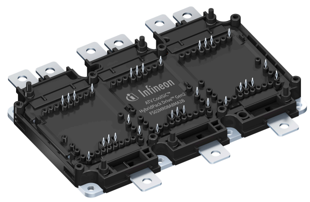
Final datasheet
HybridPACK™ Drive G2 module with SiC MOSFET



Features

- Electrical features
  - V_{DSS} = 1200 V
  - I_{DN} = 390 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

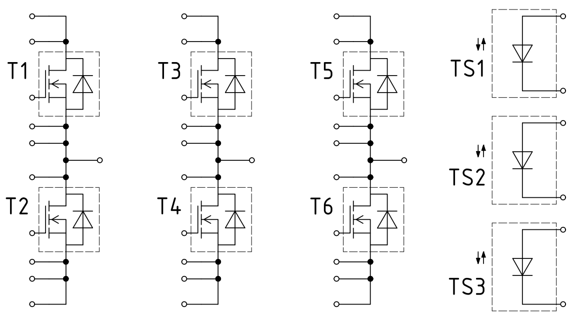
Potential applications

- 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% ethylenglycol, $\Delta V/\Delta t = 10\ dm^3/min$, $T_f = 60\ °C$		76[1]		mbar
Maximum pressure in cooling circuit	p	$T_{baseplate} < 40\ °C$			3.0	bar
		$T_{baseplate} \geq 40\ °C$ (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_{DSS}		continuous operation	1200	V
			10h over life time	1400	
DC drain current	$I_{D,nom}$	V_{GS} = 18 V, T_f = 65 °C	$T_{vj,max}$ = 175 °C	390	A
Pulsed drain current	$I_{D,pulse}$	verified by design, t_p limited by $T_{vj,max}$		780	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...0	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 = 390 A, V_{GS} = 18 V	T_{vj} = 25 °C		1.90		mΩ
			T_{vj} = 125 °C		3.20		
			T_{vj} = 175 °C		4.20		
			T_{vj} = 200 °C		4.80		
Drain-source on-resistance	$R_{DS,on}$	I_D = 390 A, V_{GS} = 15 V	T_{vj} = 25 °C		2.40		mΩ
			T_{vj} = 125 °C		3.70		
			T_{vj} = 175 °C		4.80		
			T_{vj} = 200 °C		5.50		
Gate threshold voltage	$V_{GS,th}$	I_D = 160 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			1.19		µC
Internal gate resistor	$R_{G,int}$		T_{vj} = 25 °C		0.66		Ω
Input capacitance	C_{iss}	f = 1 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		34.5		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 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		1.26		nF
Reverse transfer capacitance	C_{rss}	f = 1 MHz, V_{DS} = 750 V	T_{vj} = 25 °C		0.1		nF
C_{OSS} stored energy	E_{oss}	V_{DS} = 750 V	T_{vj} = 25 °C		1336		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 = 390 A, $R_{G,on}$ = 12 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		115		ns
			T_{vj} = 125 °C		92		
			T_{vj} = 175 °C		81		
			T_{vj} = 200 °C		76		
Rise time (inductive load)	t_r	I_D = 390 A, $R_{G,on}$ = 12 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		88		ns
			T_{vj} = 125 °C		82		
			T_{vj} = 175 °C		81		
			T_{vj} = 200 °C		80		
Turn-off delay time, inductive load	$t_{d,off}$	I_D = 390 A, $R_{G,off}$ = 3.3 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		212		ns
			T_{vj} = 125 °C		225		
			T_{vj} = 175 °C		236		
			T_{vj} = 200 °C		239		
Fall time (inductive load)	t_f	I_D = 390 A, $R_{G,off}$ = 3.3 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V	T_{vj} = 25 °C		41		ns
			T_{vj} = 125 °C		42		
			T_{vj} = 175 °C		43		
			T_{vj} = 200 °C		43		
Turn-on energy loss per pulse	E_{on}	I_D = 390 A, $R_{G,on}$ = 12 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V, L_σ = 6.5 nH	T_{vj} = 25 °C, di/dt = 3.6 kA/µs		30.60		mJ
			T_{vj} = 125 °C, di/dt = 3.9 kA/µs		30.70		
			T_{vj} = 175 °C, di/dt = 4 kA/µs		31.70		
			T_{vj} = 200 °C, di/dt = 4 kA/µs		32.70		

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values Min.	Values Typ.	Values Max.	Unit
Turn-off energy loss per pulse	E_{off}	I_D = 390 A, $R_{G,off}$ = 3.3 Ω, V_{GS} = -5/18 V, V_{DS} = 750 V, L_σ = 6.5 nH	T_{vj} = 25 °C, dv/dt = 14.6 kV/µs		11.40		mJ
			T_{vj} = 125 °C, dv/dt = 14.2 kV/µs		11.90		
			T_{vj} = 175 °C, dv/dt = 13.9 kV/µs		12.30		
			T_{vj} = 200 °C, dv/dt = 13.7 kV/µs		12.50		
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/18 V, $R_{G,on}$ = 12 Ω, $R_{G,off}$ = 3.3 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} < 1.2 µs, T_{vj} = 200 °C		6560		A
Short circuit data	I_{SC}	V_{DD} = 750 V, V_{GS} = -5/15 V, $R_{G,on}$ = 12 Ω, $R_{G,off}$ = 3.3 Ω, V_{DSmax} = V_{DSS}-L_{sDS}·di/dt	t_{SC} < 2 µs, T_{vj} = 200 °C		4790		A
Thermal resistance, junction to cooling fluid[2)]	$R_{th,j-f}$	per MOSFET, 50% water / 50% ethylenglycol, $\Delta V/\Delta t$ = 10 dm^3/min, T_f = 60 °C			0.115	0.121[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 life time

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 life time	1400	
DC body diode forward current	$I_{F,S}$	$T_{vj,max}$ = 175 °C, V_{GS} = -5 V	T_f = 65 °C	165	A
Pulsed body diode current	$I_{F,S,pulse}$	verified by design, t_p limited by $T_{vj,max}$		780	A

Table 8 **Characteristic values**

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	$V_{F,SD}$	$I_{F,S}$ = 390 A, V_{GS} = -5 V	T_{vj} = 25 °C		4.55	6.40	V
			T_{vj} = 125 °C		4.17		
			T_{vj} = 175 °C		4.04		
			T_{vj} = 200 °C		3.97		
Peak reverse recovery current	I_{rrm}	$I_{F,S}$ = 390 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C		71		A
			T_{vj} = 125 °C		104		
			T_{vj} = 175 °C		132		
			T_{vj} = 200 °C		146		
Recovered charge	Q_{rr}	$I_{F,S}$ = 390 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C		1.21		µC
			T_{vj} = 125 °C		3.27		
			T_{vj} = 175 °C		5.52		
			T_{vj} = 200 °C		6.66		
Reverse recovery energy	E_{rec}	$I_{F,S}$ = 390 A, V_{GS} = -5 V, $V_{R,DS}$ = 750 V	T_{vj} = 25 °C, -*di*/*dt* = 4.6 kA/µs		0.1		mJ
			T_{vj} = 125 °C, -*di*/*dt* = 4.7 kA/µs		0.5		
			T_{vj} = 175 °C, -*di*/*dt* = 4.8 kA/µs		1.0		
			T_{vj} = 200 °C, -*di*/*dt* = 4.9 kA/µs		1.2		

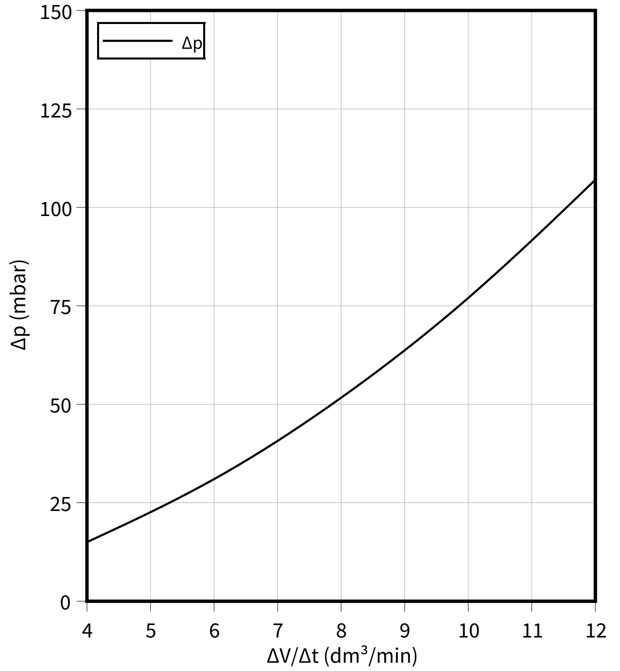
4 Temperature sensor

Table 9 **Characteristic values**

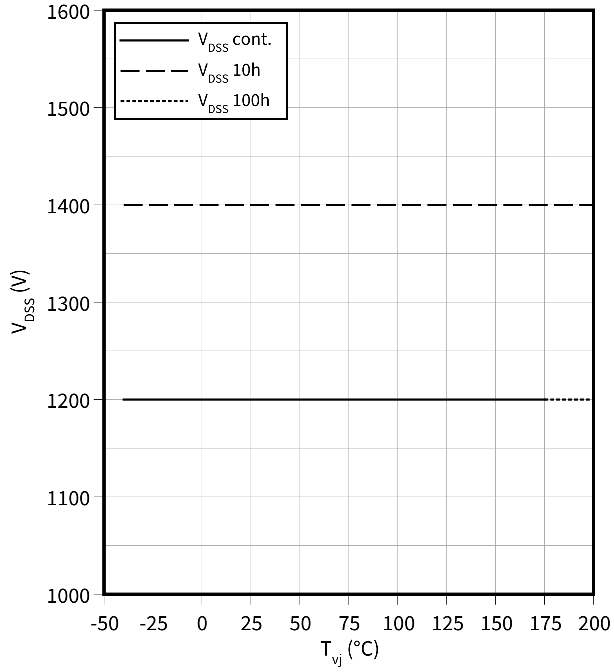
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Transient sense current	I_{TS}					10	mA
Forward voltage	V_{TS}		I_{TS} = 0.2 mA, T_{vj} = 25 °C	2.574	2.624	2.674	V
			I_{TS} = 0.2 mA, T_{vj} = 85 °C	2.169	2.234	2.299	

5 Characteristics diagrams

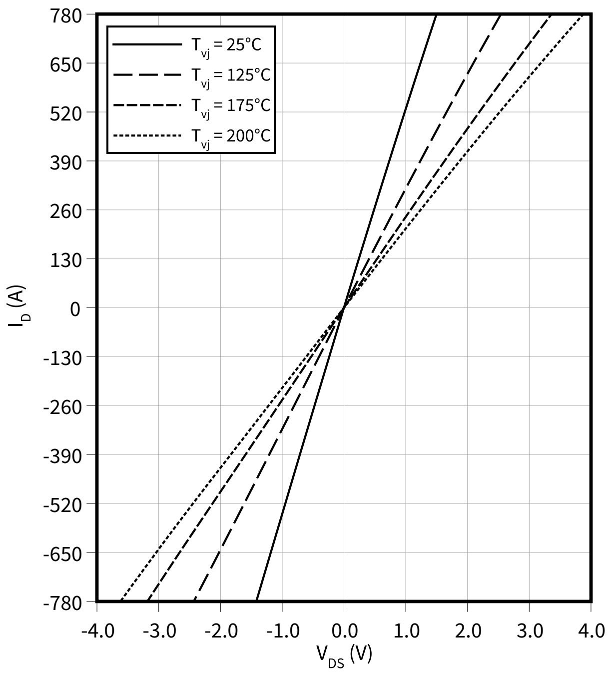
Pressure drop in cooling circuit (typical), Package
$\Delta p = f(\Delta V/\Delta t)$
T_f = 60 °C, fluid = 50% water / 50% ethylenglycol



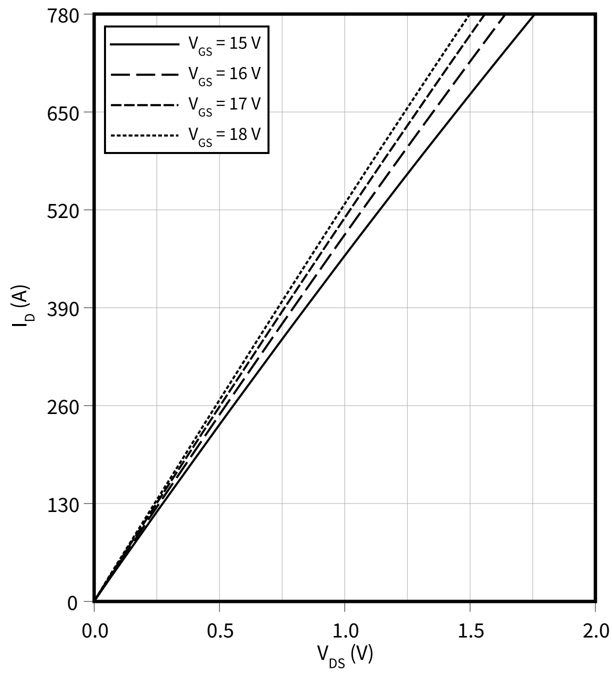
Maximum allowed drain-source voltage, MOSFET
$V_{DSS} = f(T_{vj})$
verified by characterization / design, not by test



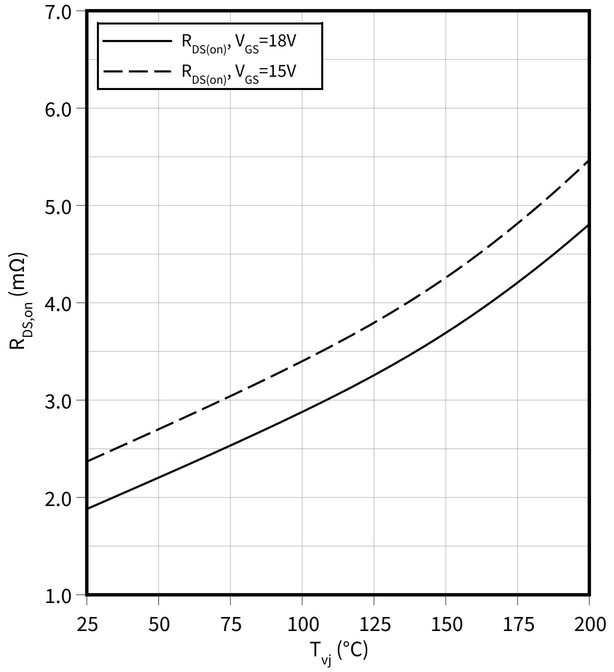
Output characteristic (typical), MOSFET
$I_D = f(V_{DS})$
V_{GS} = 18 V



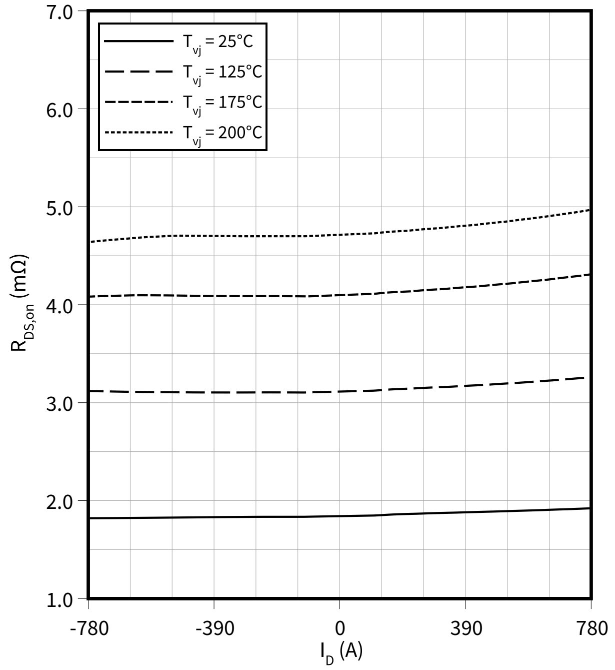
Output characteristic (typical), MOSFET
$I_D = f(V_{DS})$
T_{vj} = 25 °C



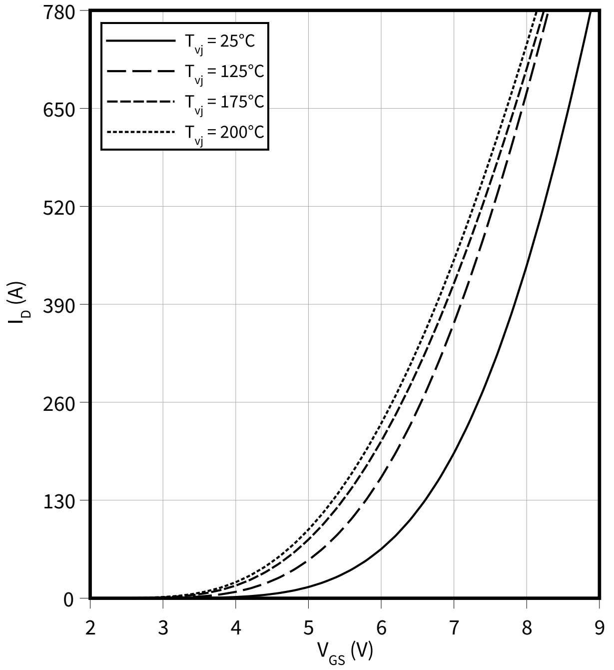
Drain-source on-resistance (typical), MOSFET
$R_{DS,on} = f(T_{vj})$
$I_D = 390$ A, $V_{GS} = 18$ V



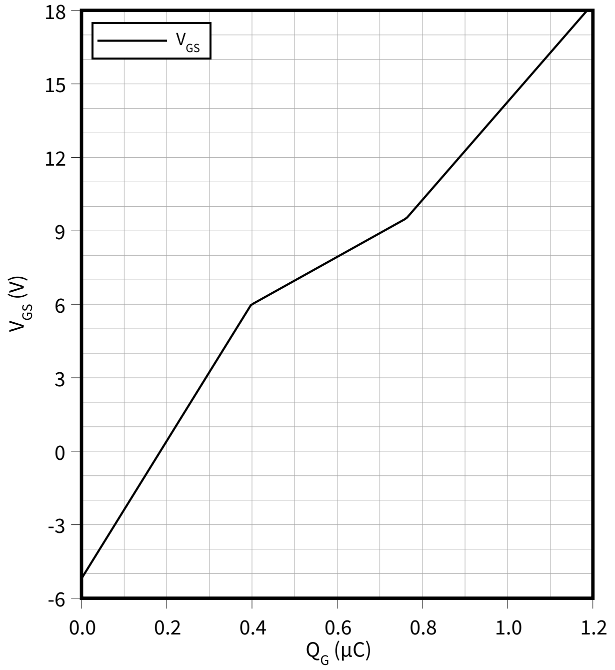
Drain-source on-resistance (typical), MOSFET
$R_{DS,on} = f(I_D)$
$V_{GS} = 18$ V



Transfer characteristic (typical), MOSFET
$I_D = f(V_{GS})$
$V_{DS} = 20$ V



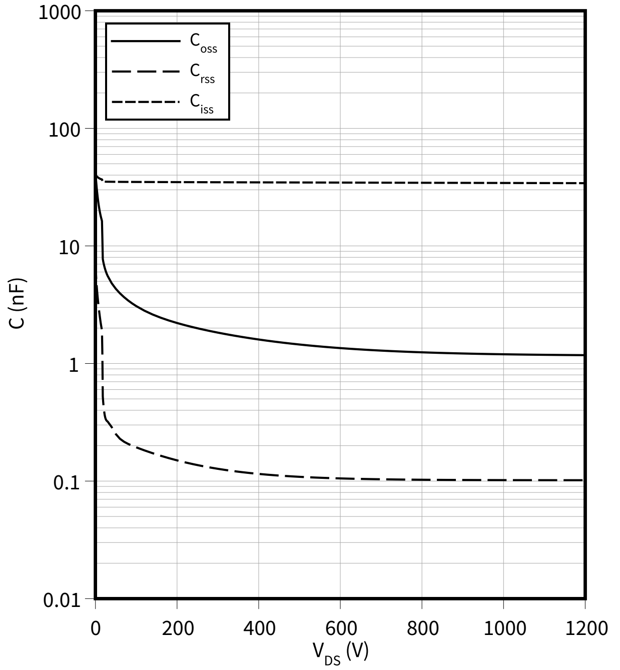
Gate charge characteristic (typical), MOSFET
$V_{GS} = f(Q_G)$
$V_{DD} = 750$ V, $T_{vj} = 25$ °C



Capacity characteristic (typical), MOSFET

$C = f(V_{DS})$

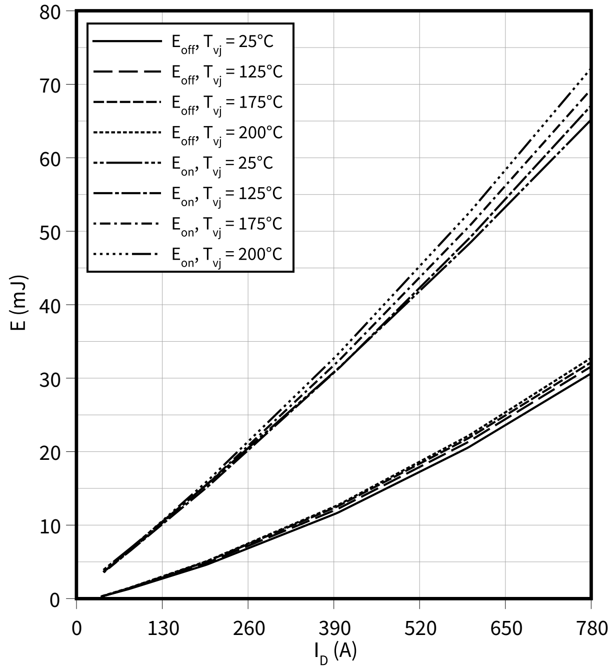
$f = 1$ MHz, $V_{GS} = -5/18$ V, $T_{vj} = 25$ °C



Switching losses (typical), MOSFET

$E = f(I_D)$

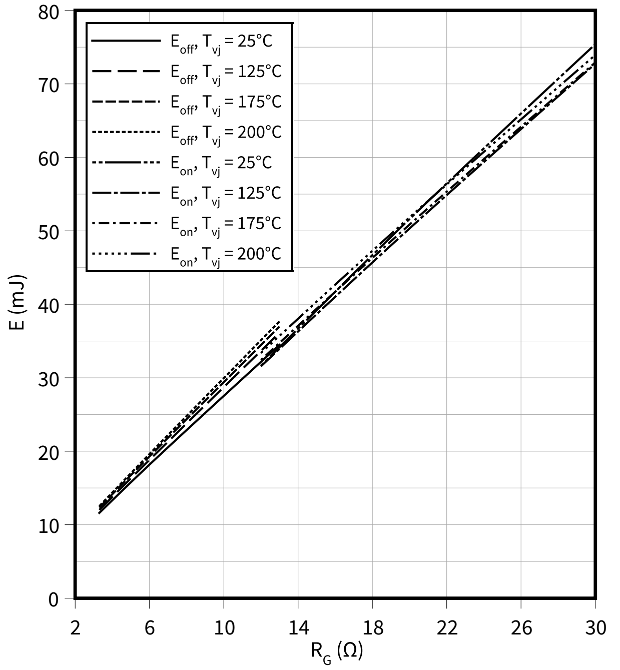
$V_{DS} = 750$ V, $R_{G,off} = 3.3\ \Omega$, $R_{G,on} = 12\ \Omega$, $V_{GS} = -5/18$ V



Switching losses (typical), MOSFET

$E = f(R_G)$

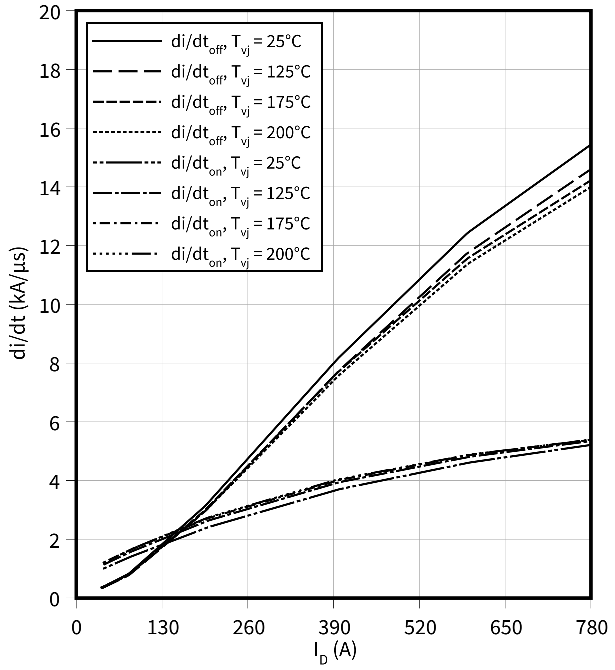
$I_D = 390$ A, $V_{DS} = 750$ V, $V_{GS} = -5/18$ V



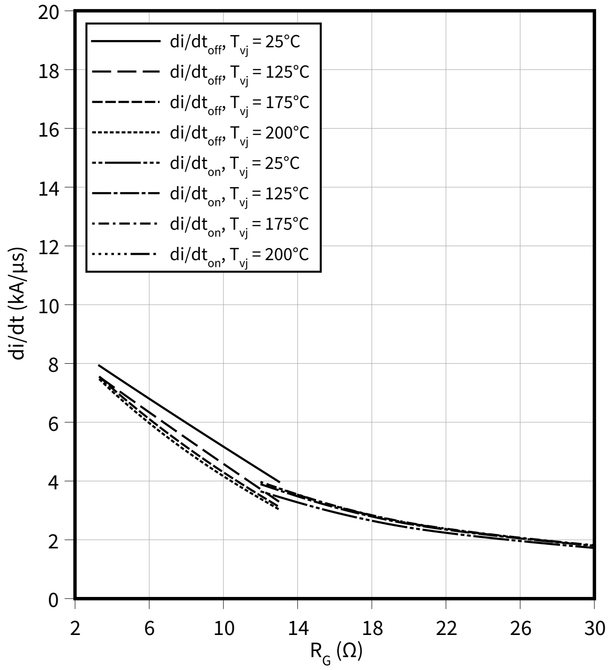
Current slope (typical), MOSFET

$di/dt = f(I_D)$

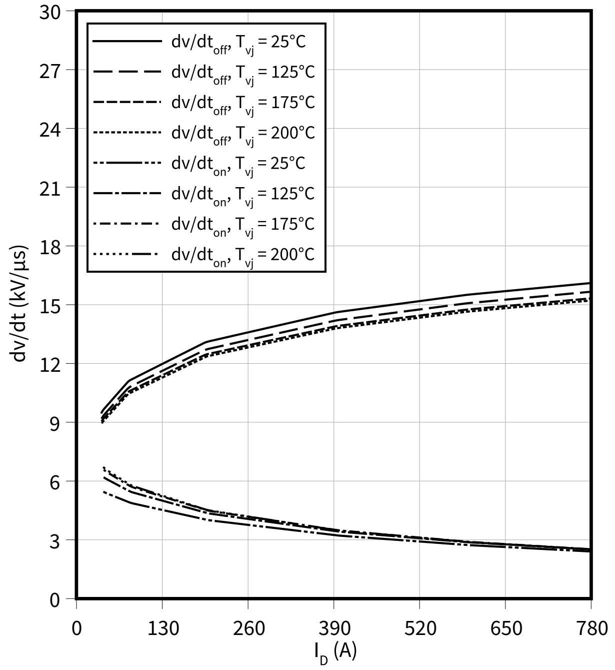
$V_{DS} = 750$ V, $R_{G,off} = 3.3\ \Omega$, $R_{G,on} = 12\ \Omega$, $V_{GS} = -5/18$ V



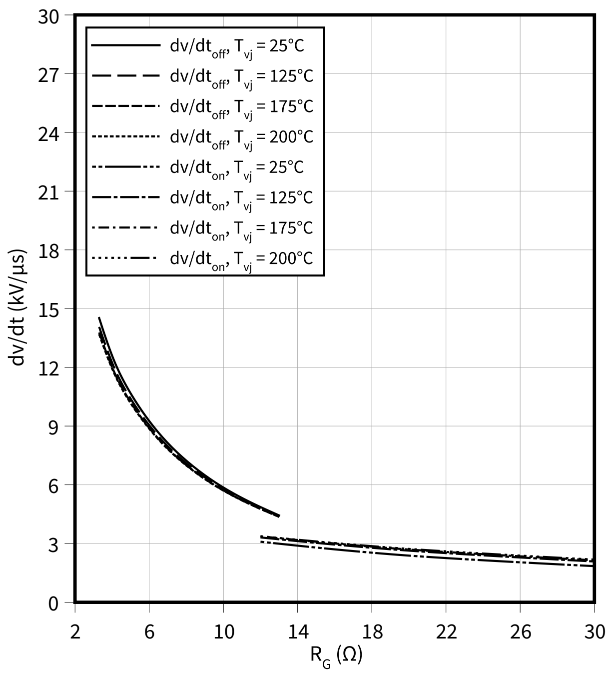
Current slope (typical), MOSFET
di/dt = f(R_G)
V_{DS} = 750 V, I_D = 390 A, V_{GS} = -5/18 V



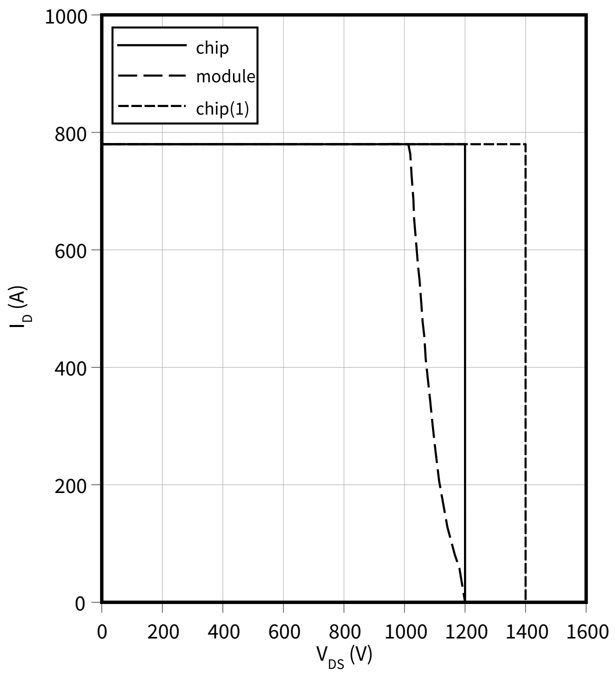
Voltage slope (typical), MOSFET
dv/dt = f(I_D)
V_{DS} = 750 V, $R_{G,off}$ = 3.3 Ω, $R_{G,on}$ = 12 Ω, V_{GS} = -5/18 V



Voltage slope (typical), MOSFET
dv/dt = f(R_G)
V_{DS} = 750 V, I_D = 390 A, V_{GS} = -5/18 V



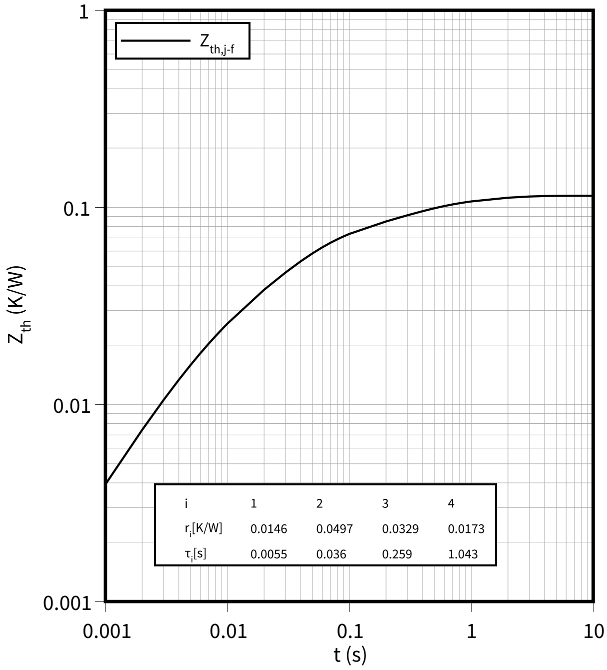
Reverse bias safe operating area (RBSOA), MOSFET
I_D = f(V_{DS})
$R_{G,off}$ = 3.3 Ω, V_{GS} = +18/-5 V, T_{vj} = 175 °C
(1) for 10h over lifetime



Transient thermal impedance (typical), MOSFET

$Z_{th} = f(t)$

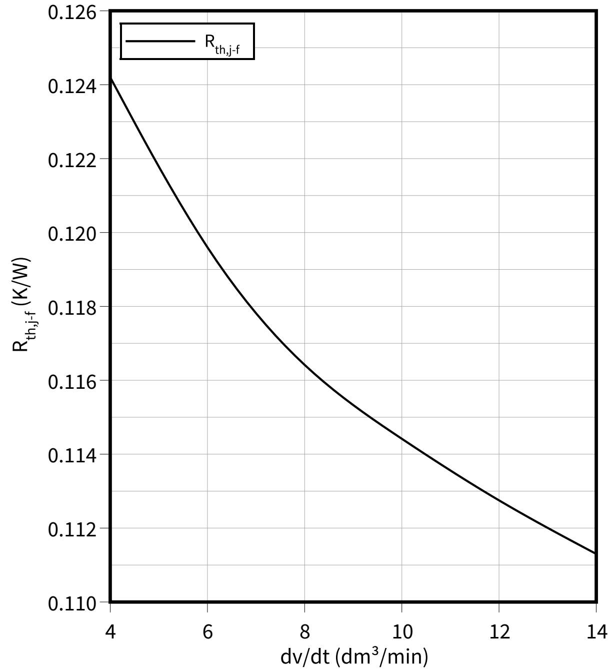
$\Delta V/\Delta t = 10\ dm^3/min$, $T_f = 60\ °C$, fluid = 50% water / 50% ethylenglycol



Thermal impedance (typical), MOSFET

$R_{th,j-f} = f(dv/dt)$

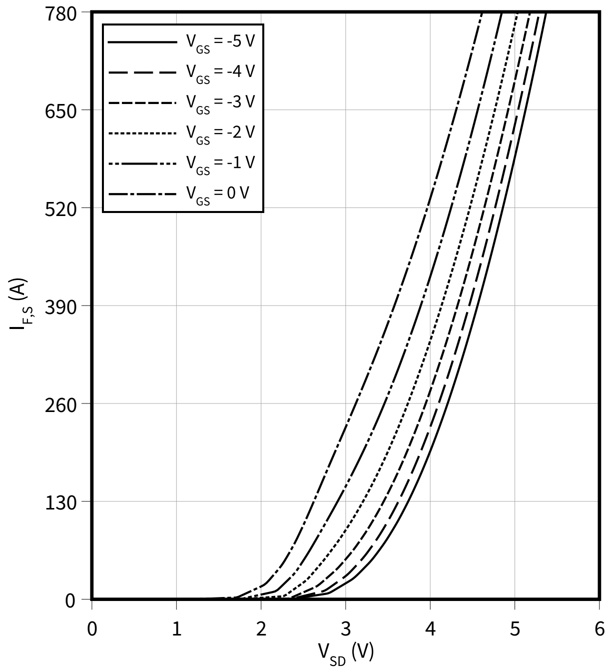
fluid = 50% water / 50% ethylenglycol , $T_f = 60\ °C$

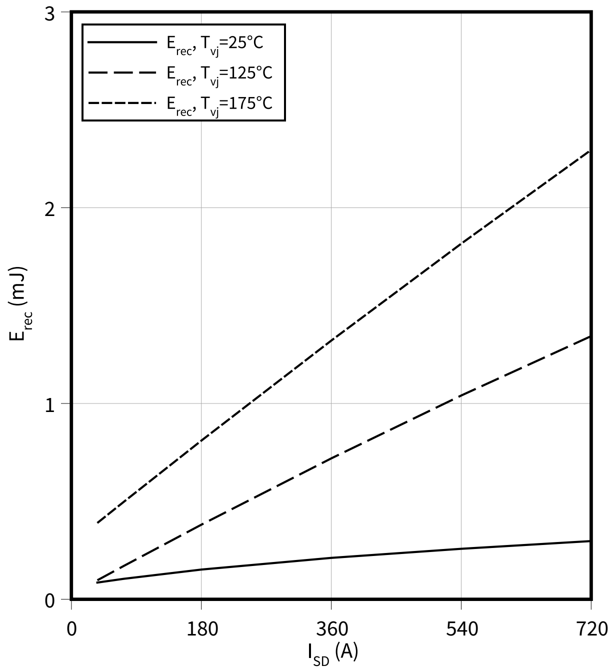


Forward characteristic body diode (typical), MOSFET

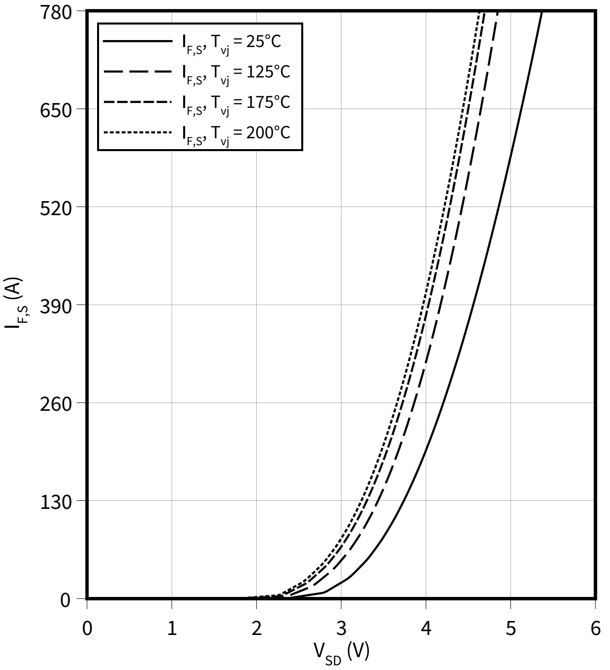
$I_{F,S} = f(V_{SD})$

$T_{vj} = 25\ °C$

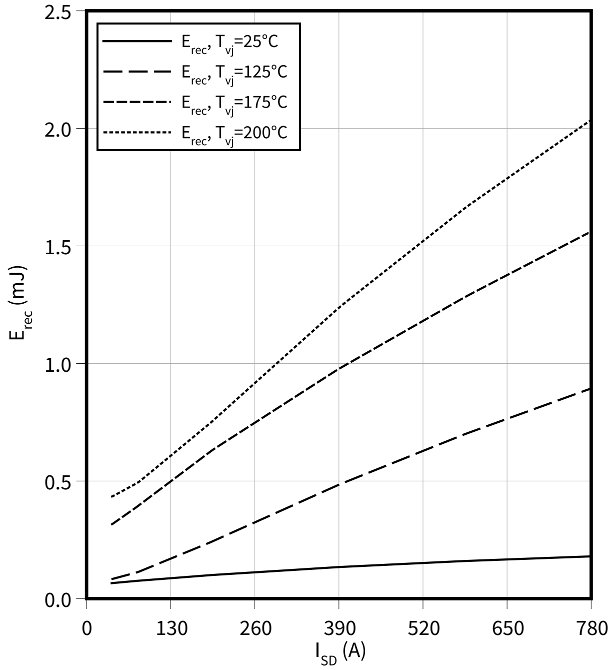




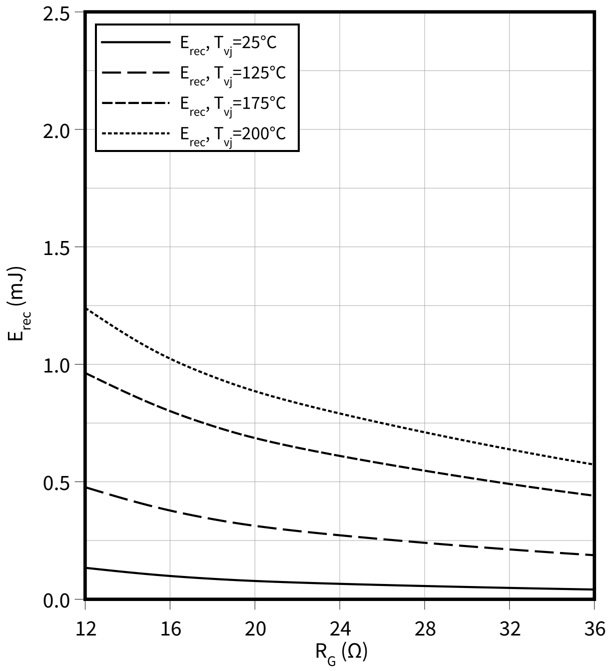
Forward characteristic body diode (typical), MOSFET
$I_{F,S} = f(V_{SD})$
$V_{GS} = -5$ V



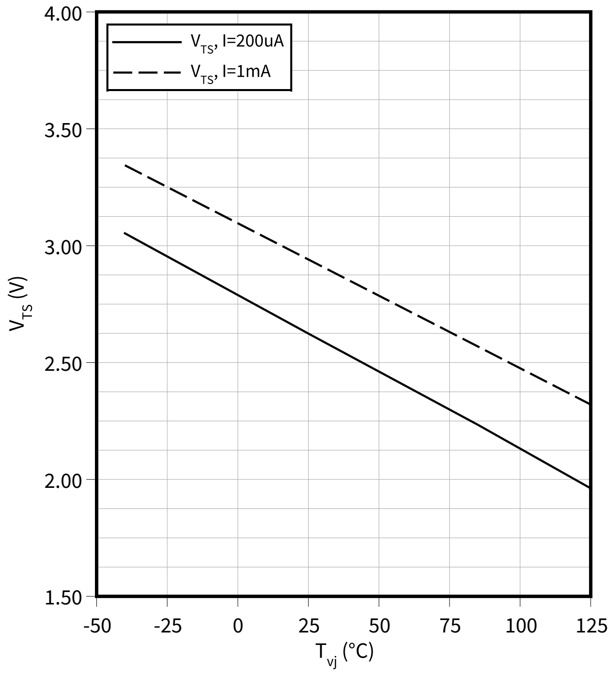
Switching losses body diode (typical), MOSFET
$E_{rec} = f(I_{SD})$
$V_r = 750$ V, $R_{G,on} = 12\ \Omega$



Switching losses body diode (typical), MOSFET
$E_{rec} = f(R_G)$
$V_r = 750$ V, $I_{F,S} = 390$ A



Temperature characteristic (typical), Temperature sensor
$V_{TS} = f(T_{vj})$
$I_{TS} = 0.2$ mA



6 Circuit diagram

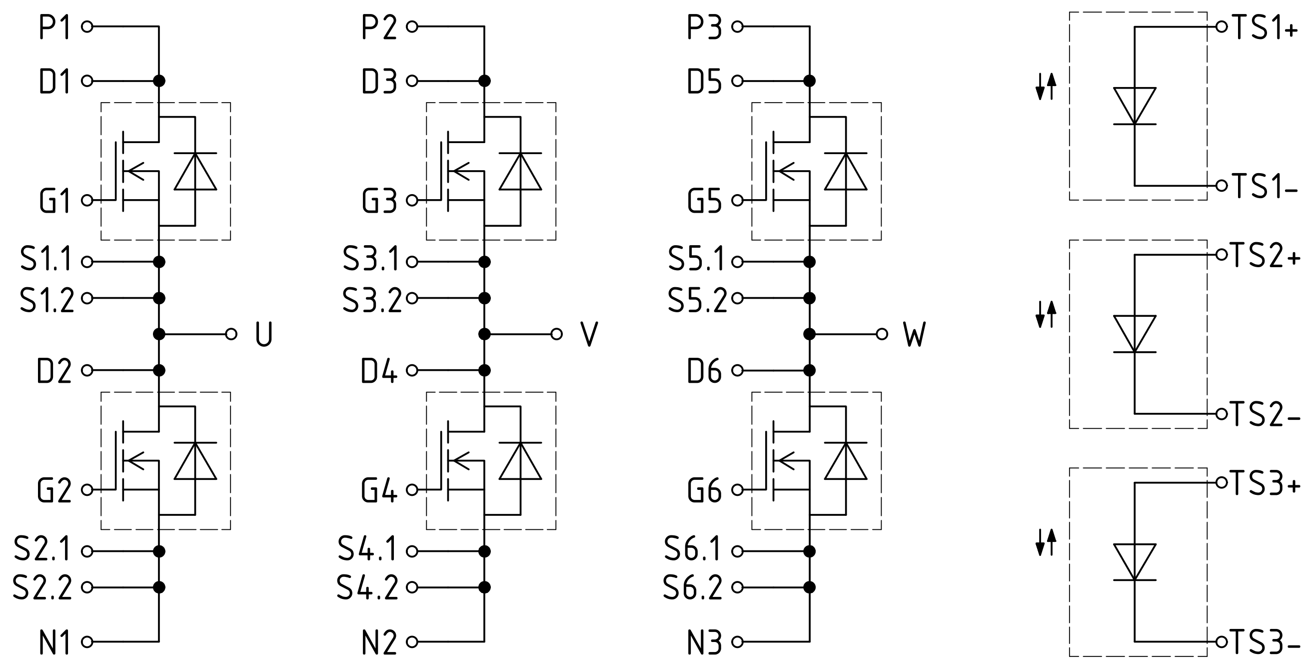


Figure 1

7 Package outlines

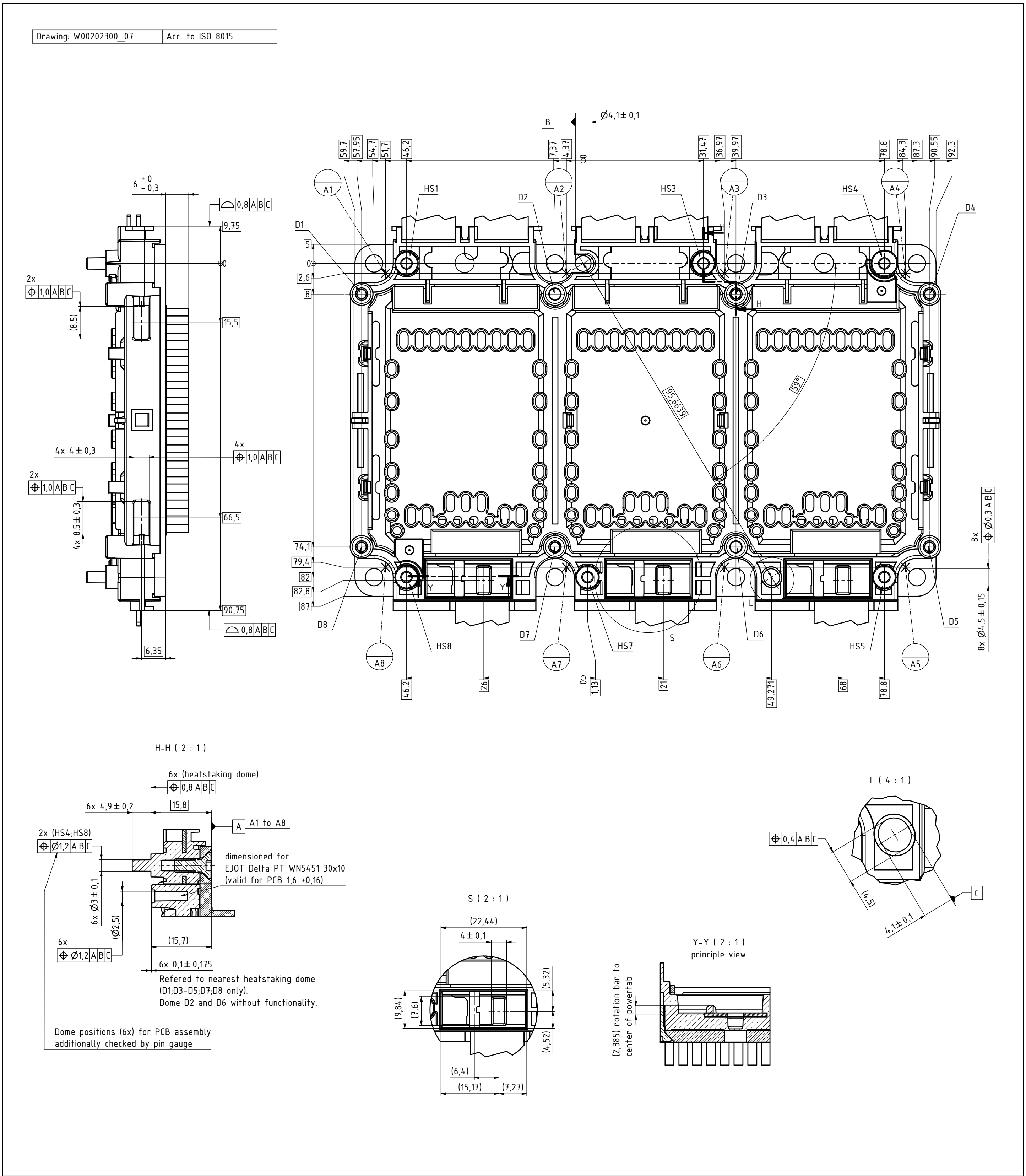


Figure 2

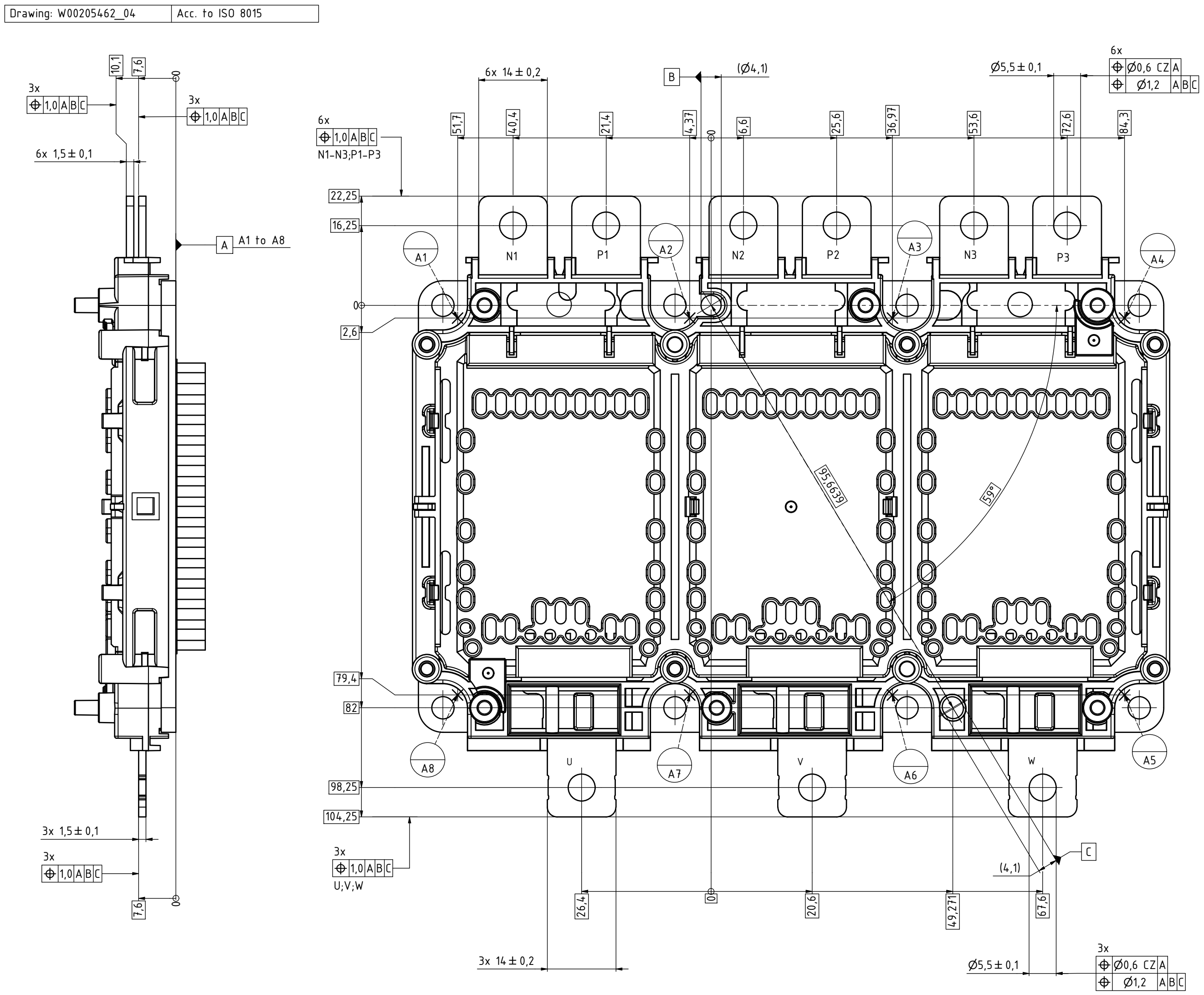
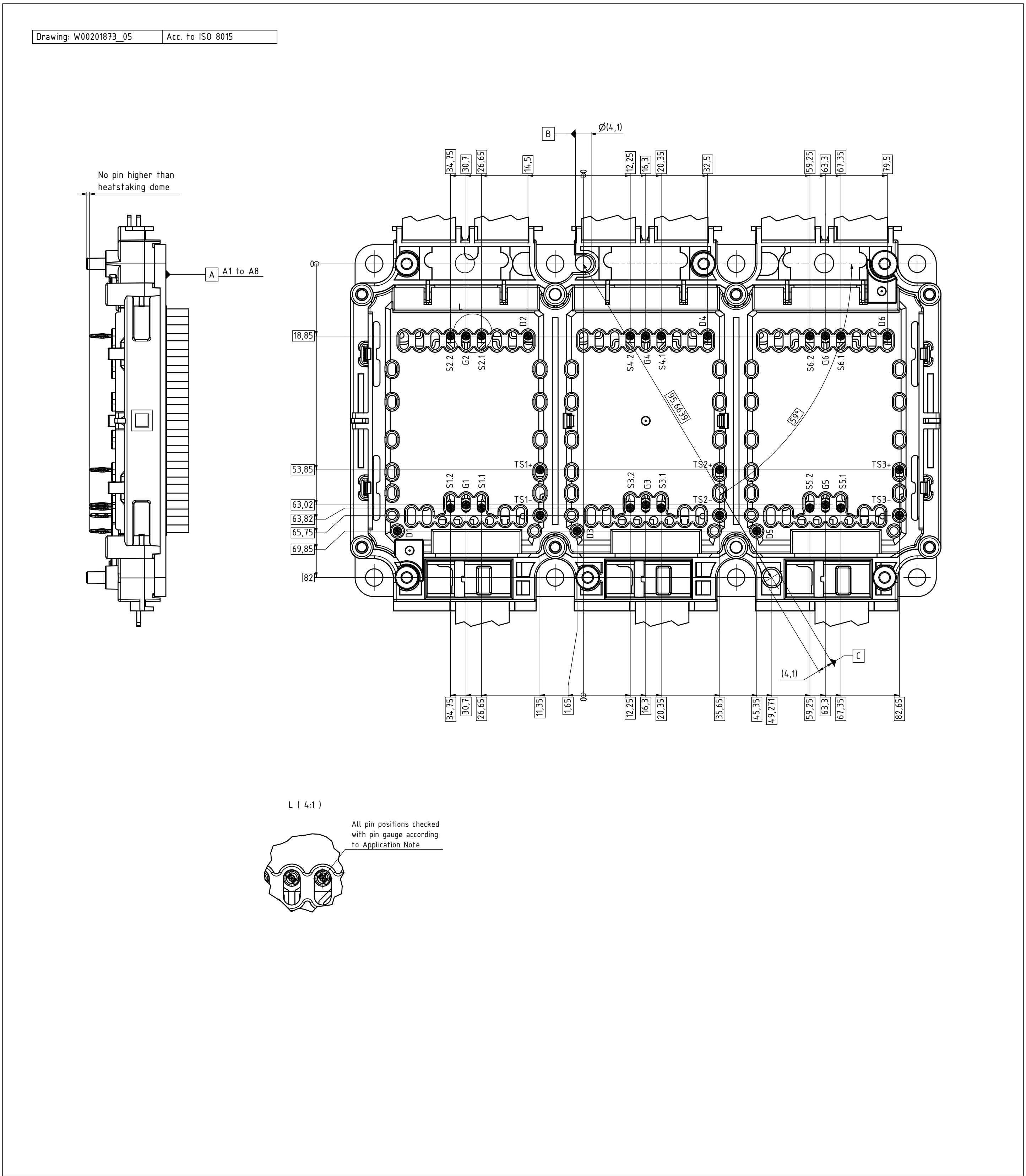

Drawing: W00205462_04
Acc. to ISO 8015
6x 14 ± 0,2
(Ø4,1)
Ø5,5 ± 0,1
6x
Ø0,6 CZ A
Ø1,2 A B C
1,0 A B C
N1-N3;P1-P3
A1 to A8
6x 1,5 ± 0,1
3x 1,5 ± 0,1
3x 14 ± 0,2
U;V;W
(4,1)
95,6639
59°
N1
P1
N2
P2
N3
P3
U
V
W
A1
A2
A3
A4
A5
A6
A7
A8
B
C
A
10,1
7,6
51,7
40,4
21,4
4,37
6,6
25,6
36,97
53,6
72,6
84,3
22,25
16,25
2,6
79,4
82
98,25
104,25
26,4
20,6
49,271
67,6

Figure 3



Drawing: W00201873_05
Acc. to ISO 8015
No pin higher than heatstaking dome
A1 to A8
S2.2 G2 S2.1 D2
S4.2 G4 S4.1 D4
S6.2 G6 S6.1 D6
S1.2 G1 S1.1 D1
S3.2 G3 S3.1 D3
S5.2 G5 S5.1 D5
TS1+ TS1-
TS2+ TS2-
TS3+ TS3-
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	2021-09-16	Initial version
0.11	2022-08-25	Target datasheet
0.20	2023-06-20	Preliminary datasheet
1.00	2024-04-19	Final datasheet

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