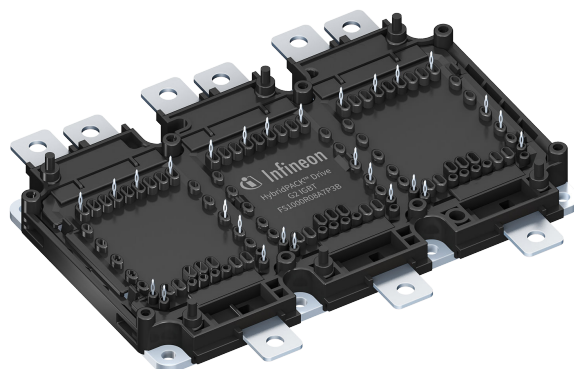


Final datasheet

HybridPACK™ Drive G2 module

Features

- Electrical features
 - $V_{CES} = 750\text{ V}$
 - $I_{CN} = 1000\text{ A} / I_{CRM} = 2000\text{ A}$
 - Low $V_{CE,sat}$
 - Low switching losses
 - Low Q_g and C_{rss}
 - Low inductive design
 - $T_{vj,op} = 175^\circ\text{C}$
 - Integrated on-chip temperature sensor
 - Short-time extended operation temperature $T_{vj,op} = 185^\circ\text{C}$
- Mechanical features
 - 4.25 kV DC 1 second insulation
 - High creepage and clearance distances
 - Direct-cooled PinFin base plate
 - Guiding elements for PCB and cooler assembly
 - PressFIT contact technology
 - RoHS compliant, lead-free
 - UL 94 V0 module frame
 - Al_2O_3 substrate with low thermal resistance



Potential applications

- Automotive applications
- (Hybrid) electrical vehicles (H)EV

Product validation

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

Description

The HybridPACK™ Drive is a very compact six-pack module (750V/1000A) optimized for hybrid and electric vehicles.

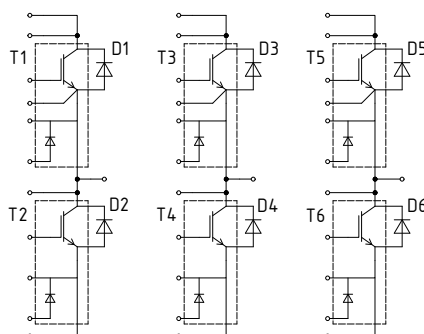


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 0$ Hz, $t = 1$ sec	4.25	kV
Material of module baseplate			Cu+Ni ¹⁾	
Internal isolation		basic insulation (class 1, IEC 61140)	Al ₂ O ₃	
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	$I_{t,rms}$	$T_{Ct} = 125$ °C	800			A
Heat-staking dome temperature ¹⁾	T_{HS}	$t_{steking} < 10$ s			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% ethylene glycol, $\Delta V / \Delta t = 10$ dm ³ /min, $T_f = 65$ °C		76 ¹⁾		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate} < 40$ °C (relative pressure)			3.0	bar
		$T_{baseplate} \geq 40$ °C (relative pressure)			2.5	
Stray inductance module	$L_{s,CE}$			8.0		nH
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_f = 25$ °C, per switch		0.73		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	0.5	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 IGBT, Inverter

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Collector-emitter voltage	V_{CES}	$T_{vj} = 25\text{ °C}$	750	V
Implemented collector current	I_{CN}		1000	A
Continuous DC collector current	$I_{C,nom}$	$T_f = 65\text{ °C}$, $T_{vj,max} = 175\text{ °C}$	600 ¹⁾	A
Repetitive peak collector current	I_{CRM}	verified by design, t_p limited by $T_{vj,max}$	2000	A
Total power dissipation	P_{tot}	$T_f = 65\text{ °C}$, $T_{vj,max} = 175\text{ °C}$	750	W
Gate-emitter peak voltage	V_{GES}		±20	V

1) Verified by characterization / design, not by test.

Table 5 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Collector-emitter saturation voltage	$V_{CE,sat}$	$I_C = 600\text{ A}$, $V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.08	1.21	V
			$T_{vj} = 175\text{ °C}$	1.09		
Collector-emitter saturation voltage	$V_{CE,sat}$	$I_C = 1000\text{ A}$, $V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.22		V
			$T_{vj} = 175\text{ °C}$	1.32		
Gate threshold voltage	$V_{GE,th}$	$I_C = 10.32\text{ mA}$, $V_{CE} = V_{GE}$	$T_{vj} = 25\text{ °C}$	4.9	5.8	V
			$T_{vj} = 175\text{ °C}$	4		
Gate charge	Q_G	$V_{CE} = 400\text{ V}$, $V_{GE} = -8...15\text{ V}$		2.65		μC
Internal gate resistor	$R_{G,int}$	$T_{vj} = 25\text{ °C}$		1.0		Ω
Input capacitance	C_{ies}	$f = 0.1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$	60.8		nF
Output capacitance	C_{oes}	$f = 0.1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$	2.1		nF
Reverse transfer capacitance	C_{res}	$f = 0.1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$	0.27		nF
Collector-emitter cut-off current	I_{CES}	$V_{CE} = 750\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		1.0	mA
			$T_{vj} = 175\text{ °C}$	15.0		
			$T_{vj} = 185\text{ °C}$	28.0		
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0\text{ V}$, $V_{GE} = 20\text{ V}$	$T_{vj} = 25\text{ °C}$		400	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	$t_{d,on}$	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $V_{GE} = -8/15\text{ V}$, $R_{G,on} = 2.4\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		222		ns
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		255		
Rise time, inductive load	t_r	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $V_{GE} = -8/15\text{ V}$, $R_{G,on} = 2.4\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		50.0		ns
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		55.0		
Turn-off delay time, inductive load	$t_{d,off}$	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $V_{GE} = -8/15\text{ V}$, $R_{G,off} = 7.5\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		929		ns
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		1060		
Fall time, inductive load	t_f	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $V_{GE} = -8/15\text{ V}$, $R_{G,off} = 7.5\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		91.0		ns
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		199		
Turn-on energy loss per pulse	E_{on}	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $L_{\sigma} = 7\text{ nH}$, $V_{GE} = -8/15\text{ V}$, $R_{G,on} = 2.4\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$, $di/dt = 9600\text{ A}/\mu\text{s}$		4.5		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$, $di/dt = 8700\text{ A}/\mu\text{s}$		10.7		
Turn-off energy loss per pulse	E_{off}	$I_C = 600\text{ A}$, $V_{CE} = 400\text{ V}$, $L_{\sigma} = 7\text{ nH}$, $V_{GE} = -8/15\text{ V}$, $R_{G,off} = 7.5\ \Omega$	$T_{vj} = 25\text{ }^{\circ}\text{C}$, $dv/dt = 4000\text{ V}/\mu\text{s}$		31.1		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$, $dv/dt = 2700\text{ V}/\mu\text{s}$		43.0		
SC data	I_{SC}	$V_{CC} = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $V_{CEmax} = V_{CES} - L_{s,CE} \cdot di/dt$	$T_{vj} = 25\text{ }^{\circ}\text{C}$, $t_p = 3.0\ \mu\text{s}$		8500		A
			$T_{vj} = 175\text{ }^{\circ}\text{C}$, $t_p = 3.0\ \mu\text{s}$		6700		
			$T_{vj} = 185\text{ }^{\circ}\text{C}$, $t_p = 2.5\ \mu\text{s}$		6600		
Thermal resistance, junction to cooling fluid ¹⁾	$R_{th,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ }^{\circ}\text{C}$			0.134		K/W
Variance of thermal resistance, junction to cooling fluid ¹⁾	$\sigma_{Rth,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ }^{\circ}\text{C}$			0.002		K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	$^{\circ}\text{C}$
			extended operation			185 ²⁾	

- 1) Cooler design and flow direction according to application note AN-G2-ASSEMBLY. EoL criteria see AQG324, verified by characterization.
2) For limitation see QPAC documentation.

3 Diode, Inverter

Table 6 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Repetitive peak reverse voltage	V_{RRM}	$T_{vj} = 25\text{ °C}$		750	V
Implemented forward current	I_{FN}			1000	A
Continuous DC forward current	$I_{F,nom}$			600	A
Repetitive peak forward current	I_{FRM}	verified by design, t_p limited by $T_{vj,max}$		2000	A
I^2t - value	I^2t	$V_R = 0\text{ V}$, $t_p = 10\text{ ms}$	$T_{vj} = 175\text{ °C}$	24500	A ² s

Table 7 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_F	$I_F = 600\text{ A}$	$T_{vj} = 25\text{ °C}$		1.76	2.08	V
			$T_{vj} = 175\text{ °C}$		1.57		
Forward voltage	V_F	$I_F = 1000\text{ A}$	$T_{vj} = 25\text{ °C}$		2.09		V
			$T_{vj} = 175\text{ °C}$		1.95		
Peak reverse recovery current	I_{rm}	$I_F = 600\text{ A}$, $V_{GE} = -8\text{ V}$, $V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$		351		A
			$T_{vj} = 175\text{ °C}$		526		
Recovered charge	Q_r	$I_F = 600\text{ A}$, $V_R = 400\text{ V}$, $V_{GE} = -8\text{ V}$	$T_{vj} = 25\text{ °C}$		14.4		μC
			$T_{vj} = 175\text{ °C}$		43.1		
Reverse recovery energy	E_{rec}	$I_F = 600\text{ A}$, $V_{GE} = -8\text{ V}$, $V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$, $-di_F/dt = 16.2\text{ A/ns}$		4.90		mJ
			$T_{vj} = 175\text{ °C}$, $-di_F/dt = 13.4\text{ A/ns}$		13.40		
Thermal resistance, junction to cooling fluid ¹⁾	$R_{th,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ °C}$			0.173		K/W
Variance of thermal resistance, junction to cooling fluid ¹⁾	$\sigma_{Rth,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ °C}$			0.0027		K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	°C
			extended operation			185 ²⁾	

1) Cooler design and flow direction according to application note AN-G2-ASSEMBLY. EoL criteria see AQG324, verified by characterization.

2) For limitation see QPAC documentation.

4 Temperature sensor

Table 8 Characteristic values

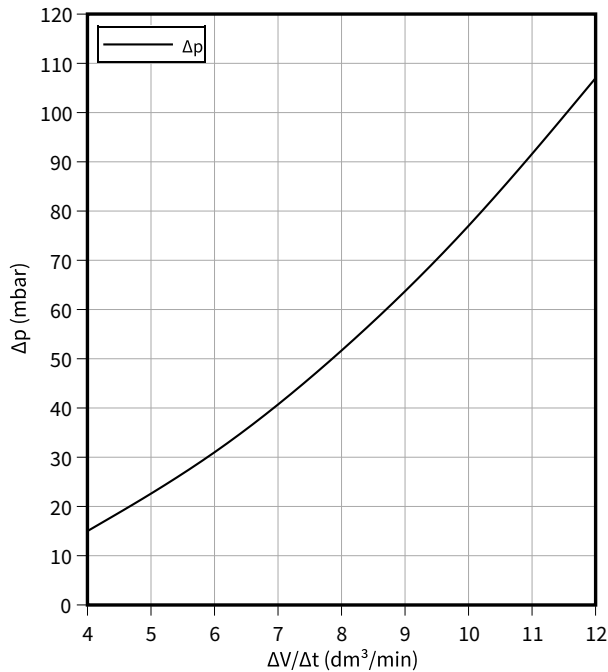
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Transient sense current	I_{TS}					10	mA
Continuous sense current	I_{TS}					1	mA
Forward voltage	V_{TS}		$I_{TS} = 0.2\text{ mA},$ $T_{vj} = 25\text{ °C}$		2.280		V
Temperature coefficient (TCR)	TC_{TS}	$I_{TS} = 0.2\text{ mA}$			-5.50		mV/K

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

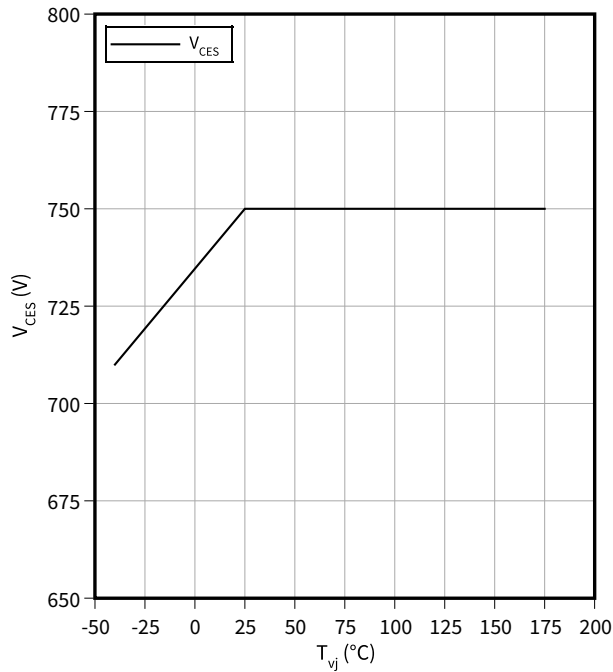
$T_f = 65\text{ }^{\circ}\text{C}$, 50% water / 50% ethylene glycol



Maximum collector-emitter voltage, IGBT, Inverter

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

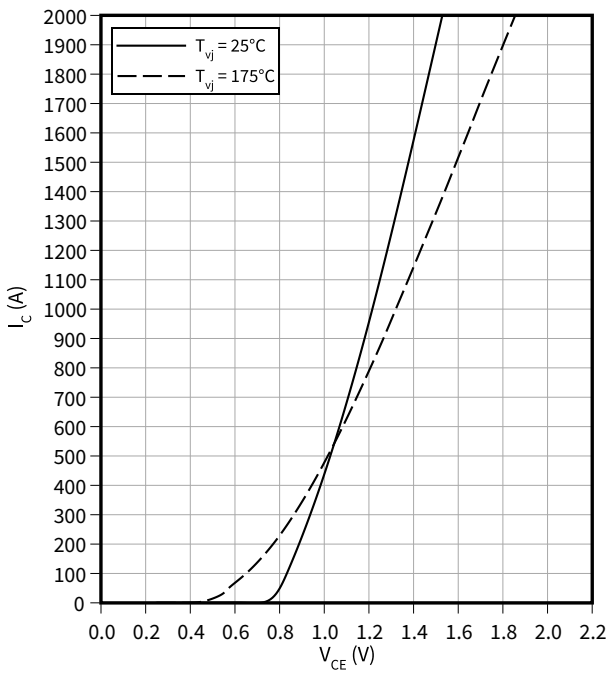
Verified by characterization / design, not by test



Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

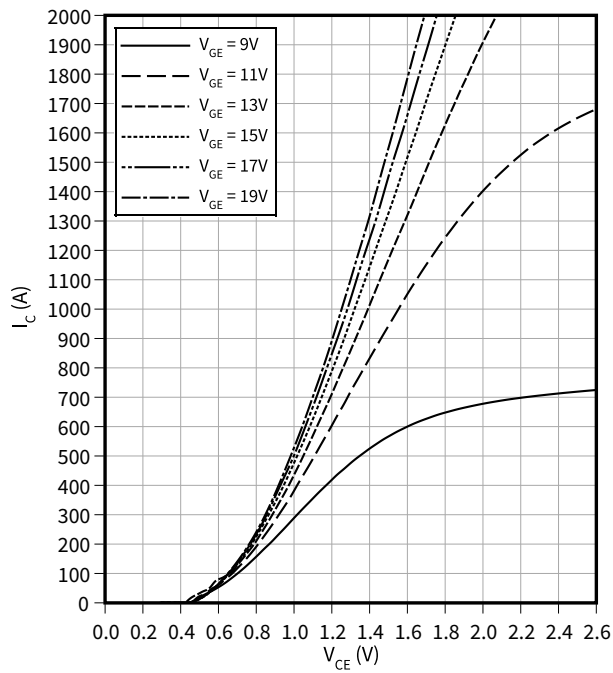
$V_{GE} = 15\text{ V}$



Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

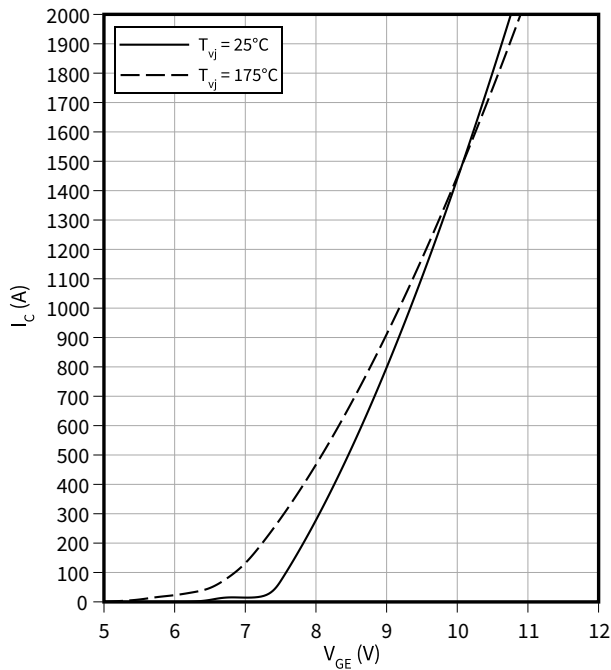
$T_{vj} = 175\text{ }^{\circ}\text{C}$



5 Characteristics diagrams

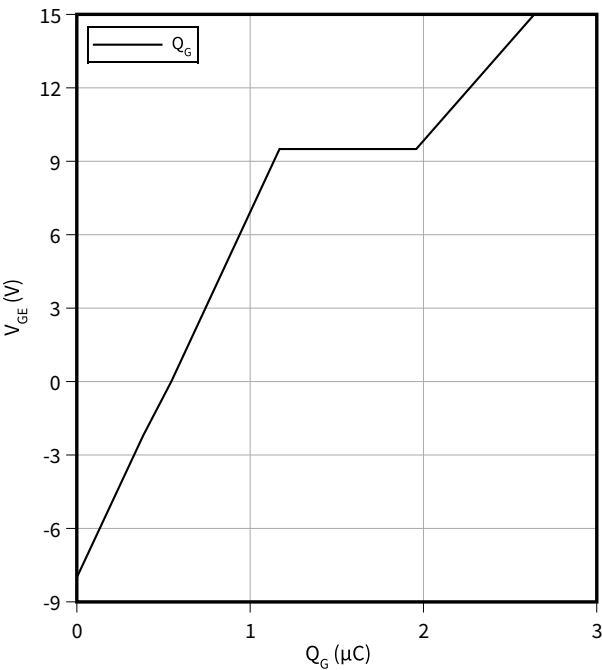
Transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$
 $V_{CE} = 20\text{ V}$



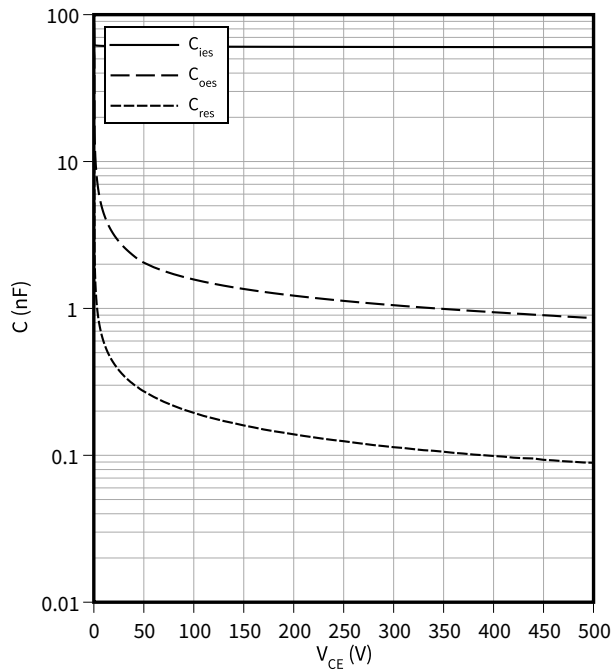
Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$
 $T_{vj} = 25^\circ\text{C}$, $V_{CE} = 400\text{ V}$, $I_C = 600\text{ A}$



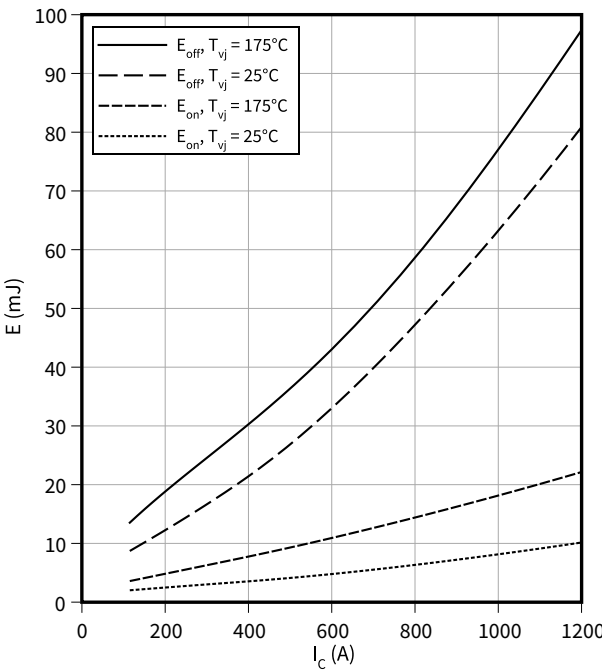
Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$
 $V_{GE} = 0\text{ V}$, $T_{vj} = 25^\circ\text{C}$, $f = 0.1\text{ MHz}$



Switching losses (typical), IGBT, Inverter

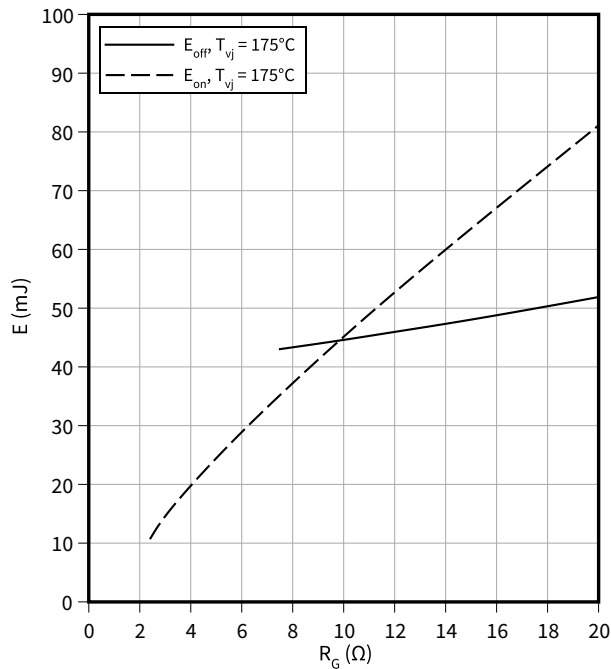
$E = f(I_C)$
 $V_{GE} = -8/15\text{ V}$, $R_{G,off} = 7.5\ \Omega$, $R_{G,on} = 2.4\ \Omega$, $V_{CE} = 400\text{ V}$



5 Characteristics diagrams

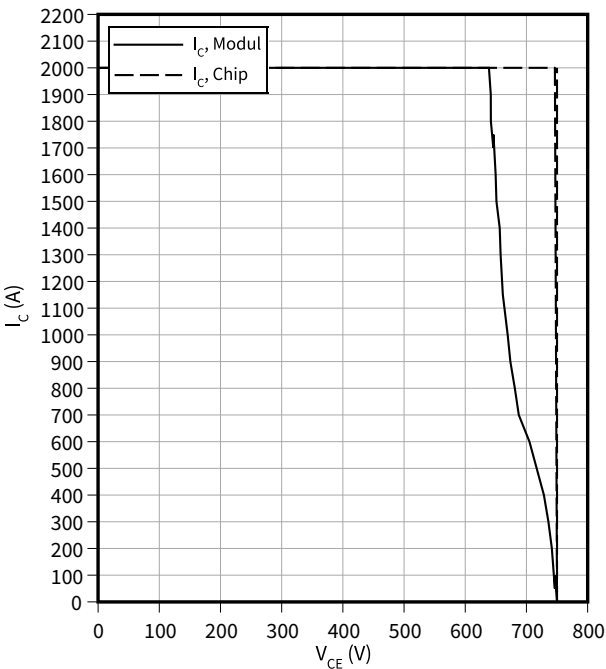
Switching losses (typical), IGBT, Inverter

$E = f(R_G)$
 $V_{GE} = -8/15\text{ V}$, $V_{CE} = 400\text{ V}$, $I_C = 600\text{ A}$



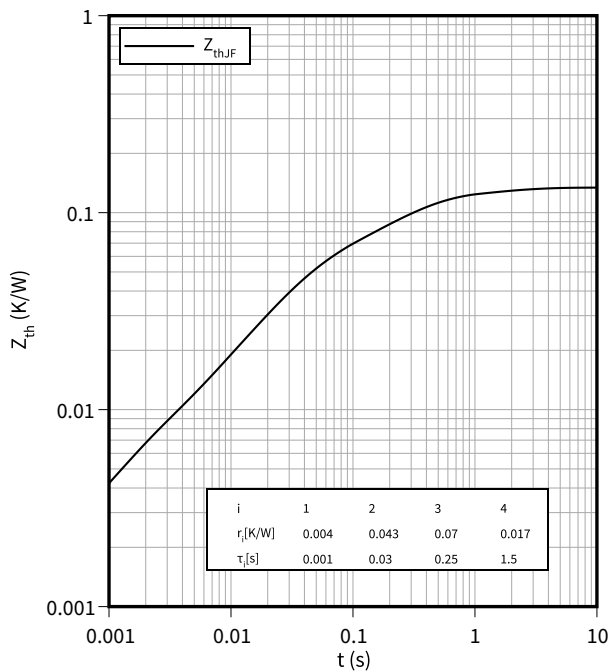
Reverse bias safe operating area (RBSOA), IGBT, Inverter

$I_C = f(V_{CE})$
 $T_{vj} = 175\text{ °C}$, $V_{GE} = -8/15\text{ V}$, $R_{G,off} = 7.5\text{ Ω}$



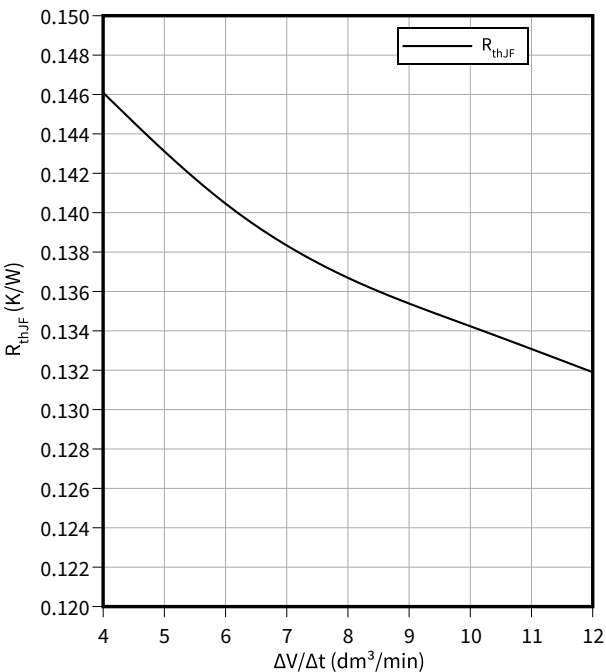
Transient thermal impedance (typical), IGBT, Inverter

$Z_{th} = f(t)$
 $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, 50% water / 50% ethylene glycol, $T_f = 65\text{ °C}$



Thermal impedance (typical), IGBT, Inverter

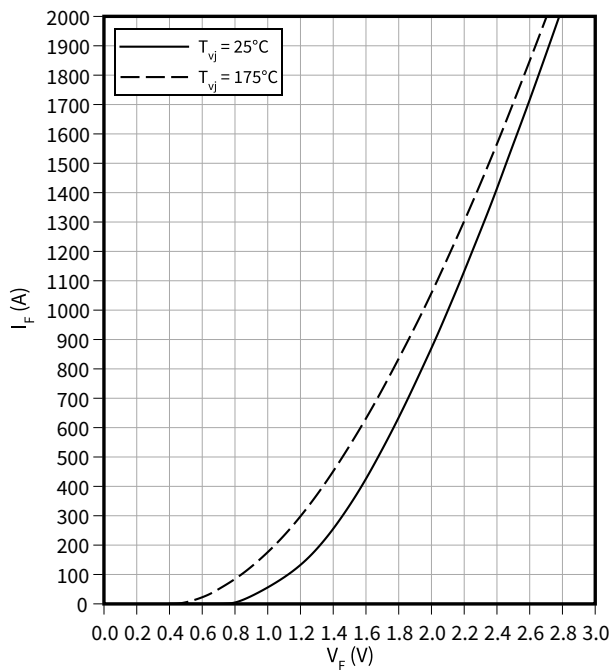
$R_{th,JF} = f(\Delta V/\Delta t)$
 $T_f = 65\text{ °C}$, 50% water / 50% ethylene glycol



5 Characteristics diagrams

Forward characteristic (typical), Diode, Inverter

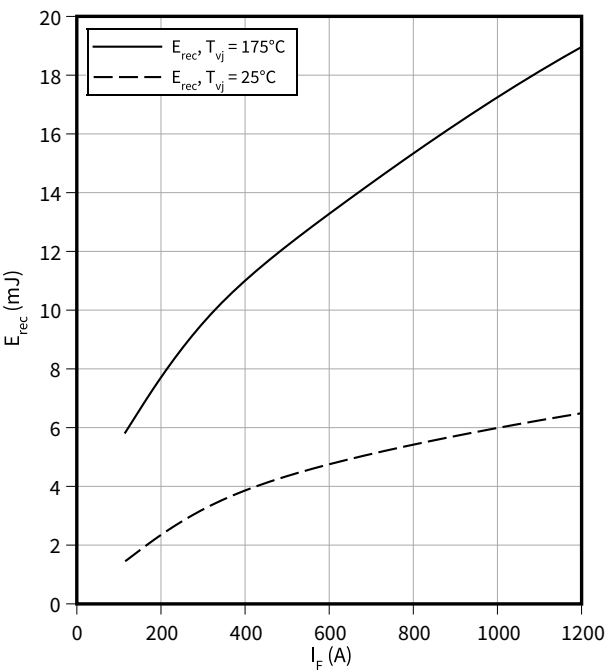
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

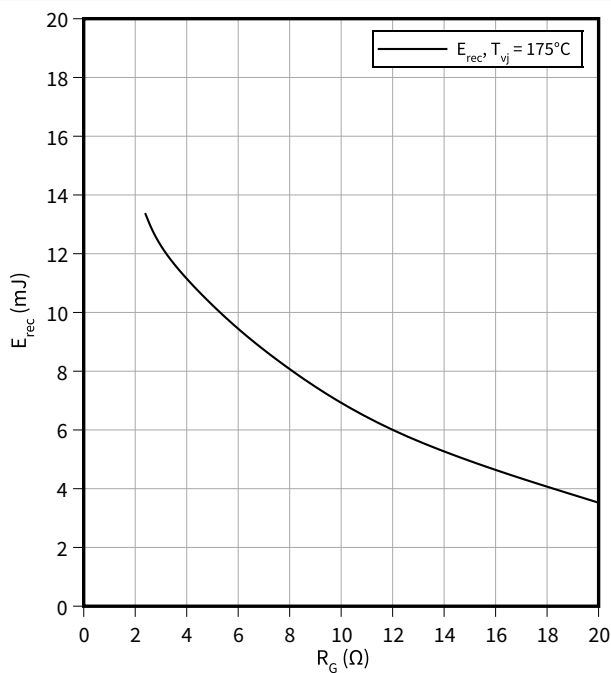
$V_{CE} = 400\text{ V}, V_{GE} = -8\text{ V}, R_G = 2.4\ \Omega$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

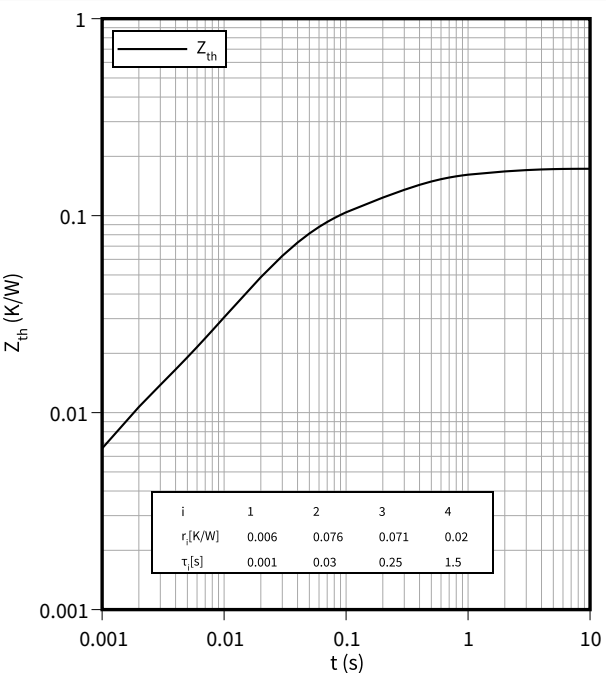
$V_{CE} = 400\text{ V}, I_F = 600\text{ A}$



Transient thermal impedance (typical), Diode, Inverter

$Z_{th} = f(t)$

$\Delta V/\Delta t = 10\text{ dm}^3/\text{min}, 50\%\text{ water} / 50\%\text{ ethylene glycol}, T_f = 65^\circ\text{C}$

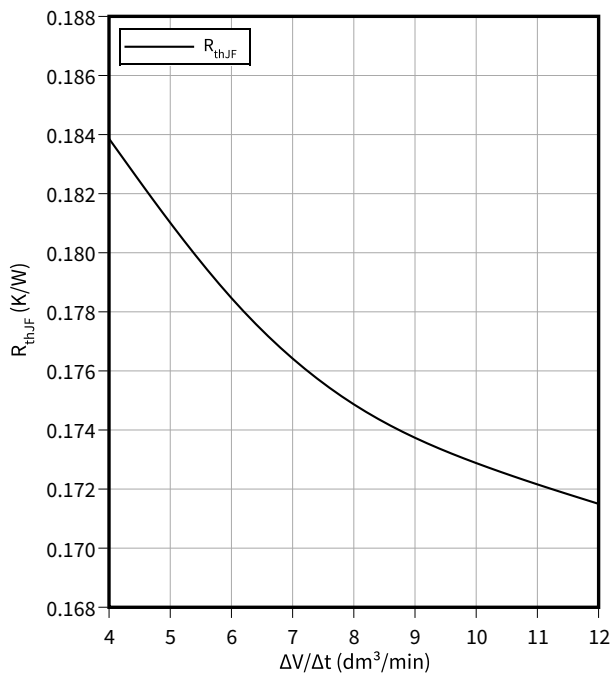


5 Characteristics diagrams

Thermal impedance (typical), Diode, Inverter

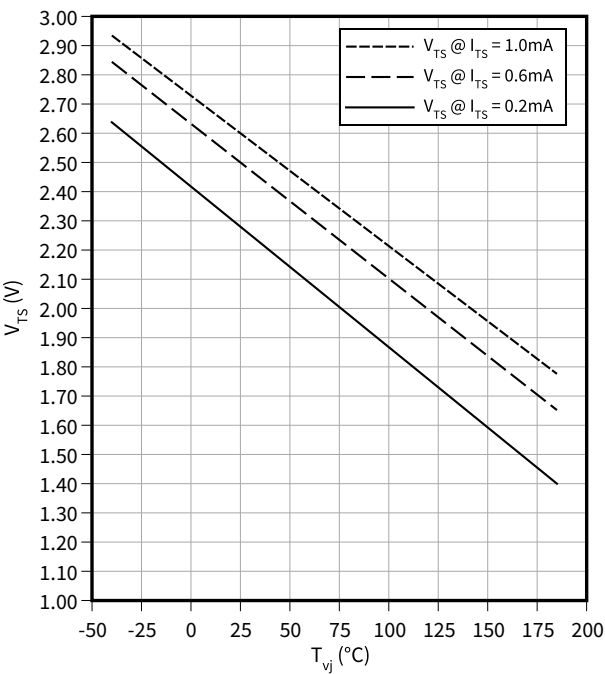
$R_{thJF} = f(\Delta V/\Delta t)$

$T_f = 65\text{ }^{\circ}\text{C}$, 50% water / 50% ethylene glycol



Temperature characteristic (typical), Temperature sensor

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



6 Circuit diagram

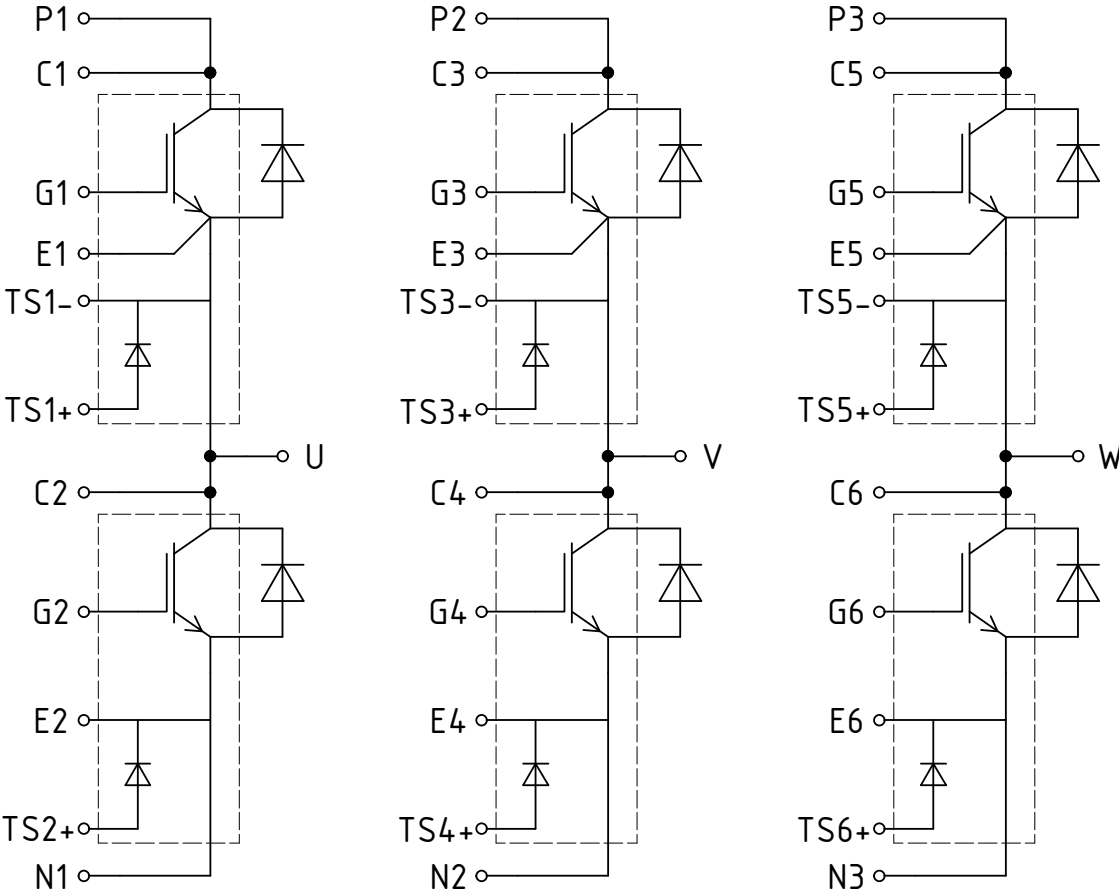


Figure 1

7 Package outlines

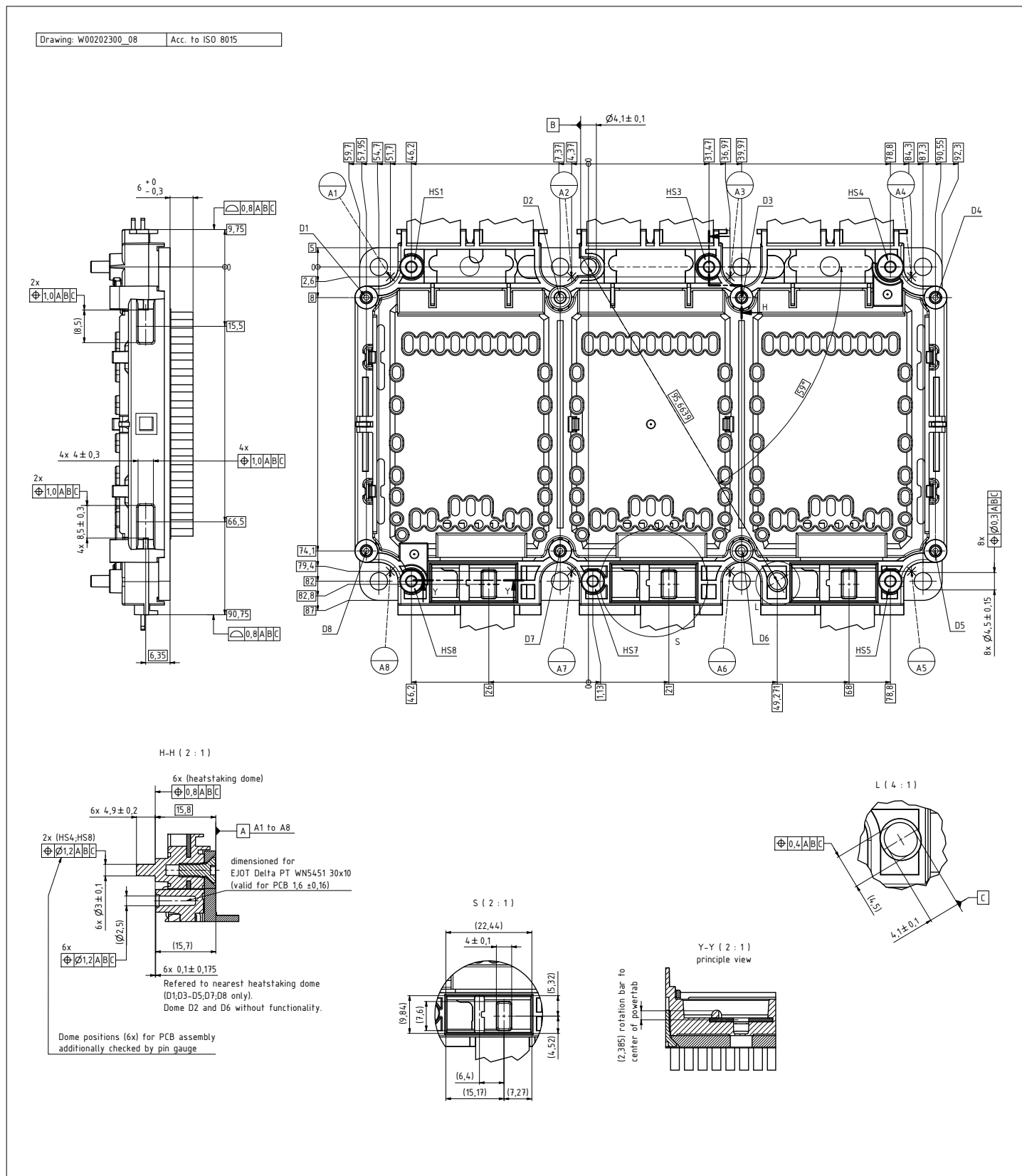


Figure 2

7 Package outlines

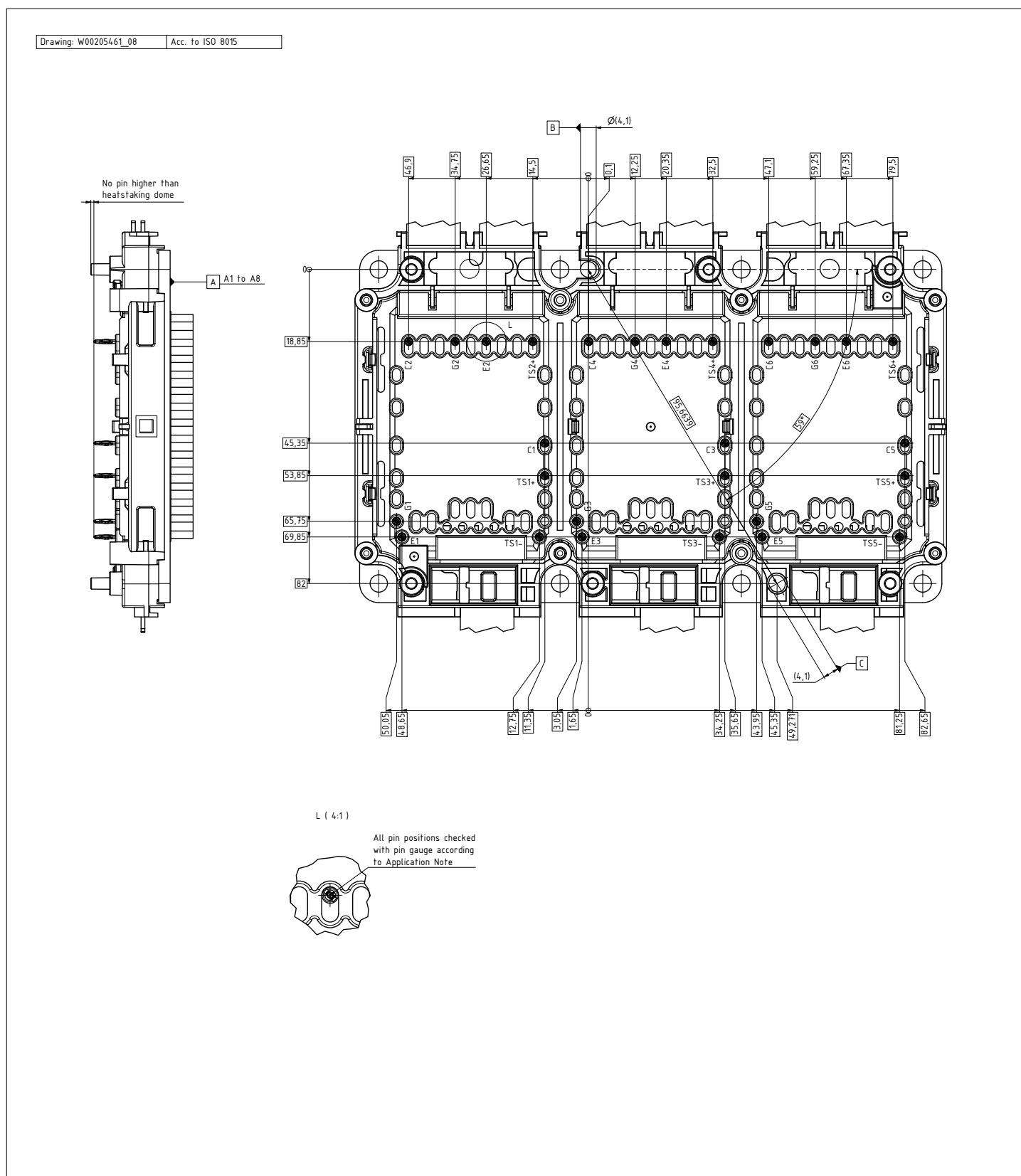


Figure 4

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	<i>Content</i> Module serial number Module material number Production order number Date code (production year) Date code (production week)	<i>Digit</i> 1 – 5 6 - 11 12 - 19 20 – 21 22 – 23	<i>Example</i> 71549 142846 55054991 15 30	
Example	 7154914284655054991153071549142846550549911530			

Packing label code				
Code format	Barcode Code128			
Encoding	Code Set A			
Symbol size	34 digits			
Standard	IEC8859-1			
Code content	<i>Content</i> Backend Construction Number Production Lot Number Serial Number Date code Box Quantity	<i>Identifier</i> X 1T S 9D Q	<i>Digit</i> 2 – 9 12 – 19 21 – 25 28 – 31 33 – 34	<i>Example</i> 95056609 2X0003E0 754389 1139 15
Example	 X950566091T2X0003E0S754389D1139Q15			

Figure 5



Revision history

Revision history

Document revision	Date of release	Description of changes
0.10	2023-05-04	Initial version
0.20	2025-02-26	Preliminary datasheet
1.00	2025-07-01	Final datasheet

Trademarks

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