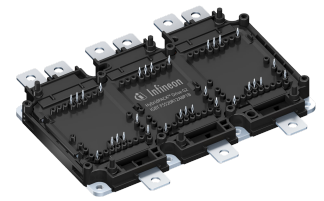


Final datasheet
HybridPACK™ Drive G2 module

Features

- Electrical features
 - $V_{CES} = 1200\text{ V}$
 - $I_{CN} = 520\text{ A} / I_{CRM} = 1040\text{ A}$
 - 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
- Mechanical features
 - 4.25 kV DC 1 second insulation
 - High creepage and clearance distances
 - Compact design
 - High power density
 - Direct-cooled PinFin base plate
 - Guiding elements for PCB and cooler assembly
 - PressFIT contact technology
 - RoHS compliant, lead-free
 - UL 94 V0 module frame
 - High-performance Si_3N_4 ceramic
 - 1.5 mm thick terminals for higher package output current capability



- Lead-free
- RoHS
- Green

Potential applications

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

Product validation

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

Description

The HybridPACK™ Drive is a very compact six-pack module (1200V/520A) optimized for hybrid and electric vehicles.

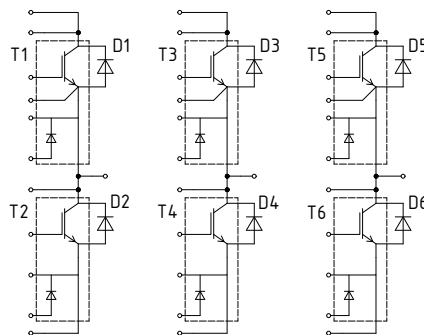


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1 Package

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 insulation		basic insulation (class 1, IEC 61140)	Si ₃ N 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	$I_{t,rms}$	$T_{Ct} = 125$ °C	900			A
Heat-staking dome temperature ¹⁾	T_{HS}	$t_{staking} < 10$ 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	0.50	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 IGBT, Inverter

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Collector-emitter voltage	V_{CES}	$T_{vj} = 25\text{ °C}$	1200			V
Implemented collector current	I_{CN}		520			A
Continuous DC collector current	$I_{C,nom}$	$T_f = 65\text{ °C}, T_{vj,max} = 175\text{ °C}$	300 ¹⁾			A
Repetitive peak collector current	I_{CRM}	verified by design, t_p limited by $T_{vj,max}$	1040			A
Total power dissipation	P_{tot}	$T_f = 65\text{ °C}, T_{vj,max} = 175\text{ °C}$	1000			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	$V_{CE,sat}$	$I_C = 300\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.48	1.58	V
			$T_{vj} = 150\text{ °C}$	1.62		
			$T_{vj} = 175\text{ °C}$	1.66		
Gate threshold voltage	$V_{GE,th}$	$I_C = 9.6\text{ mA}, V_{CE} = V_{GE}$	5	5.8	6.5	V
Gate charge	Q_G	$V_{CE} = 800\text{ V}, V_{GE} = -8...15\text{ V}$		2.95		μC
Internal gate resistor	$R_{G,int}$			0.5		Ω
Input capacitance	C_{ies}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$		25		nF
Output capacitance	C_{oes}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$		1.7		nF
Reverse transfer capacitance	C_{res}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$		1.1		nF
Collector-emitter cut-off current	I_{CES}	$V_{CE} = 1200\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		1.0	mA
			$T_{vj} = 175\text{ °C}$		23.8	
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0\text{ V}, V_{GE} = 20\text{ V}$			400	nA
Turn-on delay time, inductive load	$t_{d,on}$	$I_C = 300\text{ A}, V_{CE} = 800\text{ V}, V_{GE} = -8/15\text{ V}, R_{G,on} = 1.5\text{ Ω}, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C}$	107		ns
			$T_{vj} = 150\text{ °C}$	86.0		
			$T_{vj} = 175\text{ °C}$	79.0		

(table continues...)

Table 5 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Rise time, inductive load	t_r	$I_C = 300\text{ A}, V_{CE} = 800\text{ V},$ $V_{GE} = -8/15\text{ V},$ $R_{G,on} = 1.5\ \Omega, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C}$	46.0		ns
			$T_{vj} = 150\text{ °C}$	56.0		
			$T_{vj} = 175\text{ °C}$	59.0		
Turn-off delay time, inductive load	$t_{d,off}$	$I_C = 300\text{ A}, V_{CE} = 800\text{ V},$ $V_{GE} = -8/15\text{ V},$ $R_{G,off} = 1.5\ \Omega, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C}$	466		ns
			$T_{vj} = 150\text{ °C}$	594		
			$T_{vj} = 175\text{ °C}$	628		
Fall time, inductive load	t_f	$I_C = 300\text{ A}, V_{CE} = 800\text{ V},$ $V_{GE} = -8/15\text{ V},$ $R_{G,off} = 1.5\ \Omega, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C}$	77.0		ns
			$T_{vj} = 150\text{ °C}$	183		
			$T_{vj} = 175\text{ °C}$	217		
Turn-on energy loss per pulse	E_{on}	$I_C = 300\text{ A}, V_{CE} = 800\text{ V},$ $L_\sigma = 20\text{ nH}, V_{GE} = -8/15\text{ V},$ $R_{G,on} = 1.5\ \Omega, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C},$ $di/dt = 5300\text{ A}/\mu\text{s}$	26.5		mJ
			$T_{vj} = 150\text{ °C},$ $di/dt = 4300\text{ A}/\mu\text{s}$	44.1		
			$T_{vj} = 175\text{ °C},$ $di/dt = 4100\text{ A}/\mu\text{s}$	49.3		
Turn-off energy loss per pulse	E_{off}	$I_C = 300\text{ A}, V_{CE} = 800\text{ V},$ $L_\sigma = 20\text{ nH}, V_{GE} = -8/15\text{ V},$ $R_{G,off} = 1.5\ \Omega, C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C},$ $dv/dt = 6700\text{ V}/\mu\text{s}$	24.3		mJ
			$T_{vj} = 150\text{ °C},$ $dv/dt = 4100\text{ V}/\mu\text{s}$	44.3		
			$T_{vj} = 175\text{ °C},$ $dv/dt = 3700\text{ V}/\mu\text{s}$	50.3		
SC data	I_{SC}	$V_{CC} = 800\text{ V}, V_{GE} = 15\text{ V},$ ¹⁾ $V_{CEmax} = V_{CES} - L_{s,CE} \cdot di/dt$	$T_{vj} = 25\text{ °C},$ $t_p = 3.0\ \mu\text{s}$	4200		A
			$T_{vj} = 175\text{ °C},$ $t_p = 3.0\ \mu\text{s}$	3350		
Thermal resistance, junction to cooling fluid ²⁾	$R_{th,j-f}$	50 % water / 50 % ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}, T_f = 65\text{ °C}$		0.102		K/W
Standard deviation of thermal resistance, junction to cooling fluid ²⁾	$\sigma_{Rth,j-f}$	50 % water / 50 % ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}, T_f = 65\text{ °C}$		0.0018		K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40	175	°C

1) with $C_{GE}=82\text{nF}$

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

3 Diode, Inverter

Table 6 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Repetitive peak reverse voltage	V_{RRM}	$T_{vj} = 25\text{ °C}$	1200	V
Implemented forward current	I_{FN}		520	A
Continuous DC forward current	$I_{F,nom}$		300	A
Repetitive peak forward current	I_{FRM}	verified by design, t_p limited by $T_{vj,max}$	1040	A
I^2t - value	I^2t	$V_R = 0\text{ V}$, $t_p = 10\text{ ms}$ $T_{vj} = 175\text{ °C}$	40000	A ² s

Table 7 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	$I_F = 300\text{ A}$	$T_{vj} = 25\text{ °C}$	1.68	2.03	V
			$T_{vj} = 150\text{ °C}$	1.46		
			$T_{vj} = 175\text{ °C}$	1.41		
Peak reverse recovery current	I_{rm}	$I_F = 300\text{ A}$, $V_{GE} = -8\text{ V}$, $V_R = 800\text{ V}$	$T_{vj} = 25\text{ °C}$	342		A
			$T_{vj} = 150\text{ °C}$	506		
			$T_{vj} = 175\text{ °C}$	538		
Recovered charge	Q_r	$I_F = 300\text{ A}$, $V_R = 800\text{ V}$, $V_{GE} = -8\text{ V}$	$T_{vj} = 25\text{ °C}$	25.0		μC
			$T_{vj} = 150\text{ °C}$	60.0		
			$T_{vj} = 175\text{ °C}$	70.0		
Reverse recovery energy	E_{rec}	$I_F = 300\text{ A}$, $V_{GE} = -8\text{ V}$, $R_G = 1.5\ \Omega$, $C_{GE} = 82\text{ nF}$, $V_R = 800\text{ V}$	$T_{vj} = 25\text{ °C}$, $-di_F/dt = 8000\text{ A}/\mu\text{s}$	10.90		mJ
			$T_{vj} = 150\text{ °C}$, $-di_F/dt = 7100\text{ A}/\mu\text{s}$	28.40		
			$T_{vj} = 175\text{ °C}$, $-di_F/dt = 6800\text{ A}/\mu\text{s}$	33.50		
Thermal resistance, junction to cooling fluid ¹⁾	$R_{th,j-f}$	50 % water / 50 % ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ °C}$		0.135		K/W
Standard deviation of thermal resistance, junction to cooling fluid ¹⁾	$\sigma_{R_{th,j-f}}$	50 % water / 50 % ethylene glycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ °C}$		0.0029		K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40	175	°C

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

4 Temperature sensor

Table 8 Characteristic values

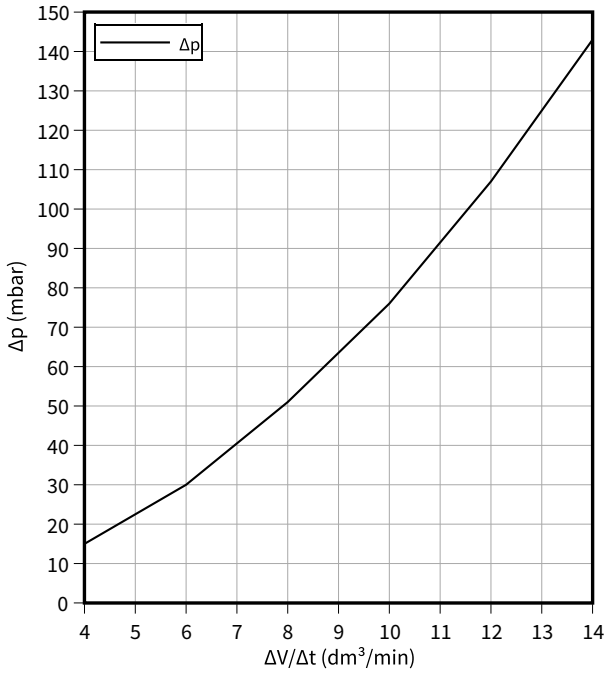
Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Transient sense current	I_{TS}				10	mA
Continuous sense current	I_{TS}				1	mA
Forward voltage	V_{TS}	$I_{TS} = 0.2 \text{ mA}$, $T_{vj} = 25 \text{ °C}$	2.495	2.576	2.660	V
Temperature coefficient (TCR)	TC_{TS}	$I_{TS} = 0.2 \text{ mA}$		-7.94		mV/K

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

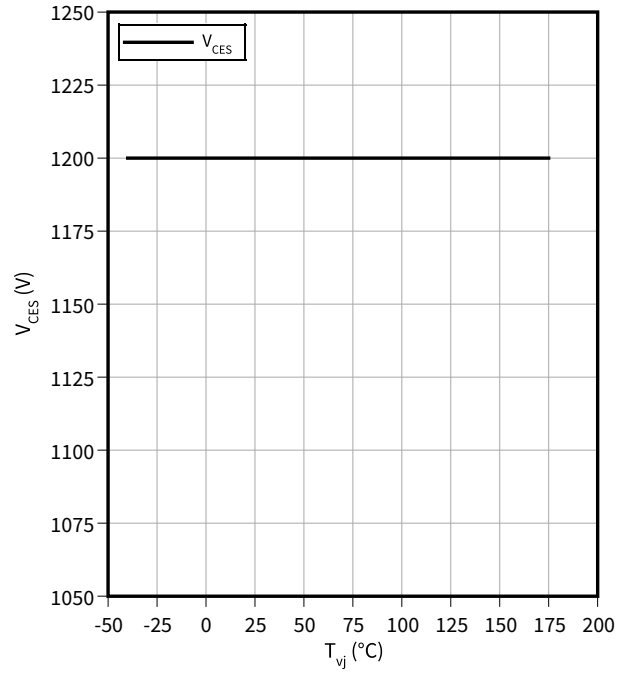
$T_f = 65^\circ\text{C}$, 50 % water / 50 % ethylene glycol



Maximum collector-emitter voltage, IGBT, Inverter

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

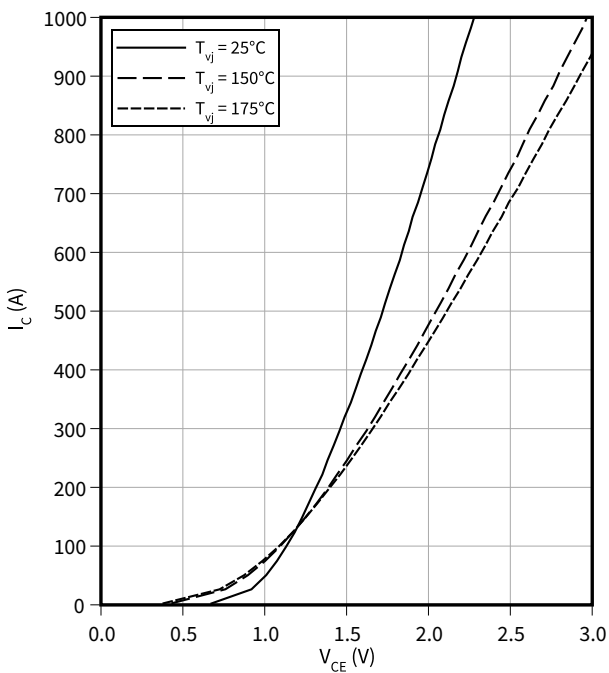
Verified by characterization / design, not by test.



Output characteristic (typical), IGBT, Inverter

$$I_{\text{C}} = f(V_{\text{CE}})$$

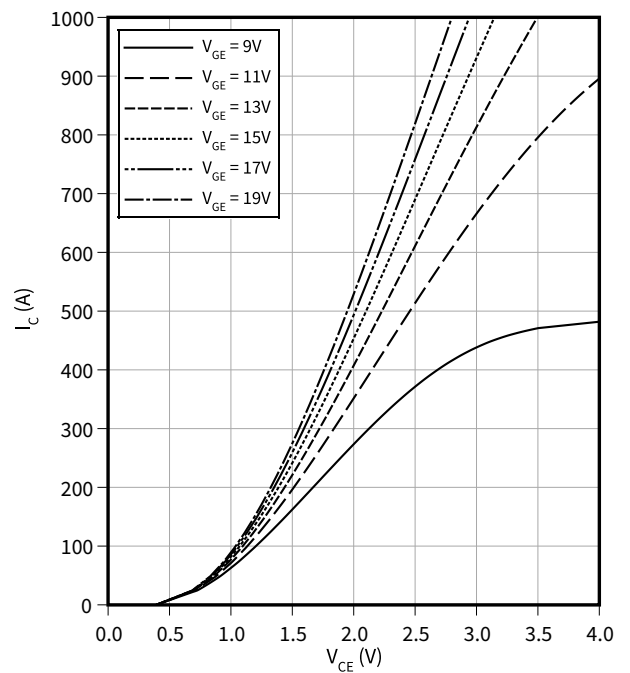
$V_{\text{GE}} = 15\text{V}$



Output characteristic (typical), IGBT, Inverter

$$I_{\text{C}} = f(V_{\text{CE}})$$

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

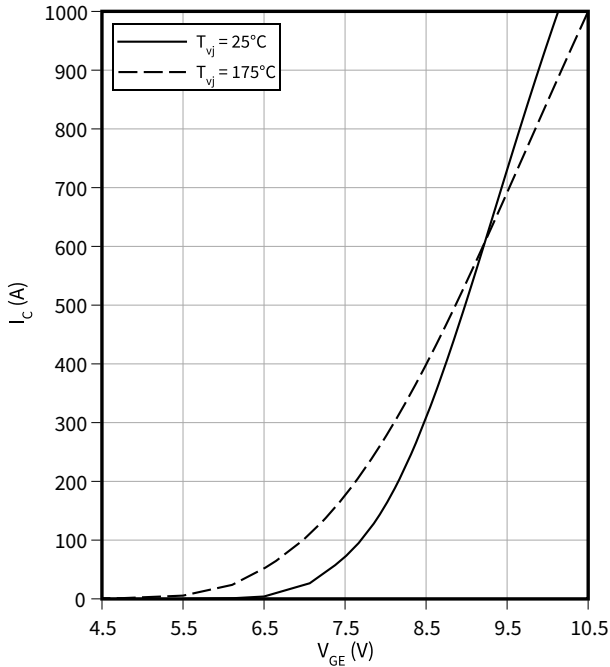


5 Characteristics diagrams

Transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$

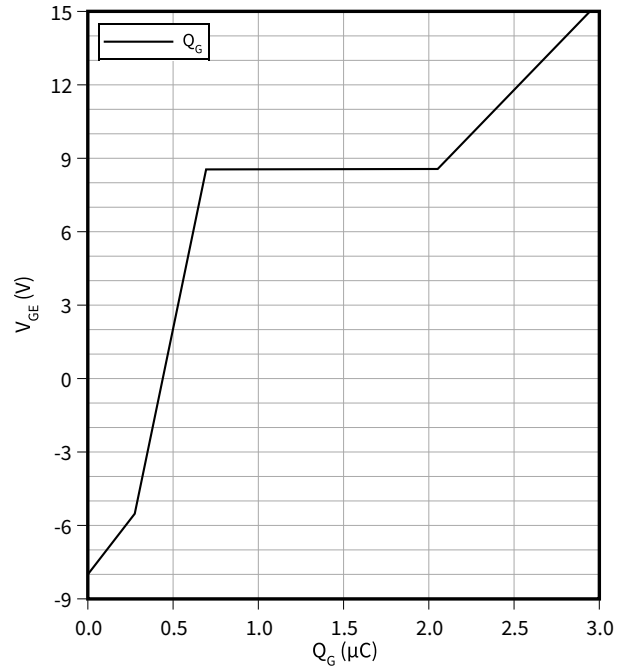
$V_{CE} = 20\text{ V}$



Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$

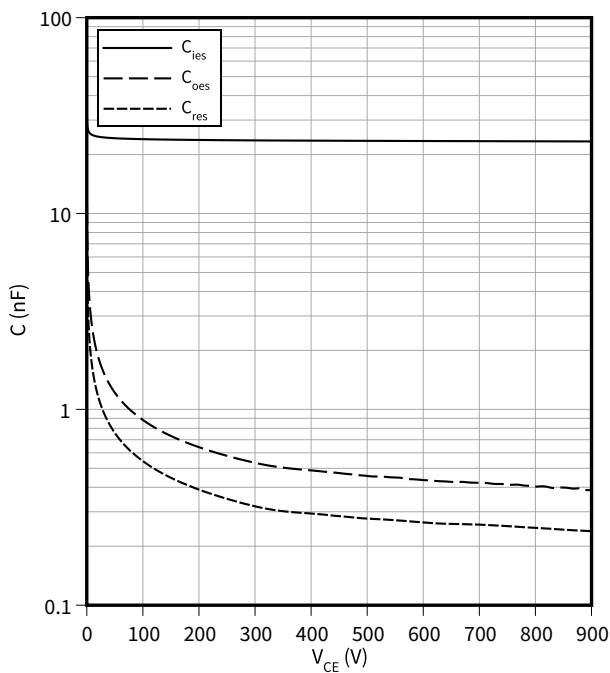
$T_{vj} = 25^\circ\text{C}, V_{CE} = 800\text{ V}, I_C = 300\text{ A}$



Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$

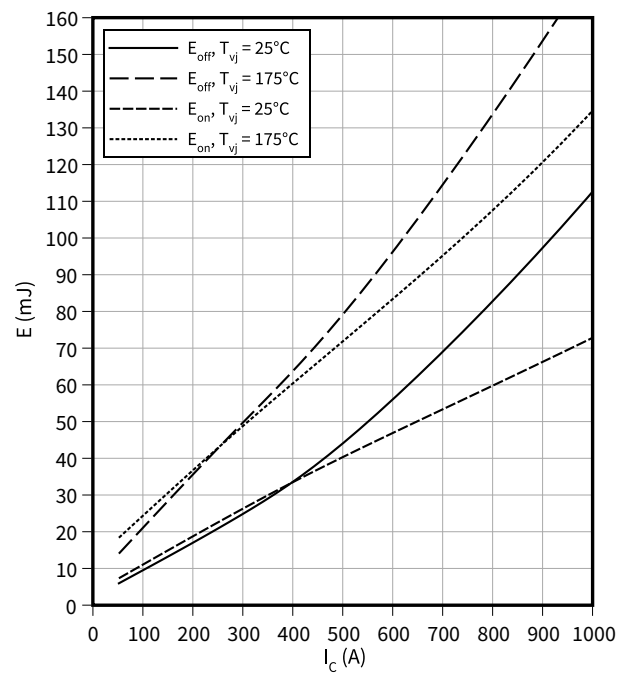
$V_{GE} = 0\text{ V}, T_{vj} = 25^\circ\text{C}, f = 0.1\text{ MHz}$



Switching losses (typical), IGBT, Inverter

$E = f(I_C)$

$C_{GE} = 82\text{ nF}, V_{GE} = -8/15\text{ V}, R_{G,off} = 1.5\text{ }\Omega, R_{G,on} = 1.5\text{ }\Omega, V_{CE} = 800\text{ V}$

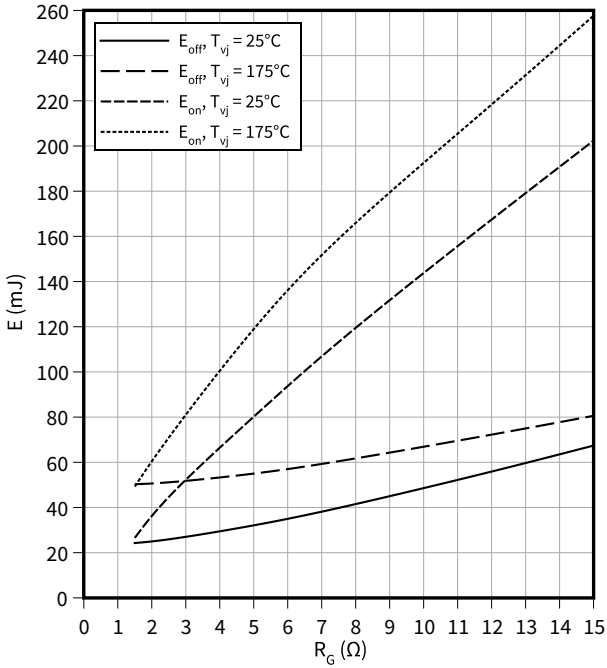


5 Characteristics diagrams

Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

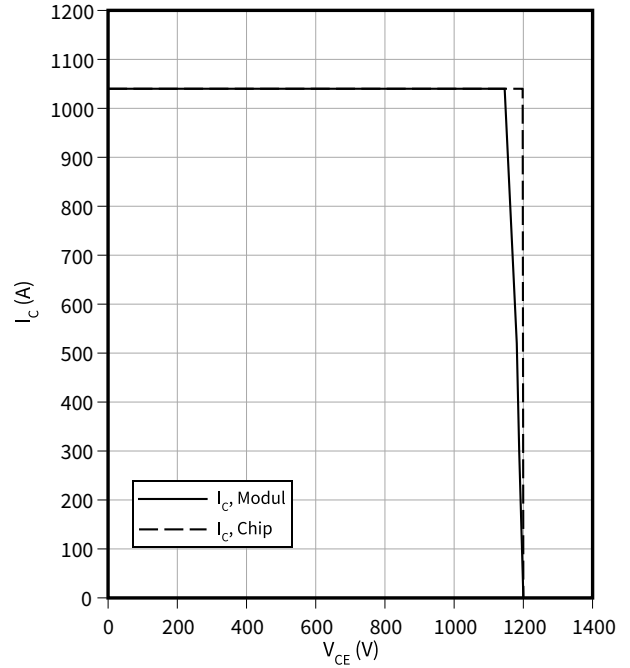
$C_{GE} = 82 \text{ nF}$, $V_{GE} = -8/15 \text{ V}$, $V_{CE} = 800 \text{ V}$, $I_C = 300 \text{ A}$



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

$I_C = f(V_{CE})$

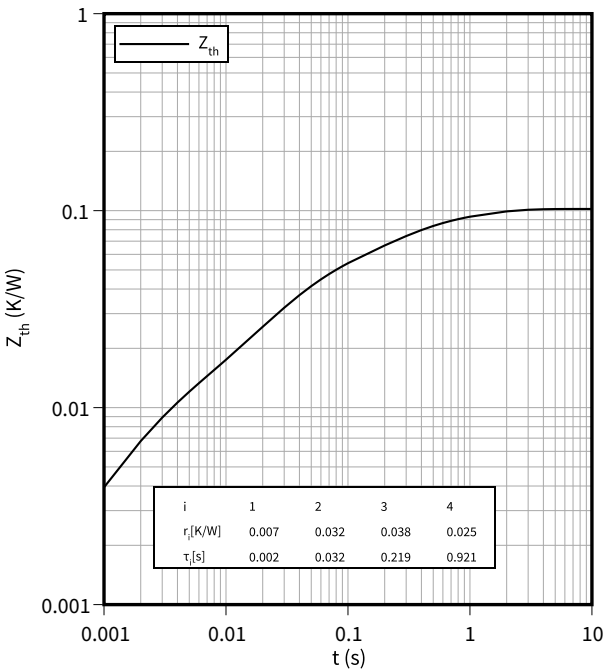
$C_{GE} = 82 \text{ nF}$, $T_{vj} = 175 \text{ °C}$, $V_{GE} = -8/15 \text{ V}$, $R_{G,off} = 1.5 \text{ Ω}$



Transient thermal impedance (typical), IGBT, Inverter

$Z_{th} = f(t)$

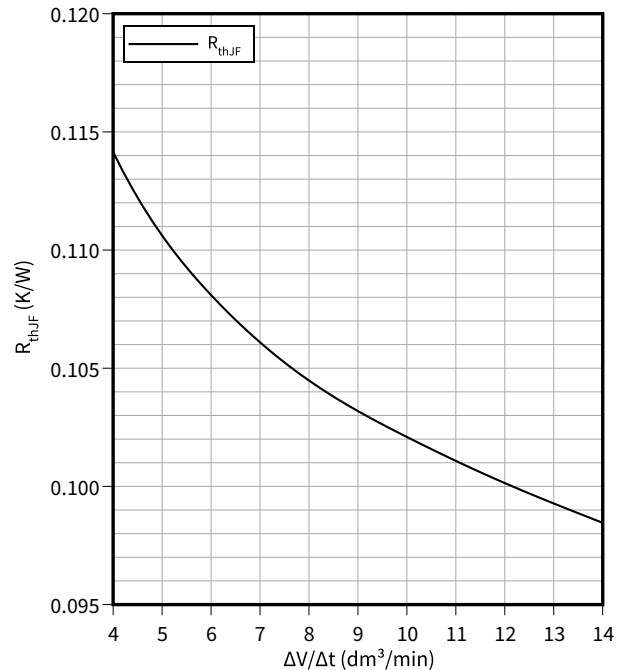
$\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 65 \text{ °C}$,
 50 % water / 50 % ethylene glycol



Thermal resistance (typical), IGBT, Inverter

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

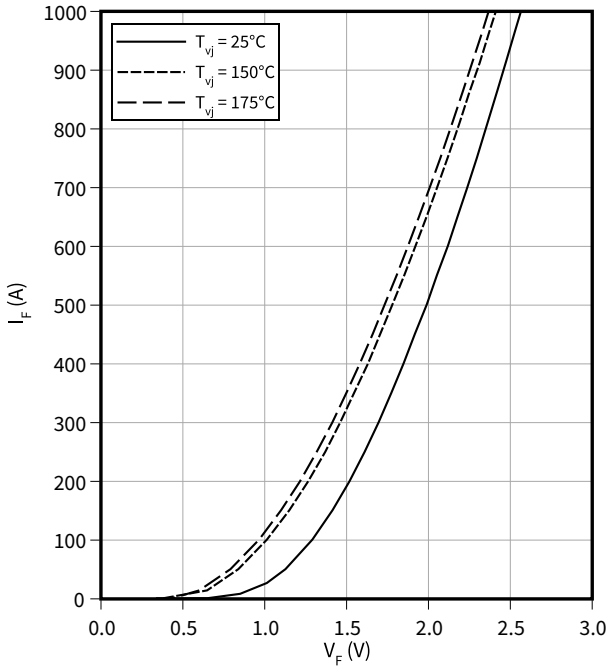
$T_f = 65 \text{ °C}$, 50 % water / 50 % ethylene glycol



5 Characteristics diagrams

Forward characteristic (typical), Diode, Inverter

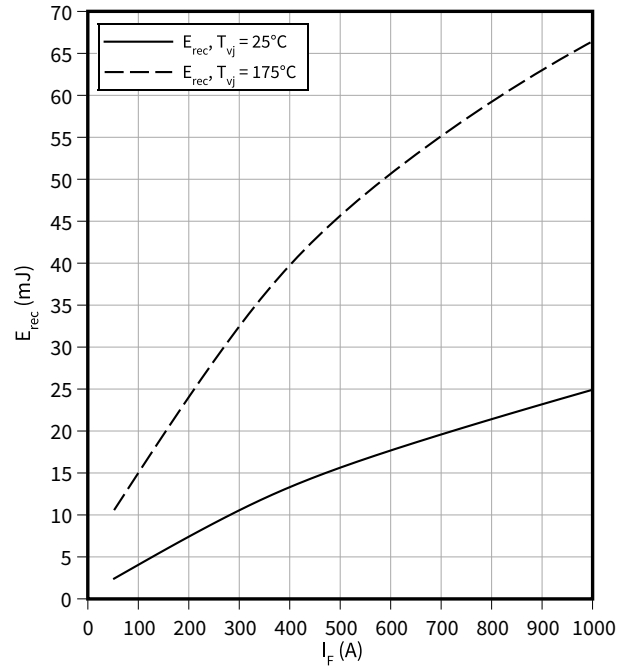
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

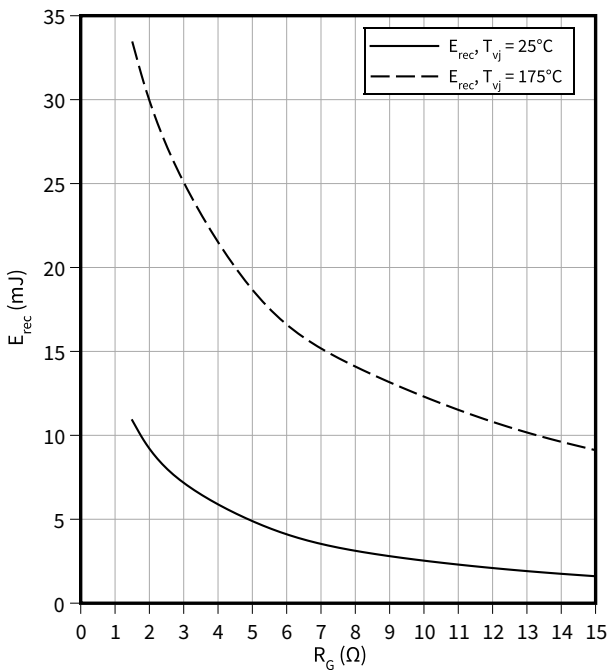
$C_{GE} = 82 \text{ nF}, V_{CE} = 800 \text{ V}, V_{GE} = -8 \text{ V}, R_G = 1.5 \Omega$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

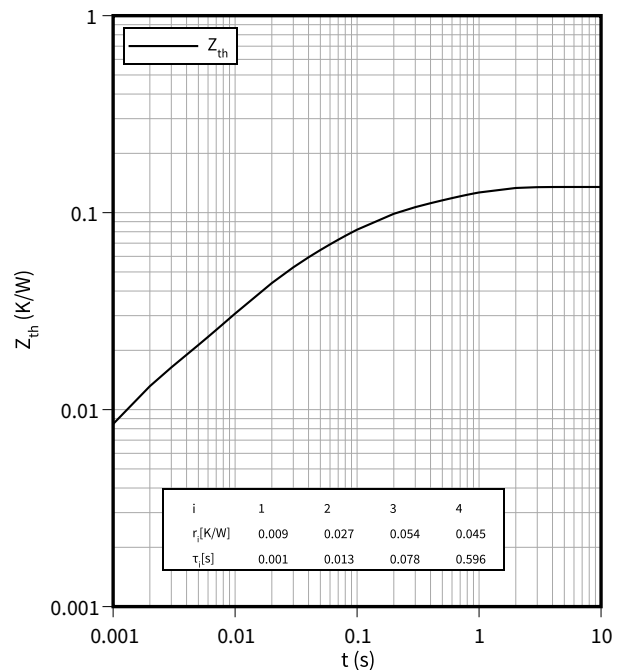
$C_{GE} = 82 \text{ nF}, V_{CE} = 800 \text{ V}, V_{GE} = -8 \text{ V}, I_F = 300 \text{ A}$



Transient thermal impedance (typical), Diode, Inverter

$Z_{th} = f(t)$

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

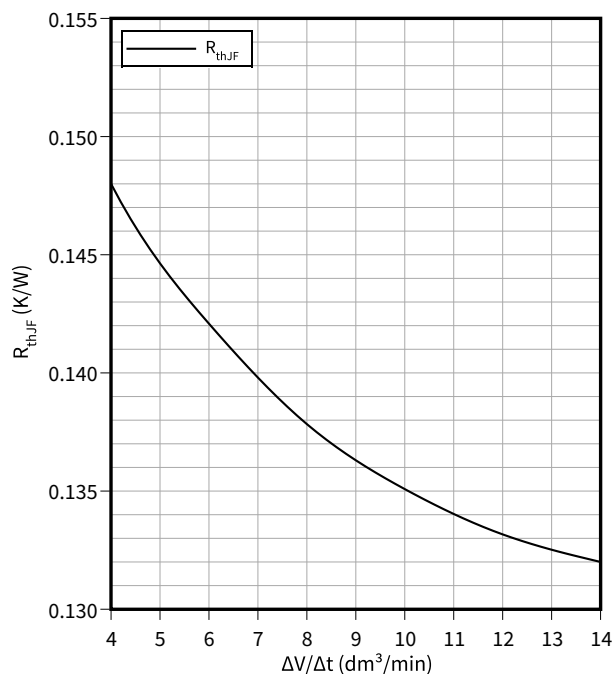


5 Characteristics diagrams

Thermal resistance (typical), Diode, Inverter

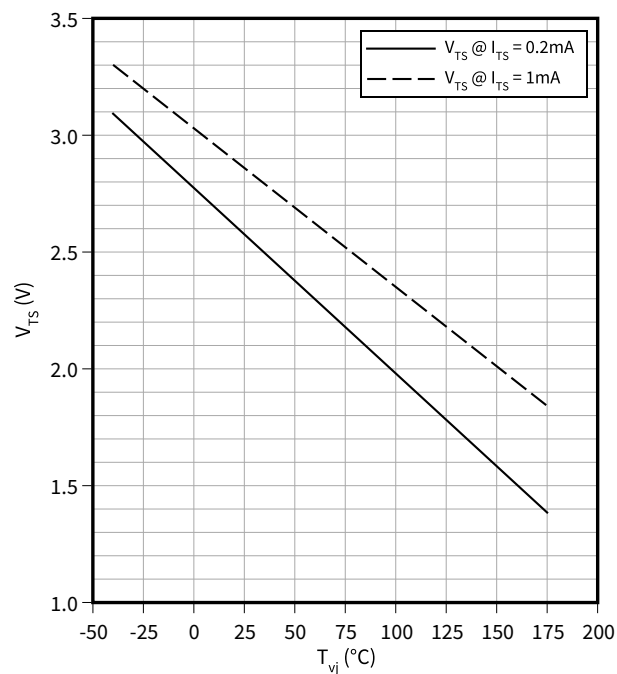
$$R_{thJF} = f(\Delta V/\Delta t)$$

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



Temperature characteristic (typical), Temperature sensor

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



6 Circuit diagram

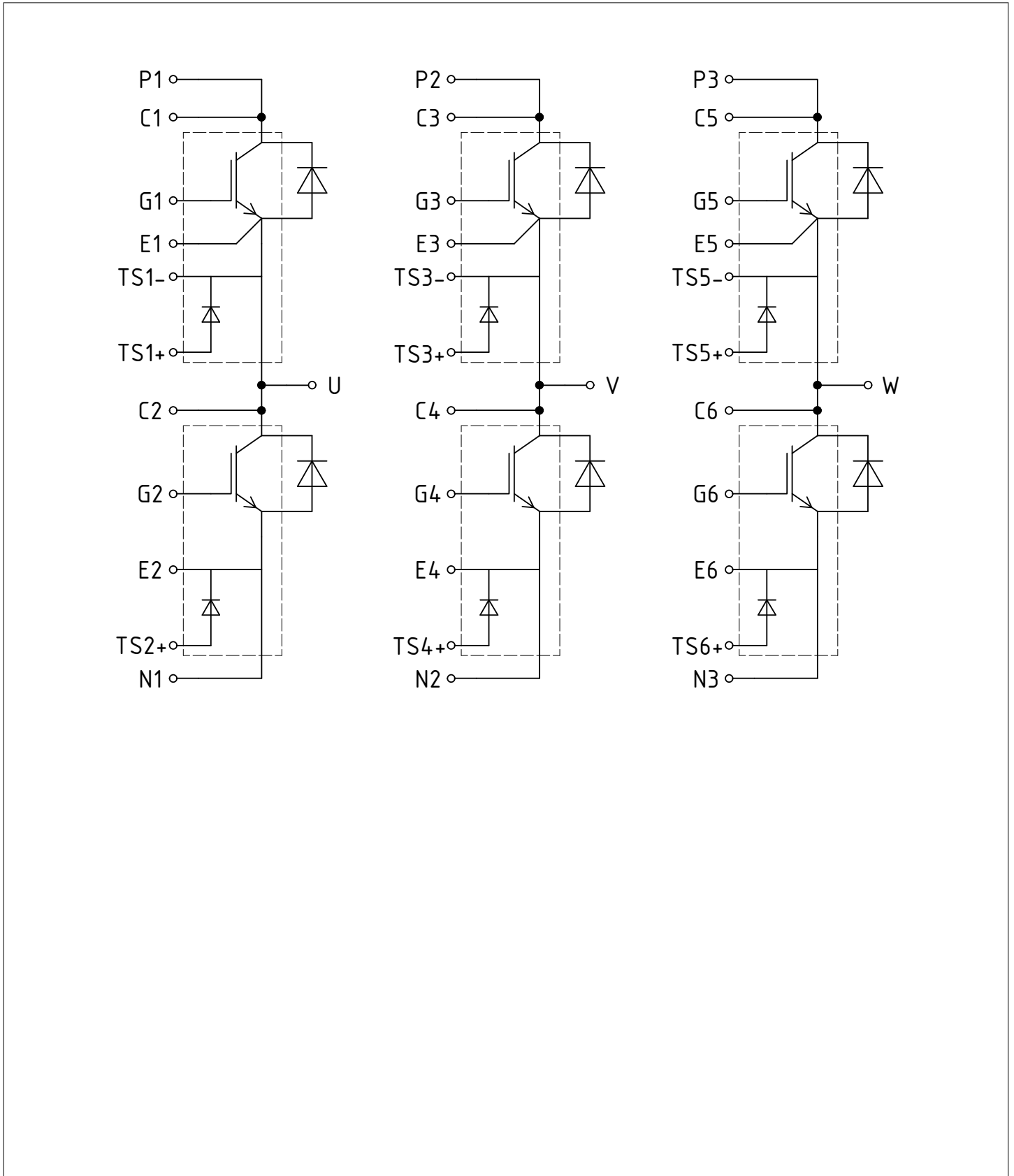


Figure 1

7 Package outlines

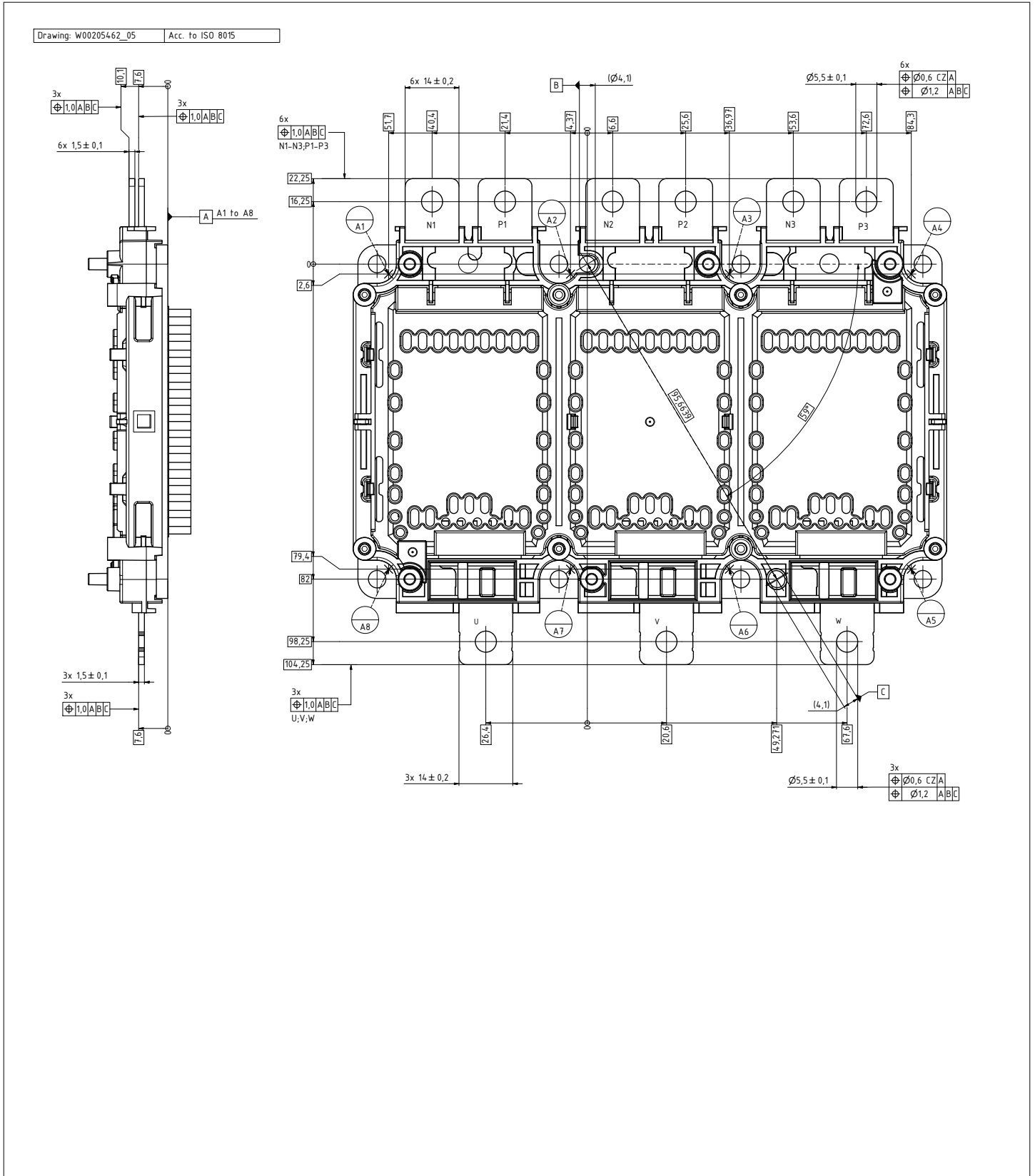


Figure 3

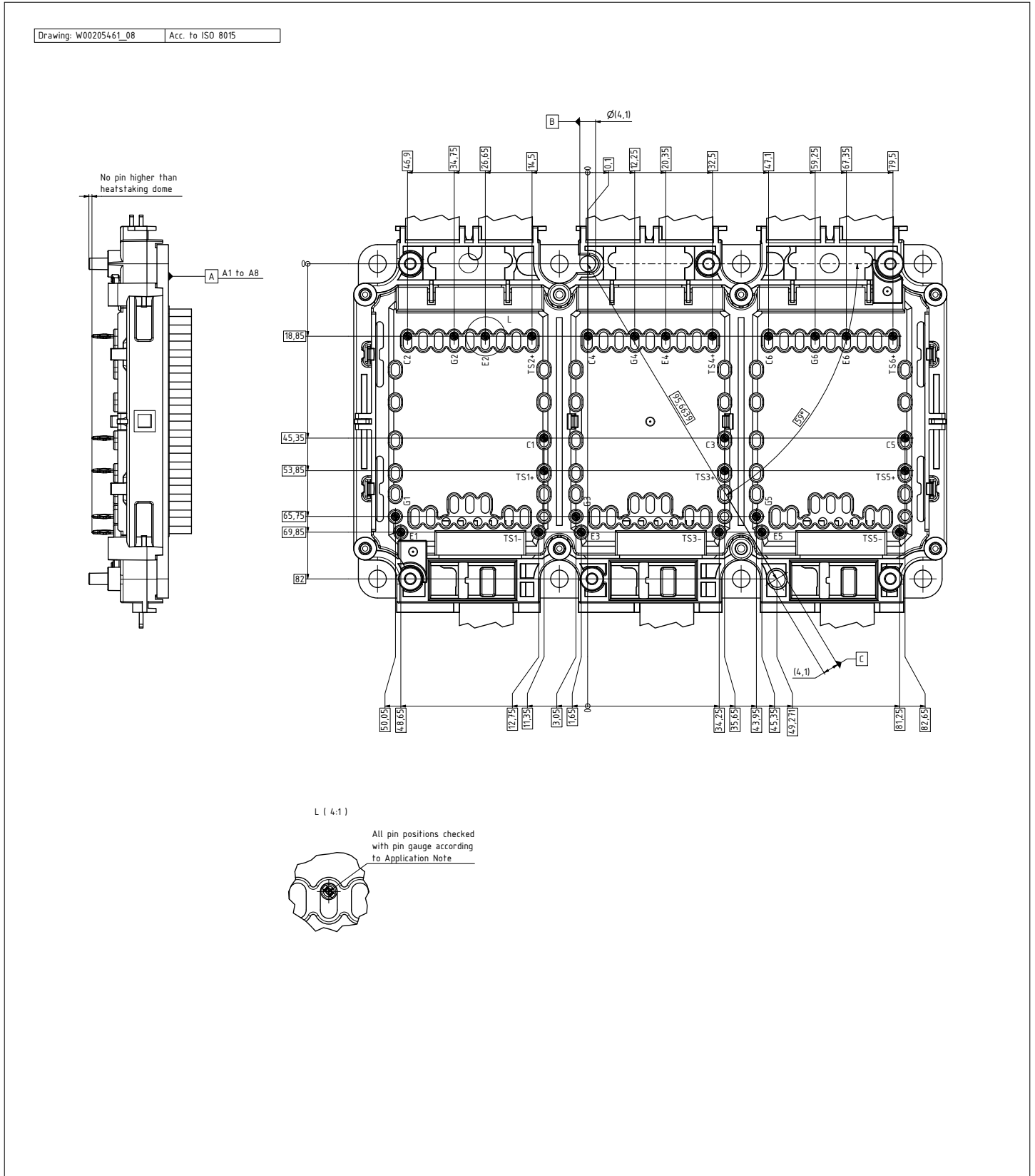


Figure 4

8 Module label code



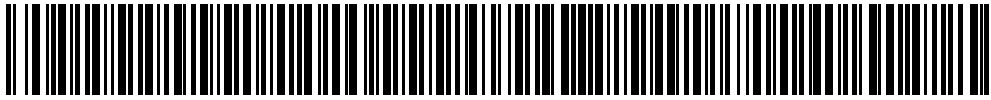
Module label code				
Code format	Data Matrix	Barcode Code128		
Encoding	ASCII text	Code Set A		
Symbol size	16x16	23 digits		
Standard	IEC24720 and IEC16022	IEC8859-1		
Code content	<i>Content</i>	<i>Digit</i>	<i>Example</i>	
	Module serial number	1 - 5	71549	
	Module material number	6 - 11	142846	
	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>
	Backend Construction Number	X	2 - 9	95056609
	Production Lot Number	1T	12 - 19	2X0003E0
	Serial Number	S	21 - 25	754389
	Date code	9D	28 - 31	1139
	Box Quantity	Q	33 - 34	15
Example				
	X950566091T2X0003E0S754389D1139Q15			

Figure 5

Revision history

Revision history

Document revision	Date of release	Description of changes
1.00	2026-02-12	Final datasheet

Trademarks

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