

Final datasheet

XHP™2 module with CoolSiC™ Trench MOSFET

Features

- Electrical features
 - $V_{DS} = 3300\text{ V}$
 - $I_{DN} = 1000\text{ A}$ / $I_{DRM} = 2000\text{ A}$
 - $T_{vj,op} = 175^{\circ}\text{C}$
 - Low switching losses
 - High current density
 - Low inductive design
- Mechanical features
 - High power density
 - Package with CTI > 600
 - High creepage and clearance distances
 - AlSiC base plate for increased thermal cycling capability
 - AlN substrate with low thermal resistance



Potential applications

- Traction drives
- High-power converters
- High-frequency switching application

Product validation

- Qualified for industrial applications according to the relevant tests of IEC 60747, 60749 and 60068

Description

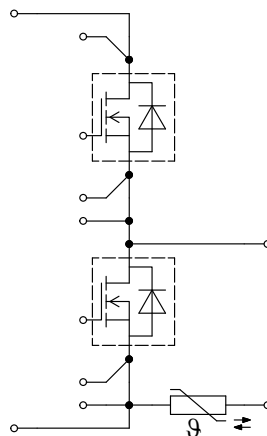


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 50 \text{ Hz}$, $t = 1 \text{ min}$	6.0	kV
Partial discharge extinction voltage	V_{isol}	RMS, $f = 50 \text{ Hz}$, $Q_{PD} \leq 10 \text{ pC}$	2.6	kV
DC stability	$V_{CE(D)}$	$T_{vj} = 25 \text{ °C}$, 100 Fit	2100	V
Material of module baseplate			AlSiC	
Creepage distance	$d_{Creep \text{ nom}}$	terminal to baseplate, nom.	40.0	mm
Creepage distance	$d_{Creep \text{ nom}}$	terminal to terminal, nom.	34.0	mm
Clearance	$d_{Clear \text{ nom}}$	terminal to baseplate, nom.	31.0	mm
Clearance	$d_{Clear \text{ nom}}$	terminal to terminal, nom.	8.0	mm
Comparative tracking index	CTI		> 600	

Table 2 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Stray inductance module	L_{sCE}				10		nH
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	T _C = 25 °C, per switch			0.43		mΩ
Storage temperature	T_{stg}			-40		150	°C
Maximum baseplate operation temperature	T_{BPmax}					150	°C
Mounting torque for module mounting	M	- Mounting according to valid application note	M6, Screw	4.25		5.75	Nm
Terminal connection torque	M	- Mounting according to valid application note	M3, Screw	0.9		1.1	Nm
			M8, Screw	8		10	
Weight	G				720		g

2 MOSFET

Table 3 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Drain-source voltage	V_{DSS}	$T_{vj} = 25 \text{ °C}$	3300	V
Implemented drain current	I_{DN}		1000	A
Continuous DC drain current	I_{DDC}	$T_{vj} = 175 \text{ °C}$, $V_{GS} = 15 \text{ V}$ $T_C = 25 \text{ °C}$	925	A

(table continues...)

Table 3 (continued) Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Repetitive peak drain current	I_{DRM}	verified by design, t_p limited by $T_{vj\text{max}}$	2000	A
Gate-source voltage, max. transient voltage	V_{GS}	$D < 0.01$	-10/23	V
Gate-source voltage, max. static voltage	V_{GS}		-7/20	V

Table 4 Recommended values

Parameter	Symbol	Note or test condition	Values	Unit
On-state gate voltage	$V_{\text{GS(on)}}$		15...18	V
Off-state gate voltage	$V_{\text{GS(off)}}$		-5	V

Table 5 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-resistance	$R_{\text{DS(on)}}$	$I_{\text{D}} = 1000 \text{ A}$	$V_{\text{GS}} = 15 \text{ V}, T_{vj} = 25 \text{ °C}$		1.9	2.4	mΩ
			$V_{\text{GS}} = 15 \text{ V}, T_{vj} = 125 \text{ °C}$		3.7	4.6	
			$V_{\text{GS}} = 15 \text{ V}, T_{vj} = 175 \text{ °C}$		5.3	6.6	
Gate threshold voltage	$V_{\text{GS(th)}}$	$I_{\text{D}} = 900 \text{ mA}, V_{\text{DS}} = V_{\text{GS}}, T_{vj} = 25 \text{ °C},$ (tested after 1ms pulse at $V_{\text{GS}} = +20 \text{ V}$)		3.45	4.3	5.55	V
Total gate charge	Q_{G}	$V_{\text{DD}} = 1800 \text{ V}, V_{\text{GS}} = -5/15 \text{ V}$			5		μC
Internal gate resistor	R_{Gint}	$T_{vj} = 25 \text{ °C}$			0.75		Ω
Input capacitance	C_{ISS}	$f = 100 \text{ kHz}, V_{\text{DS}} = 1800 \text{ V}, V_{\text{GS}} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$		203		nF
Output capacitance	C_{OSS}	$f = 100 \text{ kHz}, V_{\text{DS}} = 1800 \text{ V}, V_{\text{GS}} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$		2.8		nF
Reverse transfer capacitance	C_{RSS}	$f = 100 \text{ kHz}, V_{\text{DS}} = 1800 \text{ V}, V_{\text{GS}} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$		0.115		nF
C_{OSS} stored energy	E_{OSS}	$V_{\text{DS}} = 1800 \text{ V}, V_{\text{GS}} = -5/15 \text{ V}, T_{vj} = 25 \text{ °C}$			5.8		mJ
Drain-source leakage current	I_{DSS}	$V_{\text{DS}} = 3300 \text{ V}, V_{\text{GS}} = -5 \text{ V}$	$T_{vj} = 25 \text{ °C}$			2000	μA
Gate-source leakage current	I_{GSS}	$V_{\text{DS}} = 0 \text{ V}, T_{vj} = 25 \text{ °C}$	$V_{\text{GS}} = 20 \text{ V}$			10000	nA

(table continues...)

Table 5 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-on delay time (inductive load)	$t_{d\ on}$	$I_D = 1000\ A$, $R_{Gon} = 0.75\ \Omega$, $V_{DD} = 1800\ V$, $V_{GS} = -5/15\ V$	$T_{vj} = 25\ ^\circ C$	480		ns
			$T_{vj} = 125\ ^\circ C$	420		
			$T_{vj} = 175\ ^\circ C$	420		
Rise time (inductive load)	t_r	$I_D = 1000\ A$, $R_{Gon} = 0.75\ \Omega$, $V_{DD} = 1800\ V$, $V_{GS} = -5/15\ V$	$T_{vj} = 25\ ^\circ C$	170		ns
			$T_{vj} = 125\ ^\circ C$	210		
			$T_{vj} = 175\ ^\circ C$	210		
Turn-off delay time (inductive load)	$t_{d\ off}$	$I_D = 1000\ A$, $R_{Goff} = 1.2\ \Omega$, $V_{DD} = 1800\ V$, $V_{GS} = -5/15\ V$	$T_{vj} = 25\ ^\circ C$	330		ns
			$T_{vj} = 125\ ^\circ C$	370		
			$T_{vj} = 175\ ^\circ C$	380		
Fall time (inductive load)	t_f	$I_D = 1000\ A$, $R_{Goff} = 1.2\ \Omega$, $V_{DD} = 1800\ V$, $V_{GS} = -5/15\ V$	$T_{vj} = 25\ ^\circ C$	82		ns
			$T_{vj} = 125\ ^\circ C$	82		
			$T_{vj} = 175\ ^\circ C$	82		
Turn-on time (resistive load)	t_{on_R}	$I_D = 500\ A$, $V_{DD} = 2000\ V$, $V_{GS} = -5/15\ V$, $R_{Gon} = 0.75\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.50		μs
Turn-on energy loss per pulse	E_{on}	$I_D = 1000\ A$, $V_{DD} = 1800\ V$, $L_\sigma = 30\ nH$, $V_{GS} = -5/15\ V$, $R_{Gon} = 0.75\ \Omega$, $di/dt = 7.8\ kA/\mu s$ ($T_{vj} = 175\ ^\circ C$)	$T_{vj} = 25\ ^\circ C$	280		mJ
			$T_{vj} = 125\ ^\circ C$	350		
			$T_{vj} = 175\ ^\circ C$	420		
Turn-off energy loss per pulse	E_{off}	$I_D = 1000\ A$, $V_{DD} = 1800\ V$, $L_\sigma = 30\ nH$, $V_{GS} = -5/15\ V$, $R_{Goff} = 1.2\ \Omega$, $dv/dt = 18.2\ kV/\mu s$ ($T_{vj} = 175\ ^\circ C$)	$T_{vj} = 25\ ^\circ C$	160		mJ
			$T_{vj} = 125\ ^\circ C$	160		
			$T_{vj} = 175\ ^\circ C$	160		
SC data	I_{SC}	$V_{GS} = -5/15\ V$, $V_{DD} = 2400\ V$, $V_{DSmax} = V_{DSS} - L_{sDS} \cdot di/dt$, $R_G = 0.75\ \Omega$	$t_P = 3\ \mu s$, $T_{vj} = 175\ ^\circ C$	9100		A
Thermal resistance, junction to case	R_{thJC}	per MOSFET			26.3	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per MOSFET, $\lambda_{grease} = 1\ W/(m^*K)$		21.5		K/kW
Temperature under switching conditions	$T_{vj\ op}$		-40		175	$^\circ C$

3 Body diode (MOSFET)

Table 6 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
DC body diode forward current	I_{SD}	$T_{vj} = 175\text{ °C}$, $V_{GS} = -5\text{ V}$	$T_C = 55\text{ °C}$	1000	A
I^2t - value	I^2t	$V_{DS} = 0\text{ V}$, $V_{GS} = -5\text{ V}$, $t_P = 10\text{ ms}$	$T_{vj} = 175\text{ °C}$	500	kA ² s

Table 7 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_{SD}	$I_{SD} = 1000\text{ A}$, $V_{GS} = -5\text{ V}$	$T_{vj} = 25\text{ °C}$		4.6	5.8	V
			$T_{vj} = 125\text{ °C}$		3.9	4.9	
			$T_{vj} = 175\text{ °C}$		3.6	4.5	
Reverse recovery energy	E_{rec}	$I_{SD} = 1000\text{ A}$, $di_s/dt = 7.8\text{ kA}/\mu\text{s}$ ($T_{vj} = 175\text{ °C}$), $V_{DD} = 1800\text{ V}$, $V_{GS} = -5\text{ V}$	$T_{vj} = 25\text{ °C}$		40		mJ
			$T_{vj} = 125\text{ °C}$		62		
			$T_{vj} = 175\text{ °C}$		105		

4 NTC-Thermistor

Table 8 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Rated resistance	R_{25}	$T_{NTC} = 25\text{ °C}$		5		kΩ
Deviation of R_{100}	$\Delta R/R$	$T_{NTC} = 100\text{ °C}$, $R_{100} = 493\text{ Ω}$	-5		5	%
Power dissipation	P_{25}	$T_{NTC} = 25\text{ °C}$			20	mW
B-value	$B_{25/50}$	$R_2 = R_{25} \exp[B_{25/50}(1/T_2 - 1/(298,15\text{ K}))]$		3375		K
B-value	$B_{25/80}$	$R_2 = R_{25} \exp[B_{25/80}(1/T_2 - 1/(298,15\text{ K}))]$		3411		K
B-value	$B_{25/100}$	$R_2 = R_{25} \exp[B_{25/100}(1/T_2 - 1/(298,15\text{ K}))]$		3433		K

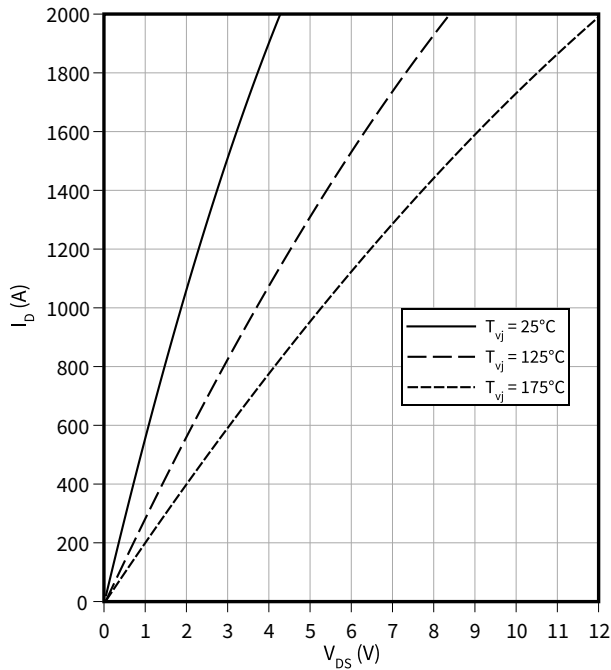
Note: Specification according to the valid application note.

5 Characteristics diagrams

Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

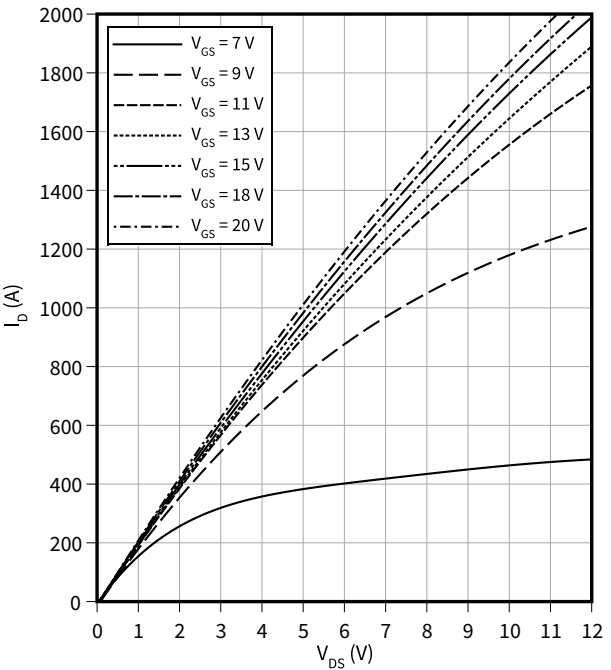
$V_{GS} = 15\text{ V}$



Output characteristic field (typical), MOSFET

$I_D = f(V_{DS})$

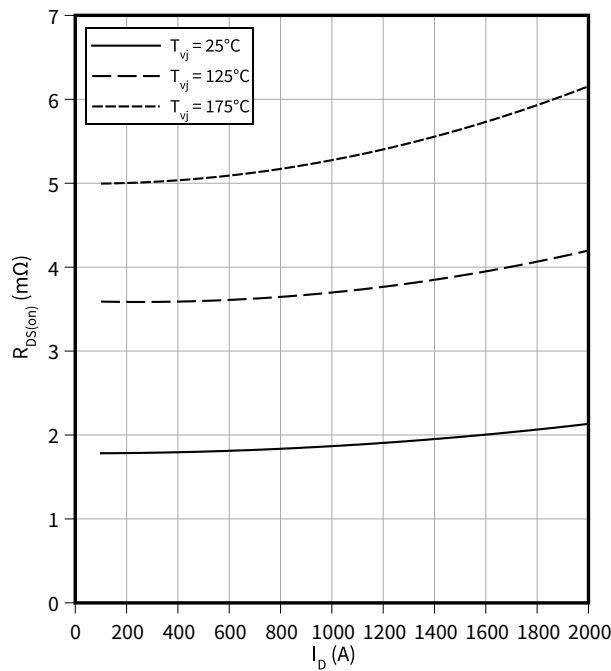
$T_{vj} = 175^\circ\text{C}$



Drain source on-resistance (typical), MOSFET

$R_{DS(on)} = f(I_D)$

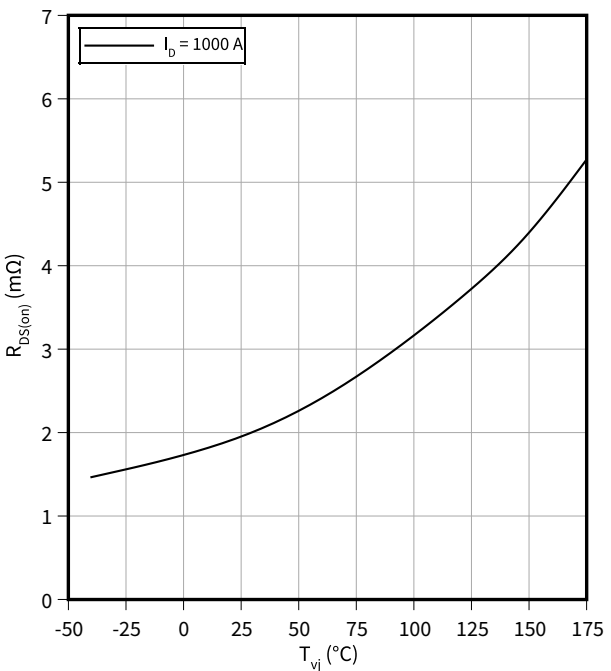
$V_{GS} = 15\text{ V}$



Drain source on-resistance (typical), MOSFET

$R_{DS(on)} = f(T_{vj})$

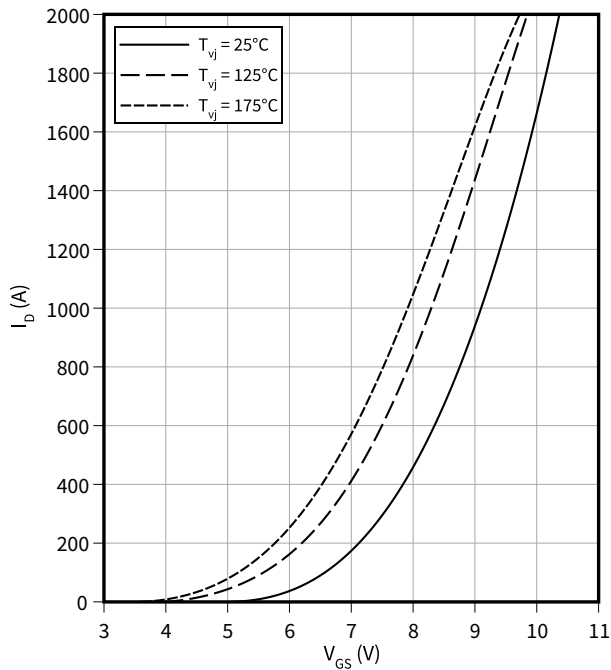
$V_{GS} = 15\text{ V}$



5 Characteristics diagrams

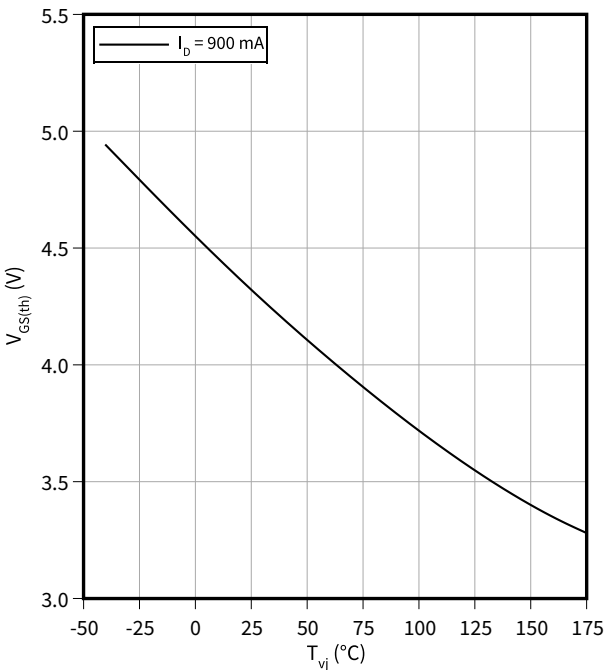
Transfer characteristic (typical), MOSFET

$I_D = f(V_{GS})$
 $V_{DS} = 20\text{ V}$



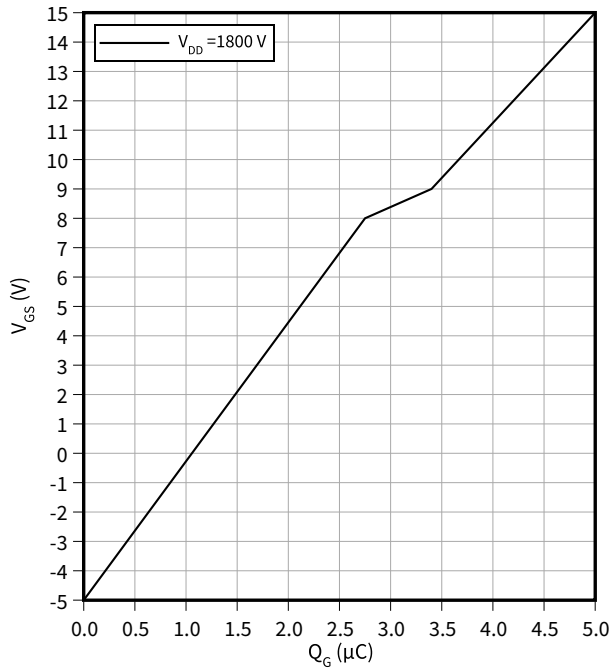
Gate-source threshold voltage (typical), MOSFET

$V_{GS(th)} = f(T_{vj})$
 $V_{GS} = V_{DS}$



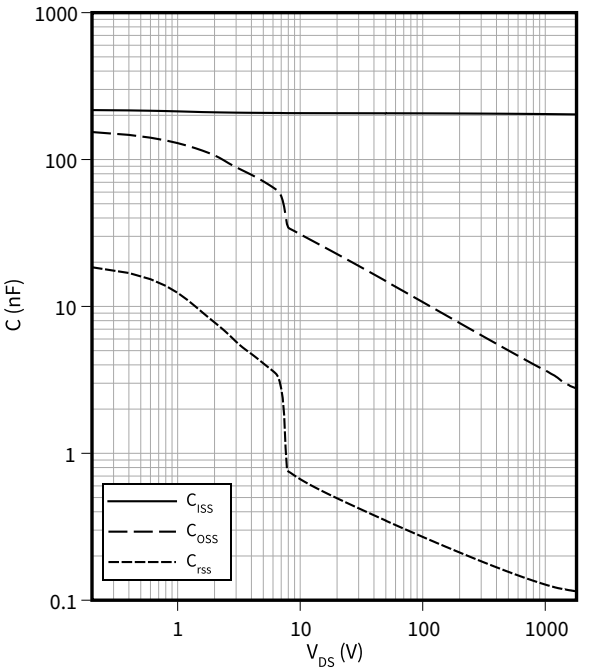
Gate charge characteristic (typical), MOSFET

$V_{GS} = f(Q_G)$
 $I_D = 1000\text{ A}$, $T_{vj} = 25^\circ\text{C}$



Capacity characteristic (typical), MOSFET

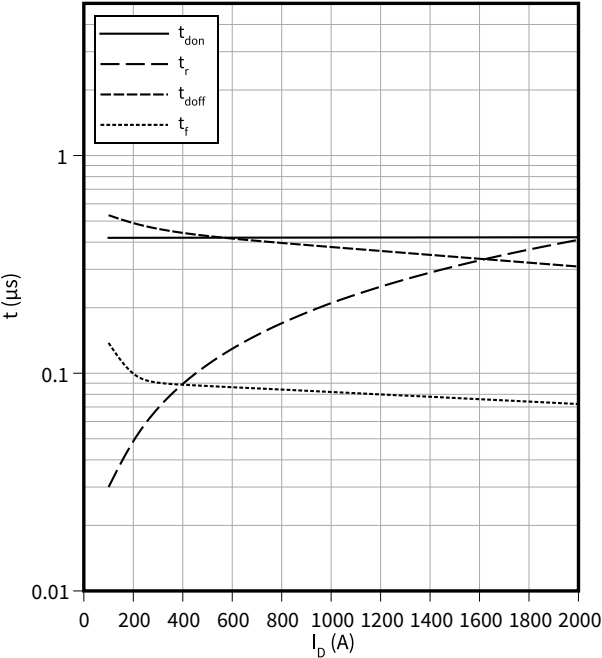
$C = f(V_{DS})$
 $f = 100\text{ kHz}$, $T_{vj} = 25^\circ\text{C}$, $V_{GS} = 0\text{ V}$



5 Characteristics diagrams

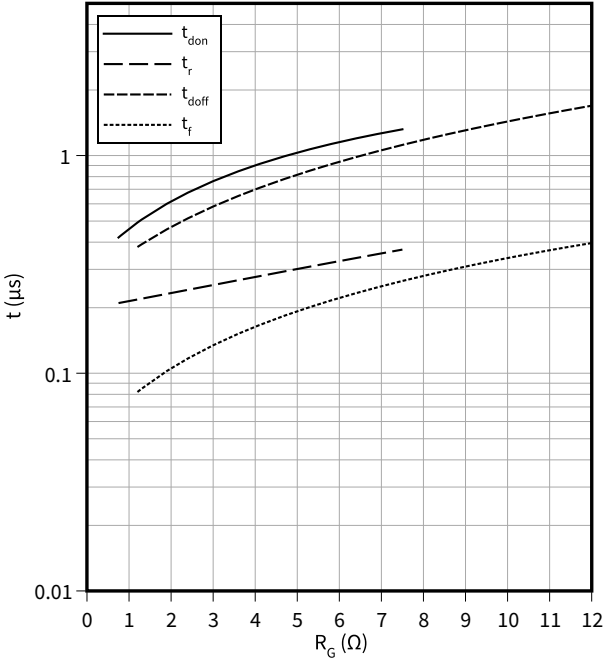
Switching times (typical), MOSFET

$t = f(I_D)$
 $R_{Goff} = 1.2 \, \Omega$, $R_{Gon} = 0.75 \, \Omega$, $V_{DD} = 1800 \, V$, $T_{vj} = 175 \, ^\circ C$, $V_{GS} = -5/15 \, V$



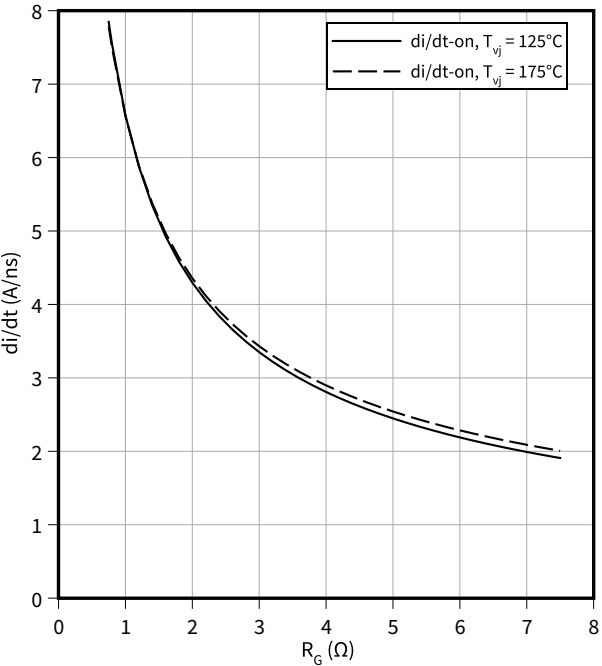
Switching times (typical), MOSFET

$t = f(R_G)$
 $V_{DD} = 1800 \, V$, $I_D = 1000 \, A$, $T_{vj} = 175 \, ^\circ C$, $V_{GS} = -5/15 \, V$



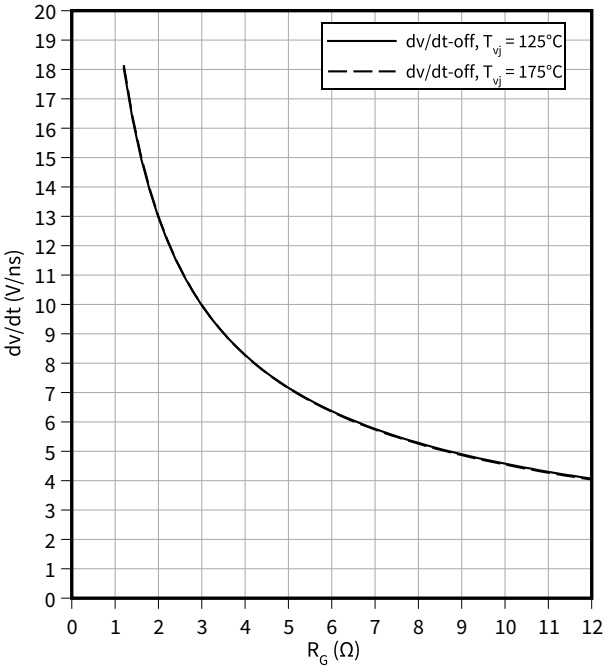
Current slope (typical), MOSFET

$di/dt = f(R_G)$
 $V_{DD} = 1800 \, V$, $I_D = 1000 \, A$, $V_{GS} = -5/15 \, V$



Voltage slope (typical), MOSFET

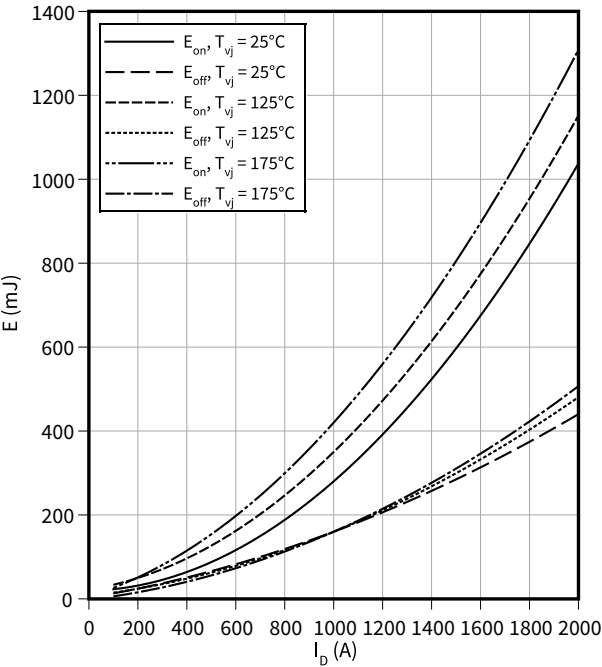
$dv/dt = f(R_G)$
 $V_{DD} = 1800 \, V$, $I_D = 1000 \, A$, $V_{GS} = -5/15 \, V$



5 Characteristics diagrams

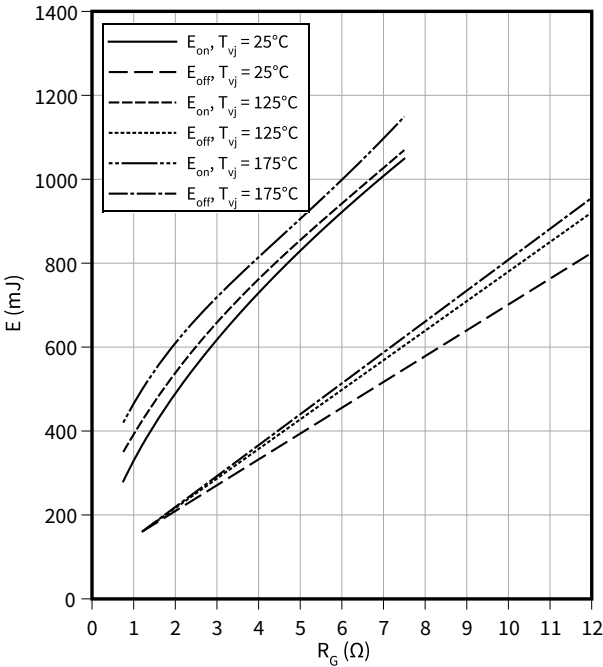
Switching losses (typical), MOSFET

$E = f(I_D)$
 $R_{Goff} = 1.2 \, \Omega$, $R_{Gon} = 0.75 \, \Omega$, $V_{DD} = 1800 \, V$, $V_{GS} = -5/15 \, V$



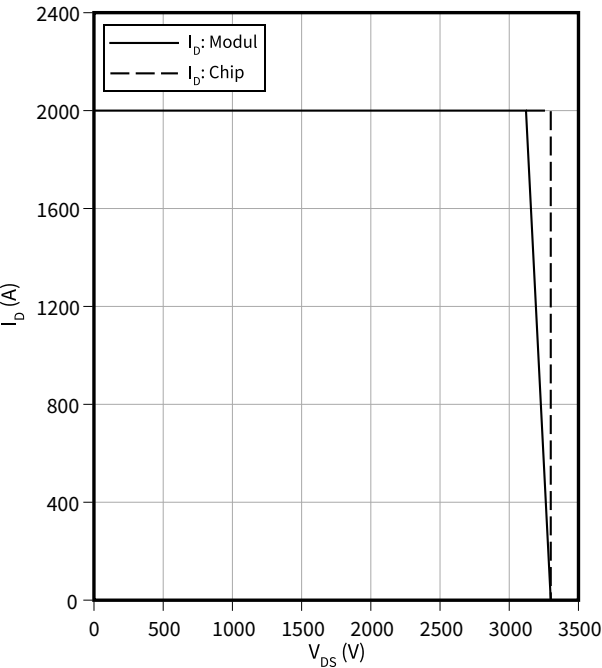
Switching losses (typical), MOSFET

$E = f(R_G)$
 $V_{DD} = 1800 \, V$, $I_D = 1000 \, A$, $V_{GS} = -5/15 \, V$



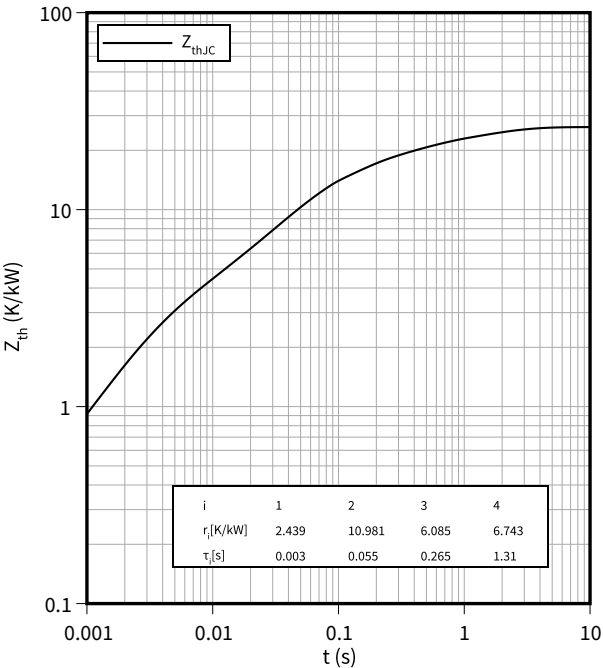
Reverse bias safe operating area (RBSOA), MOSFET

$I_D = f(V_{DS})$
 $R_{Goff} = 1.2 \, \Omega$, $T_{vj} = 175 \, ^\circ C$, $V_{GS} = -5/15 \, V$



Transient thermal impedance, MOSFET

$Z_{th} = f(t)$

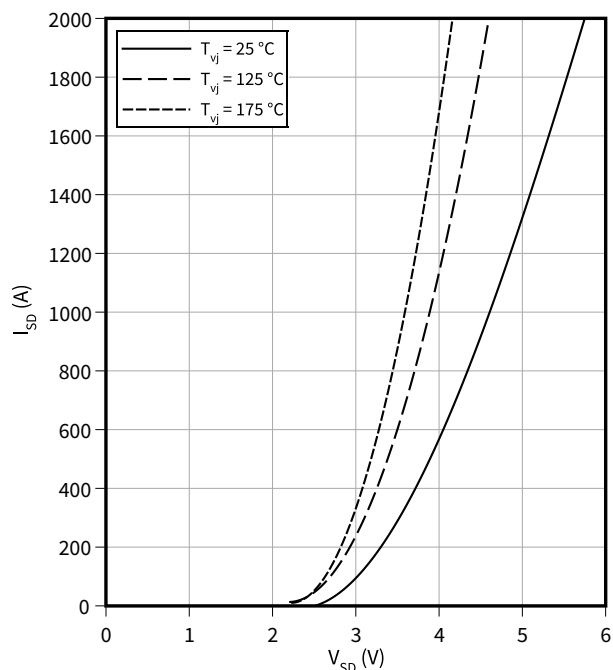


5 Characteristics diagrams

Forward characteristic body diode (typical), MOSFET

$$I_{SD} = f(V_{SD})$$

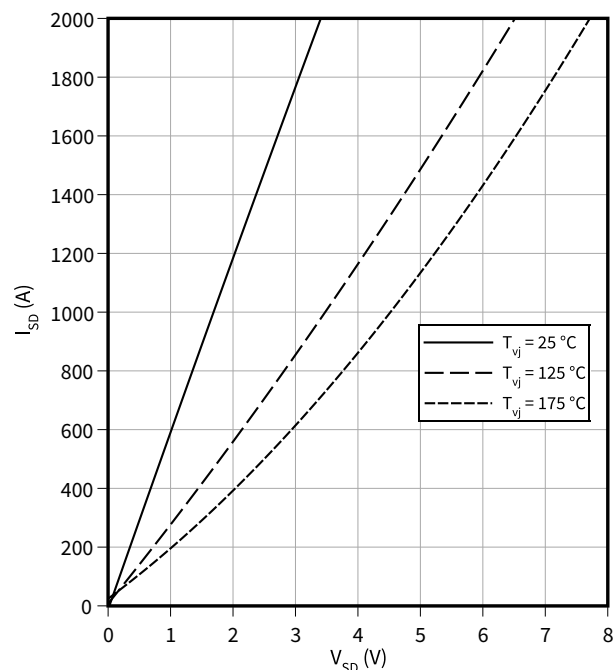
$$V_{GS} = -5 \text{ V}$$



Forward characteristic body diode (typical), MOSFET

$$I_{SD} = f(V_{SD})$$

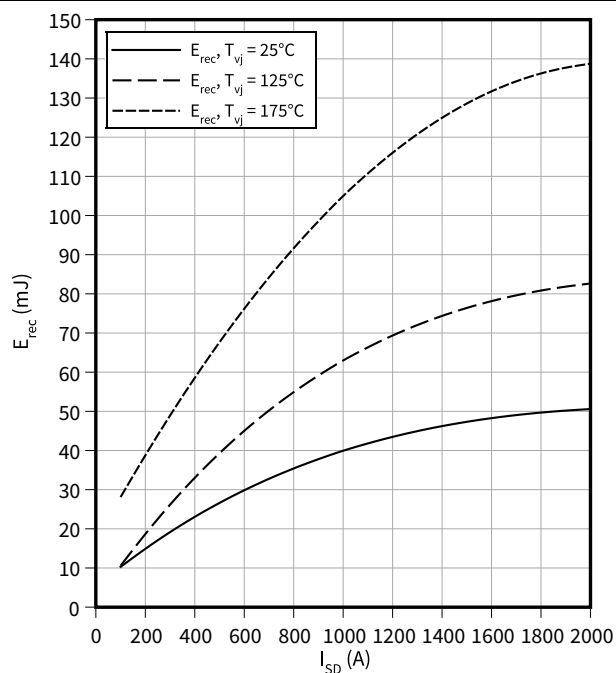
$$V_{GS} = 15 \text{ V}$$



Switching losses body diode (typical), MOSFET

$$E_{rec} = f(I_{SD})$$

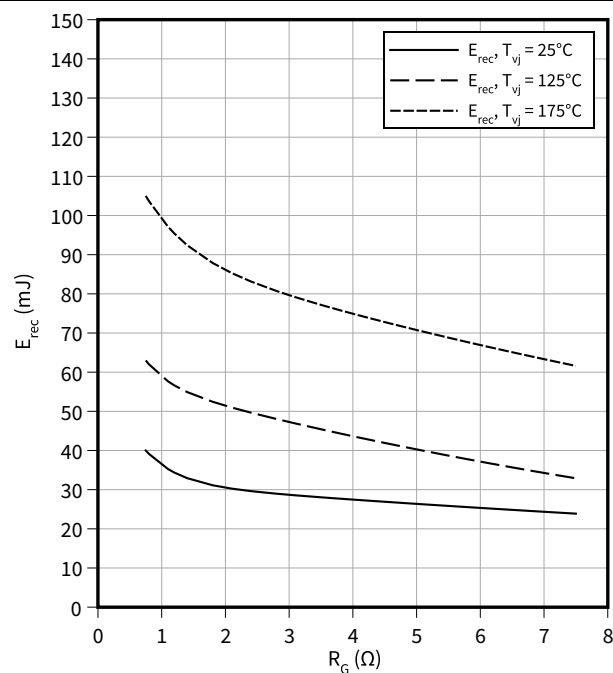
$$R_{Gon} = 0.75 \text{ } \Omega, V_{DD} = 1800 \text{ V}$$



Switching losses body diode (typical), MOSFET

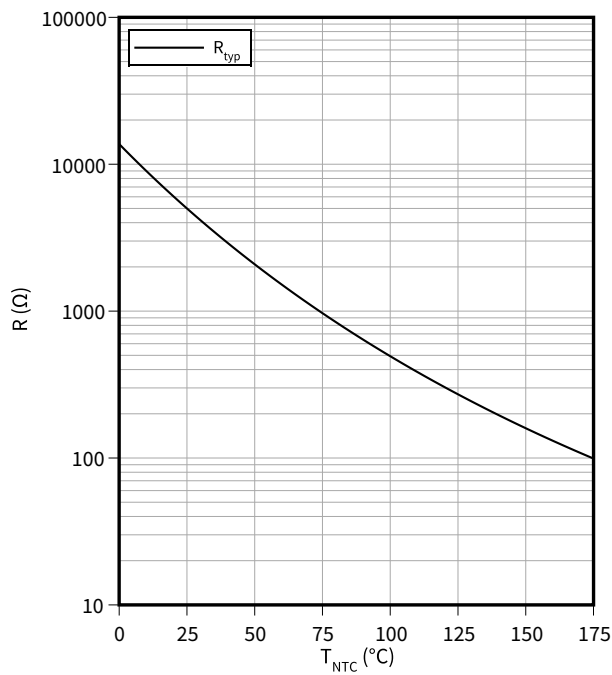
$$E_{rec} = f(R_G)$$

$$V_{DD} = 1800 \text{ V}, I_{SD} = 1000 \text{ A}$$



Temperature characteristic (typical), NTC-Thermistor

$R = f(T_{NTC})$



6 Circuit diagram

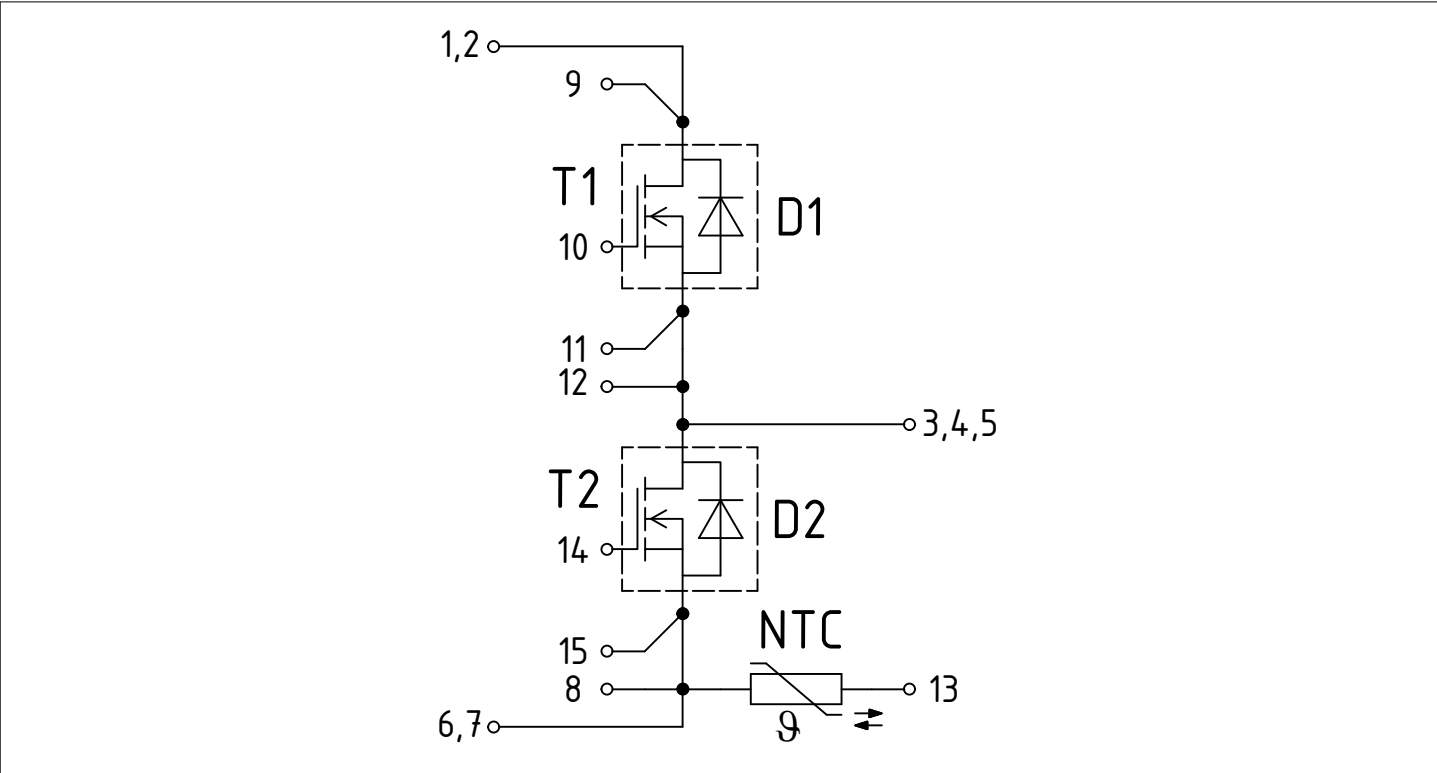


Figure 1

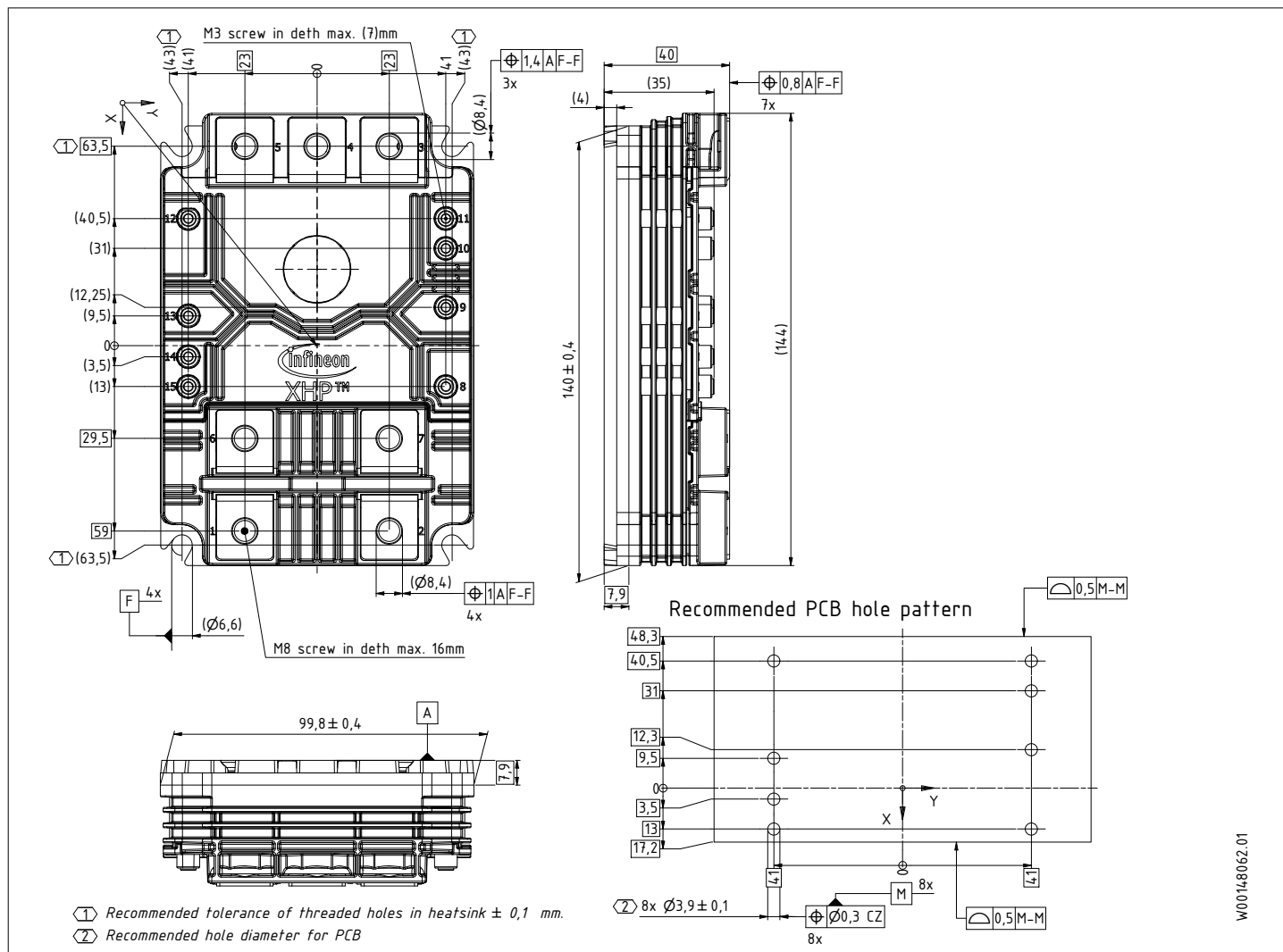


Figure 2

8 Module label code

Module label code			
Code format	Data Matrix		Barcode Code128
Encoding	ASCII text		Code Set A
Symbol size	16x16		23 digits
Standard	IEC24720 and IEC16022		IEC8859-1
Code content	<i>Content</i>	<i>Digit</i>	<i>Example</i>
	Module serial number	1 – 5	71549
	Module material number	6 - 11	142846
	Production order number	12 - 19	55054991
	Date code (production year)	20 – 21	15
	Date code (production week)	22 – 23	30
Example			
	 71549142846550549911530	 71549142846550549911530	

Figure 3



Revision history

Revision history

Document revision	Date of release	Description of changes
V1.0	2019-12-17	Target datasheet
n/a	2020-09-01	Datasheet migrated to a new system with a new layout and new revision number schema: target or preliminary datasheet = 0.xy; final datasheet = 1.xy
0.20	2023-11-21	Preliminary datasheet
1.00	2024-04-16	Final datasheet

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Edition 2024-04-16

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference
IFX-AAY262-003

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