

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
- $T_{j,max}=175^{\circ}C$ 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

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

Type / Ordering Code	Package	Marking	Related Links
IMT65R039M1H	PG-HSOF-8	65R039M1	see Appendix A

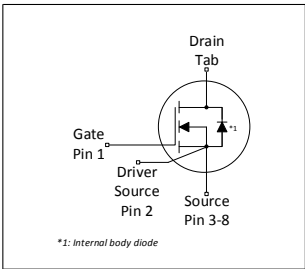
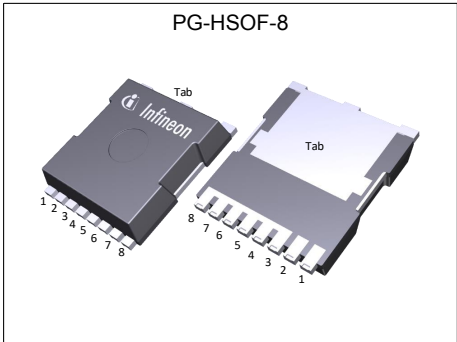


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1 Maximum ratings

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	-	-	61 43	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	$V_{DS} = 0\ldots 400\text{ V}$
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}	-	-	263	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}	-	-	61 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}	-	-	0.57	°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 MSL2

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 notice:** If the gate source voltage of the device in application exceeds the operating range (Table 4), the device $R_{DS(on)}$ and $V_{GS(th)}$ might exceed the maximum value stated in the datasheet at the end of the lifetime of the device. In order to ensure sound operation of the device over the planned lifetime, the maximum ratings (Table 2) and the CoolSiC™ MOSFET 650V M1 trench power device application note AN_1907_PL52_1911_144109 must be considered.

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	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ Ω}$; see table 10
Rise time	t_r	-	10.9	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ Ω}$; see table 10
Turn-off delay time	$t_{d(off)}$	-	17.4	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ Ω}$; see table 10
Fall time	t_f	-	7	-	ns	$V_{DD} = 400\text{ V}$, $V_{GS} = 18\text{ V}$, $I_D = 25.0\text{ A}$, $R_G = 1.8\text{ Ω}$; 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

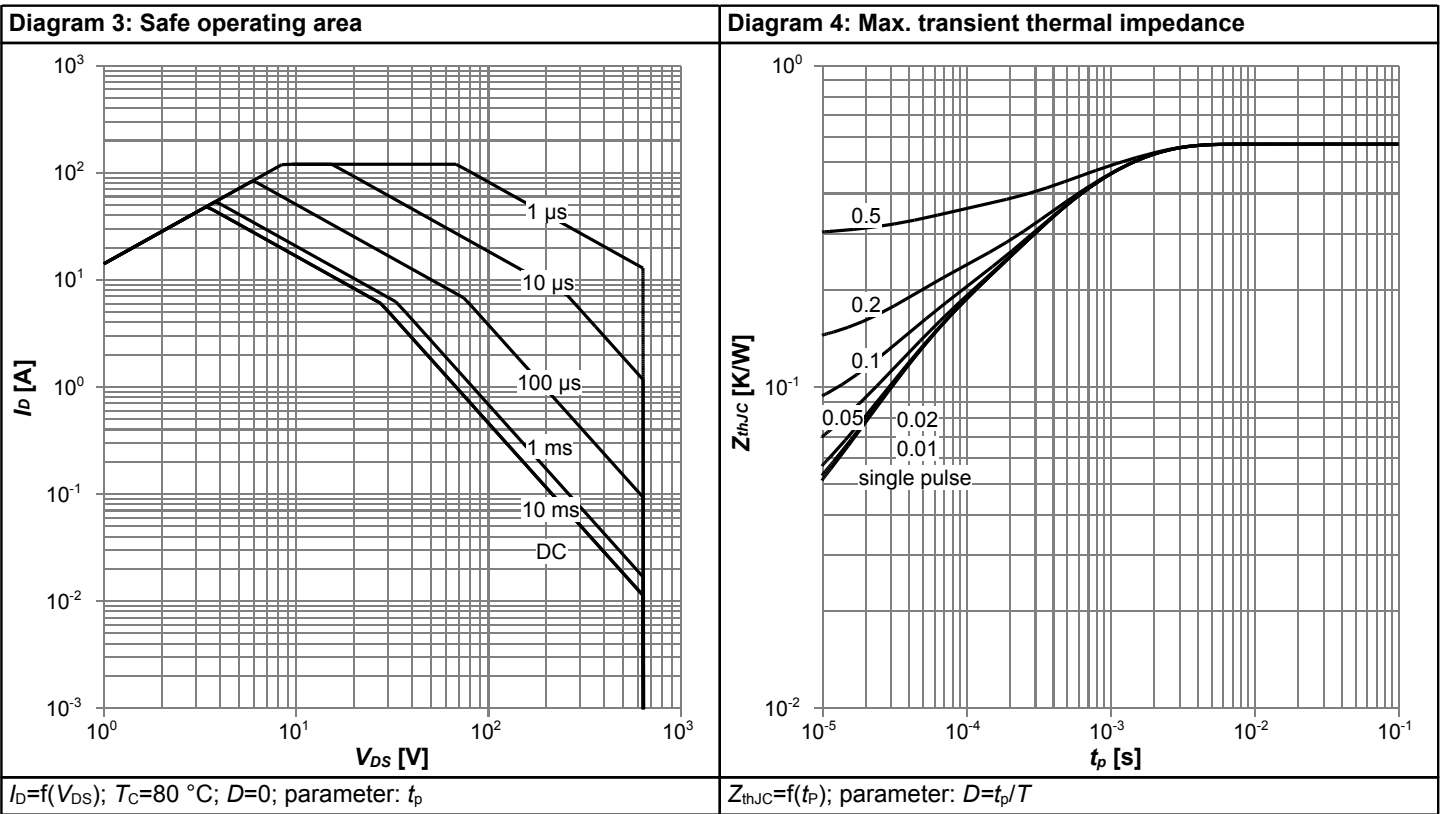
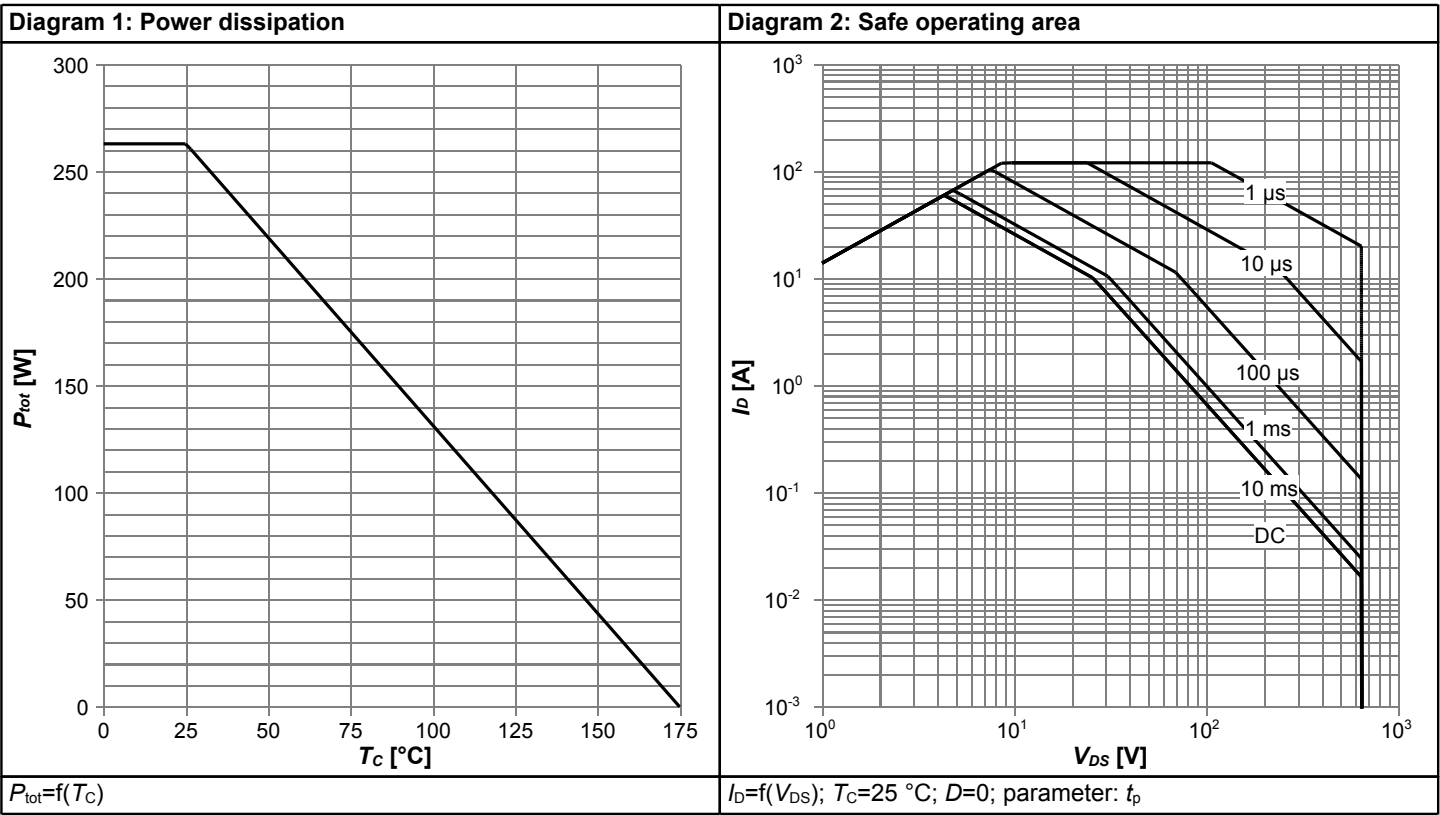
Table 7 Gate charge characteristics

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

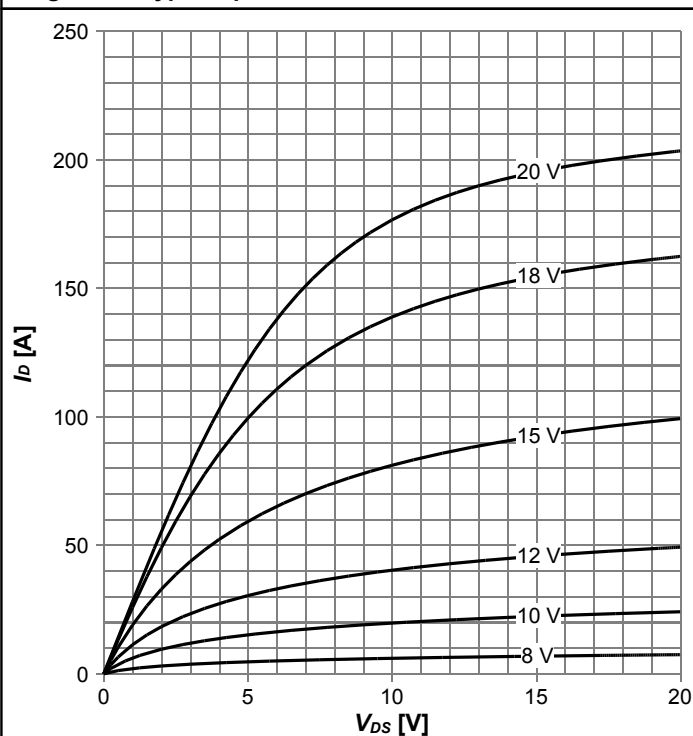
Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Drain-source reverse voltage	V_{SD}	-	4.0	-	V	$V_{GS} = 0\text{ V}$, $I_S = 25.0\text{ A}$, $T_J = 25\text{ °C}$
MOSFET forward recovery time	t_{fr}	-	21.2	-	ns	$V_{DD} = 400\text{ V}$, $I_{S0} = 25.0\text{ A}$, $di_S/dt = 1000\text{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



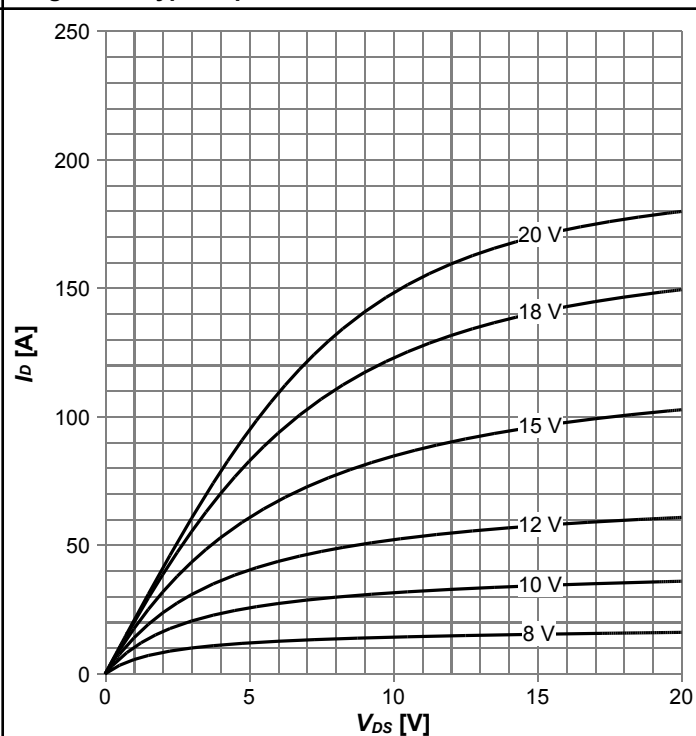
650 V CoolSiC™ M1 SiC Trench Power Device
IMT65R039M1H

Diagram 5: Typ. output characteristics



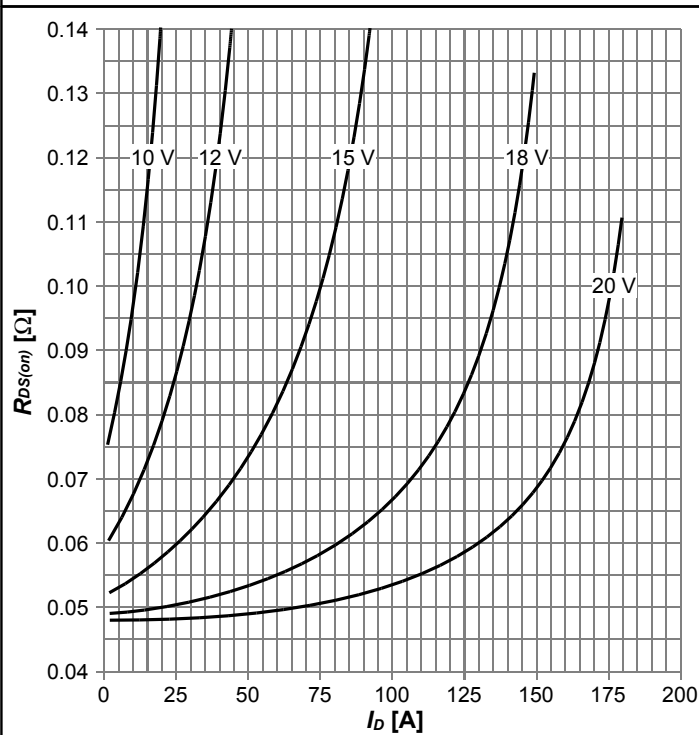
$I_D = f(V_{DS})$; $T_j = 25\text{ °C}$; parameter: V_{GS}

Diagram 6: Typ. output characteristics



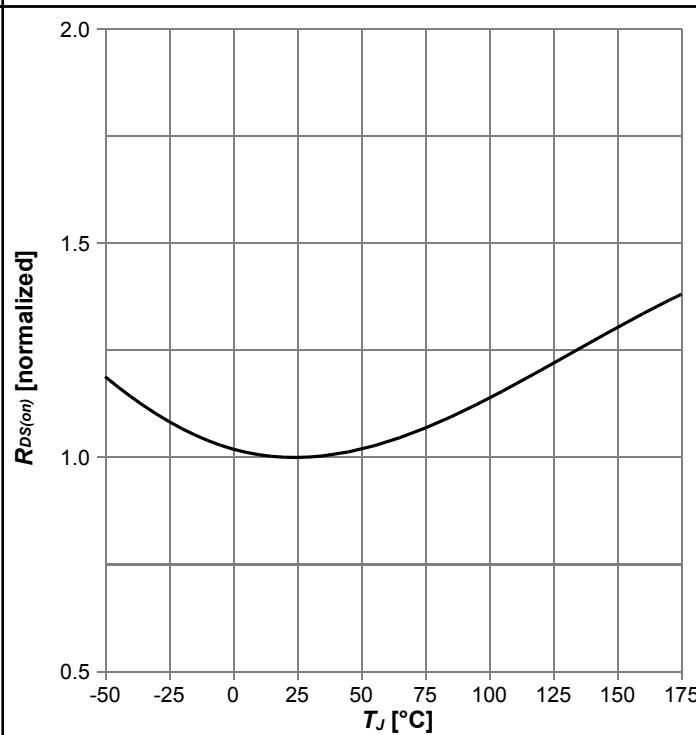
$I_D = f(V_{DS})$; $T_j = 150\text{ °C}$; parameter: V_{GS}

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

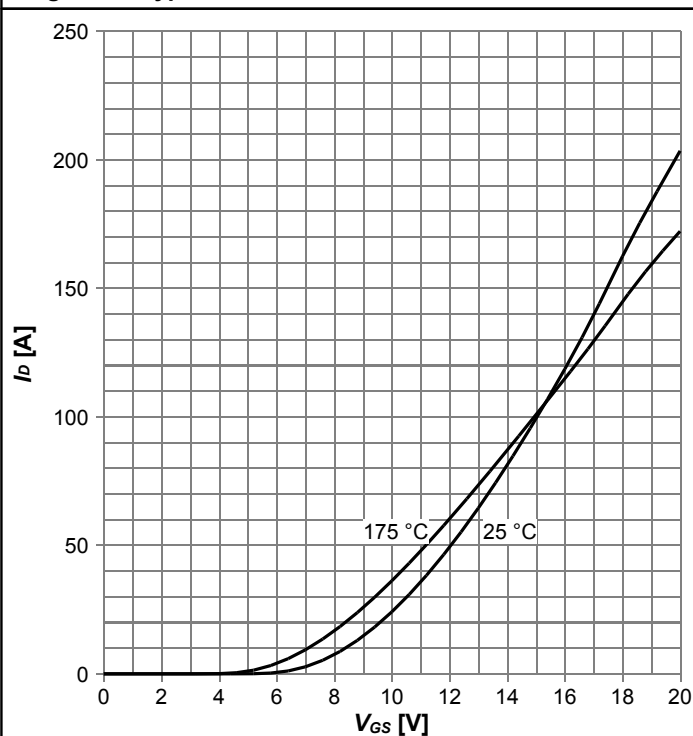


$R_{DS(on)} = f(T_j)$; $I_D = 25.0\text{ A}$; $V_{GS} = 18\text{ V}$

650 V CoolSiC™ M1 SiC Trench Power Device

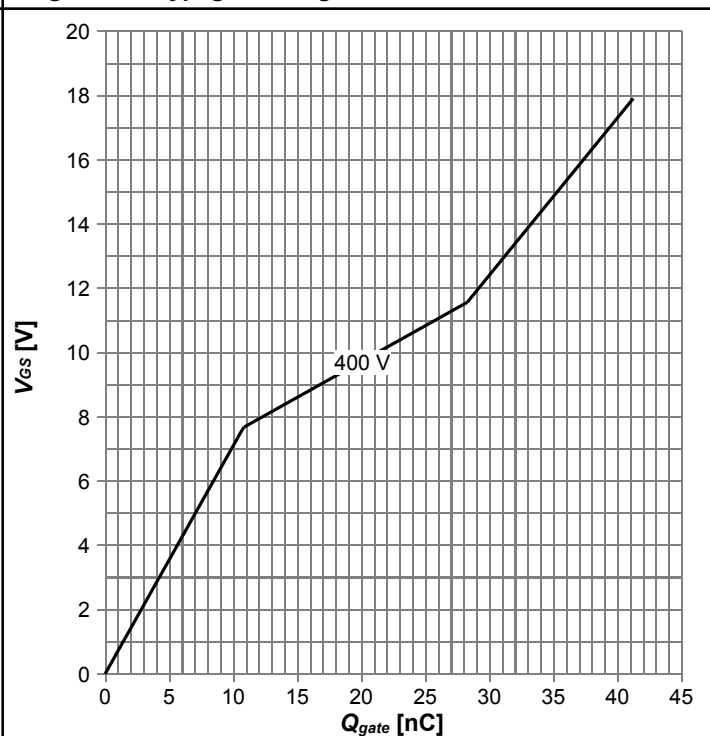
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Diagram 9: Typ. transfer characteristics



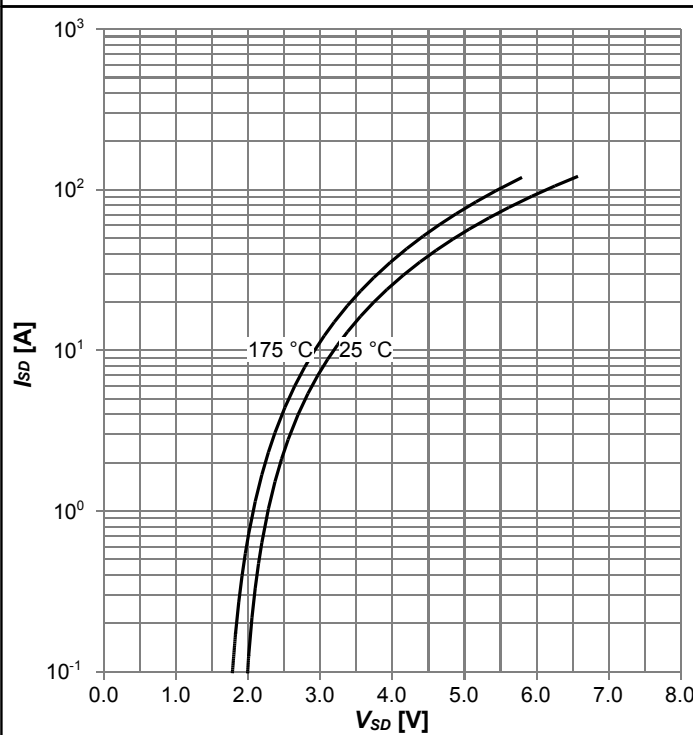
$I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 10: Typ. gate charge



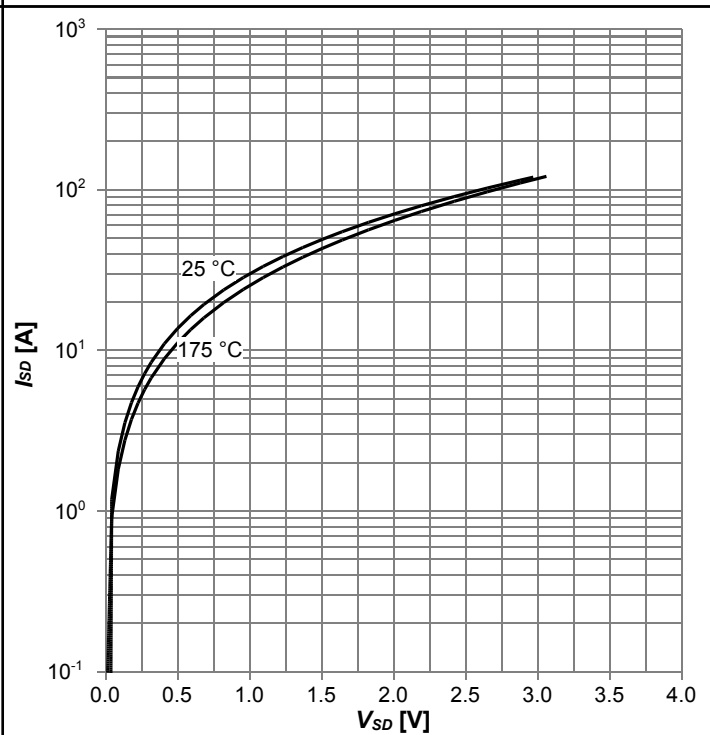
$V_{GS} = f(Q_{gate})$; $I_D = 25.0$ A pulsed; parameter: V_{DS}

Diagram 11: Typ. reverse characteristics



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

Diagram 12: Typ. reverse characteristics

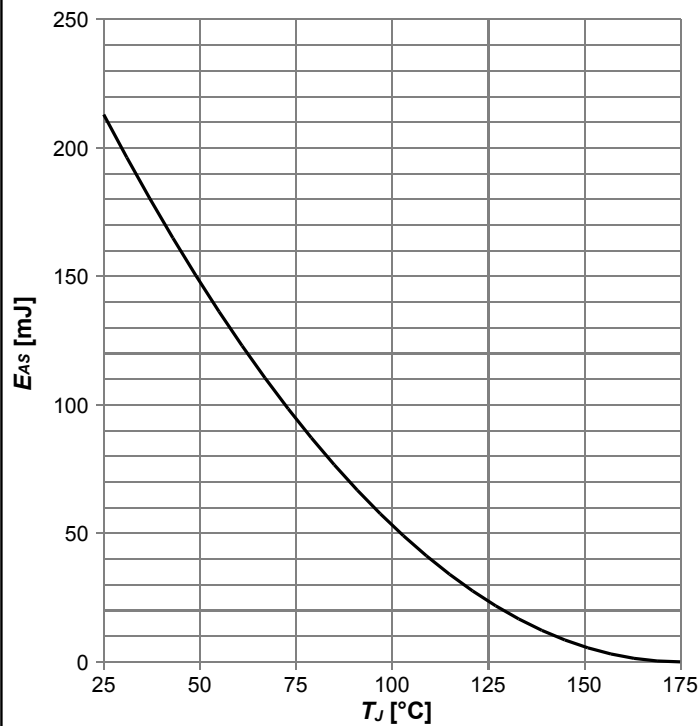


$I_{SD} = f(V_{SD})$; $V_{GS} = 18$ V; parameter: T_j

650 V CoolSiC™ M1 SiC Trench Power Device

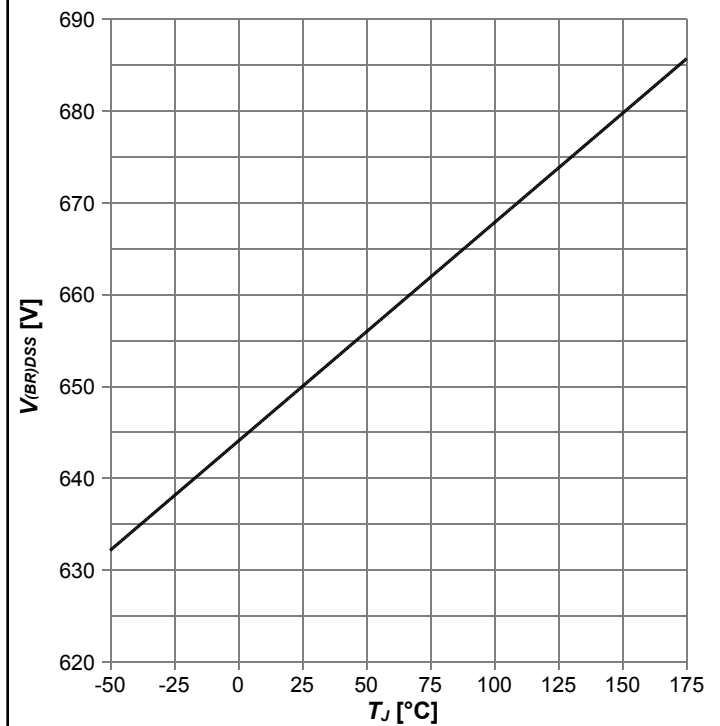
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Diagram 13: Avalanche energy



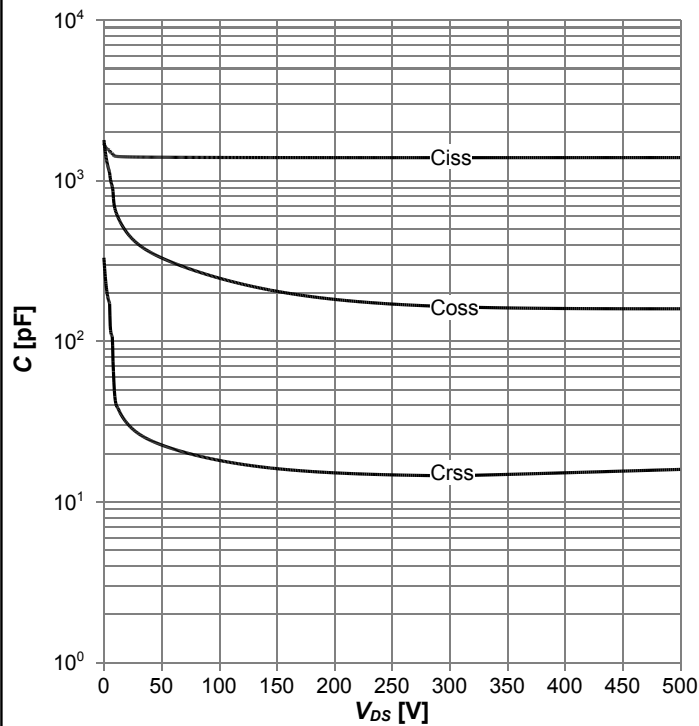
$E_{AS}=f(T_J)$; $I_D=8.0$ A; $V_{DD}=50$ V

Diagram 14: Drain-source breakdown voltage



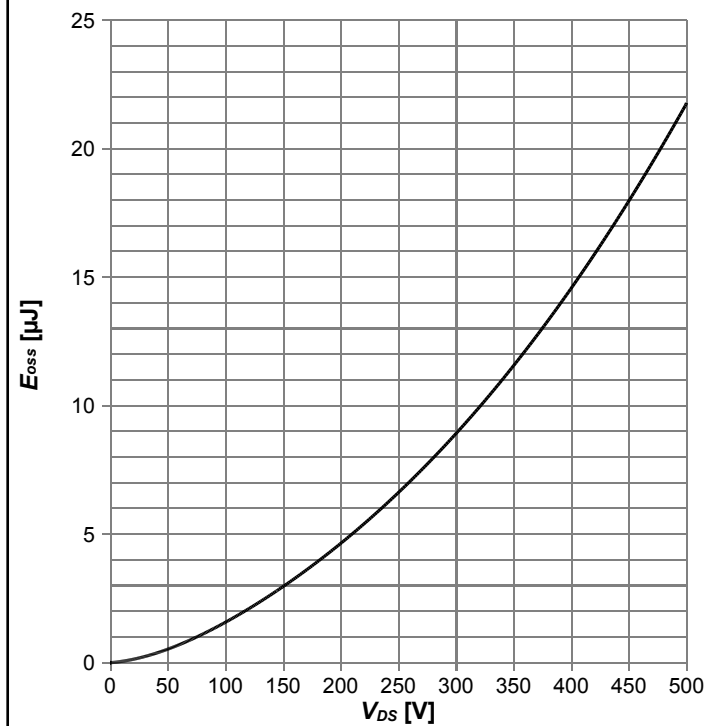
$V_{(BR)DSS}=f(T_J)$; $I_D=0.75$ mA

Diagram 15: Typ. capacitances



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

Diagram 16: Typ. Coss stored energy

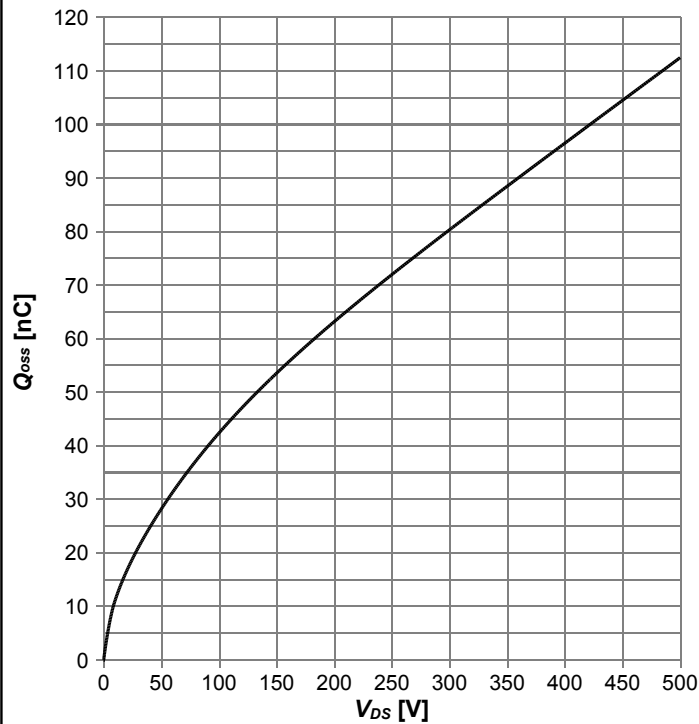


$E_{oss}=f(V_{DS})$

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Diagram 17: Typ. Qoss output charge



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

6 Test Circuits

Table 9 Body diode characteristics (CoolSiC)

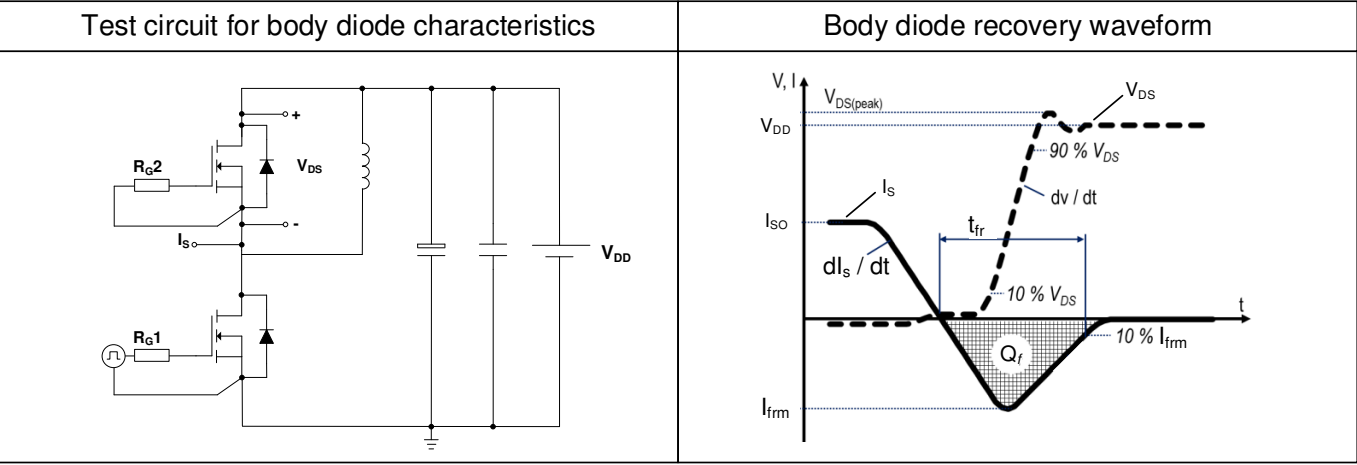


Table 10 Switching times (CoolSiC)

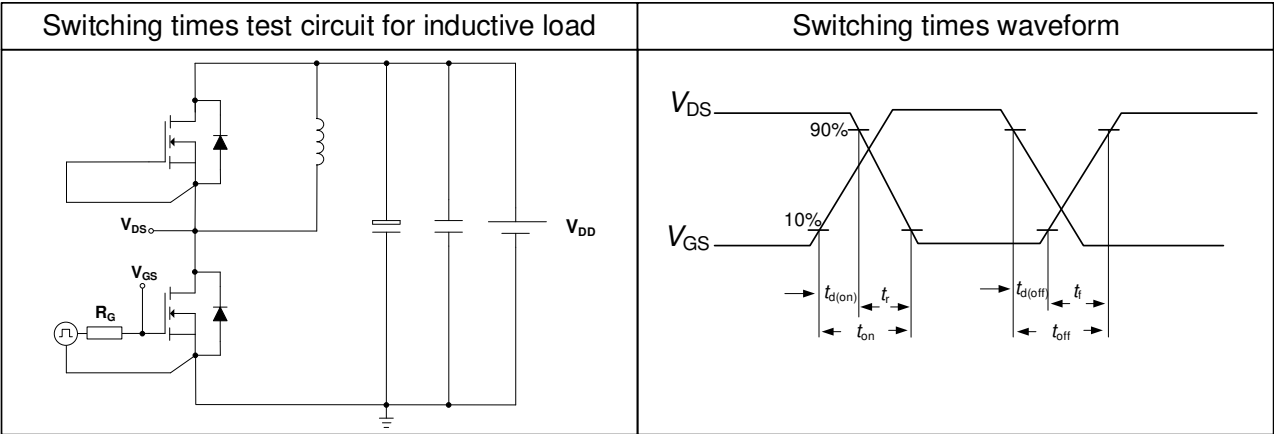
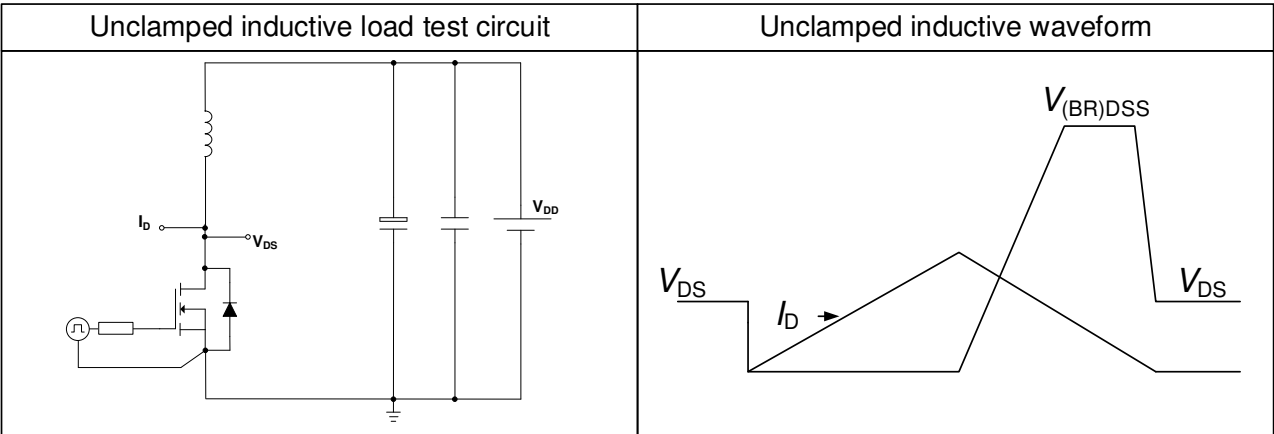
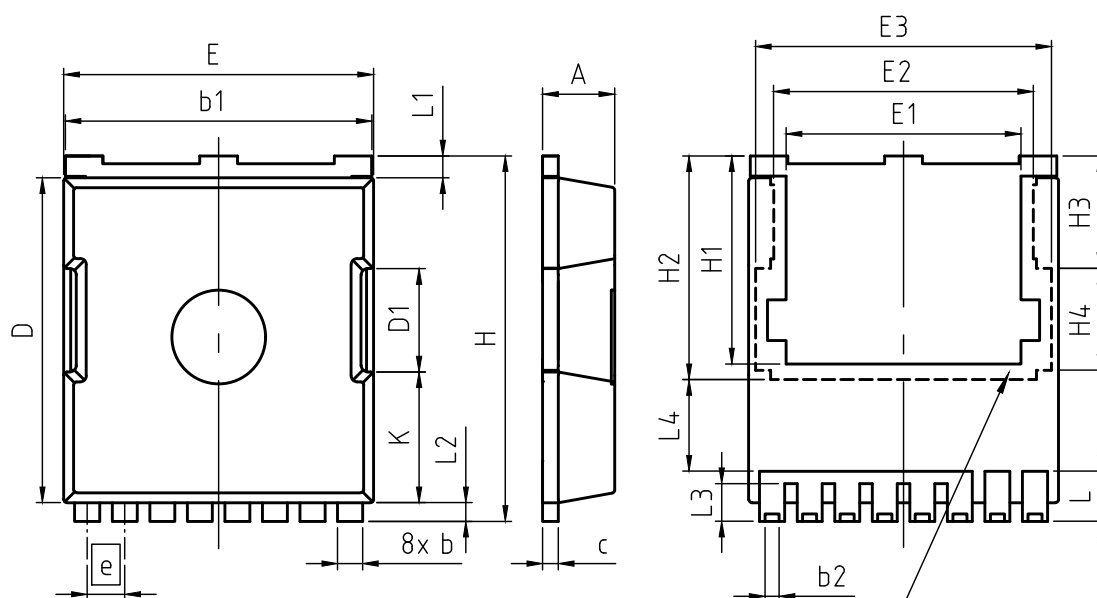


Table 11 Unclamped inductive load (CoolSiC)



7 Package Outlines



1) MOLD FLASH AREA

PACKAGE - GROUP NUMBER: PG-HSOF-8-U02		
DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	2.20	2.40
b	0.70	0.90
b1	9.70	9.90
b2	0.42	0.50
c	0.40	0.60
D	10.28	10.58
D1	3.30	
E	9.70	10.10
E1	7.50	
E2	8.50	
E3	9.46	
e	1.20 (BSC)	
H	11.48	11.88
H1	6.55	6.75
H2	7.15	
H3	3.59	
H4	3.26	
N	8	
K	4.18	
L	1.60	
L1	0.50	0.90
L2	0.50	0.70
L3	1.00	1.30
L4	2.62	2.81

1) PARTIALLY COVERED WITH MOLD FLASH

Figure 1 Outline PG-HSOF-8, dimensions in mm/inches

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

IMT65R039M1H

Revision: 2023-02-24, Rev. 2.1

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.0	2023-02-20	Release of final version
2.1	2023-02-24	Typo correction in footnote 1 page 4

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