

MOSFET

650 V CoolSiC™ M1 SiC Trench Power Device

The 650 V CoolSiC™ is built over the solid silicon carbide technology developed in Infineon in more than 20 years. Leveraging the wide bandgap SiC material characteristics, the 650V CoolSiC™ MOSFET offers a unique combination of performance, reliability and ease of use. Suitable for high temperature and harsh operations, it enables the simplified and cost effective deployment of the highest system efficiency.

Features

- Optimized switching behavior at higher currents
- Commutation robust fast body diode with low Q_f
- Superior gate oxide reliability
- $T_{j,max}=175^{\circ}\text{C}$ and excellent thermal behavior
- Lower $R_{DS(on)}$ and pulse current dependency on temperature
- Increased avalanche capability
- Compatible with standard drivers (recommended driving voltage: 0V-18V)
- Kelvin source provides up to 4 times lower switching losses

Benefits

- Unique combination of high performance, high reliability and ease of use
- Ease of use and integration
- Suitable for topologies with continuous hard commutation
- Higher robustness and system reliability
- Efficiency improvement
- Reduced system size leading to higher power density

Potential applications

- Telecom and Server SMPS
- UPS (uninterruptable power supplies)
- Solar PV inverters
- EV charging infrastructure
- Energy storage and battery formation
- Class D amplifiers

Product validation

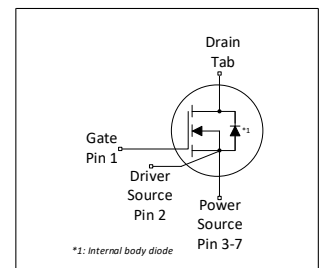
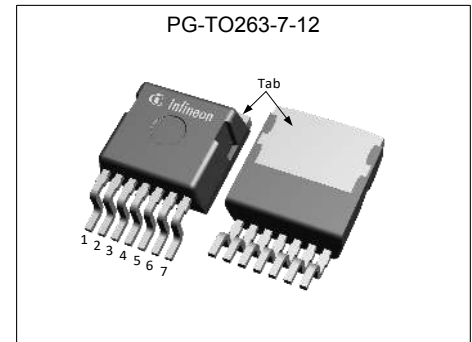
Fully qualified according to JEDEC for Industrial Applications

Please note: The source and sense source pins are not exchangeable. Their exchange might lead to malfunction.

Table 1 Key Performance Parameters

Parameter	Value	Unit
$V_{DS} @ T_J = 25^{\circ}\text{C}$	650	V
$R_{DS(on),typ}$	39	m Ω
$R_{DS(on),max}$	51	m Ω
$Q_{G,typ}$	41	nC
I_{DM}	122	A
$Q_{oss} @ 400\text{ V}$	97	nC
$E_{oss} @ 400\text{ V}$	14.6	μJ

Type / Ordering Code	Package	Marking	Related Links
IMBG65R039M1H	PG-TO263-7-12	65R039M1	see Appendix A



RoHS

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1 Maximum ratings

at $T_J = 25\text{ °C}$, unless otherwise specified

Table 2 Maximum ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous DC drain current ¹⁾	I_D	-	-	54 38	A	$T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$
Peak drain current ²⁾	I_{DM}	-	-	122	A	$T_C = 25\text{ °C}$
Avalanche energy, single pulse	E_{AS}	-	-	213	mJ	$I_D = 8.0\text{ A}$, $V_{DD} = 50\text{ V}$; see table 11
Avalanche energy, repetitive	E_{AR}	-	-	1.06	mJ	$I_D = 8.0\text{ A}$, $V_{DD} = 50\text{ V}$; see table 11
Avalanche current, single pulse	I_{AS}	-	-	8.0	A	-
MOSFET dv/dt ruggedness	dv/dt	-	-	200	V/ns	$V_{DS} = 0\text{...}400\text{ V}$
Gate source voltage (static) ³⁾	V_{GS}	-5	-	23	V	static
Gate source voltage (transient)	V_{GS}	-7	-	25	V	$t_{pulse, positive} \leq 1\%$ duty cycle/ f_{sw}
Power dissipation	P_{tot}	-	-	211	W	$T_C = 25\text{ °C}$
Storage temperature	T_{stg}	-55	-	150	°C	-
Operating junction temperature	T_J	-55	-	175	°C	-
Mounting torque	-	-	-	n.a.	Ncm	-
Continuous reverse drain current ¹⁾	I_{SDC}	-	-	54 35	A	$V_{GS}=18\text{ V}$, $T_C = 25\text{ °C}$ $V_{GS}=0\text{ V}$, $T_C = 25\text{ °C}$
Repetitive peak reverse drain current ¹⁾	I_{SRM}	-	-	122	A	$T_C = 25\text{ °C}$, pulse width $t_p \leq 250\text{ ns}$
Insulation withstand voltage	V_{ISO}	-	-	n.a.	V	V_{rms} , $T_C = 25\text{ °C}$, $t = 1\text{ min}$

¹⁾ Limited by $T_{J,max}$

²⁾ Pulse width t_p limited by $T_{J,max}$

³⁾ The maximum gate-source voltage in the application design should be in accordance to IPC-9592B

2 Thermal characteristics

Table 3 Thermal characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	R_{thJC}	-	-	0.71	°C/W	-
Thermal resistance, junction - ambient	R_{thJA}	-	-	62	°C/W	device on PCB, minimal footprint
Thermal resistance, junction - ambient for SMD version	R_{thJA}	-	35	45	°C/W	Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm ² (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling.
Soldering temperature, wave- & reflow soldering allowed	T_{sold}	-	-	260	°C	reflow MSL1

3 Operating range

Table 4 Operating range

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate-source voltage operating range including undershoots ¹⁾	V_{GS}	-2	-	20	V	-

¹⁾ **Important note: the selection of positive and negative gate-source voltages impacts the long-term behavior of the device.** The design guidelines described in the CoolSiC™ MOSFET 650 V M1 trench power device application note AN_1907_PL52_1911_144109 must be considered to ensure sound operation of the device over the planned lifetime.

4 Electrical characteristics

at $T_J = 25\text{ °C}$, unless otherwise specified

Table 5 Static characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source breakdown voltage	$V_{(BR)DSS}$	650	-	-	V	$V_{GS} = 0\text{ V}$, $I_D = 0.75\text{ mA}$
Gate threshold voltage ¹⁾	$V_{GS(th)}$	3.5	4.5	5.7	V	$V_{DS} = V_{GS}$, $I_D = 7.5\text{ mA}$
Zero gate voltage drain current	I_{DSS}	-	1 3	150 -	μA	$V_{DS} = 650\text{ V}$, $V_{GS} = 0\text{ V}$, $T_J = 25\text{ °C}$ $V_{DS} = 650\text{ V}$, $V_{GS} = 0\text{ V}$, $T_J = 175\text{ °C}$
Gate leakage current	I_{GSS}	-	-	100	nA	$V_{GS} = 20\text{ V}$, $V_{DS} = 0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	0.039 0.055	0.051 -	Ω	$V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $T_J = 25\text{ °C}$ $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $T_J = 175\text{ °C}$
Internal gate resistance	R_G	-	5.0	-	Ω	$f = 1\text{ MHz}$

Table 6 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	1393	-	pF	$V_{GS} = 0\text{ V}$, $V_{DS} = 400\text{ V}$, $f = 250\text{ kHz}$
Reverse transfer capacitance	C_{riss}	-	15	-	pF	$V_{GS} = 0\text{ V}$, $V_{DS} = 400\text{ V}$, $f = 250\text{ kHz}$
Output capacitance ²⁾	C_{oss}	-	160	208	pF	$V_{GS} = 0\text{ V}$, $V_{DS} = 400\text{ V}$, $f = 250\text{ kHz}$
Output charge ²⁾	Q_{oss}	-	97	126	nC	calculation based on C_{oss}
Effective output capacitance, energy related ³⁾	$C_{o(er)}$	-	182	-	pF	$V_{GS} = 0\text{ V}$, $V_{DS} = 0...400\text{ V}$
Effective output capacitance, time related ⁴⁾	$C_{o(tr)}$	-	241	-	pF	$I_D = \text{constant}$, $V_{GS} = 0\text{ V}$, $V_{DS} = 0...400\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	7.1	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ }\Omega$; see table 10
Rise time	t_r	-	10.9	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ }\Omega$; see table 10
Turn-off delay time	$t_{d(off)}$	-	17.4	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ }\Omega$; see table 10
Fall time	t_f	-	7	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ }\Omega$; see table 10

¹⁾ Tested after 1 ms pulse at $V_{GS} = +20\text{ V}$

²⁾ Maximum specification is defined by calculated six sigma upper confidence bound

³⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 400 V

⁴⁾ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 400 V

Table 7 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	11	-	nC	$V_{DD} = 400\text{ V}$, $I_D = 25.0\text{ A}$, $V_{GS} = 0\text{ to }18\text{ V}$
Gate to drain charge	Q_{gd}	-	9	-	nC	$V_{DD} = 400\text{ V}$, $I_D = 25.0\text{ A}$, $V_{GS} = 0\text{ to }18\text{ V}$
Gate charge total	Q_g	-	41	-	nC	$V_{DD} = 400\text{ V}$, $I_D = 25.0\text{ A}$, $V_{GS} = 0\text{ to }18\text{ V}$

Table 8 Body diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source reverse voltage	V_{SD}	-	4.0	-	V	$V_{GS} = 0\text{ V}$, $I_S = 25.0\text{ A}$, $T_J = 25\text{ °C}$
MOSFET forward recovery time	t_{fr}	-	21.2	-	ns	$V_{DD} = 400\text{ V}$, $I_{S0} = 25.0\text{ A}$, $di_S/dt = 1000\text{ A}/\mu\text{s}$; see table 9
MOSFET forward recovery charge	Q_f	-	102	-	nC	$V_{DD} = 400\text{ V}$, $I_{S0} = 25.0\text{ A}$, $di_S/dt = 1000\text{ A}/\mu\text{s}$; see table 9
MOSFET peak forward recovery current	I_{frm}	-	8.3	-	A	$V_{DD} = 400\text{ V}$, $I_{S0} = 25.0\text{ A}$, $di_S/dt = 1000\text{ A}/\mu\text{s}$; see table 9

5 Electrical characteristics diagrams

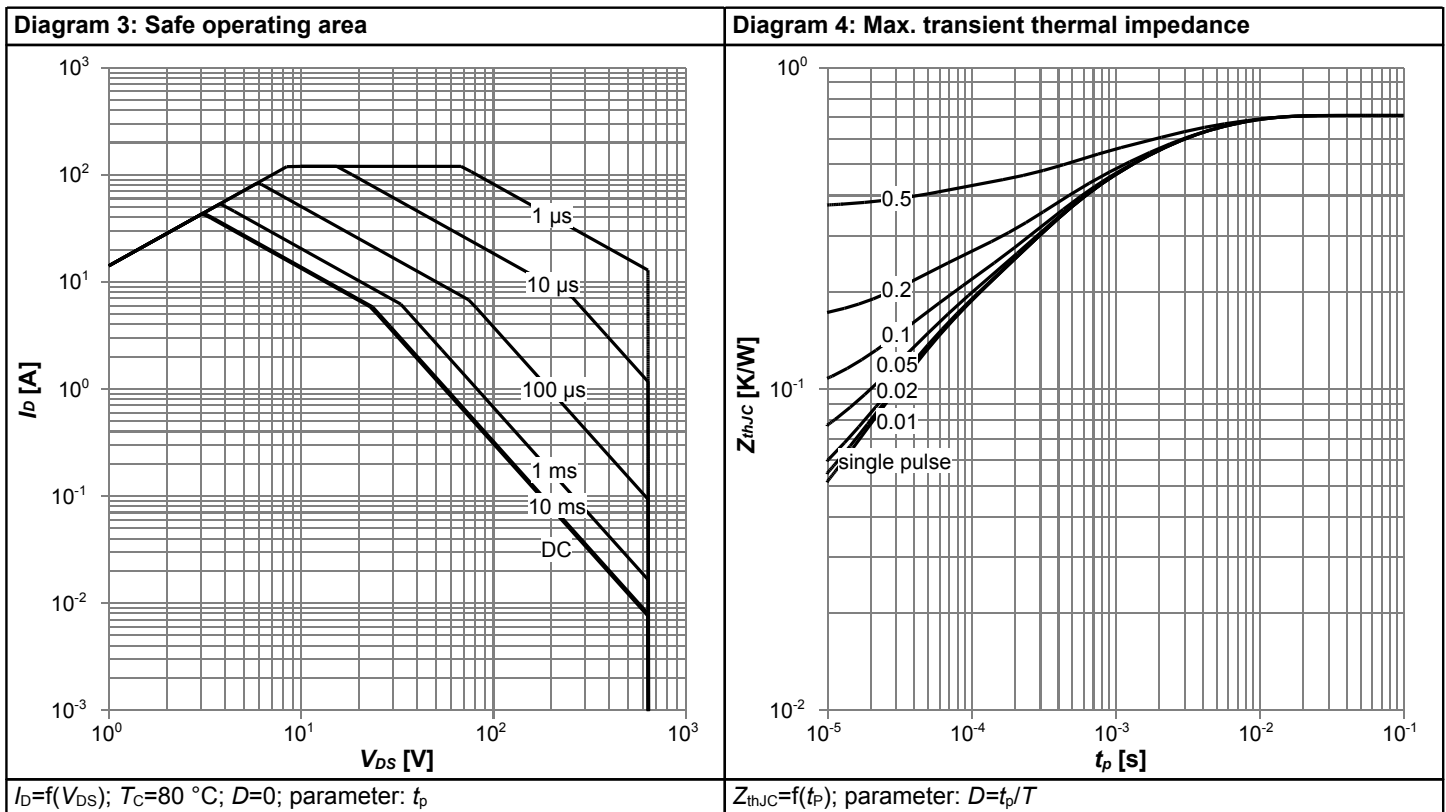
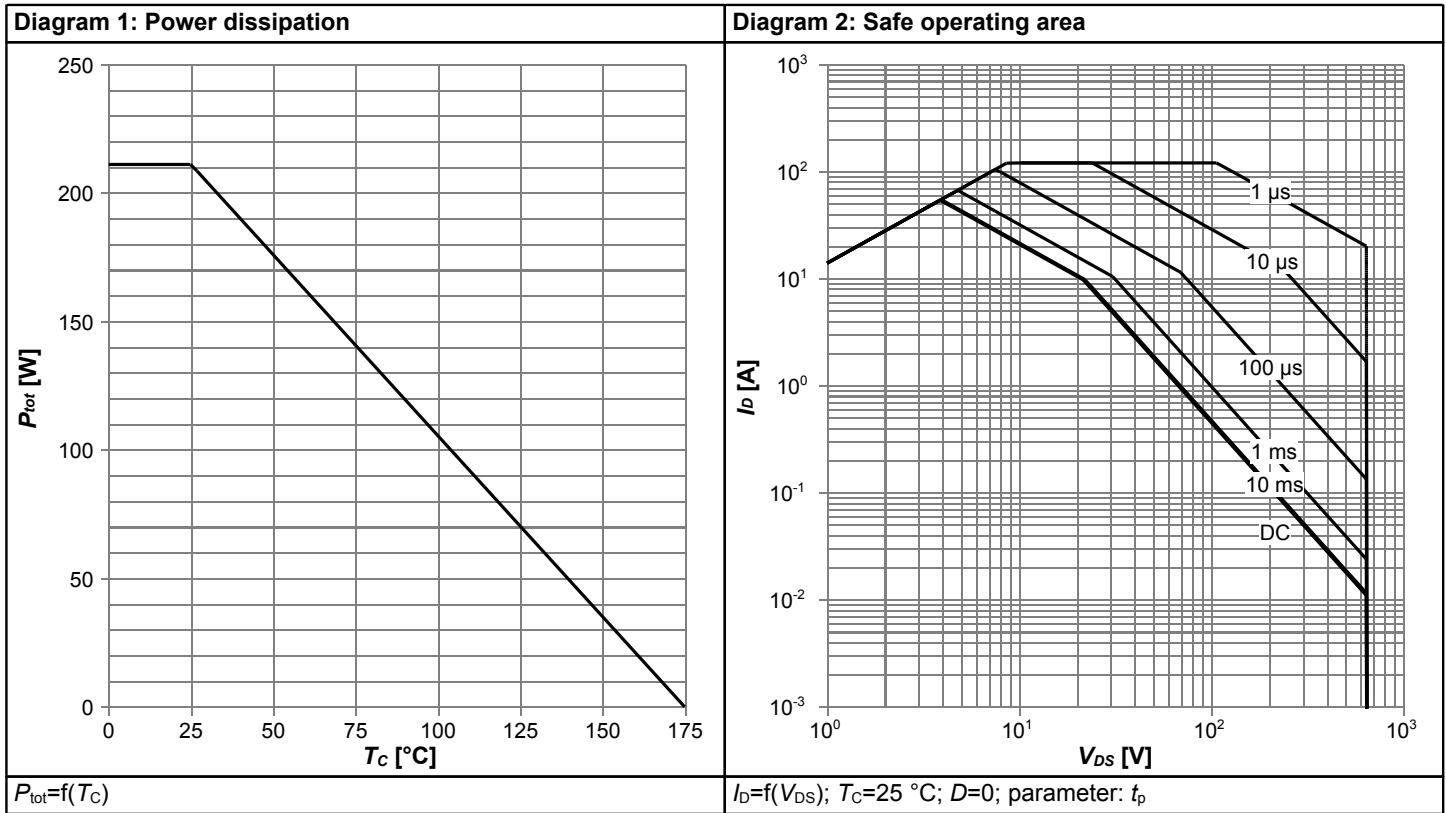
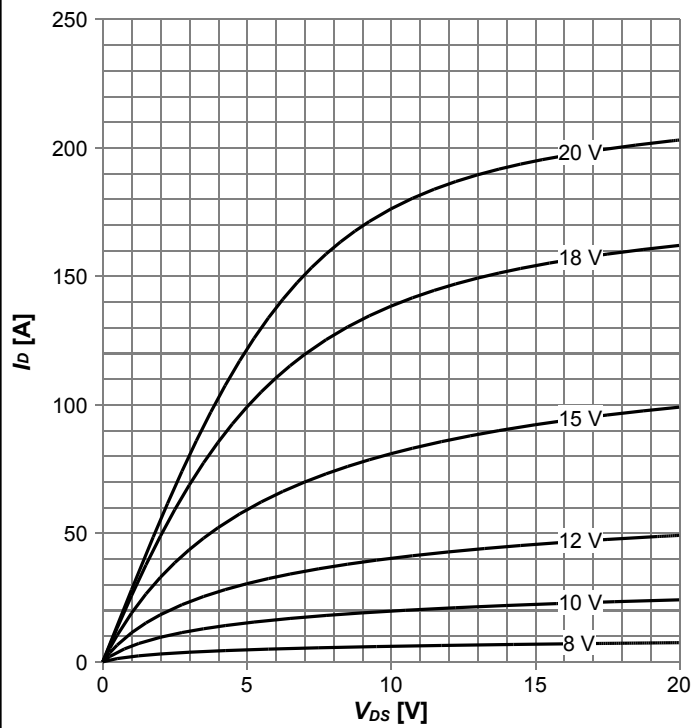
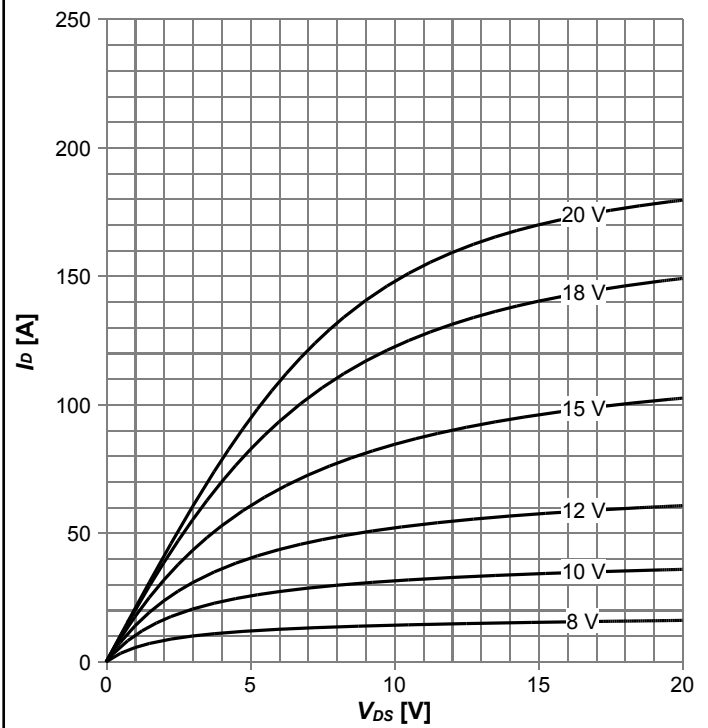


Diagram 5: Typ. output characteristics



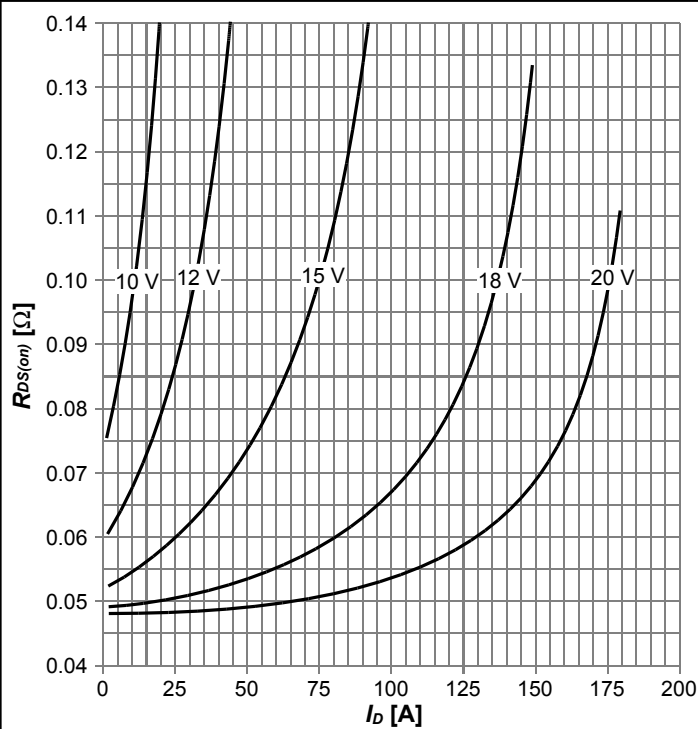
$I_D=f(V_{DS})$; $T_j=25\text{ °C}$; parameter: V_{GS}

Diagram 6: Typ. output characteristics



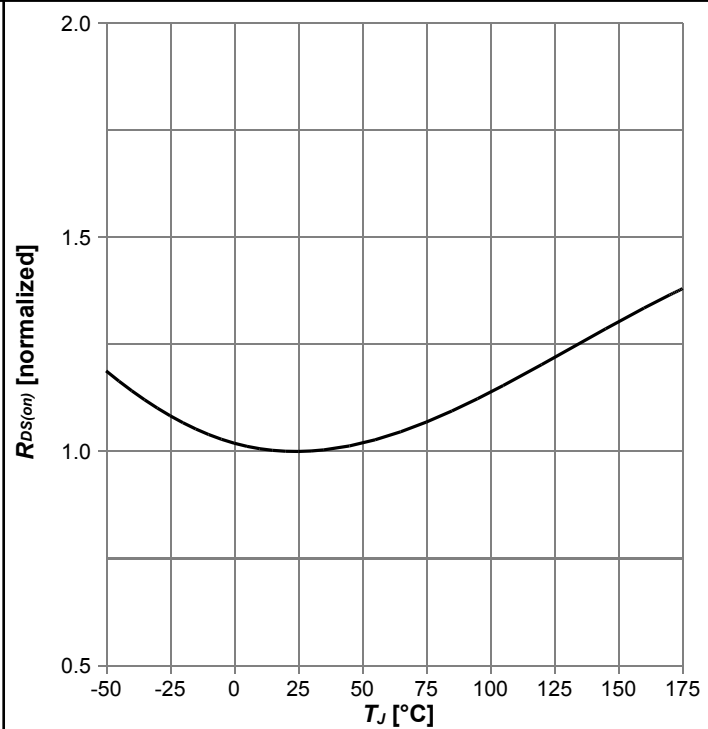
$I_D=f(V_{DS})$; $T_j=150\text{ °C}$; parameter: V_{GS}

Diagram 7: Typ. drain-source on-state resistance



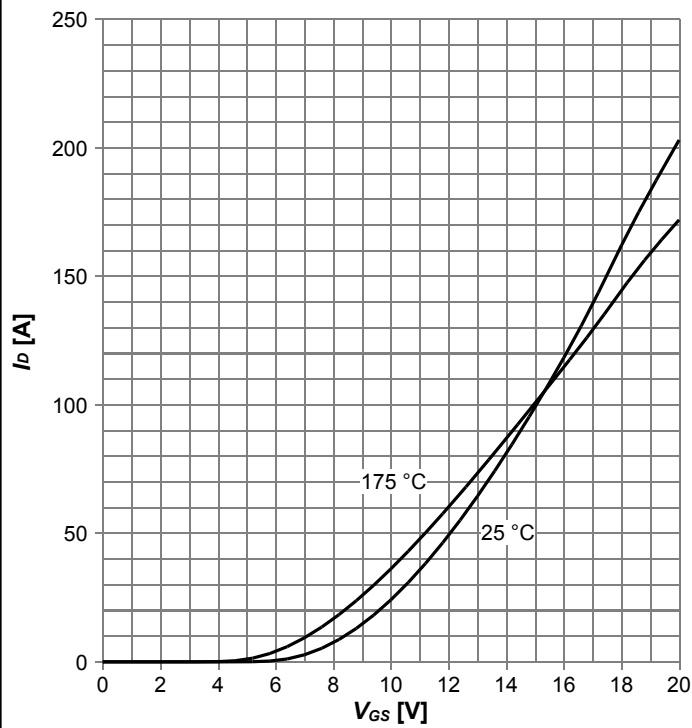
$R_{DS(on)}=f(I_D)$; $T_j=150\text{ °C}$; parameter: V_{GS}

Diagram 8: Drain-source on-state resistance



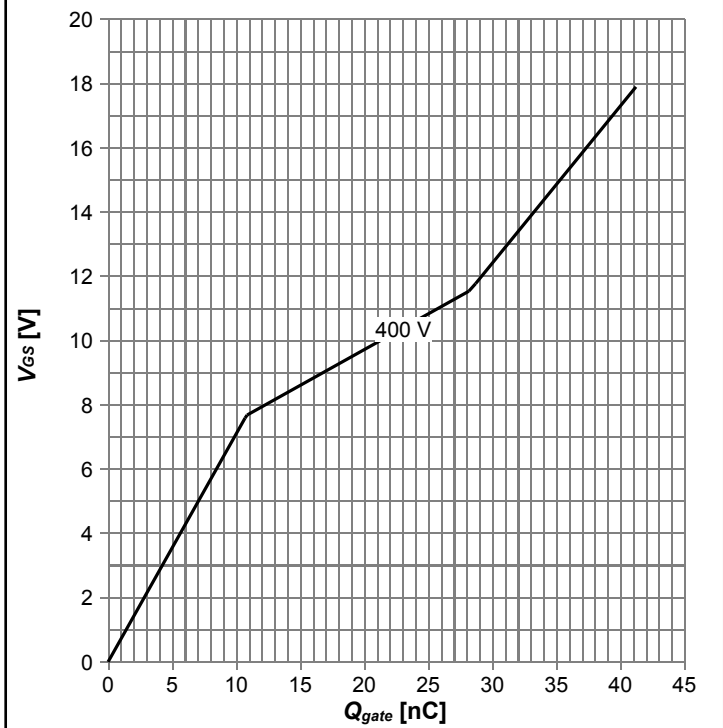
$R_{DS(on)}=f(T_j)$; $I_D=25.0\text{ A}$; $V_{GS}=18\text{ V}$

Diagram 9: Typ. transfer characteristics



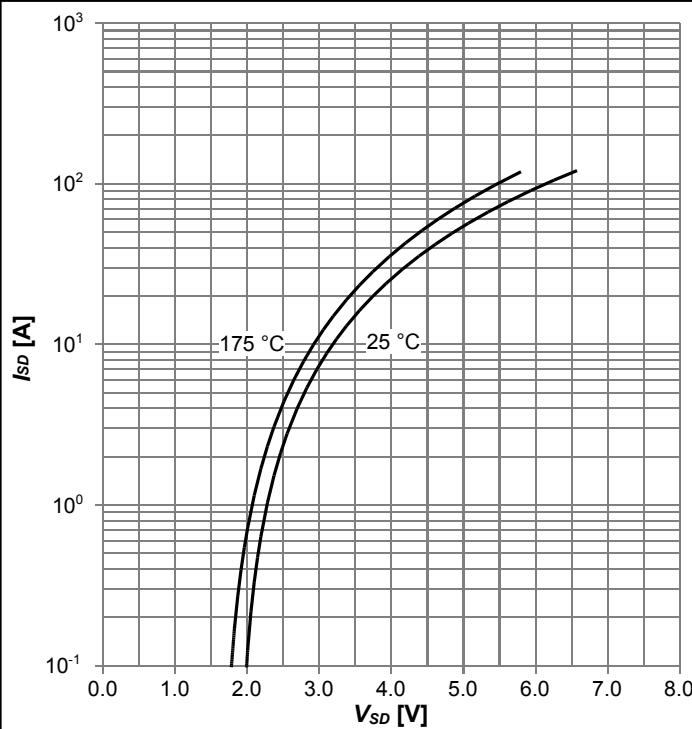
$I_D=f(V_{GS})$; $V_{DS}=20V$; parameter: T_j

Diagram 10: Typ. gate charge



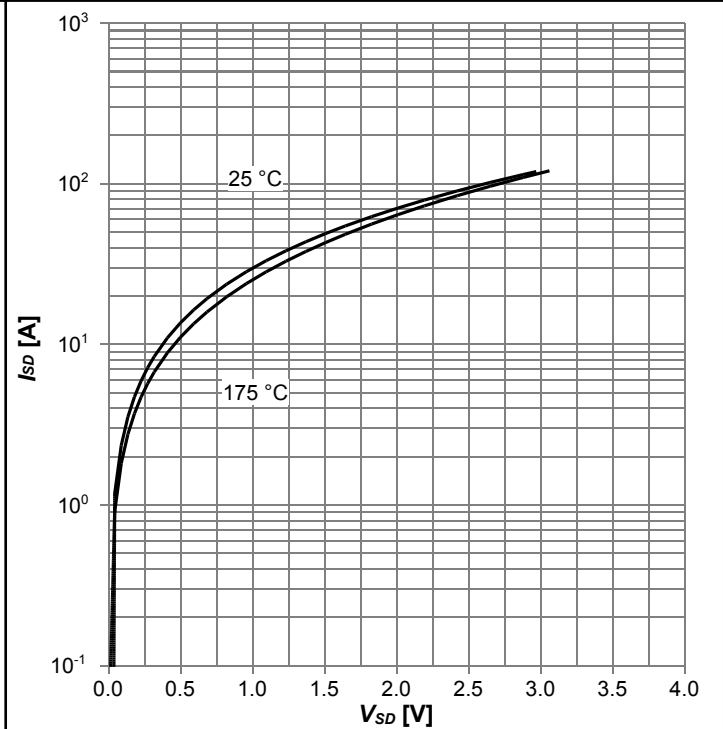
$V_{GS}=f(Q_{gate})$; $I_D=25.0$ A pulsed; parameter: V_{DD}

Diagram 11: Typ. reverse characteristics



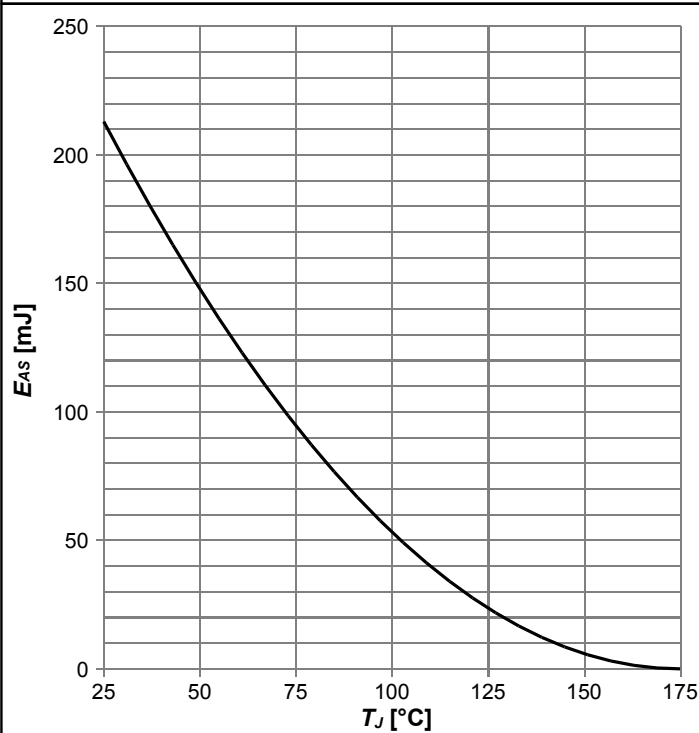
$I_{SD}=f(V_{SD})$; $V_{GS}=0$ V; parameter: T_j

Diagram 12: Typ. reverse characteristics



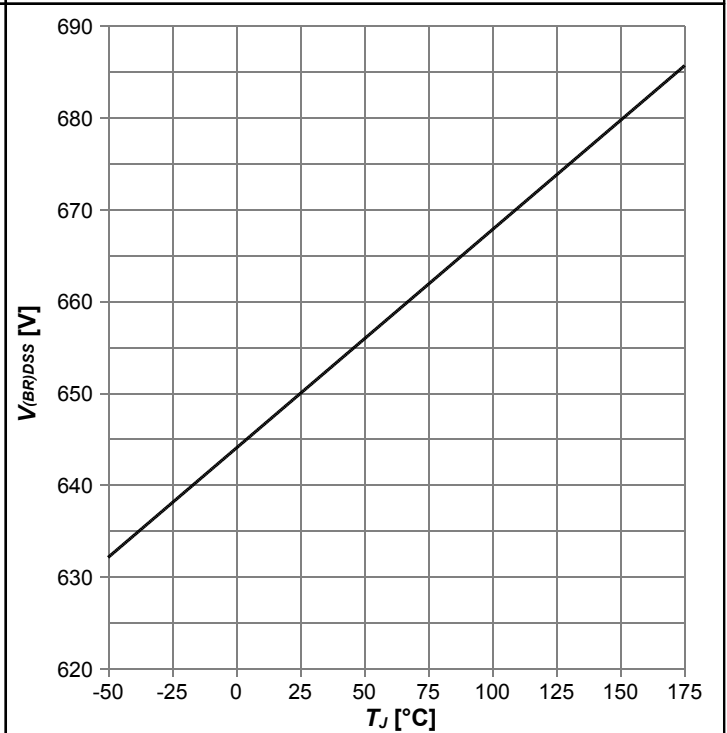
$I_{SD}=f(V_{SD})$; $V_{GS}=18$ V; parameter: T_j

Diagram 13: Avalanche energy



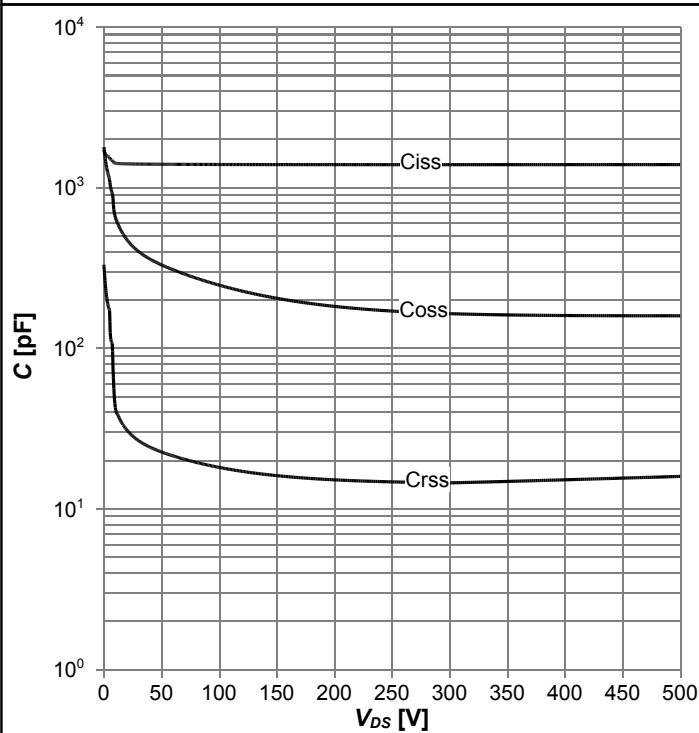
$E_{AS}=f(T_J)$; $I_D=8.0$ A; $V_{DD}=50$ V

Diagram 14: Drain-source breakdown voltage



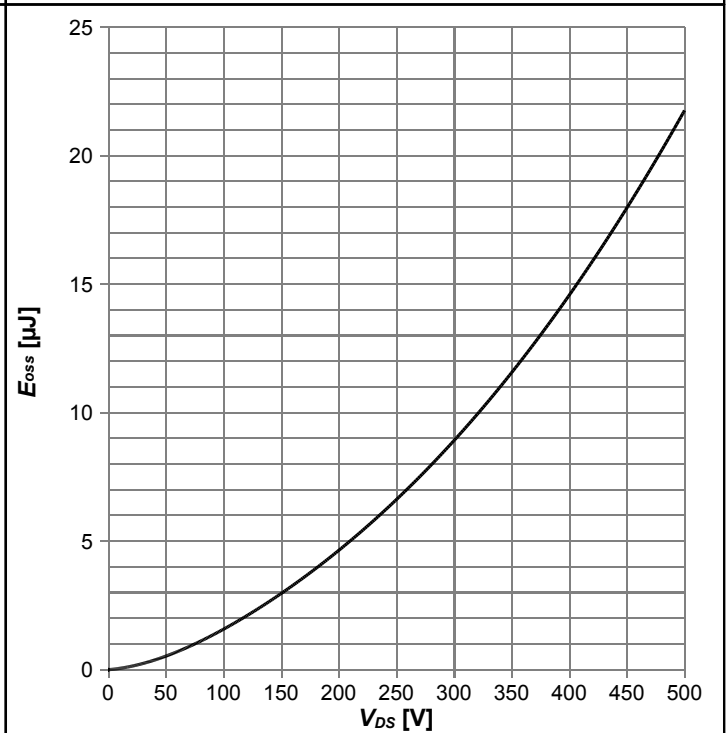
$V_{(BR)DSS}=f(T_J)$; $I_D=0.75$ mA

Diagram 15: Typ. capacitances



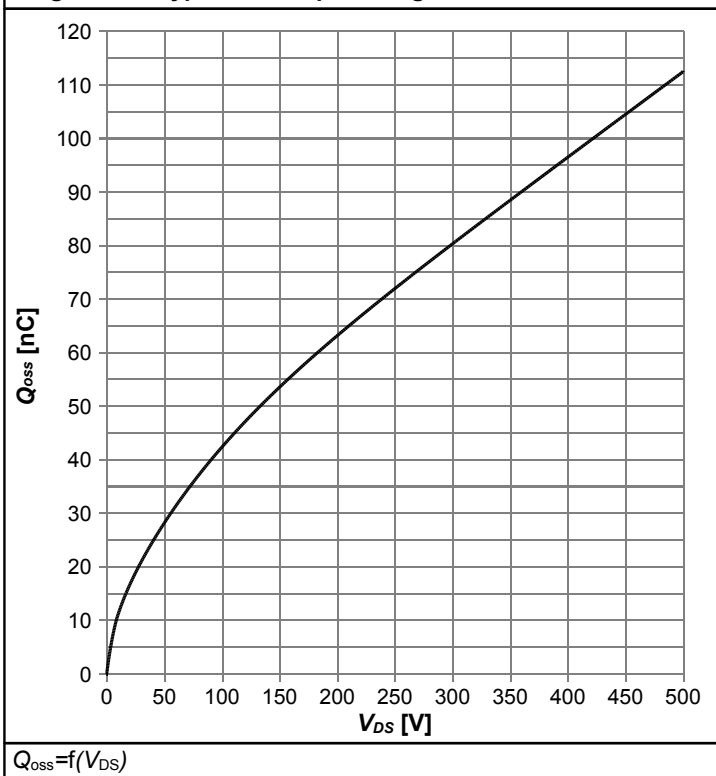
$C=f(V_{DS})$; $V_{GS}=0$ V; $f=250$ kHz

Diagram 16: Typ. Coss stored energy



$E_{oss}=f(V_{DS})$

Diagram 17: Typ. Q_{oss} output charge



6 Test Circuits

Table 9 Body diode characteristics (650V CoolSiC)

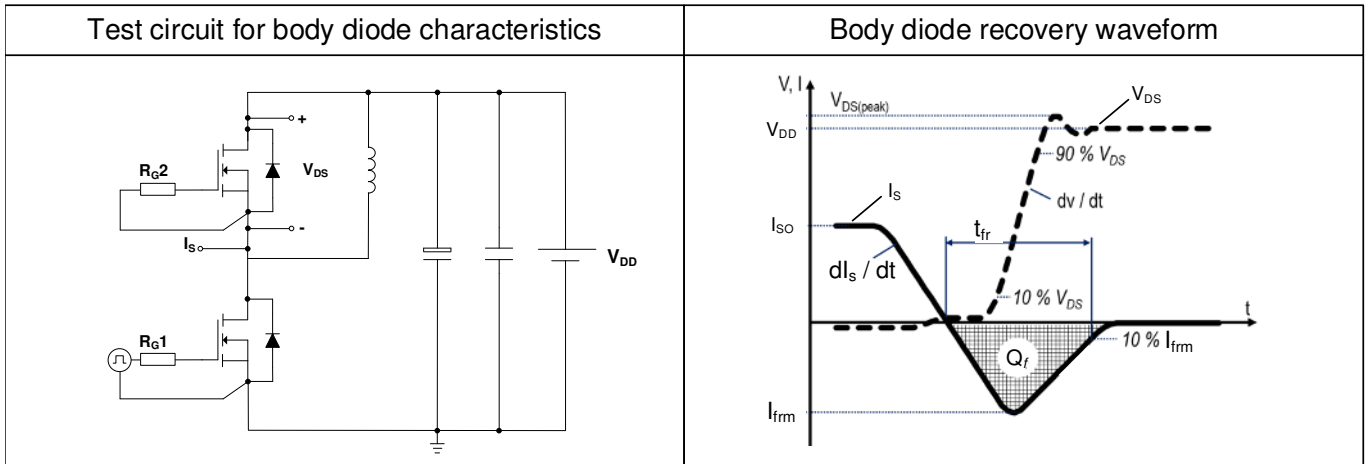


Table 10 Switching times (650V CoolSiC)

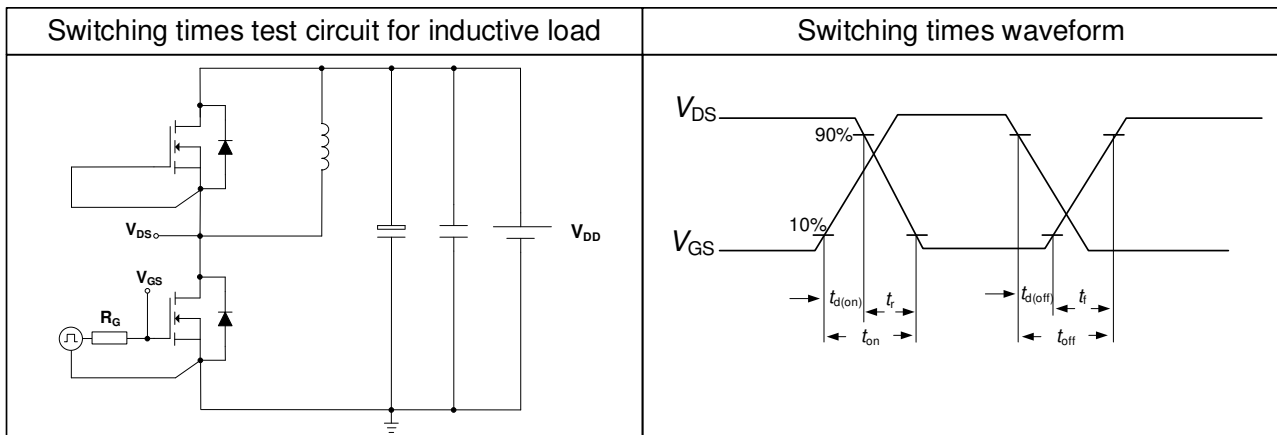
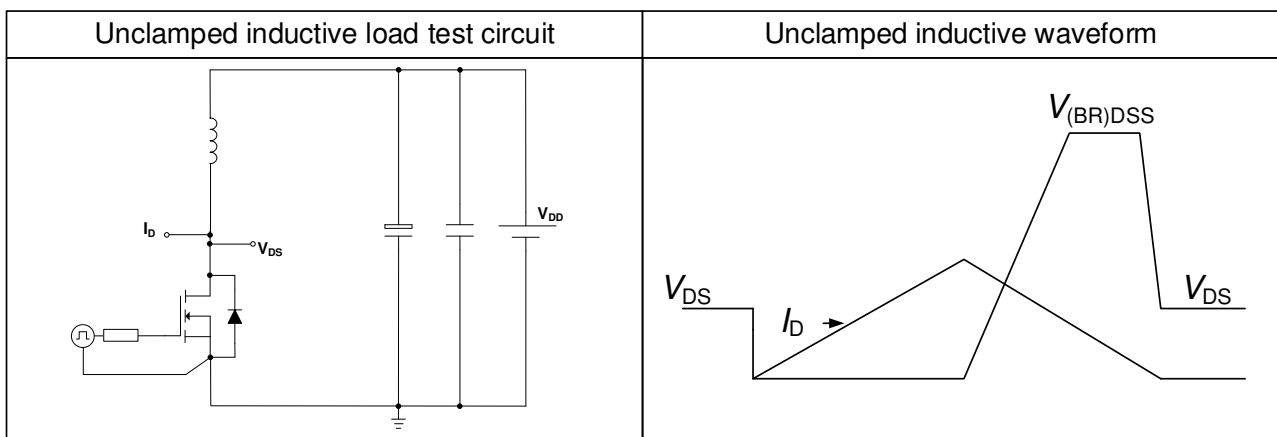


Table 11 Unclamped inductive load (650V CoolSiC)



7 Package Outlines

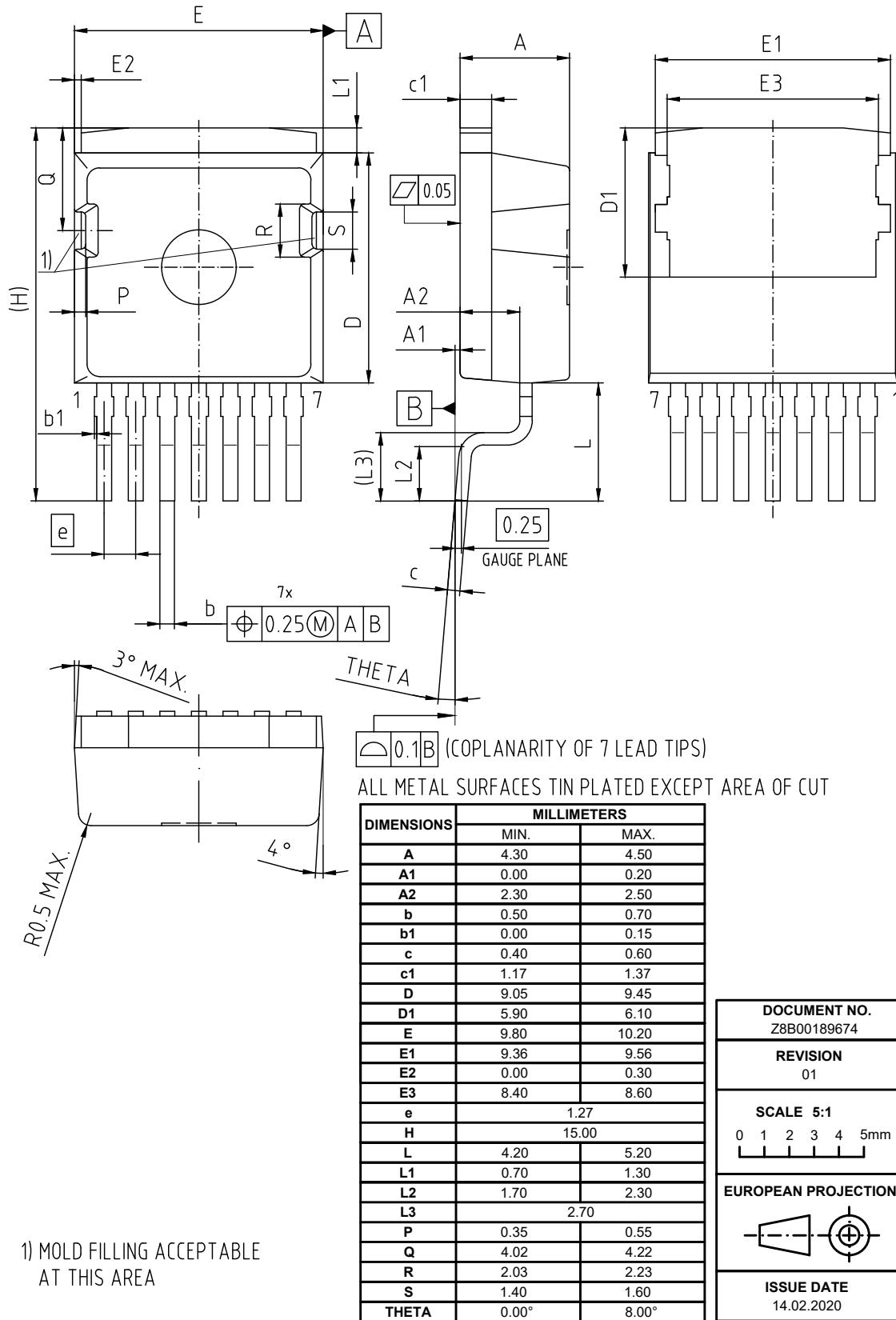


Figure 1 Outline PG-TO263-7-12, dimensions in mm

8 Appendix A

Table 12 Related Links

- **IFX CoolSiC M1 Webpage:** www.infineon.com
- **IFX CoolSiC M1 application note:** www.infineon.com
- **IFX CoolSiC M1 simulation model:** www.infineon.com
- **IFX Design tools:** www.infineon.com

Revision History

IMBG65R039M1H

Revision: 2021-12-10, Rev. 2.0

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2021-12-10	Release of final version

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