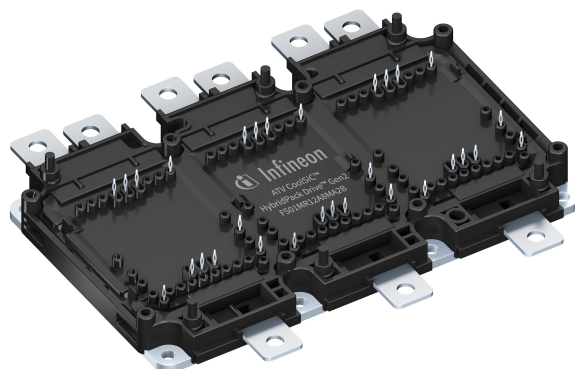


Final datasheet

HybridPACK™ Drive G2 module with SiC MOSFET

Features

- Electrical features
 - $V_{DS} = 1200\text{ V}$
 - $I_{DN} = 500\text{ A}$
 - New semiconductor material - silicon carbide
 - Low $R_{DS,on}$
 - Low switching losses
 - Low Q_g and C_{rss}
 - Low inductive design
 - $T_{vj,op} = 175^\circ\text{C}$
 - Short-time extended operation temperature $T_{vj,op} = 200^\circ\text{C}$
- Mechanical features
 - 4.2 kV DC 1 second insulation
 - High creepage and clearance distances
 - Compact design
 - High power density
 - Direct-cooled PinFin base plate
 - High-performance Si_3N_4 ceramic
 - Guiding elements for PCB and cooler assembly
 - Integrated temperature sensing diode
 - PressFIT contact technology
 - RoHS compliant, lead-free
 - UL 94 V0 module frame



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

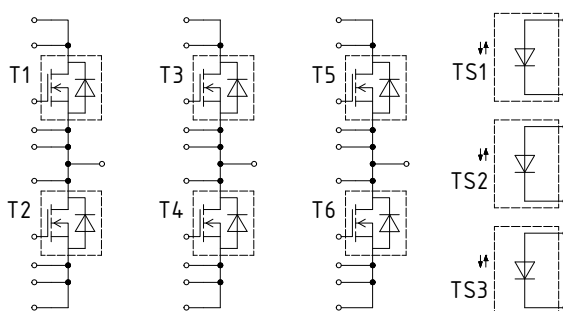




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1 Package

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	50% water / 50% ethylene glycol, $\Delta V / \Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 60$ °C		76 ¹⁾		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate} < 40$ °C			3.0	bar
		$T_{baseplate} \geq 40$ °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	0.50	0.55	
Weight	G			760		g

1) Cooler design and flow direction according to application note AN-G2-ASSEMBLY

- 2) Verified by design, not by test
3) Screw types and torque according to application note AN-G2-ASSEMBLY

2 MOSFET

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Drain-source voltage	V_{DS}		continuous operation	1200	V
			10h over lifetime	1400	
DC drain current	$I_{D,nom}$	$V_{GS} = 18\text{ V}$, $T_f = 65\text{ °C}$	$T_{vj,max} = 175\text{ °C}$	500	A
Pulsed drain current	$I_{D,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1000	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

Table 5 Recommended values

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...-3	V

Table 6 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Drain-source on-resistance	$R_{DS,on}$	$I_D = 500\text{ A}$, $V_{GS} = 18\text{ V}$	$T_{vj} = 25\text{ °C}$		1.28	1.87	mΩ
			$T_{vj} = 125\text{ °C}$		2.22		
			$T_{vj} = 175\text{ °C}$		2.95		
			$T_{vj} = 200\text{ °C}$		3.41		
Drain-source on-resistance	$R_{DS,on}$	$I_D = 500\text{ A}$, $V_{GS} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$		1.47	2.13	mΩ
			$T_{vj} = 125\text{ °C}$		2.36		
			$T_{vj} = 175\text{ °C}$		3.08		
			$T_{vj} = 200\text{ °C}$		3.53		
Gate threshold voltage	$V_{GS,th}$	$I_D = 240\text{ mA}$, $V_{GS} = V_{DS}$, (tested after 1ms pulse at $V_{GS} = +20\text{ V}$)	$T_{vj} = 25\text{ °C}$	3.20 ¹⁾	3.98	4.55	V
Total gate charge	Q_G	$V_{DS} = 750\text{ V}$, $V_{GS} = -5/18\text{ V}$			1.75		μC
Internal gate resistor	$R_{G,int}$		$T_{vj} = 25\text{ °C}$		0.44		Ω
Input capacitance	C_{iss}	$f = 1\text{ MHz}$, $V_{DS} = 750\text{ V}$	$T_{vj} = 25\text{ °C}$		51.7		nF

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Output capacitance	C_{oss}	$f = 1 \text{ MHz}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		1.90		nF
Reverse transfer capacitance	C_{rss}	$f = 1 \text{ MHz}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		0.15		nF
C_{oss} stored energy	E_{oss}	$V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		2004		μJ
Drain-source leakage current	I_{DSX}	$V_{GS} = -5 \text{ V}$, $V_{DSS} = 1200 \text{ V}$	$T_{vj} = 25 \text{ °C}$			890	μA
Gate-source leakage current	I_{GSS}	$V_{GS} = 20 \text{ V}$, $V_{DS} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$			400	nA
Turn-on delay time, inductive load	$t_{d,on}$	$I_D = 500 \text{ A}$, $R_{G,on} = 9.2 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		175		ns
			$T_{vj} = 125 \text{ °C}$		140		
			$T_{vj} = 175 \text{ °C}$		128		
			$T_{vj} = 200 \text{ °C}$		123		
Rise time (inductive load)	t_r	$I_D = 500 \text{ A}$, $R_{G,on} = 9.2 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		213		ns
			$T_{vj} = 125 \text{ °C}$		197		
			$T_{vj} = 175 \text{ °C}$		195		
			$T_{vj} = 200 \text{ °C}$		184		
Turn-off delay time, inductive load	$t_{d,off}$	$I_D = 500 \text{ A}$, $R_{G,off} = 2.8 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		214		ns
			$T_{vj} = 125 \text{ °C}$		232		
			$T_{vj} = 175 \text{ °C}$		241		
			$T_{vj} = 200 \text{ °C}$		246		
Fall time (inductive load)	t_f	$I_D = 500 \text{ A}$, $R_{G,off} = 2.8 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$		48		ns
			$T_{vj} = 125 \text{ °C}$		50		
			$T_{vj} = 175 \text{ °C}$		51		
			$T_{vj} = 200 \text{ °C}$		51		
Turn-on energy loss per pulse	E_{on}	$I_D = 500 \text{ A}$, $R_{G,on} = 9.2 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$, $L_\sigma = 6.5 \text{ nH}$	$T_{vj} = 25 \text{ °C}$, $di/dt = 4.2 \text{ kA}/\mu\text{s}$		40.90		mJ
			$T_{vj} = 125 \text{ °C}$, $di/dt = 4.5 \text{ kA}/\mu\text{s}$		40.24		
			$T_{vj} = 175 \text{ °C}$, $di/dt = 4.6 \text{ kA}/\mu\text{s}$		41.31		
			$T_{vj} = 200 \text{ °C}$, $di/dt = 4.7 \text{ kA}/\mu\text{s}$		41.73		

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-off energy loss per pulse	E_{off}	$I_D = 500 \text{ A}$, $R_{G,off} = 2.8 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$, $V_{DS} = 750 \text{ V}$, $L_\sigma = 6.5 \text{ nH}$		$T_{vj} = 25 \text{ }^\circ\text{C}$, $dv/dt = 12.6 \text{ kV}/\mu\text{s}$		mJ
				$T_{vj} = 125 \text{ }^\circ\text{C}$, $dv/dt = 12.1 \text{ kV}/\mu\text{s}$		
				$T_{vj} = 175 \text{ }^\circ\text{C}$, $dv/dt = 11.9 \text{ kV}/\mu\text{s}$		
				$T_{vj} = 200 \text{ }^\circ\text{C}$, $dv/dt = 11.7 \text{ kV}/\mu\text{s}$		
Short circuit data	I_{SC}	$V_{DD} = 750 \text{ V}$, $V_{GS} = -5/18 \text{ V}$, $R_{G,on} = 9.2 \text{ } \Omega$, $R_{G,off} = 2.8 \text{ } \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$		$t_{SC} \leq 1.2 \text{ } \mu\text{s}$, $T_{vj} = 200 \text{ }^\circ\text{C}$	7760	A
Short circuit data	I_{SC}	$V_{DD} = 750 \text{ V}$, $V_{GS} = -5/15 \text{ V}$, $R_{G,on} = 9.2 \text{ } \Omega$, $R_{G,off} = 2.8 \text{ } \Omega$, $V_{DSmax} =$ $V_{DSS} - L_{SDS} \cdot di/dt$		$t_{SC} \leq 2 \text{ } \mu\text{s}$, $T_{vj} = 200 \text{ }^\circ\text{C}$	6080	A
Thermal resistance, junction to cooling fluid ²⁾	$R_{th,j-f}$	50% water / 50% ethylene glycol, $\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, $T_f = 60 \text{ }^\circ\text{C}$		0.103	0.11 ³⁾	K/W
Temperature under switching conditions	$T_{vj,op}$			-40	175	$^\circ\text{C}$
					200 ⁴⁾	

- 1) At 0h operating time. During inverter operation the value can be lower depending on T_{vj} , $V_{GS(off)}$, (switching frequency) f_{sw} over lifetime. For a final assessment of $V_{GS,th}$ Min. value depending on customer application please contact the Infineon sales office for the necessary technical support by Infineon.
- 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
- 4) For 100h cumulated over lifetime

3 Body diode (MOSFET)

Table 7 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Drain-source voltage	V_{DSS}	continuous operation	1200	V
		10h over lifetime	1400	
DC body diode forward current	$I_{F,S}$	$V_{GS} = -5 \text{ V}$, $T_f = 65 \text{ }^\circ\text{C}$	$T_{vj,max} = 175 \text{ }^\circ\text{C}$	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$	1000	A

Table 8 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	$V_{F,SD}$	$I_{F,S} = 500 \text{ A}$, $V_{GS} = -5 \text{ V}$	$T_{vj} = 25 \text{ °C}$	4.48	5.82	V
			$T_{vj} = 125 \text{ °C}$	4.11		
			$T_{vj} = 175 \text{ °C}$	3.97		
			$T_{vj} = 200 \text{ °C}$	3.91		
Peak reverse recovery current	I_{rrm}	$I_{F,S} = 500 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$	118		A
			$T_{vj} = 125 \text{ °C}$	186		
			$T_{vj} = 175 \text{ °C}$	229		
			$T_{vj} = 200 \text{ °C}$	248		
Recovered charge	Q_{rr}	$I_{F,S} = 500 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$	2.22		μC
			$T_{vj} = 125 \text{ °C}$	6.31		
			$T_{vj} = 175 \text{ °C}$	9.43		
			$T_{vj} = 200 \text{ °C}$	11.10		
Reverse recovery energy	E_{rec}	$I_{F,S} = 500 \text{ A}$, $V_{GS} = -5 \text{ V}$, $V_{R,DS} = 750 \text{ V}$	$T_{vj} = 25 \text{ °C}$, $-di/dt = 6.1 \text{ kA}/\mu\text{s}$	0.3		mJ
			$T_{vj} = 125 \text{ °C}$, $-di/dt = 6.5 \text{ kA}/\mu\text{s}$	1.2		
			$T_{vj} = 175 \text{ °C}$, $-di/dt = 6.7 \text{ kA}/\mu\text{s}$	2.0		
			$T_{vj} = 200 \text{ °C}$, $-di/dt = 6.7 \text{ kA}/\mu\text{s}$	2.4		

4 Temperature sensor

Table 9 Characteristic values

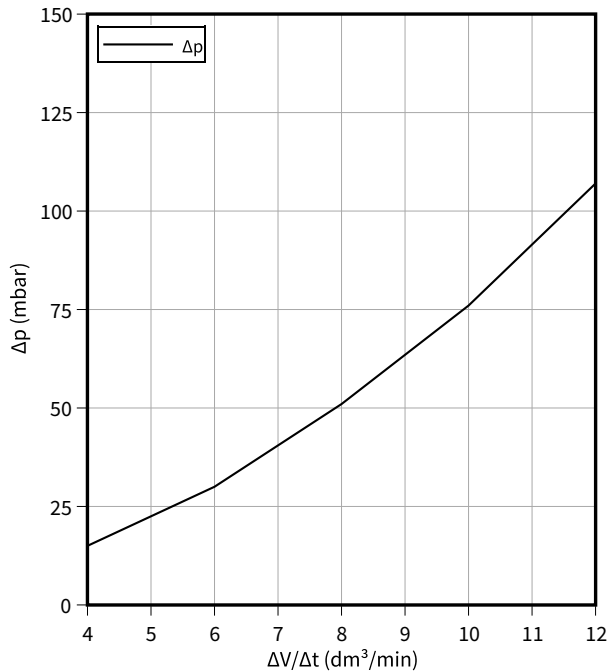
Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Transient sense current	I_{TS}				10	mA
Forward voltage	V_{TS}	$I_{TS} = 0.2 \text{ mA}$, $T_{vj} = 25 \text{ °C}$	2.574	2.624	2.674	V
		$I_{TS} = 0.2 \text{ mA}$, $T_{vj} = 85 \text{ °C}$	2.169	2.234	2.299	

5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

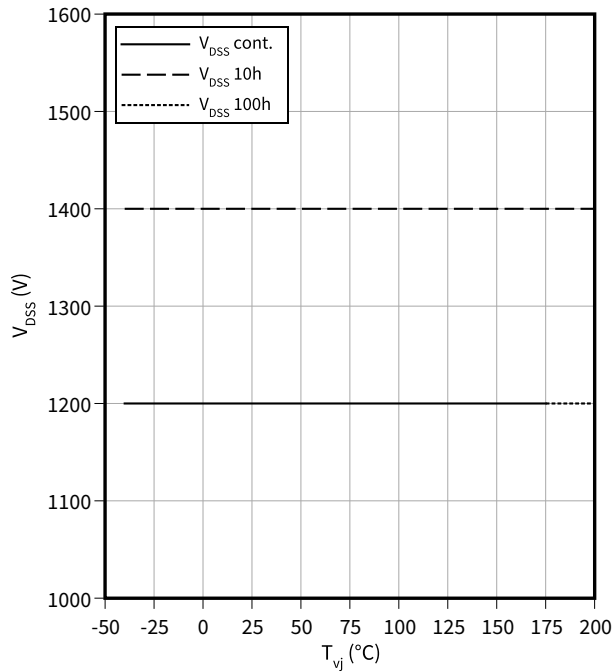
$T_f = 60\text{ }^{\circ}\text{C}$, 50% water / 50% ethylene glycol



Maximum allowed drain-source voltage, MOSFET

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

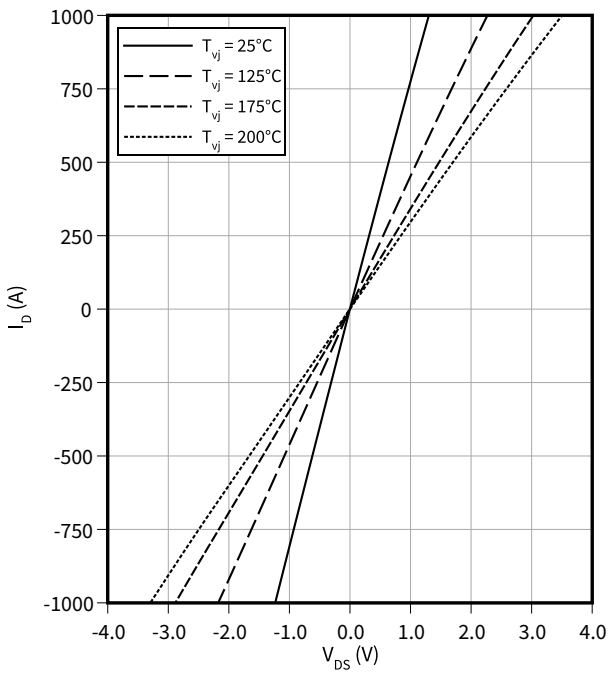
verified by characterization/design, not by test



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

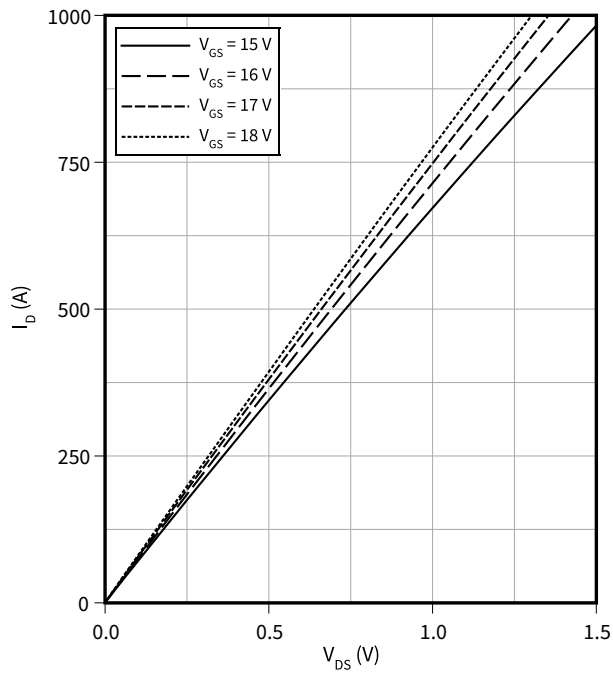
$V_{GS} = 18\text{ V}$



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

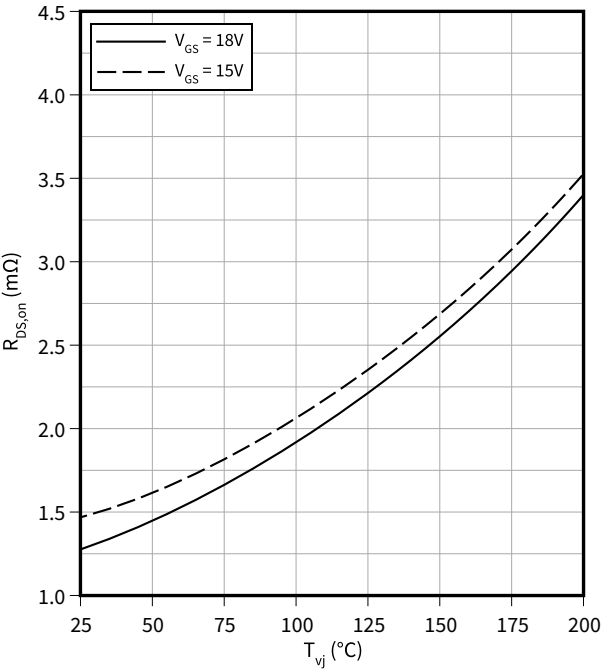
$T_{vj} = 25\text{ }^{\circ}\text{C}$



5 Characteristics diagrams

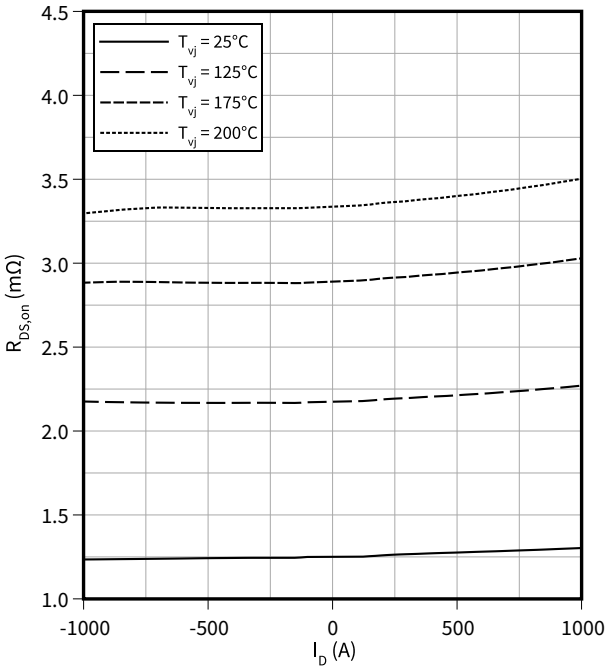
Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(T_{vj})$
 $I_D = 500\text{ A}$



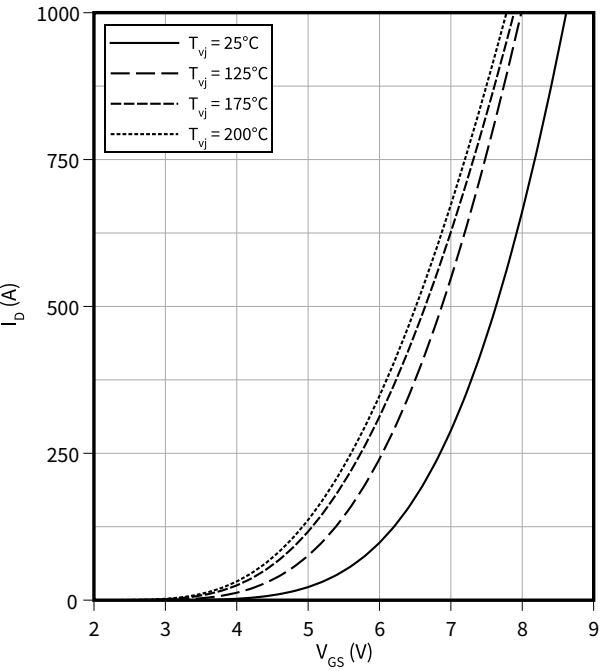
Drain-source on-resistance (typical), MOSFET

$R_{DS,on} = f(I_D)$
 $V_{GS} = 18\text{ V}$



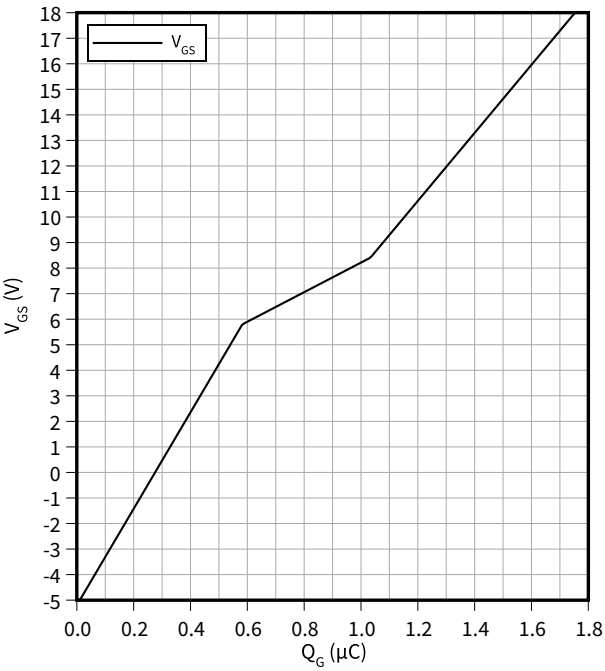
Transfer characteristic (typical), MOSFET

$I_D = f(V_{GS})$
 $V_{DS} = 20\text{ V}$



Gate charge characteristic (typical), MOSFET

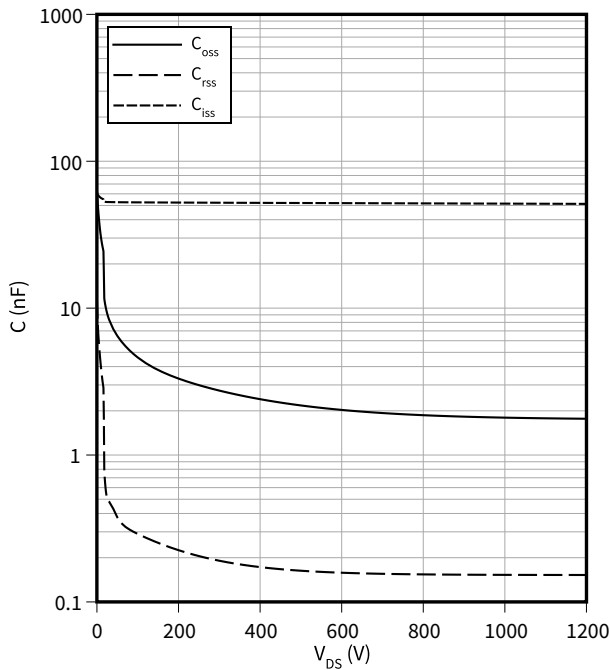
$V_{GS} = f(Q_G)$
 $V_{DD} = 750\text{ V}, T_{vj} = 25\text{ °C}$



5 Characteristics diagrams

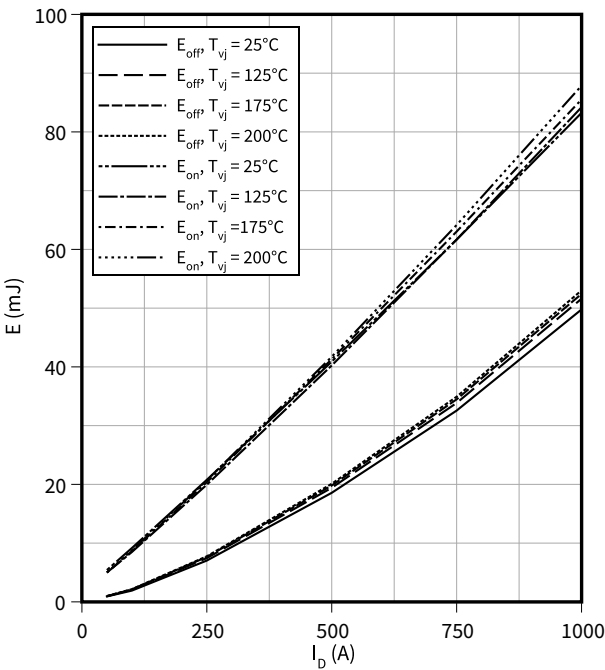
Capacity characteristic (typical), MOSFET

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



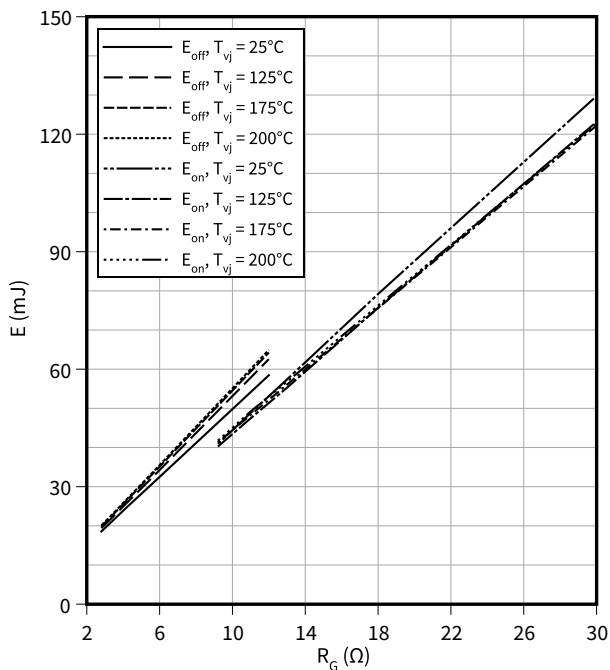
Switching losses (typical), MOSFET

$E = f(I_D)$
 $V_{DS} = 750 \text{ V}$, $R_{G,off} = 2.8 \text{ } \Omega$, $R_{G,on} = 9.2 \text{ } \Omega$, $V_{GS} = -5/18 \text{ V}$



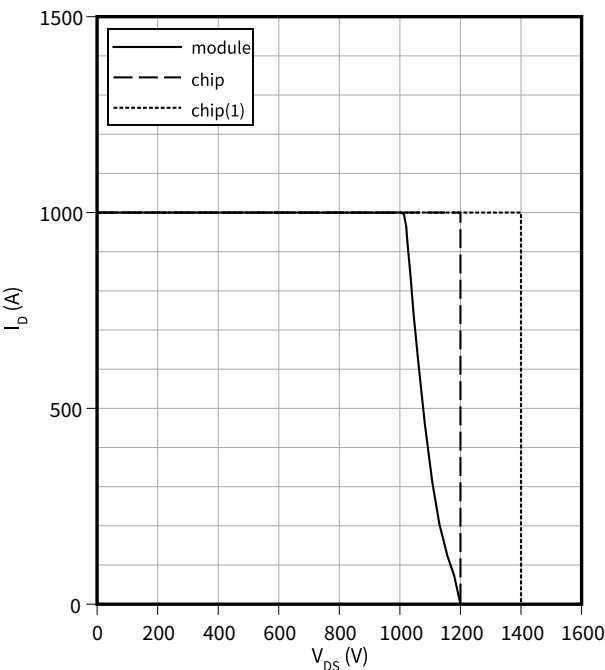
Switching losses (typical), MOSFET

$E = f(R_G)$
 $V_{DS} = 750 \text{ V}$, $I_D = 500 \text{ A}$, $V_{GS} = -5/18 \text{ V}$



Reverse bias safe operating area (RBSOA), MOSFET

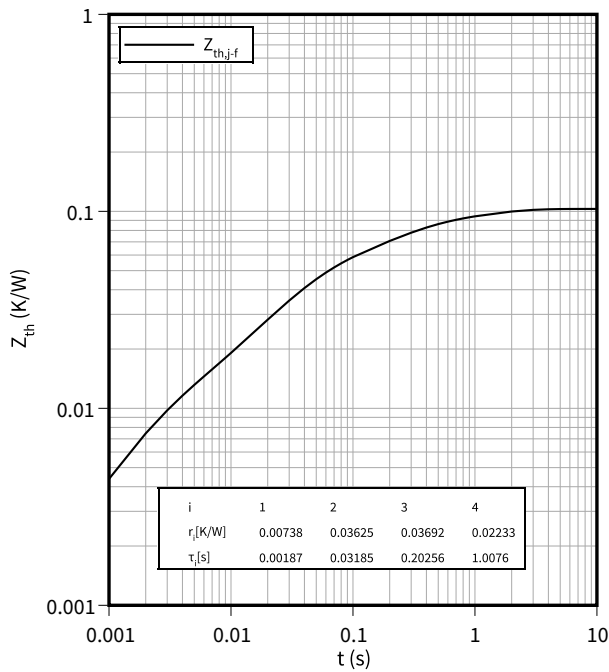
$I_D = f(V_{DS})$
 $R_{G,off} = 2.8 \text{ } \Omega$, $V_{GS} = +18/-5 \text{ V}$, $T_{vj} = 175 \text{ °C}$
(1) for 10h over lifetime



5 Characteristics diagrams

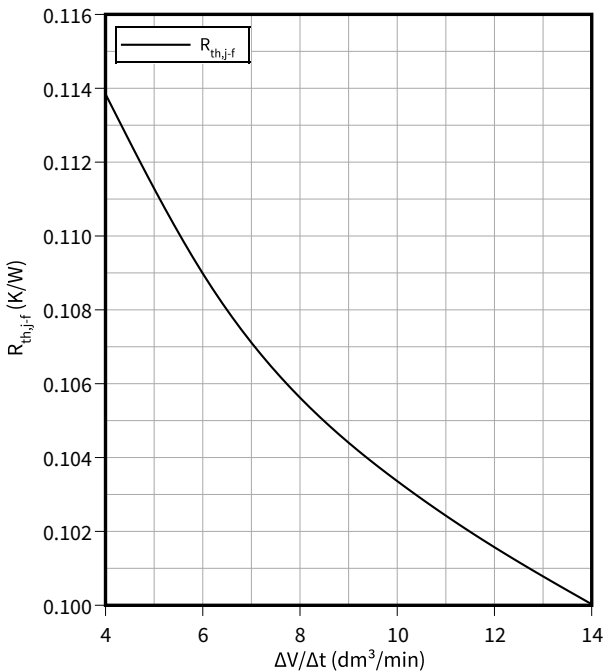
Transient thermal impedance (typical), MOSFET

$Z_{th} = f(t)$
 $\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$, 50% water / 50% ethylene glycol , $T_f = 60 \text{ }^\circ\text{C}$



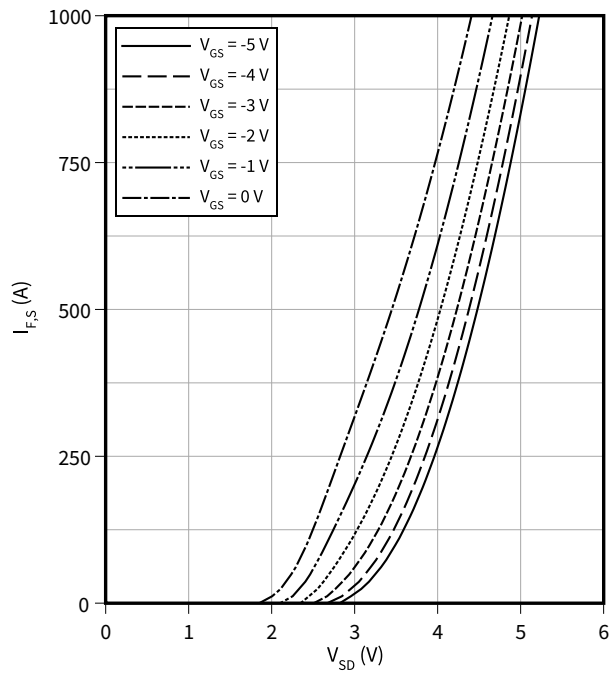
Thermal impedance (typical), MOSFET

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



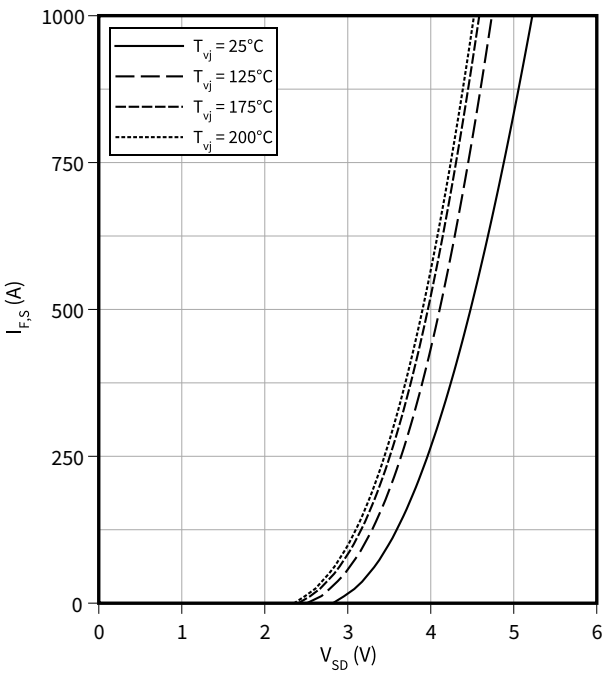
Forward characteristic body diode (typical), MOSFET

$I_{F,S} = f(V_{SD})$
 $T_{vj} = 25 \text{ }^\circ\text{C}$



Forward characteristic body diode (typical), MOSFET

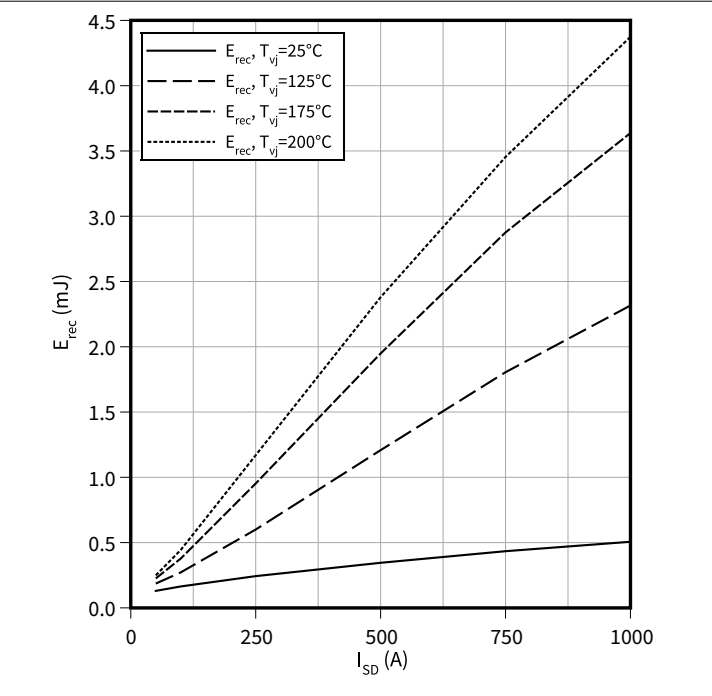
$I_{F,S} = f(V_{SD})$
 $V_{GS} = -5 \text{ V}$



5 Characteristics diagrams

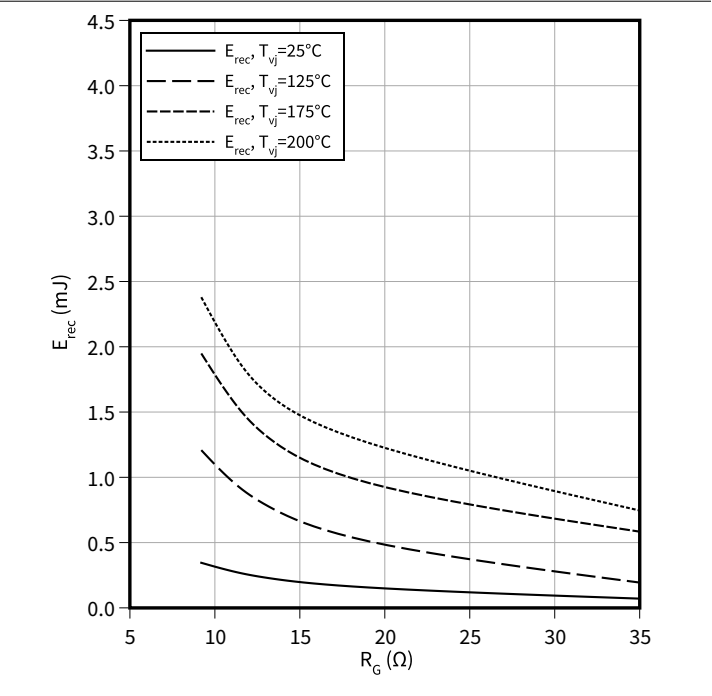
Switching losses body diode (typical), MOSFET

$E_{rec} = f(I_{SD})$
 $V_r = 750\text{ V}, R_{G,on} = 9.2\ \Omega$



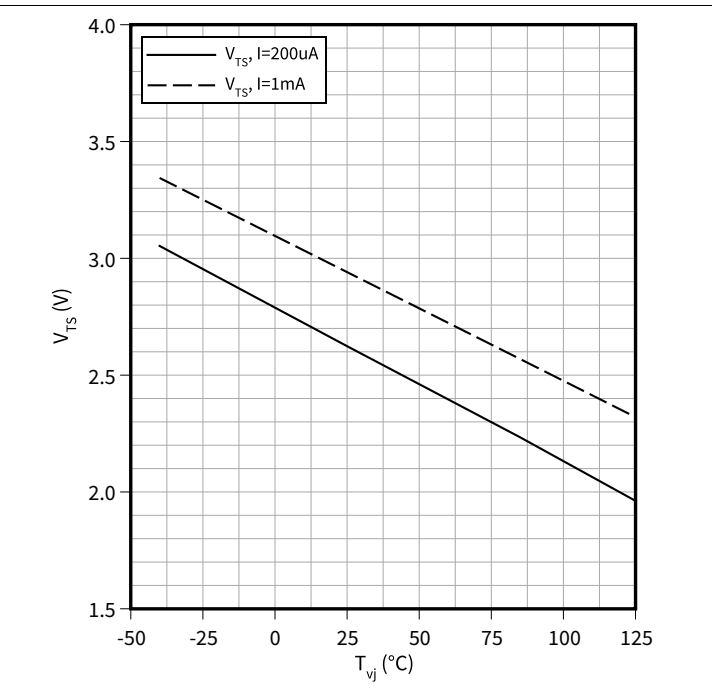
Switching losses body diode (typical), MOSFET

$E_{rec} = f(R_G)$
 $V_r = 750\text{ V}, I_{F,S} = 500\text{ A}$



Temperature characteristic (typical), Temperature sensor

$V_{TS} = f(T_{vj})$
 $I_{TS} = 0.2\text{ mA}$



6 Circuit diagram

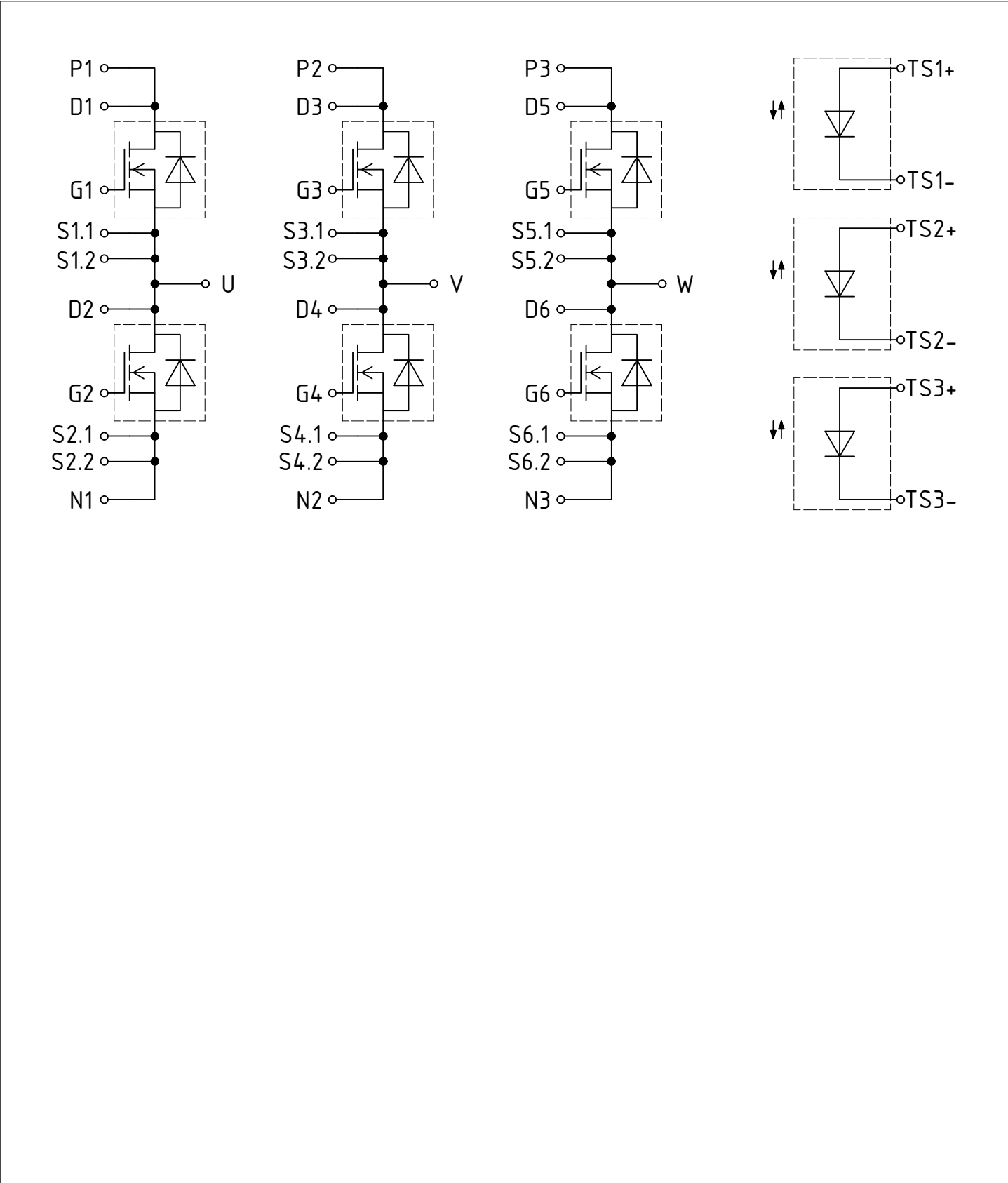


Figure 1

7 Package outlines

Figure 2

7 Package outlines

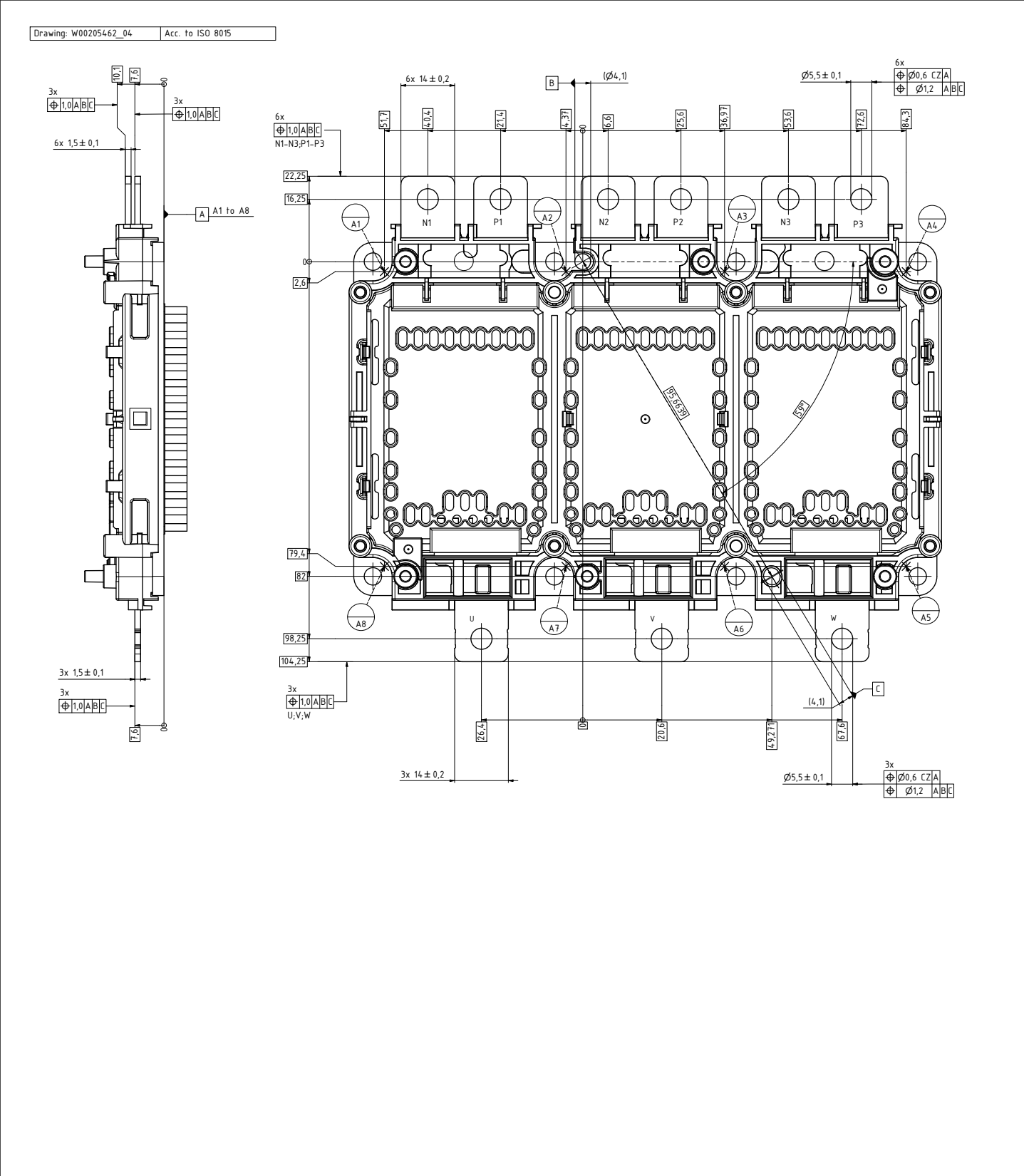


Figure 3

7 Package outlines

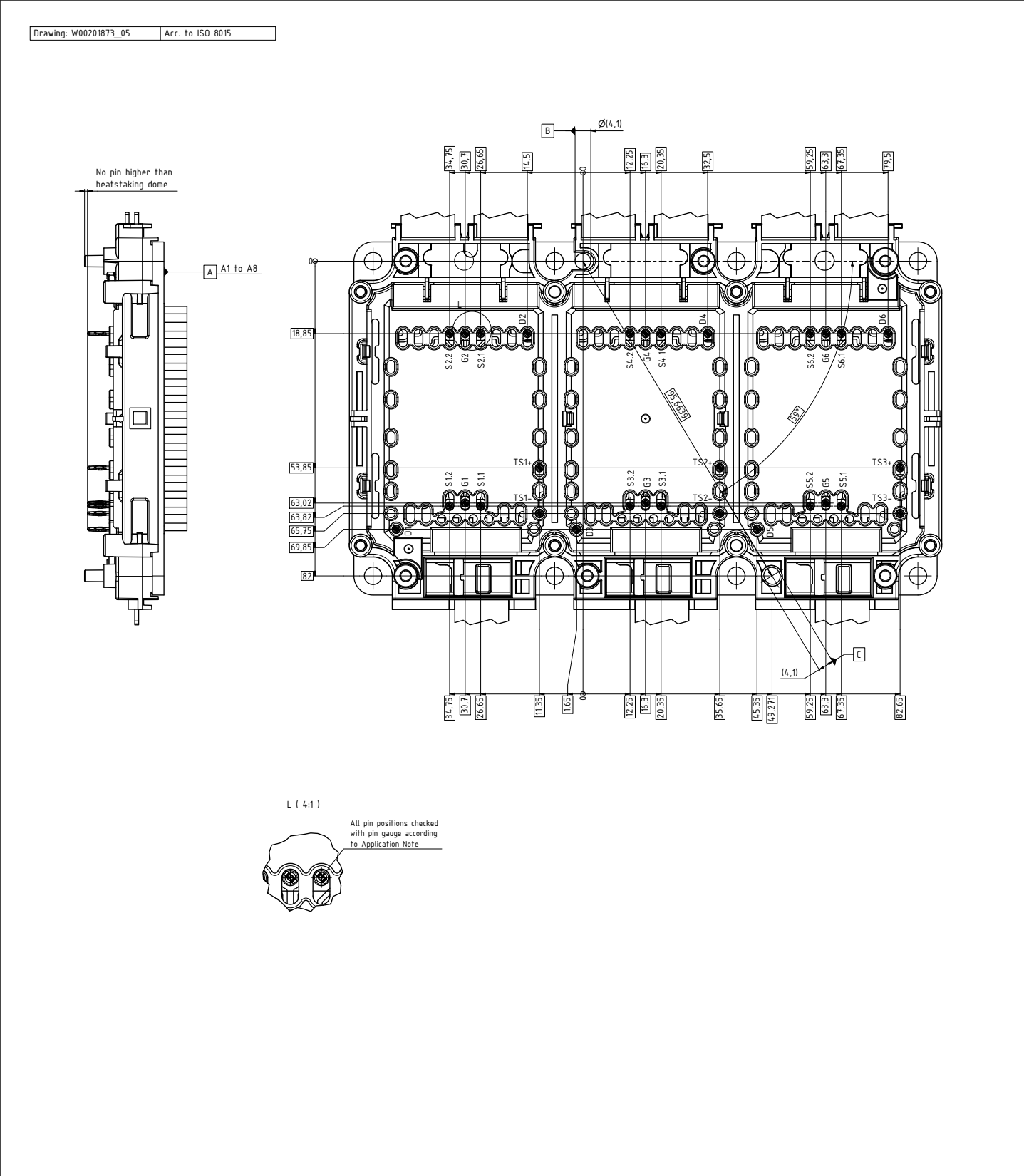


Figure 4

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

Revision history

Document revision	Date of release	Description of changes
0.10	2021-04-22	Target datasheet
0.11	2024-02-13	Target datasheet
0.20	2024-04-12	Preliminary datasheet
1.00	2024-11-20	Final datasheet

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