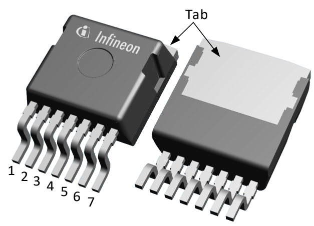
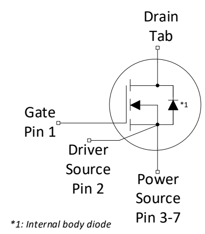
MOSFET

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.

PG-TO263-7-12





Features

- Optimized switching behavior at higher currents
- Commutation robust fast body diode with low Q_{f}
- Superior gate oxide reliability
- $T_{j,max}$=175°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 °C	650	V
$R_{DS(on),typ}$	22	mΩ
$R_{DS(on),max}$	30	mΩ
$Q_{G,typ}$	67	nC
I_{DM}	194	A
Q_{oss} @ 400 V	158	nC
E_{oss} @ 400 V	23.8	µJ

Type / Ordering Code	Package	Marking	Related Links
IMBG65R022M1H	PG-TO263-7-12	65R022M1	see Appendix A

Table of Contents

1 Maximum ratings

at T_J = 25 °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	- -	- -	64 50	A	T_C = 25 °C T_C = 100 °C
Peak drain current[2]	I_{DM}	-	-	194	A	T_C = 25 °C
Avalanche energy, single pulse	E_{AS}	-	-	350	mJ	I_D = 13.1 A, V_{DD} = 50 V; see table 11
Avalanche energy, repetitive	E_{AR}	-	-	1.75	mJ	I_D = 13.1 A, V_{DD} = 50 V; see table 11
Avalanche current, single pulse	I_{AS}	-	-	13.1	A	-
MOSFET *dv/dt* ruggedness	*dv/dt*	-	-	200	V/ns	V_{DS} = 0...400 V
Gate source voltage (static)[3]	V_{GS}	-5	-	23	V	static
Gate source voltage (transient)	V_{GS}	-7	-	25	V	$t_{pulse,positive}$ <= 1% duty cycle/f_{sw}
Power dissipation	P_{tot}	-	-	300	W	T_C = 25 °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}	- -	- -	64 53	A	V_{GS}=18V, T_C = 25 °C V_{GS}=0V, T_C = 25 °C
Repetitive peak reverse drain current[1]	I_{SRM}	-	-	194	A	T_C = 25 °C, pulse width t_p<=250ns
Insulation withstand voltage	V_{ISO}	-	-	n.a.	V	V_{rms}, T_C = 25 °C, t = 1 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}	-	-	0.50	°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 6cm² (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 °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 V, I_D = 1.23 mA
Gate threshold voltage[1]	$V_{GS(th)}$	3.5	4.5	5.7	V	V_{DS} = V_{GS}, I_D = 12.3 mA
Zero gate voltage drain current	I_{DSS}	- -	1 3	150 -	µA	V_{DS} = 650 V, V_{GS} = 0 V, T_J = 25 °C V_{DS} = 650 V, V_{GS} = 0 V, T_J = 175 °C
Gate leakage current	I_{GSS}	-	-	100	nA	V_{GS} = 20 V, V_{DS} = 0 V
Drain-source on-state resistance	$R_{DS(on)}$	- -	0.022 0.031	0.03 -	Ω	V_{GS} = 18 V, I_D = 41.1 A, T_J = 25 °C V_{GS} = 18 V, I_D = 41.1 A, T_J =175 °C
Internal gate resistance	R_G	-	3.0	-	Ω	f = 1 MHz

Table 6 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	2288	-	pF	V_{GS} = 0 V, V_{DS} = 400 V, f = 250 kHz
Reverse transfer capacitance	C_{rss}	-	24	-	pF	V_{GS} = 0 V, V_{DS} = 400 V, f = 250 kHz
Output capacitance[2]	C_{oss}	-	262	341	pF	V_{GS} = 0 V, V_{DS} = 400 V, f = 250 kHz
Output charge[2]	Q_{oss}	-	158	205	nC	calculation based on C_{oss}
Effective output capacitance, energy related[3]	$C_{o(er)}$	-	298	-	pF	V_{GS} = 0 V, V_{DS} = 0...400 V
Effective output capacitance, time related[4]	$C_{o(tr)}$	-	395	-	pF	I_D = constant, V_{GS} = 0 V, V_{DS} = 0...400 V
Turn-on delay time	$t_{d(on)}$	-	8.4	-	ns	V_{DD} = 400 V, V_{GS} = 18 V, I_D = 41.1 A, R_G = 1.8 Ω; see table 10
Rise time	t_r	-	15.1	-	ns	V_{DD} = 400 V, V_{GS} = 18 V, I_D = 41.1 A, R_G = 1.8 Ω; see table 10
Turn-off delay time	$t_{d(off)}$	-	24.7	-	ns	V_{DD} = 400 V, V_{GS} = 18 V, I_D = 41.1 A, R_G = 1.8 Ω; see table 10
Fall time	t_f	-	8	-	ns	V_{DD} = 400 V, V_{GS} = 18 V, I_D = 41.1 A, R_G = 1.8 Ω; see table 10

[1] Tested after 1 ms pulse at V_{GS} = *+20 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

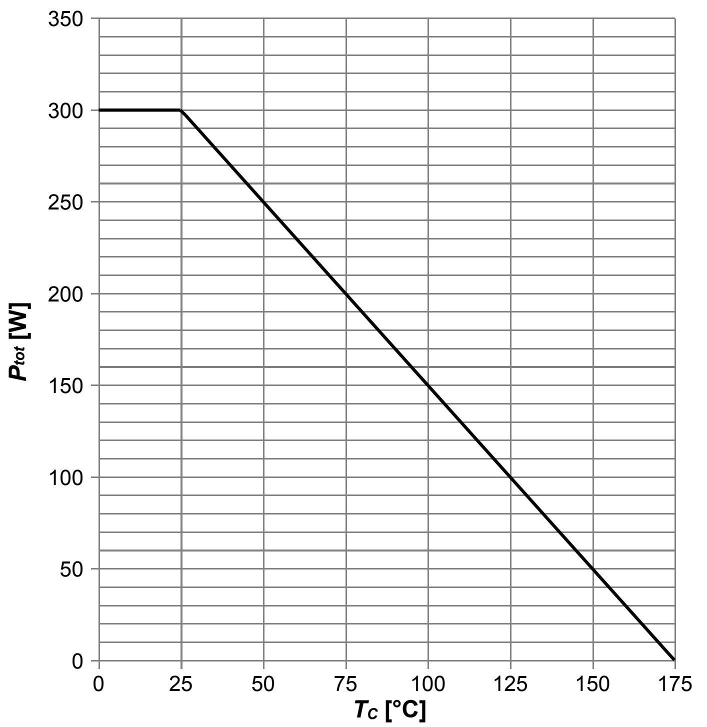
Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	Q_{gs}	-	18	-	nC	V_{DD} = 400 V, I_D = 41.1 A, V_{GS} = 0 to 18 V
Gate to drain charge	Q_{gd}	-	15	-	nC	V_{DD} = 400 V, I_D = 41.1 A, V_{GS} = 0 to 18 V
Gate charge total	Q_g	-	67	-	nC	V_{DD} = 400 V, I_D = 41.1 A, V_{GS} = 0 to 18 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 V, I_S = 41.1 A, T_J = 25 °C
MOSFET forward recovery time	t_{fr}	-	24.7	-	ns	V_{DD} = 400 V, I_{S0} = 41.1 A, di_S/dt = 1000 A/µs; see table 9
MOSFET forward recovery charge	Q_{f}	-	166	-	nC	V_{DD} = 400 V, I_{S0} = 41.1 A, di_S/dt = 1000 A/µs; see table 9
MOSFET peak forward recovery current	I_{frm}	-	11.4	-	A	V_{DD} = 400 V, I_{S0} = 41.1 A, di_S/dt = 1000 A/µs; see table 9

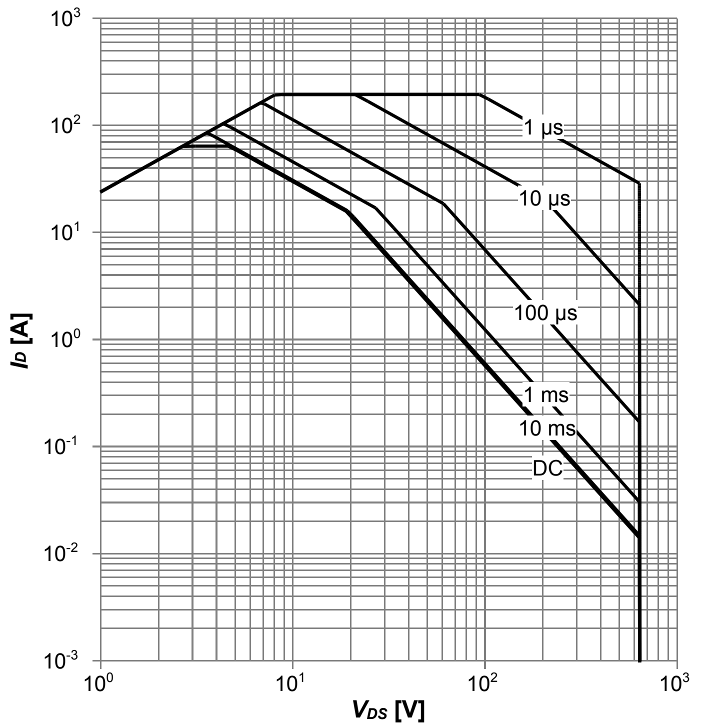
5 Electrical characteristics diagrams

Diagram 1: Power dissipation



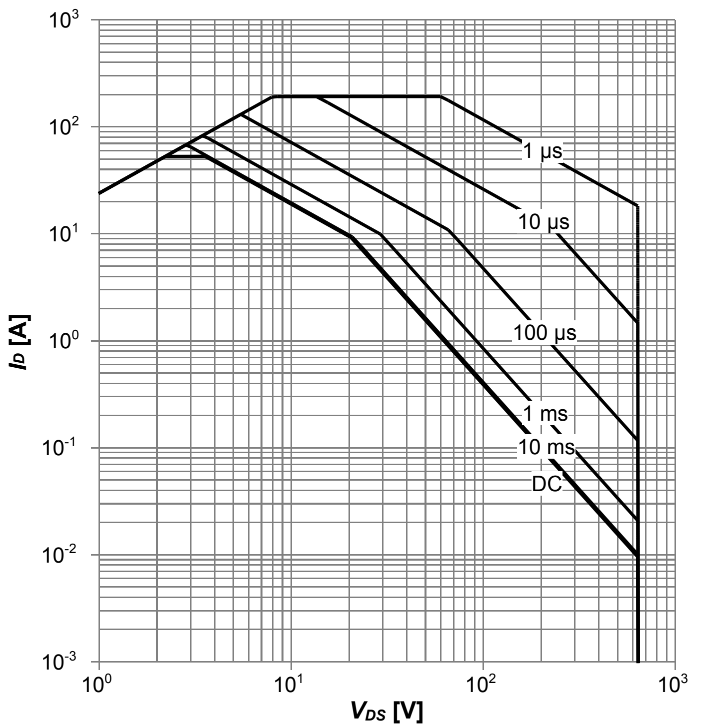
P_{tot}=f(T_C)

Diagram 2: Safe operating area



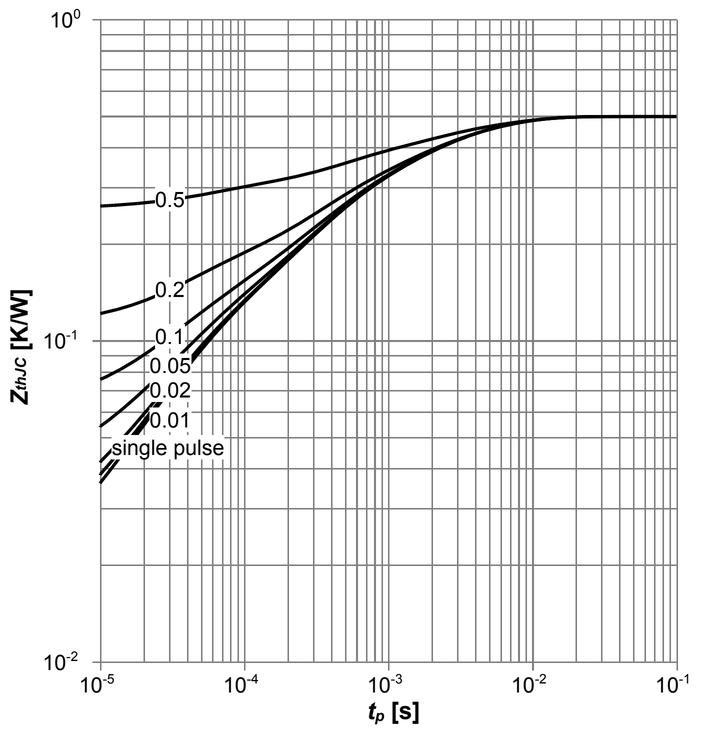
I_D=f(V_{DS}); T_C=25 °C; D=0; parameter: t_p

Diagram 3: Safe operating area



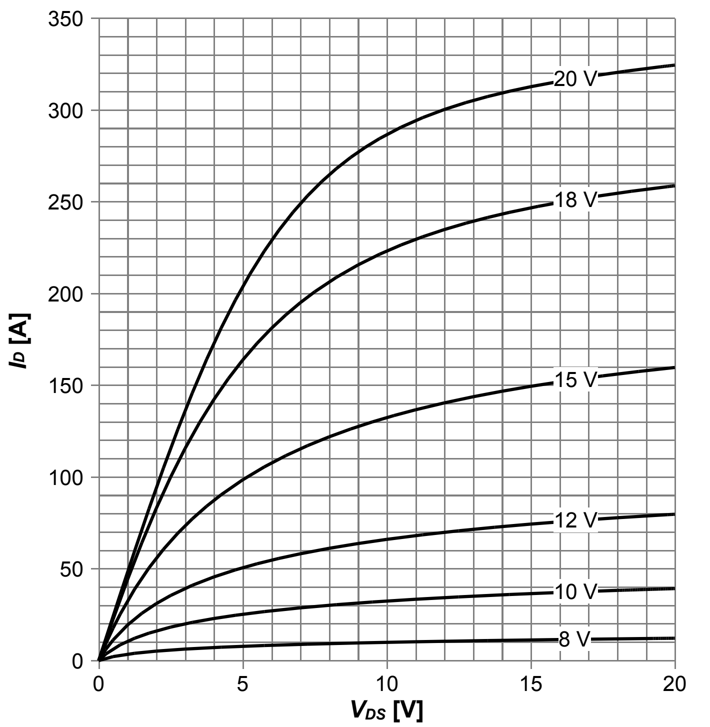
I_D=f(V_{DS}); T_C=80 °C; D=0; parameter: t_p

Diagram 4: Max. transient thermal impedance



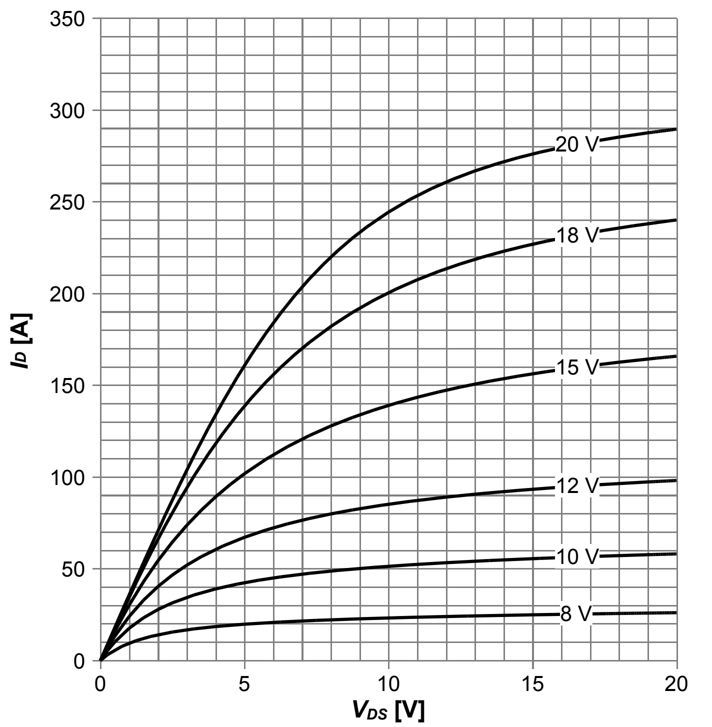
Z_{thJC}=f(t_P); parameter: D=t_p/T

Diagram 5: Typ. output characteristics



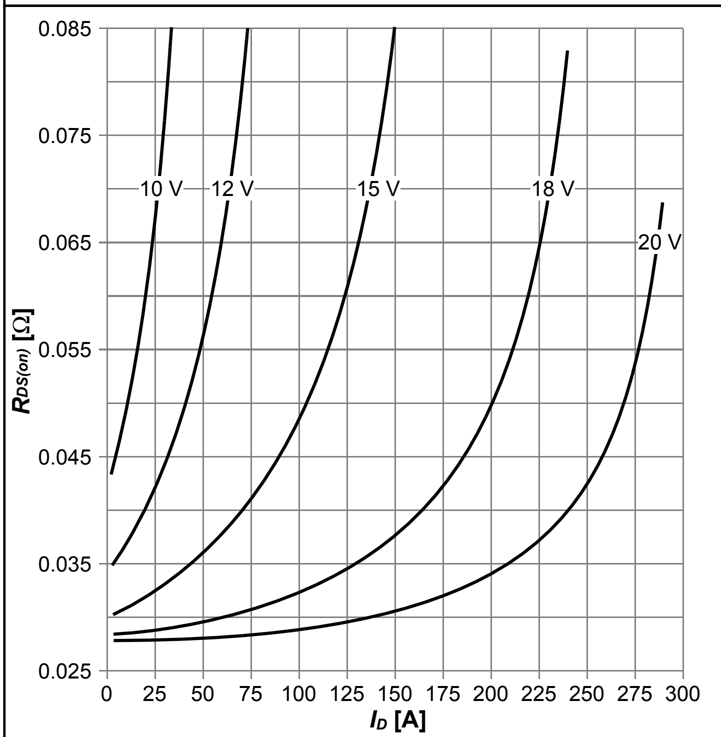
I_D=f(V_{DS}); T_j=25 °C; parameter: V_{GS}

Diagram 6: Typ. output characteristics



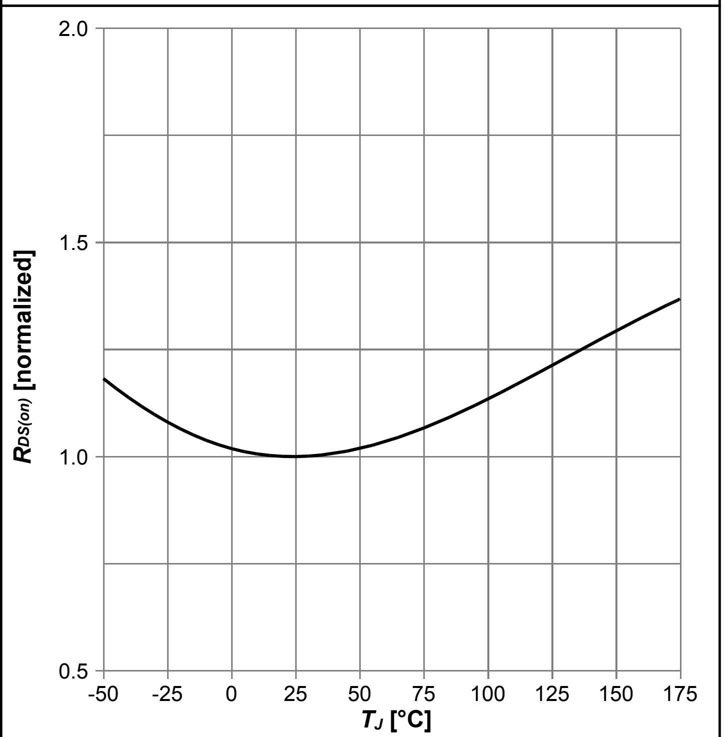
I_D=f(V_{DS}); T_j=150 °C; parameter: V_{GS}

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



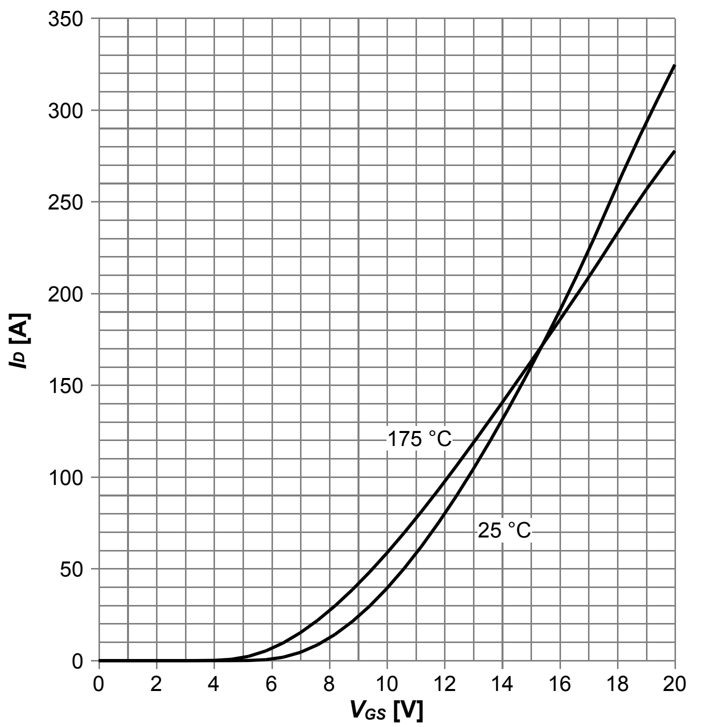
$R_{DS(on)}$=f(I_D); T_j=150 °C; parameter: V_{GS}

Diagram 8: Drain-source on-state resistance



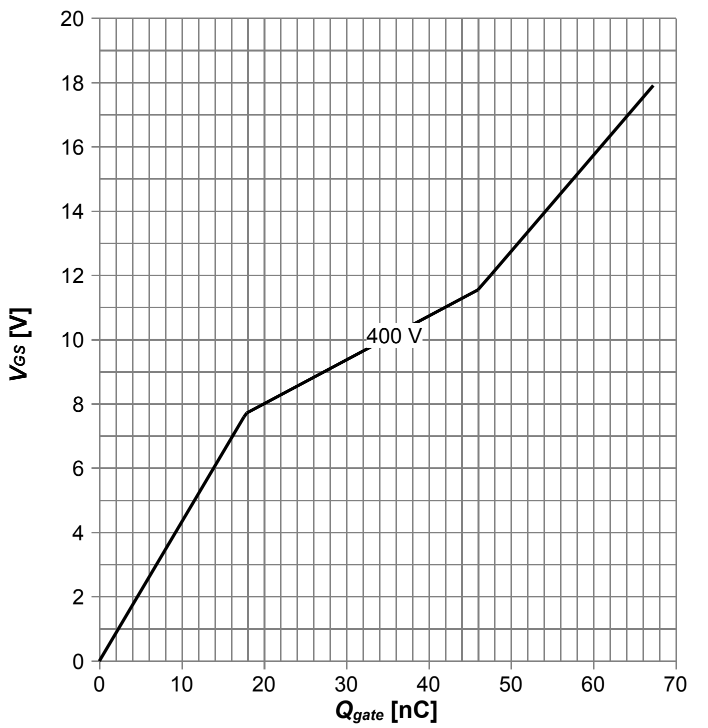
$R_{DS(on)}$=f(T_j); I_D=41.1 A; V_{GS}=18 V

Diagram 9: Typ. transfer characteristics



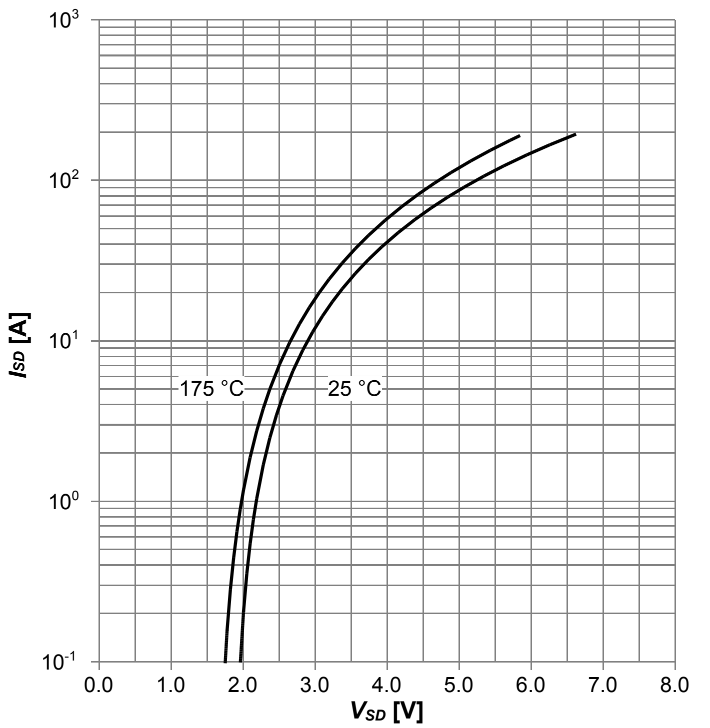
I_D=f(V_{GS}); V_{DS}=20V; parameter: T_j

Diagram 10: Typ. gate charge



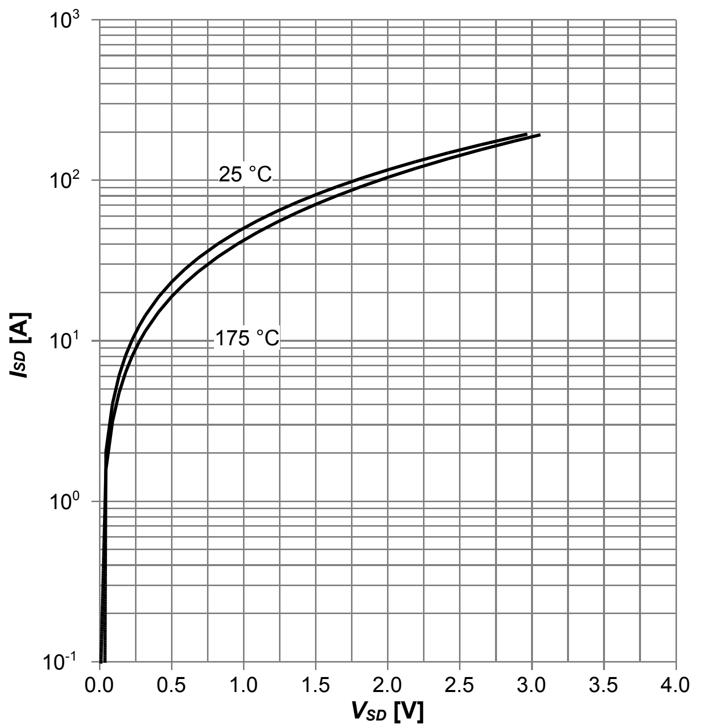
V_{GS}=f(Q_{gate}); I_D=41.1 A pulsed; parameter: V_{DD}

Diagram 11: Typ. reverse characteristics



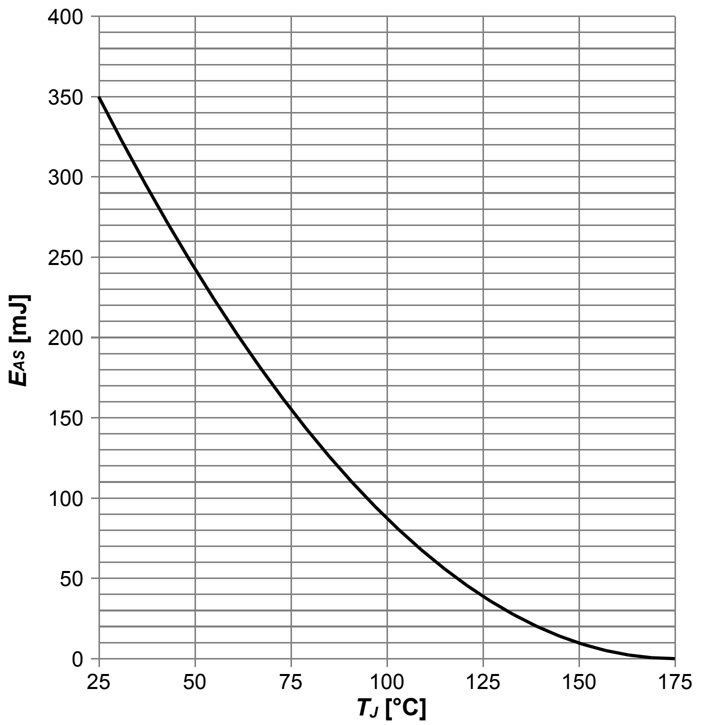
I_{SD}=f(V_{SD}); V_{GS}=0 V; parameter: T_j

Diagram 12: Typ. reverse characteristics



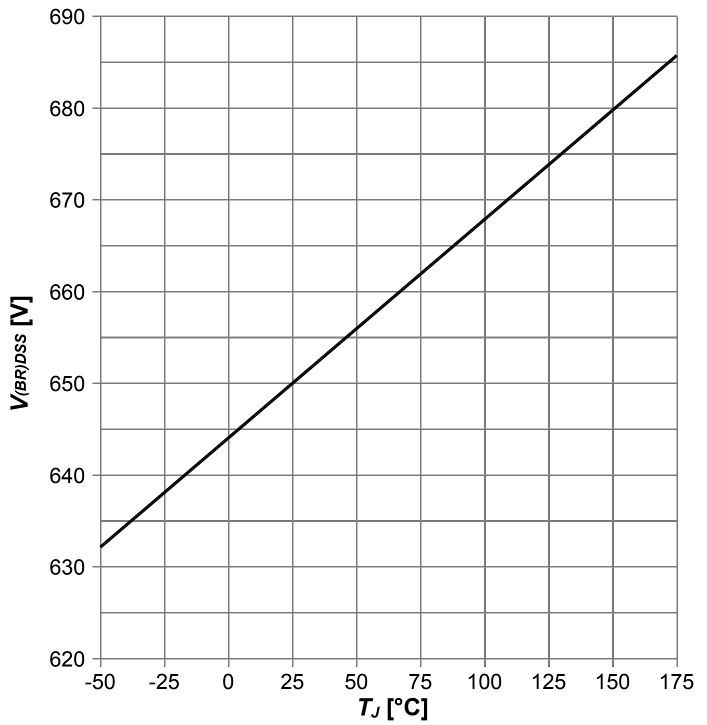
I_{SD}=f(V_{SD}); V_{GS}=18 V; parameter: T_j

Diagram 13: Avalanche energy



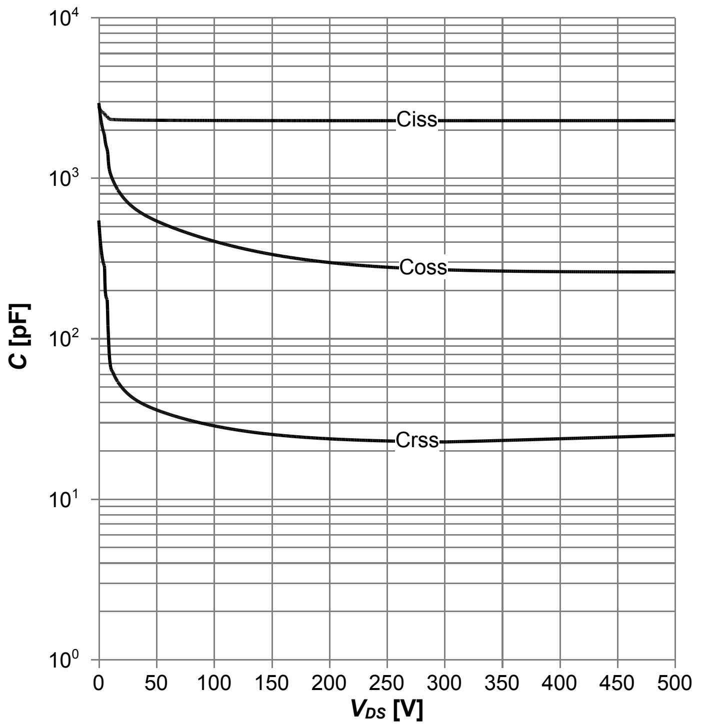
E_{AS}=f(T_j); I_D=13.1 A; V_{DD}=50 V

Diagram 14: Drain-source breakdown voltage



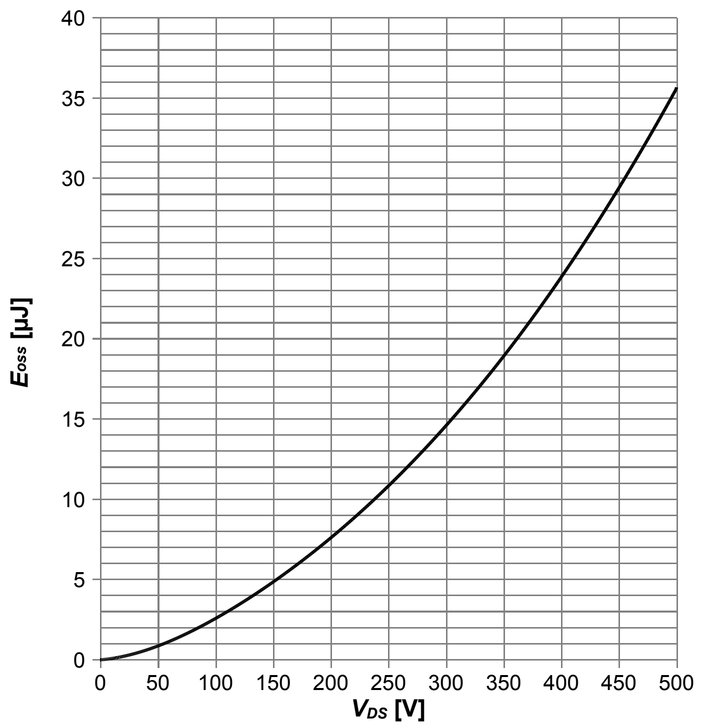
$V_{(BR)DSS}$=f(T_j); I_D=1.23 mA

Diagram 15: Typ. capacitances



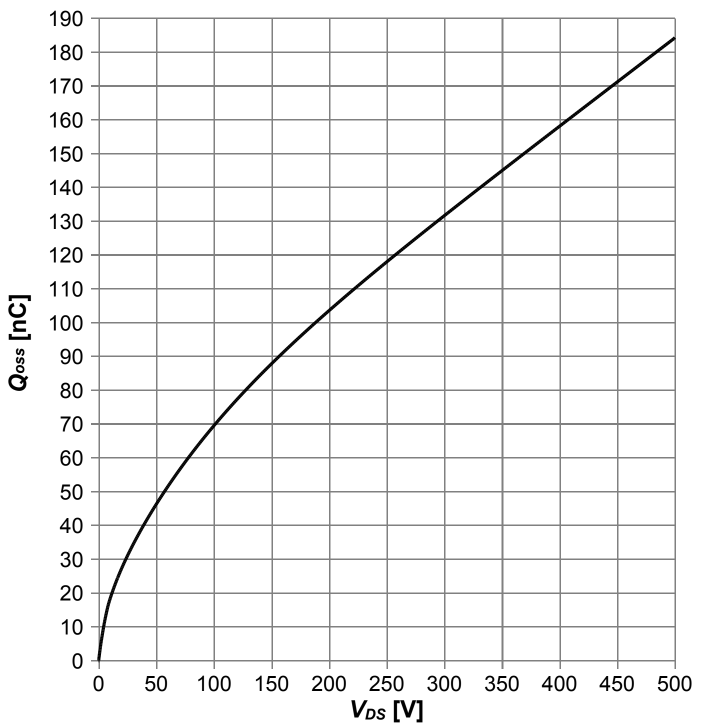
C=f(V_{DS}); V_{GS}=0 V; f=250 kHz

Diagram 16: Typ. Coss stored energy



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

Diagram 17: Typ. Qoss output charge



Q_{oss}=f(V_{DS})

6 Test Circuits

Table 9 Body diode characteristics (650V CoolSiC)

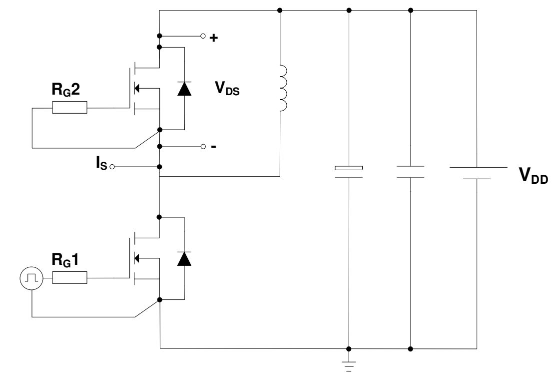
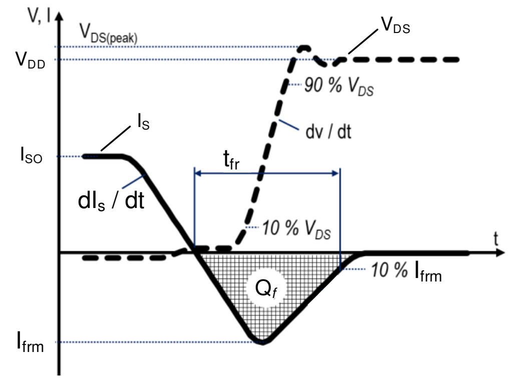
Test circuit for body diode characteristics	Body diode recovery waveform
	

Table 10 Switching times (650V CoolSiC)

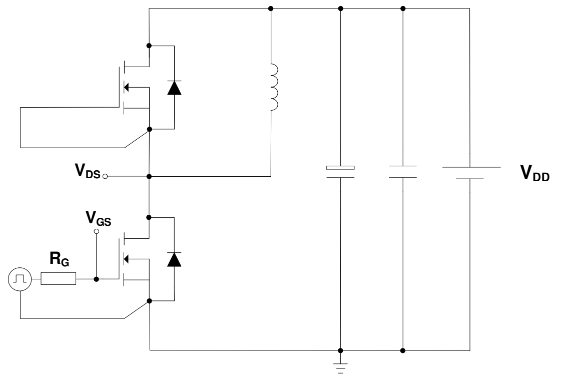
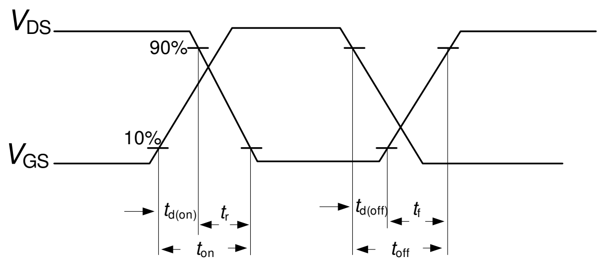
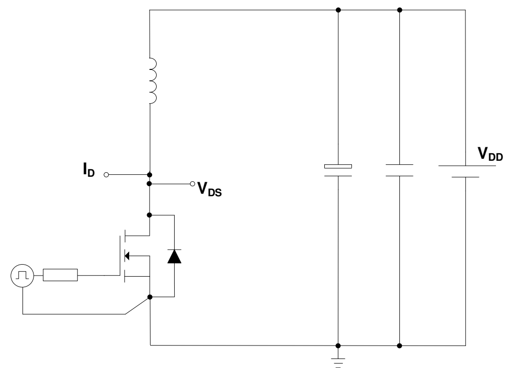
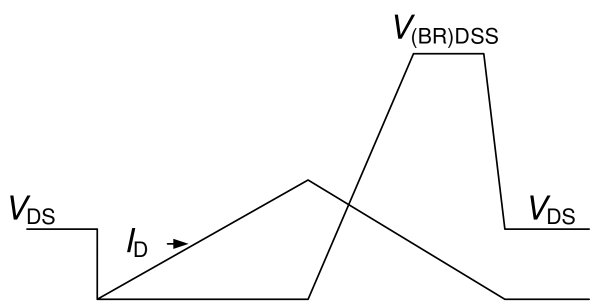
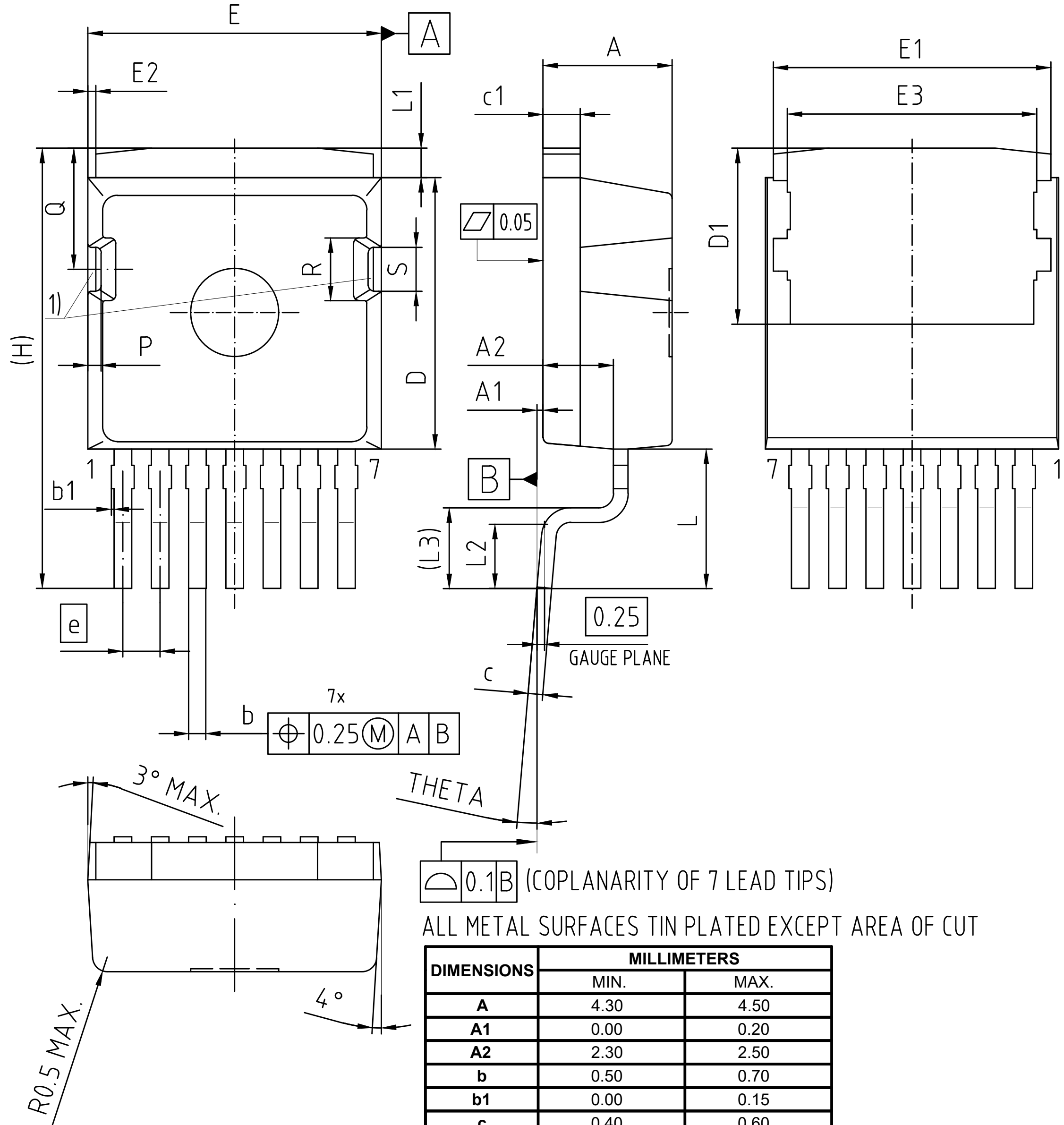
Switching times test circuit for inductive load	Switching times waveform
	

Table 11 Unclamped inductive load (650V CoolSiC)

Unclamped inductive load test circuit	Unclamped inductive waveform
	

7 Package Outlines



ALL METAL SURFACES TIN PLATED EXCEPT AREA OF CUT

DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	4.30	4.50
A1	0.00	0.20
A2	2.30	2.50
b	0.50	0.70
b1	0.00	0.15
c	0.40	0.60
c1	1.17	1.37
D	9.05	9.45
D1	5.90	6.10
E	9.80	10.20
E1	9.36	9.56
E2	0.00	0.30
E3	8.40	8.60
e	1.27	
H	15.00	
L	4.20	5.20
L1	0.70	1.30
L2	1.70	2.30
L3	2.70	
P	0.35	0.55
Q	4.02	4.22
R	2.03	2.23
S	1.40	1.60
THETA	0.00°	8.00°

DOCUMENT NO.
Z8B00189674

REVISION
01

SCALE 5:1
0 1 2 3 4 5mm

EUROPEAN PROJECTION

ISSUE DATE
14.02.2020

1) MOLD FILLING ACCEPTABLE
AT THIS AREA

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

IMBG65R022M1H

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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