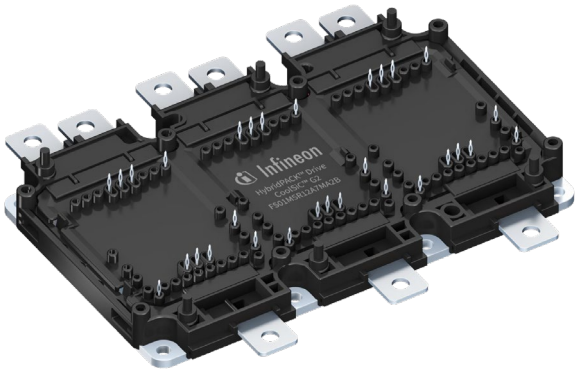
最终数据手册
英飞凌基于 SiC MOSFET的HybridPACK™ Drive G2模块

特性



- 电气特性
  - V_{DSS} = 1200 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
  - $T_{vj,op}$ = 185°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和冷却器组装的安装指导
  - 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

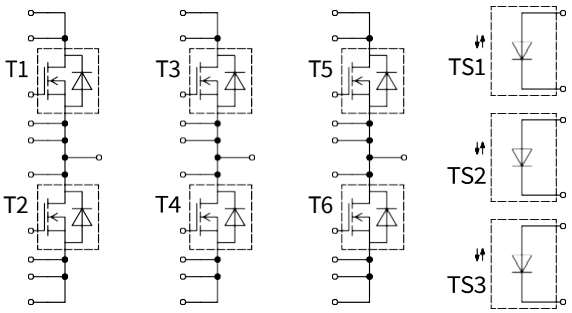
潜在应用

- 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	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) 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手册 AN-G2-ASSEMBLY。

2) 通过设计验证，而非通过测试验证
3) 螺钉类型和扭矩参考应用手册 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	1200	V
			10h over lifetime	1400	
DC drain current	$I_{D,nom}$	V_{GS} = 18 V, T_f = 65 °C	$T_{vj,max}$ = 185 °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		1.54	2.40	mΩ
			T_{vj} = 125 °C		2.60		
			T_{vj} = 185 °C		3.61		
			T_{vj} = 200 °C		3.94		
Drain-source on-resistance	$R_{DS,on}$	I_D = 430 A, V_{GS} = 15 V	T_{vj} = 25 °C		1.76	2.90	mΩ
			T_{vj} = 125 °C		2.75		
			T_{vj} = 185 °C		3.75		
			T_{vj} = 200 °C		4.07		
Gate threshold voltage	$V_{GS,th}$	I_D = 200 mA, V_{GS} = V_{DS}, (tested after 1ms pulse at V_{GS} = +20 V)	T_{vj} = 25 °C	3.20[1)]	3.98	4.55	V
Total gate charge	Q_G	V_{DS} = 750 V, V_{GS} = -5/18 V			1.50		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		0.53		Ω
Input capacitance	C_{iss}	f = 1 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		43.1		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} = 750 V	T_{vj} = 25 °C		1.58		nF
Reverse transfer capacitance	C_{rss}	f = 1 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		0.13		nF
C_{oss} stored energy	E_{oss}	V_{DS} = 750 V	T_{vj} = 25 °C		1674		µJ
Drain-source leakage current	I_{DSX}	V_{GS} = -5 V, V_{DSS} = 1200 V	T_{vj} = 25 °C			660	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, $R_{G,on}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		143		ns
			T_{vj} = 125 °C		114		
			T_{vj} = 185 °C		106		
			T_{vj} = 200 °C		101		
Rise time (inductive load)	t_r	I_D = 430 A, $R_{G,on}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		81		ns
			T_{vj} = 125 °C		75		
			T_{vj} = 185 °C		74		
			T_{vj} = 200 °C		73		
Turn-off delay time, inductive load	$t_{d,off}$	I_D = 430 A, $R_{G,off}$ = 3.6 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		232		ns
			T_{vj} = 125 °C		254		
			T_{vj} = 185 °C		264		
			T_{vj} = 200 °C		270		
Fall time (inductive load)	t_f	I_D = 430 A, $R_{G,off}$ = 3.6 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		44		ns
			T_{vj} = 125 °C		46		
			T_{vj} = 185 °C		47		
			T_{vj} = 200 °C		48		
Turn-on energy loss per pulse	E_{on}	I_D = 430 A, $R_{G,on}$ = 10 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V, L_σ = 6.5 nH	T_{vj} = 25 °C, di/dt = 4.2 kA/µs		35.30		mJ
			T_{vj} = 125 °C, di/dt = 4.5 kA/µs		35.40		
			T_{vj} = 185 °C, di/dt = 4.6 kA/µs		35.50		
			T_{vj} = 200 °C, di/dt = 4.7 kA/µs		35.60		

（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, $R_{G,off}$ = 3.6 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V, L_σ = 6.5 nH	T_{vj} = 25 °C, dv/dt = 10.6 kV/µs		16.50		mJ
			T_{vj} = 125 °C, dv/dt = 10.2 kV/µs		17.00		
			T_{vj} = 185 °C, dv/dt = 10 kV/µs		17.70		
			T_{vj} = 200 °C, dv/dt = 9.9 kV/µs		18.60		
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/18 V, $R_{G,on}$ = 10 Ω, $R_{G,off}$ = 3.6 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} < 1.2 µs, T_{vj} = 200 °C		7200		A
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/15 V, $R_{G,on}$ = 10 Ω, $R_{G,off}$ = 3.6 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} < 2 µs, T_{vj} = 200 °C		5500		A
Thermal resistance, junction to cooling fluid[2)]	$R_{th,j\text{-}f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 60 °C			0.107		K/W
Standard deviation of thermal resistance, junction to cooling fluid[2)]	$\sigma_{Rth,j\text{-}f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t$ = 10 dm³/min, T_f = 60 °C			2.4		K/kW
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		185	°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手册 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	1200	V
			10h over life time	1400	
DC body diode forward current	$I_{F,S}$	V_{GS} = -5 V, T_f = 65 °C	$T_{vj,max}$ = 185 °C	238	A

（表格续下页……）

表 7 （续）最大额定值

Parameter	Symbol	Note or test condition	Values	Unit
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		4.46	5.50	V
			T_{vj} = 125 °C		4.00		
			T_{vj} = 185 °C		3.80		
			T_{vj} = 200 °C		3.80		
Peak reverse recovery current	I_{rrm}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C		135		A
			T_{vj} = 125 °C		180		
			T_{vj} = 185 °C		219		
			T_{vj} = 200 °C		238		
Recovered charge	Q_{rr}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C		2.60		µC
			T_{vj} = 125 °C		5.20		
			T_{vj} = 185 °C		8.10		
			T_{vj} = 200 °C		9.70		
Reverse recovery energy	E_{rec}	$I_{F,S}$ = 430 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C, $-di/dt$ = 4.2 kA/µs		0.290		mJ
			T_{vj} = 125 °C, $-di/dt$ = 4.5 kA/µs		0.820		
			T_{vj} = 185 °C, $-di/dt$ = 4.6 kA/µs		1.40		
			T_{vj} = 200 °C, $-di/dt$ = 4.7 kA/µs		1.75		

4 温度传感器

表 9 特征值

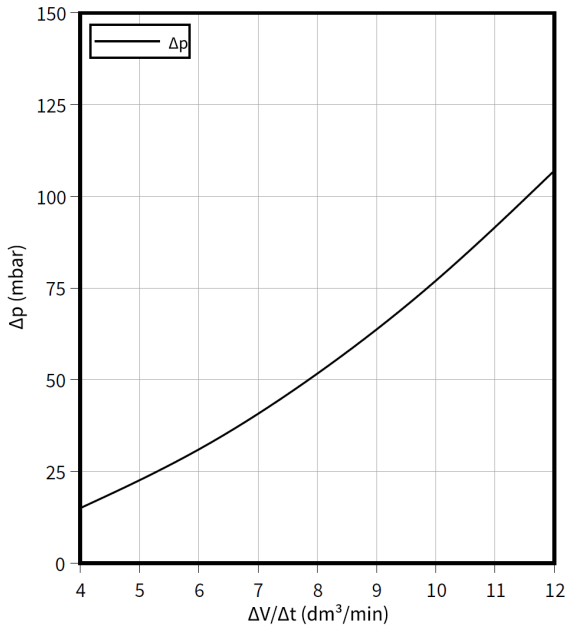
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Transient sense current	I_{TS}					10	mA
Forward voltage	V_{TS}		I_{TS} = 0.2 mA, T_{vj} = 25 °C	2.574	2.624	2.674	V
			I_{TS} = 0.2 mA, T_{vj} = 85 °C	2.169	2.234	2.299	

5 特性图

Pressure drop in cooling circuit (typical), Package

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

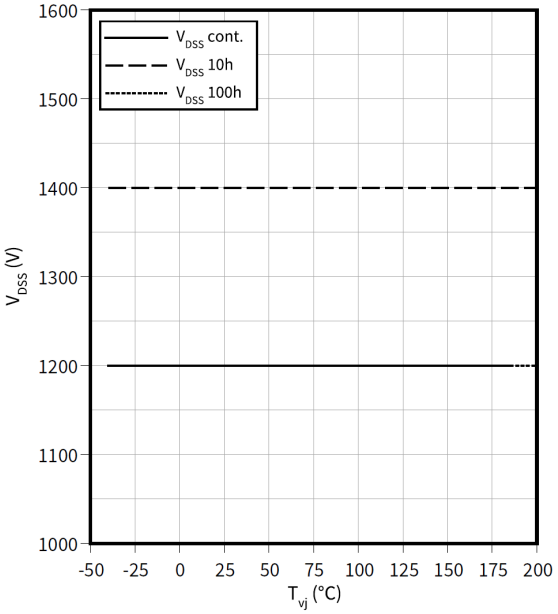
T_f = 60 °C, 50% water / 50% ethylene glycol



Maximum allowed drain-source voltage, MOSFET

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

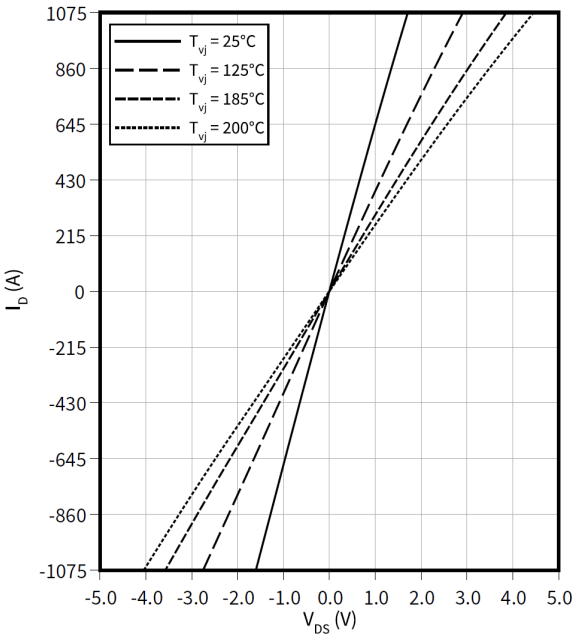
verified by characterization / design, not by test



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

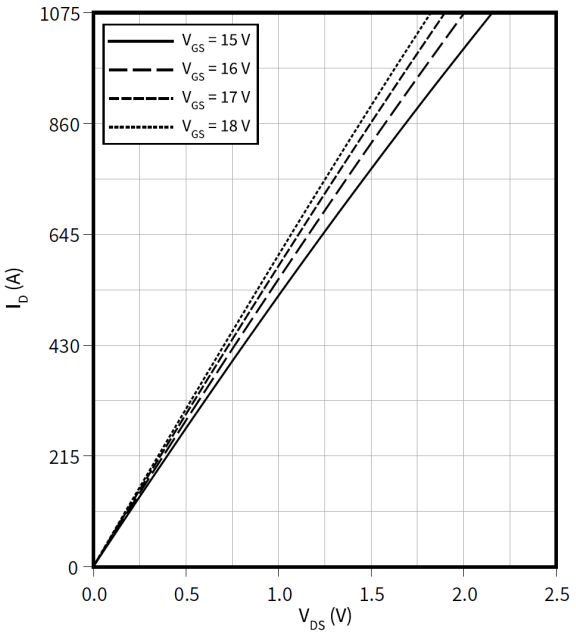
V_{GS} = 18 V



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

T_{vj} = 25 °C

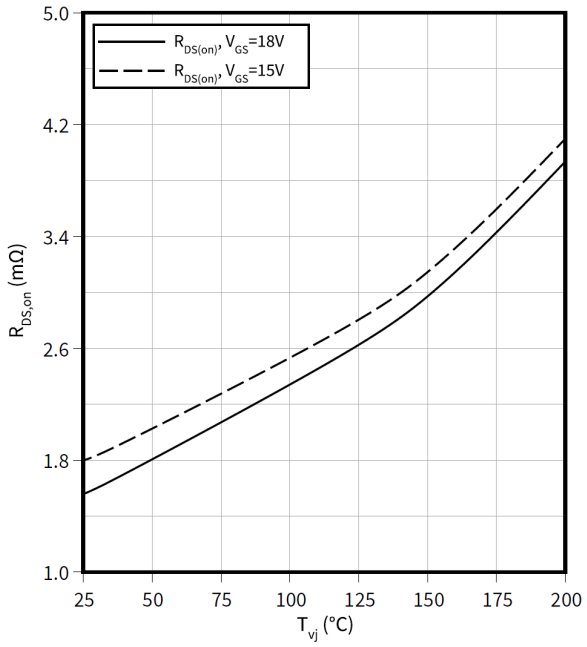


5 特性图

Drain-source on-resistance (typical), MOSFET

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

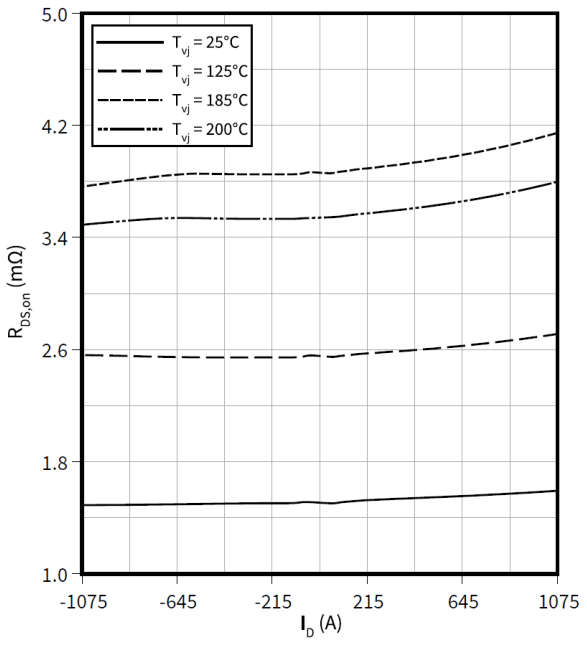
$I_D = 430$ A, $V_{GS} = 18$ V



Drain-source on-resistance (typical), MOSFET

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

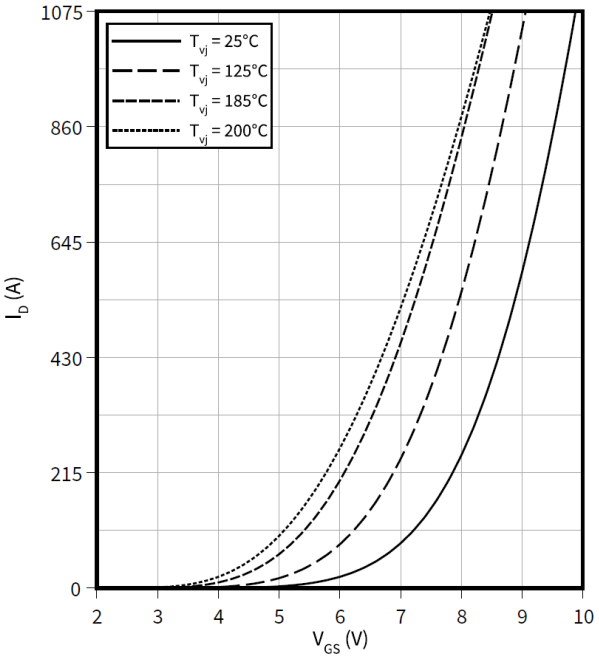
$V_{GS} = 18$ V



Transfer characteristic (typical), MOSFET

$I_D = f(V_{GS})$

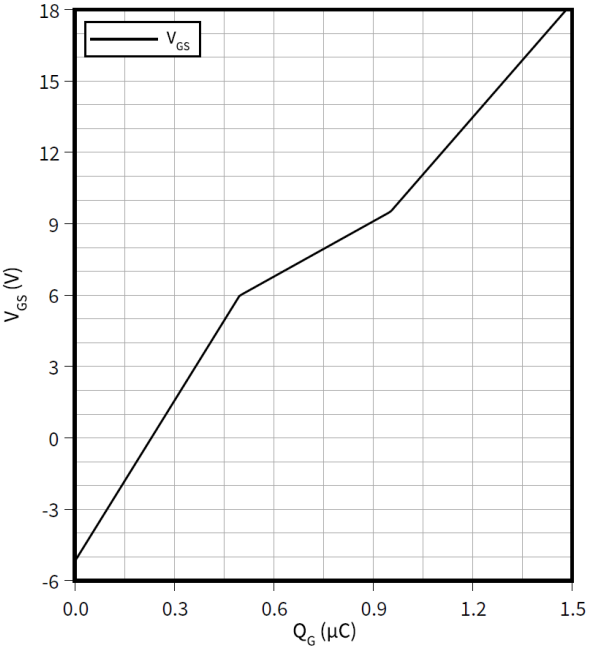
$V_{DS} = 20$ V



Gate charge characteristic (typical), MOSFET

$V_{GS} = f(Q_G)$

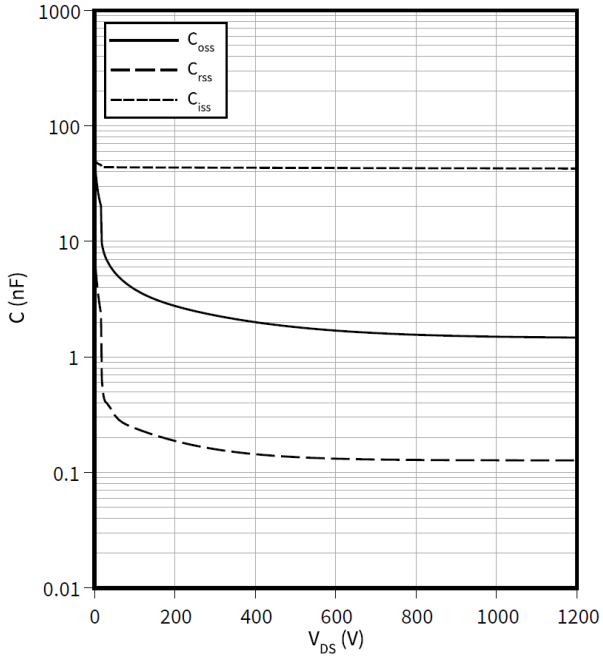
$V_{DD} = 750$ V, $T_{vj} = 25$ °C



Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$

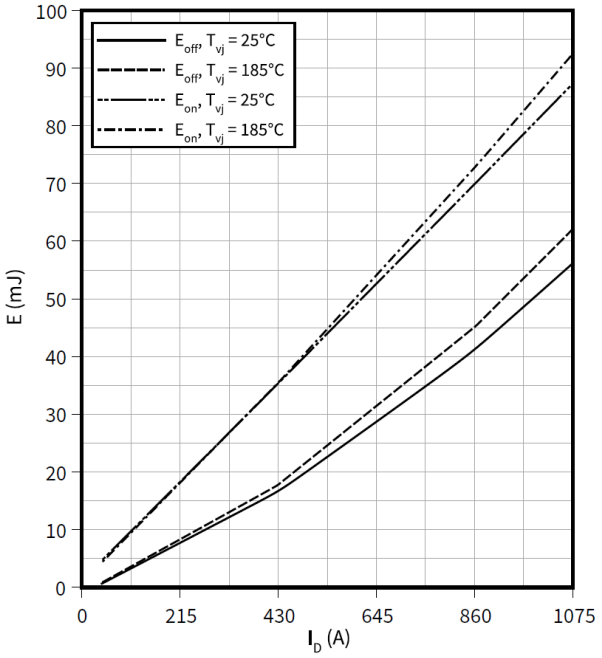
$f = 1$ MHz, $V_{GS} = -5/18$ V, $T_{vj} = 25$ °C



Switching losses (typical), MOSFET

$E = f(I_D)$

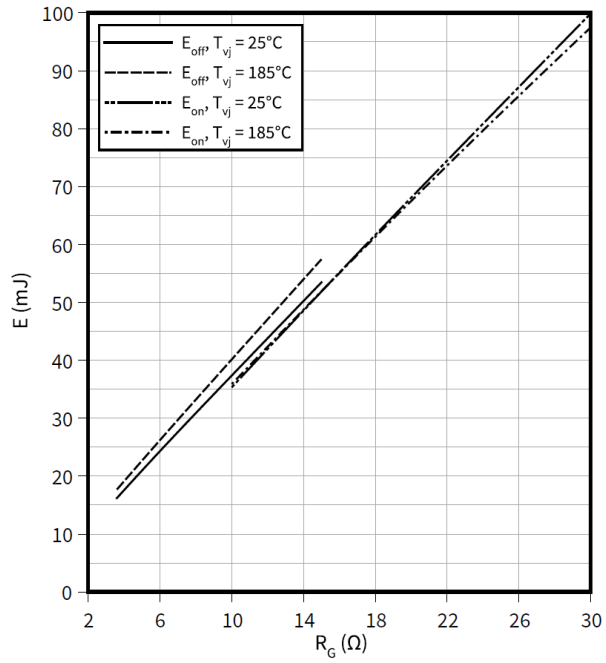
$V_{DS} = 750$ V, $R_{G,off} = 3.6\ \Omega$, $R_{G,on} = 10\ \Omega$, $V_{GS} = -5/18$ V



Switching losses (typical), MOSFET

$E = f(R_G)$

$V_{DS} = 750$ V, $I_D = 430$ A, $V_{GS} = -5/18$ V

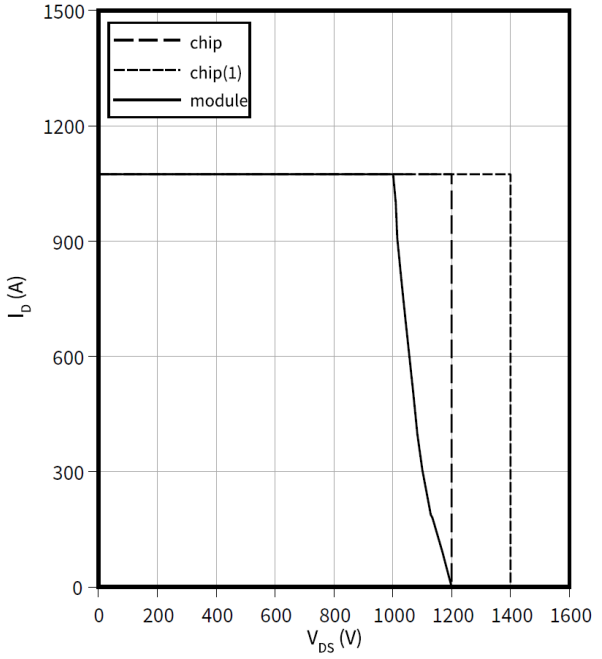


Reverse bias safe operating area (RBSOA), MOSFET

$I_D = f(V_{DS})$

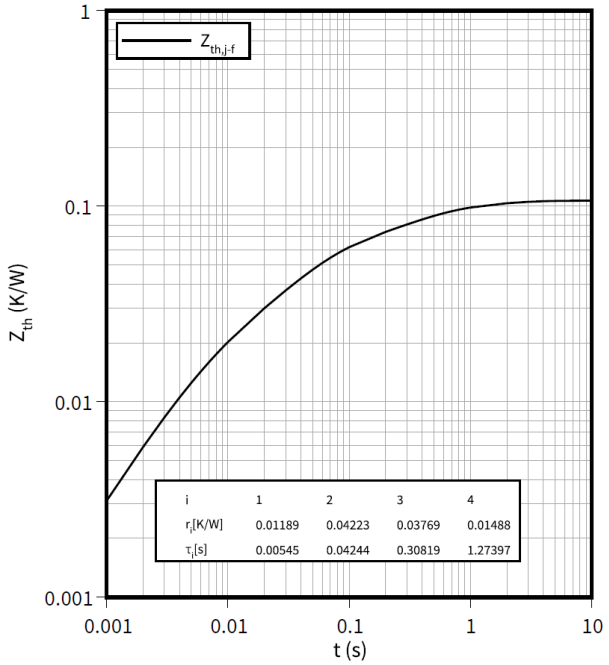
$R_{G,off} = 3.6\ \Omega$, $V_{GS} = +18/-5$ V, $T_{vj} = 185$ °C

(1) for 10h over lifetime



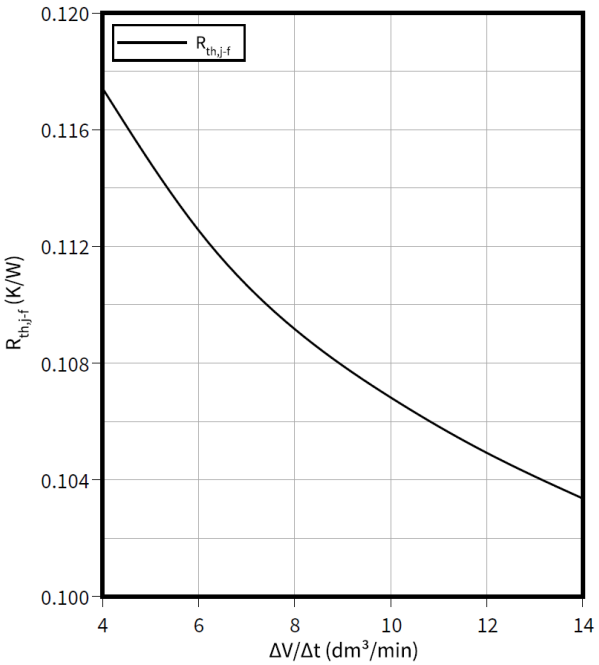
Transient thermal impedance (typical), MOSFET

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



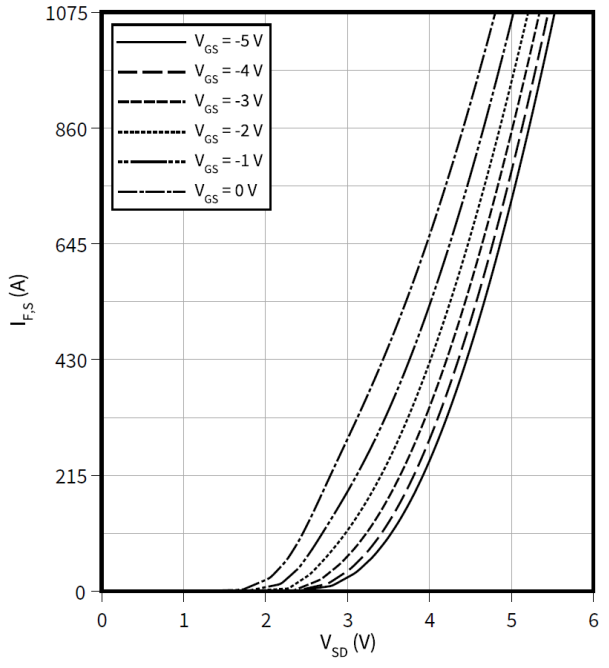
Thermal impedance (typical), MOSFET

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



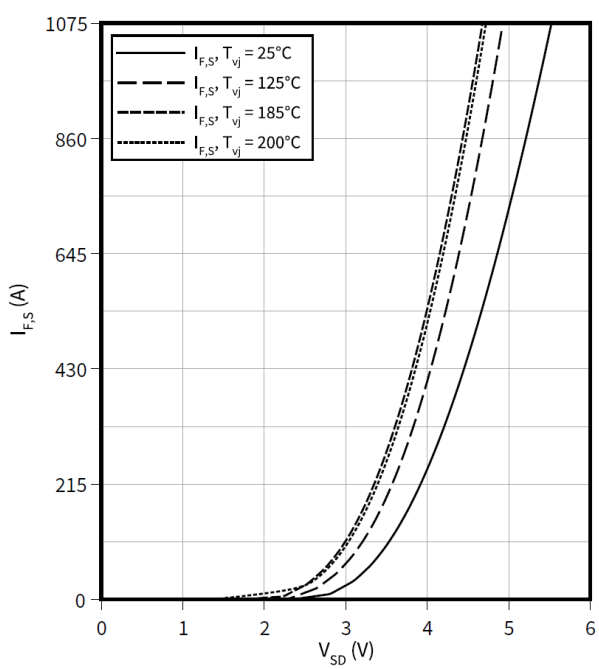
Forward characteristic body diode (typical), MOSFET

$I_{F,S} = f(V_{SD})$
T_{vj} = 25 °C



Forward characteristic body diode (typical), MOSFET

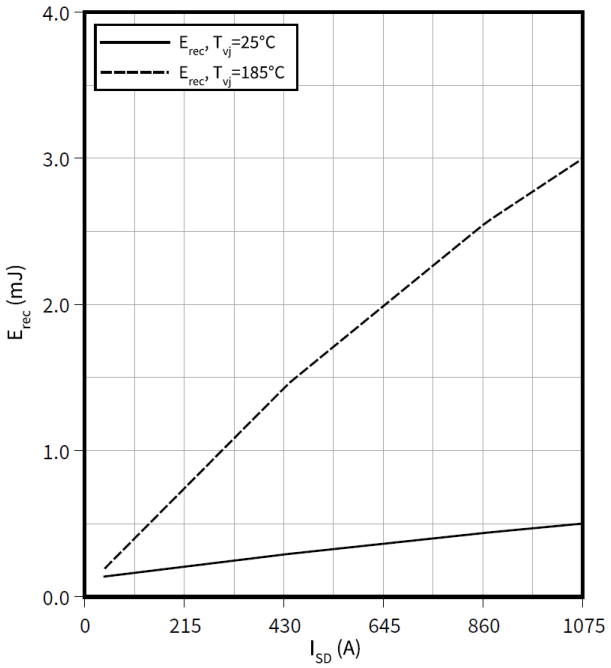
$I_{F,S} = f(V_{SD})$
V_{GS} = -5 V



Switching losses body diode (typical), MOSFET

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

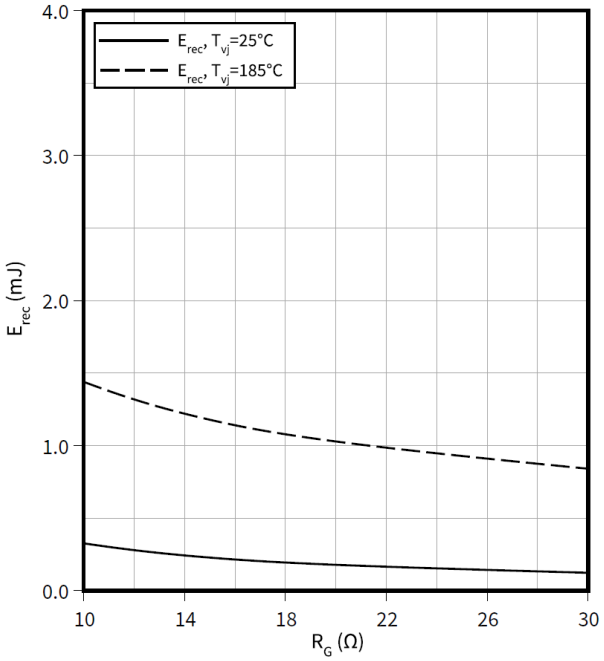
$R_{G,on} = 10\ \Omega$, $V_{R,DS} = 750\ V$



Switching losses body diode (typical), MOSFET

$E_{rec} = f(R_G)$

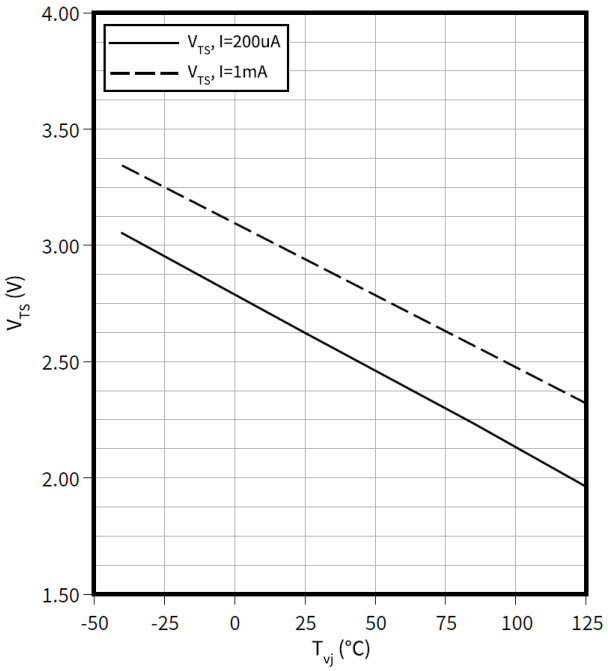
$I_{F,S} = 430\ A$, $V_{R,DS} = 750\ V$



Temperature characteristic (typical), Temperature sensor

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

$I_{TS} = 0.2\ mA$



6 电路图

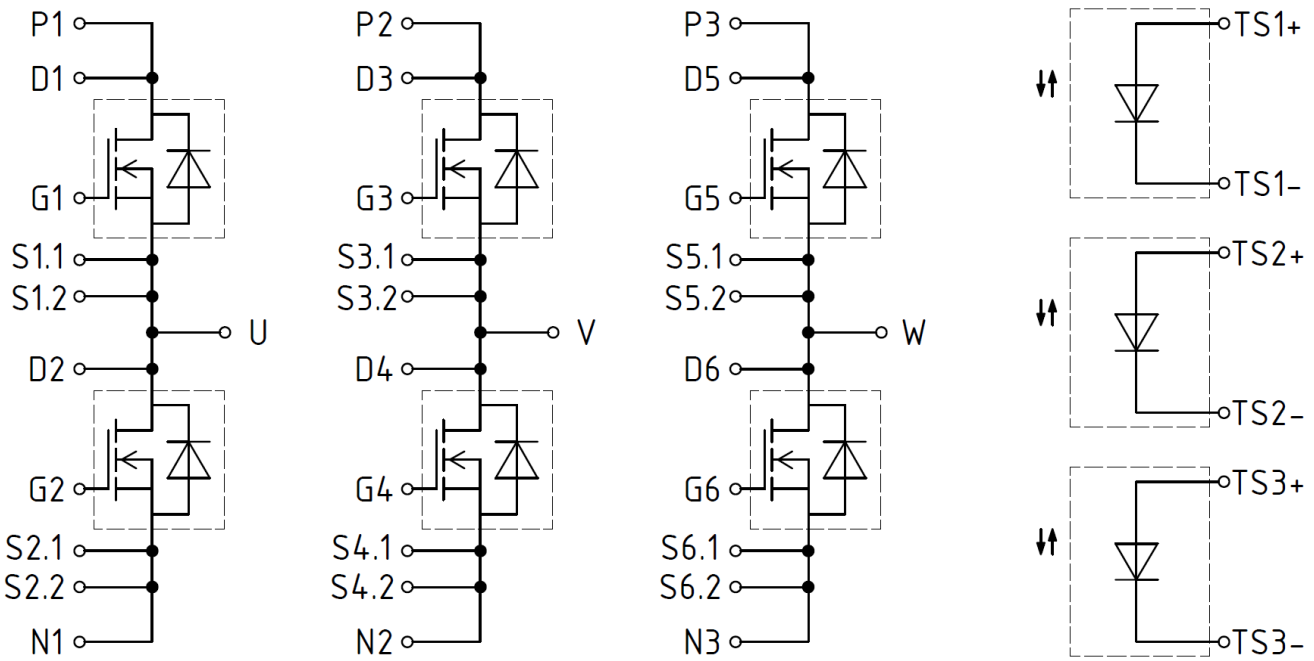

P1
D1
G1
S1.1
S1.2
U
D2
G2
S2.1
S2.2
N1
P2
D3
G3
S3.1
S3.2
V
D4
G4
S4.1
S4.2
N2
P3
D5
G5
S5.1
S5.2
W
D6
G6
S6.1
S6.2
N3
TS1+
TS1–
TS2+
TS2–
TS3+
TS3–

图 1

7 封装外形

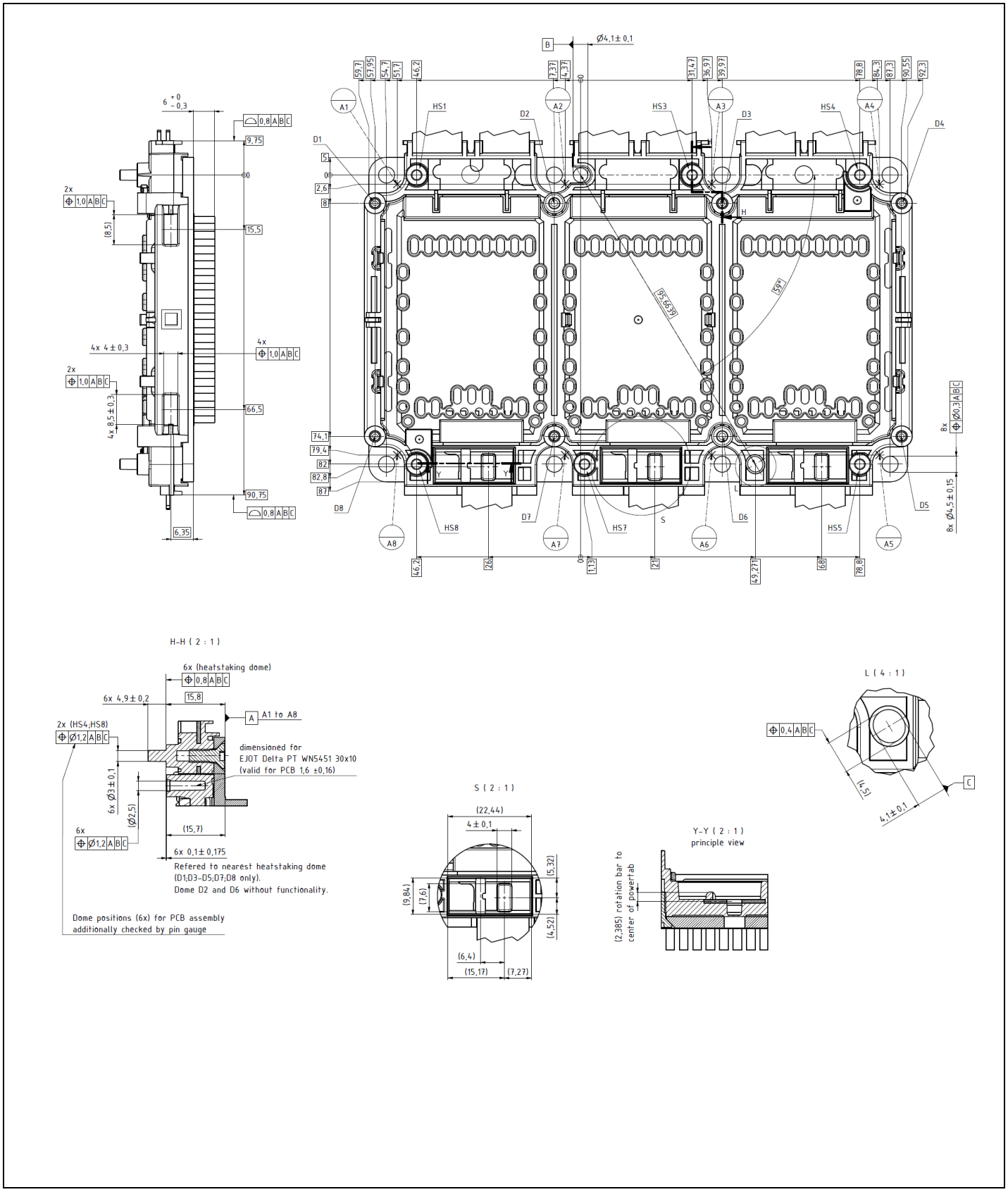

H–H (2 : 1)
6x (heatstaking dome)
6x 4,9 ± 0,2
15,8
A1 to A8
2x (HS4;HS8)
dimensioned for
EJOT Delta PT WN5451 30x10
(valid for PCB 1,6 ±0,16)
6x Ø3 ± 0,1
(Ø2,5)
6x
(15,7)
6x 0,1 ± 0,175
Refered to nearest heatstaking dome
(D1;D3-D5;D7;D8 only).
Dome D2 and D6 without functionality.
Dome positions (6x) for PCB assembly
additionally checked by pin gauge
S (2 : 1)
(22,44)
4 ± 0,1
(9,84)
(7,6)
(5,32)
(4,52)
(6,4)
(15,17)
(7,27)
Y–Y (2 : 1)
principle view
(2,385) rotation bar to
center of powertab
L (4 : 1)
(4,5)
4,1 ± 0,1
Ø4,1 ± 0,1
HS1
HS3
HS4
HS8
HS7
HS5
A1
A2
A3
A4
A5
A6
A7
A8
D1
D2
D3
D4
D5
D6
D7
D8
59,7
57,95
54,7
51,7
46,2
7,37
4,37
31,47
36,97
39,97
78,8
84,3
87,3
90,55
92,3
74,1
79,4
82
82,8
87
26
1,13
21
49,27
68
78,8
6 +0 -0,3
9,75
15,5
66,5
90,75
6,35
(8,5)
4x 4 ± 0,3
4x 8,5 ± 0,3
Ø0,4 A B C
8x Ø4,5 ± 0,15
55,64°
59°

图 2

7 封装外形

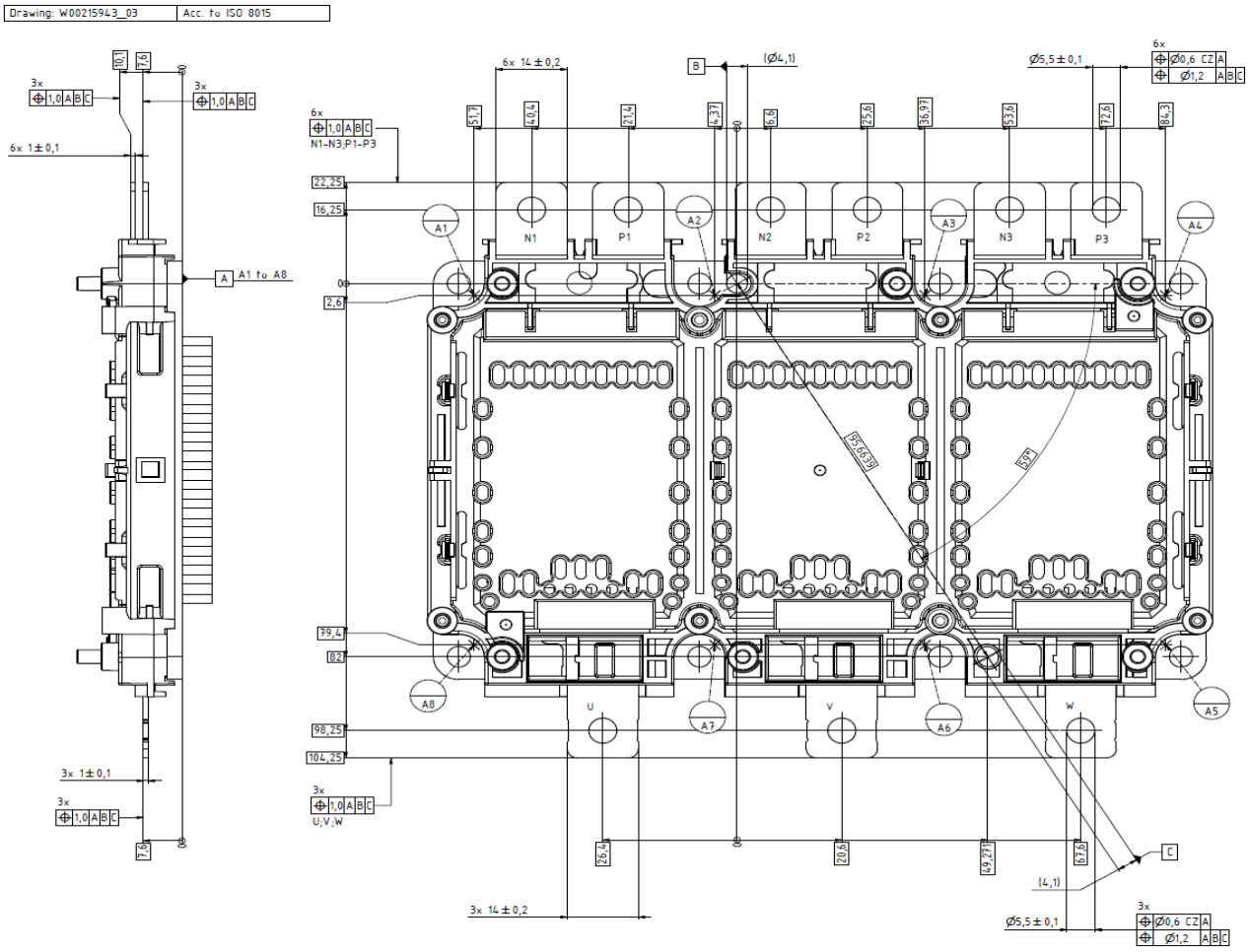

Drawing: W00215943_03
Acc. to ISO 8015
6x 14 ± 0,2
(Ø4,1)
Ø5,5 ± 0,1
6x Ø0,6 CZ A Ø1,2 A B C
6x 1,0 A B C N1-N3;P1-P3
3x 1,0 A B C
6x 1 ± 0,1
A A1 to A8
22,25
16,25
0
2,6
79,4
82
98,25
104,25
3x 1,0 A B C U;V;W
3x 1 ± 0,1
3x 14 ± 0,2
51,7
40,4
21,4
4,37
15,6
25,6
36,97
53,6
72,8
84,3
N1
P1
N2
P2
N3
P3
A1
A2
A3
A4
A5
A6
A7
A8
U
V
W
95,6
6,57
26,4
20,6
49,27
67,6
(4,1)
C

图 3

7 封装外形

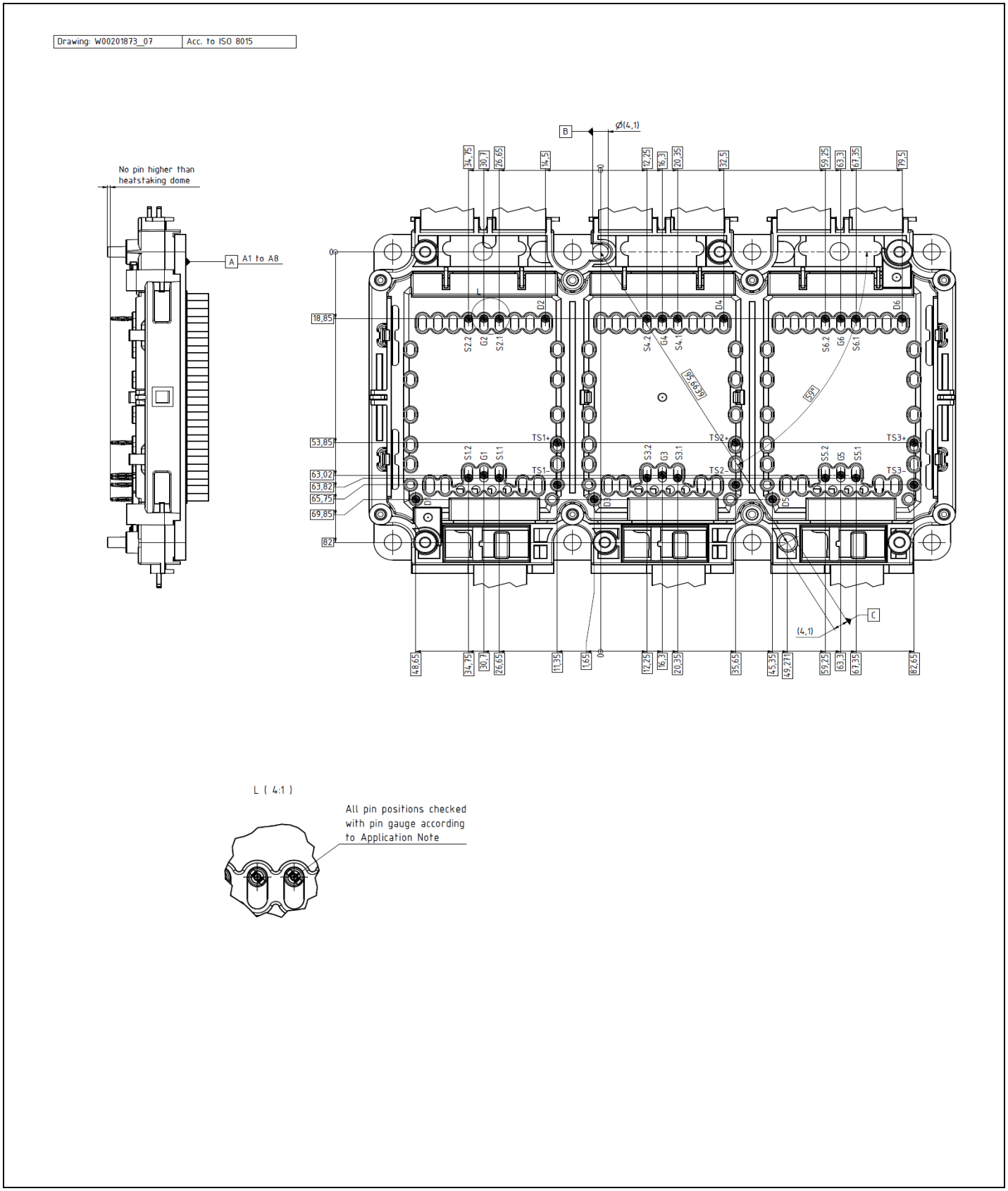

Drawing: W00201873_07
Acc. to ISO 8015
No pin higher than heatstaking dome
A
A1 to A8
B
Ø(4,1)
C
(4,1)
TS1+
TS2+
TS3+
TS1-
TS2-
TS3-
L (4:1)
All pin positions checked with pin gauge according to Application Note

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* Module serial number Module material number Production order number Date code (production year) Date code (production week)	*Digit* 1 – 5 6 - 11 12 - 19 20 – 21 22 – 23	*Example* 71549 142846 55054991 15 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* Backend Construction Production Lot Number Serial Number Date code Box Quantity	*Identifier* X 1T S 9D Q	*Digit* 2 – 9 12 – 19 21 – 25 28 – 31 33 – 34	*Example* 95056609 2X0003E0 754389 1139 15
Example	X950566091T2X0003E0S754389D1139Q15			

图 5

修订记录

Document revision	Date of release	Description of changes
0.10	2025-06-13	Target datasheet
1.00	2025-10-07	Final datasheet

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