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

MSCSM120X10CTYZBNMG

Product Overview

The MSCSM120X10CTYZBNMG device is a three-phase bridge, brake, soft start, and solenoid power module.

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

Figure 1. Electrical Diagram

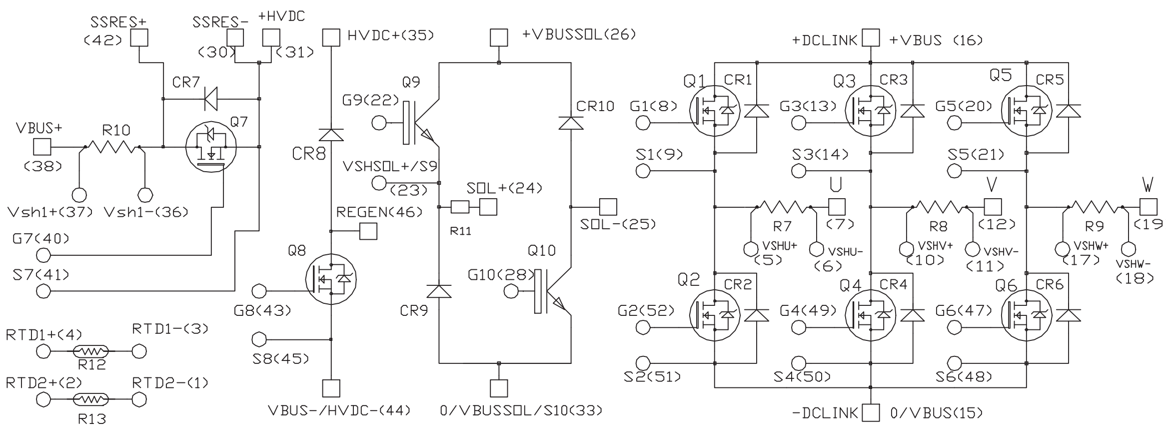
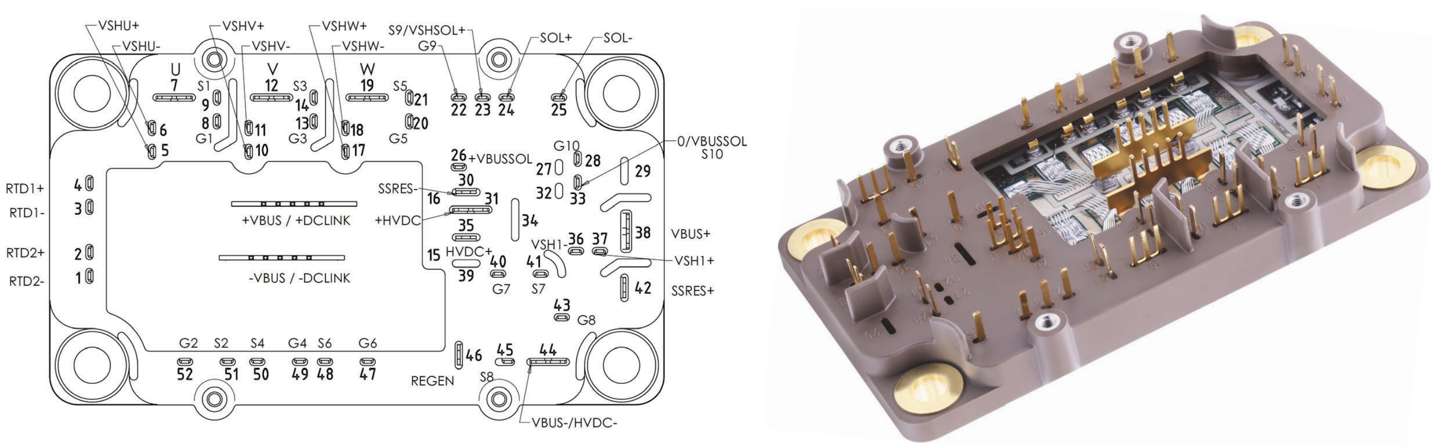


Figure 2. Pinout Location



Note: All ratings are at T_J = 25 °C, unless otherwise specified.

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

Features

The MSCSM120X10CTYZBNMG device has the following key features:

- Silicon Carbide (SiC) MOSFET
- SiC Schottky Diode
- Low stray inductance
- Lead frames for power connections
- Si_3N_4 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 MSCSM120X10CTYZBNMG 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 MSCSM120X10CTYZBNMG 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 MSCSM120X10CTYZBNMG 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_{DSS}	Drain-source voltage		1200	V
I_D	Continuous drain current	T_C = 25 °C	28[1]	A
		T_C = 80 °C	22[1]	
I_{DM}	Pulsed drain current		60	
V_{GS}	Gate-source voltage		−10/23	V
$R_{DS(on)}$	Drain-source ON resistance		100	mΩ
P_D	Power dissipation	T_C = 25 °C	116	W

Note: Specification of Q1 to Q6 SiC MOSFET device, but output current must be limited due to the shunt resistor (for more information, see Electrical Shunt Characteristics).

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} = 0V; V_{DS} = 1200V		—	10	100	μA
$R_{DS(on)}$	Drain-source ON resistance	V_{GS} = 20V I_D = 15A	T_J = 25 °C	—	80	100	mΩ
			T_J = 175 °C	—	116	—	
$V_{GS(th)}$	Gate threshold voltage	V_{GS} = V_{DS}; I_D = 1 mA		1.8	2.8	—	V
I_{GSS}	Gate-source leakage current	V_{GS} = 20V; V_{DS} = 0V		—	—	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 V_{DS} = 1000V f = 1 MHz		—	838	—	pF
C_{oss}	Output capacitance			—	84	—	
C_{rss}	Reverse transfer capacitance			—	9	—	
Q_g	Total gate charge	V_{GS} = –5V/20V V_{Bus} = 800V I_D = 15A		—	64	—	nC
Q_{gs}	Gate-source charge			—	12	—	
Q_{gd}	Gate-drain charge			—	19	—	
$T_{d(on)}$	Turn-on delay time	V_{GS} = −5V/20V V_{Bus} = 600V I_D = 20A R_{GON} = 20Ω R_{GOFF} = 11.7Ω	T_J = 150 °C	—	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	V_{GS} = −5V/20V V_{Bus} = 600V I_D = 20A R_{GON} = 20Ω R_{GOFF} = 11.7Ω	T_J = 150 °C	—	0.4	—	mJ
E_{off}	Turn-off energy			—	0.26	—	
R_{Gint}	Internal gate resistance			—	6.9	—	Ω
R_{thJC}	Junction-to-case thermal resistance			—	—	1.29	°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} = 15A	—	4	—	V
t_{rr}	Reverse recovery time	I_{SD} = 15A V_{GS} = –5V V_R = 800V di_F/dt = 1000 A/µs	—	34	—	ns
Q_{rr}	Reverse recovery charge		—	200	—	nC
I_{rr}	Reverse recovery current		—	6.5	—	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 °C	—	10	200	µA
			T_J = 175 °C	—	50	—	
I_F	DC forward current		T_C = 100 °C	—	15	—	A
V_F	Diode forward voltage	I_F = 15A	T_J = 25 °C	—	1.5	1.8	V
			T_J = 175 °C	—	2	—	
Q_C	Total capacitive charge	V_R = 600V		—	73	—	nC
C	Total capacitance	f = 1 MHz, V_R = 400V		—	80	—	pF
		f = 1 MHz, V_R = 800V		—	59	—	
R_{thJC}	Junction-to-case thermal resistance			—	—	1.94	°C/W

1.3. Q7 SiC MOSFET: Soft Start

The following table lists the absolute maximum ratings of the Q7 SiC MOSFET.

Table 1-6. Absolute Maximum Ratings: Q7 SiC MOSFET

Symbol	Parameter		Maximum Ratings	Unit
V_{DSS}	Drain-source voltage		1200	V
I_D	Continuous drain current	T_C = 25 °C	49	A
		T_C = 80 °C	39	
I_{DM}	Pulsed drain current		94	
V_{GS}	Gate-source voltage		−10/23	V
$R_{DS(on)}$	Drain-source ON resistance		50	mΩ
P_D	Power dissipation	T_C = 25 °C	196	W

The following table lists the electrical characteristics of the Q7 SiC MOSFET.

Table 1-7. Electrical Characteristics: Q7 SiC MOSFET

Symbol	Characteristic	Test Conditions		Min.	Typ.	Max.	Unit
I_{DSS}	Zero gate voltage drain current	V_{GS} = 0V V_{DS} = 1200V		—	10	100	µA
$R_{DS(on)}$	Drain-source ON resistance	V_{GS} = 20V I_D = 40A	T_J = 25 °C	—	40	50	mΩ
			T_J = 175 °C	—	64	—	
$V_{GS(th)}$	Gate threshold voltage	V_{GS} = V_{DS} I_D = 2 mA		1.8	2.7	—	V
I_{GSS}	Gate-source leakage current	V_{GS} = 20V V_{DS} = 0V		—	—	150	nA

The following table lists the dynamic characteristics of the Q7 SiC MOSFET.

Table 1-8. Dynamic Characteristics: Q7 SiC MOSFET

Symbol	Characteristic	Test Conditions		Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	V_{GS} = 0V V_{DS} = 1000V f = 1 MHz		—	1990	—	pF
C_{oss}	Output capacitance			—	156	—	
C_{rss}	Reverse transfer capacitance			—	17	—	
Q_g	Total gate charge	V_{GS} = −5/20V V_{Bus} = 800V I_D = 40A		—	137	—	nC
Q_{gs}	Gate-source charge			—	29	—	
Q_{gd}	Gate-drain charge			—	31	—	
$T_{d(on)}$	Turn-on delay time	V_{GS} = −5/20V V_{Bus} = 600V I_D = 40A R_{GON} = 10Ω R_{GOFF} = 5.8Ω	T_J = 150 °C	—	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	V_{GS} = −5/20V V_{Bus} = 600V I_D = 40A R_{GON} = 10Ω R_{GOFF} = 5.8Ω	T_J = 150 °C	—	0.8	—	mJ
E_{off}	Turn-off energy			—	0.53	—	
R_{Gint}	Internal gate resistance			—	6.2	—	Ω
R_{thJC}	Junction-to-case thermal resistance			—	—	0.76	°C/W

The following table lists the body diode ratings and characteristics of the Q7 SiC MOSFET.

Table 1-9. Body Diode Ratings and Characteristics: Q7 SiC MOSFET

Symbol	Characteristic	Test Conditions	Min.	Typ.	Max.	Unit
V_{SD}	Diode forward voltage	V_{GS} = 0V; I_{SD} = 40A	—	3.9	—	V
t_{rr}	Reverse recovery time	I_{SD} = 40A V_{GS} = −5V V_R = 800V di_F/dt = 1800 A/µs	—	31	—	ns
Q_{rr}	Reverse recovery charge		—	610	—	nC
I_{rr}	Reverse recovery current		—	40	—	A

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 1-10. 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 °C	—	10	200	µA
			T_J = 175 °C	—	150	—	
I_F	DC forward current	T_J = 175 °C	T_C = 80 °C	—	30	—	A
V_F	Diode forward voltage	I_F = 30A	T_J = 25 °C	—	1.5	1.8	V
			T_J = 175 °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	°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 1-11. 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 °C	27	A
		T_C = 80 °C	15	
I_{CM}	Pulsed collector current	T_C = 25 °C	30	
V_{GE}	Gate-emitter voltage		±20	V
P_D	Power dissipation	T_C = 25 °C	80	W

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

Table 1-12. 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 °C	1.6	1.85	2.1	V
			T_J = 150 °C	—	2.25	—	
$V_{GE(th)}$	Gate threshold voltage	V_{GE} = V_{CE} I_C = 0.3 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 V_{CE} = 25V f = 1 MHz		—	490	—	pF
C_{res}	Reverse transfer capacitance			—	30	—	
R_{thJC}	Junction-to-case thermal resistance			—	—	1.85	°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 1-13. 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 °C	—	15	200	µA
			T_J = 175 °C	—	50	—	
I_F	DC forward current	T_J = 175 °C	T_C = 80 °C	—	10	—	A
V_F	Diode forward voltage	I_F = 10A	T_J = 25 °C	—	1.5	1.8	V
			T_J = 175 °C	—	2.1	—	
Q_C	Total capacitive charge	V_R = 600V		—	48	—	nC
C	Total capacitance	f = 1 MHz, V_R = 400V		—	55	—	pF
		f = 1 MHz, V_R = 800V		—	43	—	
R_{thJC}	Junction-to-case thermal resistance			—	—	3	°C/W

1.7. Electrical Shunt Characteristics

The following tables list the electrical shunt characteristics of the MSCSM120X10CTYZBNMG device.

Table 1-14. Shunt (R7 to R9)

Symbol	Characteristic		Min.	Typ.	Max.	Unit
R_i	Resistance value	i = 7, 8, and 9	—	5	—	mΩ
T_{Ri}	Tolerance	TCR Max 50 ppm/°C (from 20 °C to 60 °C)	—	1	1.5	%
P_{Ri}	Load capacity		—	—	3	W
I_{Ri}	Current capacity		—	—	24	A

Table 1-15. Shunt (R10)

Symbol	Characteristic		Min.	Typ.	Max.	Unit
R_i	Resistance value	i = 10	—	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 1-16. 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 in accordance with IPC A610, class 3.

1.8. Temperature Sensor PTC

The following table lists the temperature sensor PTC of the MSCSM120X10CTYZBNMG device.

Table 1-17. Temperature Sensor PTC

Symbol	Characteristic	Typ.	Unit
R_0	Resistance at 0 °C	1000	Ω
A	—	3.9083×10^{-3}	$°C^{-1}$
B	—	-5.775×10^{-7}	$°C^{-2}$
C	—	-4.183×10^{-12}	$°C^{-4}$
ΔT	—	$\pm(0.3 + 0.005 \times \lvert T \rvert)$	°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 MSCSM120X10CTYZBNMG device.

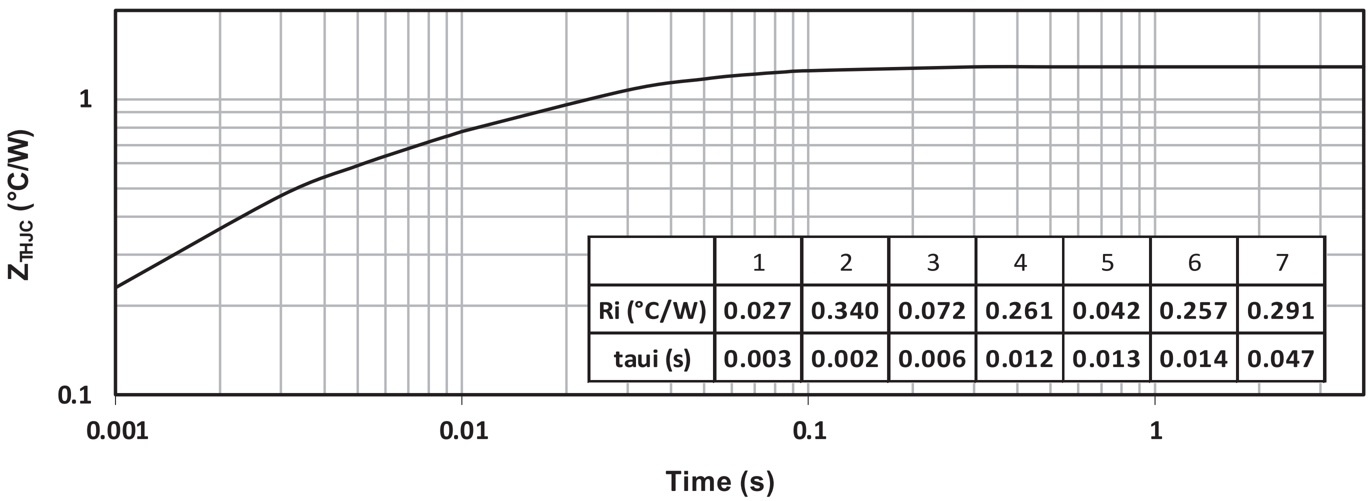
Table 1-18. Thermal and Package Characteristics

Symbol	Characteristic			Min.	Max.	Unit
V_{ISOL}	RMS isolation voltage, any terminal to case, t = 1 min, at 1 bar			4000	—	V
V_{ISOL}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	°C
T_{JOP}	Recommended junction temperature under switching conditions			–55	T_{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



	1	2	3	4	5	6	7
Ri (°C/W)	0.027	0.340	0.072	0.261	0.042	0.257	0.291
taui (s)	0.003	0.002	0.006	0.012	0.013	0.014	0.047

Figure 1-2. Output Characteristics, T_J = 25 °C

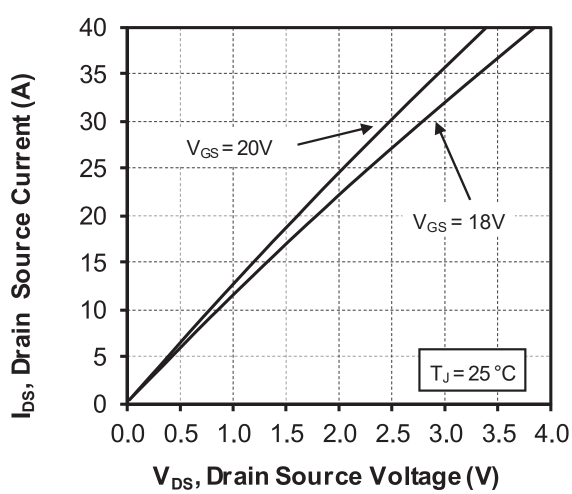


Figure 1-3. Output Characteristics, T_J = 175 °C

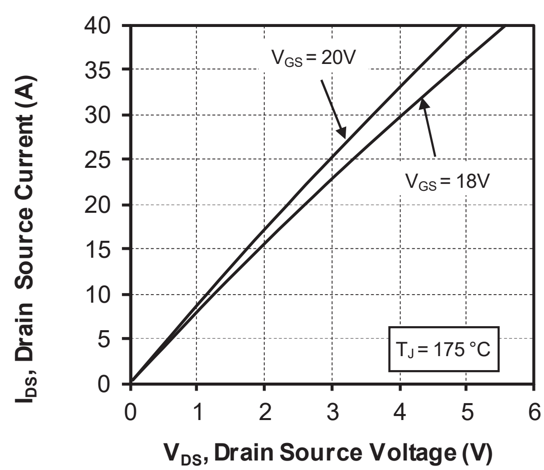


Figure 1-4. Normalized $R_{DS(on)}$ vs. Temperature

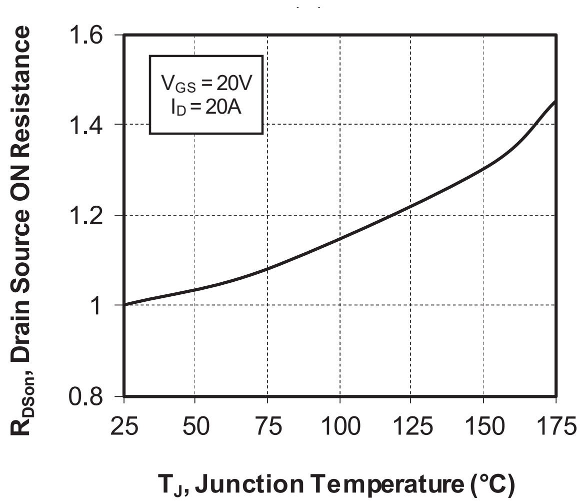


Figure 1-5. Transfer Characteristics

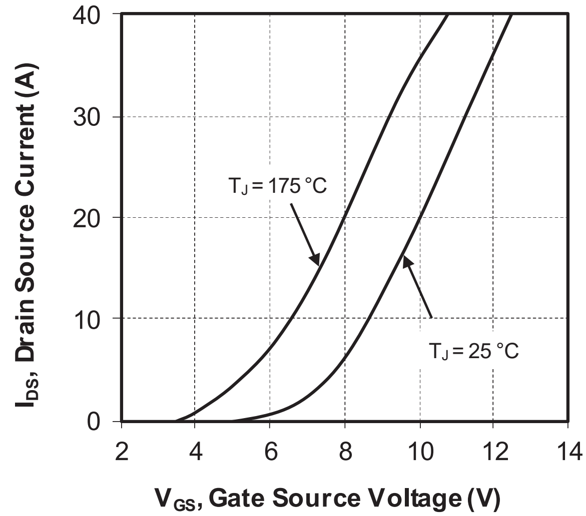


Figure 1-6. Switching Energy vs. Rg

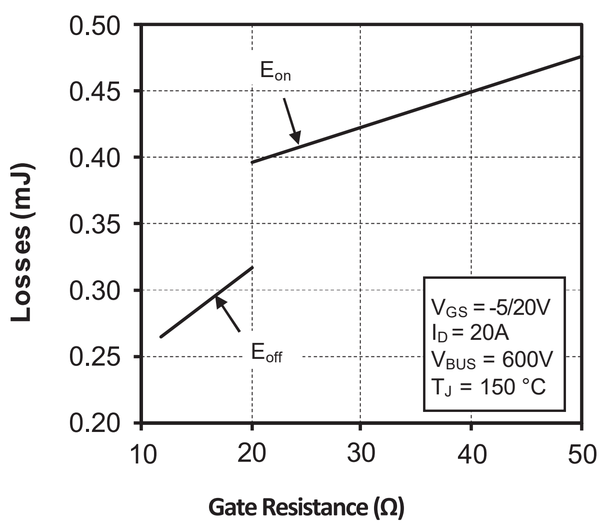


Figure 1-7. Switching Energy vs. Current

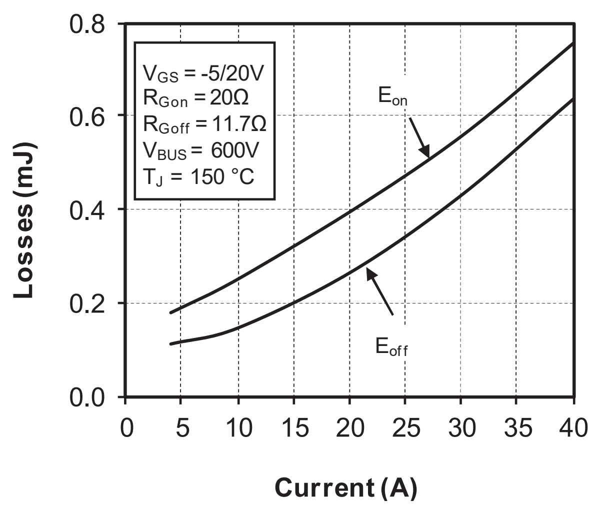


Figure 1-8. Capacitance vs. Drain Source Voltage

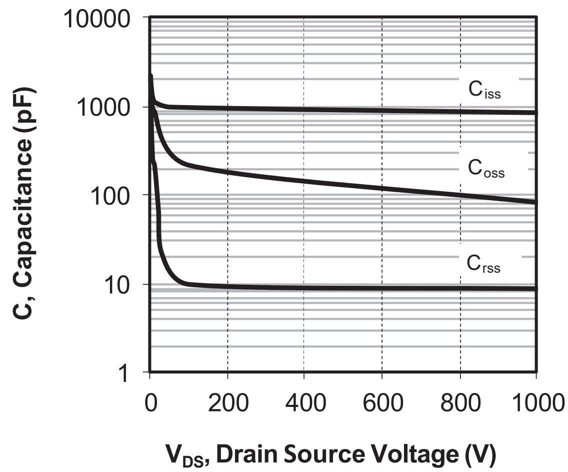


Figure 1-9. Gate Charge vs. Gate Source Voltage

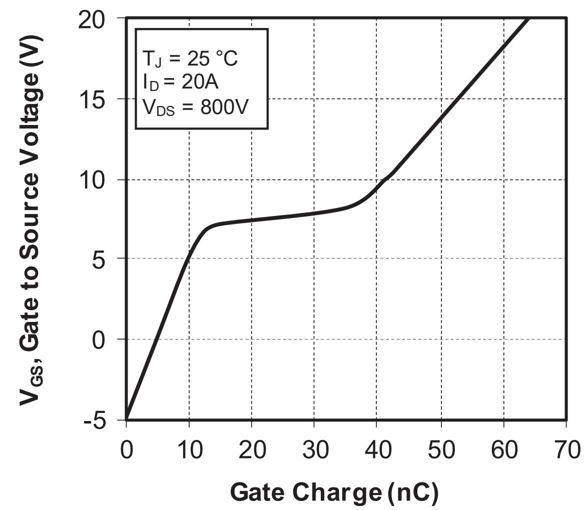


Figure 1-10. Body Diode Characteristics, T_J = 25 °C

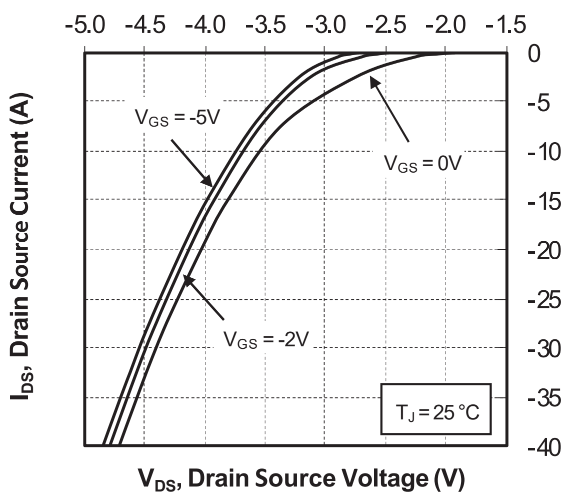


Figure 1-11. 3rd Quadrant Characteristics, T_J = 25 °C

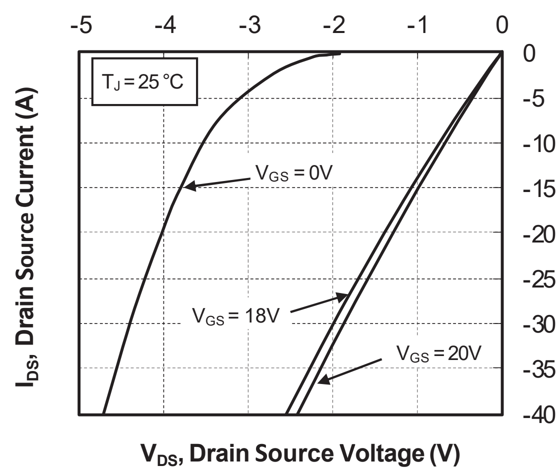


Figure 1-12. Body Diode Characteristics, T_J = 175 °C

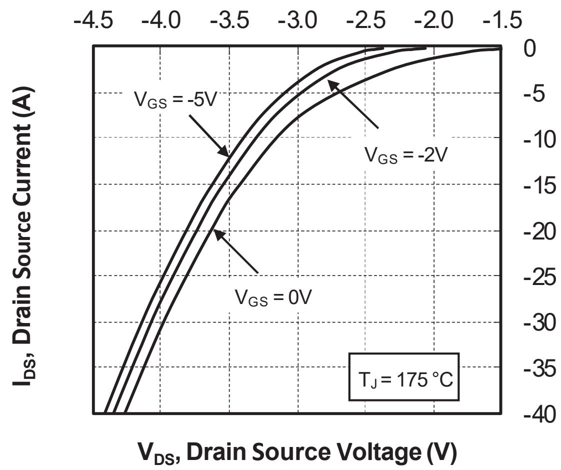


Figure 1-13. 3rd Quadrant Characteristics, T_J = 175 °C

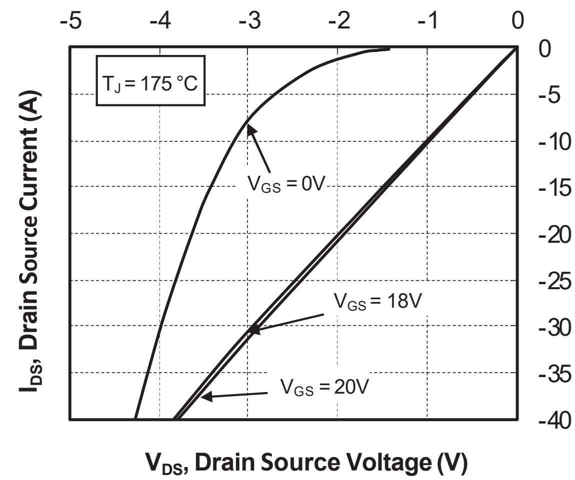
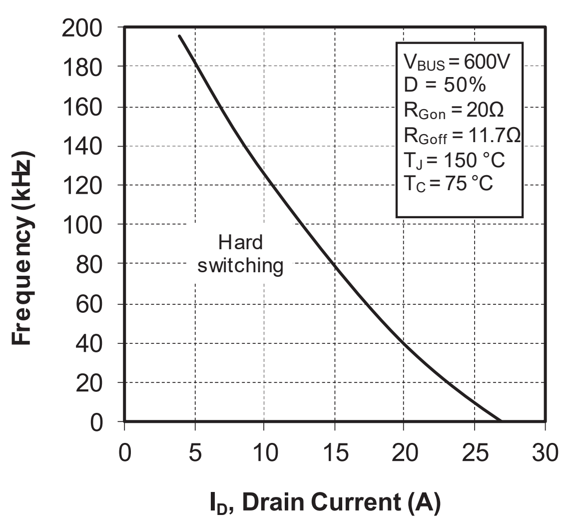


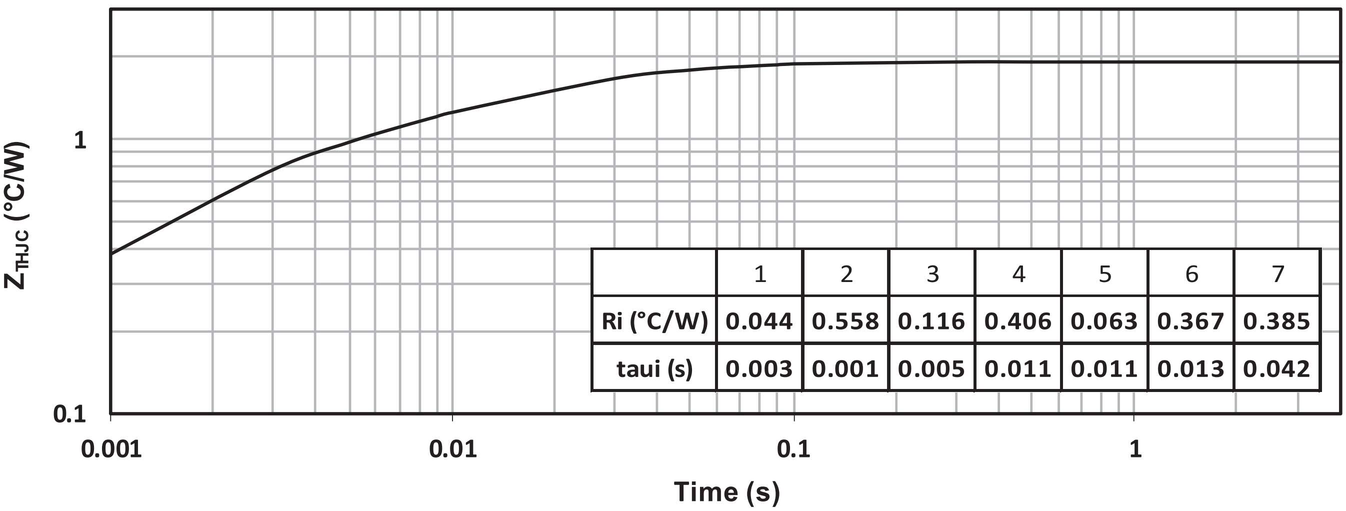
Figure 1-14. Operating Frequency vs. Drain Current



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



	1	2	3	4	5	6	7
Ri (°C/W)	0.044	0.558	0.116	0.406	0.063	0.367	0.385
taui (s)	0.003	0.001	0.005	0.011	0.011	0.013	0.042

Figure 1-16. Forward Characteristics

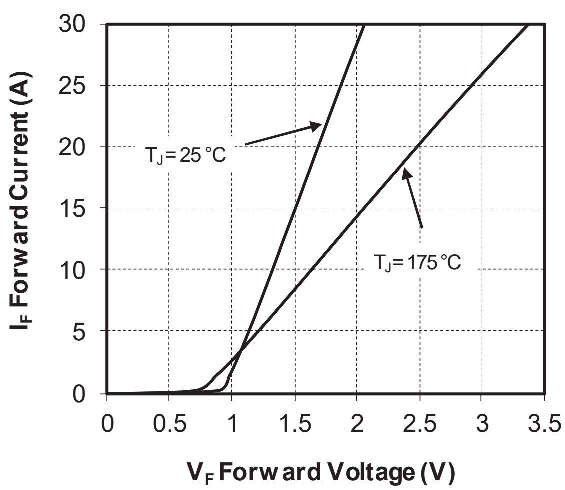
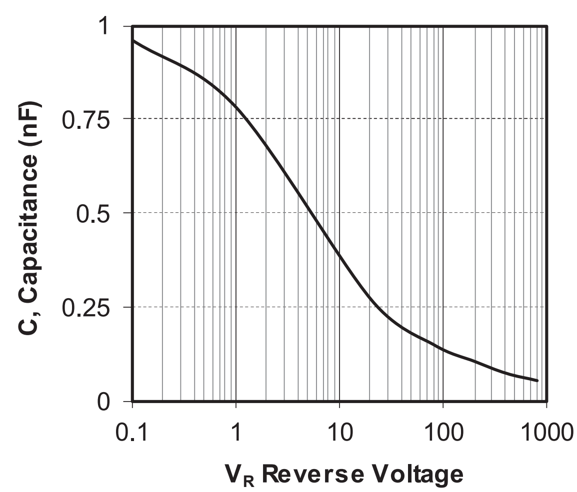


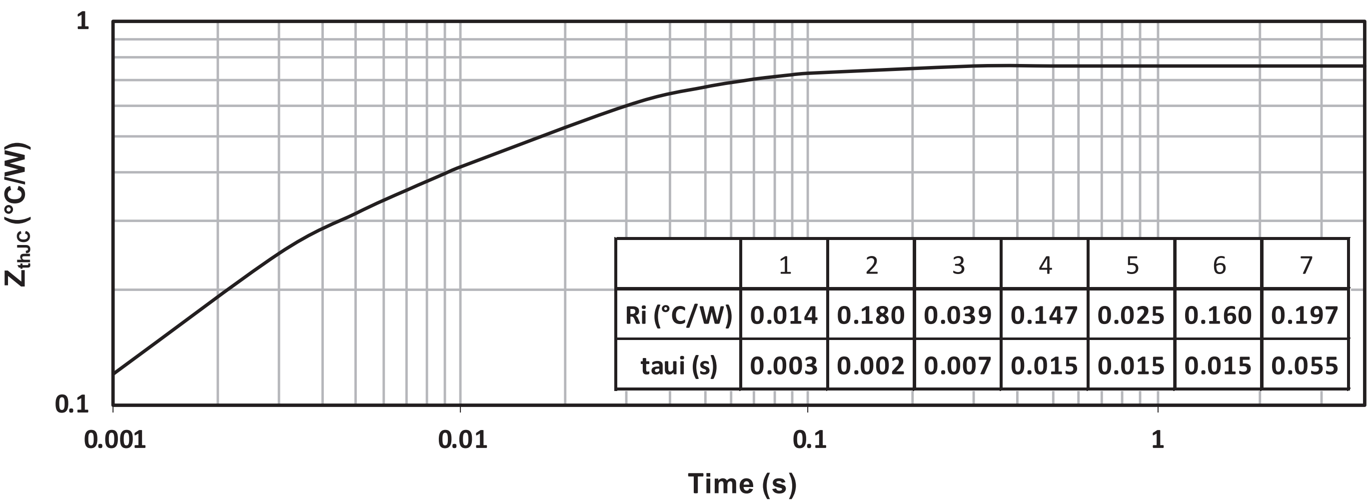
Figure 1-17. Capacitance vs. Reverse Voltage



1.12. Typical SiC MOSFET Performance Curve (Q7)

The following figures show the performance curves of the Q7 SiC MOSFETs.

Figure 1-18. Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.014	0.180	0.039	0.147	0.025	0.160	0.197
taui (s)	0.003	0.002	0.007	0.015	0.015	0.015	0.055

Figure 1-19. Output Characteristics, T_J = 25 °C

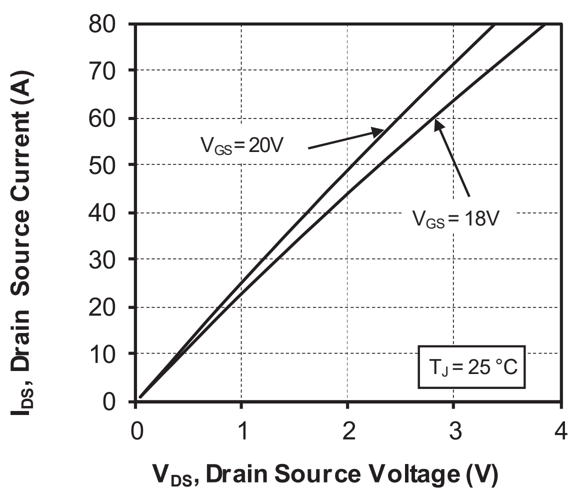


Figure 1-20. Output Characteristics, T_J = 175 °C

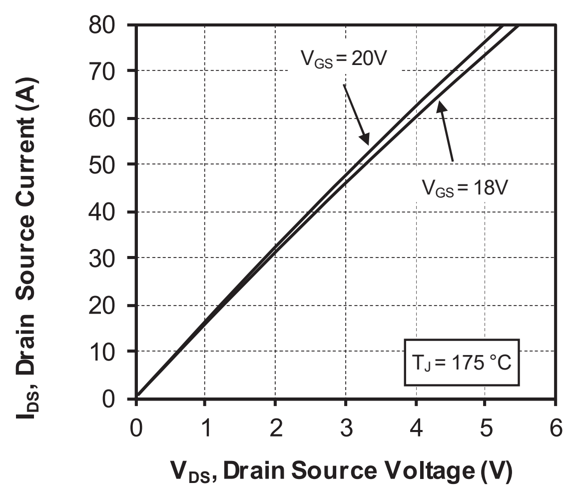


Figure 1-21. Normalized $R_{DS(on)}$ vs. Temperature

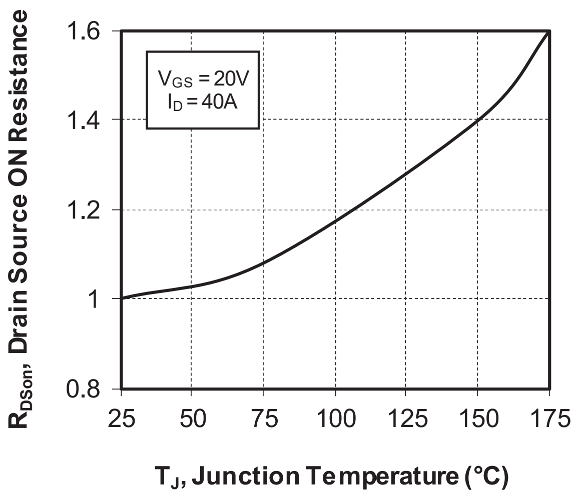


Figure 1-22. Transfer Characteristics

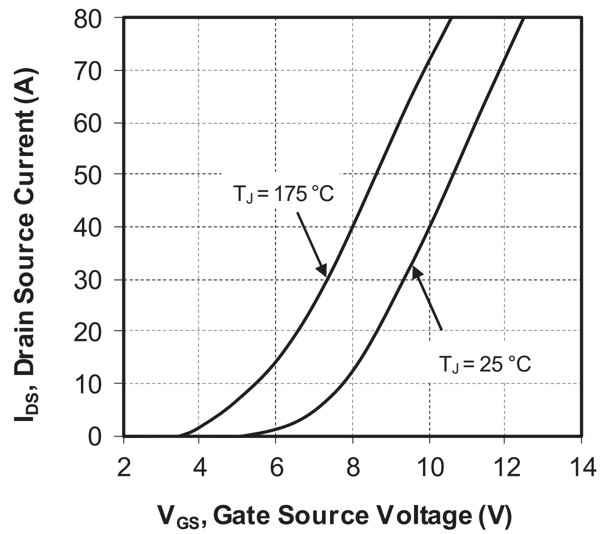


Figure 1-23. Switching Energy vs. Rg

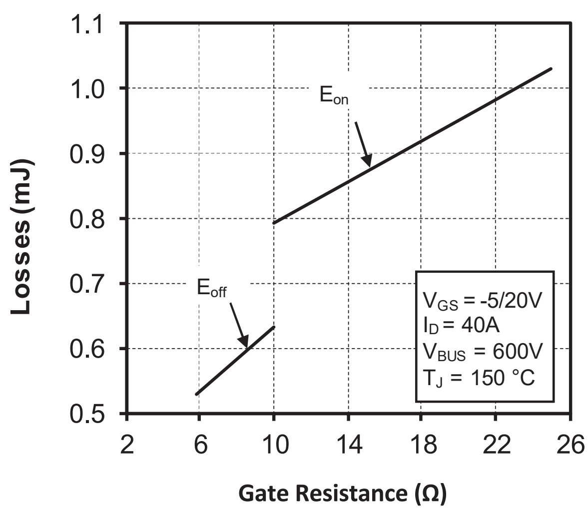


Figure 1-24. Switching Energy vs. Current

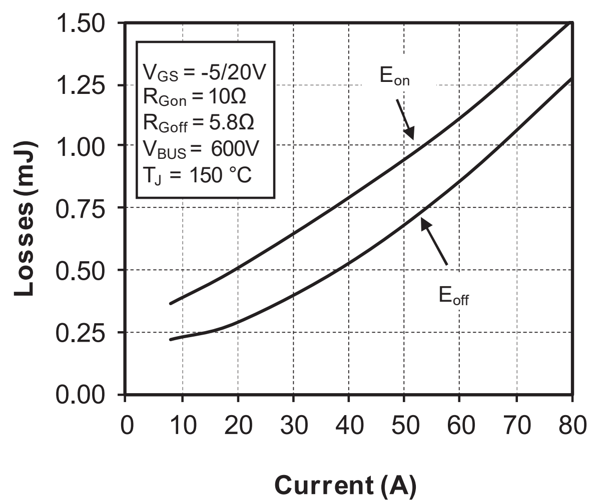


Figure 1-25. Capacitance vs. Drain Source Voltage

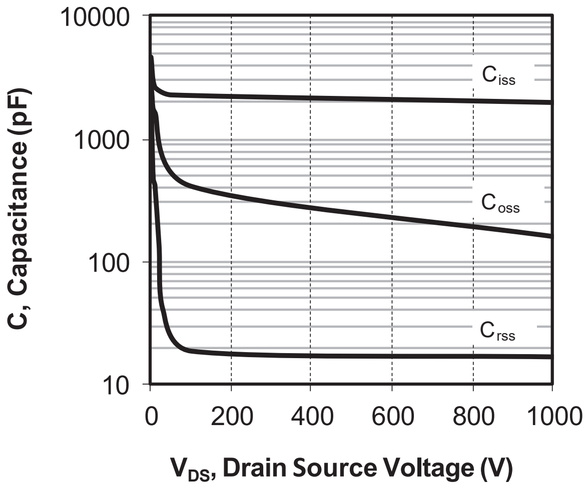


Figure 1-26. Gate Charge vs. Gate Source Voltage

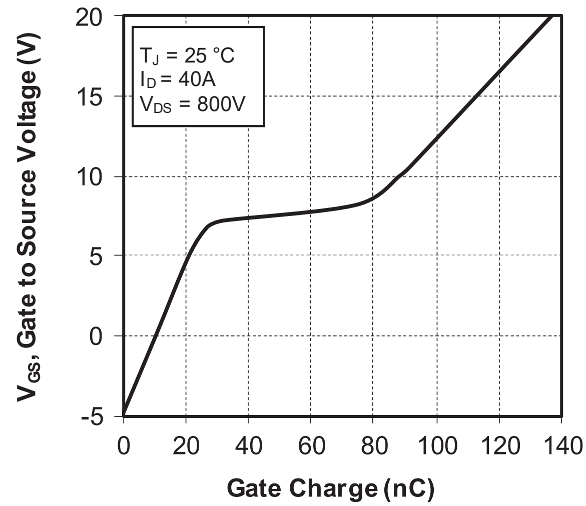


Figure 1-27. Body Diode Characteristics, T_J = 25 °C

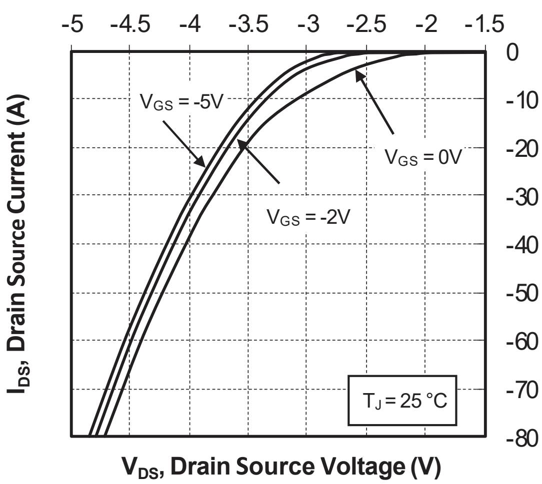


Figure 1-28. 3rd Quadrant Characteristics, T_J = 25 °C

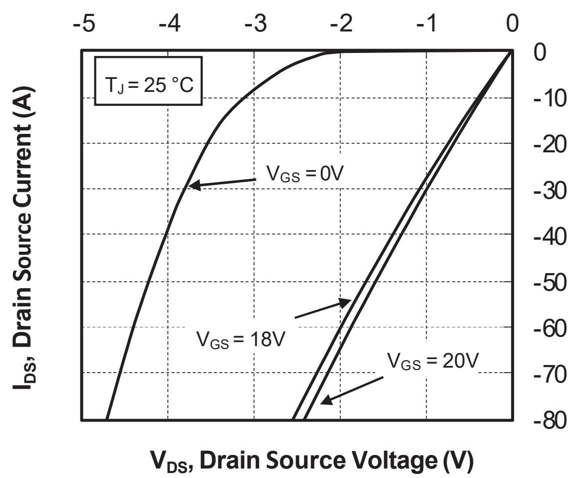


Figure 1-29. Body Diode Characteristics, T_J = 175 °C

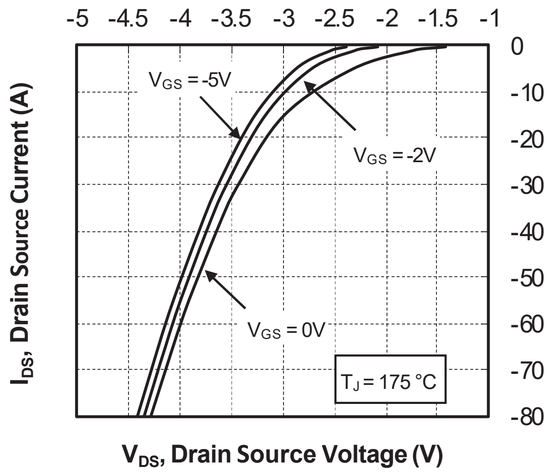


Figure 1-30. 3[rd] Quadrant Characteristics, T_J = 175 °C

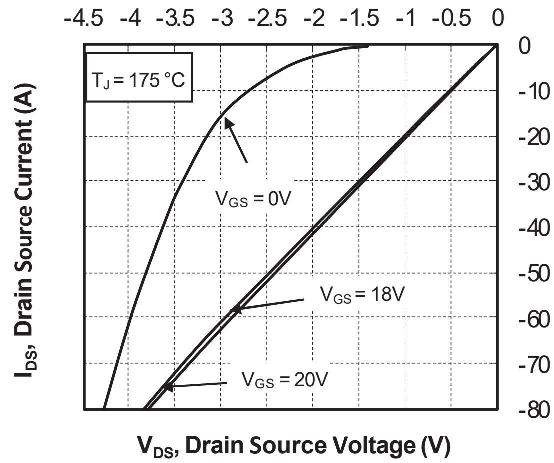
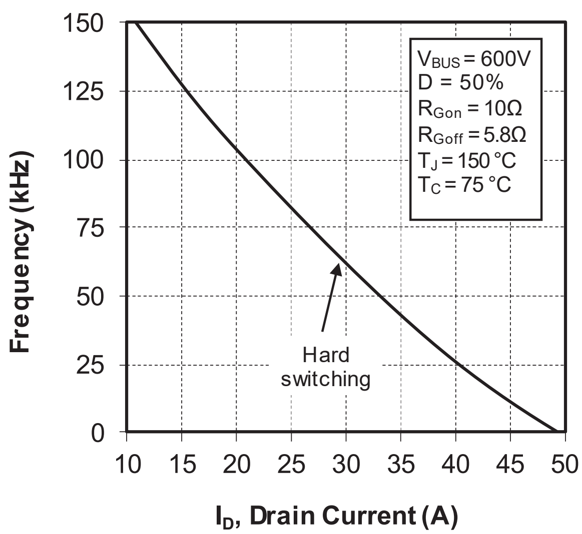


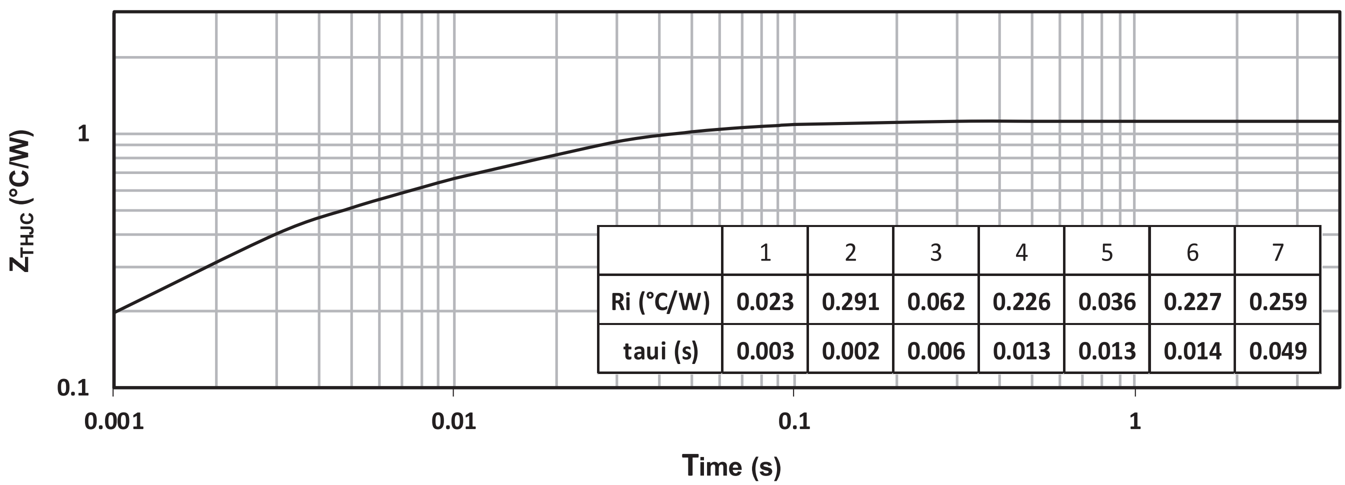
Figure 1-31. Operating Frequency vs. Drain Current



1.13. Typical SiC Diode Performance Curve (CR7 to CR8)

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

Figure 1-32. Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	0.023	0.291	0.062	0.226	0.036	0.227	0.259
taui (s)	0.003	0.002	0.006	0.013	0.013	0.014	0.049

Figure 1-33. Forward Characteristics

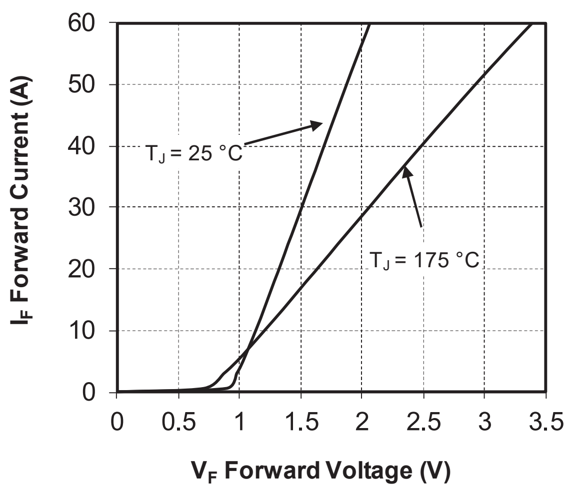
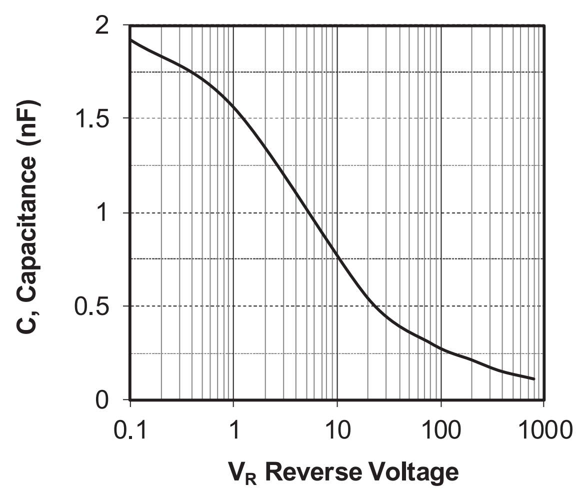


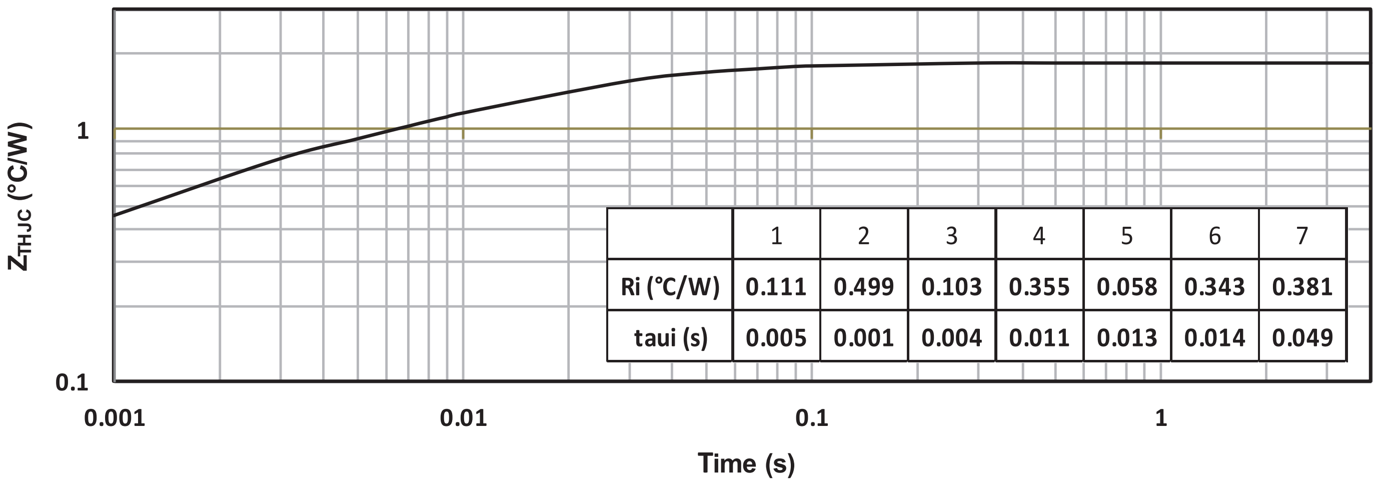
Figure 1-34. Capacitance vs. Reverse Voltage



1.14. Typical IGBT Performance Curve (Q9 and Q10)

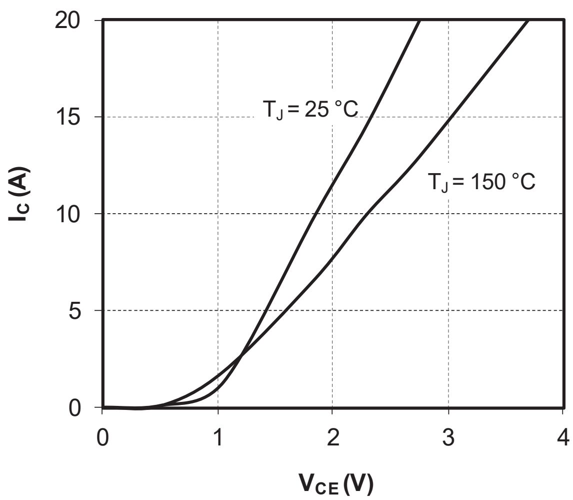
The following figures show the performance curves of the Q9 and Q10 IGBTs.

Figure 1-35. Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	**0.111**	**0.499**	**0.103**	**0.355**	**0.058**	**0.343**	**0.381**
taui (s)	**0.005**	**0.001**	**0.004**	**0.011**	**0.013**	**0.014**	**0.049**

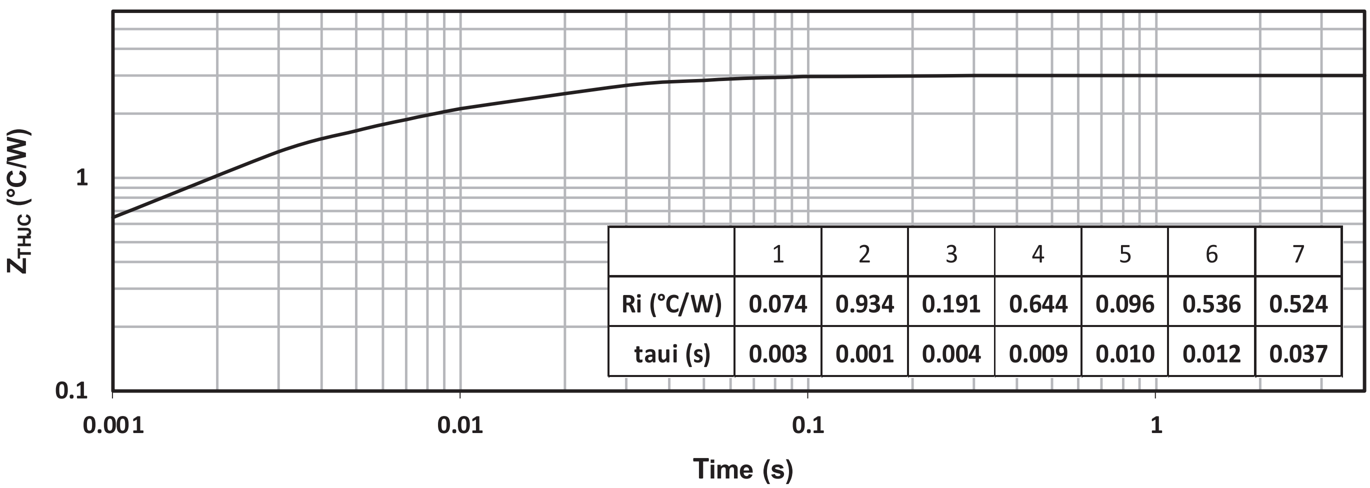
Figure 1-36. Output Characteristics (V_{GE} = 15V)



1.15. Typical SiC Diode Performance Curve (CR9 and CR10)

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

Figure 1-37. Maximum Thermal Impedance



	1	2	3	4	5	6	7
Ri (°C/W)	**0.074**	**0.934**	**0.191**	**0.644**	**0.096**	**0.536**	**0.524**
taui (s)	**0.003**	**0.001**	**0.004**	**0.009**	**0.010**	**0.012**	**0.037**

Figure 1-38. Forward Characteristics

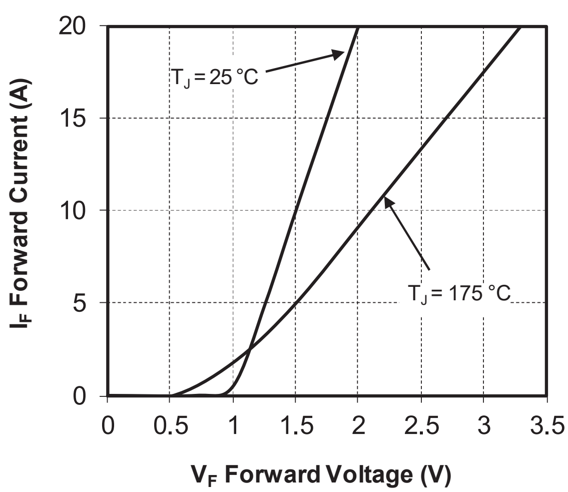
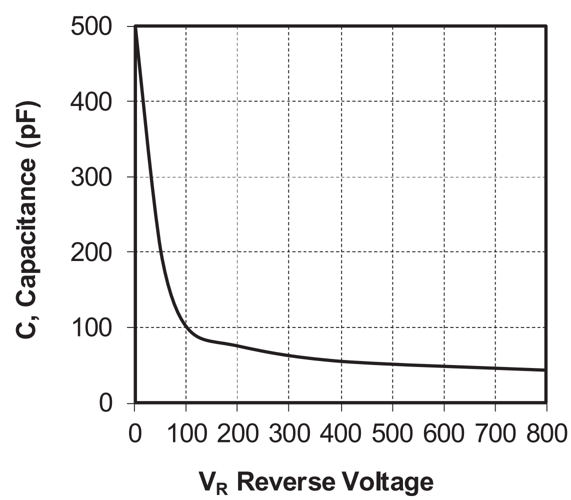


Figure 1-39. Capacitance vs. Reverse Voltage



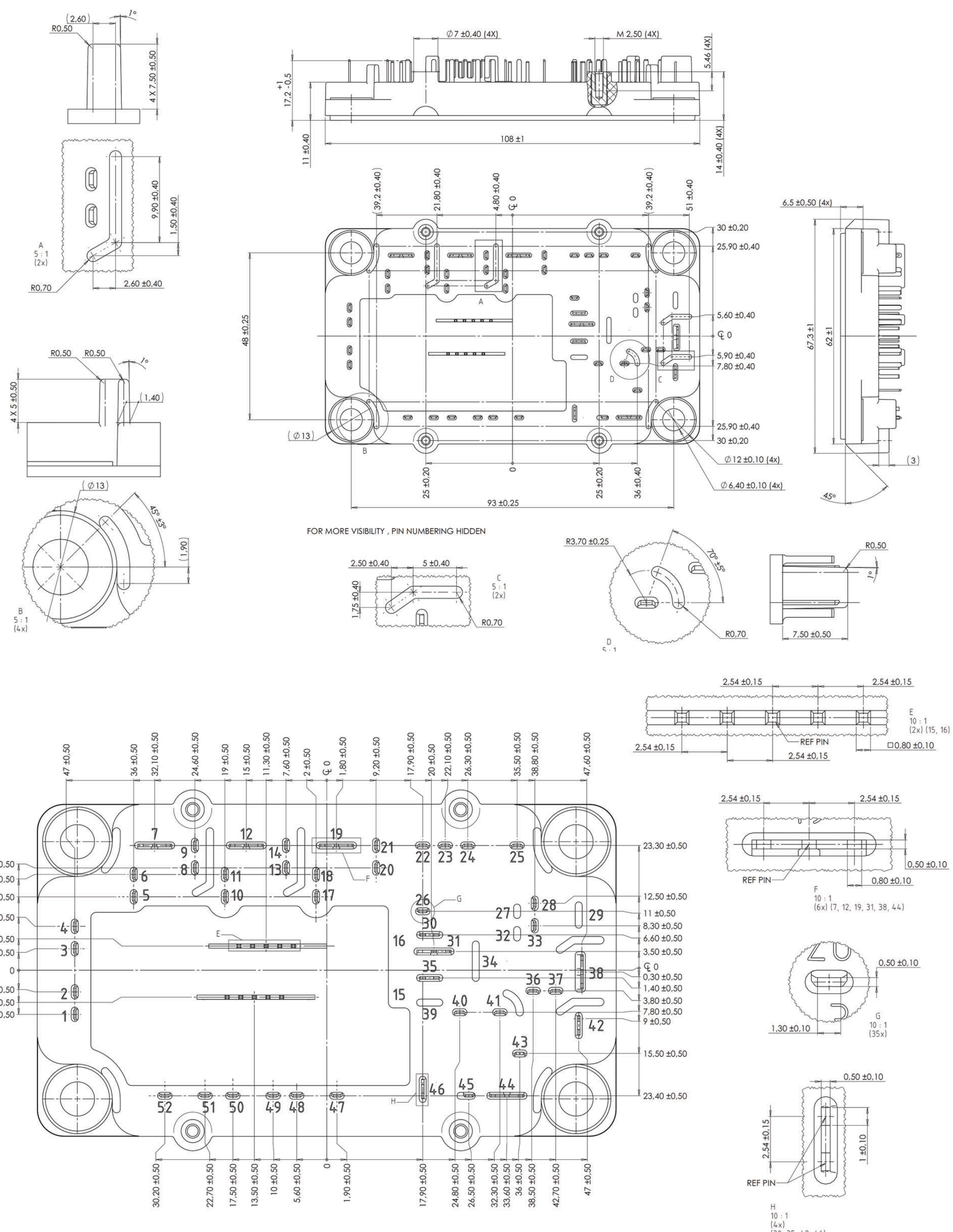
2. Package Specifications

The following section describes the package specification of the MSCSM120X10CTYZBNMG device.

2.1. Package Outline

The following figure shows the package outline drawing of the MSCSM120X10CTYZBNMG 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
B	11/2025	Updated R_I and I_{Ri} values in Table 1-14.
A	04/2023	Initial revision

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