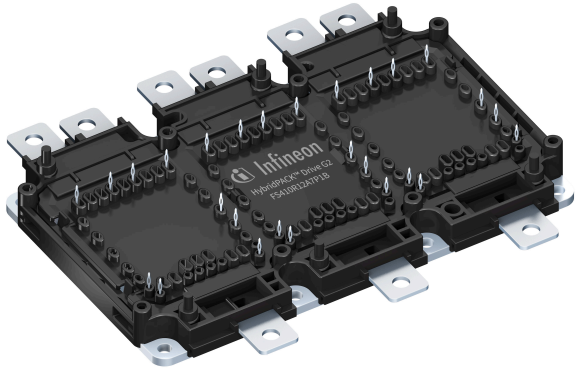
Final datasheet
HybridPACK™ Drive G2 module



Lead-free
RoHS
Green

Features

- Electrical features
  - V_{CES} = 1200 V
  - I_{CN} = 410 A / I_{CRM} = 820 A
  - Low $V_{CE,sat}$
  - Low switching losses
  - Low Q_g and C_{rss}
  - Low inductive design
  - $T_{vj,op}$ = 175°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
  - Al_2O_3 substrate with low thermal resistance

Potential applications

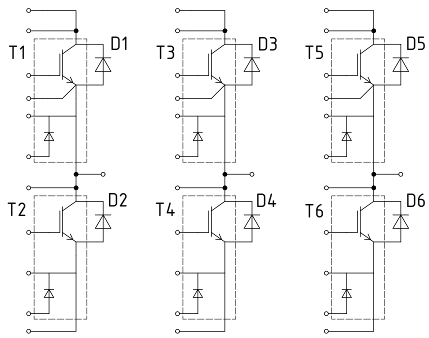
- Automotive applications
- (Hybrid) electrical vehicles (H)EV
- Motor drives
- Commercial, construction and agricultural vehicles (CAV)

Product validation

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

Description

The HybridPACKTM Drive is a very compact six-pack module (1200V/410A) 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_2O_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}	$t_{staking}$ < 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% 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
		$T_{baseplate}$ ≥ 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
Collector-emitter voltage	V_{CES}		T_{vj} = 25 °C	1200	V
Implemented collector current	I_{CN}			410	A
Continuous DC collector current	$I_{C,nom}$	T_f = 65 °C, $T_{vj,max}$ = 175 °C		300[1)]	A
Repetitive peak collector current	I_{CRM}	verified by design, t_p limited by $T_{vj,max}$		820	A
Total power dissipation	P_{tot}	T_f = 65 °C, $T_{vj,max}$ = 175 °C		775	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 A, V_{GE} = 15 V	T_{vj} = 25 °C		1.48	1.58	V
			T_{vj} = 150 °C		1.62		
			T_{vj} = 175 °C		1.66		
Gate threshold voltage	$V_{GE,th}$	I_C = 9.6 mA, V_{CE} = V_{GE}	T_{vj} = 25 °C	5	5.8	6.5	V
Gate charge	Q_G	V_{CE} = 800 V, V_{GE} = -8...15 V			2.95		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		0.5		Ω
Input capacitance	C_{ies}	f = 0.1 MHz, V_{CE} = 25 V, V_{GE} = 0 V	T_{vj} = 25 °C		24.6		nF
Output capacitance	C_{oes}	f = 0.1 MHz, V_{CE} = 25 V, V_{GE} = 0 V	T_{vj} = 25 °C		1.7		nF
Reverse transfer capacitance	C_{res}	f = 0.1 MHz, V_{CE} = 25 V, V_{GE} = 0 V	T_{vj} = 25 °C		1.06		nF
Collector-emitter cut-off current	I_{CES}	V_{CE} = 1200 V, V_{GE} = 0 V	T_{vj} = 25 °C			1.0	mA
			T_{vj} = 175 °C		23.8		
Gate-emitter leakage current	I_{GES}	V_{CE} = 0 V, V_{GE} = 20 V	T_{vj} = 25 °C			400	nA
Turn-on delay time, inductive load	$t_{d,on}$	I_C = 300 A, V_{CE} = 800 V, V_{GE} = -8/15 V, $R_{G,on}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C		107		ns
			T_{vj} = 150 °C		86.0		
			T_{vj} = 175 °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 A, V_{CE} = 800 V, V_{GE} = -8/15 V, $R_{G,on}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C		46.0		ns
			T_{vj} = 150 °C		56.0		
			T_{vj} = 175 °C		59.0		
Turn-off delay time, inductive load	$t_{d,off}$	I_C = 300 A, V_{CE} = 800 V, V_{GE} = -8/15 V, $R_{G,off}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C		466		ns
			T_{vj} = 150 °C		594		
			T_{vj} = 175 °C		628		
Fall time, inductive load	t_f	I_C = 300 A, V_{CE} = 800 V, V_{GE} = -8/15 V, $R_{G,off}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C		77.0		ns
			T_{vj} = 150 °C		183		
			T_{vj} = 175 °C		217		
Turn-on energy loss per pulse	E_{on}	I_C = 300 A, V_{CE} = 800 V, L_σ = 20 nH, V_{GE} = -8/15 V, $R_{G,on}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C, di/dt = 5300 A/µs		26.5		mJ
			T_{vj} = 150 °C, di/dt = 4300 A/µs		44.1		
			T_{vj} = 175 °C, di/dt = 4100 A/µs		49.3		
Turn-off energy loss per pulse	E_{off}	I_C = 300 A, V_{CE} = 800 V, L_σ = 20 nH, V_{GE} = -8/15 V, $R_{G,off}$ = 1.5 Ω, C_{GE} = 82 nF	T_{vj} = 25 °C, dv/dt = 6700 V/µs		24.3		mJ
			T_{vj} = 150 °C, dv/dt = 4100 V/µs		44.3		
			T_{vj} = 175 °C, dv/dt = 3700 V/µs		50.3		
SC data	I_{SC}	V_{CC} = 800 V, V_{GE} = 15 V,[1] $V_{CEmax} = V_{CES} - L_{s,CE} \cdot di/dt$	T_{vj} = 25 °C, t_P = 3.0 µs		4200		A
			T_{vj} = 175 °C, t_P = 3.0 µs		3350		
Thermal resistance, junction to cooling fluid[2]	$R_{th,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 65 °C			0.130		K/W
Variance of thermal resistance, junction to cooling fluid[2]	$\sigma_{Rth,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 65 °C			0.0027		K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	°C

1) with C_{GE} = 82nF
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 °C		1200	V
Implemented forward current	I_{FN}			410	A
Continuous DC forward current	$I_{F,nom}$			300	A
Repetitive peak forward current	I_{FRM}	verified by design, t_p limited by $T_{vj,max}$		820	A
I^2t - value	I^2t	V_R = 0 V, t_P = 10 ms	T_{vj} = 175 °C	38000	A^2s

Table 7 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_F	I_F = 300 A	T_{vj} = 25 °C		1.68	2.03	V
			T_{vj} = 150 °C		1.46		
			T_{vj} = 175 °C		1.41		
Peak reverse recovery current	I_{rm}	I_F = 300 A, V_{GE} = -8 V, V_R = 800 V	T_{vj} = 25 °C		342		A
			T_{vj} = 150 °C		506		
			T_{vj} = 175 °C		538		
Recovered charge	Q_r	I_F = 300 A, V_R = 800 V, V_{GE} = -8 V	T_{vj} = 25 °C		25.0		µC
			T_{vj} = 150 °C		60.0		
			T_{vj} = 175 °C		70.0		
Reverse recovery energy	E_{rec}	I_F = 300 A, V_{GE} = -8 V, R_G = 1.5 Ω, C_{GE} = 82 nF, V_R = 800 V	T_{vj} = 25 °C, $-di_F/dt$ = 8000 A/µs		10.90		mJ
			T_{vj} = 150 °C, $-di_F/dt$ = 7100 A/µs		28.40		
			T_{vj} = 175 °C, $-di_F/dt$ = 6800 A/µs		33.50		
Thermal resistance, junction to cooling fluid[1)]	$R_{th,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm^3/min, T_f = 65 °C			0.175		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 dm^3/min, T_f = 65 °C			0.0025		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.

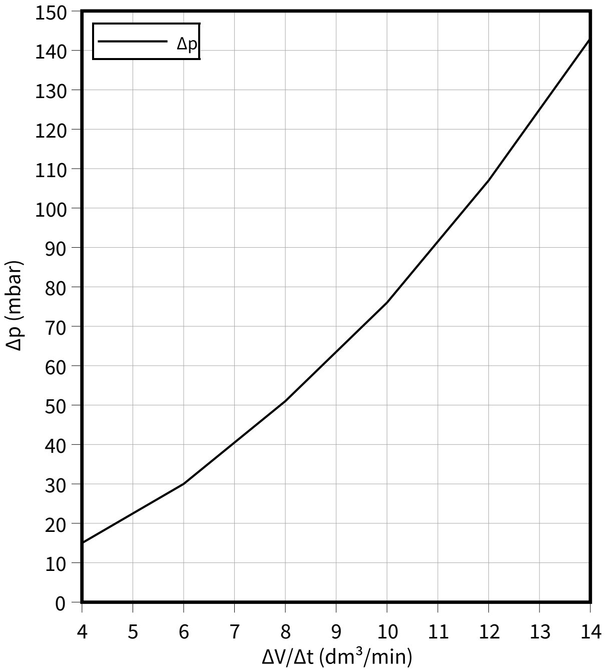
4 Temperature sensor

Table 8 Characteristic values

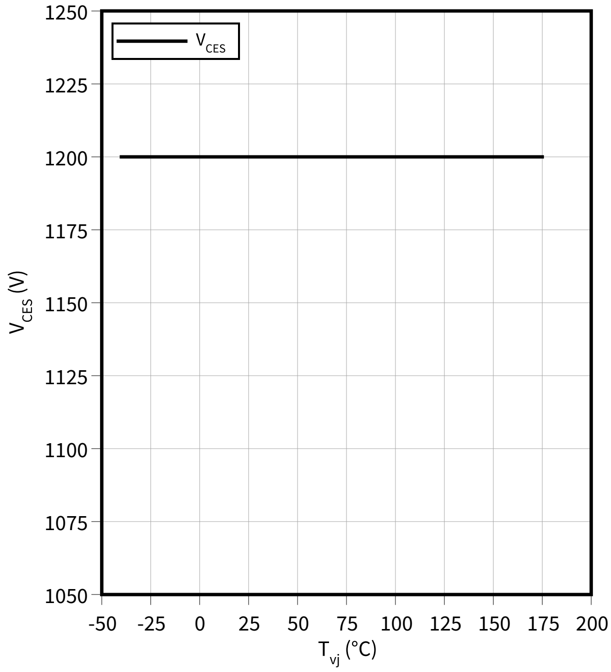
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Transient sense current	I_{TS}					10	mA
Continuous sense current	I_{TS}					1	mA
Forward voltage	V_{TS}		I_{TS} = 0.2 mA, T_{vj} = 25 °C	2.495	2.576	2.660	V
Temperature coefficient (TCR)	TC_{TS}	I_{TS} = 0.2 mA			-7.94		mV/K

5 Characteristics diagrams

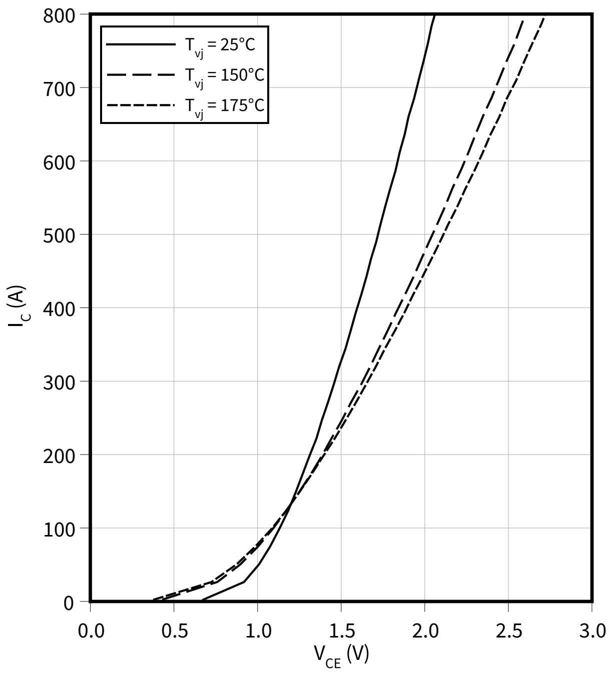
Pressure drop in cooling circuit (typical), Package
$\Delta p = f(\Delta V/\Delta t)$
T_f = 65 °C, 50% water / 50% ethylene glycol



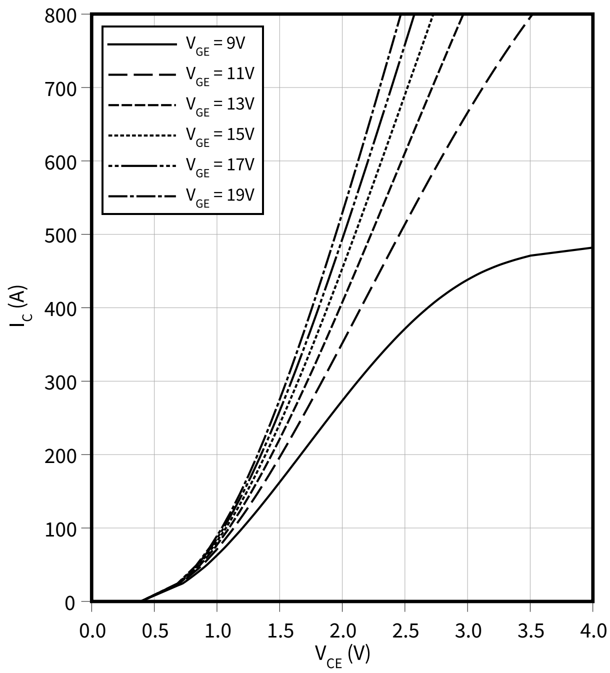
Maximum collector-emitter voltage, IGBT, Inverter
$V_{CES} = f(T_{vj})$
Note = Verified by characterization / design, not by test.



Output characteristic (typical), IGBT, Inverter
$I_C = f(V_{CE})$
V_{GE} = 15 V



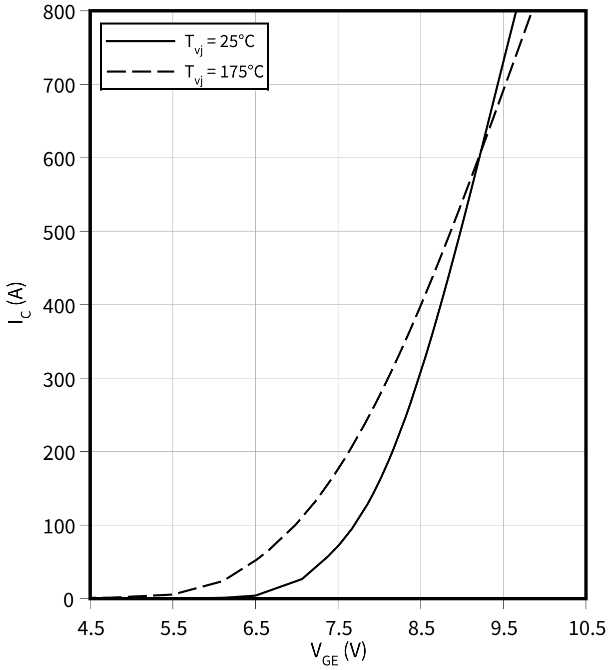
Output characteristic (typical), IGBT, Inverter
$I_C = f(V_{CE})$
T_{vj} = 175 °C



Transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$

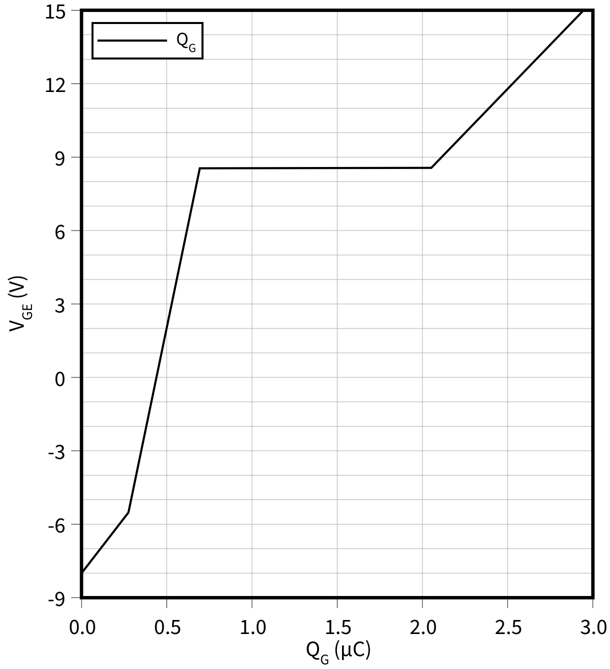
$V_{CE} = 20$ V



Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$

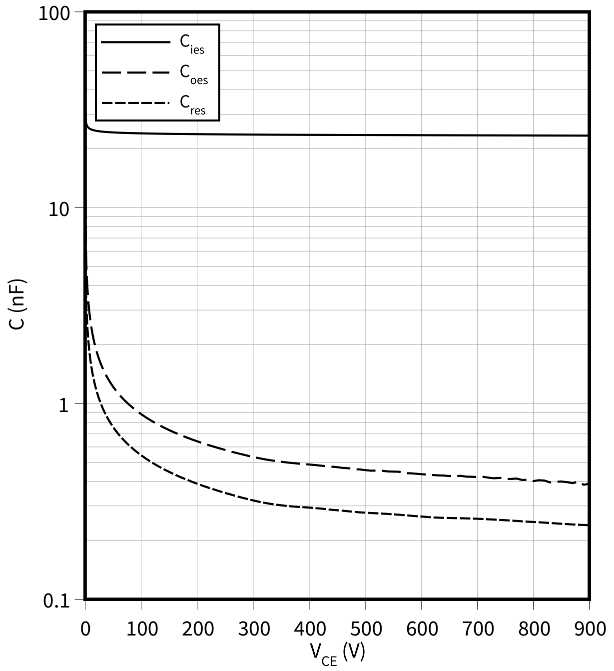
$T_{vj} = 25$ °C, $V_{CE} = 800$ V, $I_C = 300$ A



Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$

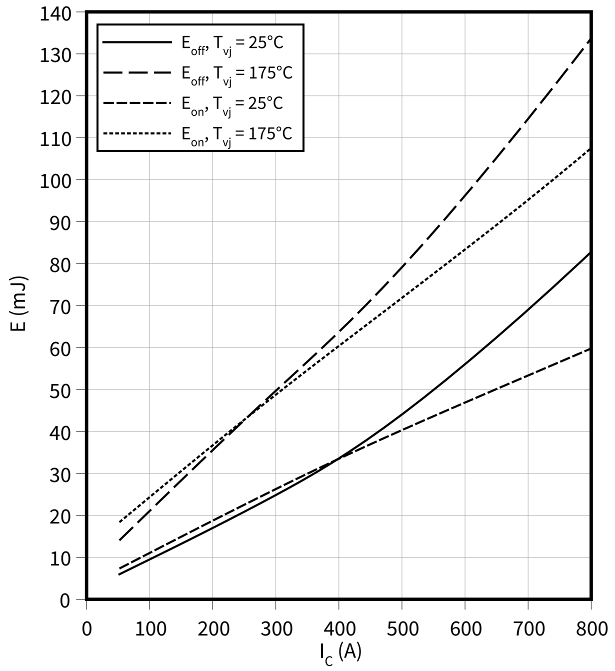
$V_{GE} = 0$ V, $T_{vj} = 25$ °C, f = 0.1 MHz



Switching losses (typical), IGBT, Inverter

$E = f(I_C)$

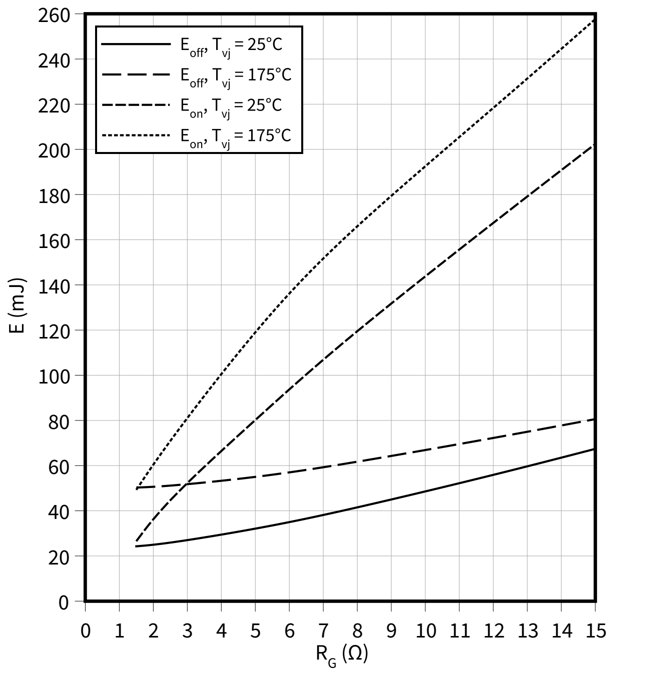
$C_{GE} = 82$ nF, $V_{GE} = -8/15$ V, $R_{G,off} = 1.5\ \Omega$, $R_{G,on} = 1.5\ \Omega$, $V_{CE} = 800$ V



Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

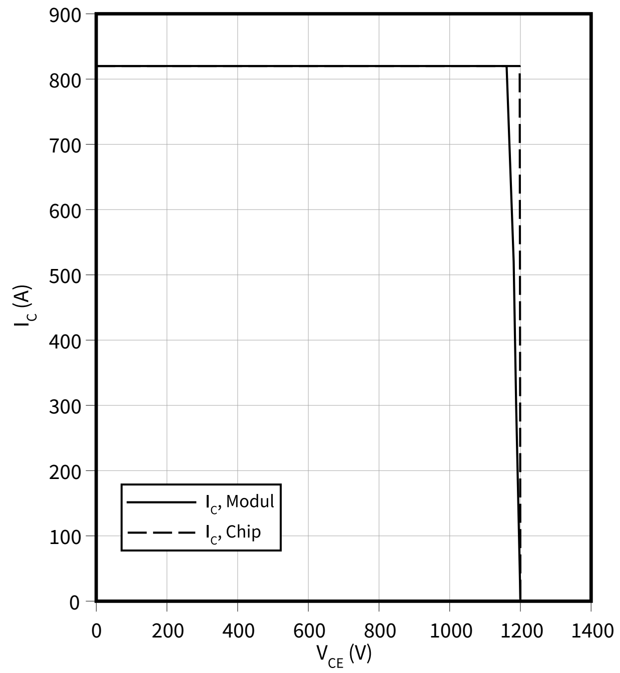
C_{GE} = 82 nF, V_{GE} = -8/15 V, V_{CE} = 800 V, I_C = 300 A



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

$I_C = f(V_{CE})$

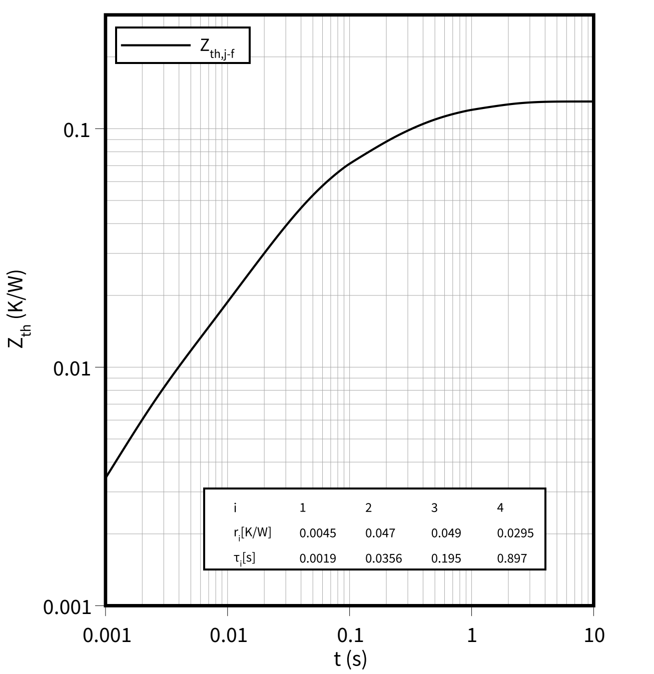
T_{vj} = 175 °C, $R_{G,off}$ = 1.5 Ω, C_{GE} = 82 nF, V_{GE} = -8/15 V



Transient thermal impedance (typical), IGBT, Inverter

$Z_{th} = f(t)$

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

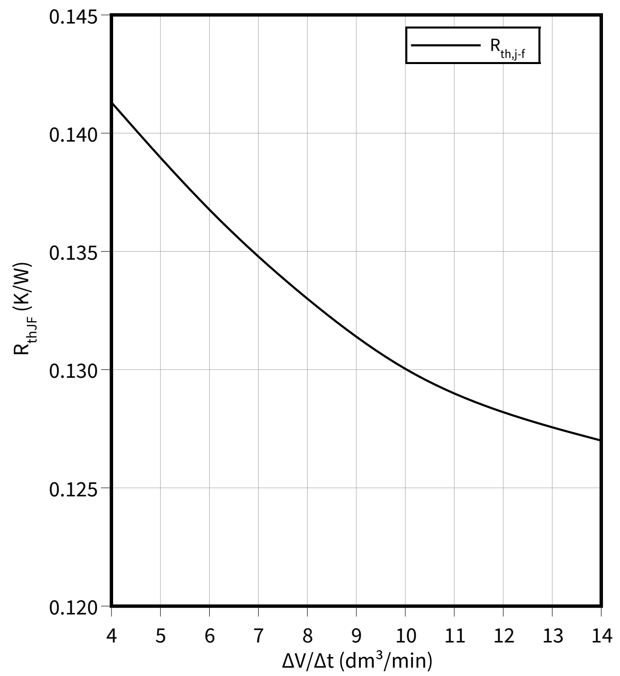


i	1	2	3	4
r_i[K/W]	0.0045	0.047	0.049	0.0295
τ_i[s]	0.0019	0.0356	0.195	0.897

Thermal impedance (typical), IGBT, Inverter

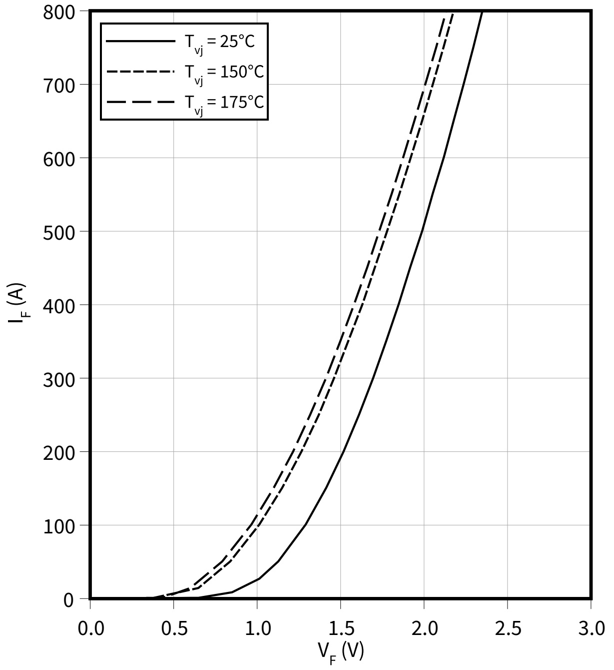
$R_{thJF} = f(\Delta V/\Delta t)$

T_f = 65 °C, 50% water / 50% ethylene glycol



Forward characteristic (typical), Diode, Inverter

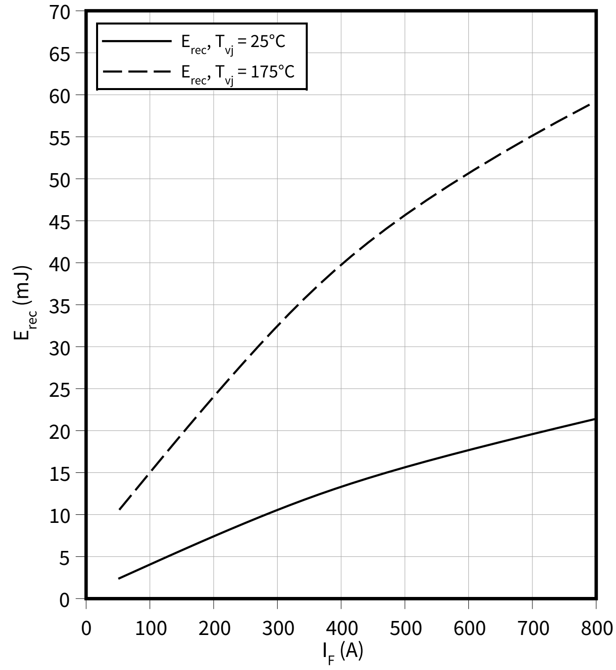
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

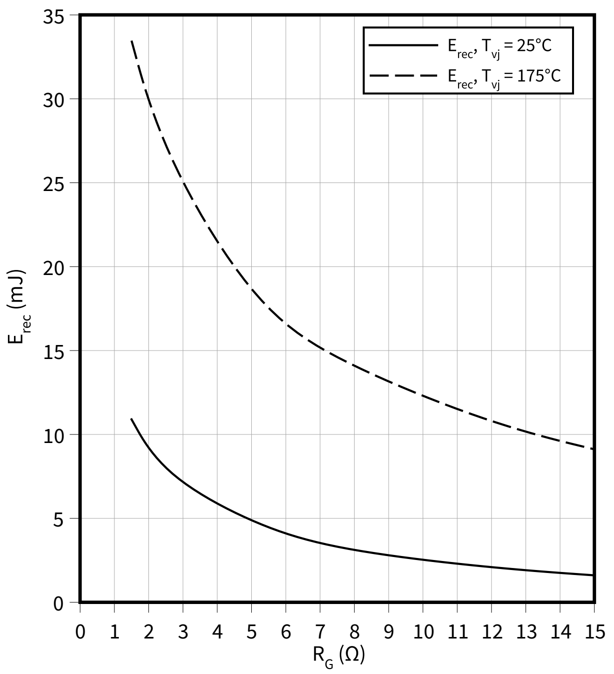
C_{GE} = 82 nF, V_{CE} = 800 V, V_{GE} = -8 V, R_G = 1.5 Ω



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

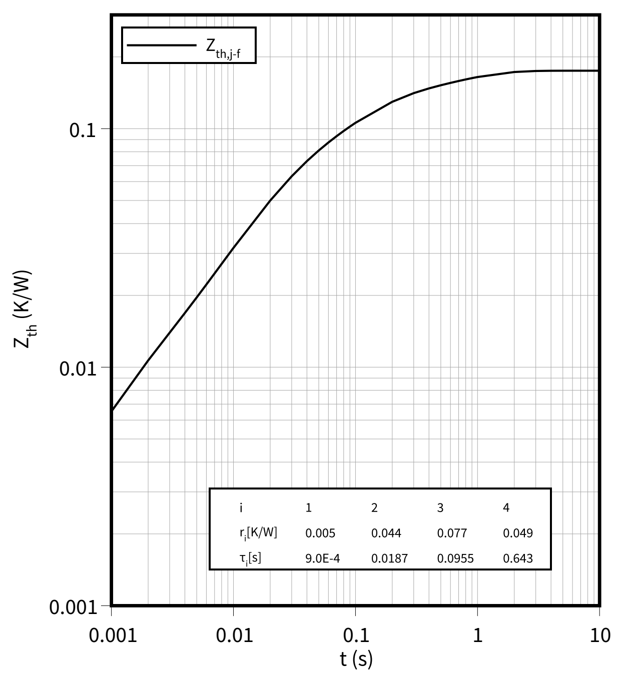
C_{GE} = 82 nF, V_{CE} = 800 V, V_{GE} = -8 V, I_F = 300 A



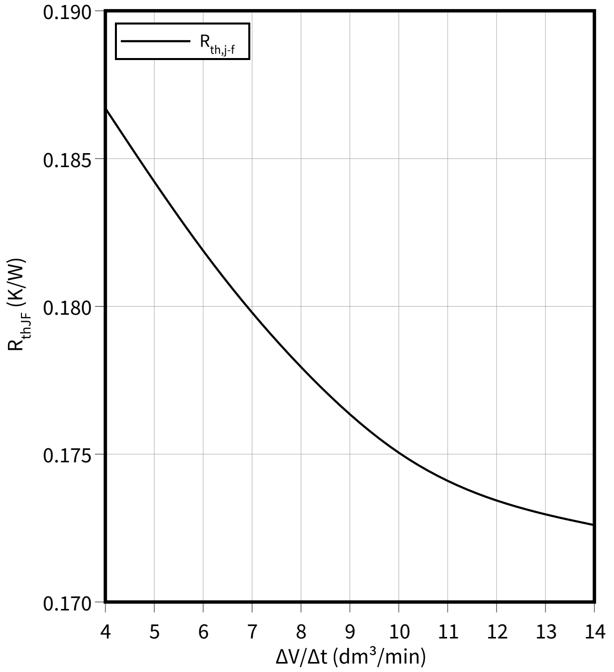
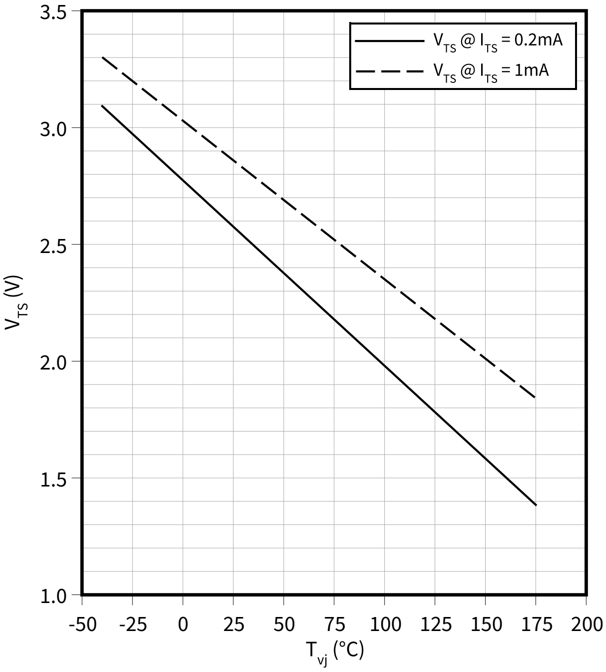
Transient thermal impedance (typical), Diode, Inverter

$Z_{th} = f(t)$

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



i	1	2	3	4
r_i[K/W]	0.005	0.044	0.077	0.049
τ_i[s]	9.0E-4	0.0187	0.0955	0.643

Thermal impedance (typical), Diode, Inverter $R_{thJF} = f(\Delta V/\Delta t)$ T_f = 65 °C, 50% water / 50% ethylene glycol	**Temperature characteristic (typical), Temperature sensor** $V_{TS} = f(T_{vj})$
	

6 Circuit diagram

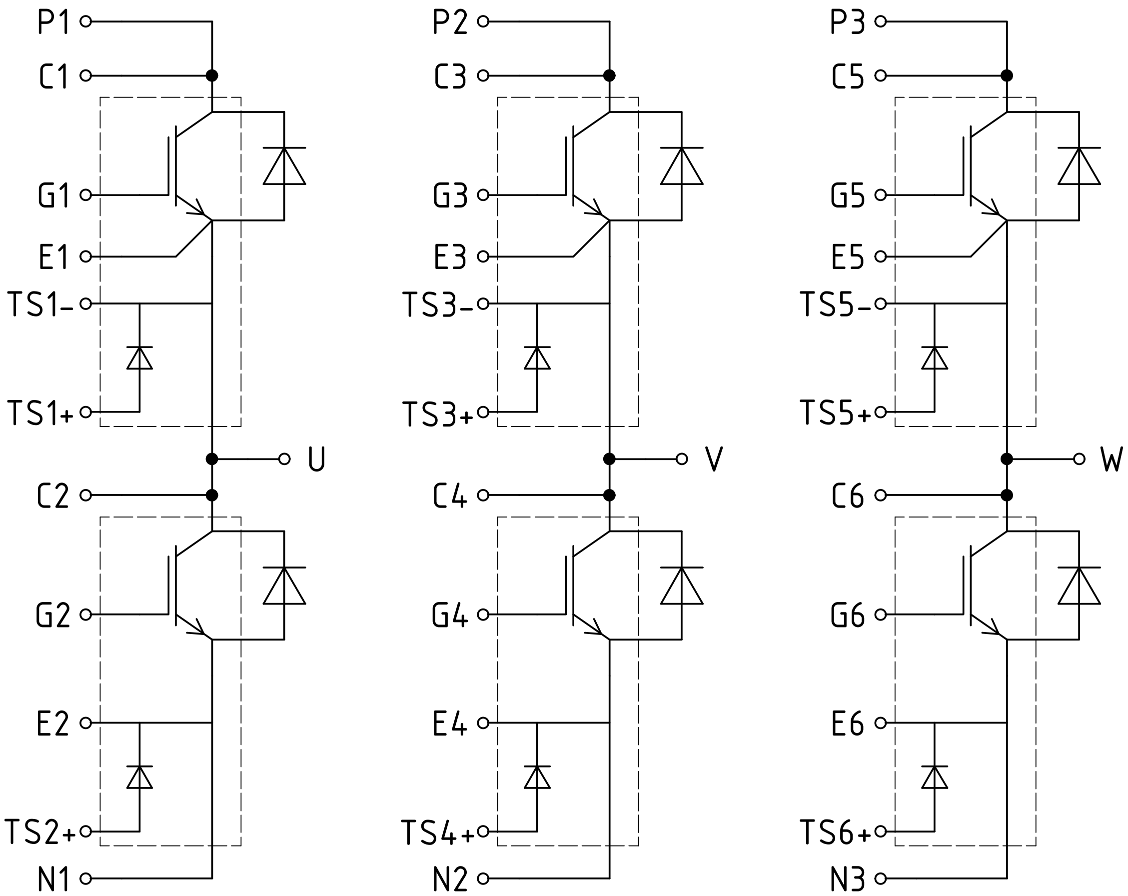


Figure 1

7 Package outlines

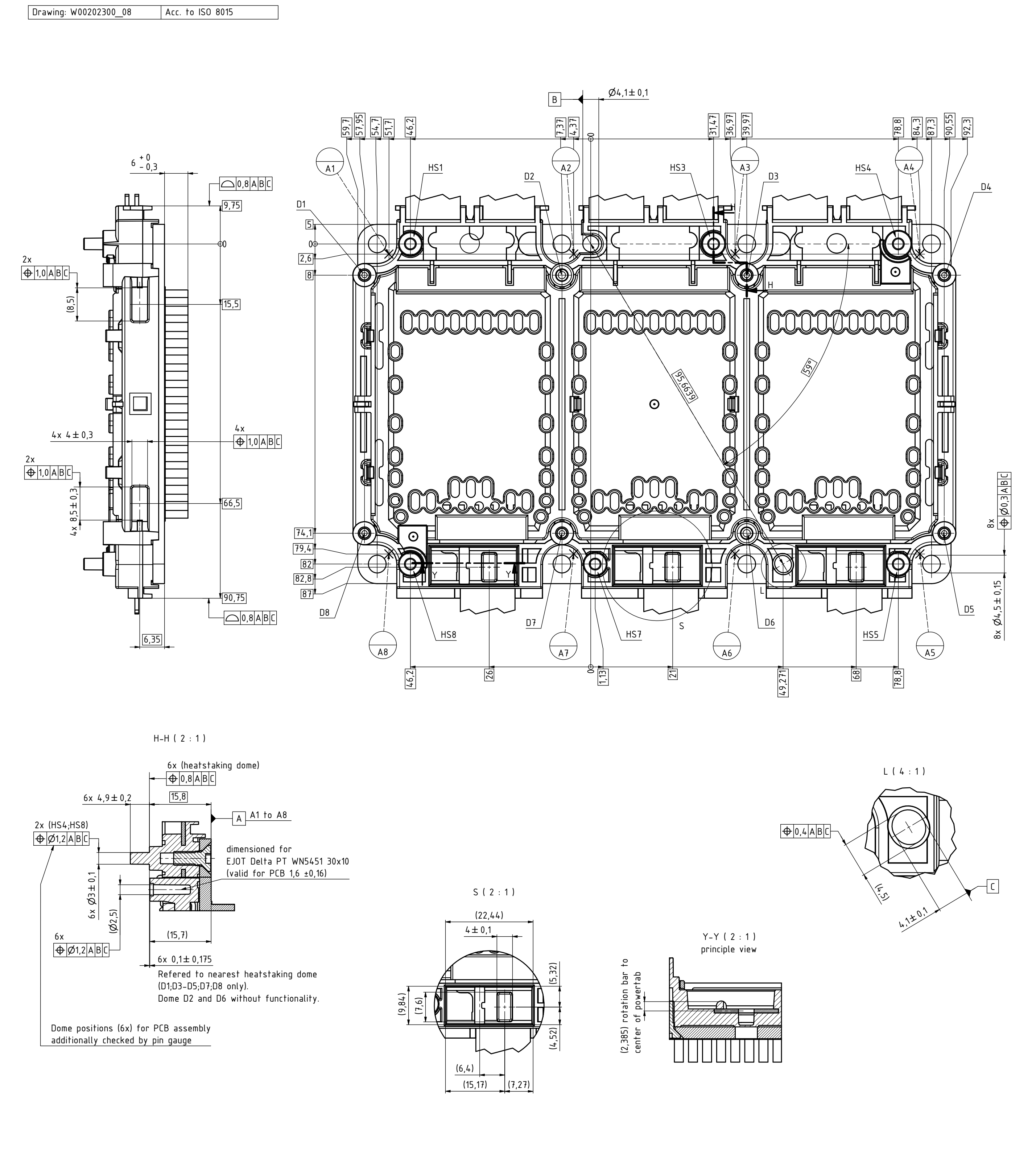


Figure 2

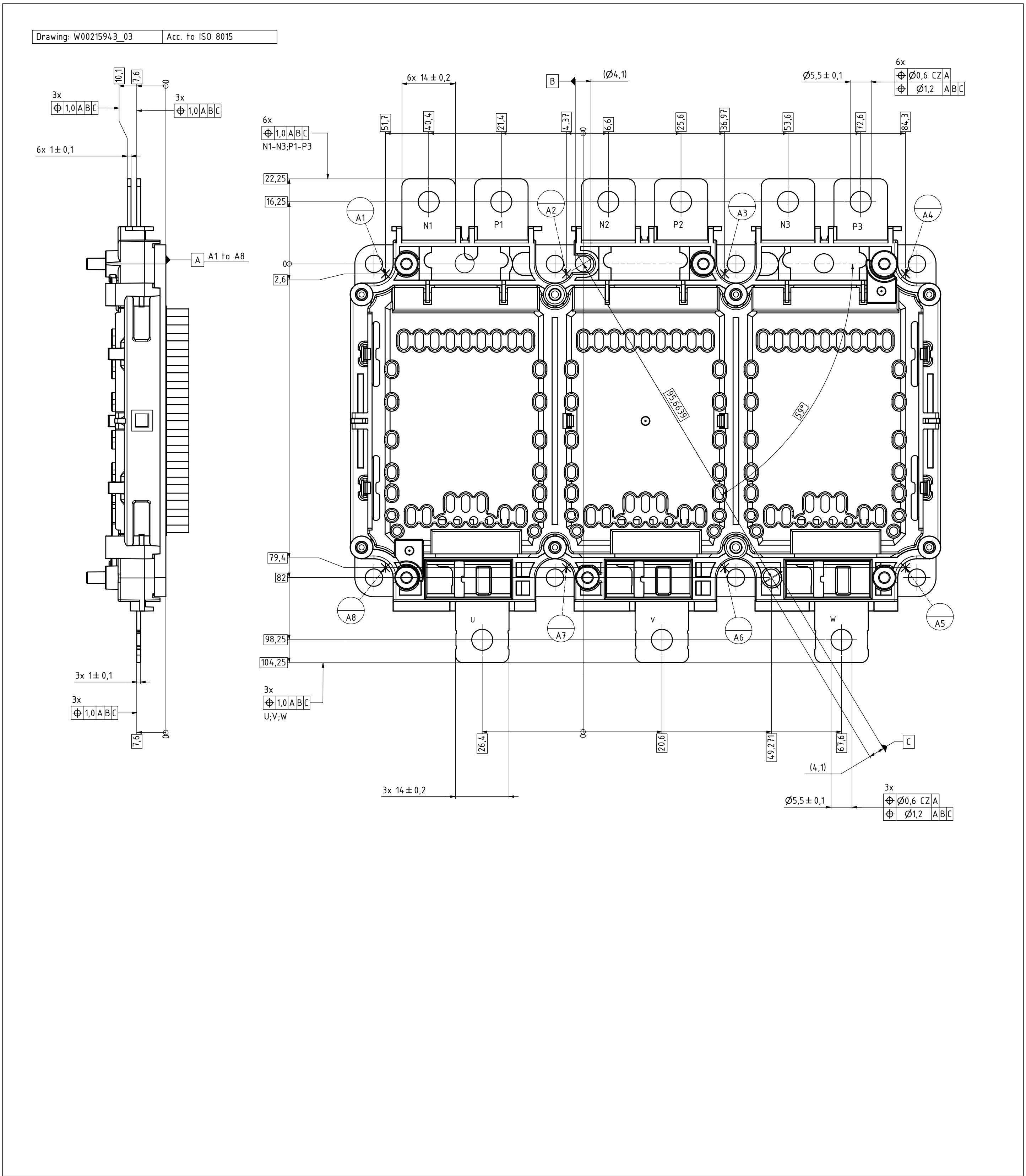

Drawing: W00215943_03
Acc. to ISO 8015
N1
P1
N2
P2
N3
P3
U
V
W
A1 to A8

Figure 3

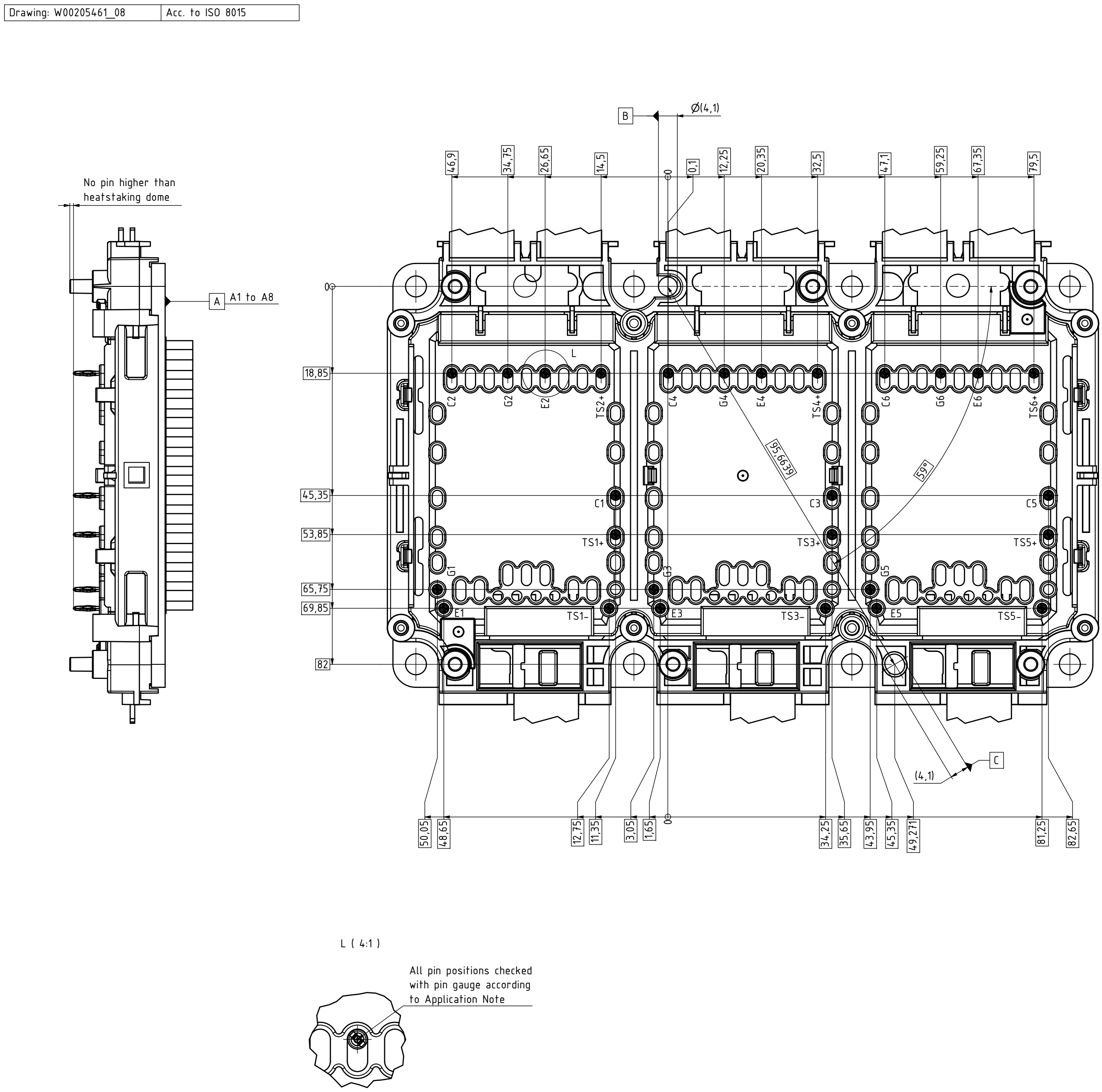

Drawing: W00205461_08
Acc. to ISO 8015
No pin higher than heatstaking dome
A1 to A8
B
Ø(4,1)
C
(4,1)
59°
95,6639
L
L (4:1)
All pin positions checked with pin gauge according to Application Note
C1
C2
C3
C4
C5
C6
G1
G2
G3
G4
G5
G6
E1
E2
E3
E4
E5
E6
TS1+
TS1-
TS2+
TS3+
TS3-
TS4+
TS5+
TS5-
TS6+
46,9
34,75
26,65
14,5
0
0,1
12,25
20,35
32,5
47,1
59,25
67,35
79,5
18,85
45,35
53,85
65,75
69,85
82
50,05
48,65
12,75
11,35
3,05
1,65
34,25
35,65
43,95
45,35
49,271
81,25
82,65

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	71549142846550549911530		71549142846550549911530

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

Document revision	Date of release	Description of changes
0.10	2023-05-25	Initial version
0.20	2024-11-28	Preliminary datasheet
1.00	2025-06-10	Final datasheet

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