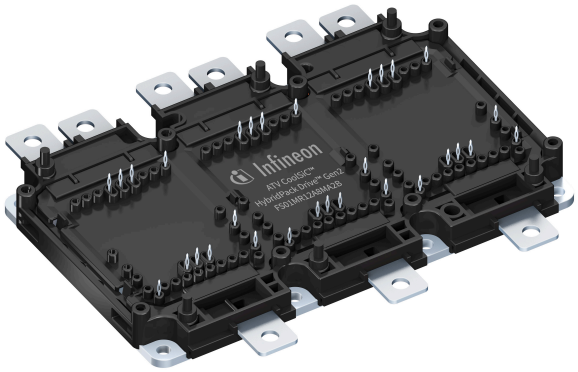
Final datasheet
HybridPACK™ Drive G2 module with SiC MOSFET

Features



- Electrical features
  - V_{DSS} = 1200 V
  - I_{DN} = 500 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°C
  - Short-time extended operation temperature $T_{vj,op}$ = 200 °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

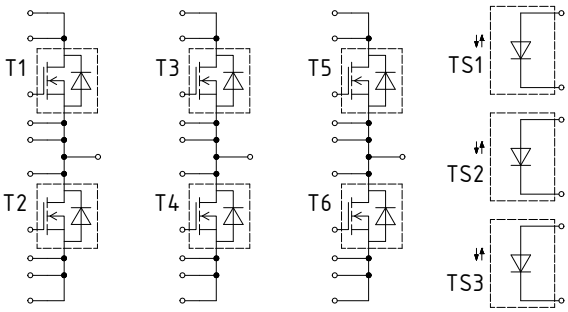
Potential applications

- 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}	$t_{staking}$ < 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 = 60 °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	$L_{s,DS}$			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

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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_{DSS}		continuous operation	1200	V
			10h over lifetime	1400	
DC drain current	$I_{D,nom}$	V_{GS} = 18 V, T_f = 65 °C	$T_{vj,max}$ = 175 °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 A, V_{GS} = 18 V	T_{vj} = 25 °C		1.28	1.87	mΩ
			T_{vj} = 125 °C		2.22		
			T_{vj} = 175 °C		2.95		
			T_{vj} = 200 °C		3.41		
Drain-source on-resistance	$R_{DS,on}$	I_D = 500 A, V_{GS} = 15 V	T_{vj} = 25 °C		1.47	2.13	mΩ
			T_{vj} = 125 °C		2.36		
			T_{vj} = 175 °C		3.08		
			T_{vj} = 200 °C		3.53		
Gate threshold voltage	$V_{GS,th}$	I_D = 240 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			1.75		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		0.44		Ω
Input capacitance	C_{iss}	f = 1 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		51.7		nF

(table continues...)

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Table 6 (continued) Characteristic values

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

(table continues...)

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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 A, $R_{G,off}$ = 2.8 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V, L_σ = 6.5 nH	T_{vj} = 25 °C, dv/dt = 12.6 kV/µs		18.56		mJ
			T_{vj} = 125 °C, dv/dt = 12.1 kV/µs		19.42		
			T_{vj} = 175 °C, dv/dt = 11.9 kV/µs		19.81		
			T_{vj} = 200 °C, dv/dt = 11.7 kV/µs		20.10		
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/18 V, $R_{G,on}$ = 9.2 Ω, $R_{G,off}$ = 2.8 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} ≤ 1.2 µs, T_{vj} = 200 °C		7760		A
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/15 V, $R_{G,on}$ = 9.2 Ω, $R_{G,off}$ = 2.8 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} ≤ 2 µs, T_{vj} = 200 °C		6080		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			0.103	0.11[3)]	K/W
Temperature under switching conditions	$T_{vj,op}$		continuous operation	-40		175	°C
			extended operation			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 V, T_f = 65 °C	$T_{vj,max}$ = 175 °C	215	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$		1000	A

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Table 8 Characteristic values

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

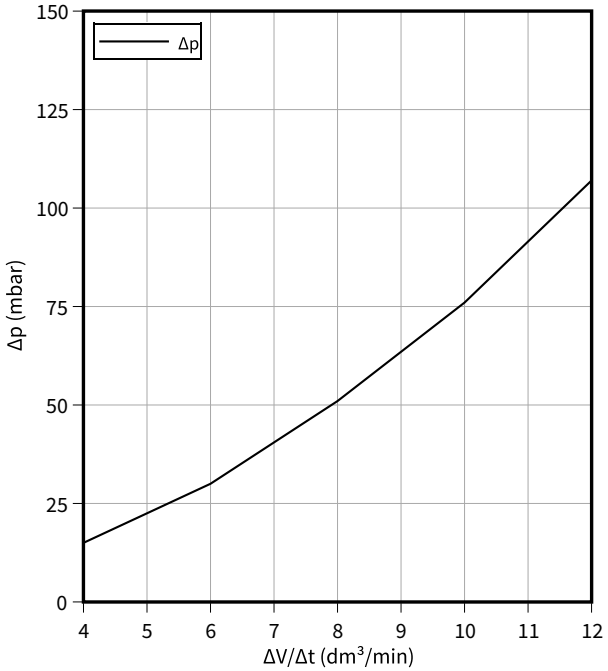
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5 Characteristics diagrams

Pressure drop in cooling circuit (typical), Package

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

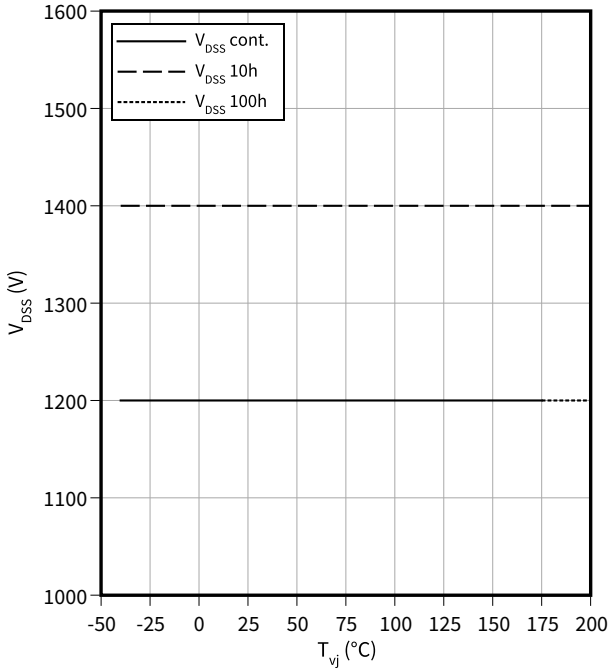
T_f = 60 °C, 50% water / 50% ethylene glycol



Maximum allowed drain-source voltage, MOSFET

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

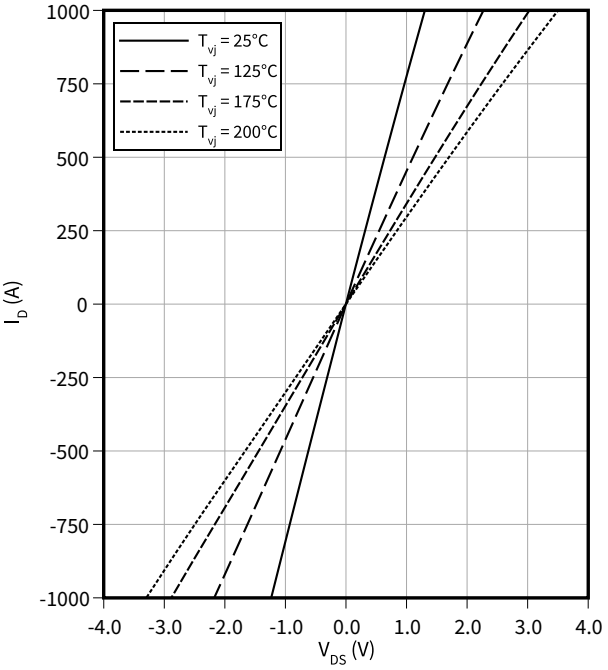
verified by characterization/design, not by test



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

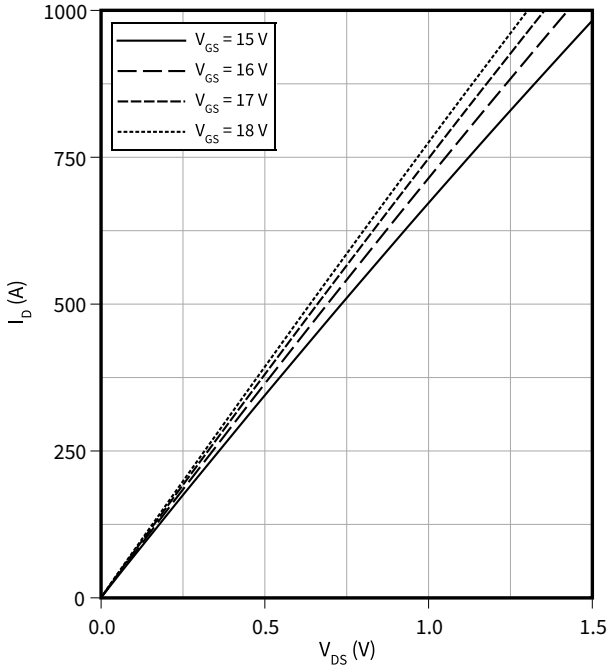
V_{GS} = 18 V



Output characteristic (typical), MOSFET

$I_D = f(V_{DS})$

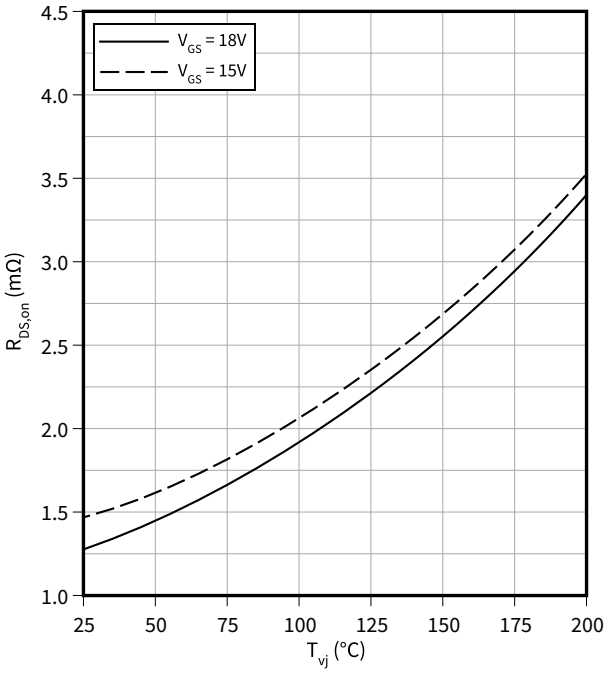
T_{vj} = 25 °C



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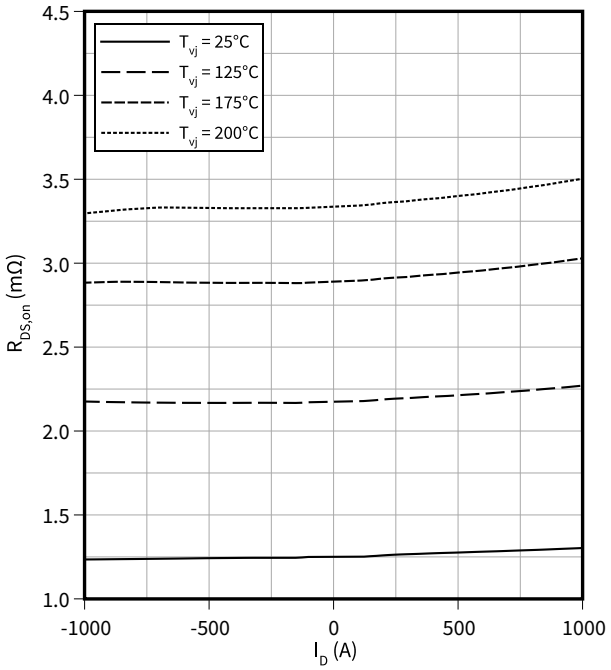
Drain-source on-resistance (typical), MOSFET

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



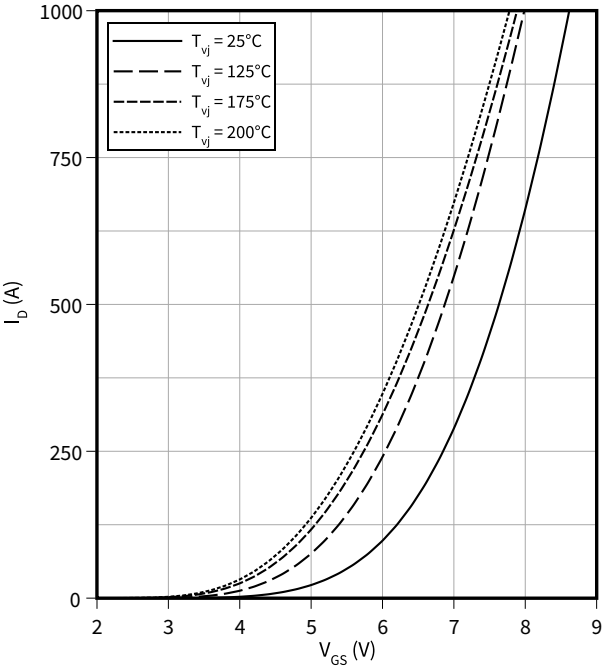
Drain-source on-resistance (typical), MOSFET

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



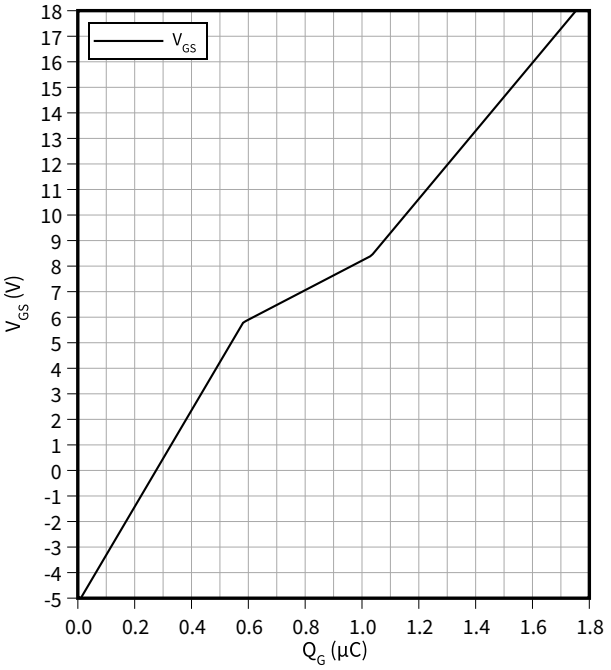
Transfer characteristic (typical), MOSFET

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



Gate charge characteristic (typical), MOSFET

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

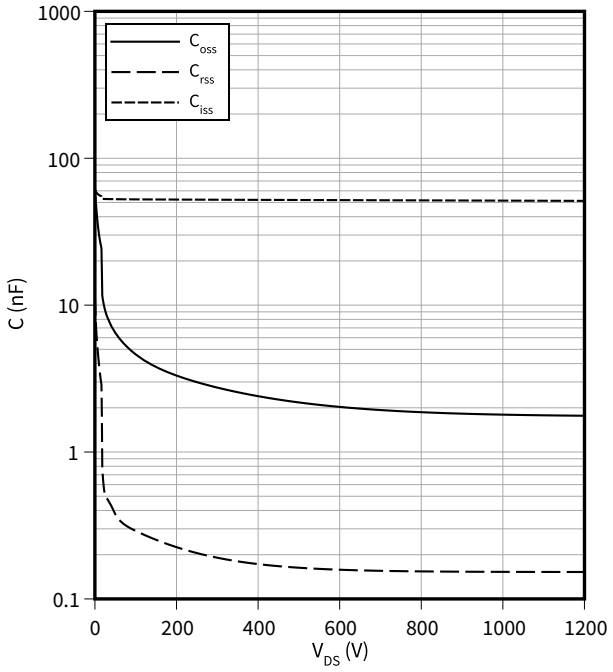


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Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$

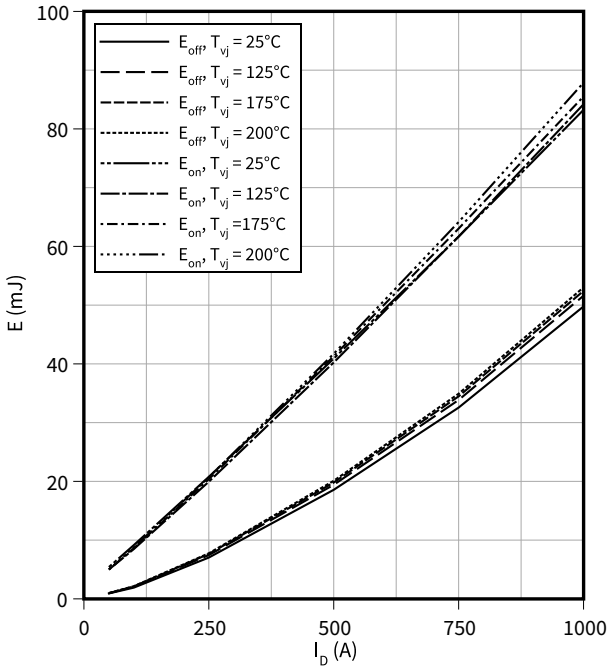
$f = 1$ MHz, $V_{GS} = -5/18$ V, $T_{vj} = 25$ °C



Switching losses (typical), MOSFET

$E = f(I_D)$

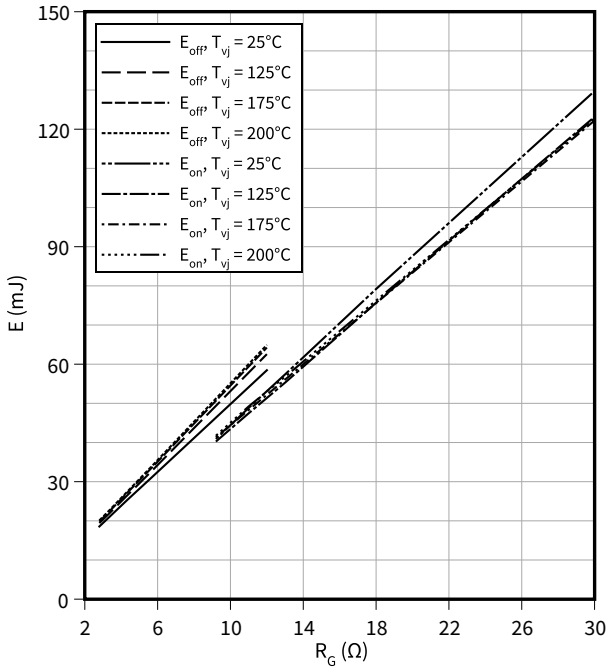
$V_{DS} = 750$ V, $R_{G,off} = 2.8\ \Omega$, $R_{G,on} = 9.2\ \Omega$, $V_{GS} = -5/18$ V



Switching losses (typical), MOSFET

$E = f(R_G)$

$V_{DS} = 750$ V, $I_D = 500$ A, $V_{GS} = -5/18$ V

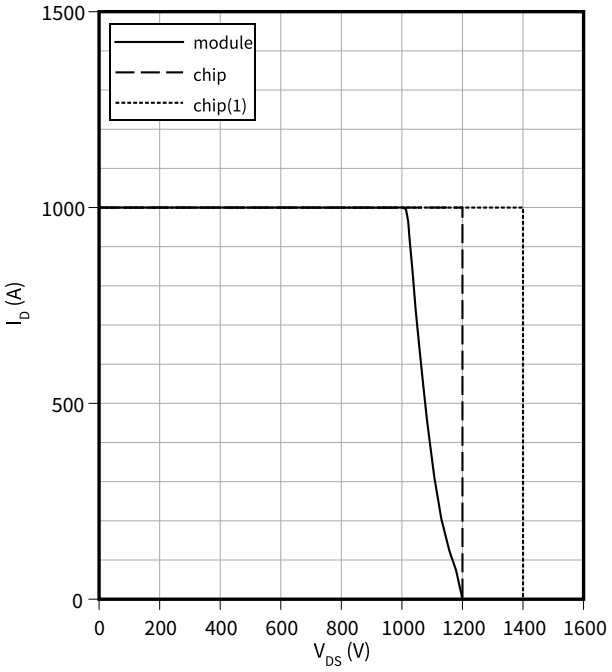


Reverse bias safe operating area (RBSOA), MOSFET

$I_D = f(V_{DS})$

$R_{G,off} = 2.8\ \Omega$, $V_{GS} = +18/-5$ V, $T_{vj} = 175$ °C

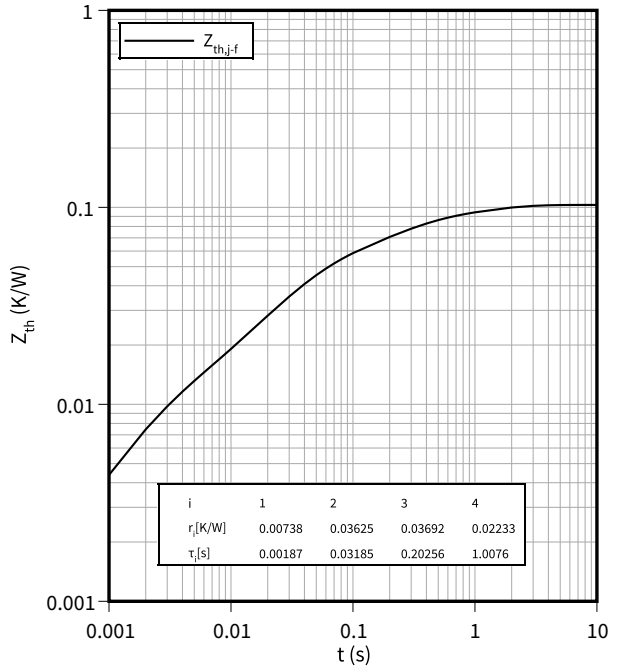
(1) for 10h over lifetime



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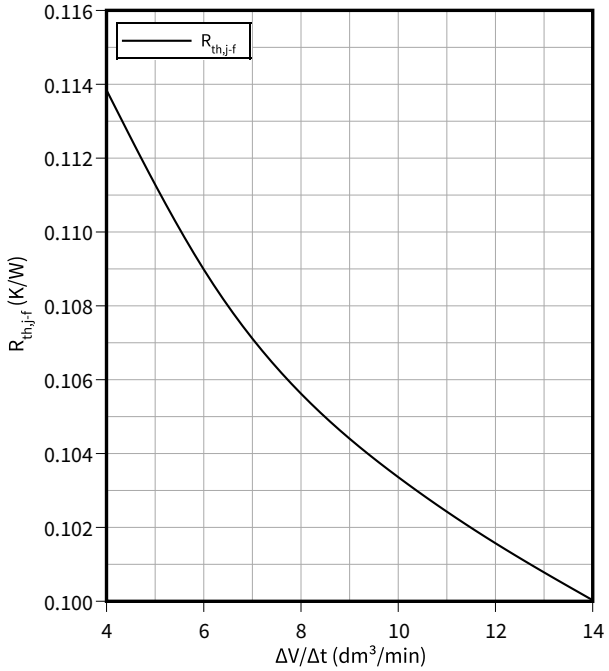
Transient thermal impedance (typical), MOSFET

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



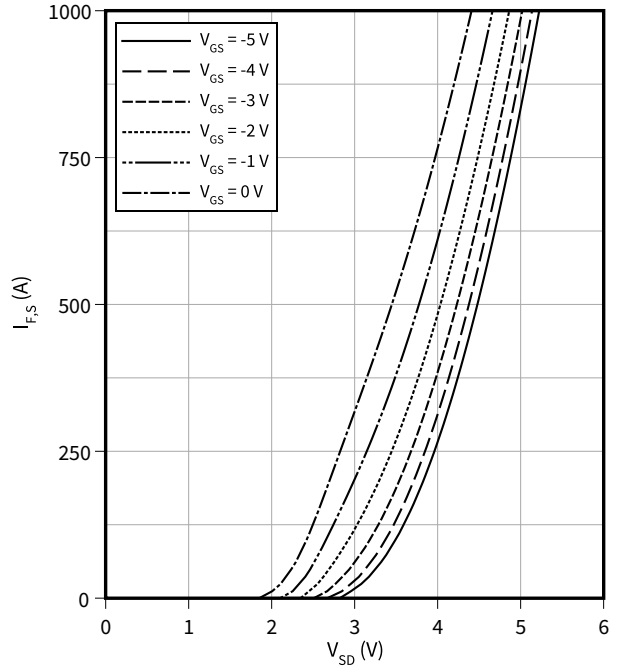
Thermal impedance (typical), MOSFET

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



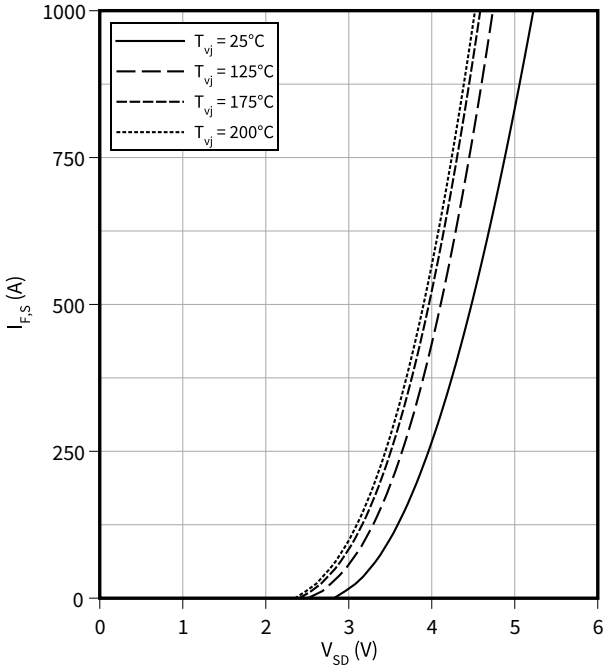
Forward characteristic body diode (typical), MOSFET

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



Forward characteristic body diode (typical), MOSFET

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

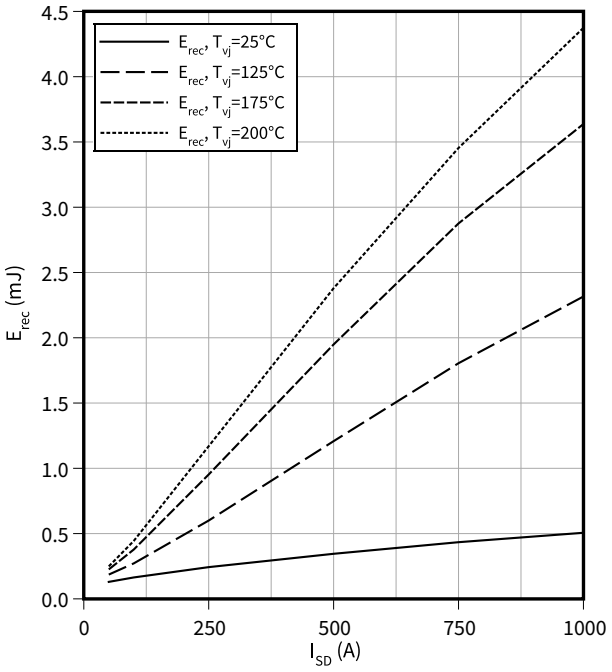


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Switching losses body diode (typical), MOSFET

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

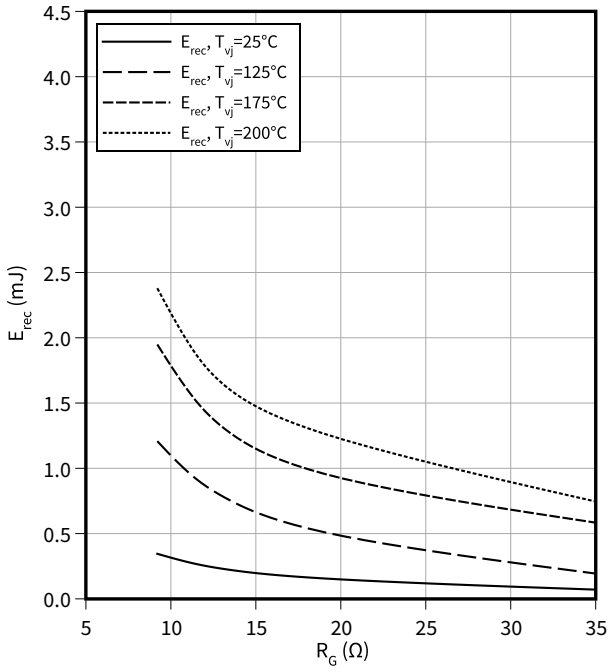
$V_r = 750\ V$, $R_{G,on} = 9.2\ \Omega$



Switching losses body diode (typical), MOSFET

$E_{rec} = f(R_G)$

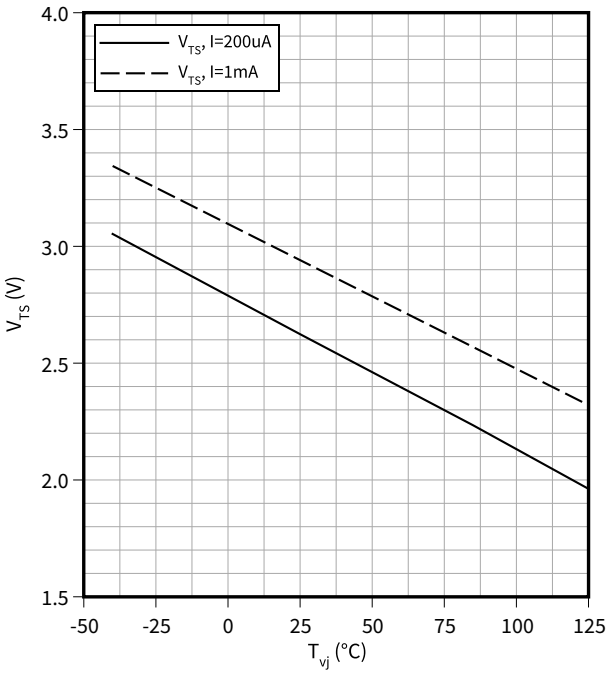
$V_r = 750\ V$, $I_{F,S} = 500\ A$



Temperature characteristic (typical), Temperature sensor

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

$I_{TS} = 0.2\ mA$



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6 Circuit diagram

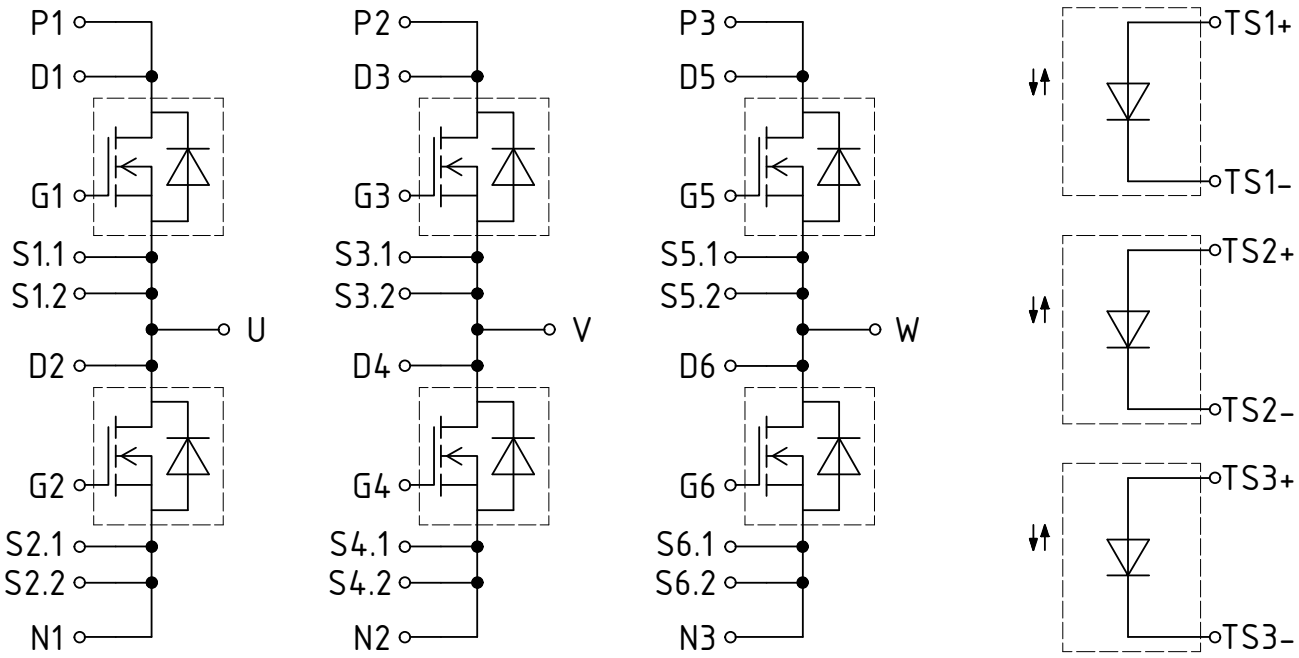


Figure 1

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7 Package outlines

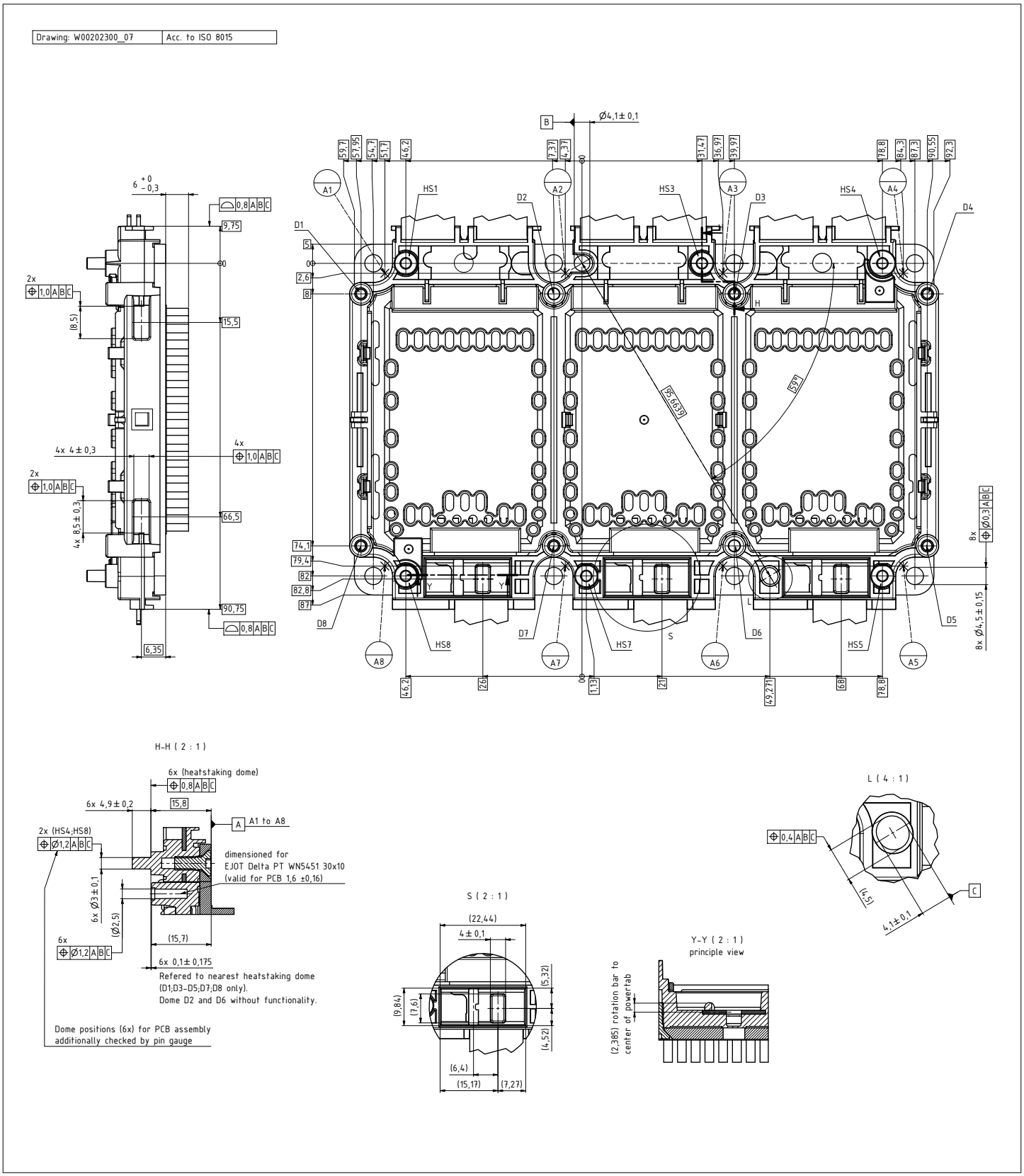


Figure 2

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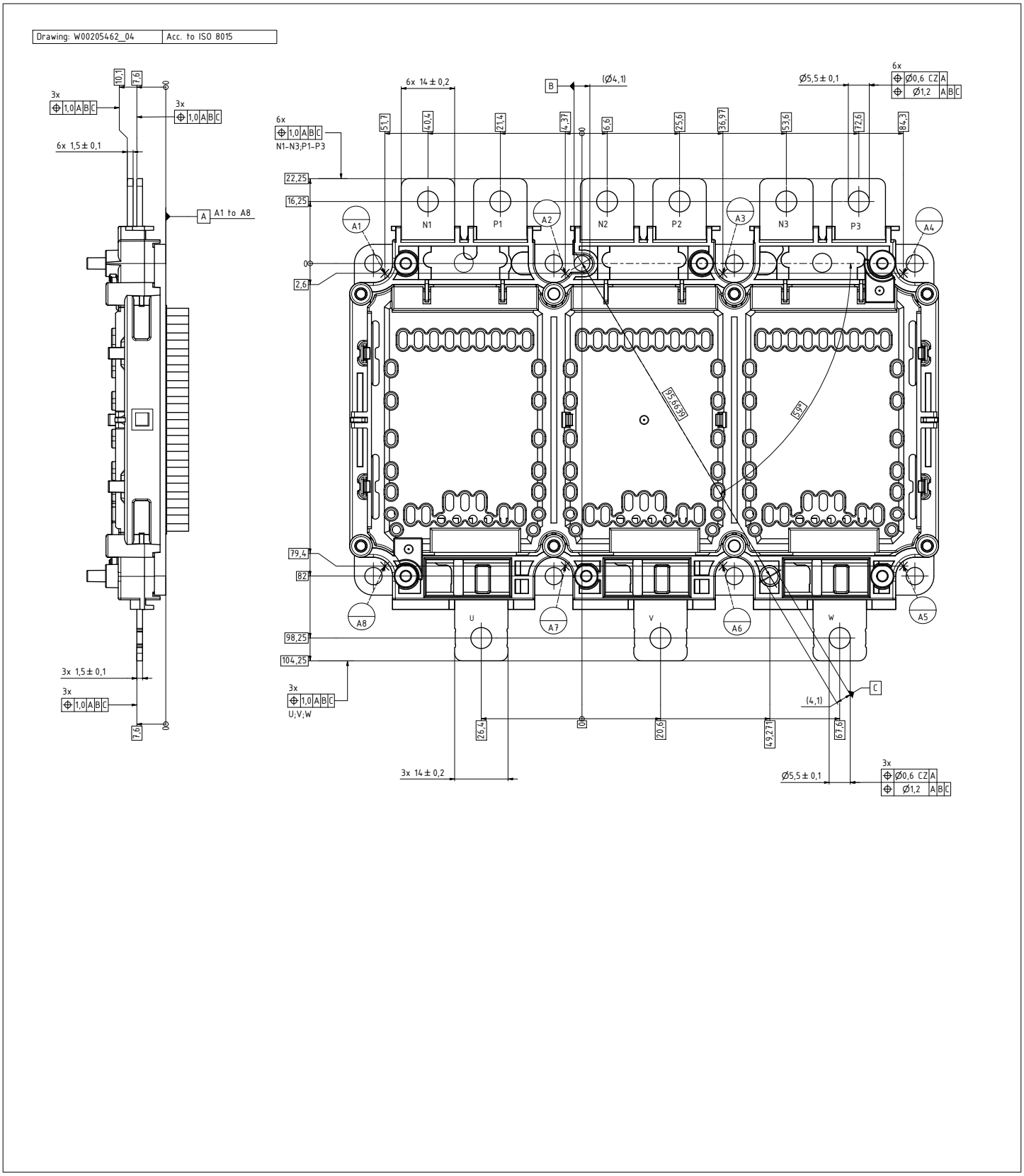


Figure 3

Downloaded from Arrow.com.

7 Package outlines

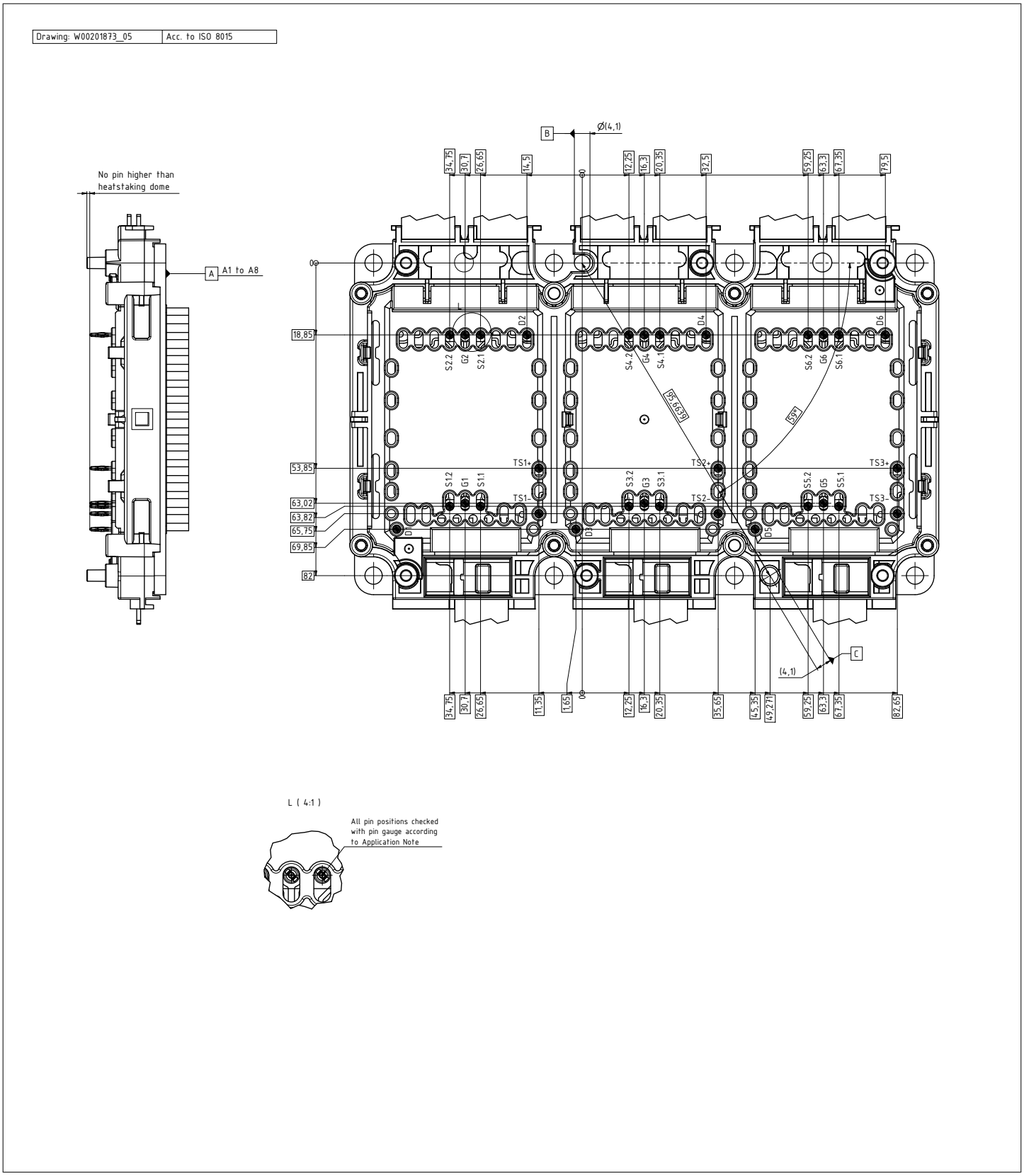


Figure 4

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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* 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* Module serial number Module material number Production order number Date code (production year) Date code (production week)	*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			

Figure 5

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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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