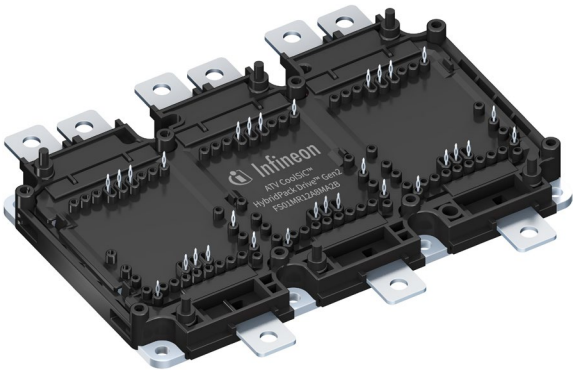
最终数据手册
英飞凌基于 SiC MOSFET的HybridPACK™ Drive G2模块

特性



- 电气特性
  - V_{DSS} = 750 V
  - $I_{D,nom}$ = 430 A / $I_{D,pulse}$ = 1075 A
  - 新型半导体材料—碳化硅
  - 低 $R_{DS,on}$
  - 低开关损耗
  - 低 Q_g和 C_{rss}
  - 低杂散电感设计
  - $T_{vj,op}$ = 175°C
  - 短时延长工作温度 $T_{vj,op}$ = 200 °C
- 机械特性
  - 4.25 kV DC 1 s绝缘
  - 高爬电距离和电气间隙
  - 紧凑型设计
  - 高功率密度
  - 直冷式 PinFin底板
  - 高性能Si_3N_4陶瓷
  - PCB和冷却器装配的安装指导
  - 集成温度传感二极管
  - PressFIT 压接技术
  - 符合 RoHS 标准，无铅
  - UL 94 V0 模块框架

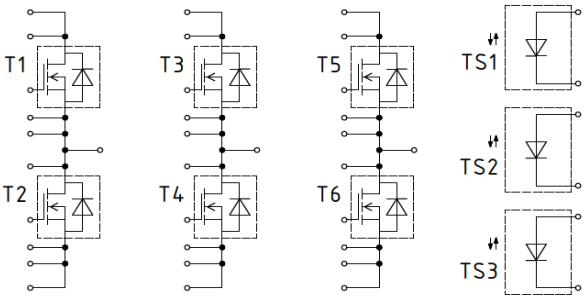
潜在应用

- 汽车应用
- 混合动力汽车 (H)EV
- 电机驱动
- 商用、建筑和农用车辆（CAV）

产品验证

- 符合 AQG 324 标准，发布号：03.1/2021

描述



本数据手册的原文使用英文撰写。为方便起见，英飞凌提供了译文；由于翻译过程中可能使用了自动化工具，英飞凌不保证译文的准确性。 为确认准确性，请务必访问 infineon.com 参考最新的英文版本（控制文档）。

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1 封装

表 1 绝缘配合

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_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) 镀镍铜底板

表 2 最大额定值

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) 热熔组装参考应用手册 AN-G2-ASSEMBLY。

表 3 特征值

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 = 60 °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	$L_{s,DS}$			8.0		nH
Module lead resistance, terminals - chip	$R_{DD'+SS'}$	T_f = 25 °C, per switch		0.64		mΩ
Storage temperature	T_{stg}		-40[2)]		125	°C
Mounting torque for module mounting[3)]	*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) 冷却器设计和流动方向参考应用笔记 AN-G2-ASSEMBLY。

2) 通过设计验证，而非通过测试验证
3) 螺丝类型和扭矩参考应用笔记 AN-G2-ASSEMBLY。

2 MOSFET

表4 最大额定值

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage	V_{DSS}		continuous operation	750	V
			only for transient overshoot	900	
DC drain current	$I_{D,nom}$	V_{GS} = 18 V, T_f = 65 °C	$T_{vj,max}$ = 175 °C	430	A
Pulsed drain current	$I_{D,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1075	A
Gate-source voltage, max. static voltage	V_{GS}			-5/19	V
Gate-source voltage, max. transient voltage	V_{GS}	Duty Cycle < 1 % (first transient maximum peak)		-10/23	V

表 5 建议值

Parameter	Symbol	Note or test condition	Values	Unit
On-state gate voltage	$V_{GS(on)}$		15...18	V
Off-state gate voltage	$V_{GS(off)}$		-5	V

表 6 特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-resistance	$R_{DS,on}$	I_D = 430 A, V_{GS} = 18 V	T_{vj} = 25 °C		1.75	2.65	mΩ
			T_{vj} = 125 °C		2.47		
			T_{vj} = 175 °C		3.07		
			T_{vj} = 200 °C		3.43		
Drain-source on-resistance	$R_{DS,on}$	I_D = 430 A, V_{GS} = 15 V	T_{vj} = 25 °C		2.14	3.58	mΩ
			T_{vj} = 125 °C		2.75		
			T_{vj} = 175 °C		3.33		
			T_{vj} = 200 °C		3.69		
Gate threshold voltage	$V_{GS,th}$	I_D = 120 mA, V_{GS} = V_{DS}, (tested after 1ms pulse at V_{GS} = +20 V)	T_{vj} = 25 °C	3.20[1)]	3.90	4.55	V
Total gate charge	Q_G	V_{DS} = 470 V, V_{GS} = -5/18 V			0.890		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		0.88		Ω
Input capacitance	C_{iss}	f = 1 MHz, V_{DS} = 470 V	T_{vj} = 25 °C		26		nF

（表格续下页……）

表6　　（续）特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Output capacitance	C_{oss}	f = 1 MHz, V_{DS} = 470 V	T_{vj} = 25 °C		1.71		nF
Reverse transfer capacitance	C_{rss}	f = 1 MHz, V_{DS} = 470 V	T_{vj} = 25 °C		0.15		nF
C_{oss} stored energy	E_{oss}	V_{DS} = 470 V	T_{vj} = 25 °C		750		µJ
Drain-source leakage current	I_{DSX}	V_{GS} = -5 V, V_{DSS} = 750 V	T_{vj} = 25 °C			530	µA
Gate-source leakage current	I_{GSS}	V_{GS} = 20 V, V_{DS} = 0 V	T_{vj} = 25 °C			100	nA
Turn-on delay time, inductive load	$t_{d,on}$	I_D = 430 A, $R_{G,on}$ = 11 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V	T_{vj} = 25 °C		92		ns
			T_{vj} = 125 °C		77		
			T_{vj} = 175 °C		70		
			T_{vj} = 200 °C		68		
Rise time (inductive load)	t_r	I_D = 430 A, $R_{G,on}$ = 11 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V	T_{vj} = 25 °C		77		ns
			T_{vj} = 125 °C		74		
			T_{vj} = 175 °C		73		
			T_{vj} = 200 °C		72		
Turn-off delay time, inductive load	$t_{d,off}$	I_D = 430 A, $R_{G,off}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V	T_{vj} = 25 °C		325		ns
			T_{vj} = 125 °C		351		
			T_{vj} = 175 °C		363		
			T_{vj} = 200 °C		372		
Fall time (inductive load)	t_f	I_D = 430 A, $R_{G,off}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V	T_{vj} = 25 °C		58		ns
			T_{vj} = 125 °C		65		
			T_{vj} = 175 °C		69		
			T_{vj} = 200 °C		72		
Turn-on energy loss per pulse	E_{on}	I_D = 430 A, $R_{G,on}$ = 11 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V, L_σ = 6.5 nH	T_{vj} = 25 °C, di/dt = 4.48 kA/µs		14.9		mJ
			T_{vj} = 125 °C, di/dt = 4.68 kA/µs		14.6		
			T_{vj} = 175 °C, di/dt = 4.74 kA/µs		15.1		
			T_{vj} = 200 °C, di/dt = 4.8 kA/µs		15.3		

（表格续下页……）

表 6（续）特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Turn-off energy loss per pulse	E_{off}	I_D = 430 A, $R_{G,off}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 470 V, L_σ = 6.5 nH	T_{vj} = 25 °C, dv/dt = 4.46 kV/µs		17.9		mJ
			T_{vj} = 125 °C, dv/dt = 4.34 kV/µs		18.8		
			T_{vj} = 175 °C, dv/dt = 4.31 kV/µs		19.3		
			T_{vj} = 200 °C, dv/dt = 4.3 kV/µs		19.4		
Short circuit data	I_{SC}	V_{DD} = 470 V, V_{GS} = -5/18 V, $R_{G,on}$ = 11 Ω, $R_{G,off}$ = 10 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} = 1.2 µs, T_{vj} = 200 °C		4700		A
Short circuit data	I_{SC}	V_{DD} = 470 V, V_{GS} = -5/15 V, $R_{G,on}$ = 11 Ω, $R_{G,off}$ = 10 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} = 2 µs, T_{vj} = 200 °C		3700		A
Thermal resistance, junction to cooling fluid[2)]	$R_{th,j-f}$	per MOSFET, 50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 60 °C			0.139		K/W
Standard deviation of thermal resistance, junction to cooling fluid[2)]	$\sigma_{Rth,j-f}$	per MOSFET, 50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min			1.1		K/kW
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	°C
			extended operation			200[3)]	

1) 在工作时间为 0h。在逆变器工作期间，该值可能会较低，具体取决于生命周期内的 T_{vj}、$V_{GS(off)}$、(开关频率)f_{sw}。对于 $V_{GS,th}$ Min 的最终评估值取决于客户应用，请联系英飞凌销售以获得英飞凌必要的技术支持。

2) 冷却器设计和流动方向参考应用笔记AN-G2-ASSEMBLY。EoL 标准见 AQG324，通过特性验证。

3) 相关限制，请参见 QPAC 文档。

3 体二极管（MOSFET）

表 7 最大额定值

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage	V_{DSS}		continuous operation	750	V
			only for transient overshoot	900	

（表格续下页……）

表 7　　（续）最大额定值

Parameter	Symbol	Note or test condition		Values	Unit
DC body diode forward current	$I_{F,S}$	V_{GS} = -5 V, T_f = 65 °C	$T_{vj,max}$ = 175 °C	148	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1075	A

表 8　　特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	$V_{F,SD}$	$I_{F,S}$ = 430 A, V_{GS} = -5 V	T_{vj} = 25 °C		4.57	7.33	V
			T_{vj} = 125 °C		4.13		
			T_{vj} = 175 °C		3.96		
			T_{vj} = 200 °C		3.87		
Peak reverse recovery current	I_{rrm}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 470 V	T_{vj} = 25 °C		114		A
			T_{vj} = 125 °C		152		
			T_{vj} = 175 °C		174		
			T_{vj} = 200 °C		189		
Recovered charge	Q_{rr}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 470 V	T_{vj} = 25 °C		1.89		µC
			T_{vj} = 125 °C		3.52		
			T_{vj} = 175 °C		4.81		
			T_{vj} = 200 °C		5.71		
Reverse recovery energy	E_{rec}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 470 V	T_{vj} = 25 °C, $-di/dt$ = 4.5 kA/µs		0.175		mJ
			T_{vj} = 125 °C, $-di/dt$ = 4.7 kA/µs		0.459		
			T_{vj} = 175 °C, $-di/dt$ = 4.7 kA/µs		0.693		
			T_{vj} = 200 °C, $-di/dt$ = 4.8 kA/µs		0.85		

4　温度传感器

表 9　　特征值

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Transient sense current	I_{TS}				10	mA

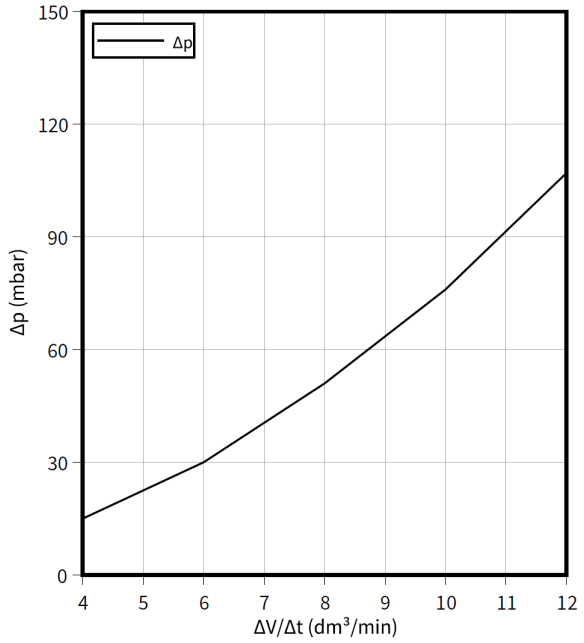
（表格续下页……）

表 9 （续） 特征值

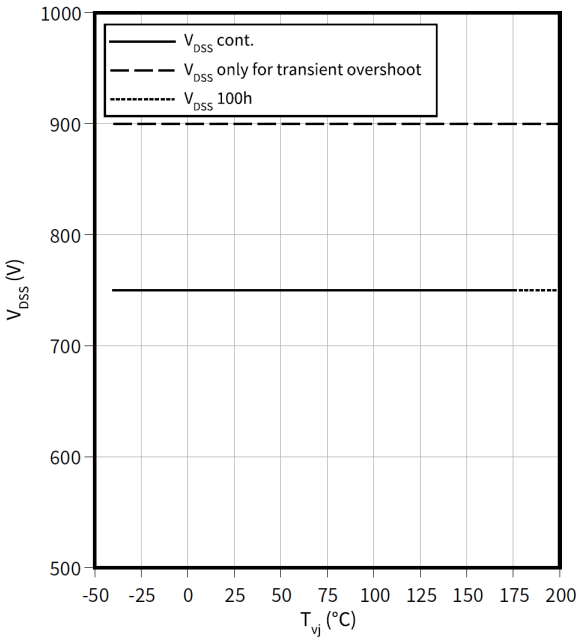
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_{TS}		I_{TS} = 0.2 mA, T_{vj} = 25 °C	2.574	2.624	2.674	V
			I_{TS} = 0.2 mA, T_{vj} = 85 °C	2.169	2.234	2.299	

5 特性图

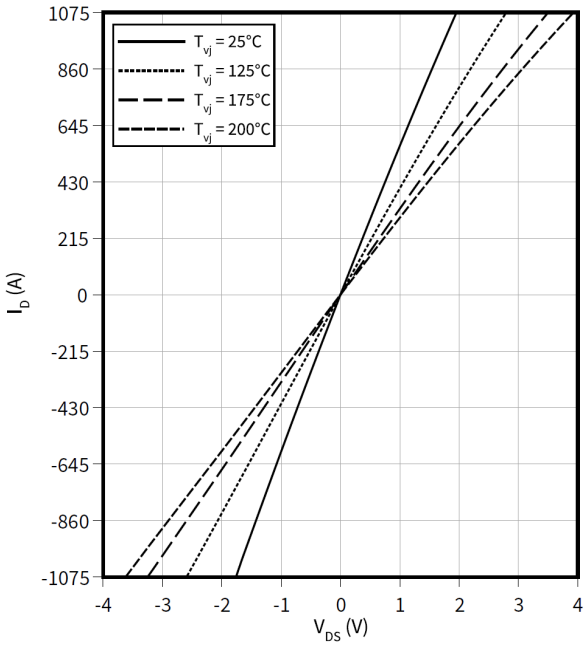
Pressure drop in cooling circuit (typical), Package
$\Delta p = f(\Delta V/\Delta t)$
T_f = 60 °C, 50% water / 50% ethylene glycol



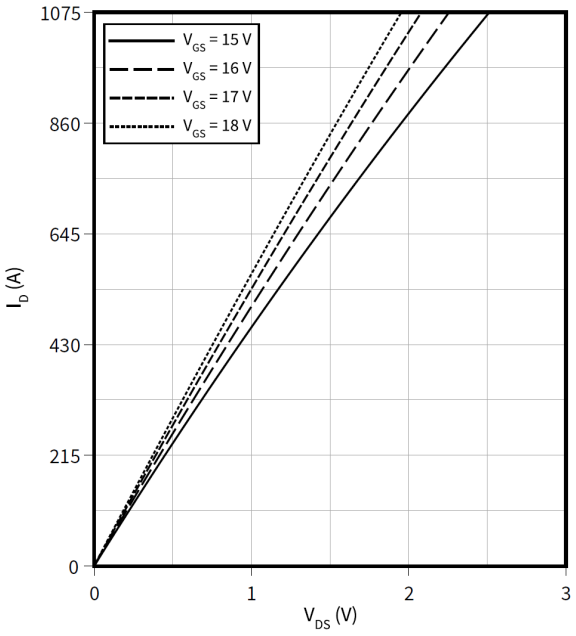
Maximum allowed drain-source voltage, MOSFET
$V_{DSS} = f(T_{vj})$
Verified by characterization / design, not by test



Output characteristic (typical), MOSFET
$I_D = f(V_{DS})$
V_{GS} = 18 V



Output characteristic (typical), MOSFET
$I_D = f(V_{DS})$
T_{vj} = 25 °C

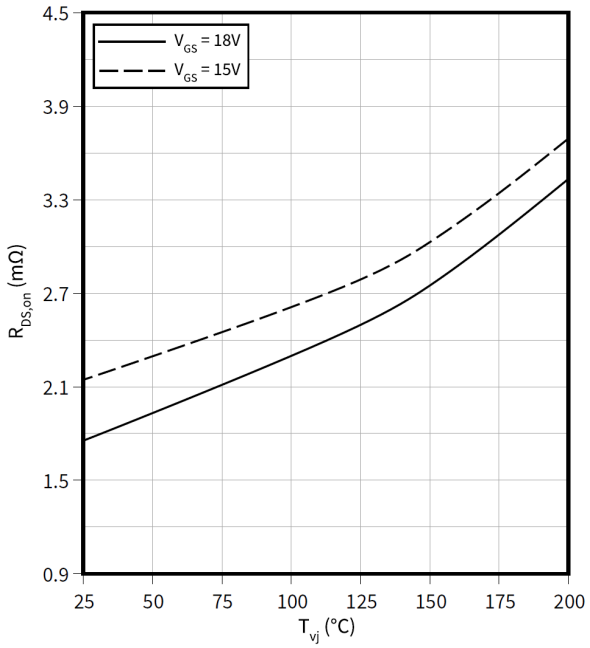


5 特性图

Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(T_{vj})$

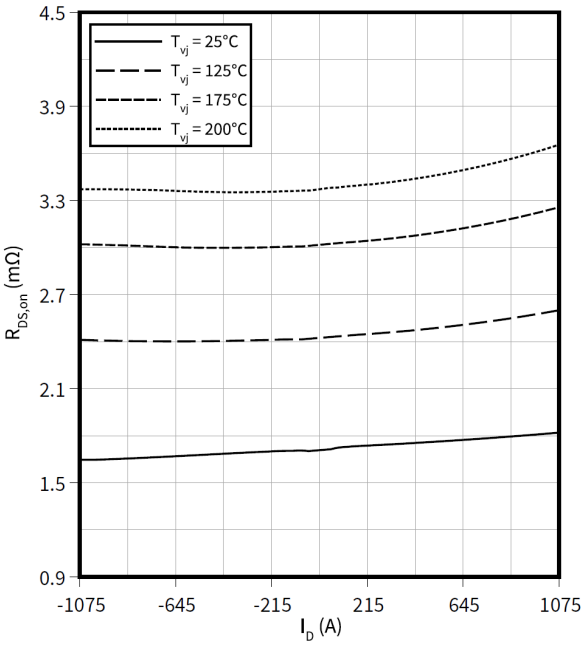
$I_D = 430$ A



Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(I_D)$

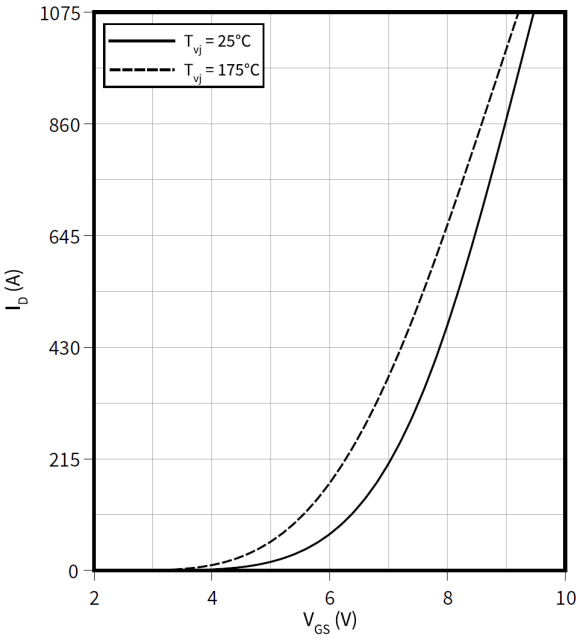
$V_{GS} = 18$ V



Transfer characteristic (typical), MOSFET

$I_D = f(V_{GS})$

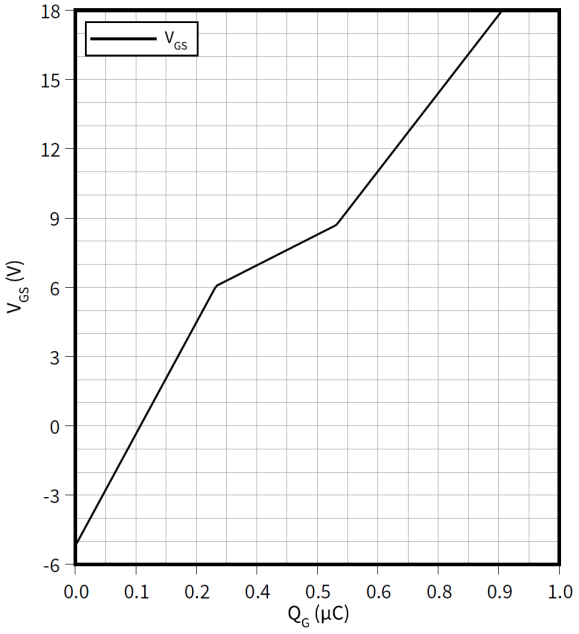
$V_{DS} = 20$ V



Gate charge characteristic (typical), MOSFET

$V_{GS} = f(Q_G)$

$V_{DD} = 470$ V, $T_{vj} = 25$ °C

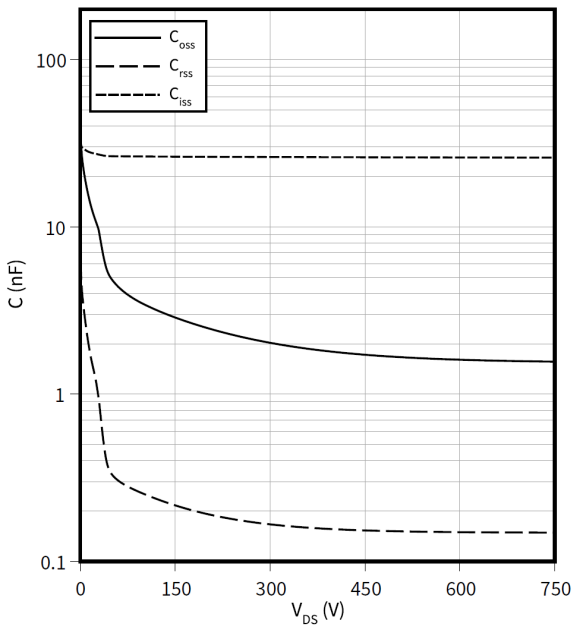


5 特性图

Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$

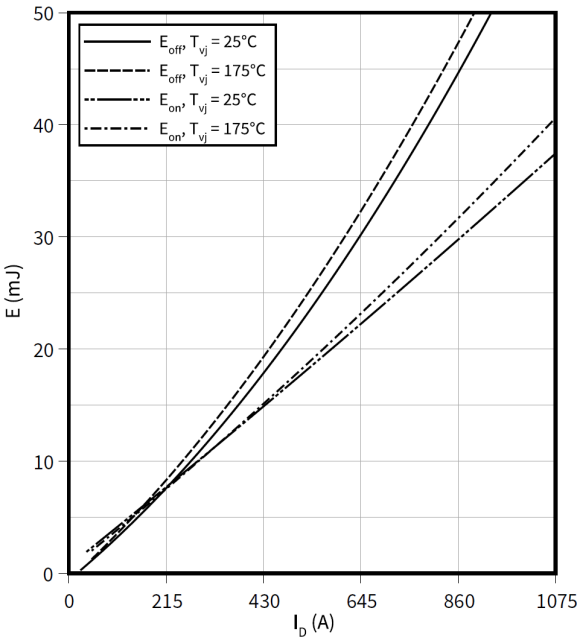
$f = 1\ MHz$, $V_{GS} = -5/18\ V$, $T_{vj} = 25\ °C$



Switching losses (typical), MOSFET

$E = f(I_D)$

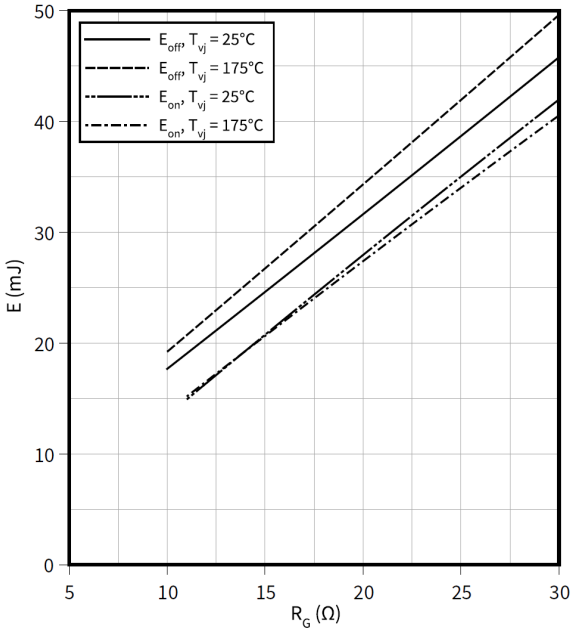
$V_{DS} = 470\ V$, $R_{G,off} = 10\ Ω$, $R_{G,on} = 11\ Ω$, $V_{GS} = -5/18\ V$



Switching losses (typical), MOSFET

$E = f(R_G)$

$V_{DS} = 470\ V$, $I_D = 430\ A$, $V_{GS} = -5/18\ V$

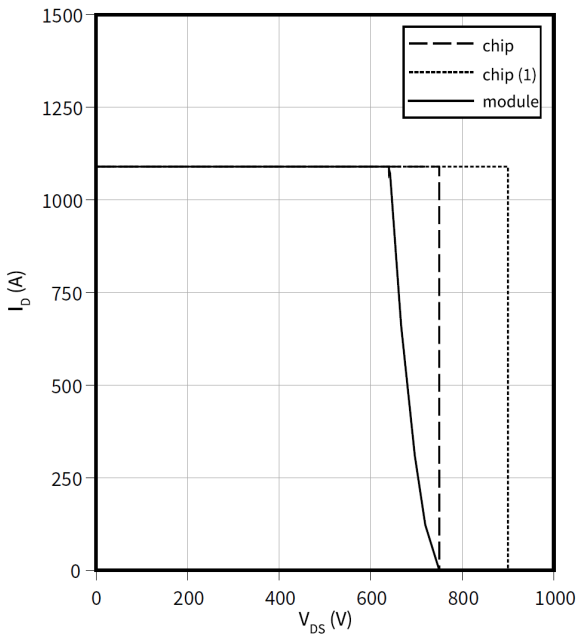


Reverse bias safe operating area (RBSOA), MOSFET

$I_D = f(V_{DS})$

$R_{G,off} = 10\ Ω$, $V_{GS} = +18/-5\ V$, $T_{vj} = 175\ °C$

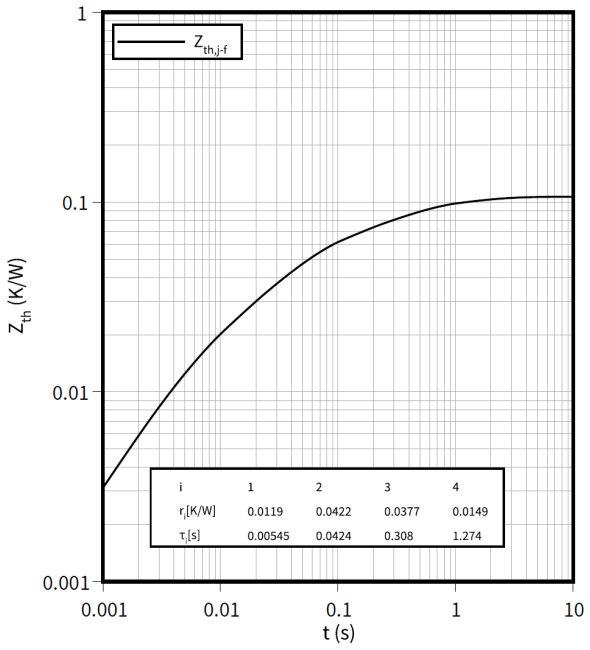
(1) for 10h over lifetime



5 特性图

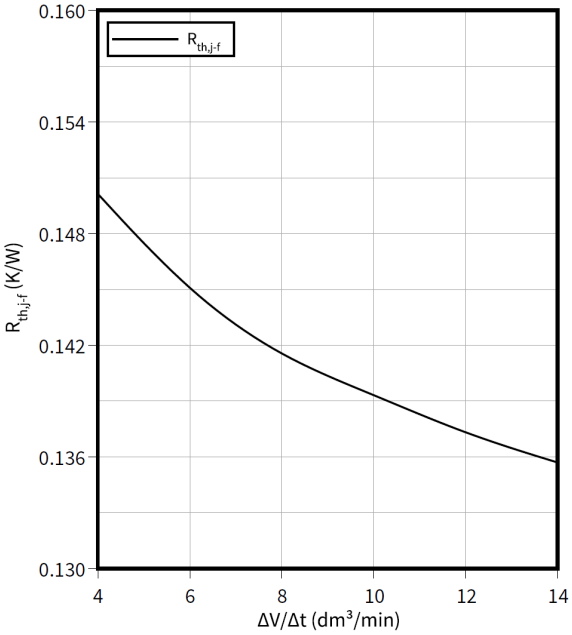
Transient thermal impedance (typical), MOSFET

$Z_{th} = f(t)$
$\Delta V/\Delta t$ = 10 dm³/min, T_f = 60 °C,
per MOSFET, 50% water / 50% ethylenglycol



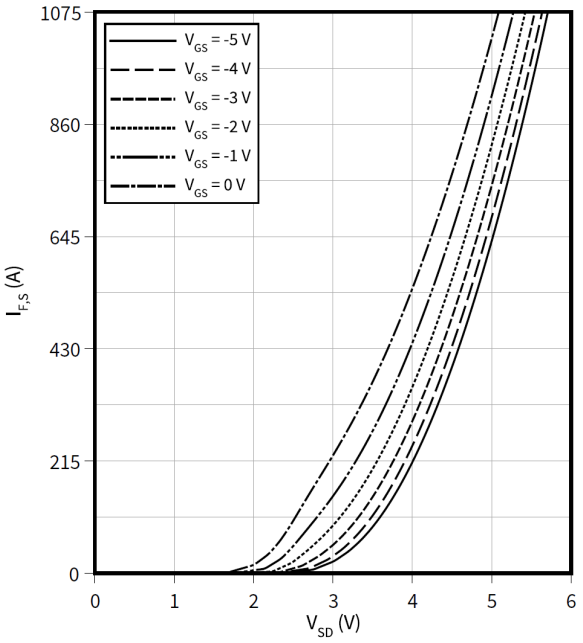
Thermal resistance (typical), MOSFET

$R_{th,j\text{-}f} = f(\Delta V/\Delta t)$
50% water / 50% ethylene glycol , T_f = 60 °C



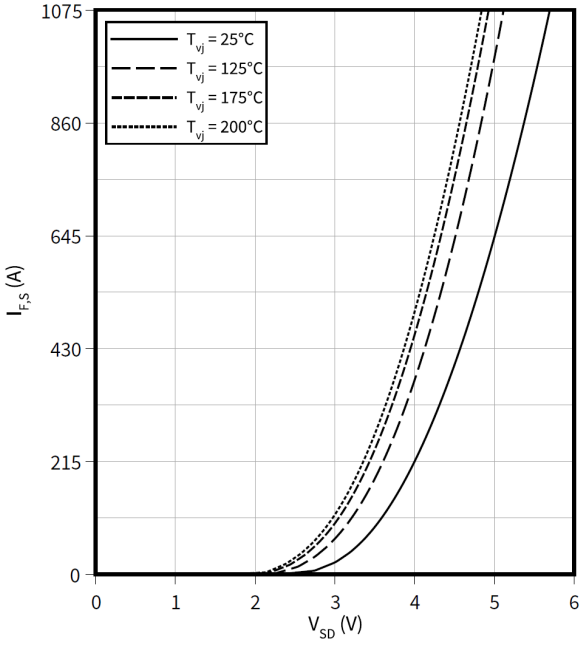
Forward characteristic body diode (typical), MOSFET

$I_{F,S} = f(V_{SD})$
T_{vj} = 25 °C



Forward characteristic body diode (typical), MOSFET

$I_{F,S} = f(V_{SD})$
V_{GS} = -5 V

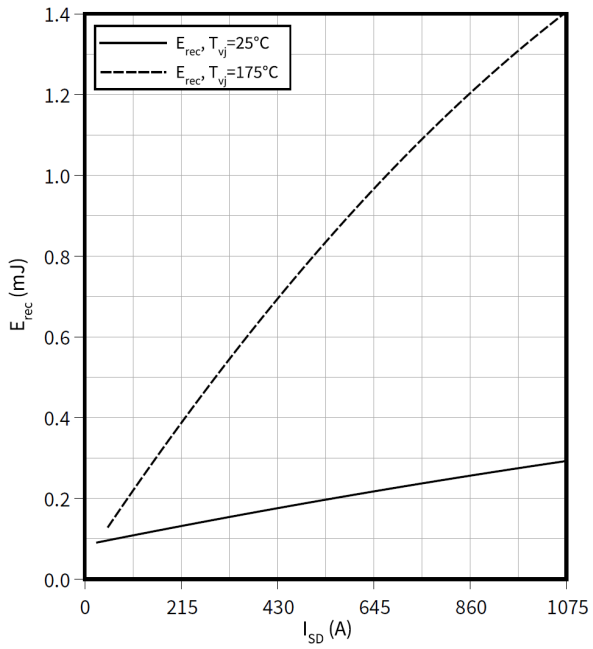


5 特性图

Switching losses body diode (typical), MOSFET

$E_{rec} = f(I_{SD})$

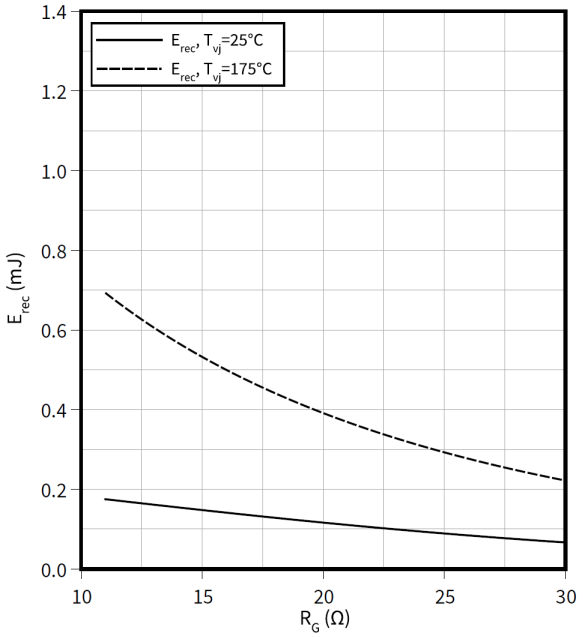
$V_R = 470\ V$, $R_{G,on} = 11\ \Omega$



Switching losses body diode (typical), MOSFET

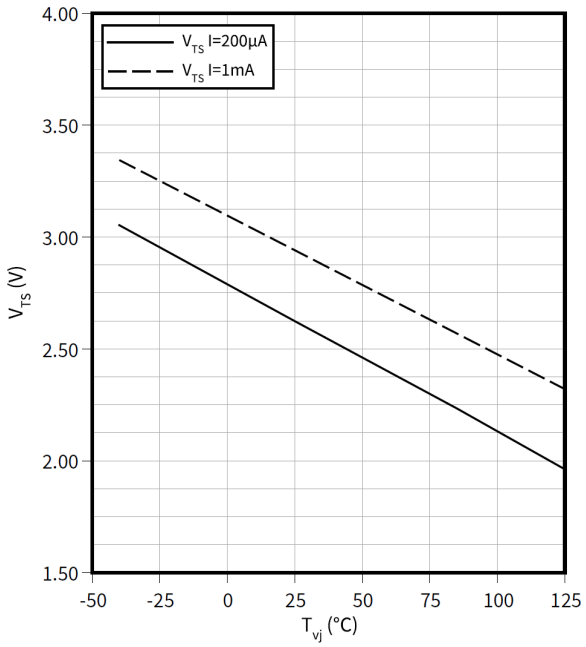
$E_{rec} = f(R_G)$

$V_R = 470\ V$, $I_{F,S} = 430\ A$



Temperature characteristic (typical), Temperature sensor

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



6 电路图

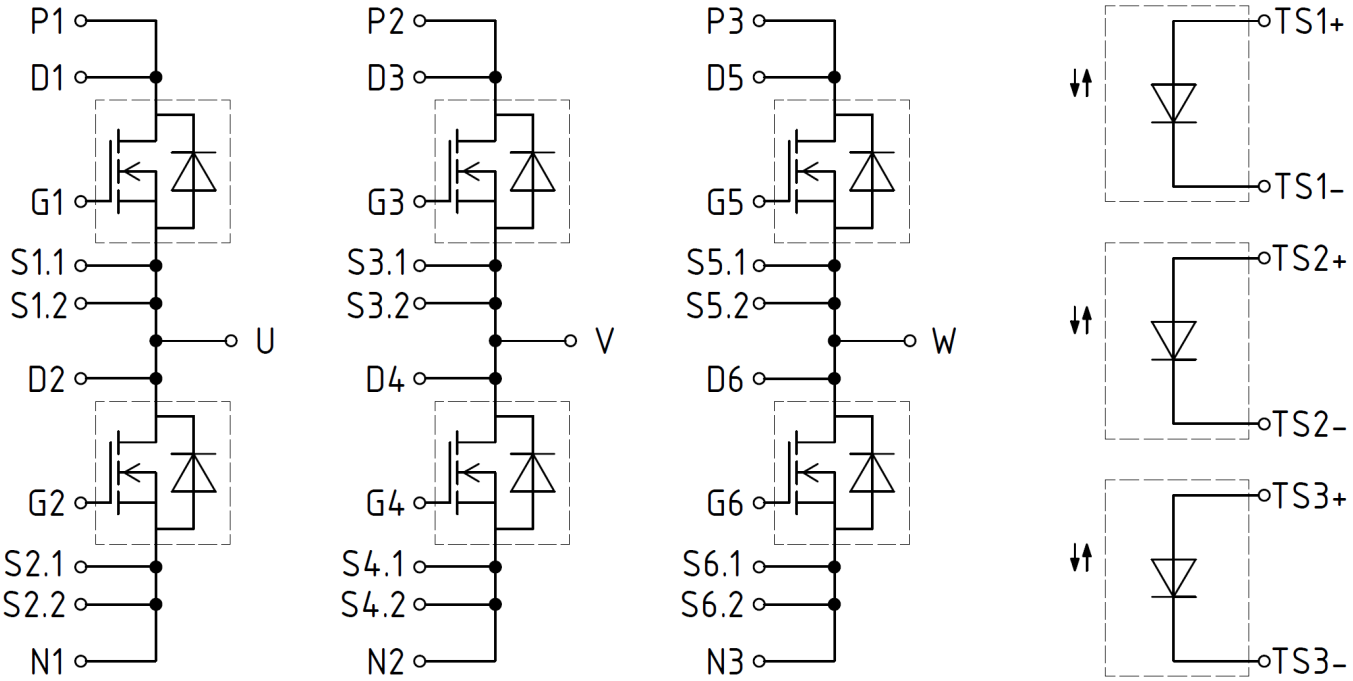

P1
D1
G1
S1.1
S1.2
U
D2
G2
S2.1
S2.2
N1
P2
D3
G3
S3.1
S3.2
V
D4
G4
S4.1
S4.2
N2
P3
D5
G5
S5.1
S5.2
W
D6
G6
S6.1
S6.2
N3
TS1+
TS1-
TS2+
TS2-
TS3+
TS3-

图 1

7 封装外形

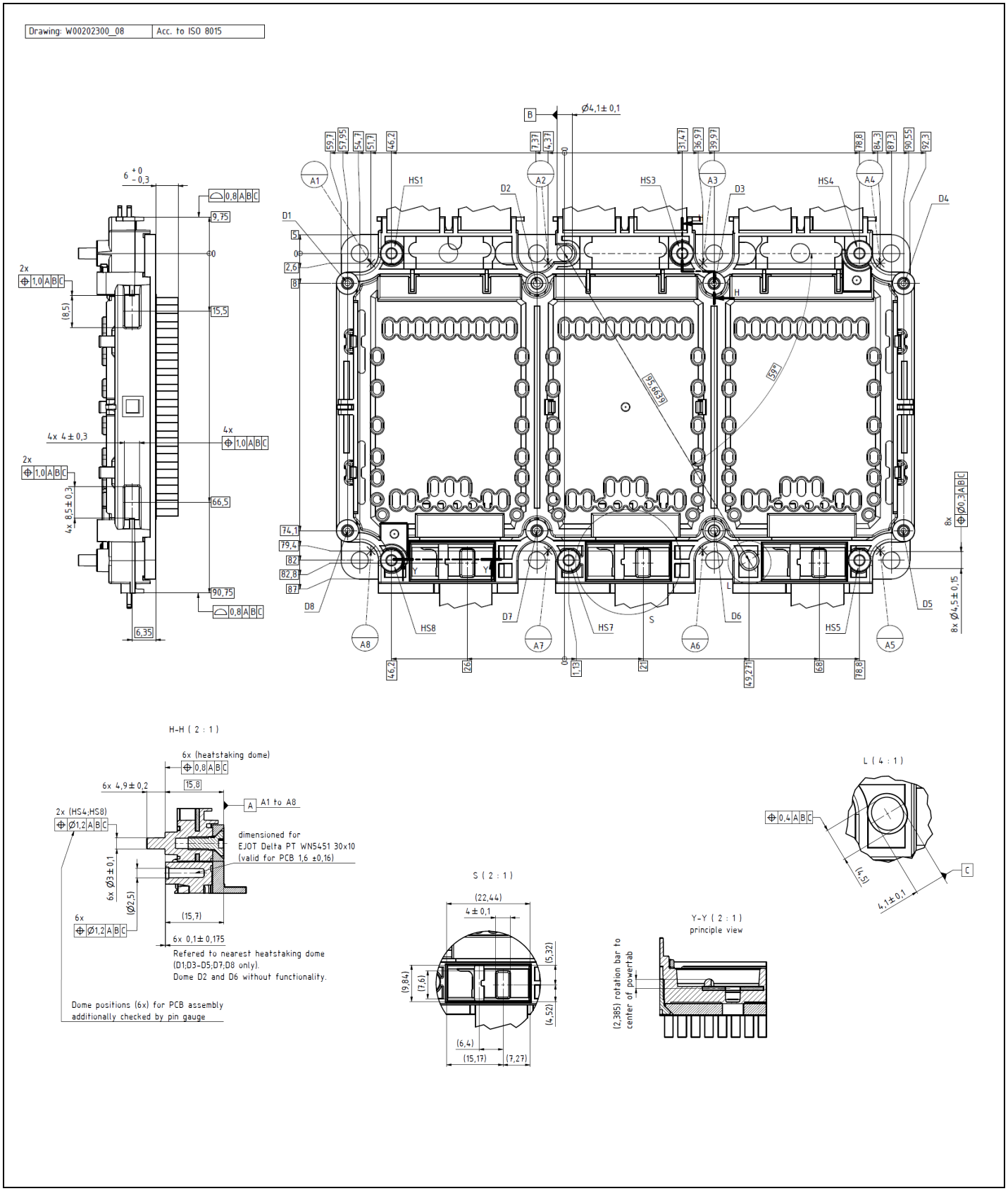

Drawing: W00202300_08
Acc. to ISO 8015
H-H (2 : 1)
6x (heatstaking dome)
6x 4,9 ± 0,2
15,8
A1 to A8
2x (HS4;HS8)
dimensioned for
EJOT Delta PT WN5451 30x10
(valid for PCB 1,6 ±0,16)
6x 0,1 ± 0,175
Refered to nearest heatstaking dome
(D1;D3-D5;D7;D8 only).
Dome D2 and D6 without functionality.
Dome positions (6x) for PCB assembly
additionally checked by pin gauge
S (2 : 1)
L (4 : 1)
Y-Y (2 : 1)
principle view
(2,385) rotation bar to
center of powertab

图 2

7 封装外形

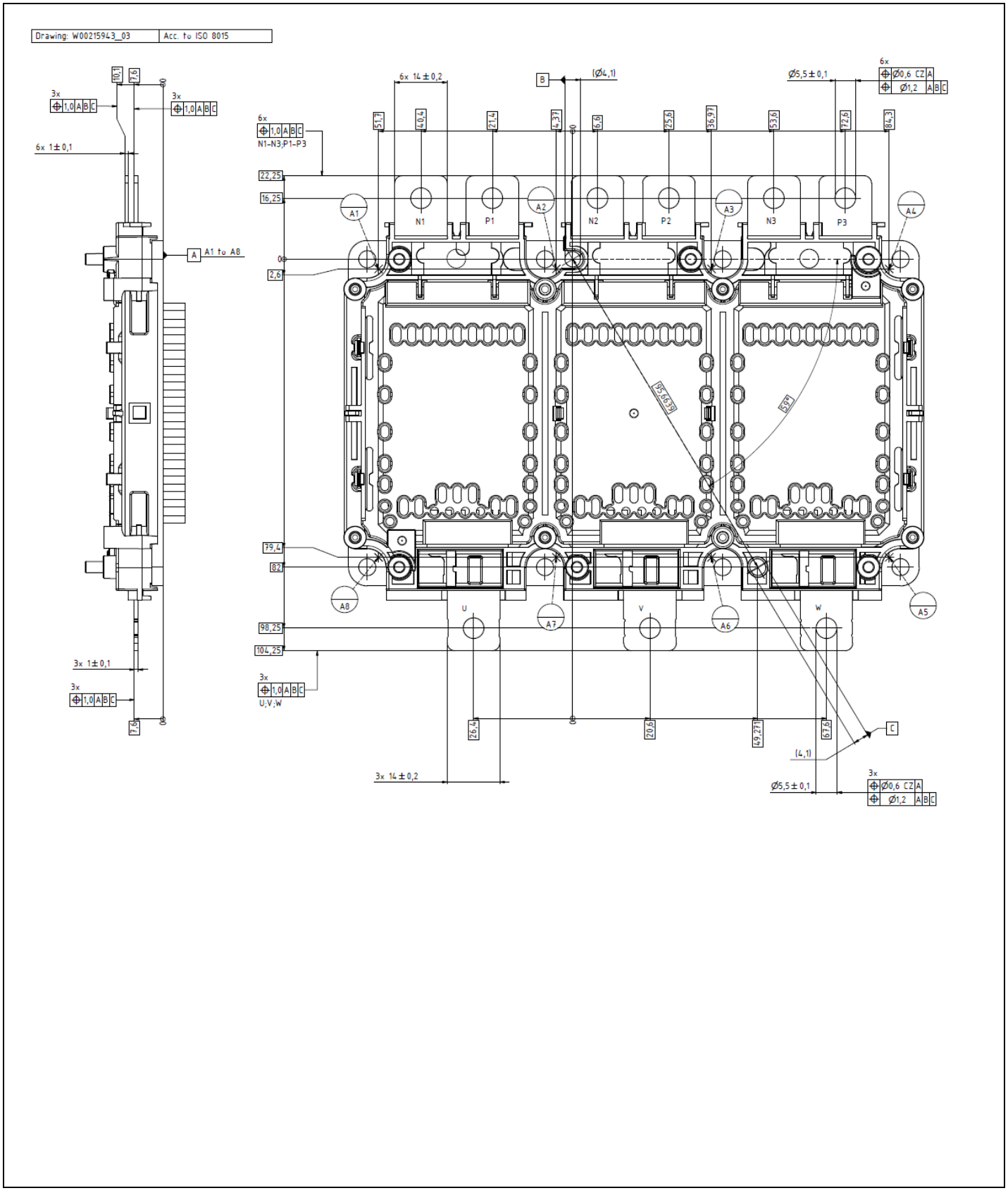

Drawing: W0021943_03
Acc. to ISO 8015
6x 14 ± 0,2
(Ø4,1)
Ø5,5 ± 0,1
6x 1 ± 0,1
3x 1 ± 0,1
A1 to A8
N1-N3;P1-P3
N1
P1
N2
P2
N3
P3
U
V
W
A1
A2
A3
A4
A5
A6
A7
A8
22,25
16,25
2,6
79,4
82
98,25
104,25
3x 14 ± 0,2
26,4
20,6
49,27
67,6
(4,1)
51,7
40,4
21,4
4,37
6,8
25,6
36,97
53,6
72,8
84,3
55,66
59°

图 3

7 封装外形

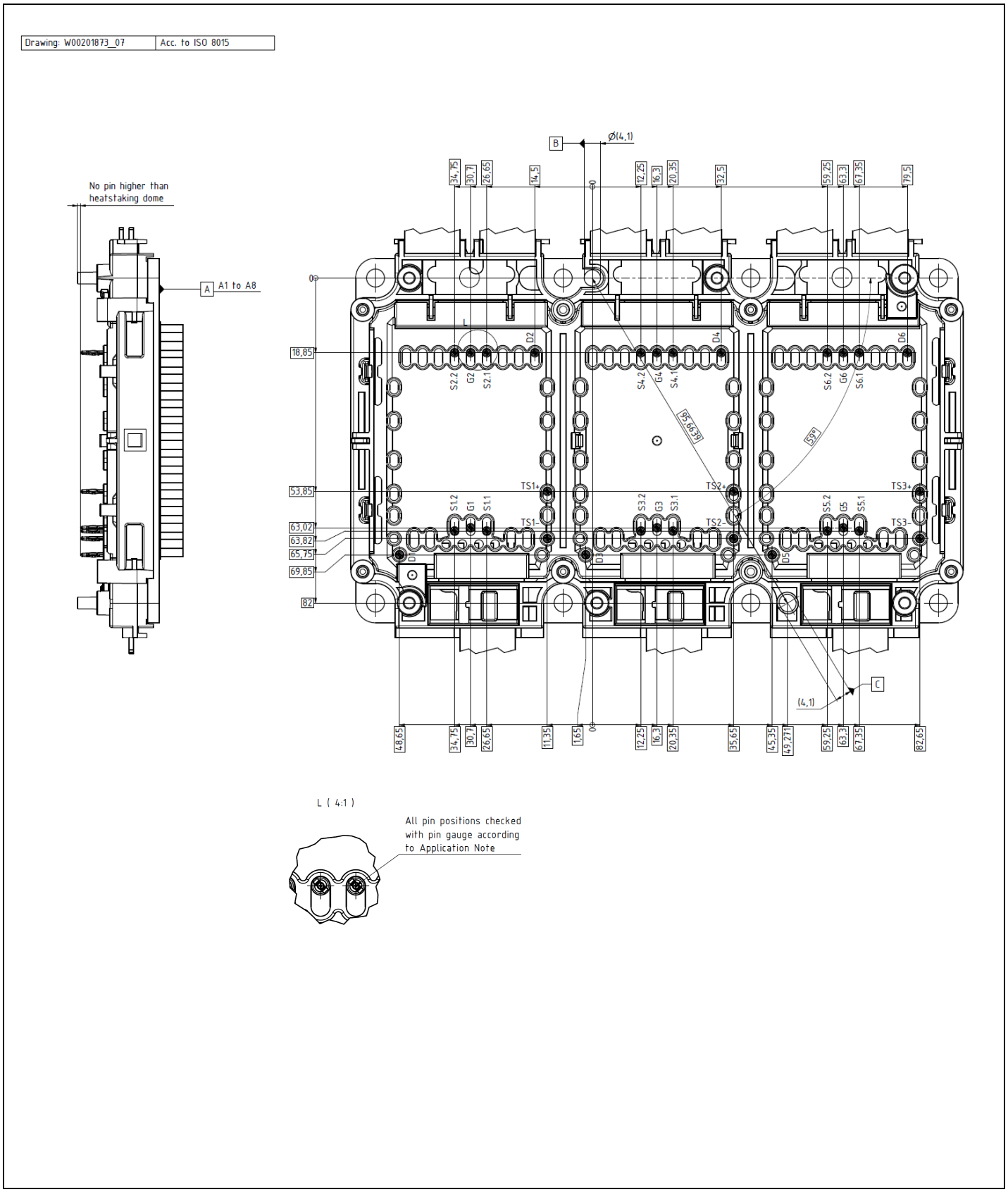

Drawing: W00201873_07
Acc. to ISO 8015
No pin higher than heatstaking dome
A
A1 to A8
B
Ø(4,1)
34,75
30,7
26,65
14,5
12,25
16,3
20,35
32,5
59,25
63,3
67,35
79,5
0
18,85
53,85
63,02
63,82
65,75
69,85
82
D2
D4
D6
S2.2
G2
S2.1
S4.2
G4
S4.1
S6.2
G6
S6.1
TS1+
TS2+
TS3+
TS1-
TS2-
TS3-
S1.2
G1
S1.1
S3.2
G3
S3.1
S5.2
G5
S5.1
D1
D3
D5
55°
C
(4,1)
48,65
11,35
1,65
35,65
45,35
49,21
L (4:1)
All pin positions checked with pin gauge according to Application Note

图 4

8 模块标签代码

模块标签代码

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



7154914284655054991530



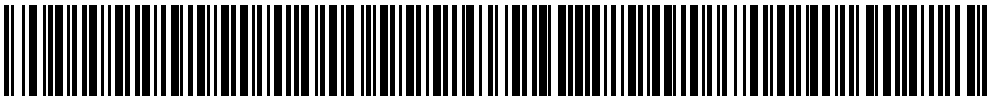
7154914284655054991530

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	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

图 5

修订记录

Document revision	Date of release	Description of changes
0.10	2025-05-08	Target datasheet
1.00	2025-12-15	Final datasheet

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