Final datasheet
HybridPACK™ Drive G2 module

Lead-free
RoHS
Green

Features

- Electrical features
  - V_{CES} = 750 V
  - I_{CN} = 1150 A / I_{CRM} = 2300 A
  - Blocking voltage 750 V
  - 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
  - Short-time extended operation temperature $T_{vj,op}$ = 185 °C
- Mechanical features
  - 4.2 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
  - High-performance Si_3N_4 ceramic
  - High power and thermal cycling capability

Potential applications

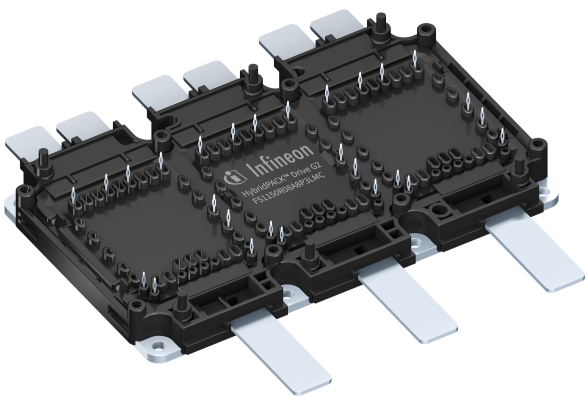
- Automotive applications
- (Hybrid) electrical vehicles (H)EV

Product validation

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

Description

The HybridPACKTM Drive is a very compact six-pack module (750V/1150A) optimized for hybrid and electric vehicles.



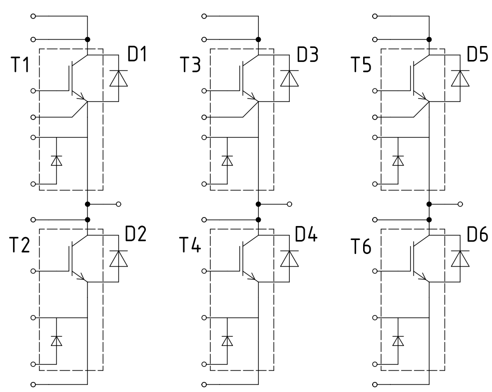


Table of contents

	Description	1
	Features	1
	Potential applications	1
	Product validation	1
	Table of contents	2
1	**Package**	3
2	**IGBT, Inverter**	4
3	**Diode, Inverter**	6
4	**Temperature sensor**	7
5	**Characteristics diagrams**	8
6	**Circuit diagram**	13
7	**Package outlines**	14
8	**Module label code**	17
	Revision history	18
	Disclaimer	19

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	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}	$t_{staking}$ < 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% ethylenglycol, $\Delta V/\Delta t$ = 10 dm^3/min, T_f = 65 °C		76[1)]		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate}$ < 40 °C			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	750	V
Implemented collector current	I_{CN}			1150	A
Continuous DC collector current	$I_{C,nom}$	T_f = 65 °C, $T_{vj,max}$ = 175 °C		600[1)]	A
Repetitive peak collector current	I_{CRM}	verified by design, t_p limited by $T_{vj,max}$		2300	A
Total power dissipation	P_{tot}	T_f = 65 °C, $T_{vj,max}$ = 175 °C		1000[1)]	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 A, V_{GE} = 15 V	T_{vj} = 25 °C		1.08	1.21	V
			T_{vj} = 175 °C		1.09		
Collector-emitter saturation voltage	$V_{CE,sat}$	I_C = 1000 A, V_{GE} = 15 V	T_{vj} = 25 °C		1.22		V
			T_{vj} = 175 °C		1.32		
Gate threshold voltage	$V_{GE,th}$	I_C = 10.3 mA, V_{CE} = V_{GE}	T_{vj} = 25 °C	4.9	5.8	6.65	V
			T_{vj} = 175 °C		4		
Gate charge	Q_G	V_{CE} = 400 V, V_{GE} = -8...15 V			2.6		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		1.0		Ω
Input capacitance	C_{ies}	f = 0.1 MHz, V_{CE} = 50 V, V_{GE} = 0 V	T_{vj} = 25 °C		60.8		nF
Output capacitance	C_{oes}	f = 0.1 MHz, V_{CE} = 50 V, V_{GE} = 0 V	T_{vj} = 25 °C		2.0		nF
Reverse transfer capacitance	C_{res}	f = 0.1 MHz, V_{CE} = 50 V, V_{GE} = 0 V	T_{vj} = 25 °C		0.27		nF
Collector-emitter cut-off current	I_{CES}	V_{CE} = 750 V, V_{GE} = 0 V	T_{vj} = 25 °C			1.0	mA
			T_{vj} = 175 °C		15.0		
			T_{vj} = 185 °C		28.0		
Gate-emitter leakage current	I_{GES}		T_{vj} = 25 °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 A, V_{CE} = 400 V, V_{GE} = -8/15 V, $R_{G,on}$ = 2.4 Ω	T_{vj} = 25 °C		222		ns
			T_{vj} = 175 °C		255		
Rise time, inductive load	t_r	I_C = 600 A, V_{CE} = 400 V, V_{GE} = -8/15 V, $R_{G,on}$ = 2.4 Ω	T_{vj} = 25 °C		50.0		ns
			T_{vj} = 175 °C		55.0		
Turn-off delay time, inductive load	$t_{d,off}$	I_C = 600 A, V_{CE} = 400 V, V_{GE} = -8/15 V, $R_{G,off}$ = 7.5 Ω	T_{vj} = 25 °C		929		ns
			T_{vj} = 175 °C		1060		
Fall time, inductive load	t_f	I_C = 600 A, V_{CE} = 400 V, V_{GE} = -8/15 V, $R_{G,off}$ = 7.5 Ω	T_{vj} = 25 °C		91.0		ns
			T_{vj} = 175 °C		199		
Turn-on energy loss per pulse	E_{on}	I_C = 600 A, V_{CE} = 400 V, L_σ = 7 nH, V_{GE} = -8/15 V, $R_{G,on}$ = 2.4 Ω	T_{vj} = 25 °C, di/dt = 9600 A/µs		4.5		mJ
			T_{vj} = 175 °C, di/dt = 8700 A/µs		10.7		
Turn-off energy loss per pulse	E_{off}	I_C = 600 A, V_{CE} = 400 V, L_σ = 7 nH, V_{GE} = -8/15 V, $R_{G,off}$ = 7.5 Ω	T_{vj} = 25 °C, dv/dt = 4000 V/µs		31.1		mJ
			T_{vj} = 175 °C, dv/dt = 2700 V/µs		43.0		
SC data	I_{SC}	V_{CC} = 400 V, V_{GE} = 15 V, $V_{CEmax} = V_{CES}-L_{sCE}\cdot di/dt$	T_{vj} = 25 °C, t_P = 3.0 µs		8500		A
			T_{vj} = 175 °C, t_P = 3.0 µs		6700		
			T_{vj} = 185 °C, t_P = 2.5 µs		6600		
Thermal resistance, junction to cooling fluid[1)]	$R_{th,j-f}$	50% water / 50% ethylenglycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 65 °C			0.100	0.110[2)]	K/W
Temperature under switching conditions[3)]	$T_{vj,op}$	continuous operation		-40		175	°C
		extended operation				185	

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.
3) Tvj>175°C only blocking and short circuit capability specified

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		750	V
Implemented forward current	I_{FN}			1150	A
Continuous DC forward current	$I_{F,nom}$			600	A
Repetitive peak forward current	I_{FRM}	verified by design, t_p limited by $T_{vj,max}$		2300	A
I^2t - value	I^2t	V_R = 0 V, t_P = 10 ms	T_{vj} = 175 °C	31250	A^2s

Table 7 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_F	I_F = 600 A	T_{vj} = 25 °C		1.76	2.08	V
			T_{vj} = 175 °C		1.57		
Forward voltage	V_F	I_F = 1000 A	T_{vj} = 25 °C		2.09		V
			T_{vj} = 175 °C		1.95		
Peak reverse recovery current	I_{rm}	I_F = 600 A, V_{GE} = -8 V, V_R = 400 V	T_{vj} = 25 °C		351		A
			T_{vj} = 175 °C		526		
Recovered charge	Q_r	I_F = 600 A, V_R = 400 V, V_{GE} = -8 V	T_{vj} = 25 °C		14.4		µC
			T_{vj} = 175 °C		43.1		
Reverse recovery energy	E_{rec}	I_F = 600 A, V_{GE} = -8 V, V_R = 400 V	T_{vj} = 25 °C, $-di_F/dt$ = 16200 A/µs		4.90		mJ
			T_{vj} = 175 °C, $-di_F/dt$ = 13400 A/µs		13.40		
Thermal resistance, junction to cooling fluid[1]	$R_{th,j-f}$	50% water / 50% ethylenglycol, $\Delta V/\Delta t$ = 10 dm^3/min, T_f = 65 °C			0.129	0.142[2]	K/W
Temperature under switching conditions[3]	$T_{vj,op}$	continuous operation		-40		175	°C
		extended operation				185	

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.
3) Tvj>175°C only blocking specified

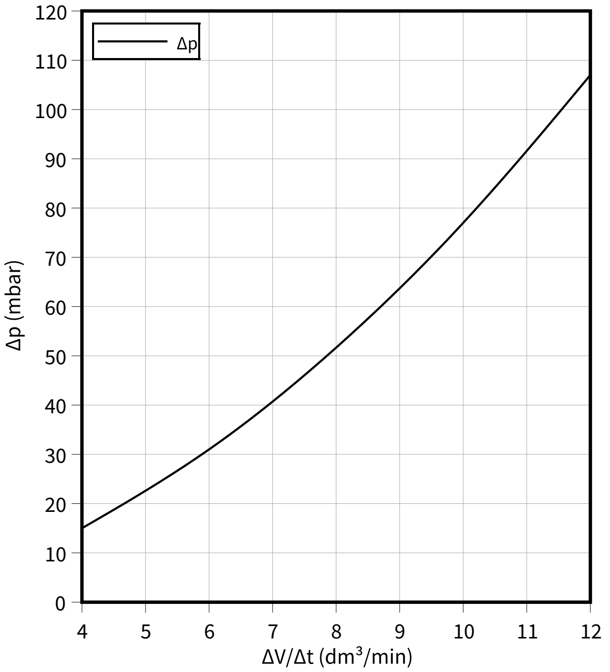
4 Temperature sensor

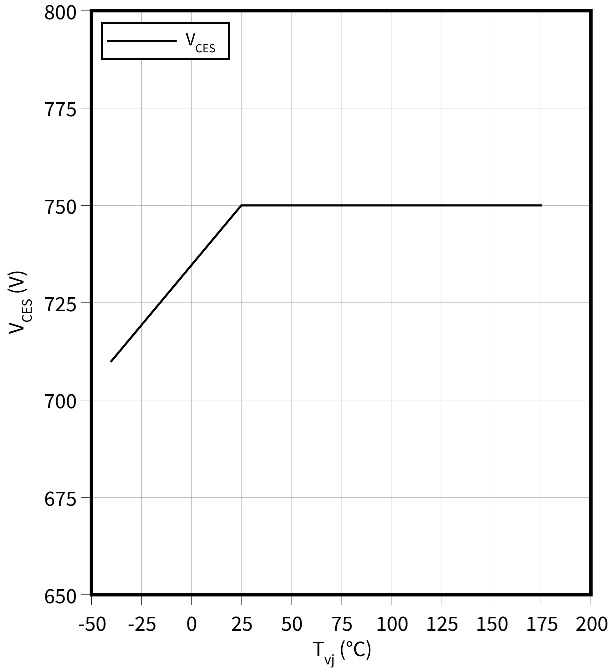
Table 8 Characteristic values

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 mA, T_{vj} = 25 °C		2.280		V
Temperature coefficient (TCR)	TC_{TS}	I_{TS} = 0.2 mA			-5.50		mV/K

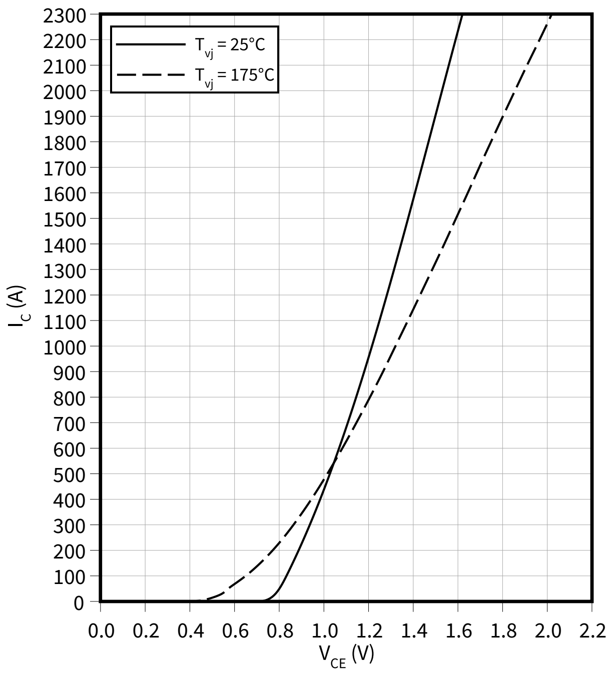
5 Characteristics diagrams

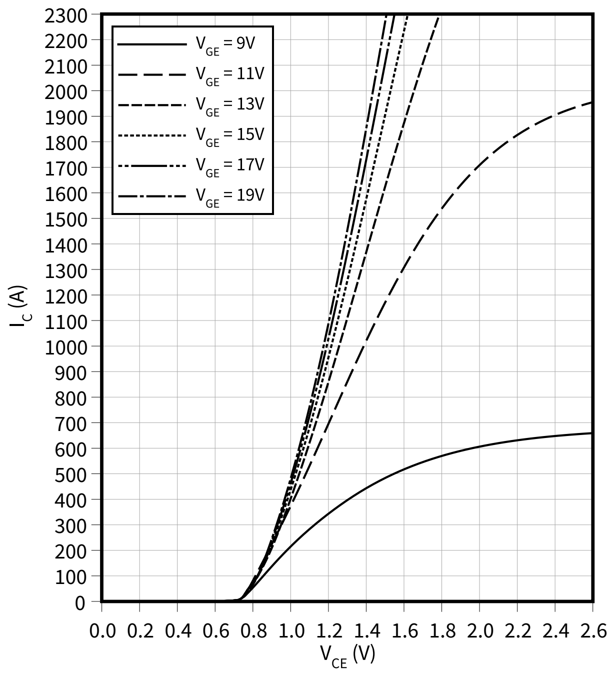
Pressure drop in cooling circuit (typical), Package $\Delta p = f(\Delta V/\Delta t)$ fluid = 50% water / 50% ethylenglycol , T_f = 65 °C	**Maximum collector-emitter voltage, IGBT, Inverter** $V_{CES} = f(T_{vj})$ Note = verified by characterization / design, not by test



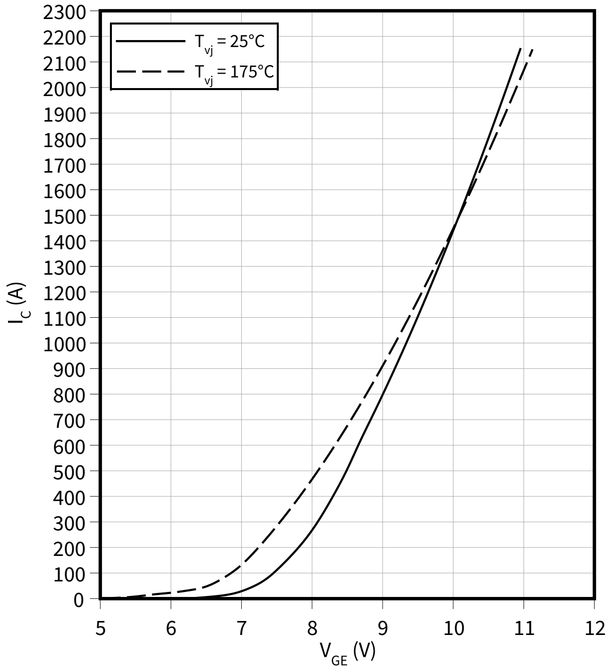


Output characteristic (typical), IGBT, Inverter $I_C = f(V_{CE})$ V_{GE} = 15 V	**Output characteristic (typical), IGBT, Inverter** $I_C = f(V_{CE})$ T_{vj} = 25 °C

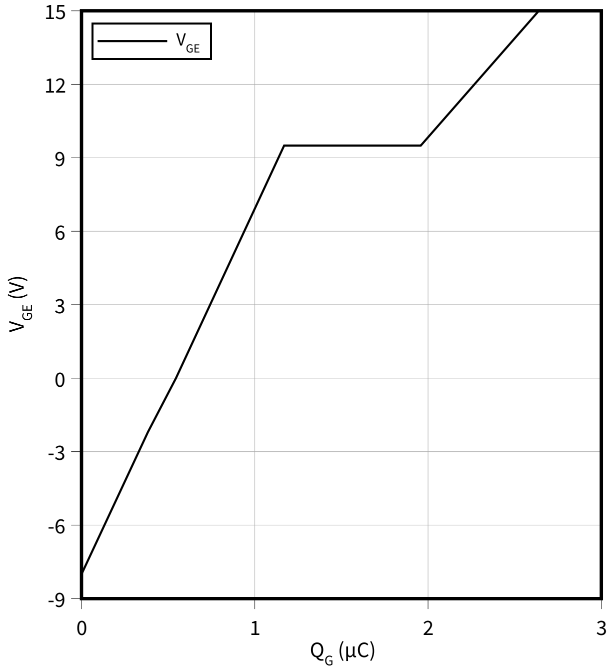




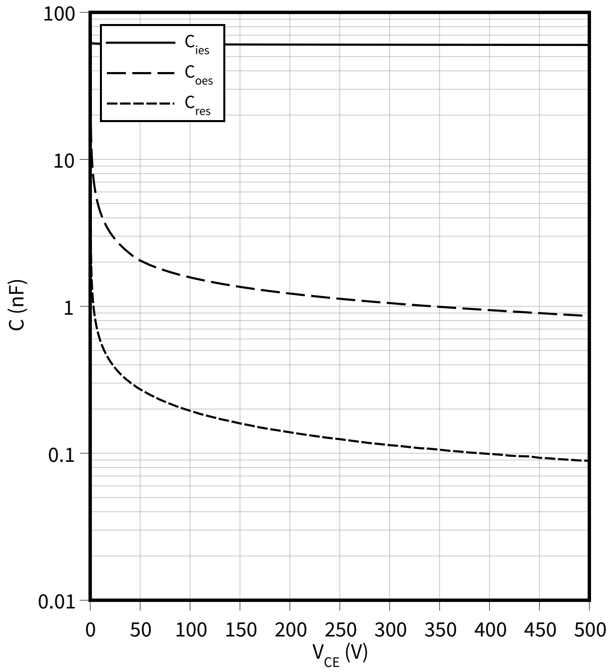
Transfer characteristic (typical), IGBT, Inverter
$I_C = f(V_{GE})$
$V_{CE} = 20$ V



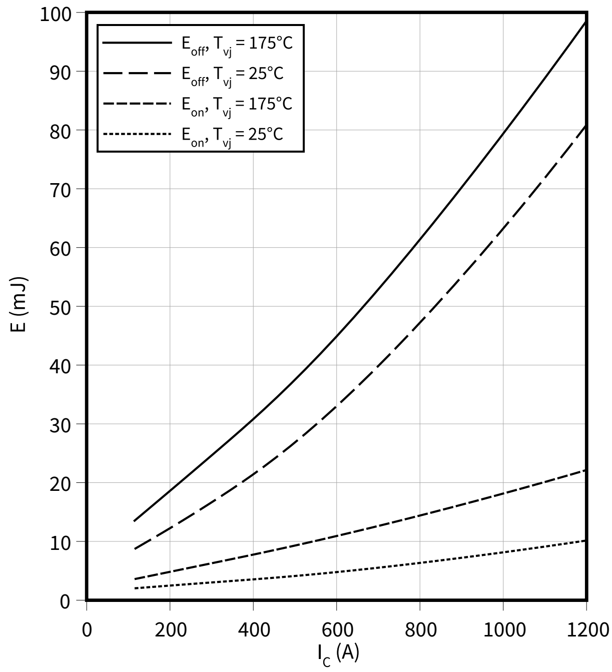
Gate charge characteristic (typical), IGBT, Inverter
$V_{GE} = f(Q_G)$
$T_{vj} = 25$ °C, $V_{CE} = 400$ V, $I_C = 600$ A



Capacity characteristic (typical), IGBT, Inverter
$C = f(V_{CE})$
$T_{vj} = 25$ °C, f = 0.1 MHz, $V_{GE} = 0$ V



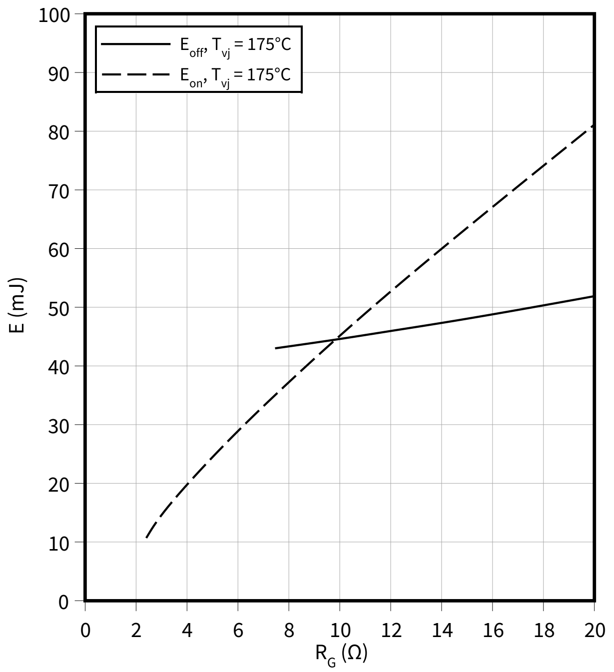
Switching losses (typical), IGBT, Inverter
$E = f(I_C)$
$R_{G,off} = 7.5\ \Omega$, $R_{G,on} = 2.4\ \Omega$, $V_{CE} = 400$ V, $V_{GE} = +15/-8$ V



Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

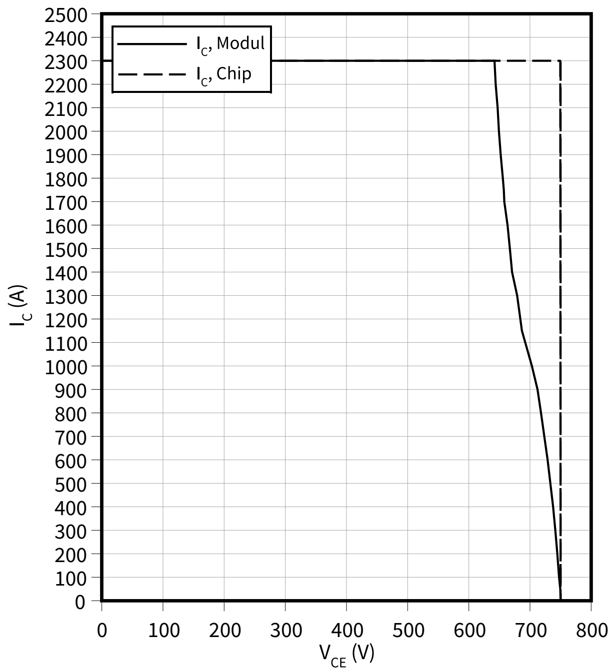
V_{CE} = 400 V, V_{GE} = +15/-8 V, I_C = 600 A



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

$I_C = f(V_{CE})$

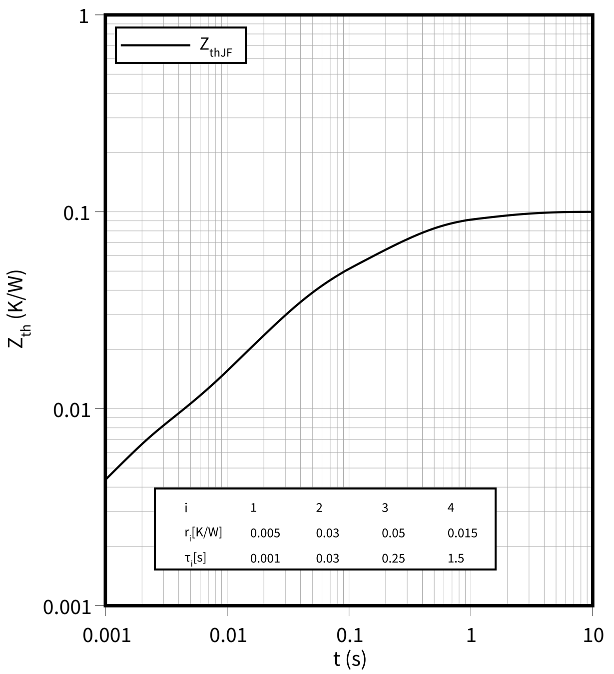
T_{vj} = 175 °C, $R_{G,off}$ = 7.5 Ω, V_{GE} = +15/-8 V



Transient thermal impedance (typical), IGBT, Inverter

$Z_{th} = f(t)$

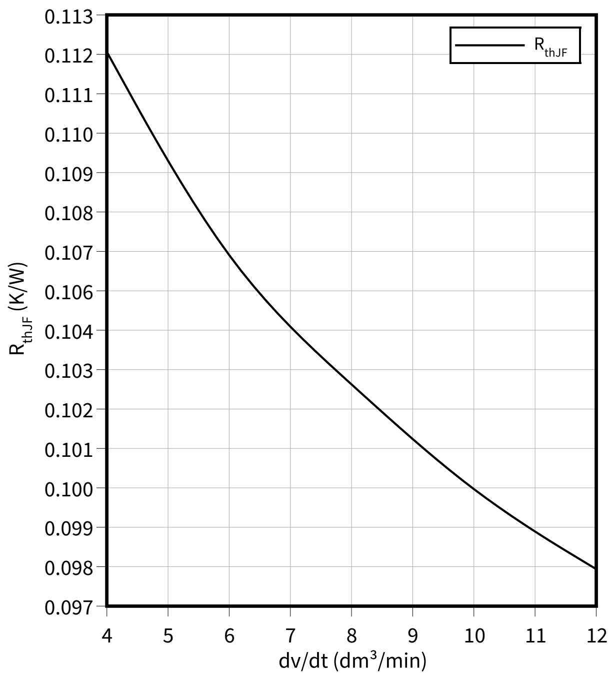
ΔV/Δt = 10 dm^3/min, fluid = 50% water / 50% ethylenglycol , T_f = 65 °C



Thermal impedance (typical), IGBT, Inverter

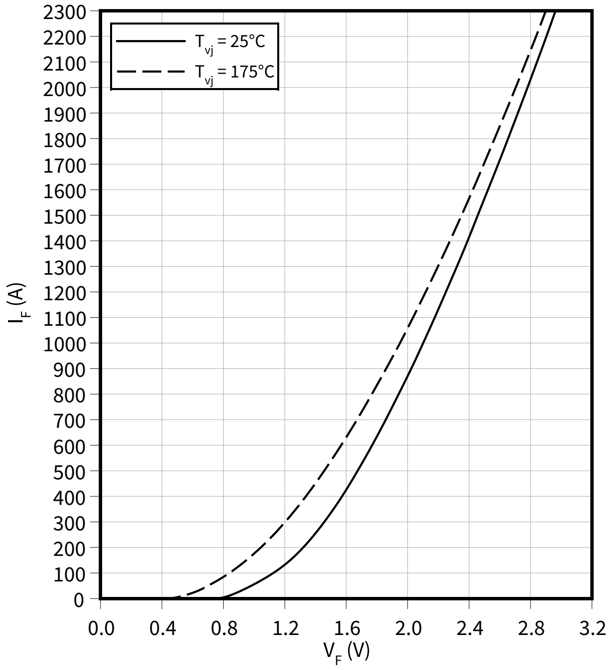
$R_{thJF} = f(dv/dt)$

T_f = 65 °C, fluid = 50% water / 50% ethylenglycol



Forward characteristic (typical), Diode, Inverter

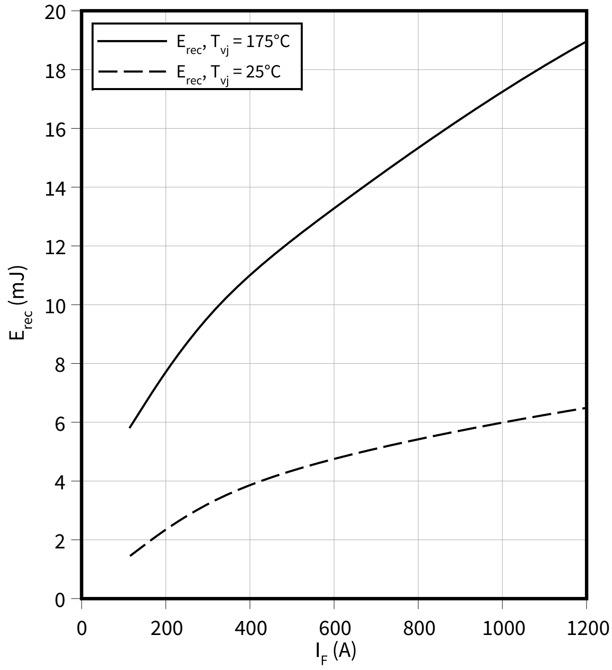
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

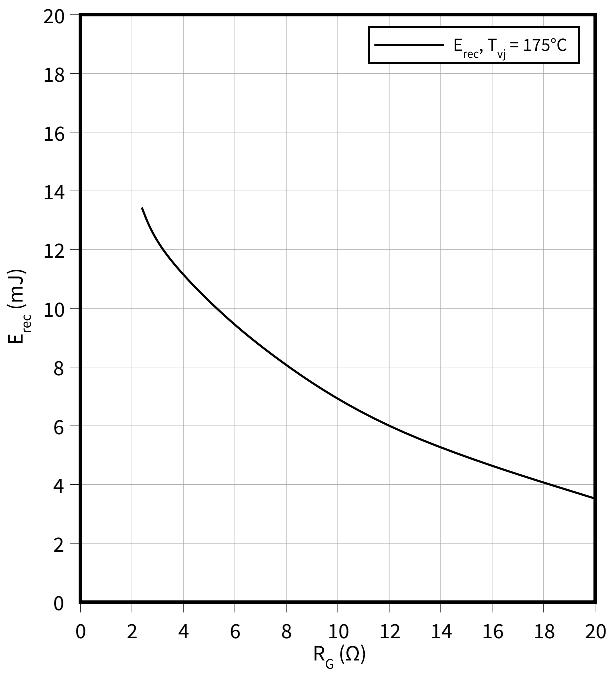
V_{CE} = 400 V, V_{GE} = +15/-8 V, R_G = 2.4 Ω



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

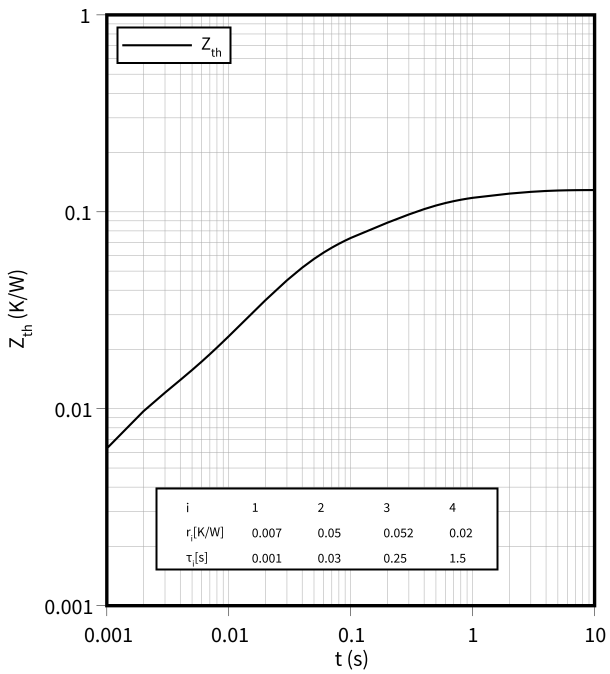
V_{CE} = 400 V, I_F = 600 A



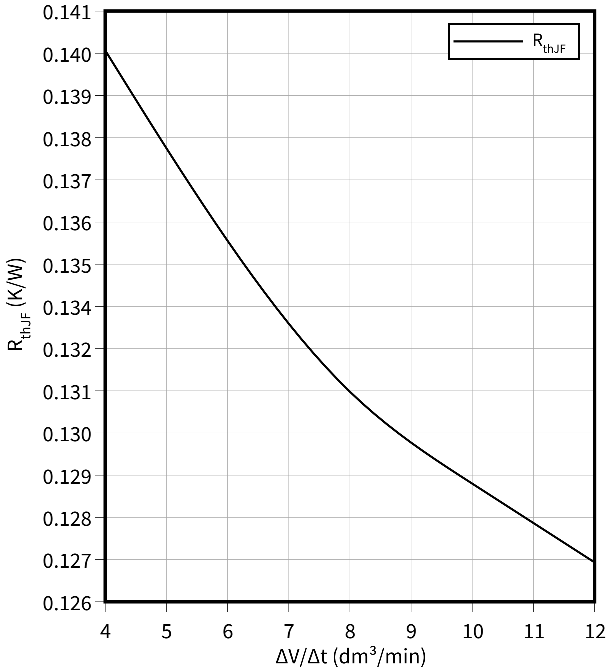
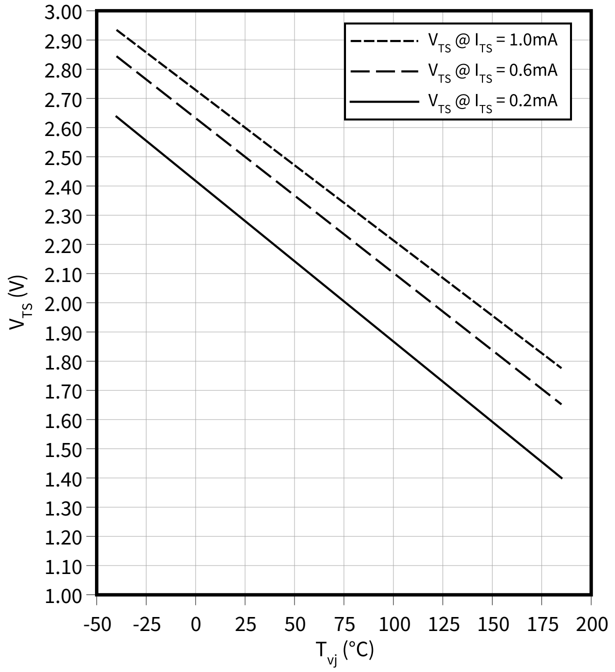
Transient thermal impedance (typical), Diode, Inverter

$Z_{th} = f(t)$

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



i	1	2	3	4
r_i[K/W]	0.007	0.05	0.052	0.02
τ_i[s]	0.001	0.03	0.25	1.5

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

6 Circuit diagram

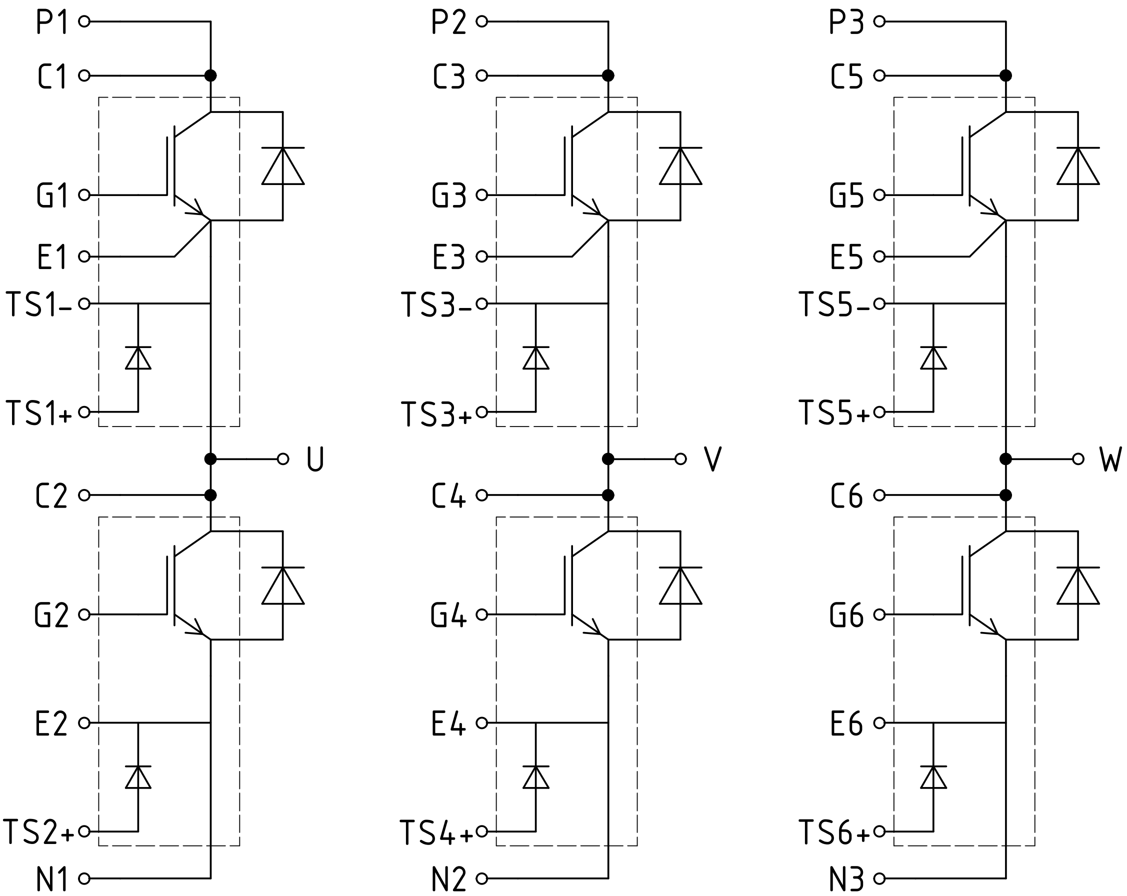


Figure 1

7 Package outlines

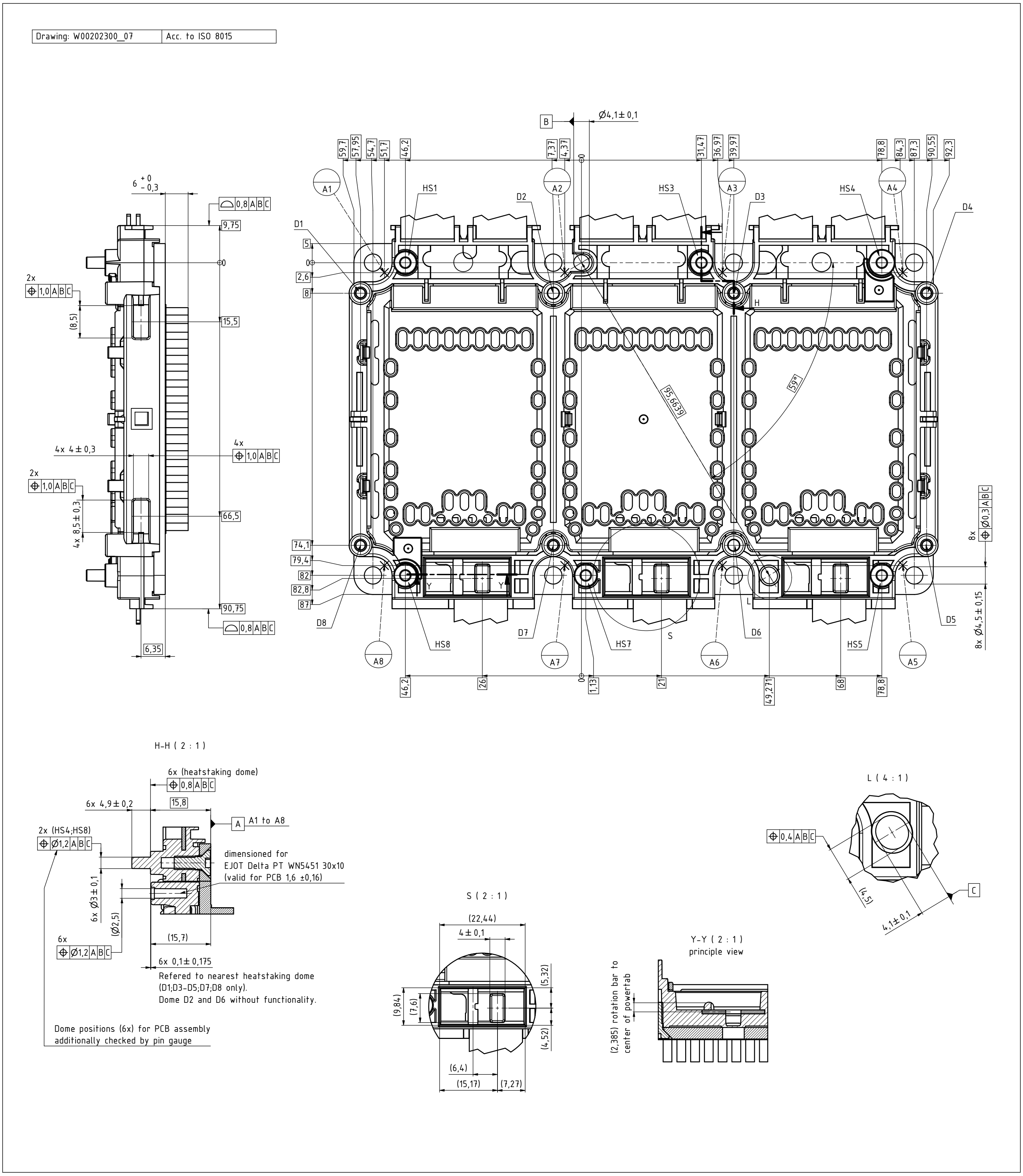


Figure 2

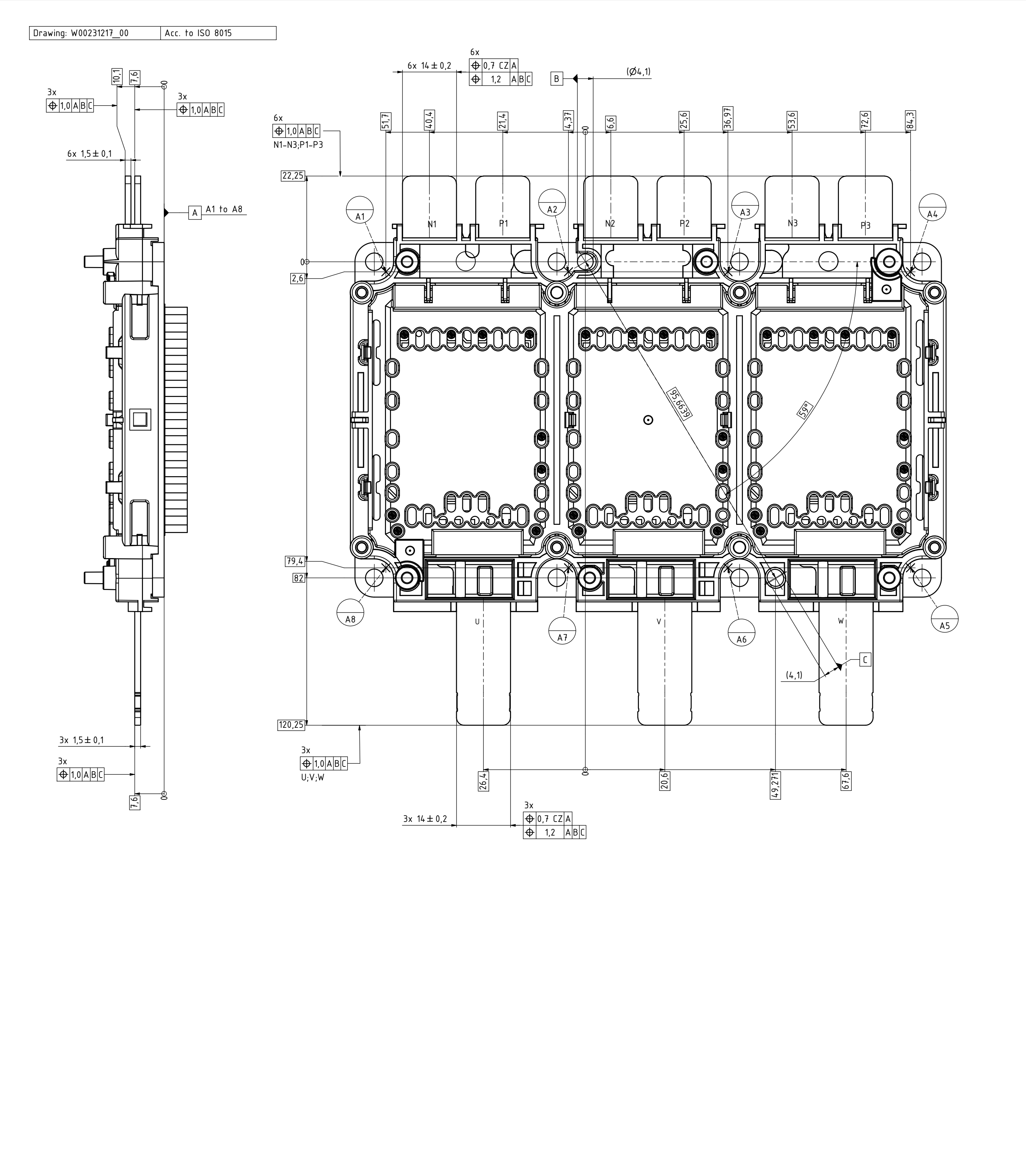

Drawing: W00231217_00
Acc. to ISO 8015
A1 to A8
N1-N3;P1-P3
U;V;W
N1
P1
N2
P2
N3
P3
U
V
W
A1
A2
A3
A4
A5
A6
A7
A8
(Ø4,1)
(4,1)
59°
95,6639
6x 14 ± 0,2
3x 14 ± 0,2
6x 1,5 ± 0,1
3x 1,5 ± 0,1
22,25
120,25
79,4
82
2,6
51,7
40,4
21,4
4,37
6,6
25,6
36,97
53,6
72,6
84,3
26,4
20,6
49,271
67,6
10,1
7,6

Figure 3

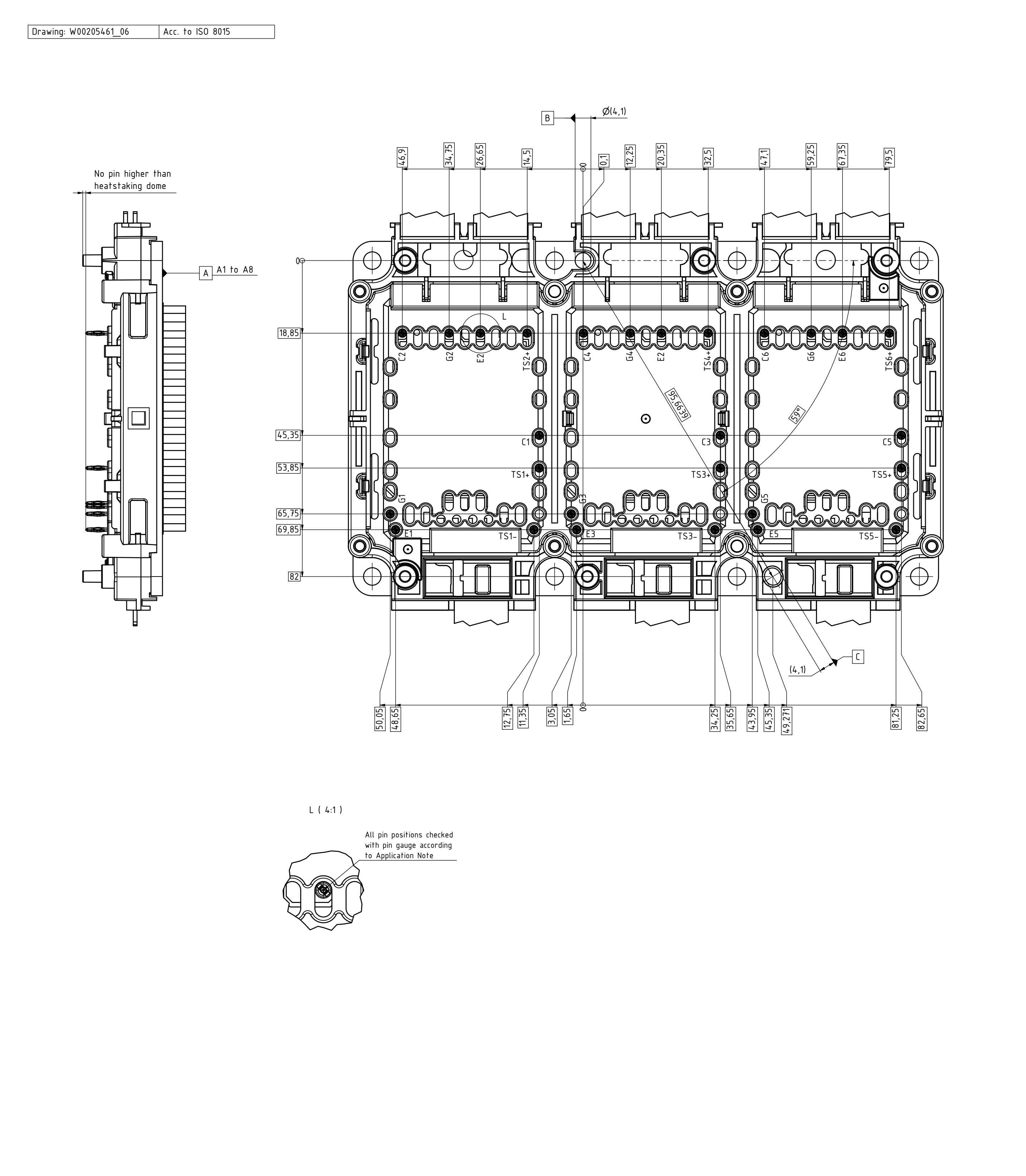

Drawing: W00205461_06
Acc. to ISO 8015
No pin higher than heatstaking dome
A1 to A8
L (4:1)
All pin positions checked with pin gauge according to Application Note

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*
	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	2024-04-10	Initial version
1.00	2024-04-19	Final datasheet

Trademarks

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