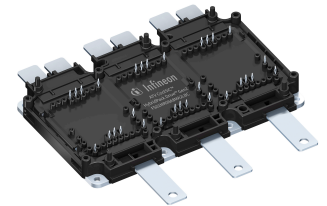


Final datasheet
HybridPACK™ Drive G2 module with SiC MOSFET

Features

- Electrical features
 - $V_{DS} = 750\text{ V}$
 - $I_{DN} = 620\text{ A}$
 - 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

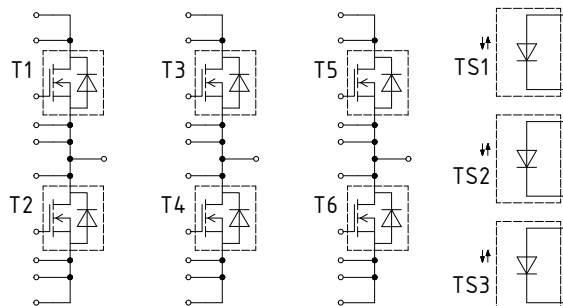


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1 Package

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 ₃ N ₄	
Creepage distance	d_{creep}	terminal to heatsink	9.5	mm
Creepage distance	d_{creep}	terminal to terminal	9.5	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, $\Delta V/\Delta t = 10$ dm ³ /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		125	°C
Mounting torque for module mounting ²⁾	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) 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
			Min.	Typ.	Max.	
Drain-source voltage	V_{DS}		continuous operation	750		V
			10h over life time	900		
DC drain current	$I_{D,nom}$	$V_{GS} = 18\text{ V}, T_f = 65\text{ °C}$			$T_{vj,max} = 175\text{ °C}$	A
Pulsed drain current	$I_{D,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1240		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	$R_{DS,on}$	$I_D = 620\text{ A}, V_{GS} = 18\text{ V}$	$T_{vj} = 25\text{ °C}$	1.03	1.69	mΩ	
			$T_{vj} = 125\text{ °C}$	1.45			
			$T_{vj} = 175\text{ °C}$	1.80			
			$T_{vj} = 200\text{ °C}$	2.00			
Drain-source on-resistance	$R_{DS,on}$	$I_D = 620\text{ A}, V_{GS} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.28	2.00	mΩ	
			$T_{vj} = 125\text{ °C}$	1.65			
			$T_{vj} = 175\text{ °C}$	1.99			
			$T_{vj} = 200\text{ °C}$	2.21			
Gate threshold voltage	$V_{GS,th}$	$I_D = 200\text{ mA}, V_{GS} = V_{DS},$ (tested after 1ms pulse at $V_{GS} = +20\text{ V}$)	$T_{vj} = 25\text{ °C}$	3.20 ¹⁾	3.90	4.55	V
Total gate charge	Q_G	$V_{DS} = 470\text{ V}, V_{GS} = -5/18\text{ V}$		1.48			μC
Internal gate resistor	$R_{G,int}$		$T_{vj} = 25\text{ °C}$	0.53			Ω
Input capacitance	C_{iss}	$f = 1\text{ MHz}, V_{DS} = 470\text{ V}$	$T_{vj} = 25\text{ °C}$	43			nF
Output capacitance	C_{oss}	$f = 1\text{ MHz}, V_{DS} = 470\text{ V}$	$T_{vj} = 25\text{ °C}$	2.85			nF

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Reverse transfer capacitance	C_{rSS}	$f = 1 \text{ MHz}, V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	0.25		nF
C_{OSS} stored energy	E_{OSS}	$V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	1250		μJ
Drain-source leakage current	I_{DSX}	$V_{GS} = -5 \text{ V}, V_{DSS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		100	μA
Gate-source leakage current	I_{GSS}	$V_{GS} = 20 \text{ V}, V_{DS} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$		100	nA
Turn-on delay time, inductive load	$t_{d,on}$	$I_D = 620 \text{ A}, R_{G,on} = 10.5 \text{ } \Omega, V_{GS} = -5/18 \text{ V}, V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	128		ns
			$T_{vj} = 125 \text{ °C}$	107		
			$T_{vj} = 175 \text{ °C}$	99		
			$T_{vj} = 200 \text{ °C}$	96		
Rise time (inductive load)	t_r	$I_D = 620 \text{ A}, R_{G,on} = 10.5 \text{ } \Omega, V_{GS} = -5/18 \text{ V}, V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	108		ns
			$T_{vj} = 125 \text{ °C}$	103		
			$T_{vj} = 175 \text{ °C}$	101		
			$T_{vj} = 200 \text{ °C}$	99		
Turn-off delay time, inductive load	$t_{d,off}$	$I_D = 620 \text{ A}, R_{G,off} = 4.2 \text{ } \Omega, V_{GS} = -5/18 \text{ V}, V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	318		ns
			$T_{vj} = 125 \text{ °C}$	339		
			$T_{vj} = 175 \text{ °C}$	352		
			$T_{vj} = 200 \text{ °C}$	359		
Fall time (inductive load)	t_f	$I_D = 620 \text{ A}, R_{G,off} = 4.2 \text{ } \Omega, V_{GS} = -5/18 \text{ V}, V_{DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ °C}$	53		ns
			$T_{vj} = 125 \text{ °C}$	57		
			$T_{vj} = 175 \text{ °C}$	58		
			$T_{vj} = 200 \text{ °C}$	59		
Turn-on energy loss per pulse	E_{on}	$I_D = 620 \text{ A}, R_{G,on} = 10.5 \text{ } \Omega, V_{GS} = -5/18 \text{ V}, V_{DS} = 470 \text{ V}, L_\sigma = 6.5 \text{ nH}$	$T_{vj} = 25 \text{ °C}, di/dt = 4.7 \text{ kA}/\mu\text{s}$	27.60		mJ
			$T_{vj} = 125 \text{ °C}, di/dt = 4.9 \text{ kA}/\mu\text{s}$	26.40		
			$T_{vj} = 175 \text{ °C}, di/dt = 5 \text{ kA}/\mu\text{s}$	26.30		
			$T_{vj} = 200 \text{ °C}, di/dt = 5 \text{ kA}/\mu\text{s}$	26.30		

(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}	$I_D = 620\text{ A}$, $R_{G,off} = 4.2\ \Omega$, $V_{GS} = -5/18\text{ V}$, $V_{DS} = 470\text{ V}$, $L_\sigma = 6.5\text{ nH}$	$T_{vj} = 25\text{ °C}$, $du/dt = 6\text{ kV}/\mu\text{s}$		22.90		mJ
			$T_{vj} = 125\text{ °C}$, $du/dt = 5.9\text{ kV}/\mu\text{s}$		23.80		
			$T_{vj} = 175\text{ °C}$, $du/dt = 5.8\text{ kV}/\mu\text{s}$		24.30		
			$T_{vj} = 200\text{ °C}$, $du/dt = 5.8\text{ kV}/\mu\text{s}$		24.50		
Short circuit data	I_{SC}	$V_{DD} = 470\text{ V}$, $V_{GS} = -5/18\text{ V}$, $R_{G,on} = 10.5\ \Omega$, $R_{G,off} = 4.2\ \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$	$t_{SC} = 1.2\ \mu\text{s}$, $T_{vj} = 200\text{ °C}$		10000		A
Short circuit data	I_{SC}	$V_{DD} = 470\text{ V}$, $V_{GS} = -5/15\text{ V}$, $R_{G,on} = 10.5\ \Omega$, $R_{G,off} = 4.2\ \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$	$t_{SC} = 2\ \mu\text{s}$, $T_{vj} = 200\text{ °C}$		6500		A
Thermal resistance, junction to cooling fluid ²⁾	$R_{th,j-f}$	per MOSFET, 50% water / 50% ethylenglycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 60\text{ °C}$			0.107	0.118 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	750	V
			10h over life time	900	
DC body diode forward current	$I_{F,S}$	$T_{vj,max} = 175\text{ °C}$, $V_{GS} = -5\text{ V}$	$T_f = 65\text{ °C}$	170	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1240	A

Table 8 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Forward voltage	$V_{F,SD}$	$I_{F,S} = 620 \text{ A}, V_{GS} = -5 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		4.64	6.73	V
			$T_{vj} = 125 \text{ }^\circ\text{C}$		4.25		
			$T_{vj} = 175 \text{ }^\circ\text{C}$		4.09		
			$T_{vj} = 200 \text{ }^\circ\text{C}$		4.04		
Peak reverse recovery current	I_{rrm}	$I_{F,S} = 620 \text{ A}, V_{GS} = -5 \text{ V}, V_{R,DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		117		A
			$T_{vj} = 125 \text{ }^\circ\text{C}$		133		
			$T_{vj} = 175 \text{ }^\circ\text{C}$		152		
			$T_{vj} = 200 \text{ }^\circ\text{C}$		162		
Recovered charge	Q_{rr}	$I_{F,S} = 620 \text{ A}, V_{GS} = -5 \text{ V}, V_{R,DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		2.20		μC
			$T_{vj} = 125 \text{ }^\circ\text{C}$		3.60		
			$T_{vj} = 175 \text{ }^\circ\text{C}$		5.00		
			$T_{vj} = 200 \text{ }^\circ\text{C}$		5.70		
Reverse recovery energy	E_{rec}	$I_{F,S} = 620 \text{ A}, V_{GS} = -5 \text{ V}, V_{R,DS} = 470 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}, -di/dt = 5.4 \text{ kA}/\mu\text{s}$		0.3		mJ
			$T_{vj} = 125 \text{ }^\circ\text{C}, -di/dt = 5.6 \text{ kA}/\mu\text{s}$		0.5		
			$T_{vj} = 175 \text{ }^\circ\text{C}, -di/dt = 5.7 \text{ kA}/\mu\text{s}$		0.8		
			$T_{vj} = 200 \text{ }^\circ\text{C}, -di/dt = 5.8 \text{ kA}/\mu\text{s}$		0.9		

4 Temperature sensor

Table 9 Characteristic values

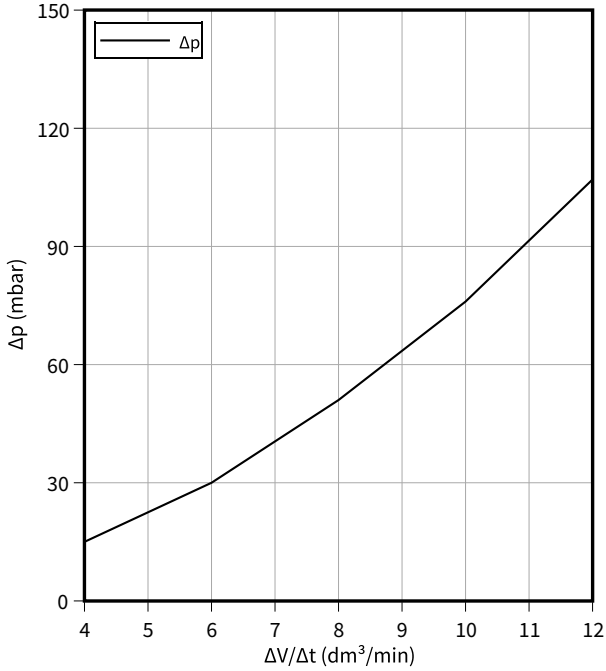
Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Transient sense current	I_{TS}				10	mA	
Forward voltage	V_{TS}		$I_{TS} = 0.2 \text{ mA}, T_{vj} = 25 \text{ }^\circ\text{C}$	2.574	2.624	2.674	V
			$I_{TS} = 0.2 \text{ mA}, T_{vj} = 85 \text{ }^\circ\text{C}$	2.169	2.234	2.299	

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

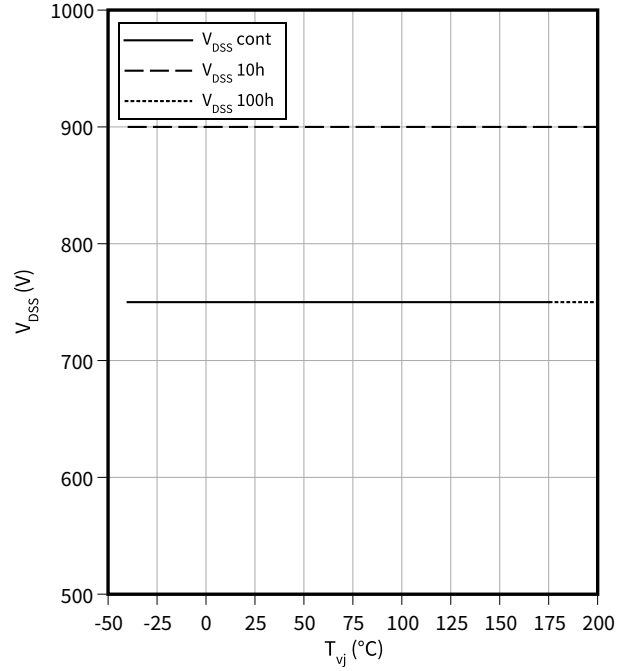
fluid = 50% water / 50% ethylenglycol, $T_f = 60\text{ °C}$



Maximum allowed drain-source voltage, MOSFET

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

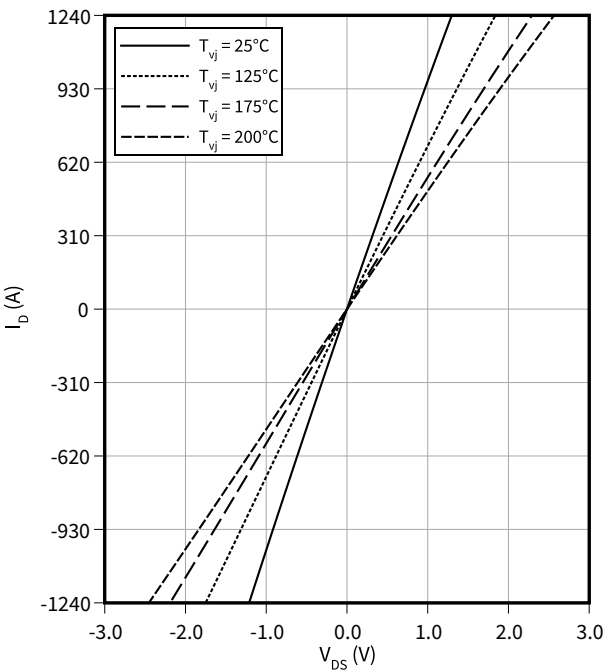
verified by characterization / design, not by test



Output characteristic (typical), MOSFET

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

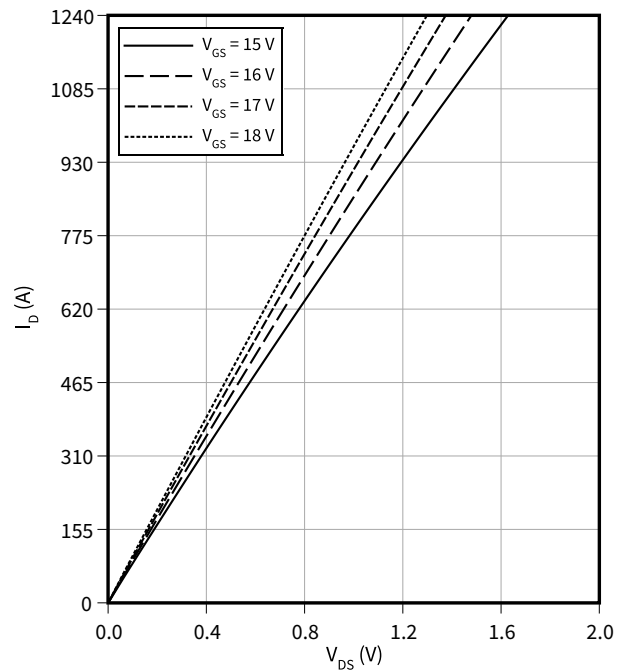
$V_{GS} = 18\text{ V}$



Output characteristic (typical), MOSFET

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

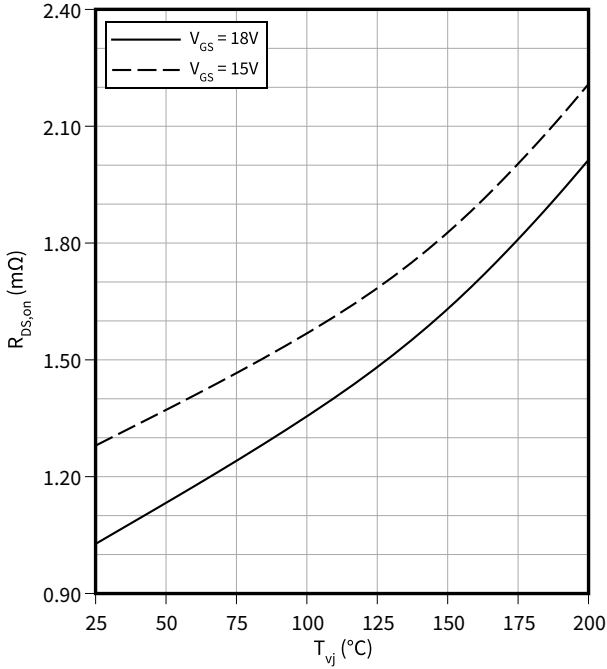
$T_{vj} = 25\text{ °C}$



5 Characteristics diagrams

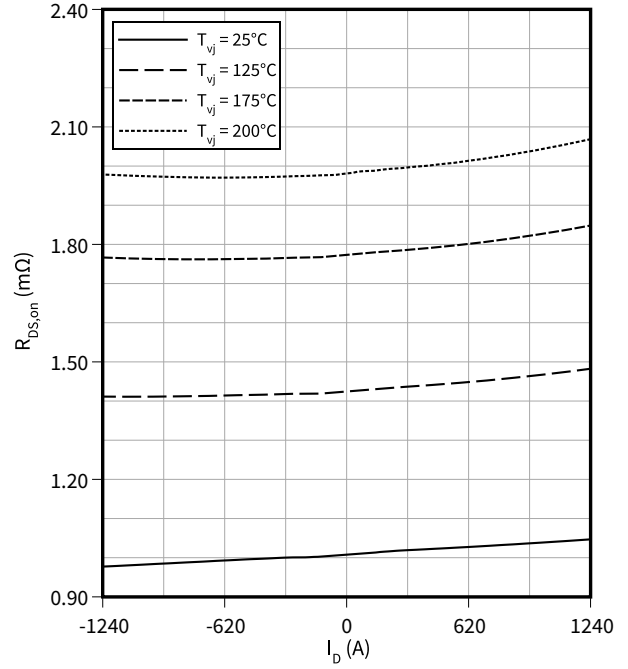
Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(T_{vj})$
 $I_D = 620 \text{ A}, V_{GS} = 18 \text{ V}$



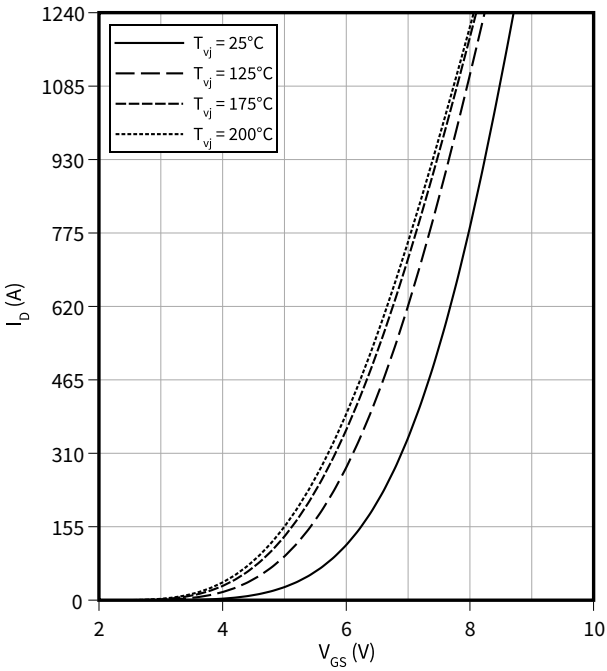
Drain-source on-resistance (typical), MOSFET

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



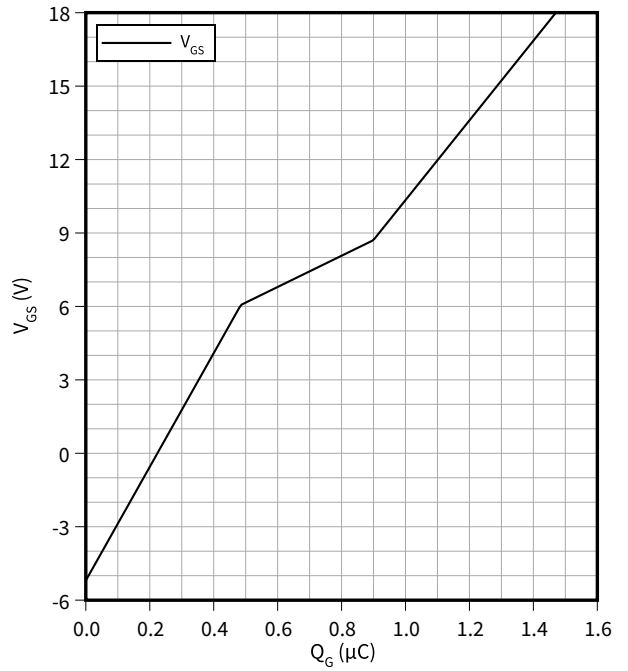
Transfer characteristic (typical), MOSFET

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



Gate charge characteristic (typical), MOSFET

$V_{GS} = f(Q_G)$
 $V_{DD} = 470 \text{ V}, T_{vj} = 25 \text{ }^{\circ}C$

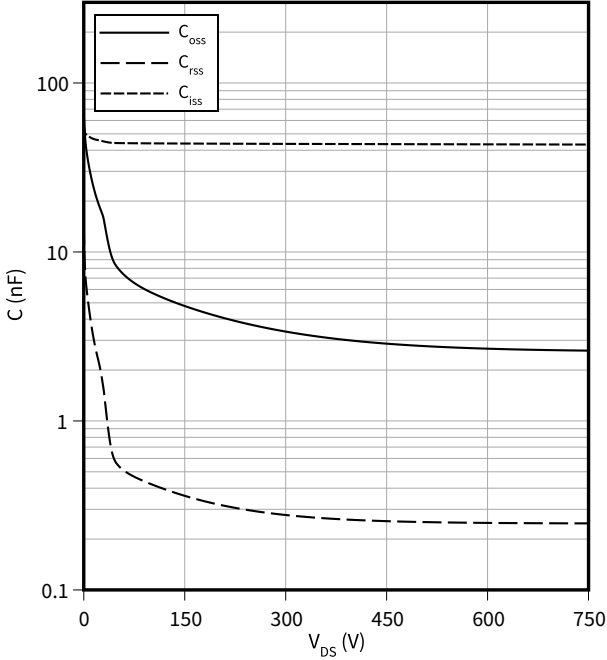


5 Characteristics diagrams

Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$

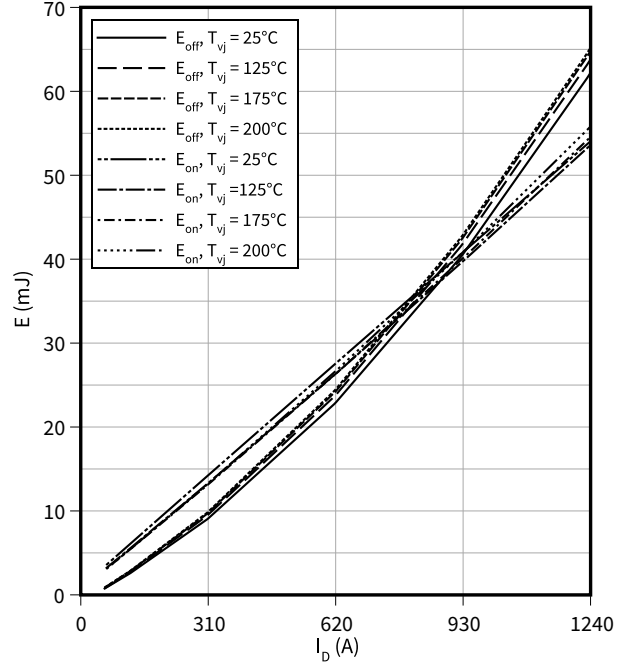
$f = 1 \text{ MHz}, V_{GS} = -5/18 \text{ V}, T_{vj} = 25 \text{ }^\circ\text{C}$



Switching losses (typical), MOSFET

$E = f(I_D)$

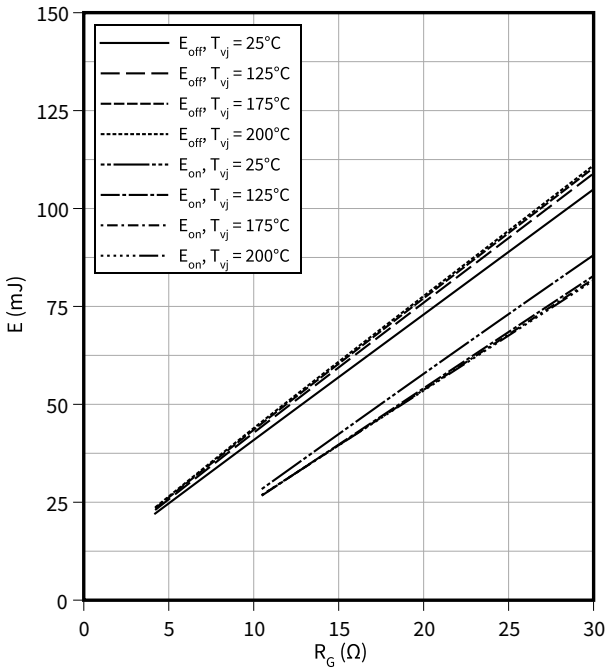
$V_{DS} = 470 \text{ V}, R_{G,off} = 4.2 \text{ } \Omega, R_{G,on} = 10.5 \text{ } \Omega, V_{GS} = -5/18 \text{ V}$



Switching losses (typical), MOSFET

$E = f(R_G)$

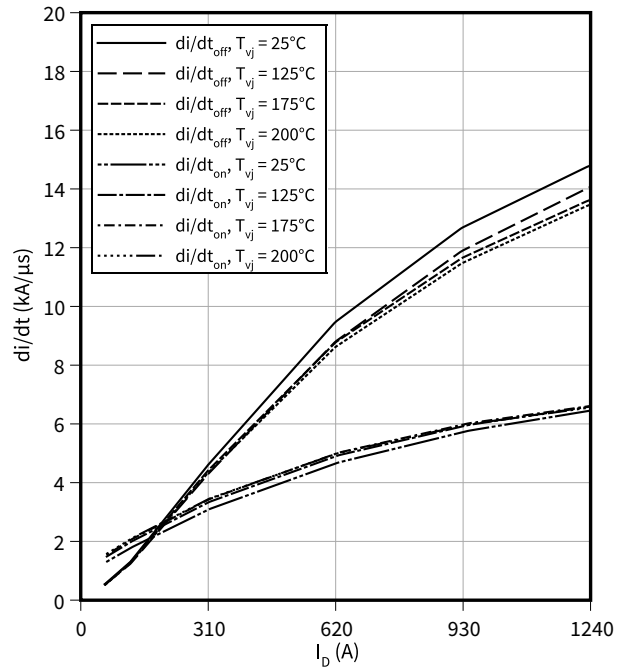
$I_D = 620 \text{ A}, V_{DS} = 470 \text{ V}, V_{GS} = -5/18 \text{ V}$



Current slope (typical), MOSFET

$di/dt = f(I_D)$

$V_{DS} = 470 \text{ V}, R_{G,off} = 4.2 \text{ } \Omega, R_{G,on} = 10.5 \text{ } \Omega, V_{GS} = -5/18 \text{ V}$

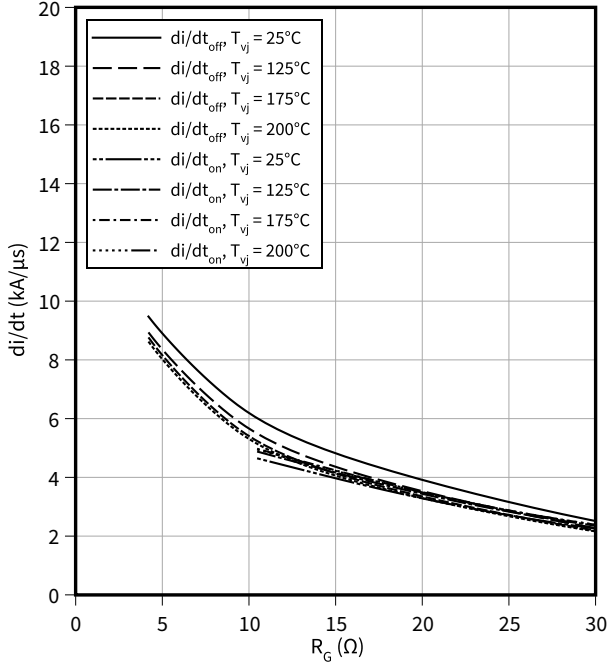


5 Characteristics diagrams

Current slope (typical), MOSFET

$di/dt = f(R_G)$

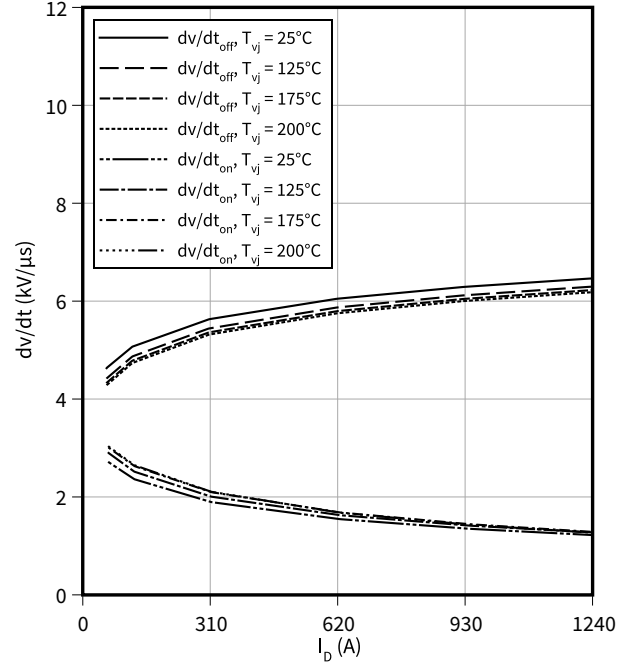
$V_{DS} = 470 \text{ V}$, $I_D = 620 \text{ A}$, $V_{GS} = -5/18 \text{ V}$



Voltage slope (typical), MOSFET

$dv/dt = f(I_D)$

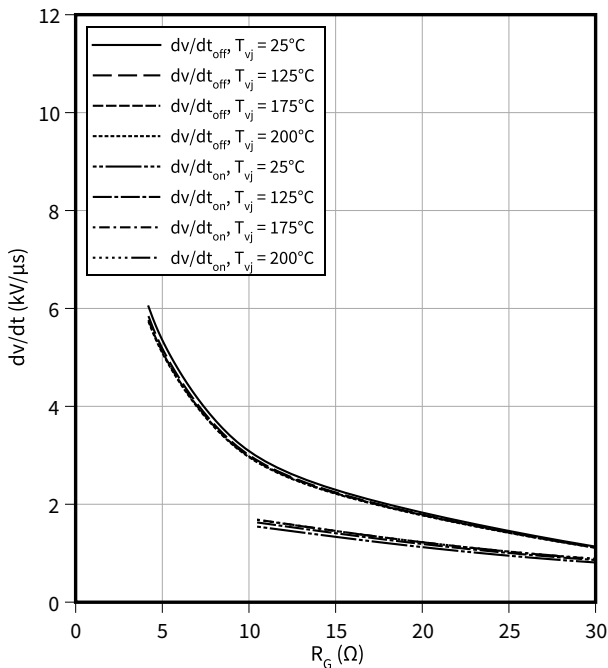
$V_{DS} = 470 \text{ V}$, $R_{G,off} = 4.2 \text{ Ω}$, $R_{G,on} = 10.5 \text{ Ω}$, $V_{GS} = -5/18 \text{ V}$



Voltage slope (typical), MOSFET

$dv/dt = f(R_G)$

$I_D = 620 \text{ A}$, $V_{DS} = 470 \text{ V}$, $V_{GS} = -5/18 \text{ V}$

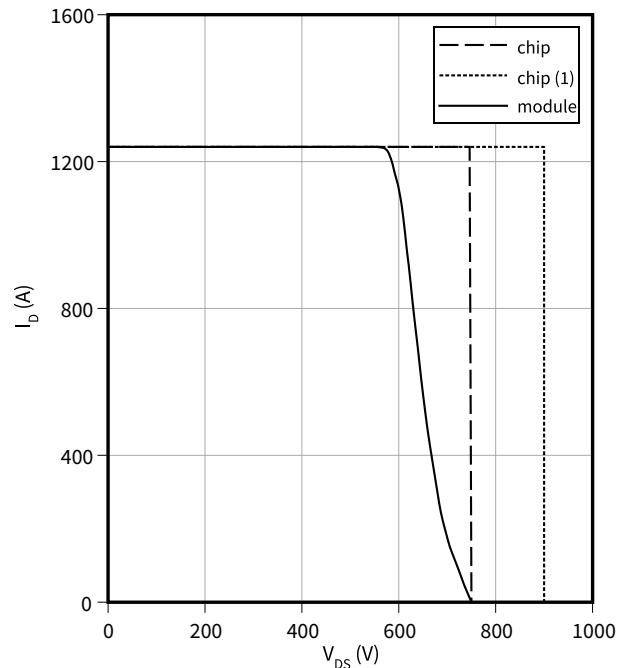


Reverse bias safe operating area (RBSOA), MOSFET

$I_D = f(V_{DS})$

$R_{G,off} = 4.2 \text{ Ω}$, $V_{GS} = +18/-5 \text{ V}$, $T_{vj} = 175 \text{ °C}$

(1) for 10h over lifetime

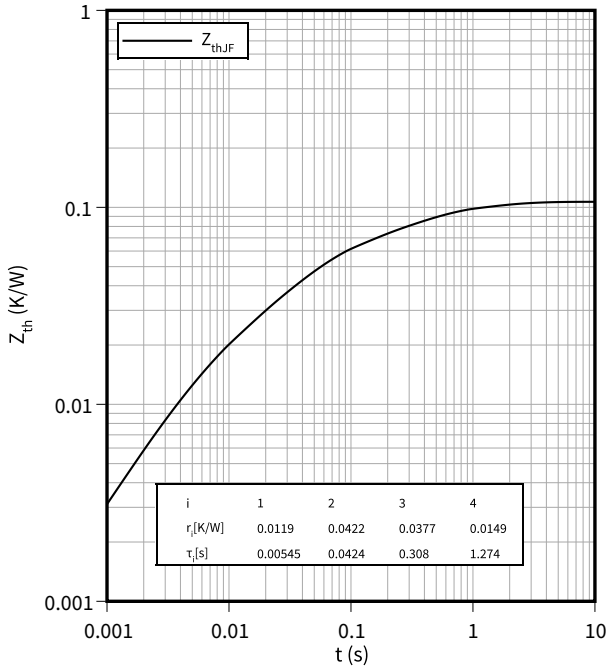


5 Characteristics diagrams

Transient thermal impedance (typical), MOSFET

$Z_{th} = f(t)$

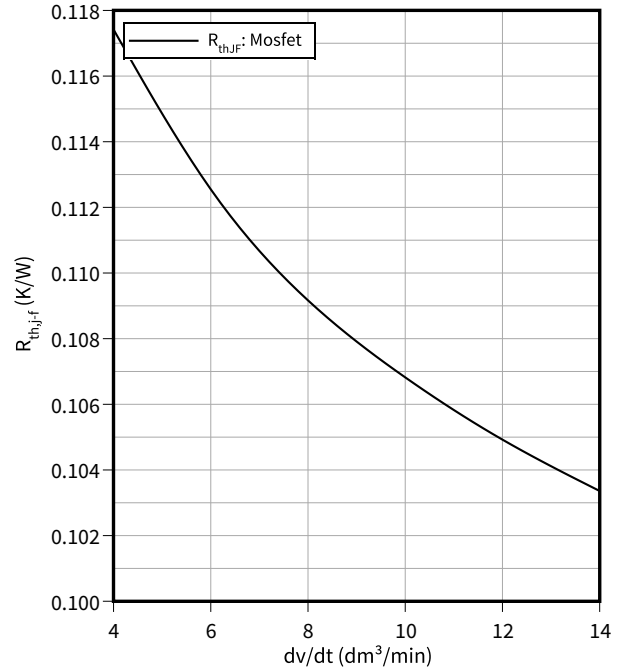
$\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, fluid = 50% water/50% ethylenglycol, $T_f = 60 \text{ }^\circ\text{C}$



Thermal impedance (typical), MOSFET

$R_{th,j-f} = f(dv/dt)$

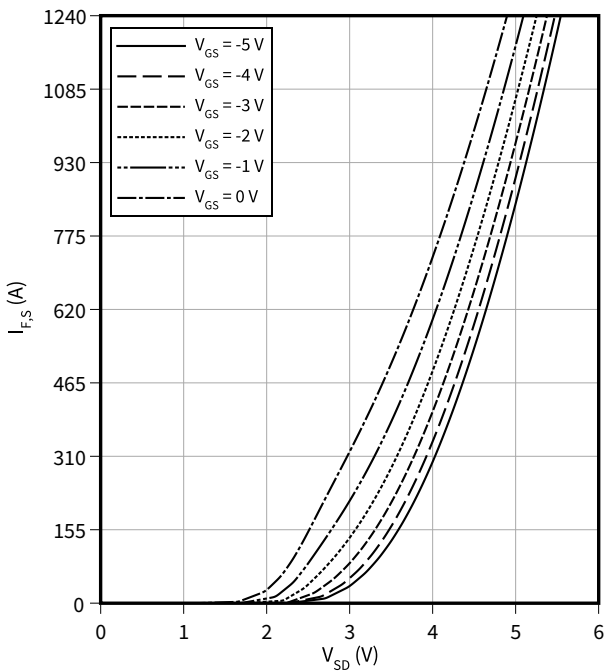
fluid = 50% water/50% ethylenglycol, $T_f = 60 \text{ }^\circ\text{C}$



Forward characteristic body diode (typical), MOSFET

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

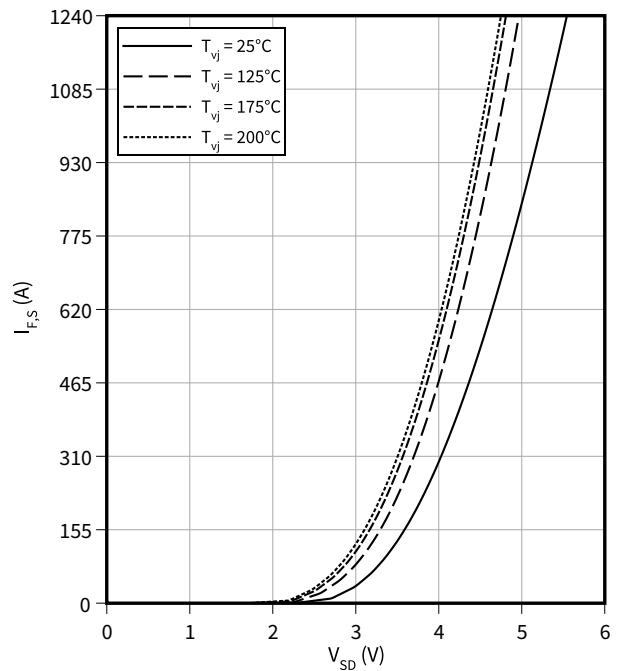
$T_{vj} = 25 \text{ }^\circ\text{C}$



Forward characteristic body diode (typical), MOSFET

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

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

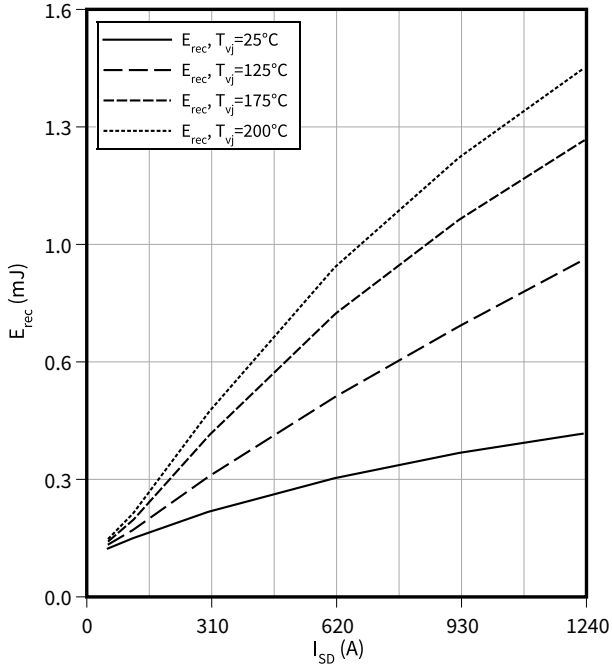


5 Characteristics diagrams

Switching losses body diode (typical), MOSFET

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

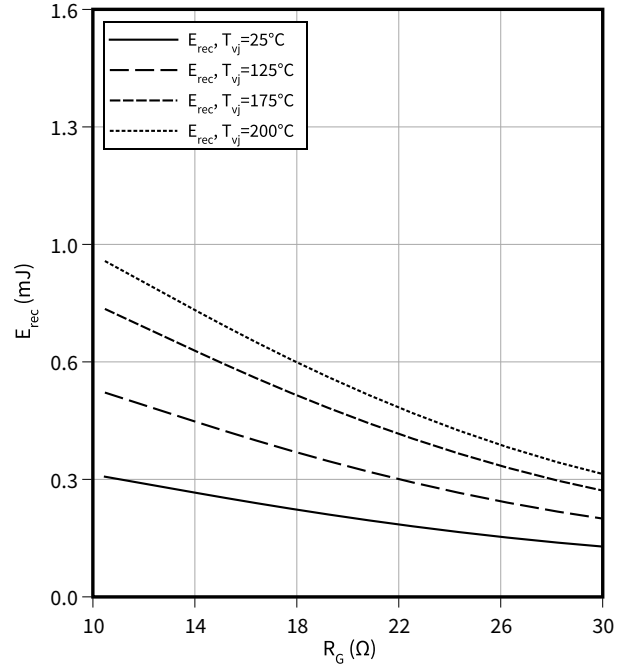
$V_r = 470\text{ V}$, $R_{G,on} = 10.5\ \Omega$



Switching losses body diode (typical), MOSFET

$E_{rec} = f(R_G)$

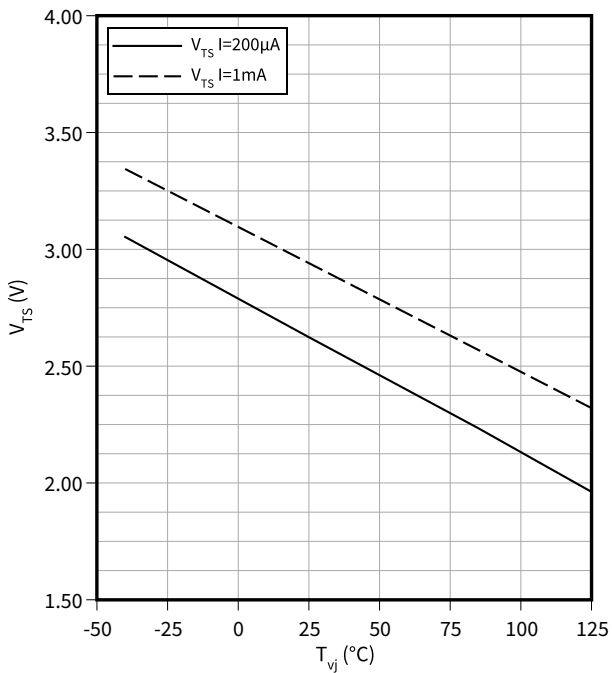
$V_r = 470\text{ V}$, $I_{F,S} = 620\text{ A}$



Temperature characteristic (typical), Temperature sensor

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

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



6 Circuit diagram

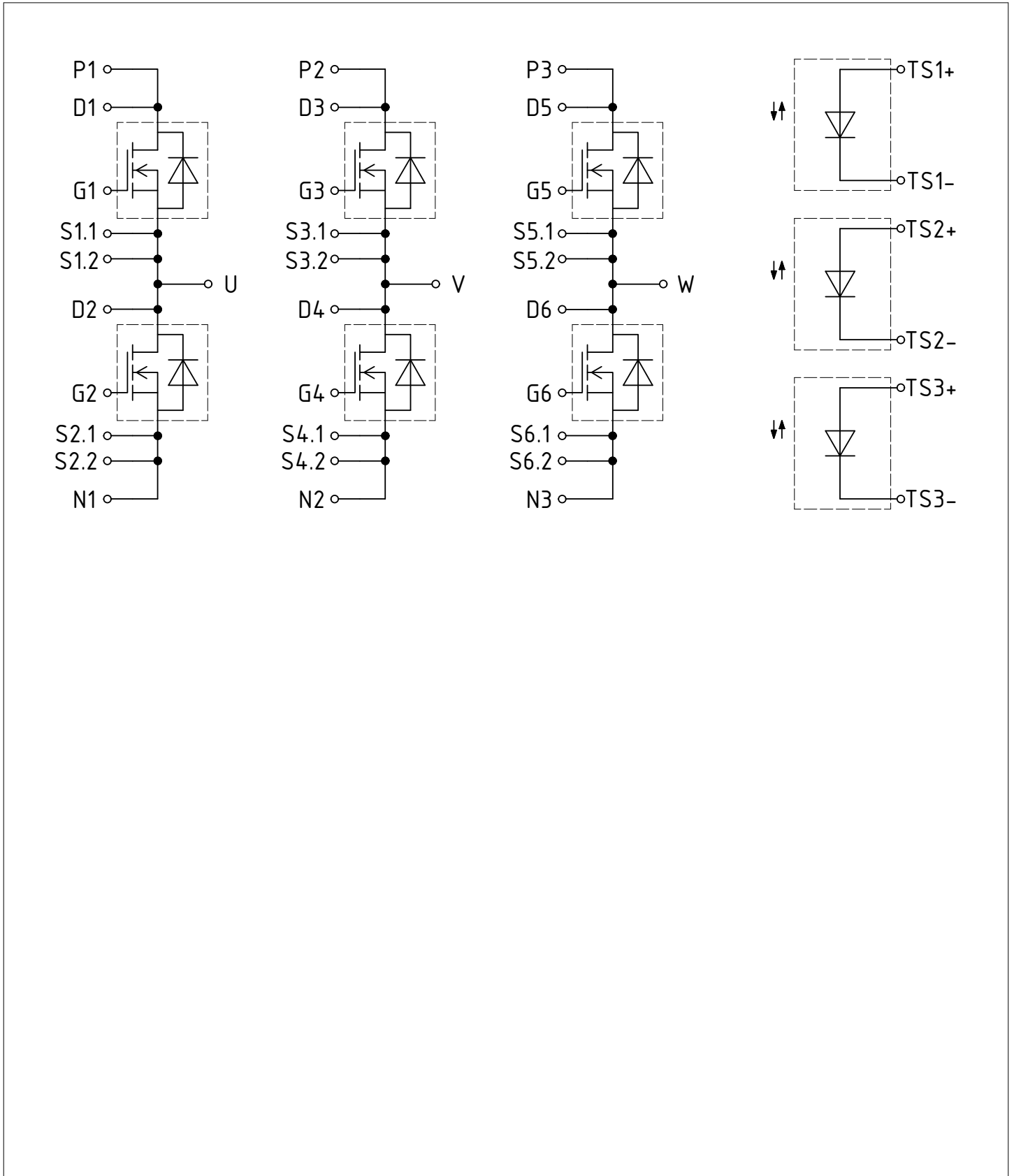


Figure 1

7 Package outlines

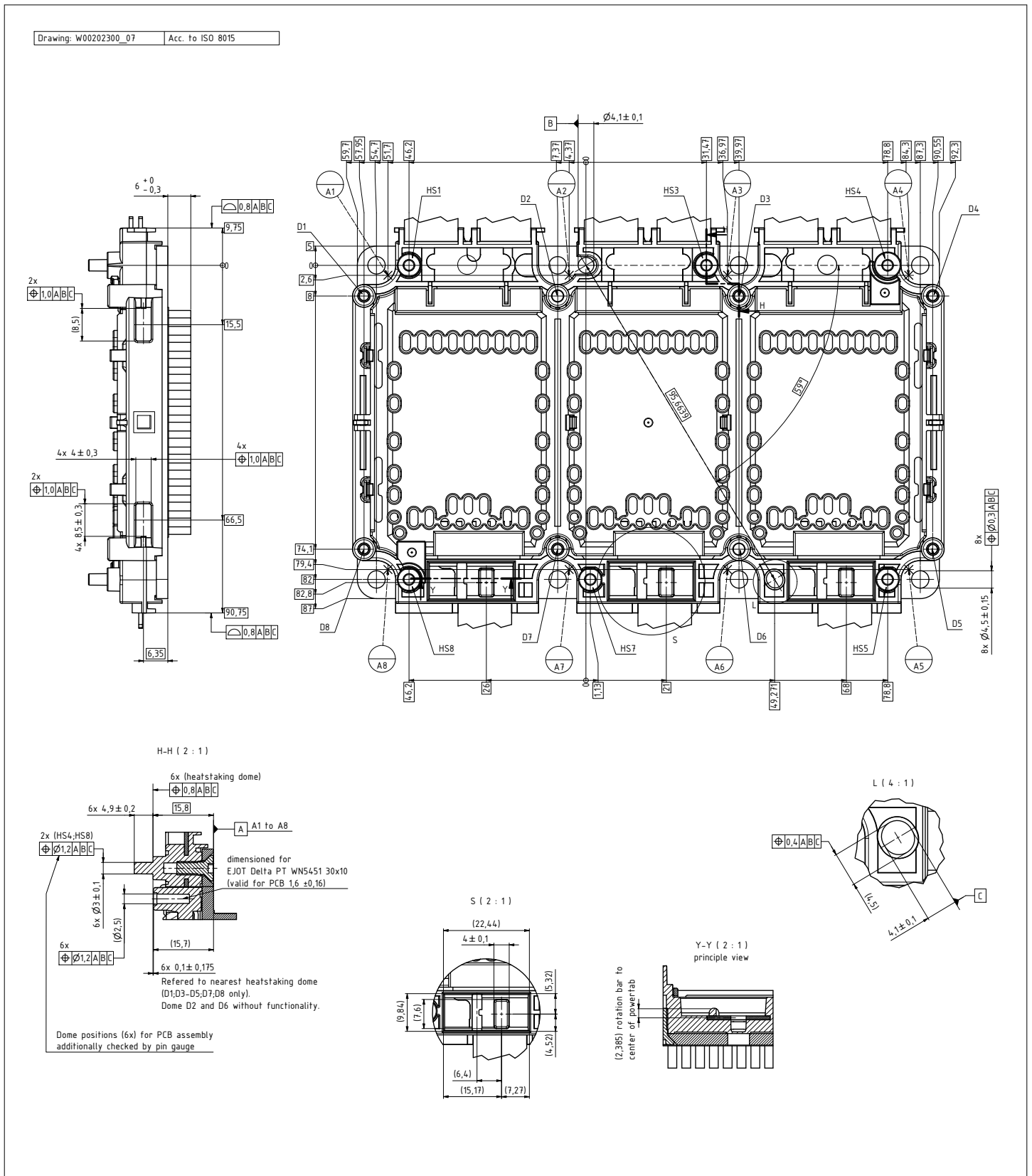


Figure 2

7 Package outlines

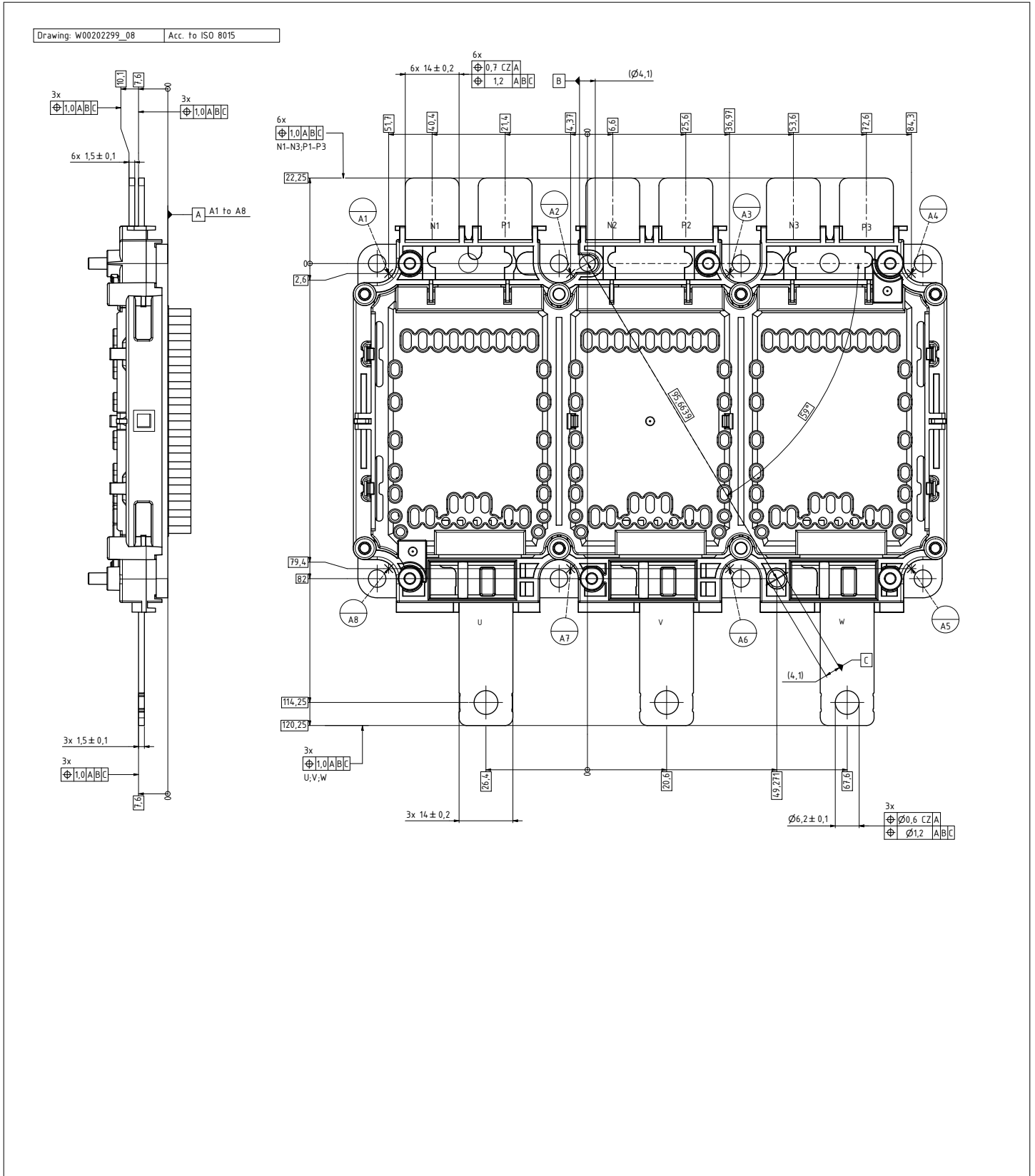


Figure 3

7 Package outlines

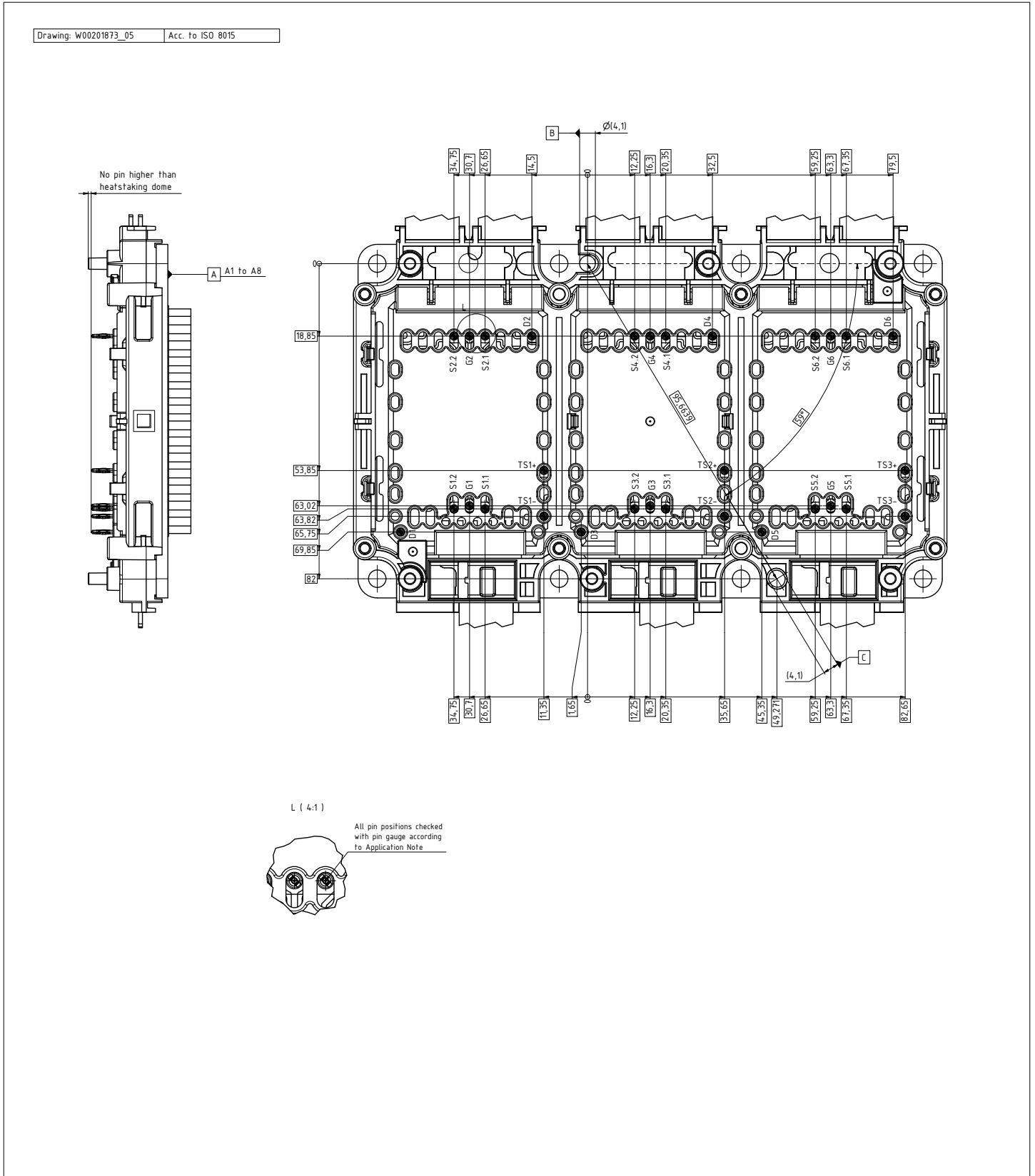


Figure 4

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	<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	
Packing label code				
Code format	Barcode Code128			
Encoding	Code Set A			
Symbol size	34 digits			
Standard	IEC8859-1			
Code content	<i>Content</i>	<i>Identifier</i>	<i>Digit</i>	<i>Example</i>
	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

Document revision	Date of release	Description of changes
0.10	2022-04-06	Initial version
0.11	2023-01-19	Target datasheet
0.20	2023-06-20	Preliminary datasheet
1.00	2024-03-14	Final datasheet

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