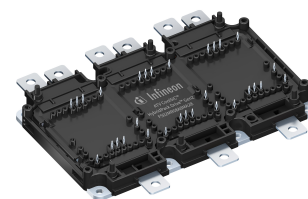


Final datasheet

HybridPACK™ Drive G2 module with SiC MOSFET

Features

- Electrical features
 - $V_{DS} = 1200\text{ V}$
 - $I_{DN} = 390\text{ A}$
 - New semiconductor material - silicon carbide
 - Low $R_{DS,on}$
 - Low switching losses
 - Low Q_g and C_{rss}
 - Low inductive design
 - $T_{vj,op} = 175^\circ\text{C}$
 - Short-time extended operation temperature $T_{vj,op} = 200^\circ\text{C}$
- Mechanical features
 - 4.2 kV DC 1 second insulation
 - High creepage and clearance distances
 - Compact design
 - High power density
 - Direct-cooled PinFin base plate
 - High-performance Si_3N_4 ceramic
 - Guiding elements for PCB and cooler assembly
 - Integrated temperature sensing diode
 - PressFIT contact technology
 - RoHS compliant, lead-free
 - UL 94 V0 module frame



Potential applications

- Automotive applications
- (Hybrid) electrical vehicles (H)EV
- Motor drives
- Commercial, construction and agricultural vehicles (CAV)

Product validation

- Qualified according to AQG 324, release no.: 03.1/2021

Description

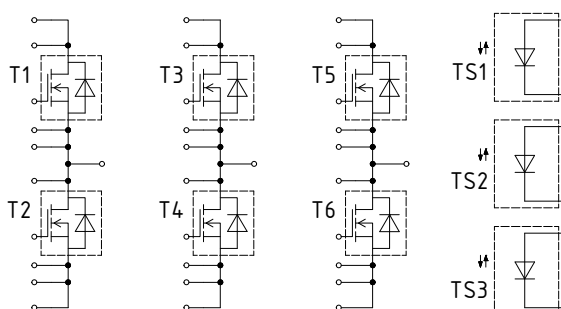


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 0$ Hz, $t = 1$ sec	4.20	kV
Material of module baseplate			Cu+Ni ¹⁾	
Internal isolation		basic insulation (class 1, IEC 61140)	Si_3N_4	
Creepage distance	d_{creep}	terminal to heatsink	10.6	mm
Creepage distance	d_{creep}	terminal to terminal	10.6	mm
Clearance	d_{clear}	terminal to heatsink	4.5	mm
Clearance	d_{clear}	terminal to terminal	4.5	mm
Comparative tracking index	CTI		> 175	

1) Ni plated Cu baseplate

Table 2 Maximum rated values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Maximum RMS module terminal current	$I_{t,rms}$		900			A
Heat-staking dome temperature ¹⁾	T_{HS}	$t_{steking} < 10s$			280	°C

1) Heat-staking according to application note AN-G2-ASSEMBLY.

Table 3 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Pressure drop in cooling circuit	Δp	50% water / 50% ethylenglycol, $\Delta V / \Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 60$ °C		76 ¹⁾		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate} < 40$ °C			3.0	bar
		$T_{baseplate} \geq 40$ °C (relative pressure)			2.5	
Stray inductance module	$L_{s,DS}$			8.0		nH
Module lead resistance, terminals - chip	$R_{DD'+SS'}$	$T_f = 25$ °C, per switch		0.64		mΩ
Storage temperature	T_{stg}		-40 ²⁾		125	°C
Mounting torque for module mounting ³⁾	M	Screw M4 baseplate to heatsink	1.8	2.0	2.2	Nm
		Screw EJOT Delta PCB to frame	0.45	0.50	0.55	
Weight	G			760		g

1) Cooler design and flow direction according to application note AN-G2-ASSEMBLY

- 2) Verified by design, not by test
3) Screw types and torque according to application note AN-G2-ASSEMBLY

2 MOSFET

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage	V_{DS}		continuous operation	1200	V
			10h over life time	1400	
DC drain current	$I_{D,nom}$	$V_{GS} = 18\text{ V}$, $T_f = 65\text{ °C}$	$T_{vj,max} = 175\text{ °C}$	390	A
Pulsed drain current	$I_{D,pulse}$	verified by design, t_p limited by $T_{vj,max}$		780	A
Gate-source voltage, max. static voltage	V_{GS}			-5/19	V
Gate-source voltage, max. transient voltage	V_{GS}	Duty Cycle < 1 % (first transient maximum peak)		-10/23	V

Table 5 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...0	V

Table 6 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-resistance	$R_{DS,on}$	$I_D = 390\text{ A}$, $V_{GS} = 18\text{ V}$	$T_{vj} = 25\text{ °C}$		1.90		mΩ
			$T_{vj} = 125\text{ °C}$		3.20		
			$T_{vj} = 175\text{ °C}$		4.20		
			$T_{vj} = 200\text{ °C}$		4.80		
Drain-source on-resistance	$R_{DS,on}$	$I_D = 390\text{ A}$, $V_{GS} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$		2.40		mΩ
			$T_{vj} = 125\text{ °C}$		3.70		
			$T_{vj} = 175\text{ °C}$		4.80		
			$T_{vj} = 200\text{ °C}$		5.50		
Gate threshold voltage	$V_{GS,th}$	$I_D = 160\text{ mA}$, $V_{GS} = V_{DS}$, (tested after 1ms pulse at $V_{GS} = +20\text{ V}$)	$T_{vj} = 25\text{ °C}$	3.20 ¹⁾	3.98	4.55	V
Total gate charge	Q_G	$V_{DS} = 750\text{ V}$, $V_{GS} = -5/18\text{ V}$			1.19		μC
Internal gate resistor	$R_{G,int}$		$T_{vj} = 25\text{ °C}$		0.66		Ω
Input capacitance	C_{iss}	$f = 1\text{ MHz}$, $V_{DS} = 750\text{ V}$	$T_{vj} = 25\text{ °C}$		34.5		nF

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Output capacitance	C_{oss}	$f = 1 \text{ MHz}$, $V_{DS} = 750 \text{ V}$		1.26		nF
Reverse transfer capacitance	C_{rss}	$f = 1 \text{ MHz}$, $V_{DS} = 750 \text{ V}$		0.1		nF
C_{oss} stored energy	E_{oss}	$V_{DS} = 750 \text{ V}$		1336		μJ
Drain-source leakage current	I_{DSX}	$V_{GS} = -5 \text{ V}$, $V_{DSS} = 1200 \text{ V}$			660	μA
Gate-source leakage current	I_{GSS}	$V_{GS} = 20 \text{ V}$, $V_{DS} = 0 \text{ V}$			100	nA
Turn-on delay time, inductive load	$t_{d,on}$	$I_D = 390 \text{ A}$, $R_{G,on} = 12 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ } ^\circ\text{C}$	115		ns
			$T_{vj} = 125 \text{ } ^\circ\text{C}$	92		
			$T_{vj} = 175 \text{ } ^\circ\text{C}$	81		
			$T_{vj} = 200 \text{ } ^\circ\text{C}$	76		
Rise time (inductive load)	t_r	$I_D = 390 \text{ A}$, $R_{G,on} = 12 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ } ^\circ\text{C}$	88		ns
			$T_{vj} = 125 \text{ } ^\circ\text{C}$	82		
			$T_{vj} = 175 \text{ } ^\circ\text{C}$	81		
			$T_{vj} = 200 \text{ } ^\circ\text{C}$	80		
Turn-off delay time, inductive load	$t_{d,off}$	$I_D = 390 \text{ A}$, $R_{G,off} = 3.3 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ } ^\circ\text{C}$	212		ns
			$T_{vj} = 125 \text{ } ^\circ\text{C}$	225		
			$T_{vj} = 175 \text{ } ^\circ\text{C}$	236		
			$T_{vj} = 200 \text{ } ^\circ\text{C}$	239		
Fall time (inductive load)	t_f	$I_D = 390 \text{ A}$, $R_{G,off} = 3.3 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ } ^\circ\text{C}$	41		ns
			$T_{vj} = 125 \text{ } ^\circ\text{C}$	42		
			$T_{vj} = 175 \text{ } ^\circ\text{C}$	43		
			$T_{vj} = 200 \text{ } ^\circ\text{C}$	43		
Turn-on energy loss per pulse	E_{on}	$I_D = 390 \text{ A}$, $R_{G,on} = 12 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$, $L_\sigma = 6.5 \text{ nH}$	$T_{vj} = 25 \text{ } ^\circ\text{C}$, $di/dt = 3.6 \text{ kA}/\mu\text{s}$	30.60		mJ
			$T_{vj} = 125 \text{ } ^\circ\text{C}$, $di/dt = 3.9 \text{ kA}/\mu\text{s}$	30.70		
			$T_{vj} = 175 \text{ } ^\circ\text{C}$, $di/dt = 4 \text{ kA}/\mu\text{s}$	31.70		
			$T_{vj} = 200 \text{ } ^\circ\text{C}$, $di/dt = 4 \text{ kA}/\mu\text{s}$	32.70		

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Turn-off energy loss per pulse	E_{off}	$I_D = 390\text{ A}$, $R_{G,off} = 3.3\ \Omega$, $V_{GS} = -5/18\text{ V}$, $V_{DS} = 750\text{ V}$, $L_\sigma = 6.5\text{ nH}$	$T_{vj} = 25\text{ °C}$, $dv/dt = 14.6\text{ kV}/\mu\text{s}$		11.40		mJ
			$T_{vj} = 125\text{ °C}$, $dv/dt = 14.2\text{ kV}/\mu\text{s}$		11.90		
			$T_{vj} = 175\text{ °C}$, $dv/dt = 13.9\text{ kV}/\mu\text{s}$		12.30		
			$T_{vj} = 200\text{ °C}$, $dv/dt = 13.7\text{ kV}/\mu\text{s}$		12.50		
Short circuit data	I_{SC}	$V_{DD} = 750\text{ V}$, $V_{GS} = -5/18\text{ V}$, $R_{G,on} = 12\ \Omega$, $R_{G,off} = 3.3\ \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$	$t_{SC} < 1.2\ \mu\text{s}$, $T_{vj} = 200\text{ °C}$		6560		A
Short circuit data	I_{SC}	$V_{DD} = 750\text{ V}$, $V_{GS} = -5/15\text{ V}$, $R_{G,on} = 12\ \Omega$, $R_{G,off} = 3.3\ \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$	$t_{SC} < 2\ \mu\text{s}$, $T_{vj} = 200\text{ °C}$		4790		A
Thermal resistance, junction to cooling fluid ²⁾	$R_{th,j-f}$	per MOSFET, 50% water / 50% ethylenglycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 60\text{ °C}$			0.115	0.121 ³⁾	K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	°C
			extended operation			200 ⁴⁾	

- 1) At 0h operating time. During inverter operation the value can be lower depending on T_{vj} , $V_{GS(off)}$, (switching frequency) f_{sw} over lifetime. For a final assessment of $V_{GS,th}$ Min. value depending on customer application please contact the Infineon sales office for the necessary technical support by Infineon.
- 2) Cooler design and flow direction according to application note AN-G2-ASSEMBLY
- 3) EoL criteria see AQG324, verified by characterization with 4.5 sigma
- 4) For 100h cumulated over life time

3 Body diode (MOSFET)

Table 7 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage	V_{DSS}		continuous operation	1200	V
			10h over life time	1400	
DC body diode forward current	$I_{F,S}$	$T_{vj,max} = 175\text{ °C}$, $V_{GS} = -5\text{ V}$	$T_f = 65\text{ °C}$	165	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$		780	A

Table 8 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	$V_{F,SD}$	$I_{F,S} = 390 \text{ A}$, $V_{GS} = -5 \text{ V}$	$T_{vj} = 25 \text{ °C}$	4.55	6.40	V
			$T_{vj} = 125 \text{ °C}$	4.17		
			$T_{vj} = 175 \text{ °C}$	4.04		
			$T_{vj} = 200 \text{ °C}$	3.97		
Peak reverse recovery current	I_{rrm}	$I_{F,S} = 390 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$	71		A
			$T_{vj} = 125 \text{ °C}$	104		
			$T_{vj} = 175 \text{ °C}$	132		
			$T_{vj} = 200 \text{ °C}$	146		
Recovered charge	Q_{rr}	$I_{F,S} = 390 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$	1.21		μC
			$T_{vj} = 125 \text{ °C}$	3.27		
			$T_{vj} = 175 \text{ °C}$	5.52		
			$T_{vj} = 200 \text{ °C}$	6.66		
Reverse recovery energy	E_{rec}	$I_{F,S} = 390 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$, $-di/dt = 4.6 \text{ kA}/\mu\text{s}$	0.1		mJ
			$T_{vj} = 125 \text{ °C}$, $-di/dt = 4.7 \text{ kA}/\mu\text{s}$	0.5		
			$T_{vj} = 175 \text{ °C}$, $-di/dt = 4.8 \text{ kA}/\mu\text{s}$	1.0		
			$T_{vj} = 200 \text{ °C}$, $-di/dt = 4.9 \text{ kA}/\mu\text{s}$	1.2		

4 Temperature sensor

Table 9 Characteristic values

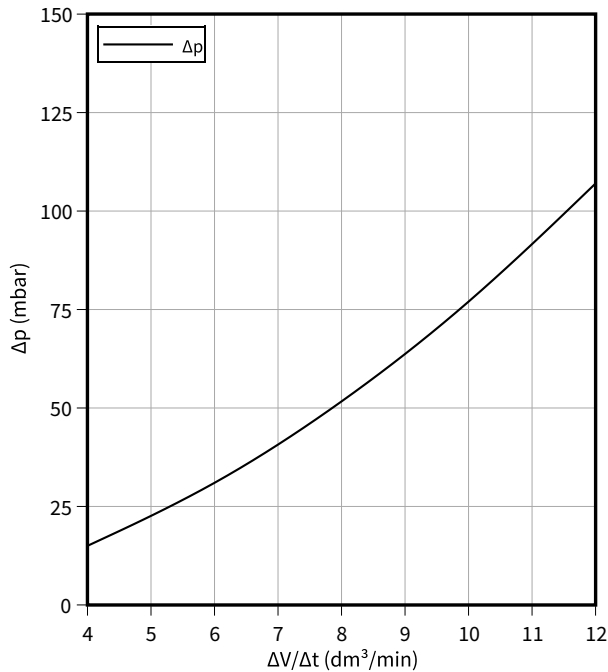
Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Transient sense current	I_{TS}				10	mA
Forward voltage	V_{TS}	$I_{TS} = 0.2 \text{ mA}$, $T_{vj} = 25 \text{ °C}$	2.574	2.624	2.674	V
		$I_{TS} = 0.2 \text{ mA}$, $T_{vj} = 85 \text{ °C}$	2.169	2.234	2.299	

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

$\Delta p = f(\Delta V/\Delta t)$

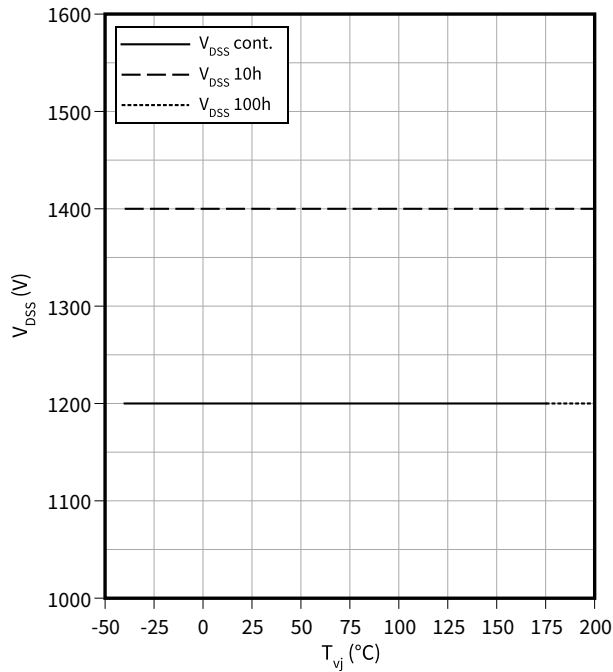
$T_f = 60\text{ }^{\circ}\text{C}$, fluid = 50% water / 50% ethylenglycol



Maximum allowed drain-source voltage, MOSFET

$V_{DSS} = f(T_{vj})$

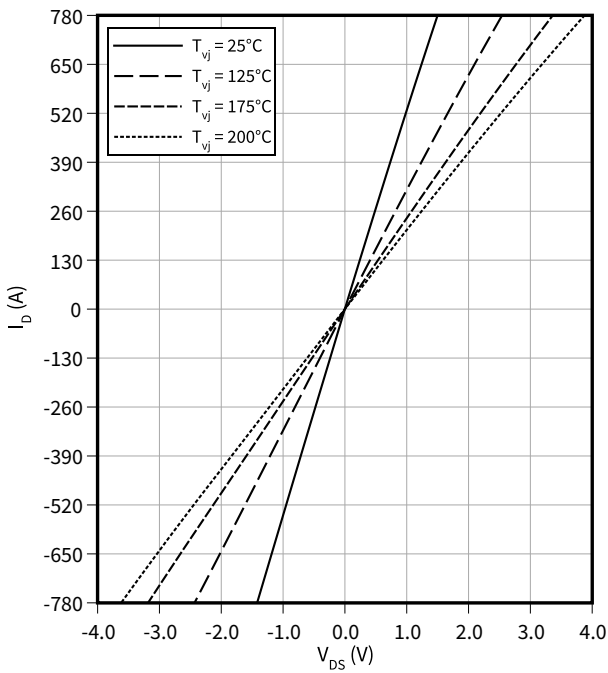
verified by characterization / design, not by test



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

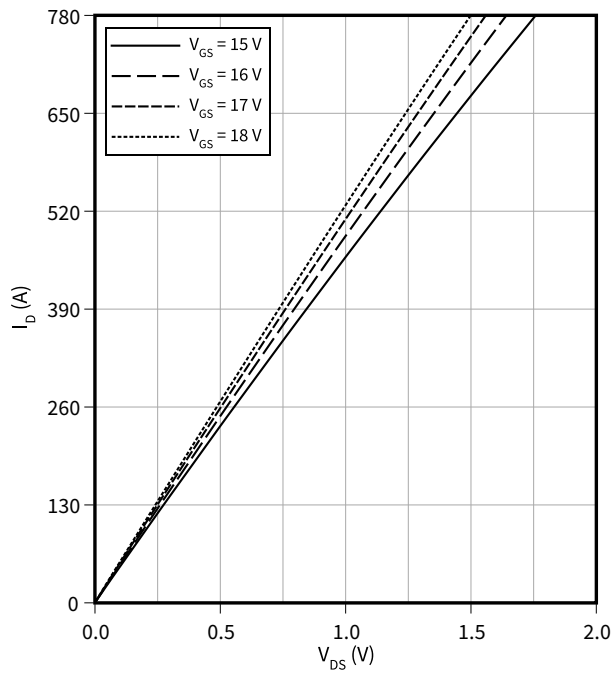
$V_{GS} = 18\text{ V}$



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

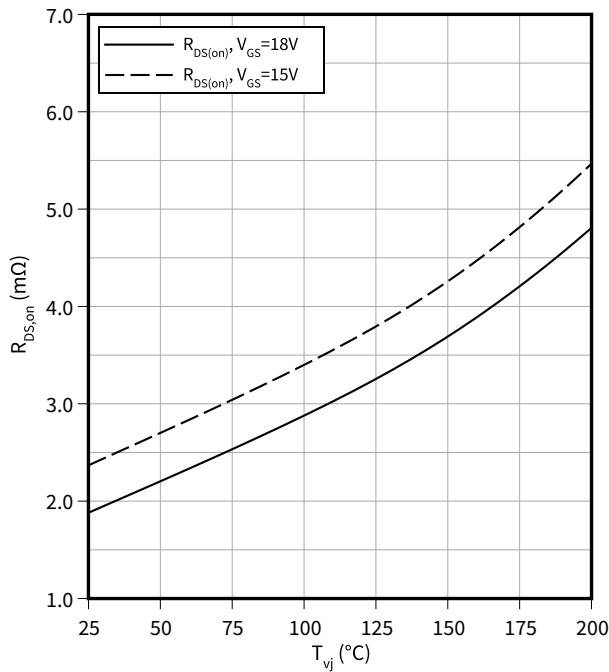
$T_{vj} = 25\text{ }^{\circ}\text{C}$



5 Characteristics diagrams

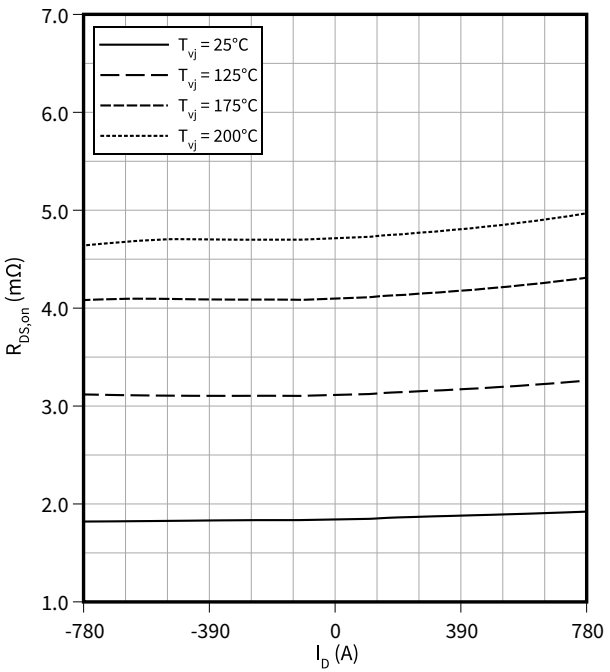
Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(T_{vj})$
 $I_D = 390\text{ A}, V_{GS} = 18\text{ V}$



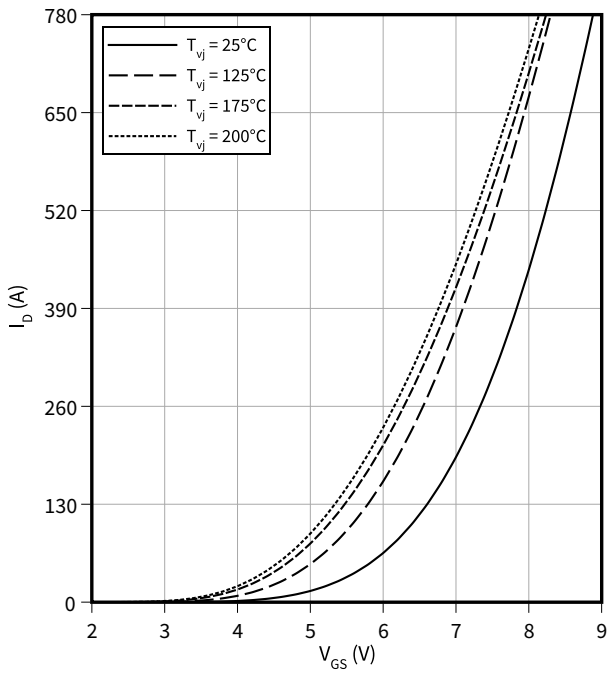
Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(I_D)$
 $V_{GS} = 18\text{ V}$



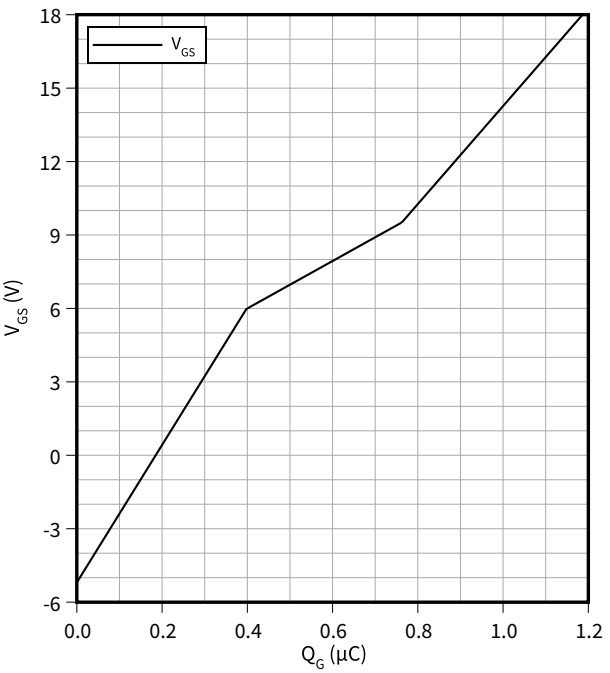
Transfer characteristic (typical), MOSFET

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



Gate charge characteristic (typical), MOSFET

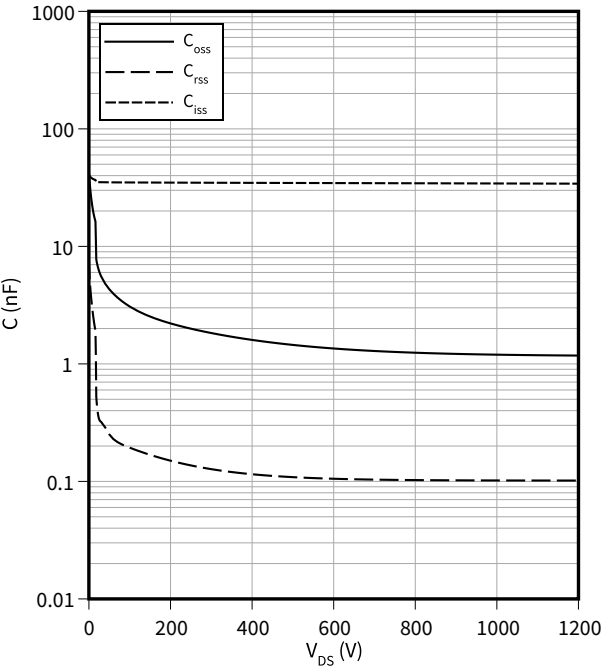
$V_{GS} = f(Q_G)$
 $V_{DD} = 750\text{ V}, T_{vj} = 25^\circ\text{C}$



5 Characteristics diagrams

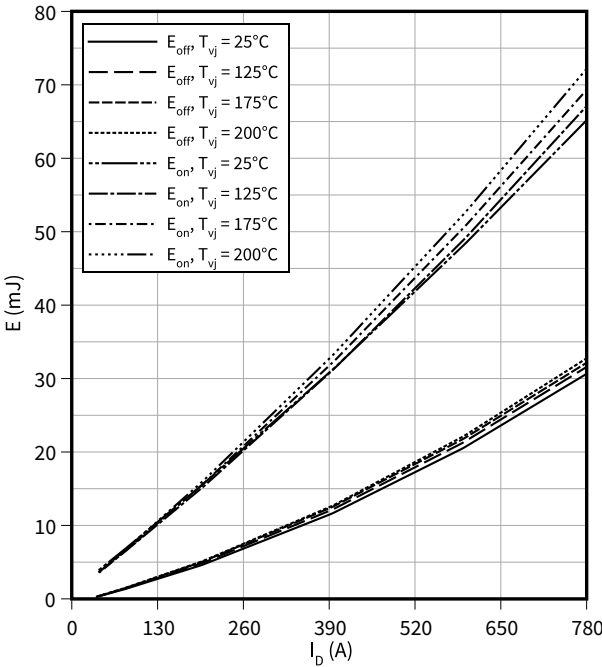
Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$
 $f = 1\text{ MHz}$, $V_{GS} = -5/18\text{ V}$, $T_{vj} = 25\text{ °C}$



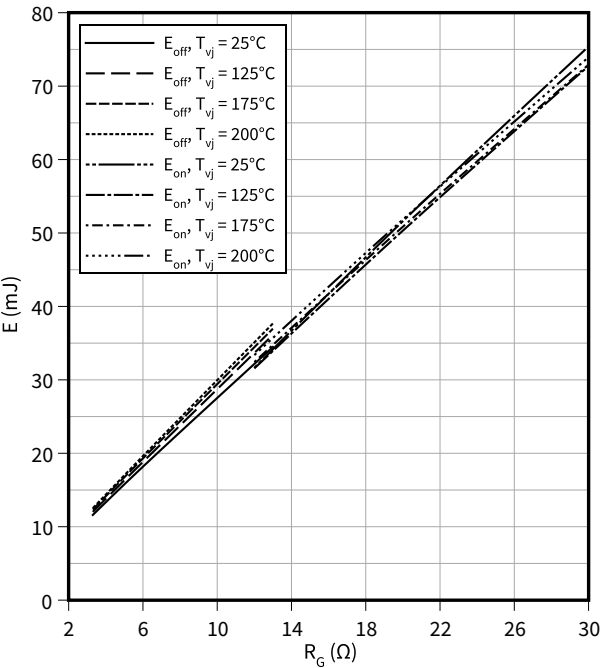
Switching losses (typical), MOSFET

$E = f(I_D)$
 $V_{DS} = 750\text{ V}$, $R_{G,off} = 3.3\text{ }\Omega$, $R_{G,on} = 12\text{ }\Omega$, $V_{GS} = -5/18\text{ V}$



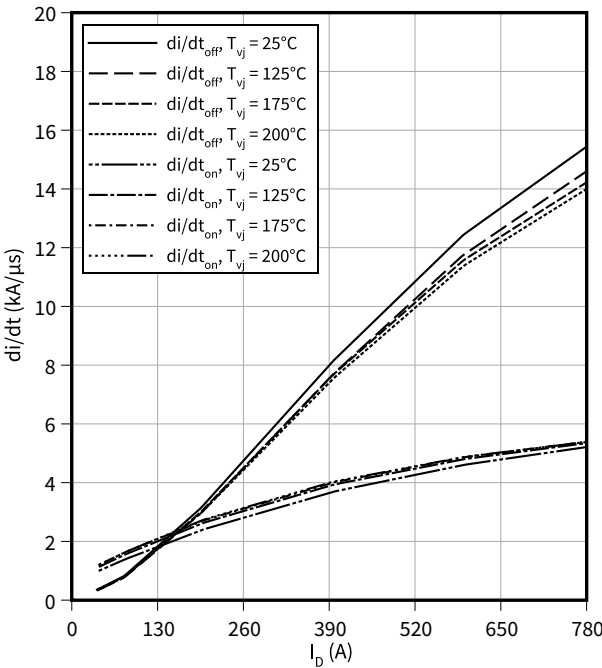
Switching losses (typical), MOSFET

$E = f(R_G)$
 $I_D = 390\text{ A}$, $V_{DS} = 750\text{ V}$, $V_{GS} = -5/18\text{ V}$



Current slope (typical), MOSFET

$di/dt = f(I_D)$
 $V_{DS} = 750\text{ V}$, $R_{G,off} = 3.3\text{ }\Omega$, $R_{G,on} = 12\text{ }\Omega$, $V_{GS} = -5/18\text{ V}$

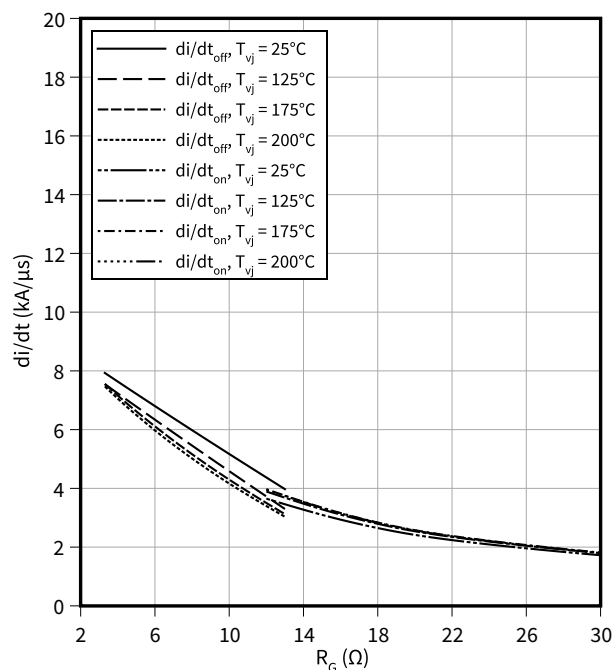


5 Characteristics diagrams

Current slope (typical), MOSFET

$$di/dt = f(R_G)$$

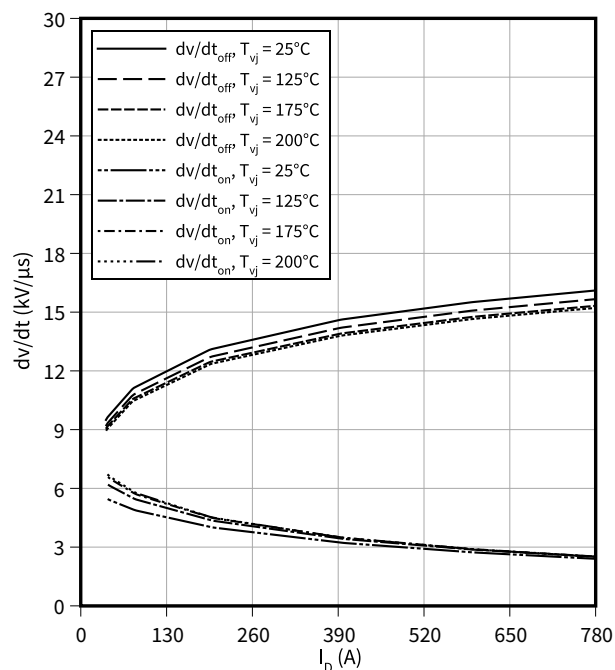
$V_{DS} = 750 \text{ V}$, $I_D = 390 \text{ A}$, $V_{GS} = -5/18 \text{ V}$



Voltage slope (typical), MOSFET

$$dv/dt = f(I_D)$$

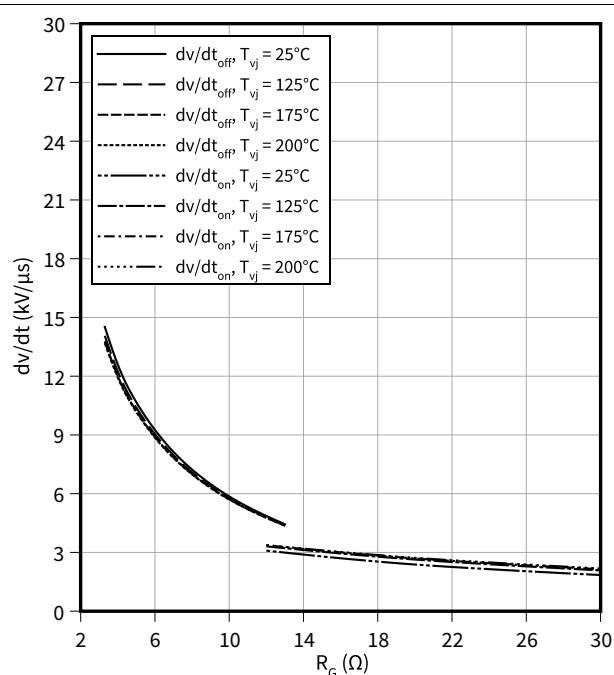
$V_{DS} = 750 \text{ V}$, $R_{G,off} = 3.3 \Omega$, $R_{G,on} = 12 \Omega$, $V_{GS} = -5/18 \text{ V}$



Voltage slope (typical), MOSFET

$$dv/dt = f(R_G)$$

$V_{DS} = 750 \text{ V}$, $I_D = 390 \text{ A}$, $V_{GS} = -5/18 \text{ V}$

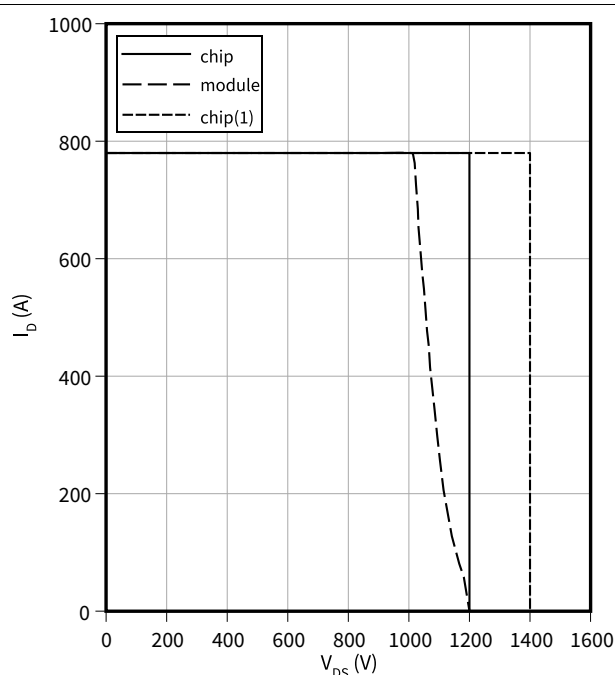


Reverse bias safe operating area (RBSOA), MOSFET

$$I_D = f(V_{DS})$$

$R_{G,off} = 3.3 \Omega$, $V_{GS} = +18/-5 \text{ V}$, $T_{vj} = 175^\circ \text{C}$

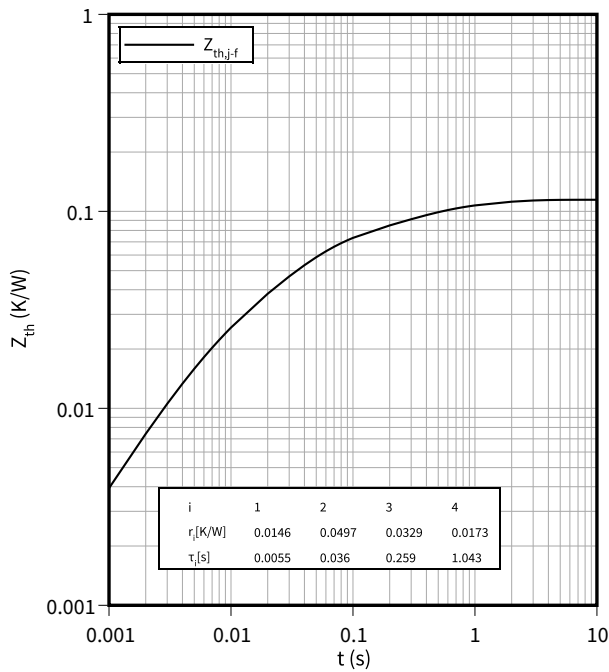
(1) for 10h over lifetime



5 Characteristics diagrams

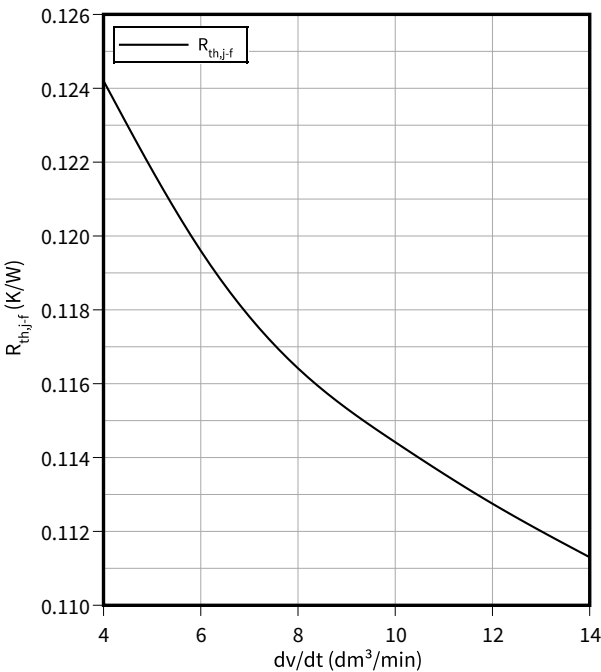
Transient thermal impedance (typical), MOSFET

$Z_{th} = f(t)$
 $\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 60 \text{ }^\circ\text{C}$, fluid = 50% water / 50% ethylenglycol



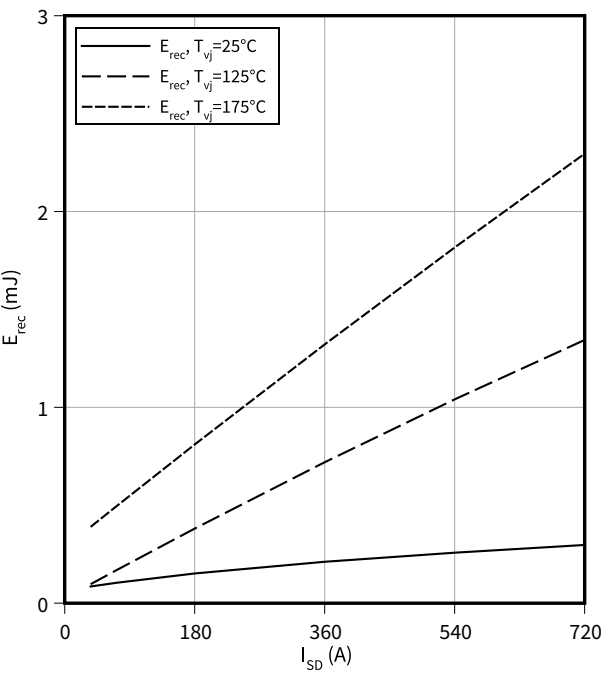
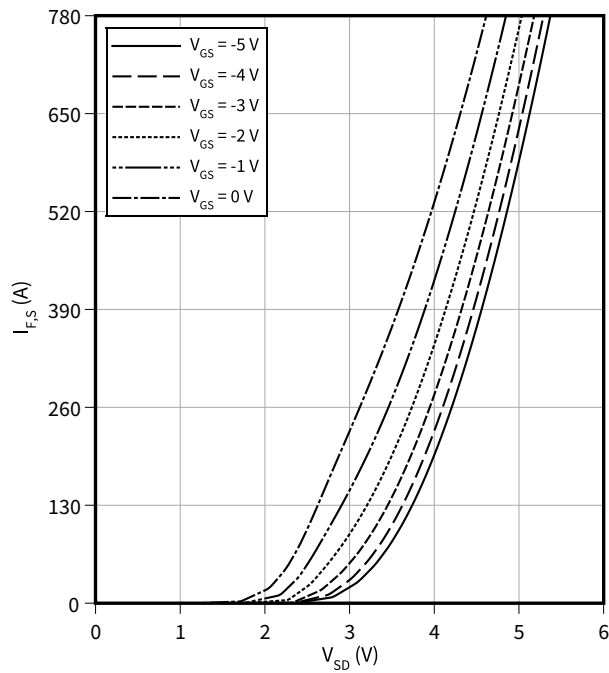
Thermal impedance (typical), MOSFET

$R_{th,j-f} = f(dv/dt)$
fluid = 50% water / 50% ethylenglycol , $T_f = 60 \text{ }^\circ\text{C}$



Forward characteristic body diode (typical), MOSFET

$I_{F,S} = f(V_{SD})$
 $T_{vj} = 25 \text{ }^\circ\text{C}$

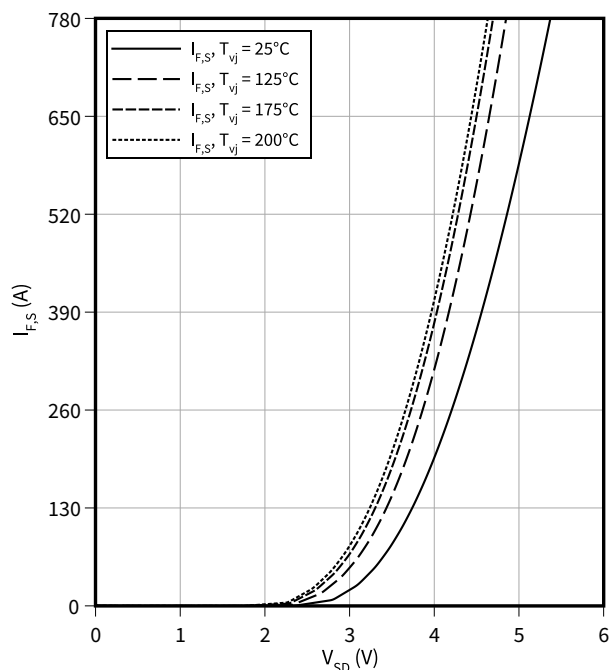


5 Characteristics diagrams

Forward characteristic body diode (typical), MOSFET

$$I_{F,S} = f(V_{SD})$$

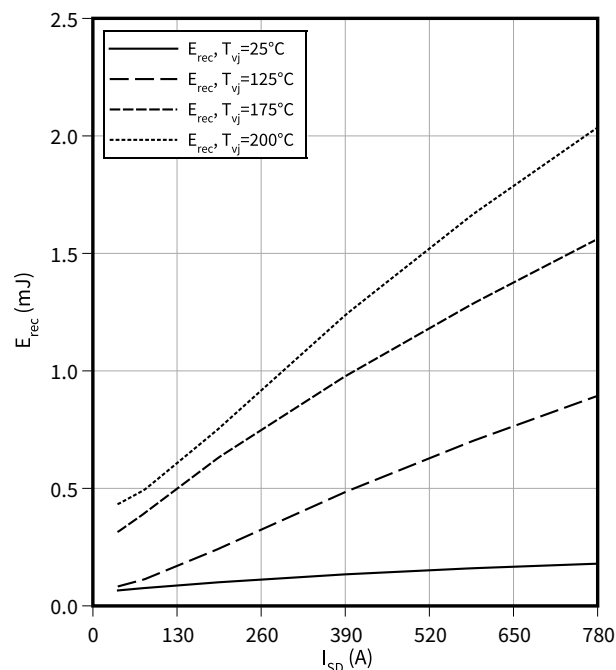
$$V_{GS} = -5 \text{ V}$$



Switching losses body diode (typical), MOSFET

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

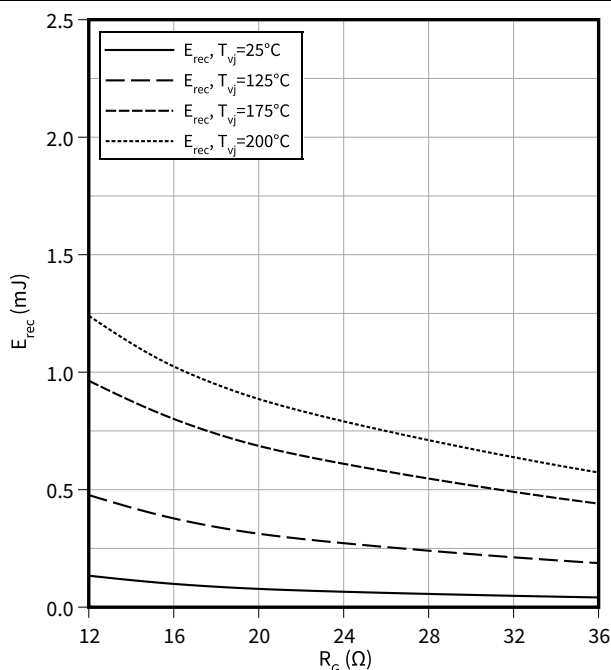
$$V_r = 750 \text{ V}, R_{G,on} = 12 \Omega$$



Switching losses body diode (typical), MOSFET

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

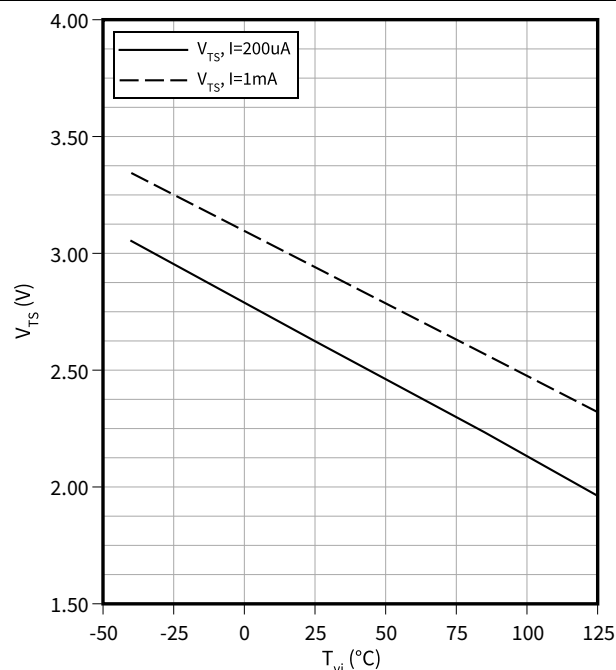
$$V_r = 750 \text{ V}, I_{F,S} = 390 \text{ A}$$



Temperature characteristic (typical), Temperature sensor

$$V_{TS} = f(T_{vj})$$

$$I_{TS} = 0.2 \text{ mA}$$



6 Circuit diagram

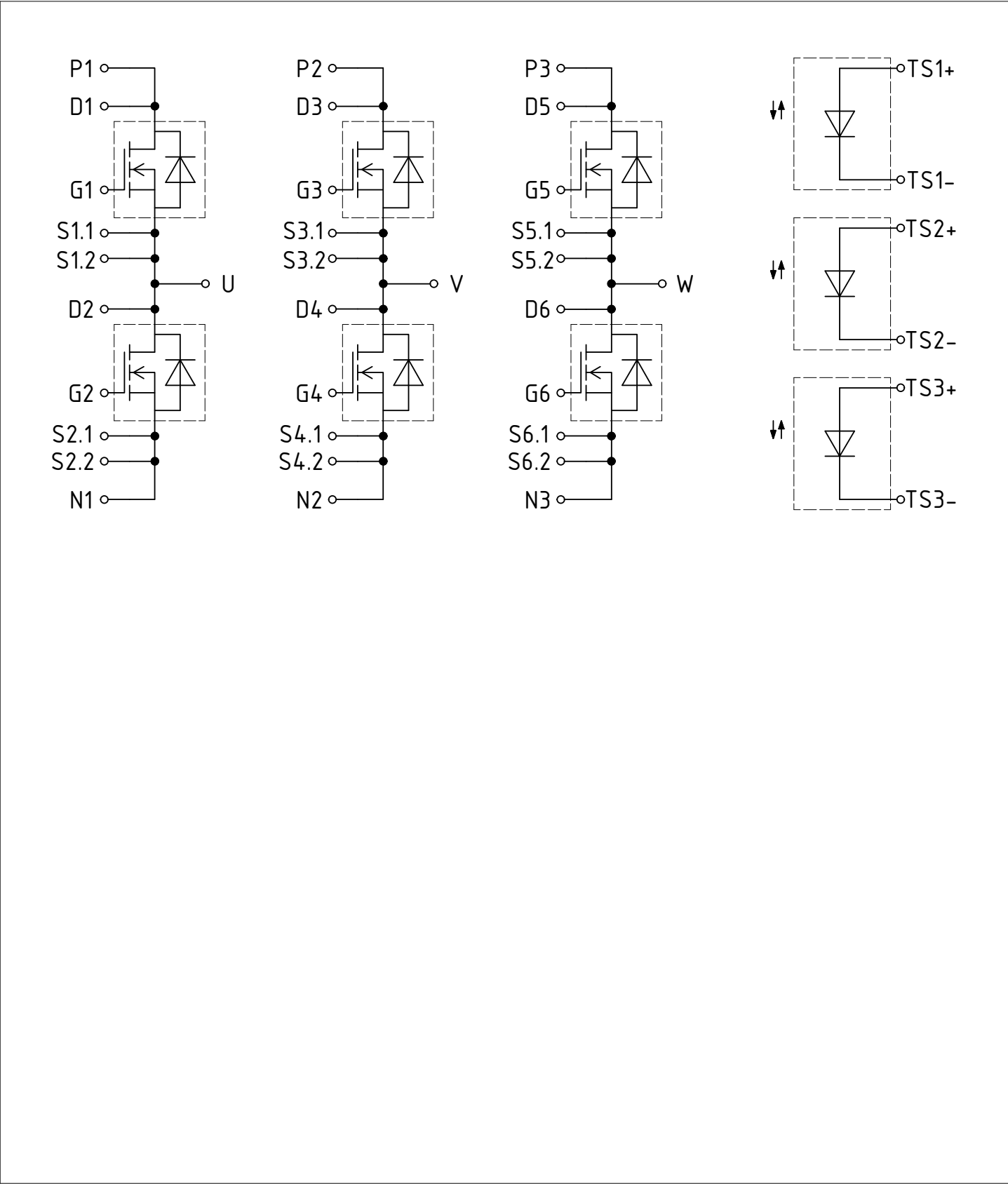


Figure 1

7 Package outlines

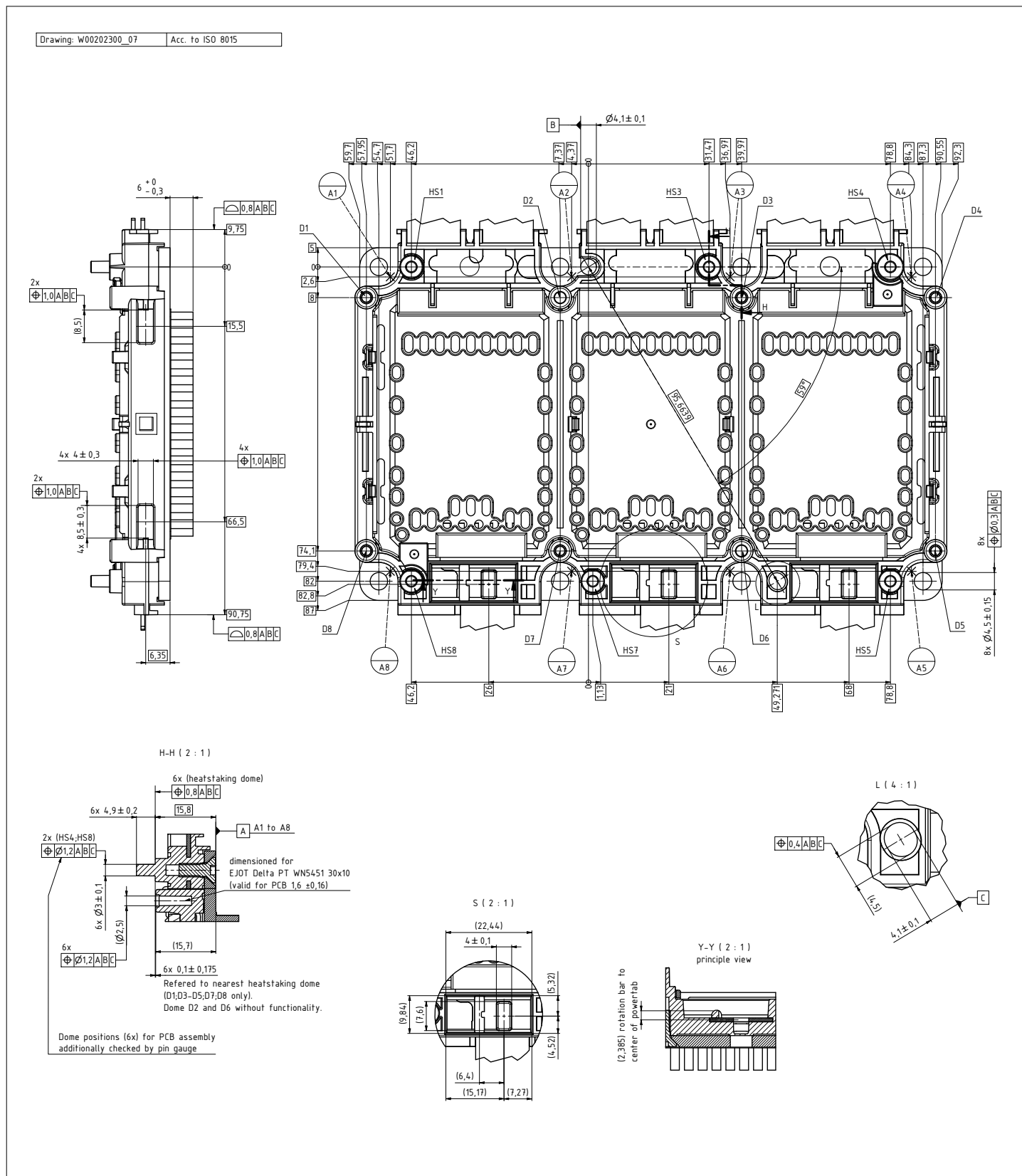


Figure 2

7 Package outlines

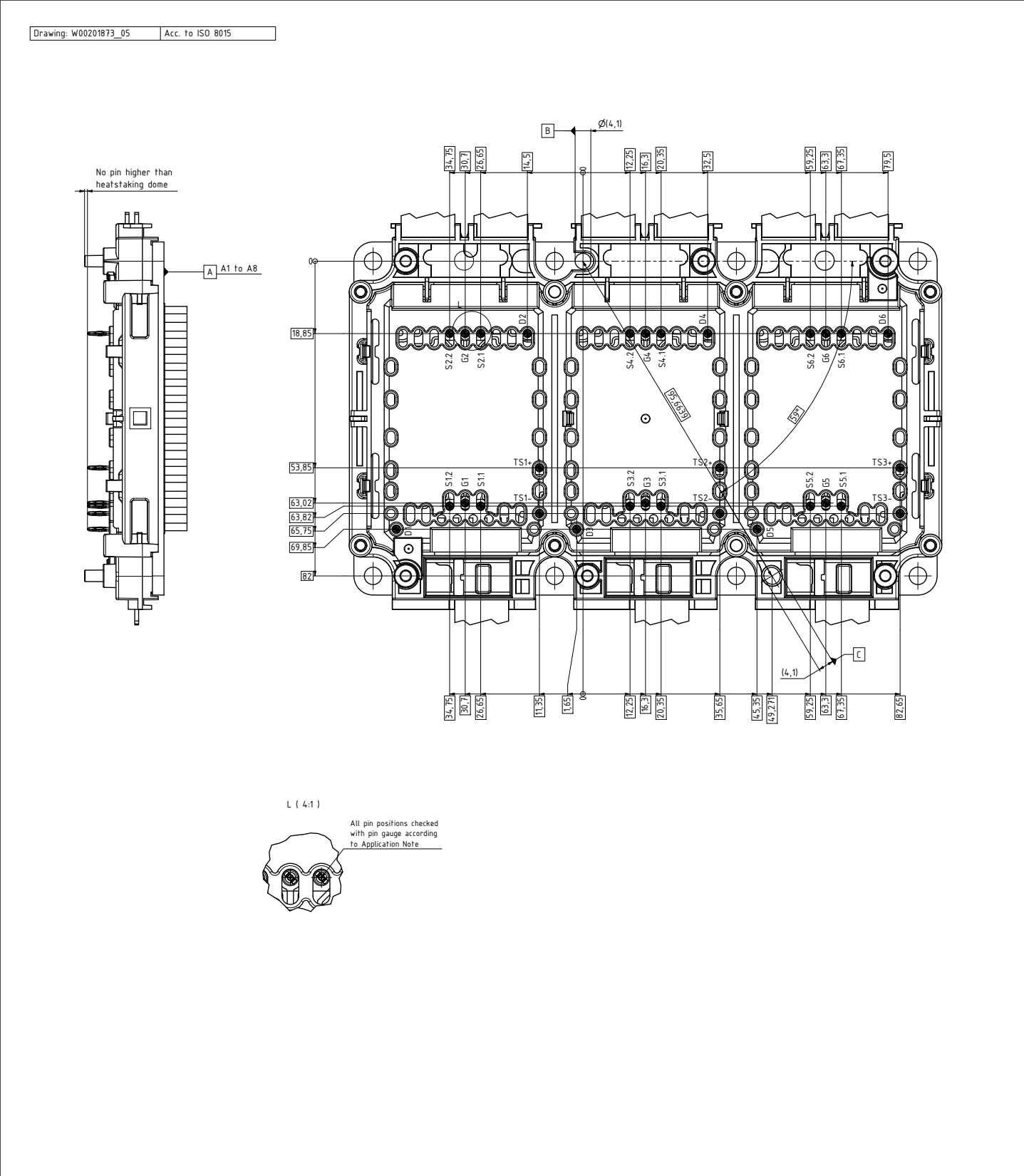


Figure 4

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	Content	Digit	Example
	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	 7154914284655054991153071549142846550549911530		

Packing label code				
Code format	Barcode Code128			
Encoding	Code Set A			
Symbol size	34 digits			
Standard	IEC8859-1			
Code content	Content	Identifier	Digit	Example
	Module serial number	X	2 – 9	95056609
	Module material number	1T	12 – 19	2X0003E0
	Production order number	S	21 – 25	754389
	Date code (production year)	9D	28 – 31	1139
	Date code (production week)	Q	33 – 34	15
Example	 X950566091T2X0003E0S754389D1139Q15			

Figure 5



Revision history

Revision history

Document revision	Date of release	Description of changes
0.10	2021-09-16	Initial version
0.11	2022-08-25	Target datasheet
0.20	2023-06-20	Preliminary datasheet
1.00	2024-04-19	Final datasheet

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Edition 2024-04-19

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference
IFX-ABC170-004

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