figure 1-20. Capacitance vs. Reverse Voltage



1.13 Typical IGBT Performance Curve (Q9 and Q10)

The following figures show the performance curves of the Q9 and Q10 IGBTs.

Figure 1-21. Maximum Thermal Impedance

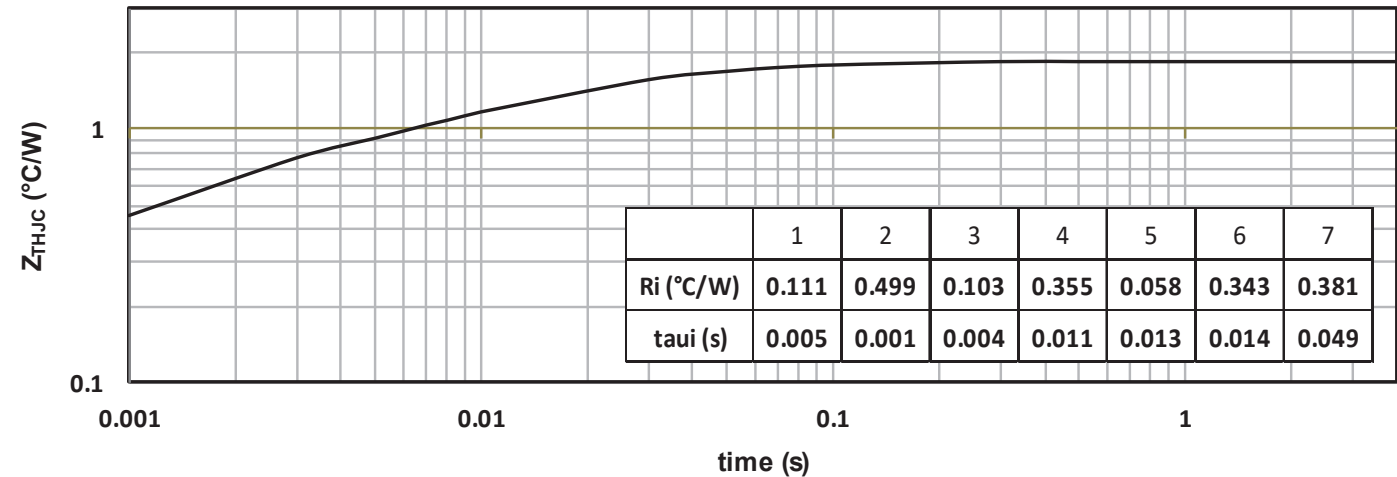
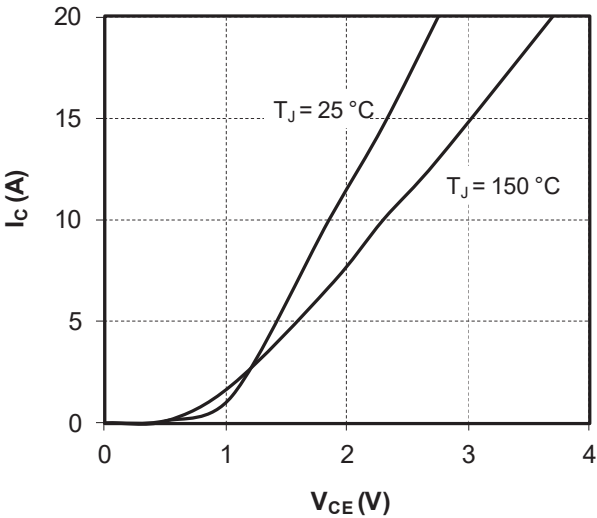


Figure 1-22. Output Characteristics ($V_{GE} = 15V$)



1.14 Typical SiC Diode Performance Curve (CR9 and CR10)

The following figures show the performance curves of the CR9 and CR10 SiC diodes.

Figure 1-23. Maximum Thermal Impedance

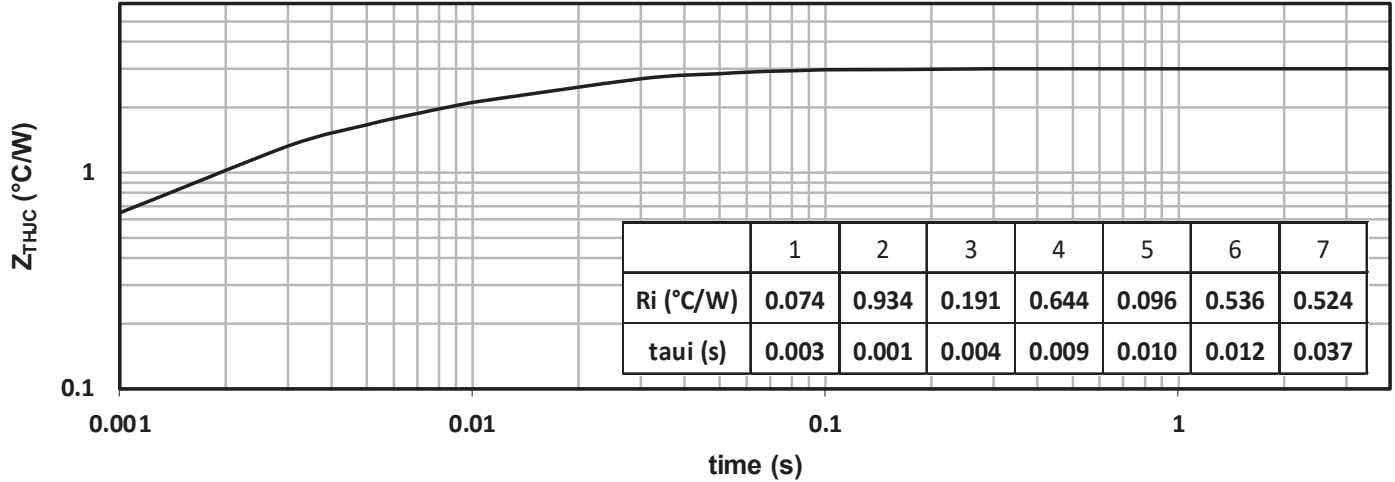


Figure 1-24. Forward Characteristics

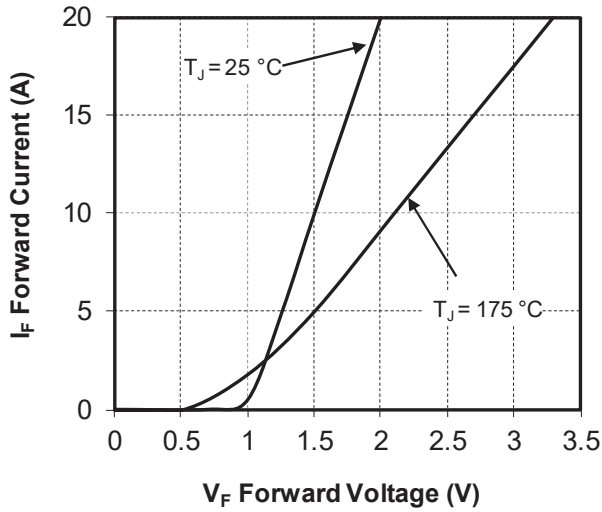
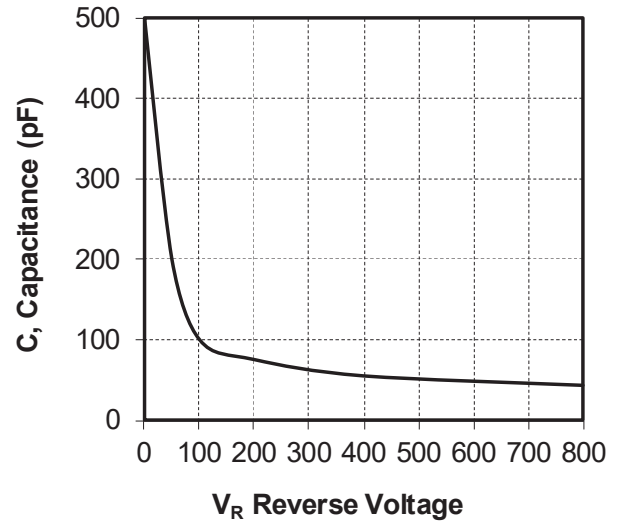


Figure 1-25. Capacitance vs. Reverse Voltage



1.15 Typical IGBT Performance Curve (Q7)

The following figures show the performance curves of the Q7 IGBT.

Figure 1-26. Maximum Thermal Impedance

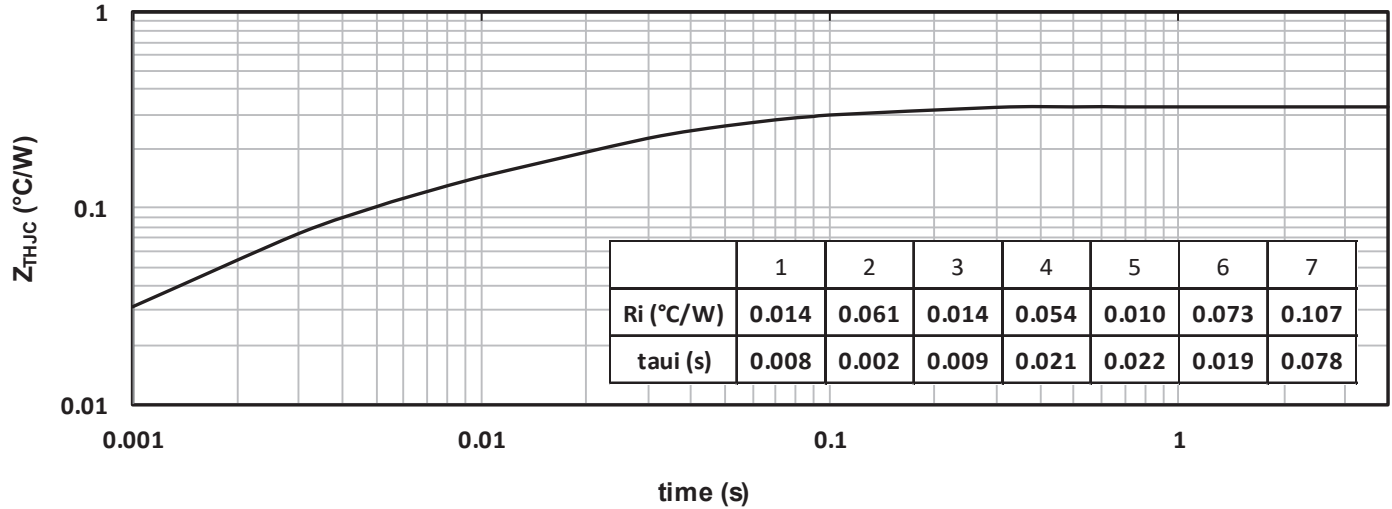


Figure 1-27. Output Characteristics ($V_{GE} = 15V$)

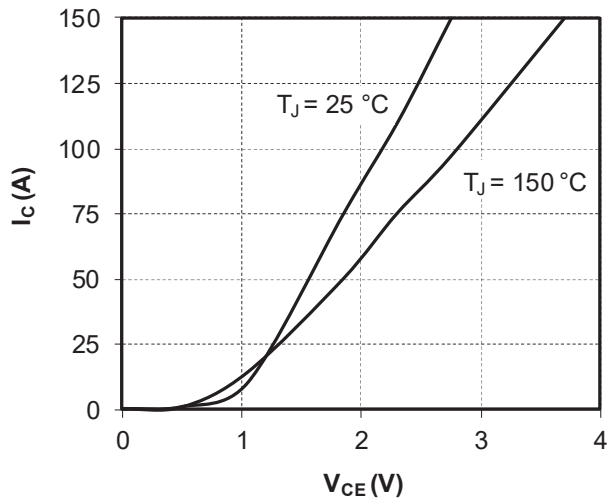
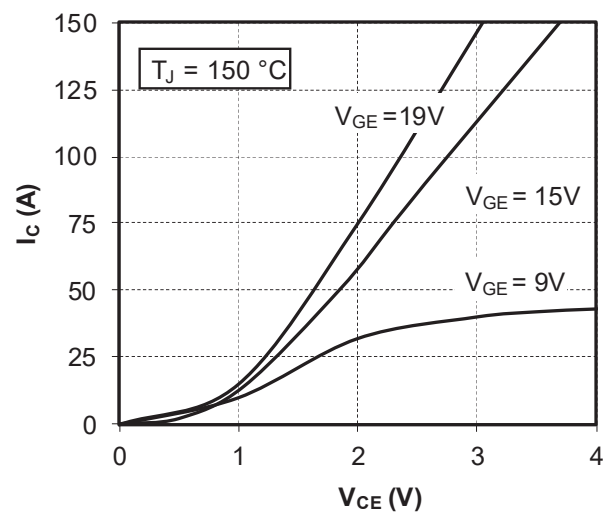


Figure 1-28. Output Characteristics



MSCSM120XM31CTYZBNMG

Electrical Specification

Figure 1-29. Transfer Characteristics

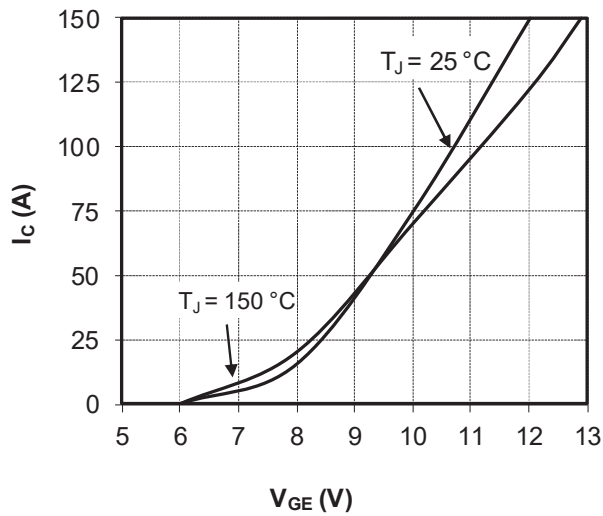


Figure 1-30. Energy Losses vs. Collector Current

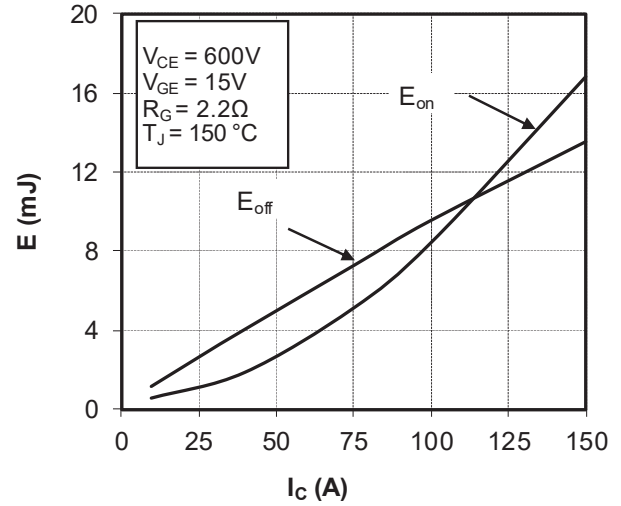


Figure 1-31. Switching Energy Losses vs. Gate Resistance

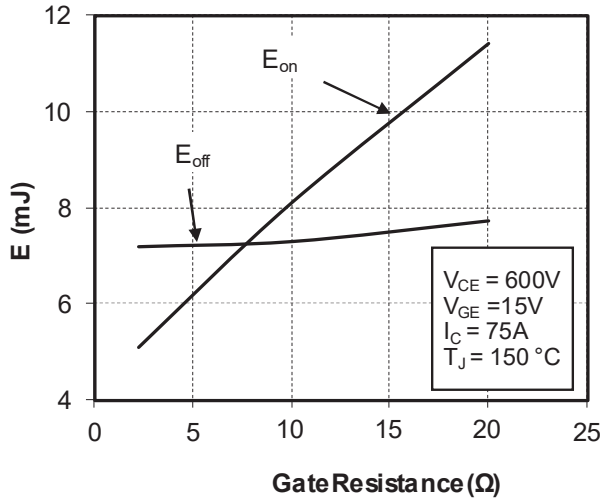
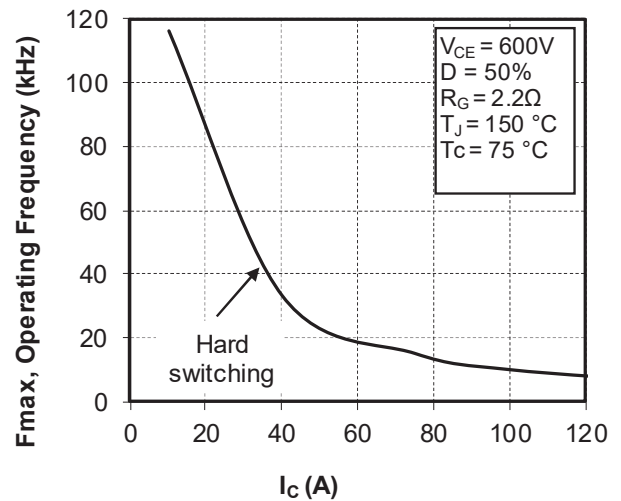


Figure 1-32. Operating Frequency vs. Collector Current



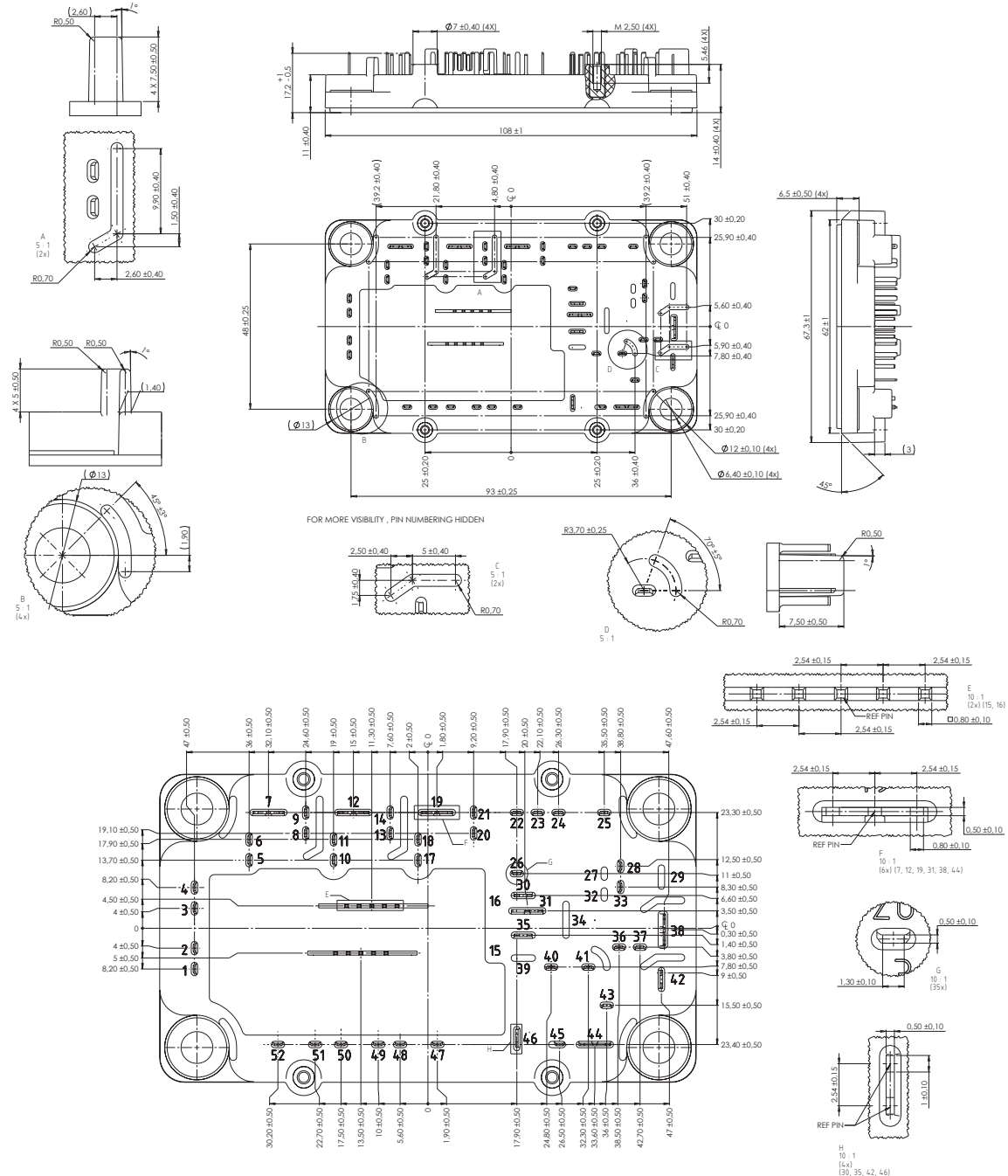
2. Package Specifications

The following section describes the package specification of the MSCSM120XM31CTYZBNMG device.

2.1 Package Outline

The following figure shows the package outline drawing of the MSCSM120XM31CTYZBNMG device. The dimensions in the following figure are in millimeters.

Figure 2-1. Package Outline Drawing



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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ISBN: 978-1-6683-1964-2

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