

Final datasheet

XHP™2 module with CoolSiC™ Trench MOSFET and NTC / pre-applied thermal interface material

Features

- Electrical features
 - $V_{DS} = 2300\text{ V}$
 - $I_{DN} = 1500\text{ A} / I_{DRM} = 3000\text{ A}$
 - High current density
 - Low inductive design
 - Low switching losses
 - $T_{vj,op} = 175^{\circ}\text{C}$
- Mechanical features
 - Substrate for low thermal resistance
 - Copper base plate
 - High creepage and clearance distances
 - High power density
 - Package with CTI > 600
 - Pre-applied thermal interface material



Potential applications

- Central inverter
- Wind power generation
- Energy storage systems
- Industrial drives
- Traction drives
- DC/DC converter
- 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

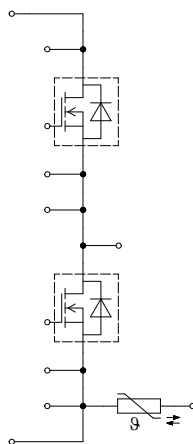


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 50 \text{ Hz}$, $t = 1 \text{ min}$	4.0	kV
Material of module baseplate			Cu	
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	$R_{CC'+EE'}$	$T_H = 25\text{ }^{\circ}\text{C}$, per switch			0.4		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	3		6	Nm
Terminal connection torque	M	- Mounting according to valid application note	M3, Screw	0.9		1.1	Nm
			M8, Screw	8		10	
Weight	G				1020		g

2 MOSFET Inverter

Table 3 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Drain-source voltage	V_{DSS}	$T_{vj} = 25 \text{ °C}$	2300	V
Implemented drain current	I_{DN}		1500	A
Continuous DC drain current	I_{DDC}	$T_{vj} = 175 \text{ °C}$, $V_{GS} = 15 \text{ V}$ $T_H = 45 \text{ °C}$	1000	A
Repetitive peak drain current	I_{DRM}	verified by design, t_p limited by T_{vjmax}	3000	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	$V_{GS(on)}$		15...18	V
Off-state gate voltage	$V_{GS(off)}$		-5	V

Table 5 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-resistance	$R_{DS(on)}$	$I_D = 1500\text{ A}$	$V_{GS} = 15\text{ V}, T_{vj} = 25\text{ °C}$		1.27	1.59	mΩ
			$V_{GS} = 15\text{ V}, T_{vj} = 125\text{ °C}$		2.27	2.84	
			$V_{GS} = 15\text{ V}, T_{vj} = 175\text{ °C}$		3.07	3.84	
Gate threshold voltage	$V_{GS(th)}$	$I_D = 675\text{ mA}, V_{DS} = V_{GS}, T_{vj} = 25\text{ °C},$ (tested after 1ms pulse at $V_{GS} = +20\text{ V}$)		3.45	4.2	5.15	V
Total gate charge	Q_G	$V_{DD} = 1500\text{ V}, V_{GS} = -5/15\text{ V}, T_{vj} = 25\text{ °C}$			3.98		μC
Internal gate resistor	R_{Gint}	$T_{vj} = 25\text{ °C}$			1.5		Ω
Input capacitance	C_{ISS}	$f = 100\text{ kHz}, V_{DS} = 1500\text{ V}, V_{GS} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		143		nF
Output capacitance	C_{OSS}	$f = 100\text{ kHz}, V_{DS} = 1500\text{ V}, V_{GS} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		3.08		nF
Reverse transfer capacitance	C_{rss}	$f = 100\text{ kHz}, V_{DS} = 1500\text{ V}, V_{GS} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		0.15		nF
C_{OSS} stored energy	E_{OSS}	$V_{DS} = 1500\text{ V}, V_{GS} = -5/15\text{ V}, T_{vj} = 25\text{ °C}$			4.35		mJ
Drain-source leakage current	I_{DSS}	$V_{DS} = 2300\text{ V}, V_{GS} = -5\text{ V}$	$T_{vj} = 25\text{ °C}$			786	μA
Gate-source leakage current	I_{GSS}	$V_{DS} = 0\text{ V}, T_{vj} = 25\text{ °C}$	$V_{GS} = 20\text{ V}$			2400	nA
Turn-on delay time (inductive load)	$t_{d on}$	$I_D = 1500\text{ A}, R_{Gon} = 0.1\text{ Ω}, V_{DD} = 1500\text{ V}, V_{GS} = -5/15\text{ V}, t_{dead} = 3000\text{ ns}, 0.1 V_{GS}$ to $0.1 I_D$	$T_{vj} = 25\text{ °C}$		210		ns
			$T_{vj} = 125\text{ °C}$		200		
			$T_{vj} = 175\text{ °C}$		200		
Rise time (inductive load)	t_r	$I_D = 1500\text{ A}, R_{Gon} = 0.1\text{ Ω}, V_{DD} = 1500\text{ V}, V_{GS} = -5/15\text{ V}, t_{dead} = 3000\text{ ns}, 0.1 I_D$ to $0.9 I_D$	$T_{vj} = 25\text{ °C}$		95		ns
			$T_{vj} = 125\text{ °C}$		95		
			$T_{vj} = 175\text{ °C}$		100		

(table continues...)

Table 5 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-off delay time (inductive load)	$t_{d\ off}$	$I_D = 1500\text{ A}$, $R_{Goff} = 1.4\ \Omega$, $V_{DD} = 1500\text{ V}$, $V_{GS} = -5/15\text{ V}$, $0.9\ V_{GS}$ to $0.9\ I_D$	$T_{vj} = 25\text{ °C}$	380		ns
			$T_{vj} = 125\text{ °C}$	420		
			$T_{vj} = 175\text{ °C}$	445		
Fall time (inductive load)	t_f	$I_D = 1500\text{ A}$, $R_{Goff} = 1.4\ \Omega$, $V_{DD} = 1500\text{ V}$, $V_{GS} = -5/15\text{ V}$, $0.9\ I_D$ to $0.1\ I_D$	$T_{vj} = 25\text{ °C}$	85		ns
			$T_{vj} = 125\text{ °C}$	115		
			$T_{vj} = 175\text{ °C}$	135		
Turn-on time (resistive load)	t_{on_R}	$I_D = 500\text{ A}$, $V_{DD} = 1500\text{ V}$, $V_{GS} = -5/15\text{ V}$, $R_{Gon} = 0.1\ \Omega$	$T_{vj} = 25\text{ °C}$	605.00		ns
Turn-on energy loss per pulse	E_{on}	$I_D = 1500\text{ A}$, $V_{DD} = 1500\text{ V}$, $L_\sigma = 14\text{ nH}$, $V_{GS} = -5/15\text{ V}$, $R_{Gon} = 0.1\ \Omega$, $di/dt = 12.7\text{ kA}/\mu\text{s}$ ($T_{vj} = 175\text{ °C}$), $t_{dead} = 3000\text{ ns}$	$T_{vj} = 25\text{ °C}$	305		mJ
			$T_{vj} = 125\text{ °C}$	390		
			$T_{vj} = 175\text{ °C}$	470		
Turn-on energy loss per pulse, optimized	$E_{on,o}$	$I_D = 1500\text{ A}$, $V_{DD} = 1500\text{ V}$, $L_\sigma = 14\text{ nH}$, $V_{GS} = -5/15\text{ V}$, $R_{Gon,o} = 0.1\ \Omega$, $di/dt = 13\text{ kA}/\mu\text{s}$ ($T_{vj} = 175\text{ °C}$), $t_{dead} = 500\text{ ns}$	$T_{vj} = 25\text{ °C}$	300		mJ
			$T_{vj} = 125\text{ °C}$	305		
			$T_{vj} = 175\text{ °C}$	330		
Turn-off energy loss per pulse	E_{off}	$I_D = 1500\text{ A}$, $V_{DD} = 1500\text{ V}$, $L_\sigma = 14\text{ nH}$, $V_{GS} = -5/15\text{ V}$, $R_{Goff} = 1.4\ \Omega$, $dv/dt = 11\text{ kV}/\mu\text{s}$ ($T_{vj} = 175\text{ °C}$)	$T_{vj} = 25\text{ °C}$	220		mJ
			$T_{vj} = 125\text{ °C}$	250		
			$T_{vj} = 175\text{ °C}$	270		
SC data	I_{SC}	$V_{GS} = -5/15\text{ V}$, $V_{DD} = 1500\text{ V}$, $V_{DSmax} = V_{DSS} - L_{SDS} \cdot di/dt$	$t_P = 3\ \mu\text{s}$, $T_{vj} = 175\text{ °C}$	9000		A
Thermal resistance, junction to heat sink	R_{thJH}	per MOSFET, Valid with IFX pre-applied Thermal Interface Material			34.1	K/kW
Temperature under switching conditions	$T_{vj\ op}$		-40		175	°C

3 Body diode (MOSFET Inverter)

Table 6 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
DC body diode forward current	I_{SD}	$T_{vj} = 175\text{ °C}$, $V_{GS} = -5\text{ V}$	870	A
I^2t - value	I^2t	$V_{DS} = 0\text{ V}$, $V_{GS} = -5\text{ V}$, $t_P = 10\text{ ms}$	$T_{vj} = 125\text{ °C}$	kA ² s
			$T_{vj} = 175\text{ °C}$	

Table 7 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	V_{SD}	$I_{SD} = 1500 \text{ A}$, $V_{GS} = -5 \text{ V}$	$T_{vj} = 25 \text{ °C}$	5	6.25	V
			$T_{vj} = 125 \text{ °C}$	4.4	5.5	
			$T_{vj} = 175 \text{ °C}$	4.2	5.25	
Reverse recovery energy	E_{rec}	$I_{SD} = 1500 \text{ A}$, $di_s/dt = 12.7 \text{ kA}/\mu\text{s}$ ($T_{vj} = 175 \text{ °C}$), $V_{DD} = 1500 \text{ V}$, $V_{GS} = -5/15 \text{ V}$, $t_{dead} = 3000 \text{ ns}$	$T_{vj} = 25 \text{ °C}$	4.35		mJ
			$T_{vj} = 125 \text{ °C}$	31		
			$T_{vj} = 175 \text{ °C}$	47		
Reverse recovery energy, optimized	$E_{rec,o}$	$I_{SD} = 1500 \text{ A}$, $di_s/dt = 13 \text{ kA}/\mu\text{s}$ ($T_{vj} = 175 \text{ °C}$), $V_{DD} = 1500 \text{ V}$, $V_{GS} = -5/15 \text{ V}$, $t_{dead} = 500 \text{ ns}$	$T_{vj} = 25 \text{ °C}$	4.35		mJ
			$T_{vj} = 125 \text{ °C}$	7.5		
			$T_{vj} = 175 \text{ °C}$	13		

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

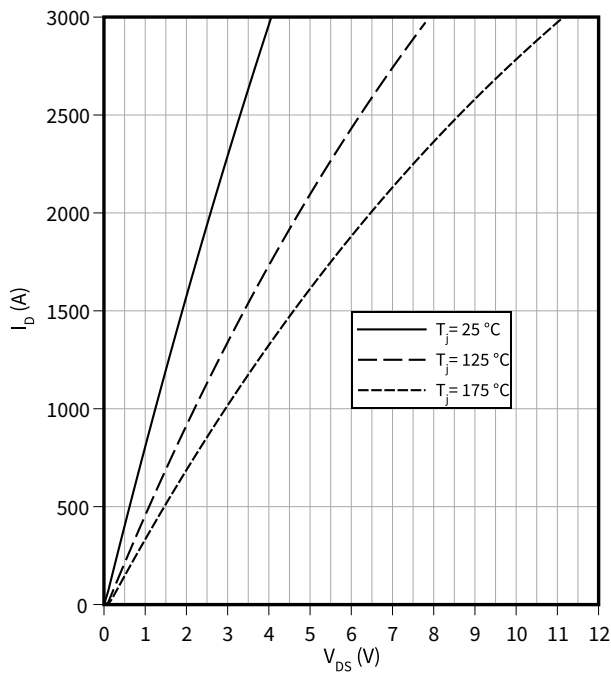
Note: For an analytical description of the NTC characteristics please refer to AN2009-10, chapter 4

5 Characteristics diagrams

Output characteristic (typical), MOSFET Inverter

$I_D = f(V_{DS})$

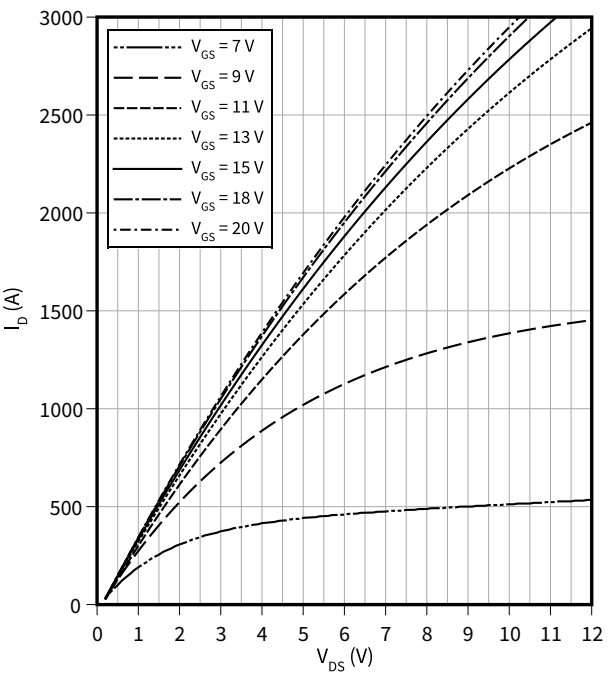
$V_{GS} = 15\text{ V}$



Output characteristic field (typical), MOSFET Inverter

$I_D = f(V_{DS})$

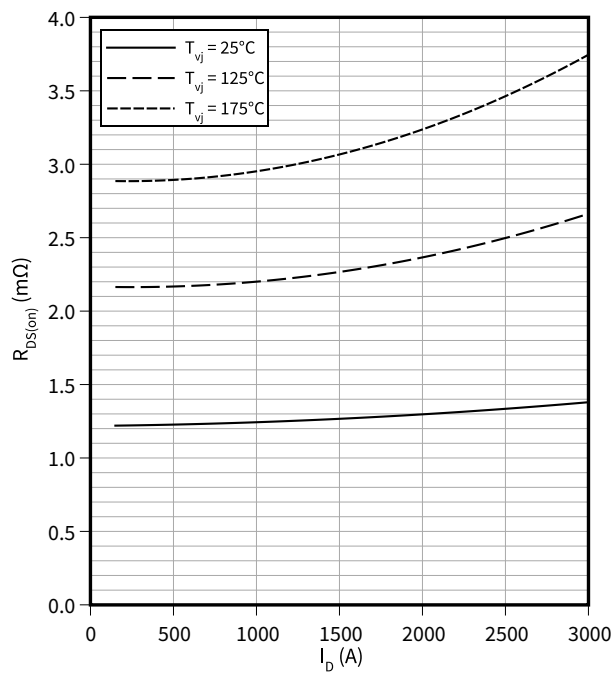
$T_{vj} = 175\text{ °C}$



Drain source on-resistance (typical), MOSFET Inverter

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

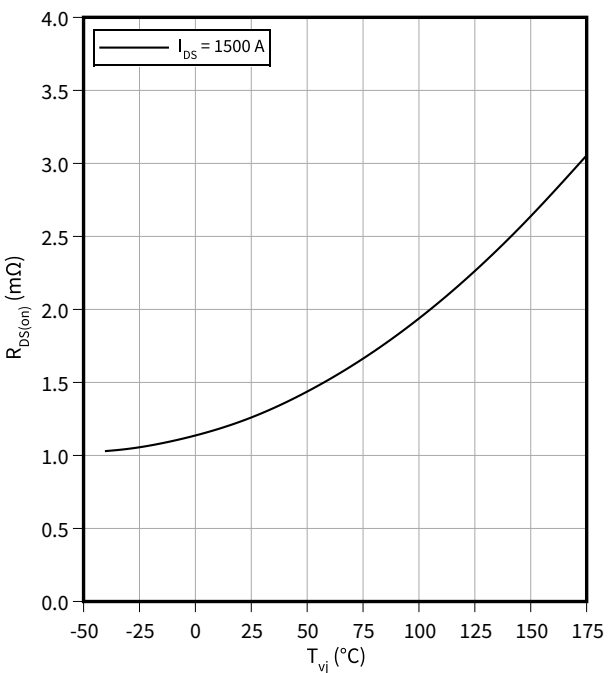
$V_{GS} = 15\text{ V}$



Drain source on-resistance (typical), MOSFET Inverter

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

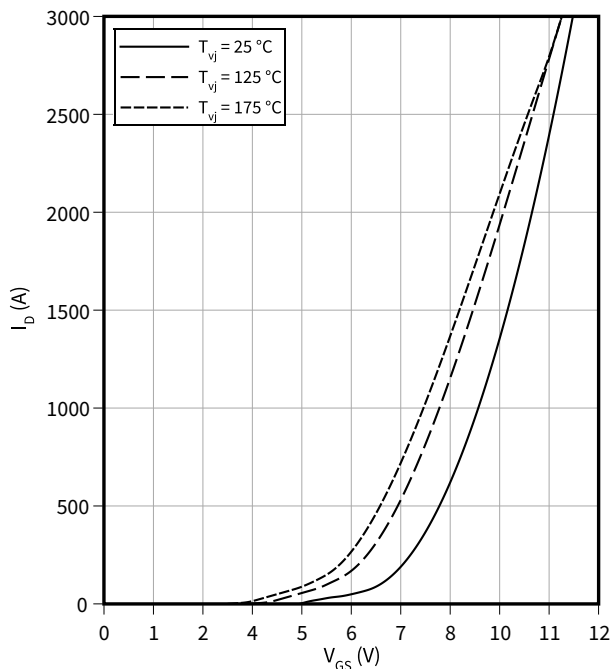
$V_{GS} = 15\text{ V}$



5 Characteristics diagrams

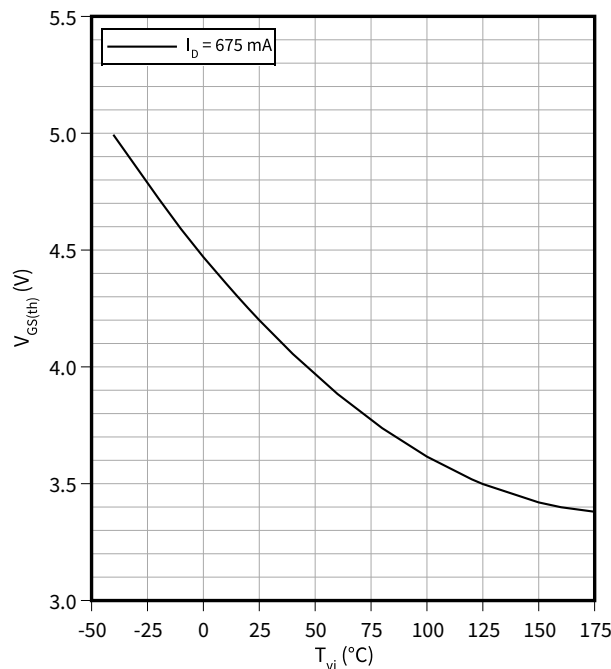
Transfer characteristic (typical), MOSFET Inverter

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



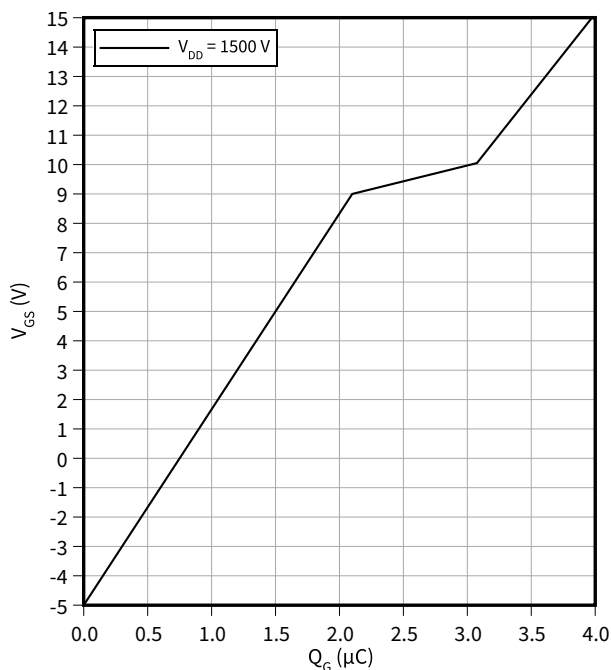
Gate-source threshold voltage (typical), MOSFET Inverter

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



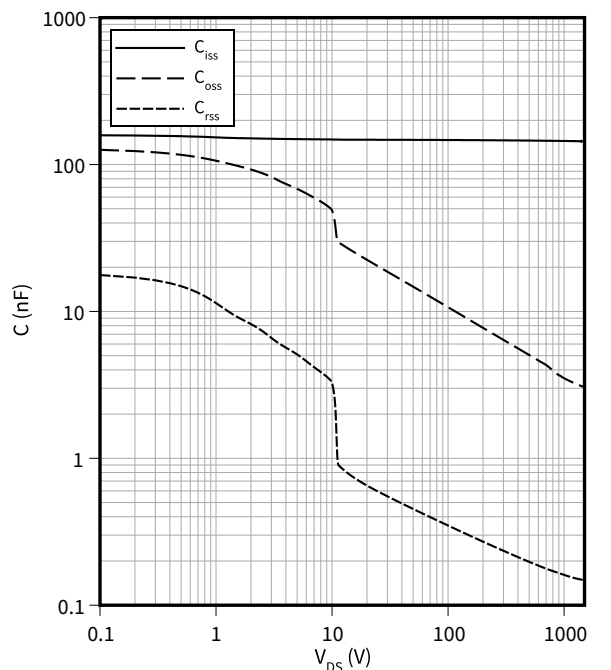
Gate charge characteristic (typical), MOSFET Inverter

$V_{GS} = f(Q_G)$
 $I_D = 1500\text{ A}, T_{vj} = 25\text{ °C}$



Capacity characteristic (typical), MOSFET Inverter

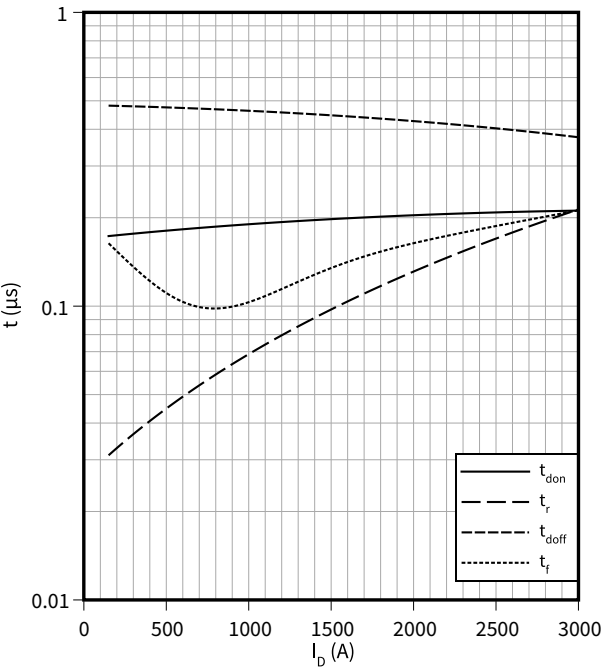
$C = f(V_{DS})$
 $f = 100\text{ kHz}, T_{vj} = 25\text{ °C}, V_{GS} = 0\text{ V}$



5 Characteristics diagrams

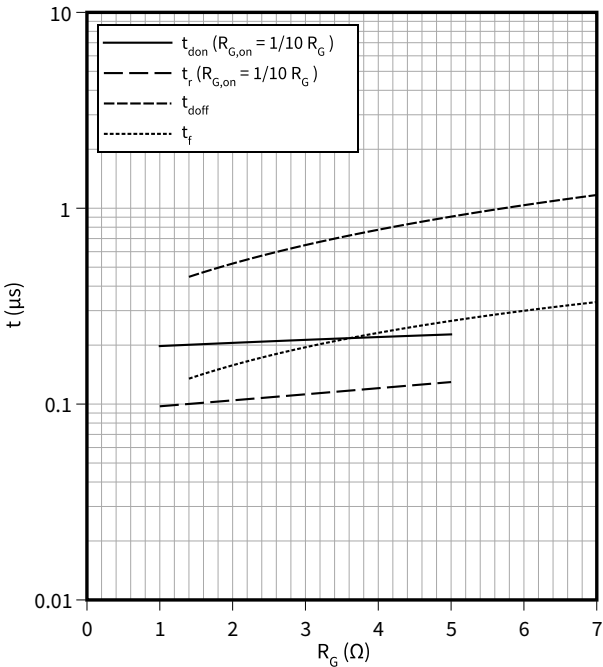
Switching times (typical), MOSFET Inverter

$t = f(I_D)$
 $R_{Goff} = 1.4 \Omega$, $R_{Gon} = 0.1 \Omega$, $V_{DD} = 1500 \text{ V}$, $T_{vj} = 175 \text{ }^\circ\text{C}$, $V_{GS} = -5/15 \text{ V}$



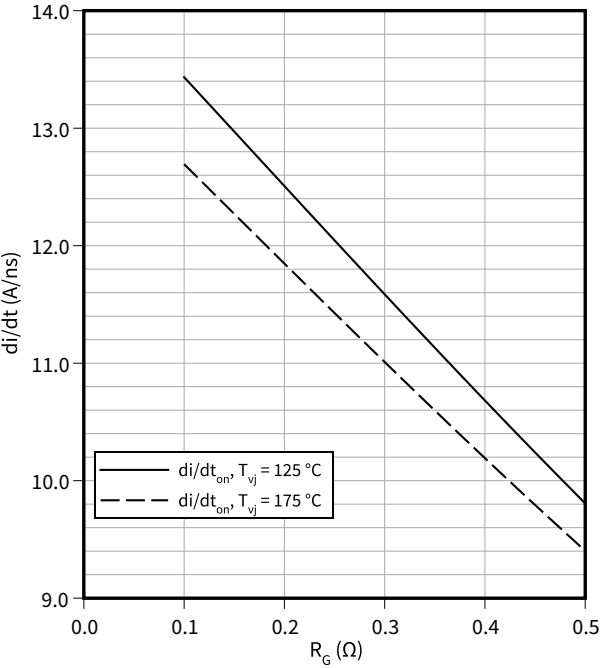
Switching times (typical), MOSFET Inverter

$t = f(R_G)$
 $V_{DD} = 1500 \text{ V}$, $I_D = 1500 \text{ A}$, $T_{vj} = 175 \text{ }^\circ\text{C}$, $V_{GS} = -5/15 \text{ V}$



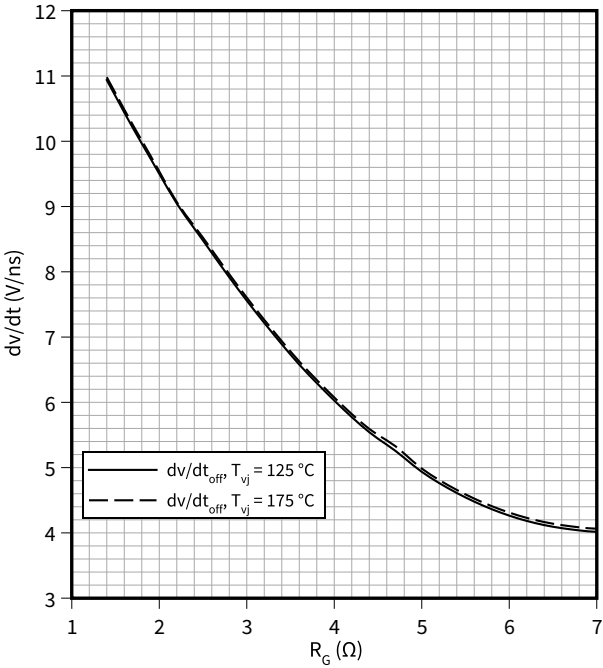
Current slope (typical), MOSFET Inverter

$di/dt = f(R_G)$
 $V_{DD} = 1500 \text{ V}$, $t_{dead} = 3000 \text{ ns}$, $I_D = 1500 \text{ A}$, $V_{GS} = -5/15 \text{ V}$



Voltage slope (typical), MOSFET Inverter

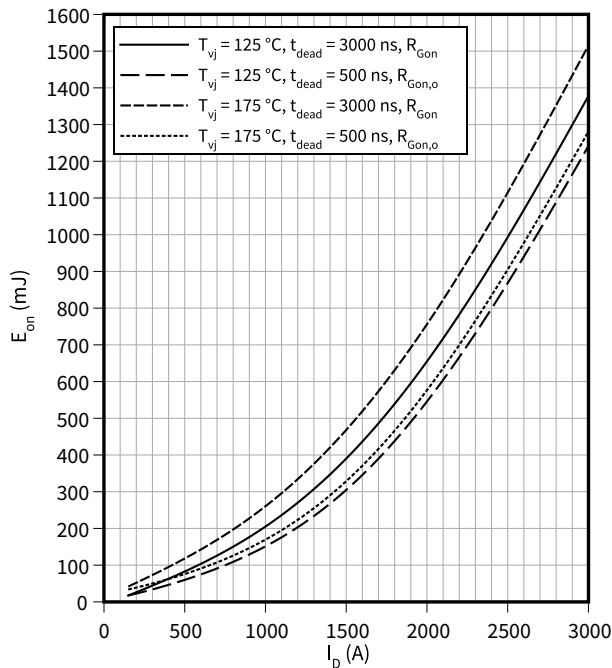
$dv/dt = f(R_G)$
 $V_{DD} = 1500 \text{ V}$, $I_D = 1500 \text{ A}$, $V_{GS} = -5/15 \text{ V}$



5 Characteristics diagrams

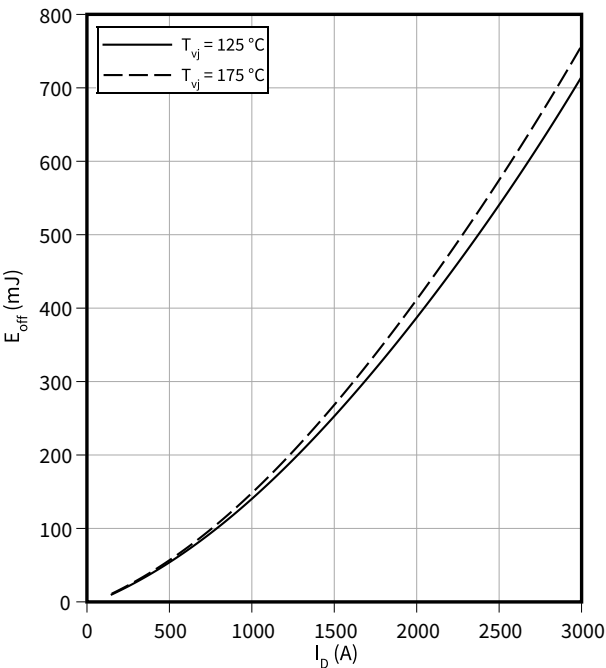
Switching losses (typical), MOSFET Inverter

$E_{on} = f(I_D)$
 $V_{DD} = 1500\text{ V}$, $R_{Gon} = 0.1\ \Omega$, $R_{Gon,o} = 0.1\ \Omega$, $V_{GS} = -5/15\text{ V}$



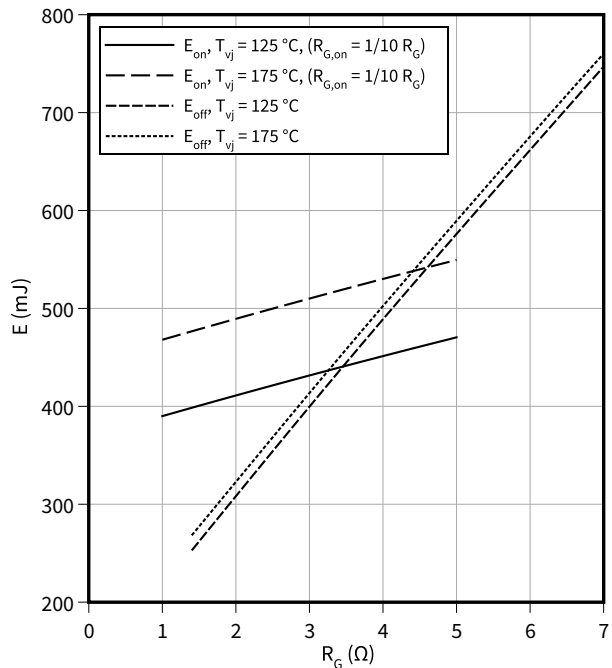
Switching losses (typical), MOSFET Inverter

$E_{off} = f(I_D)$
 $R_{Goff} = 1.4\ \Omega$, $V_{DD} = 1500\text{ V}$, $V_{GS} = -5/15\text{ V}$



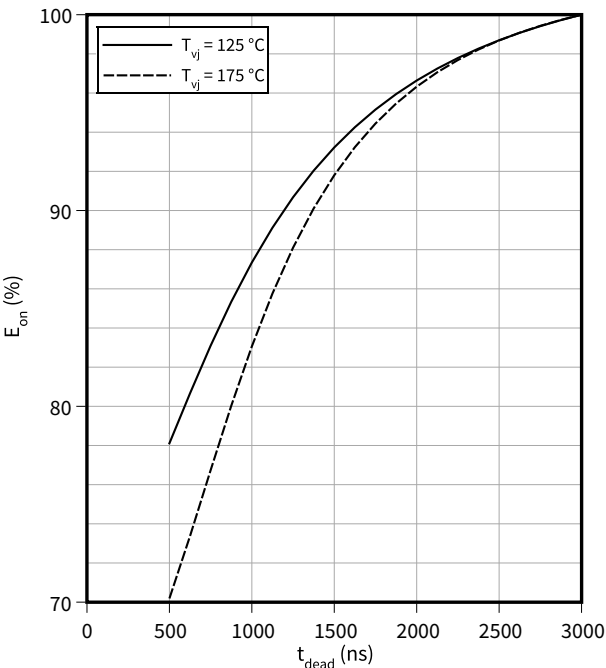
Switching losses (typical), MOSFET Inverter

$E = f(R_G)$
 $V_{DD} = 1500\text{ V}$, $t_{dead} = 3000\text{ ns}$, $I_D = 1500\text{ A}$, $V_{GS} = -5/15\text{ V}$



Switching losses (typical), MOSFET Inverter

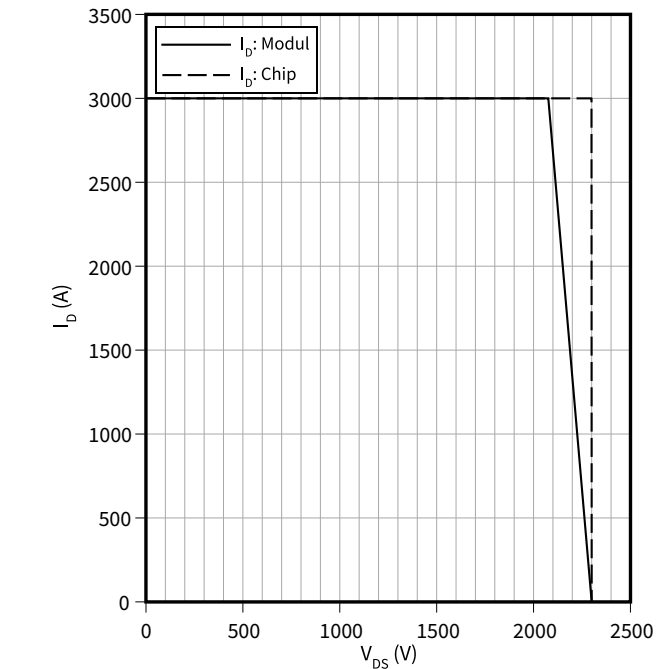
$E_{on} = f(t_{dead})$
 $R_{Gon} = 0.1\ \Omega$, $I_D = 1500\text{ A}$, $V_{DD} = 1500\text{ V}$, $V_{GS} = -5/15\text{ V}$



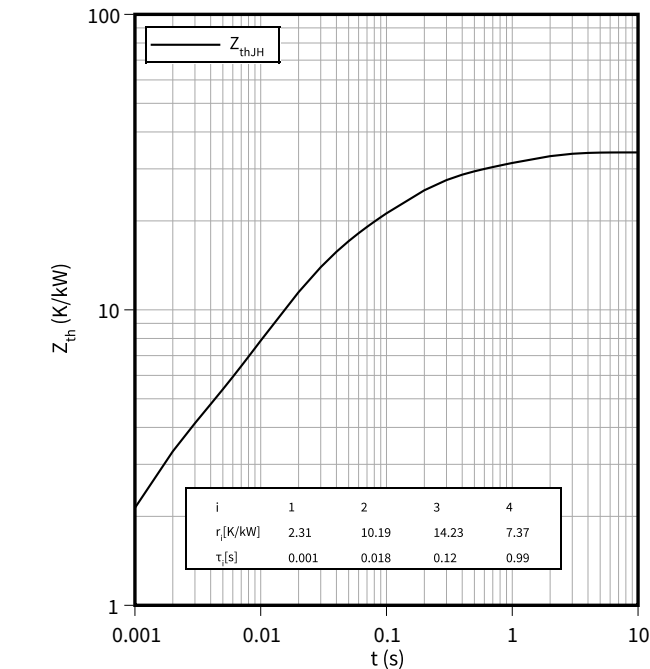
5 Characteristics diagrams

Reverse bias safe operating area (RBSOA), MOSFET Inverter

$I_D = f(V_{DS})$
 $R_{Goff} = 1.4 \Omega$, $T_{vj} = 175 \text{ }^\circ\text{C}$, $V_{GS} = -5/15 \text{ V}$

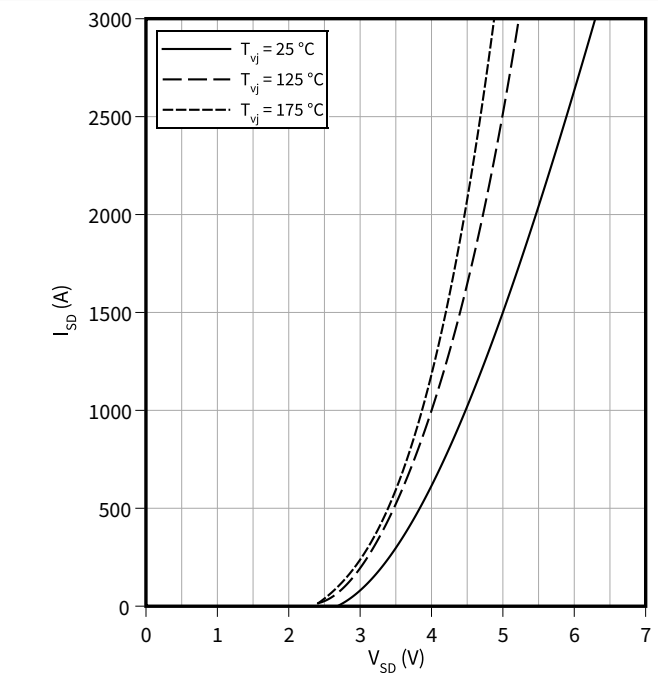


Transient thermal impedance, MOSFET Inverter
 $Z_{th} = f(t)$



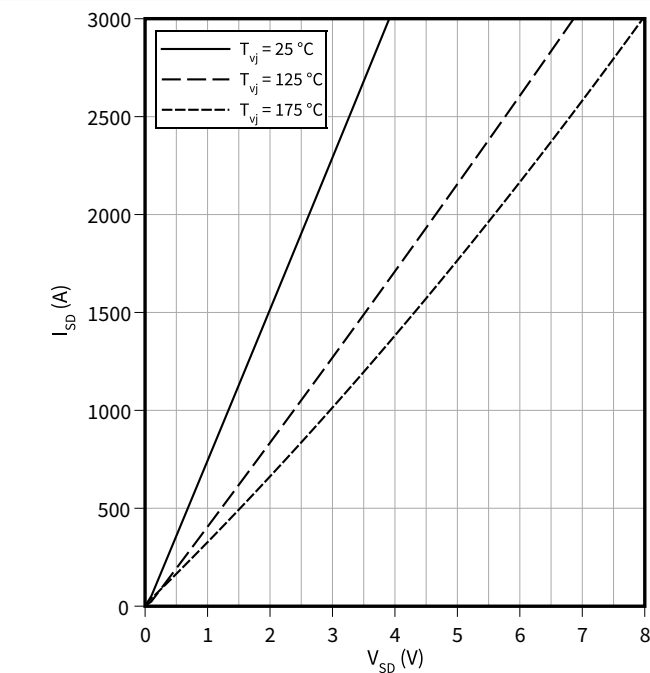
Forward characteristic body diode (typical), MOSFET Inverter

$I_{SD} = f(V_{SD})$
 $V_{GS} = -5 \text{ V}$



Forward characteristic body diode (typical), MOSFET Inverter

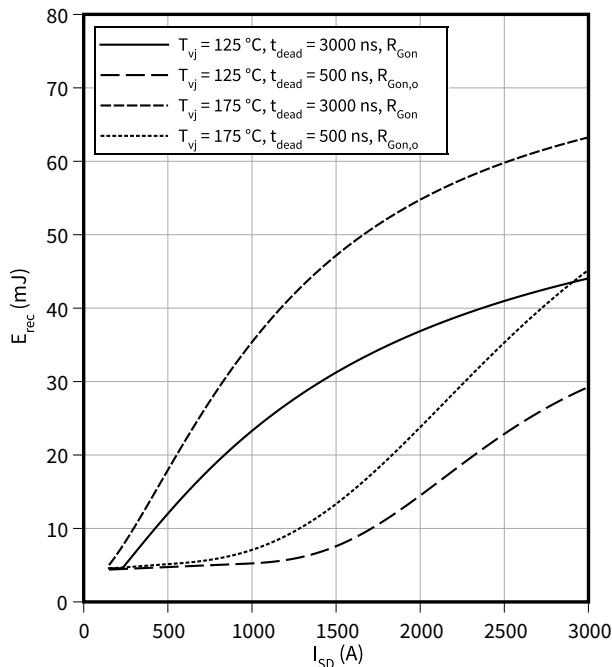
$I_{SD} = f(V_{SD})$
 $V_{GS} = 15 \text{ V}$



5 Characteristics diagrams

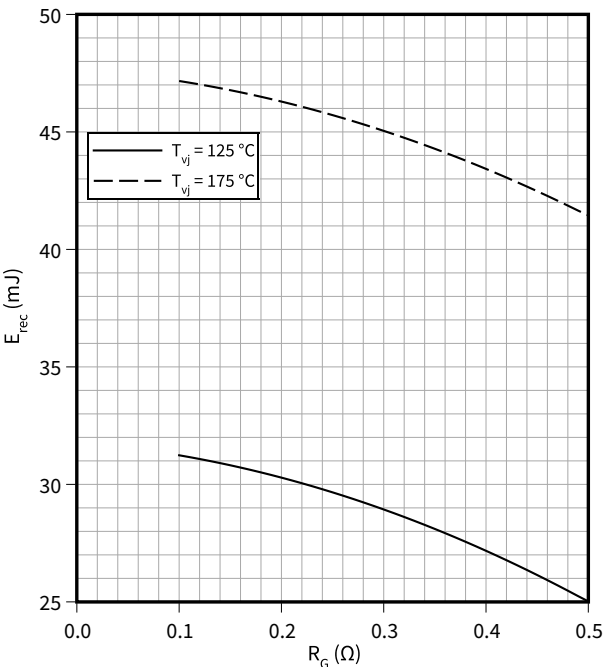
Switching losses body diode (typical), MOSFET Inverter

$E_{rec} = f(I_{SD})$
 $R_{Gon} = 0.1 \Omega$, $R_{Gon,o} = 0.1 \Omega$, $V_{DD} = 1500 \text{ V}$



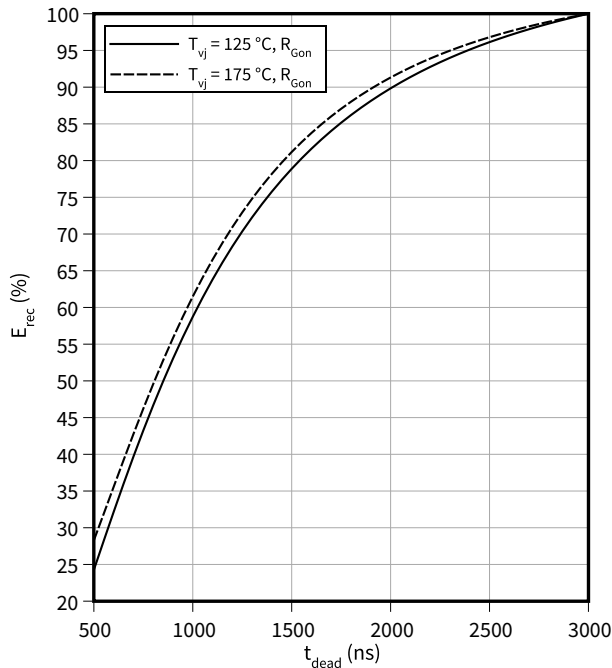
Switching losses body diode (typical), MOSFET Inverter

$E_{rec} = f(R_G)$
 $t_{dead} = 3000 \text{ ns}$, $I_{SD} = 1500 \text{ A}$, $V_{DD} = 1500 \text{ V}$



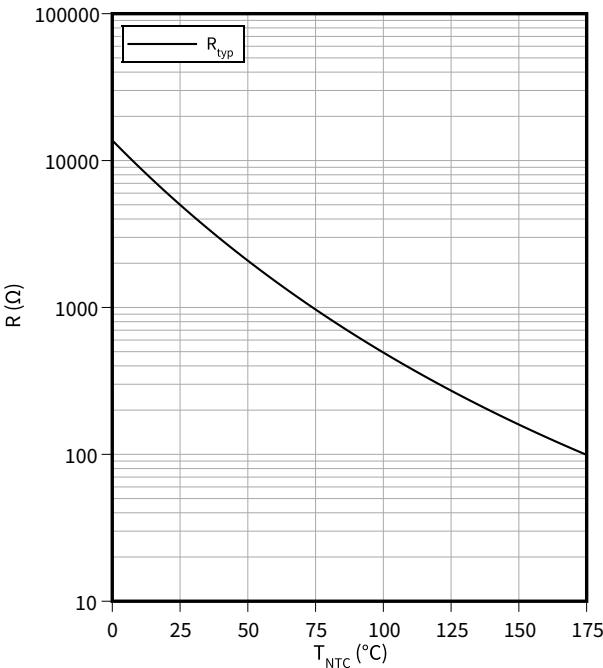
Switching losses body diode (typical), MOSFET Inverter

$E_{rec} = f(t_{dead})$
 $I_D = 1500 \text{ A}$, $V_{DD} = 1500 \text{ V}$, $V_{GS} = 15/-5 \text{ V}$



Temperature characteristic (typical), NTC-Thermistor

$R = f(T_{NTC})$



6 Circuit diagram

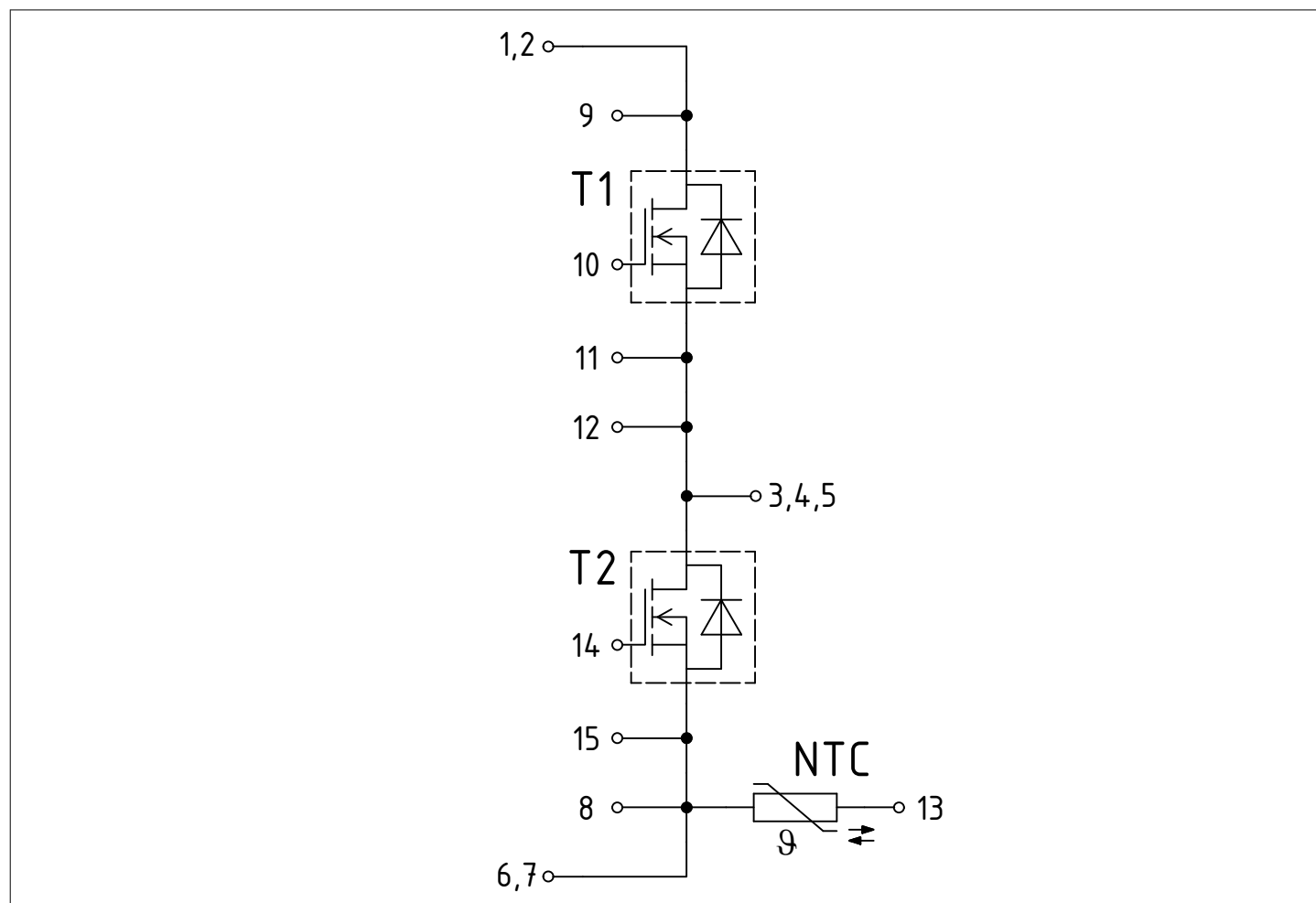


Figure 1

7 Package outlines

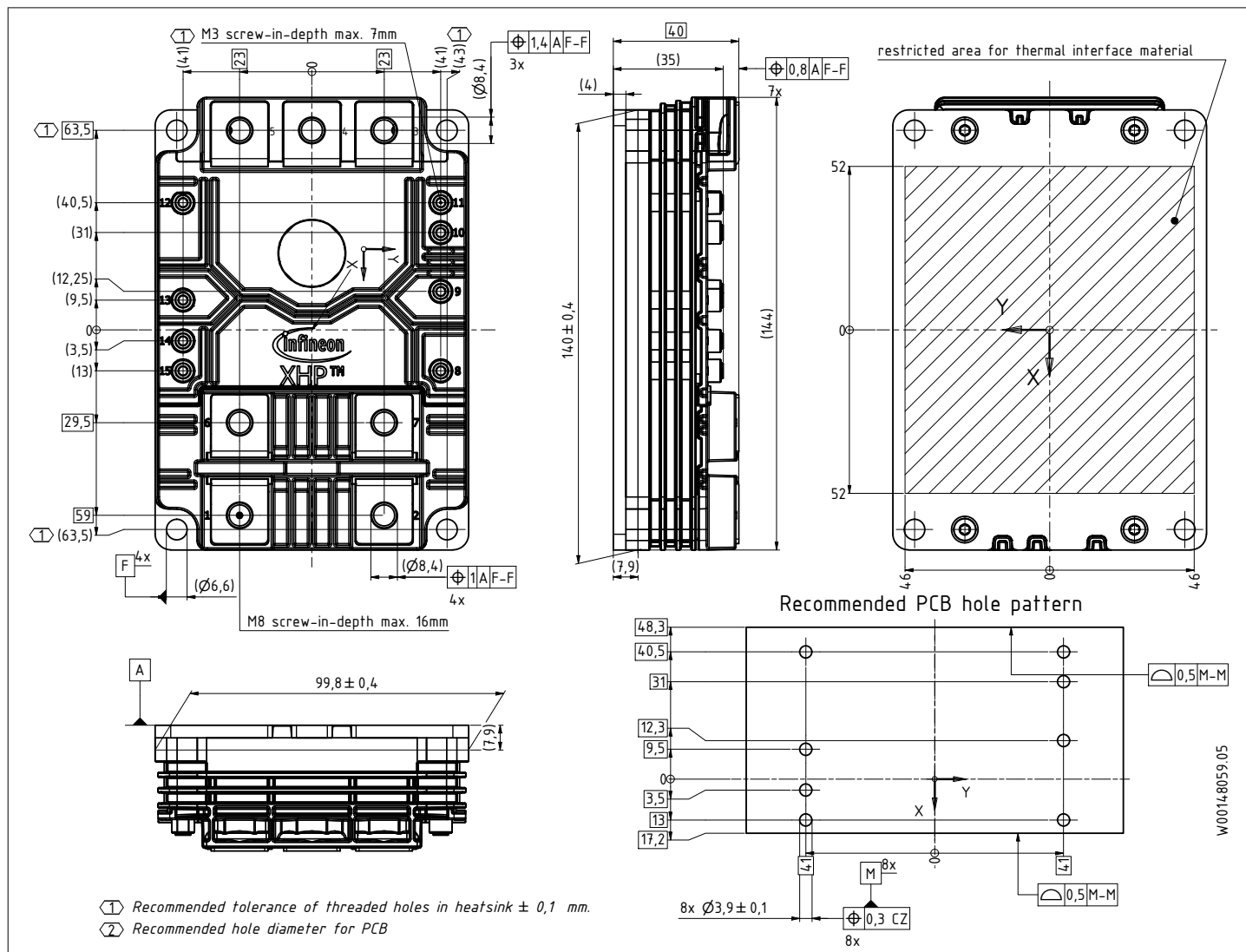


Figure 2

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

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