

Final datasheet
HybridPACK™ Drive G2 module

Features

- Electrical features
 - $V_{CES} = 1200\text{ V}$
 - $I_{CN} = 520\text{ A} / I_{CRM} = 1040\text{ A}$
 - Blocking voltage 1200 V
 - 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
 - 4.2 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



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

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

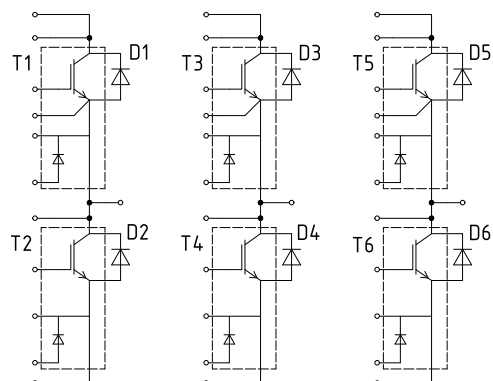
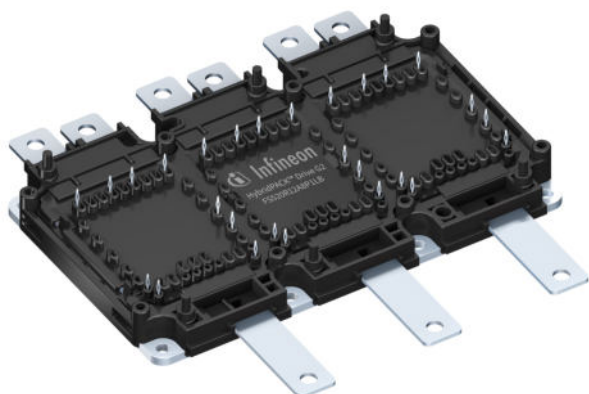


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 0$ Hz, $t = 1$ sec	4.20	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	fluid = 50% water / 50% ethylenglycol, $\Delta V / \Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 65 \text{ °C}$		76 ¹⁾		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate} < 40 \text{ °C}$			3.0	bar
		$T_{baseplate} \geq 40 \text{ °C}$ (relative pressure)			2.5	
Stray inductance module	$L_{s,CE}$			8.0		nH
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_f = 25 \text{ °C}$, 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
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	$V_{GE,th}$	$I_C = 9.6\text{ mA}, V_{CE} = V_{GE}$	$T_{vj} = 25\text{ °C}$	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	$R_{G,int}$		$T_{vj} = 25\text{ °C}$		0.5		Ω
Input capacitance	C_{ies}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		24.6		nF
Output capacitance	C_{oes}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		1.7		nF
Reverse transfer capacitance	C_{res}	$f = 0.1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$		1.06		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}		$T_{vj} = 25\text{ °C}$			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}	$V_{CC} = 800 \text{ V}$, $V_{GE} = 15 \text{ V}^{1)}$, $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$	$T_{vj} = 25 \text{ °C}$, $t_p = 3.0 \mu\text{s}$	4200		A
			$T_{vj} = 175 \text{ °C}$, $t_p = 3.0 \mu\text{s}$	3350		
Thermal resistance, junction to cooling fluid ²⁾	$R_{th,j-f}$	fluid = 50% water / 50% ethylenglycol, $\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 65 \text{ °C}$		0.102	0.110 ³⁾	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.

3) EoL criteria see AQG324, verified by characterization with 4.5 sigma.

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}	$I_F = 300\text{ A}$, $V_{GE} = -8\text{ V}$	$T_{vj} = 25\text{ °C}$		342		A
			$T_{vj} = 150\text{ °C}$		506		
			$T_{vj} = 175\text{ °C}$		538		
Recovered charge	Q_r	$I_F = 300\text{ A}$, $V_{GE} = -8\text{ V}$	$T_{vj} = 25\text{ °C}$		25.0		μC
			$T_{vj} = 150\text{ °C}$		60.0		
			$T_{vj} = 175\text{ °C}$		70.0		
Reverse recovery energy	E_{rec}	$I_F = 300\text{ A}$, $V_{GE} = -8\text{ V}$, $R_G = 1.5\text{ }\Omega$, $C_{GE} = 82\text{ nF}$	$T_{vj} = 25\text{ °C}$, $-di_F/dt = 8000\text{ A}/\mu\text{s}$		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⁾	$R_{th,j-f}$	fluid = 50% water / 50% ethylenglycol, $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$, $T_f = 65\text{ °C}$			0.135	0.148 ²⁾	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.

2) EoL criteria see AQG324, verified by characterization with 4.5 sigma.

4 Temperature sensor

Table 8 Characteristic values

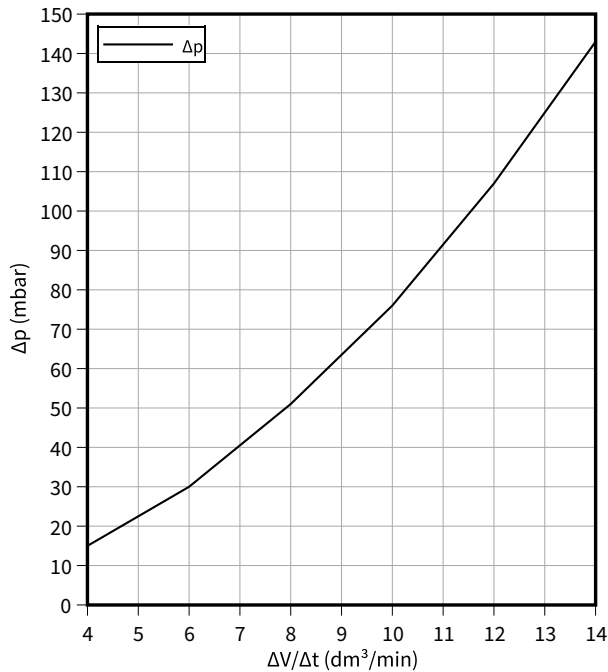
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Transient sense current	I_{TS}					10	mA
Forward voltage	V_{TS}		$I_{TS} = 0.2\text{ mA},$ $T_{vj} = 25\text{ °C}$	2.495	2.576	2.660	V
Temperature coefficient (TCR)	TC_{TS}	$I_{TS} = 0.2\text{ mA}$			-7.94		mV/K

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

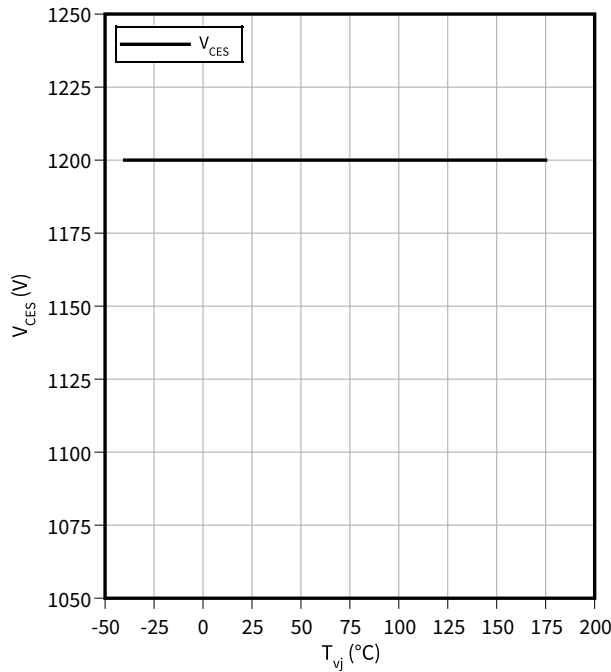
$T_f = 65\text{ }^{\circ}\text{C}$, fluid = 50% water / 50% ethylenglycol



Maximum collector-emitter voltage, IGBT, Inverter

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

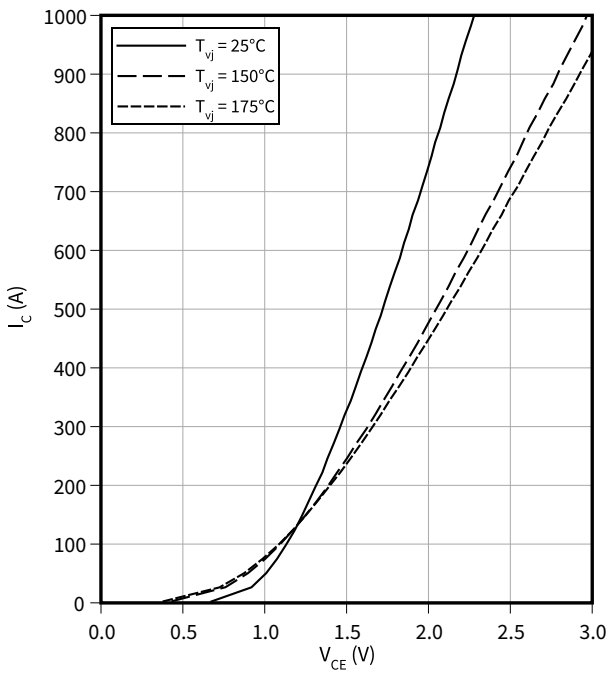
Note = Verified by characterization / design, not by test.



Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

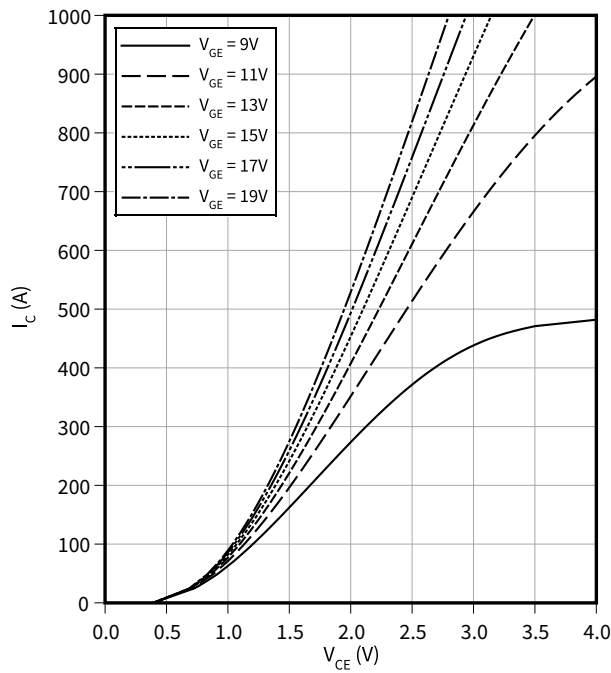
$V_{GE} = 15\text{ V}$



Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

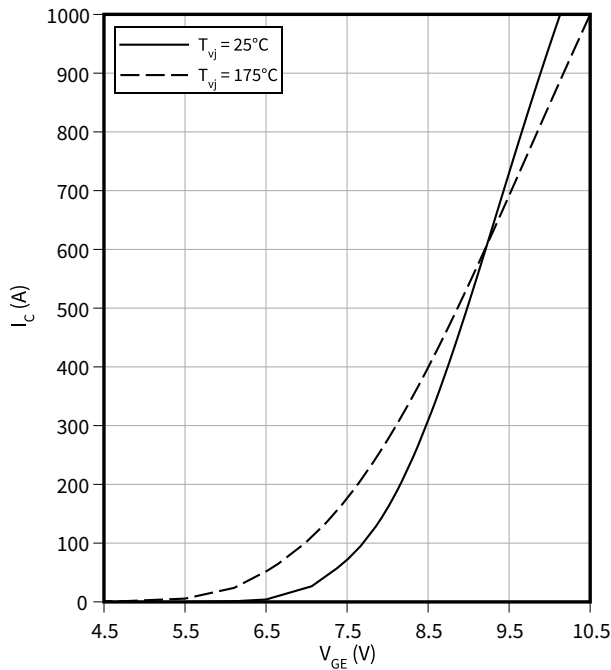
$T_{vj} = 175\text{ }^{\circ}\text{C}$



5 Characteristics diagrams

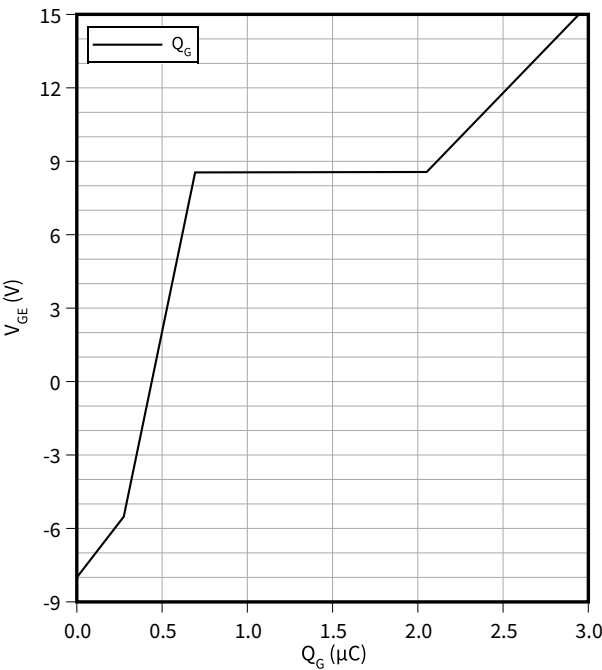
Transfer characteristic (typical), IGBT, Inverter

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



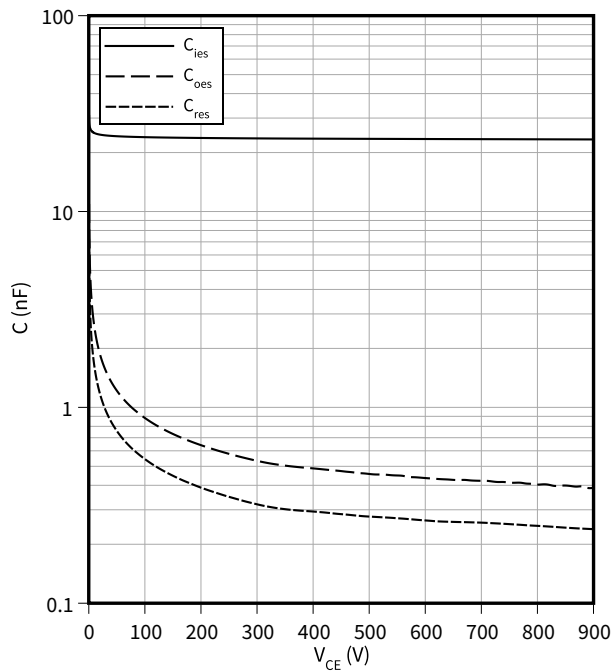
Gate charge characteristic (typical), IGBT, Inverter

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



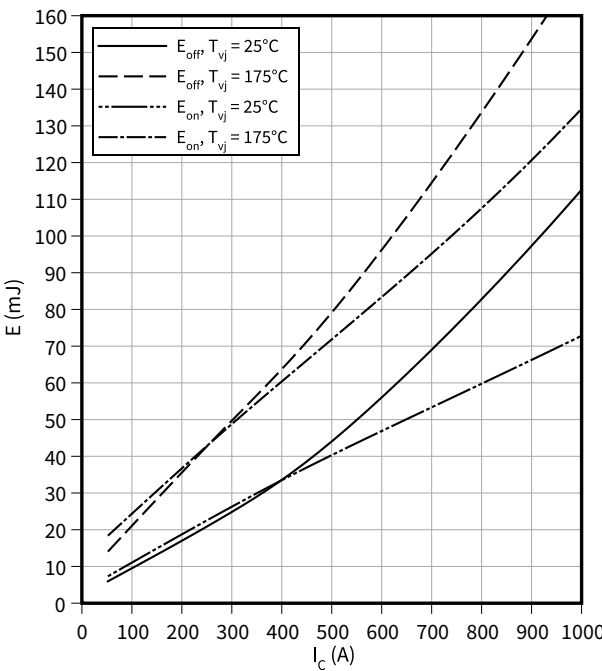
Capacity characteristic (typical), IGBT, Inverter

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



Switching losses (typical), IGBT, Inverter

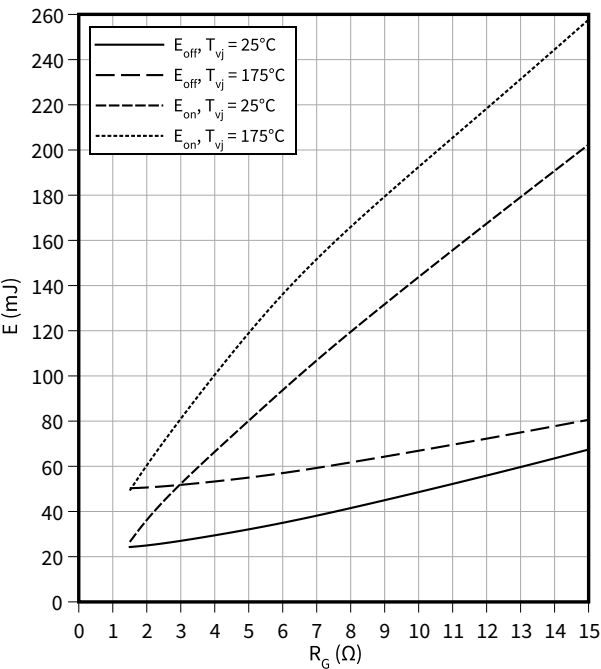
$E = f(I_C)$
 $C_{GE} = 82\text{ nF}$, $R_{G,off} = 1.5\ \Omega$, $R_{G,on} = 1.5\ \Omega$, $V_{CE} = 800\text{ V}$, $V_{GE} = -8\text{...}15\text{ V}$



5 Characteristics diagrams

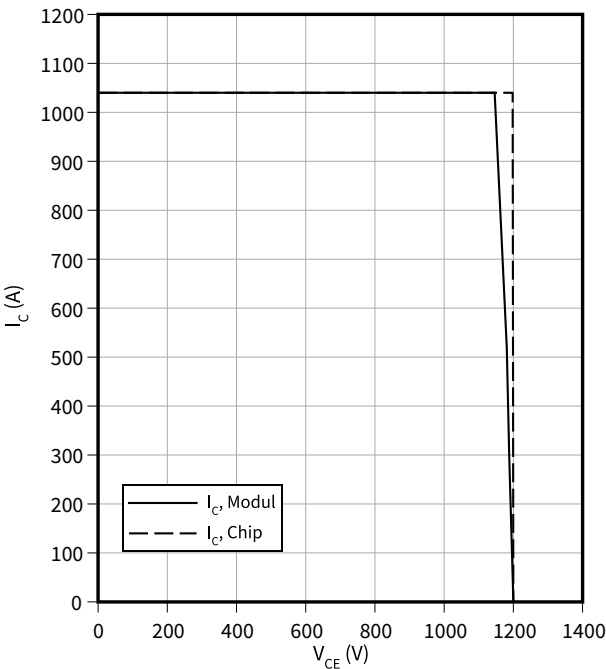
Switching losses (typical), IGBT, Inverter

$E = f(R_G)$
 $C_{GE} = 82\text{ nF}$, $V_{CE} = 800\text{ V}$, $V_{GE} = -8...15\text{ V}$, $I_C = 300\text{ A}$



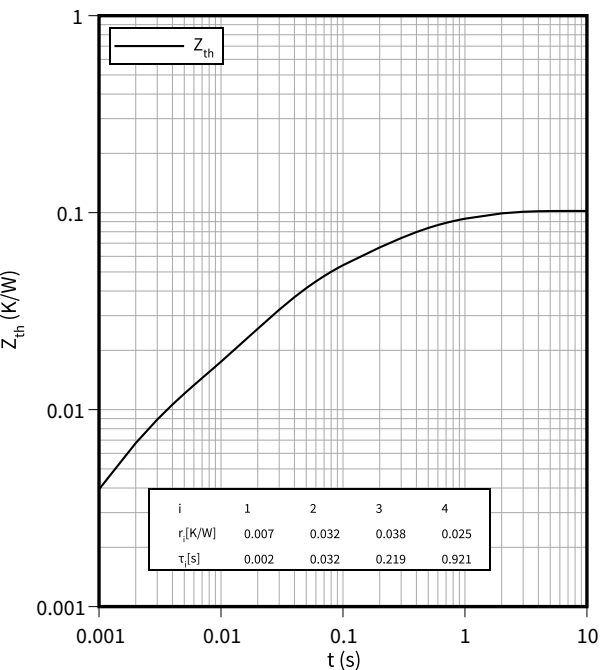
Reverse bias safe operating area (RBSOA), IGBT, Inverter

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



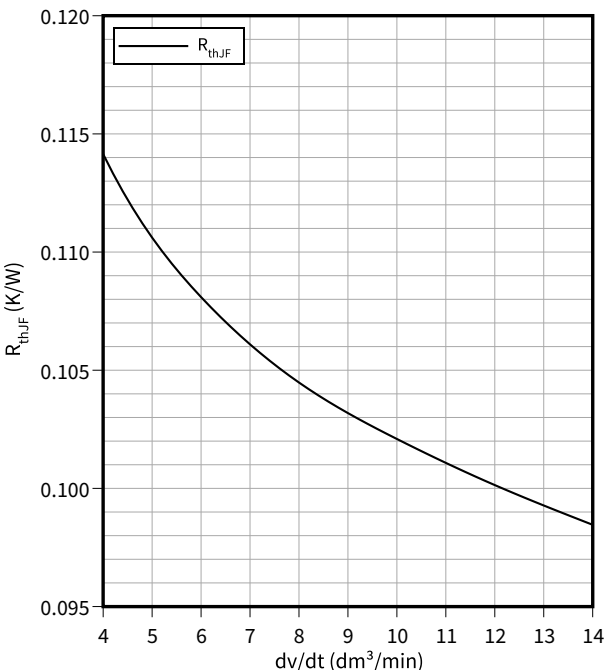
Transient thermal impedance (typical), IGBT, Inverter

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



Thermal impedance (typical), IGBT, Inverter

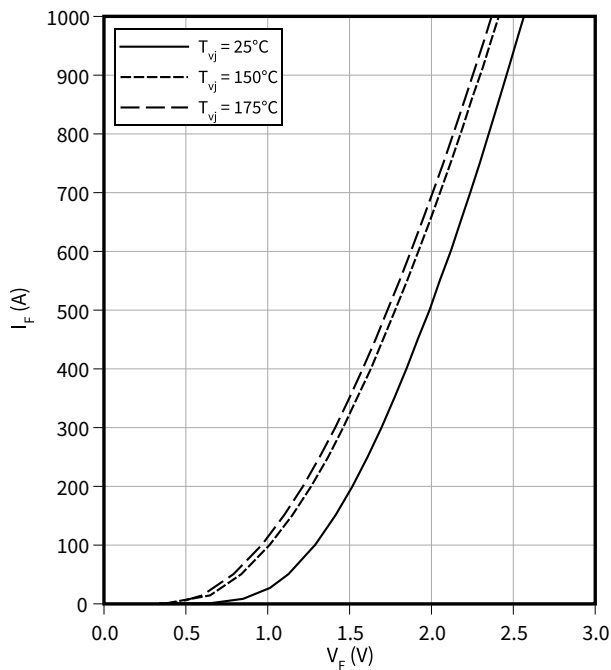
$R_{thJF} = f(dv/dt)$
 $T_f = 65\text{ °C}$, fluid = 50% water / 50% ethylenglycol



5 Characteristics diagrams

Forward characteristic (typical), Diode, Inverter

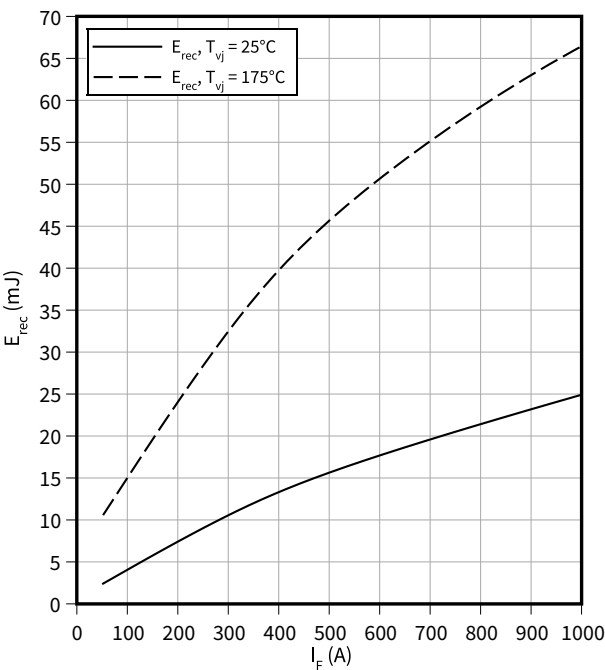
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

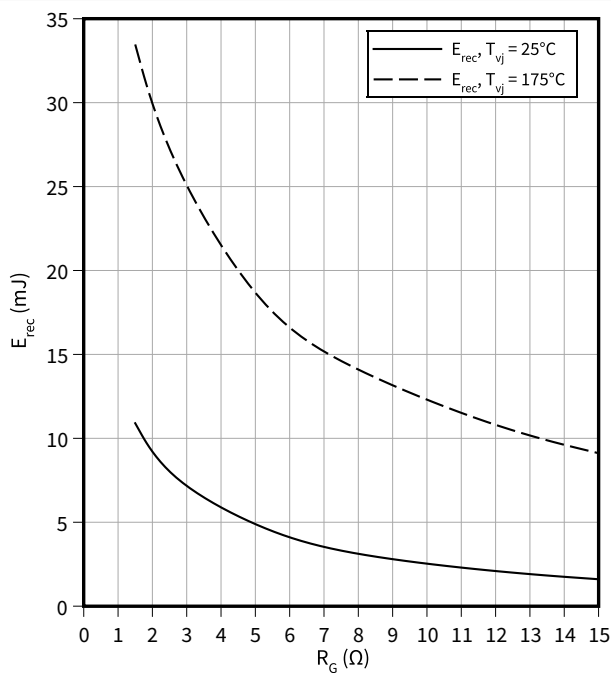
$C_{GE} = 82 \text{ nF}$, $R_{Gon} = 1.5 \Omega$, $V_{CE} = 800 \text{ V}$, $V_{GE} = -8 \dots 15 \text{ V}$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

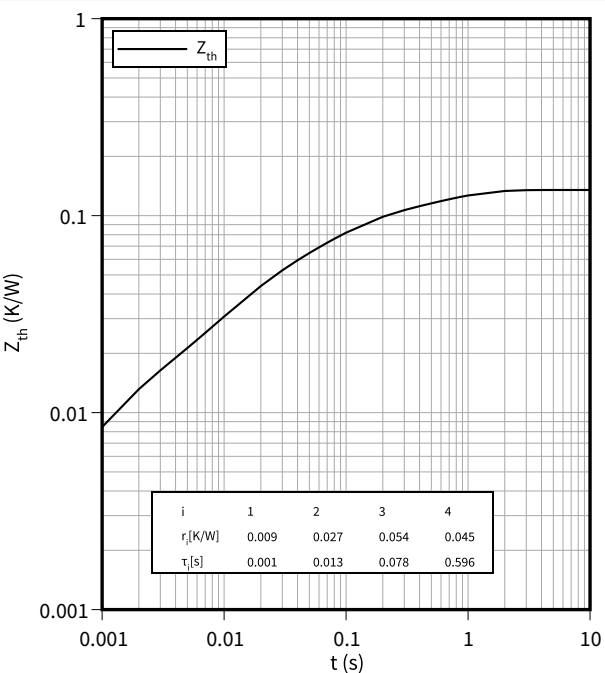
$C_{GE} = 82 \text{ nF}$, $V_{CE} = 800 \text{ V}$, $I_F = 300 \text{ A}$, $V_{GE} = -8 \dots 15 \text{ V}$



Transient thermal impedance (typical), Diode, Inverter

$Z_{th} = f(t)$

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

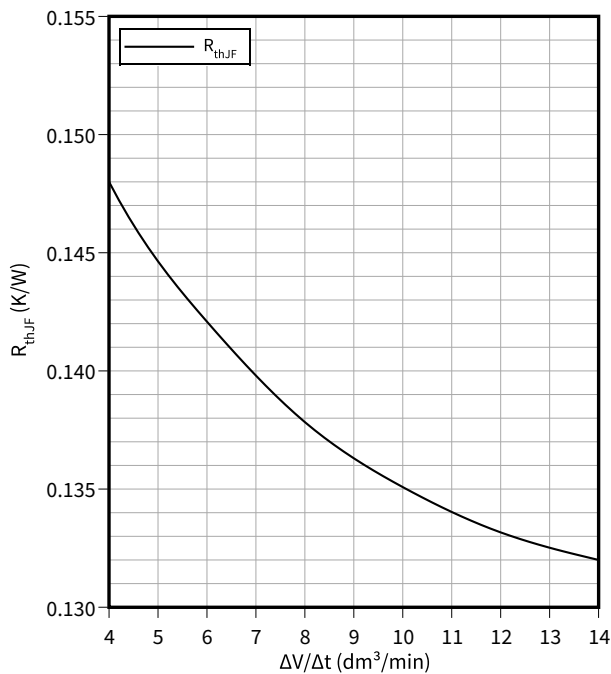


5 Characteristics diagrams

Thermal impedance (typical), Diode, Inverter

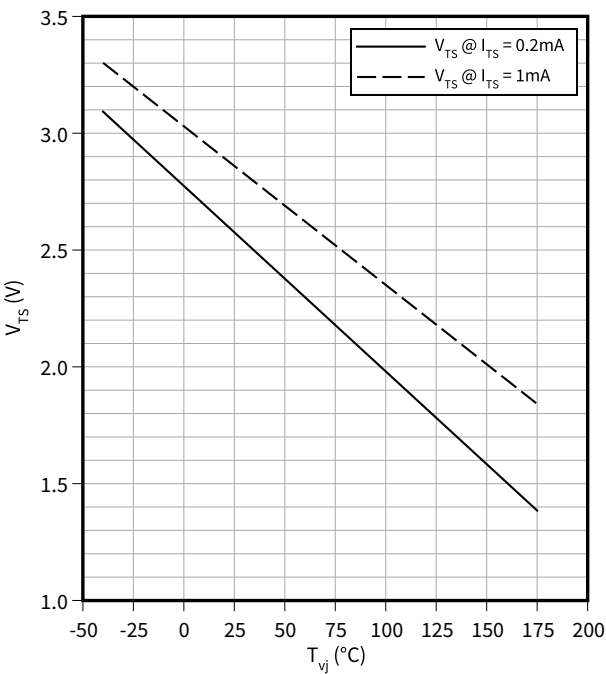
$R_{thJF} = f(\Delta V/\Delta t)$

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



Temperature characteristic (typical), Temperature sensor

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



6 Circuit diagram

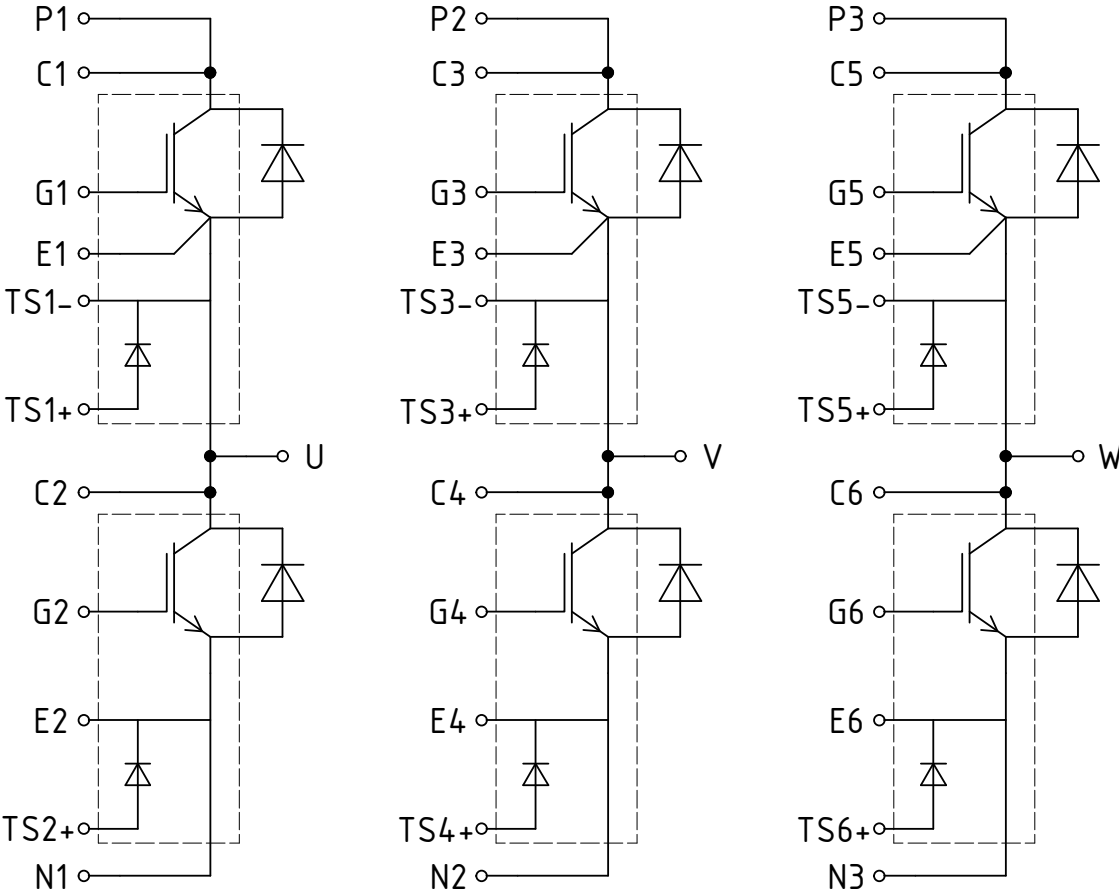


Figure 1

7 Package outlines

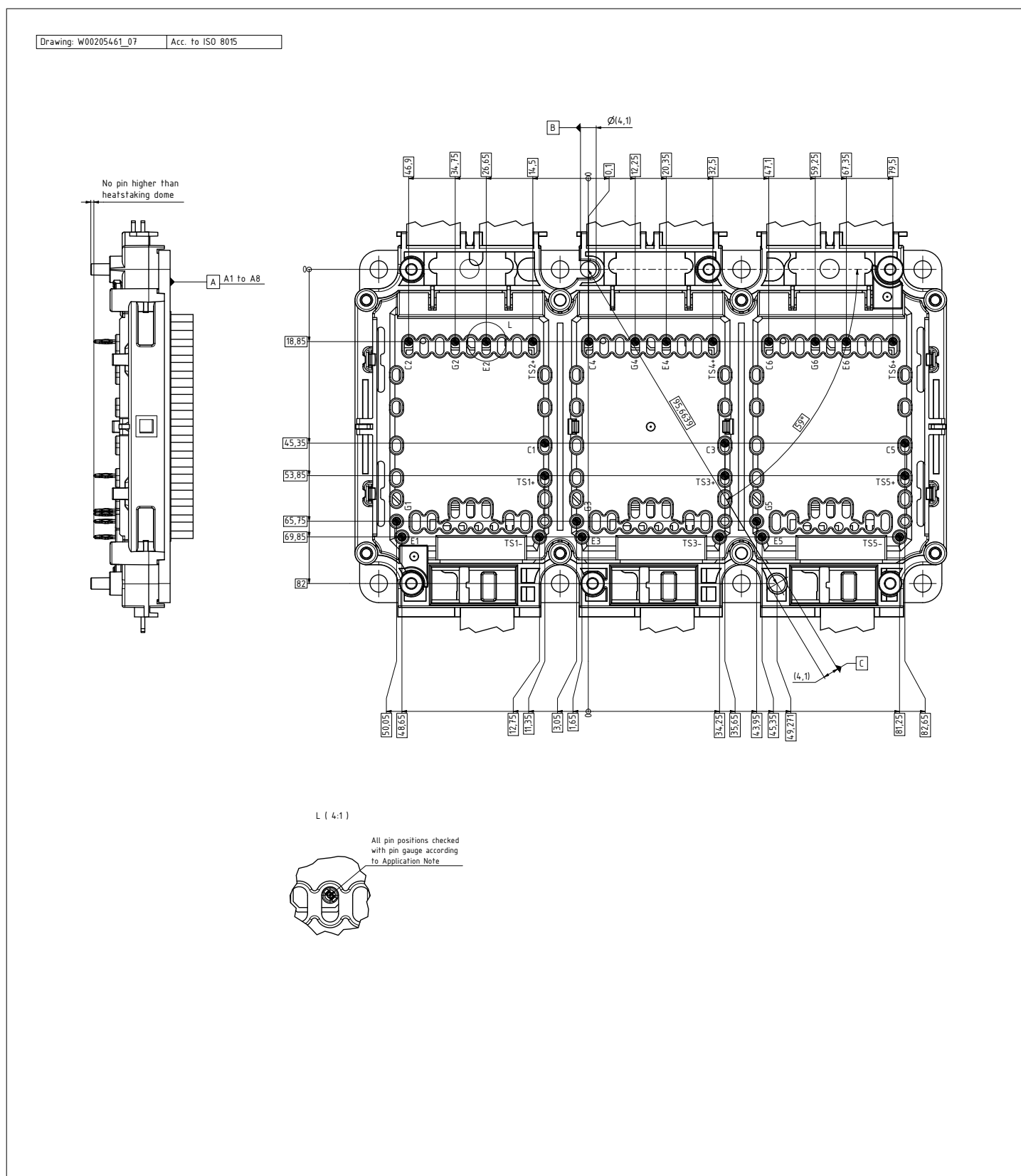


Figure 4

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

Document revision	Date of release	Description of changes
0.10	2022-08-12	Initial version
0.11	2023-03-22	Target datasheet
0.20	2023-12-07	Preliminary datasheet
0.21	2024-01-11	Preliminary datasheet
0.30	2024-03-27	Updated Preliminary datasheet
1.00	2024-06-24	Final datasheet

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Edition 2024-06-24

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference
IFX-ABE694-006

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