HybridPACK™ Drive Module

CoolSiC™ Automotive MOSFET

FS05MR12A6MA1B

Qualified for Automotive Applications.

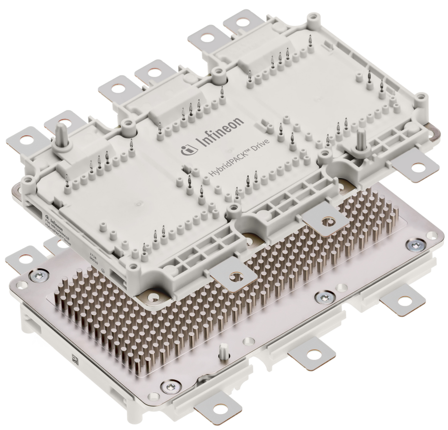
Final Data Sheet

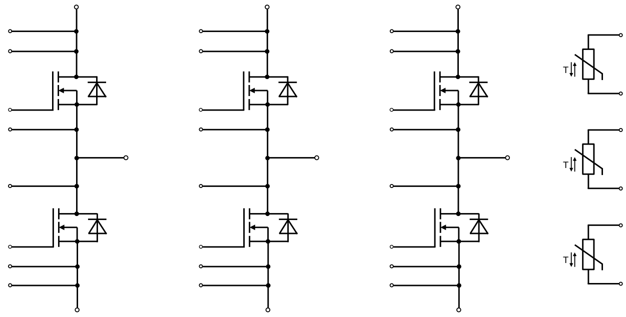
V3.1, 2020-09-17

Automotive High Power

1 Features / Description

HybridPACK™ Drive module with CoolSiC™ Automotive MOSFET





V_{DSS} = 1200 V
I_D = 200 A

Typical Applications

- Automotive Applications
- Hybrid Electrical Vehicles (H)EV
- Motor Drives
- Commercial Agriculture Vehicles

Electrical Features

- New semiconductor material - Silicon Carbide
- Blocking voltage 1200V
- Low RDSon
- Low Switching Losses
- Low Qg and Crss
- $T_{vj\ op}$ = 150°C
- Low Inductive Design <10nH

Mechanical Features

- 4.2kV DC 1sec Insulation
- High Creepage and Clearance Distances
- Compact design
- High Power Density
- Direct Cooled PinFin Base Plate
- High Performance Si3N4 Ceramic
- Guiding elements for PCB and cooler assembly
- Integrated NTC temperature sensor
- PressFIT Contact Technology
- RoHS compliant
- UL 94 V0 module frame

Description

The Automotive CoolSiC™ HybridPACK™ Drive is a six-pack module which benefits from Infineon's robust silicon carbide for hybrid and electric vehicles. The power module implements the new Automotive CoolSiC™ MOSFET 1200V, optimized for electric drivetrain applications. The chipset sets a benchmark in current density, short circuit ruggedness (singular event), high blocking voltage and reduced switching losses. It enables compact designs and helps to improve system efficiency, allowing at the same time reliable operation under harsh environmental conditions. It is qualified for automotive applications.

The Automotive CoolSiC™ HybridPACK™ Drive power module family comes with mechanical guiding elements supporting easy assembly processes for customers. Furthermore, the press-fit pins for the signal terminals avoid additional time consuming selective solder processes, which provides cost savings on system level and increases system reliability. The direct cooled baseplate with PinFin structure in the Automotive CoolSiC™ HybridPACK™ Drive product best utilizes the implemented chipset and shows superior thermal characteristics. Due to the high clearance & creepage distances, the module family is well suited for increased system working voltages. The module family benefits from the scalable HybridPACK™ Drive package.

Product Name	Ordering Code
FS05MR12A6MA1B	SP005247420

2 MOSFET

2.1 Maximum Rated Values

Parameter	Conditions		Symbol	Value	Unit
Drain-source voltage		T_{vj} = 25°C	V_{DSS}	1200	V
DC drain current	T_{vj} = 175°C, V_{GS} = 15 V	T_F = 60°C	$I_{D\ nom}$	200	A
Pulsed drain current	verified by design, t_p limited by T_{vjmax}		$I_{D\ pulse}$	400	A
Gate-source voltage			V_{GSS}	-10/20	V

2.2 Characteristic Values

Parameter	Conditions		Symbol	min.	typ.	max.	Unit
Drain-source on resistance	$I_{D\ nom}$ = 200 A V_{GS} = 15 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	$R_{DS\ on}$		5.50 8.00 9.10	7.35	mΩ
Gate threshold voltage	I_D = 120 mA, V_{DS} = V_{GS} (tested after 1ms pulse at V_{GS} = +20 V)	T_{vj} = 25°C	$V_{GS(th)}$	3.25	4.50	5.55	V
Total gate charge	V_{GS} = -5 V / 15 V, V_{DS} = 600 V		Q_G		0.66		µC
Internal gate resistor		T_{vj} = 25°C	R_{Gint}		0.45		Ω
Input capacitance	f = 1 MHz, V_{GS} = 0 V V_{DS} = 600 V	T_{vj} = 25°C	C_{iss}		21.3		nF
Output capacitance	f = 1 MHz, V_{GS} = 0 V V_{DS} = 600 V	T_{vj} = 25°C	C_{oss}		0.93		nF
Reverse transfer capacitance	f = 1 MHz, V_{GS} = 0 V V_{DS} = 600 V	T_{vj} = 25°C	C_{rss}		0.09		nF
C_{OSS} stored energy	V_{DS} = 600 V, V_{GS} = -5 / 15 V	T_{vj} = 25°C	E_{OSS}		219		µJ
Drain-source leakage current	V_{DSS} = 1200 V, V_{GS} = -5 V	T_{vj} = 25°C	I_{DSX}			100	µA
Gate-source leakage current	V_{DS} = 0 V, T_{vj} = 25°C	V_{GS} = 20 V	I_{GSS}			400	nA
Turn on delay time, inductive load	$I_{D\ nom}$ = 200 A, R_{Gon} = 5.10 Ω V_{DS} = 600 V V_{GS} = -5 / 15 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	$t_{d\ on}$		52.0 45.0 44.3		ns
Rise time, inductive load	$I_{D\ nom}$ = 200 A, R_{Gon} = 5.10 Ω V_{DS} = 600 V V_{GS} = -5 / 15 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	t_r		43.6 40.2 39.4		ns
Turn off delay time, inductive load	$I_{D\ nom}$ = 200 A, R_{Goff} = 5.10 Ω V_{DS} = 600 V V_{GS} = -5 / 15 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	$t_{d\ off}$		142 153 156		ns
Fall time, inductive load	$I_{D\ nom}$ = 200 A, R_{Goff} = 5.10 Ω V_{DS} = 600 V V_{GS} = -5 / 15 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	t_f		51.7 52.5 53.4		ns
Turn-on energy loss per pulse	$I_{D\ nom}$ = 200 A, V_{GS} = -5 / 15 V V_{DS} = 600 V, R_{Gon} = 5.10 Ω L_S = 20 nH di/dt = 4.51 kA/µs ($T_{vj\ op}$ = 150°C)	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	E_{on}		6.04 6.66 6.83		mJ
Turn-off energy loss per pulse	$I_{D\ nom}$ = 200 A, V_{GS} = -5 / 15 V V_{DS} = 600 V, R_{Goff} = 5.10 Ω L_S = 20 nH du/dt = 12.4 kV/µs ($T_{vj\ op}$ = 150°C)	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	E_{off}		4.27 4.41 4.51		mJ
SC data	V_{GS} = -5 / 15 V, R_G = 5.10 Ω V_{DD} = 800 V V_{DSmax} = V_{DSS} -L_{sDS} ·di/dt	$t_P \leq 3$ µs, T_{vj} = 25°C $t_P \leq 3$ µs, T_{vj} = 150°C	I_{SC}		2730 2480		A
Thermal resistance, junction to cooling fluid	ΔV/Δt = 10.0 dm³/min, T_F = 75°C cooling fluid = 50% water/50% ethylenglycol per MOSFET		R_{thJF}		0.150	0.180	K/W
Temperature under switching conditions			$T_{vj\ op}$	-40		150	°C

3 Body diode

3.1 Maximum Rated Values

Parameter	Conditions		Symbol	Value	Unit
DC body diode forward current	T_{vj} = 175°C, V_{GS} = -5 V	T_F = 60°C	I_{SD}	110	A
Pulsed body diode current	verified by design, t_p limited by T_{vjmax}		$I_{SD\ pulse}$	400	A

3.2 Characteristic Values

				min.	typ.	max.	
Forward voltage	I_{SD} = 200 A V_{GS} = -5 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	V_{DSR}		4.42 4.22 4.16	6.15	V
Peak reverse recovery current	I_{SD} = 200 A, V_{GS} = -5 V $-di_S/dt$ = 6.16 kA/µs V_R = 600 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	I_{rrm}		87.0 165 187		A
Recovered charge	I_{SD} = 200 A, V_{GS} = -5 V $-di_S/dt$ = 6.16 kA/µs V_R = 600 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	Q_{rr}		3.67 6.81 8.28		µC
Reverse recovery energy	I_{SD} = 200 A, V_{GS} = -5 V $-di_S/dt$ = 6.16 kA/µs V_R = 600 V	T_{vj} = 25°C T_{vj} = 125°C T_{vj} = 150°C	E_{rec}		0.46 1.15 1.40		mJ

4 NTC-Thermistor

Parameter	Conditions	Symbol	Value min.	Value typ.	Value max.	Unit
Rated resistance	T_C = 25°C	R_{25}		5.00		kΩ
Deviation of R100	T_C = 100°C, R_{100} = 493 Ω	ΔR/R	-5		5	%
Power dissipation	T_C = 25°C	P_{25}			20.0	mW
B-value	$R_2 = R_{25}\ exp\ [B_{25/50}(1/T_2 - 1/(298,15\ K))]$	$B_{25/50}$		3375		K
B-value	$R_2 = R_{25}\ exp\ [B_{25/80}(1/T_2 - 1/(298,15\ K))]$	$B_{25/80}$		3411		K
B-value	$R_2 = R_{25}\ exp\ [B_{25/100}(1/T_2 - 1/(298,15\ K))]$	$B_{25/100}$		3433		K

Specification according to the valid application note.

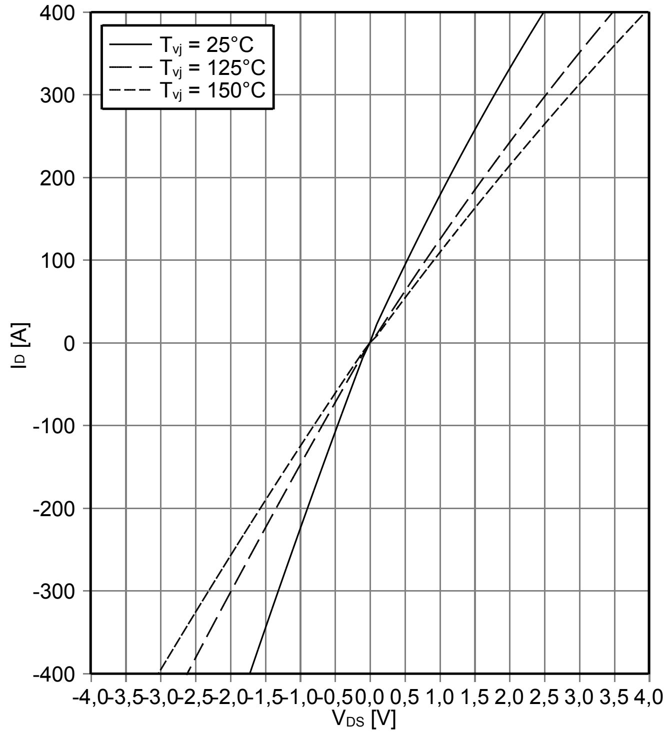
5 Module

Parameter	Conditions	Symbol	Value			Unit
Isolation test voltage	RMS, f = 0 Hz, t = 1 sec	V_{ISOL}	4.2			kV
Maximum RMS module terminal current	T_F = 75°C, T_{Ct} = 105°C	I_{tRMS}	400			A
Material of module baseplate			Cu+Ni[1]			
Internal isolation	basic insulation (class 1, IEC 61140)		Si3N4			
Creepage distance	terminal to heatsink terminal to terminal	d_{Creep}	9.0 9.0			mm
Clearance	terminal to heatsink terminal to terminal	d_{Clear}	4.5 4.5			mm
Comperative tracking index		CTI	> 200			
			min.	typ.	max.	
Pressure drop in cooling circuit	$\Delta V/\Delta t$ = 10.0 dm³/min; T_F = 75°C	Δp		64[2]		mbar
Maximum pressure in cooling circuit	$T_{baseplate}$ < 40°C $T_{baseplate}$ > 40°C (relative pressure)	p			2.5 2.0	bar
Stray inductance module		L_{sCE}		8.5		nH
Module lead resistance, terminals - chip	T_F = 25 °C, per switch	$R_{CC'+EE'}$		0.75		mΩ
Storage temperature		T_{stg}	-40		125	°C
Mounting torque for modul mounting	Screw M4 baseplate to heatsink	M	1.80	2.00	2.20	Nm
Weight		G		720		g

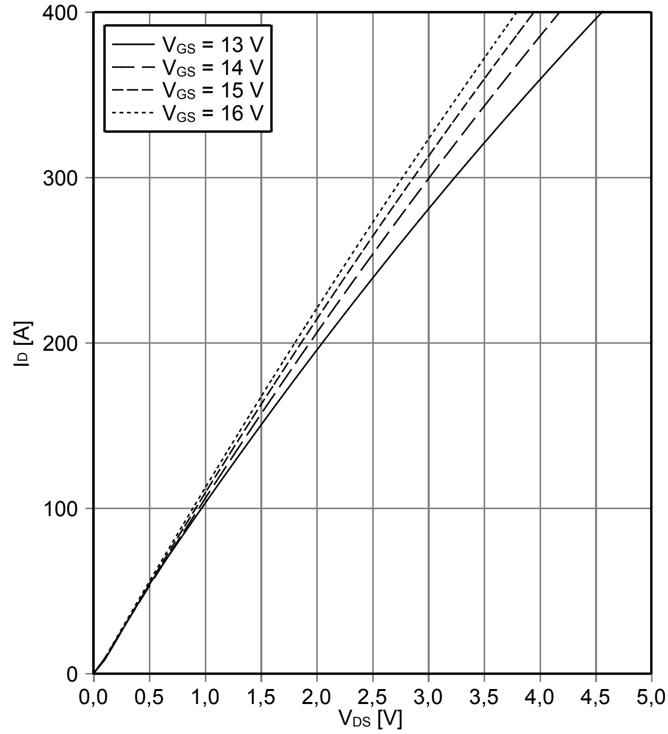
[1] Ni plated Cu baseplate.
[2] Cooler design and flow direction according to application note AN-HPD-ASSEMBLY. Cooling fluid 50% water / 50% ethylenglycol.

6 Characteristics Diagrams

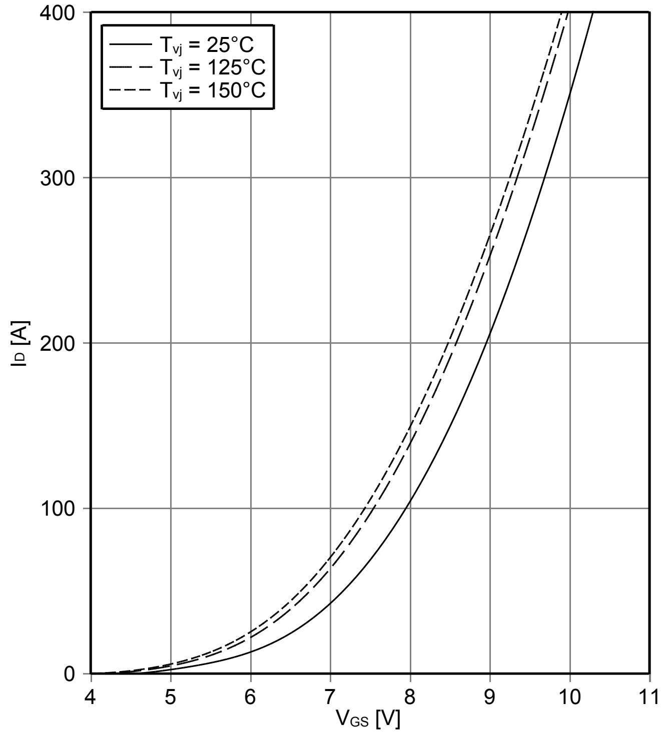
output characteristic MOSFET (typical)
$I_D = f(V_{DS})$
$V_{GS} = 15$ V



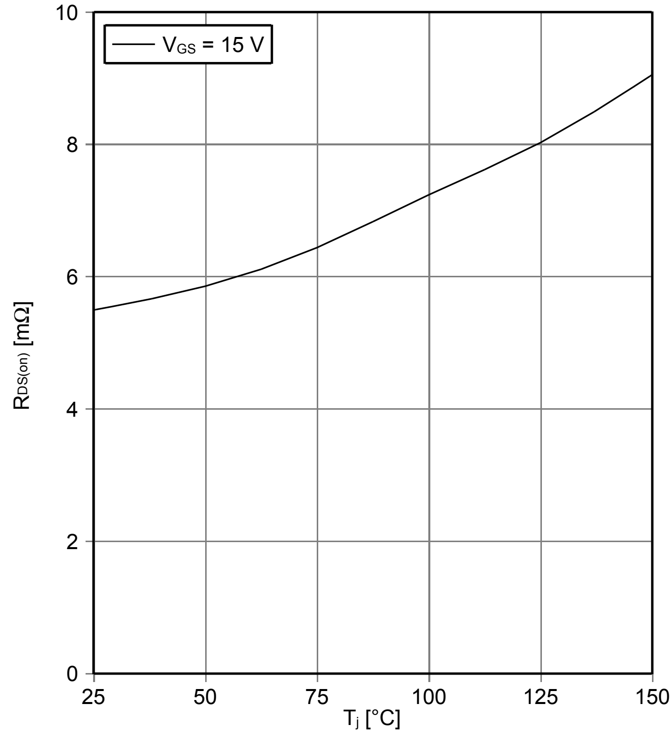
output characteristic MOSFET (typical)
$I_D = f(V_{DS})$
$T_{vj} = 150°C$



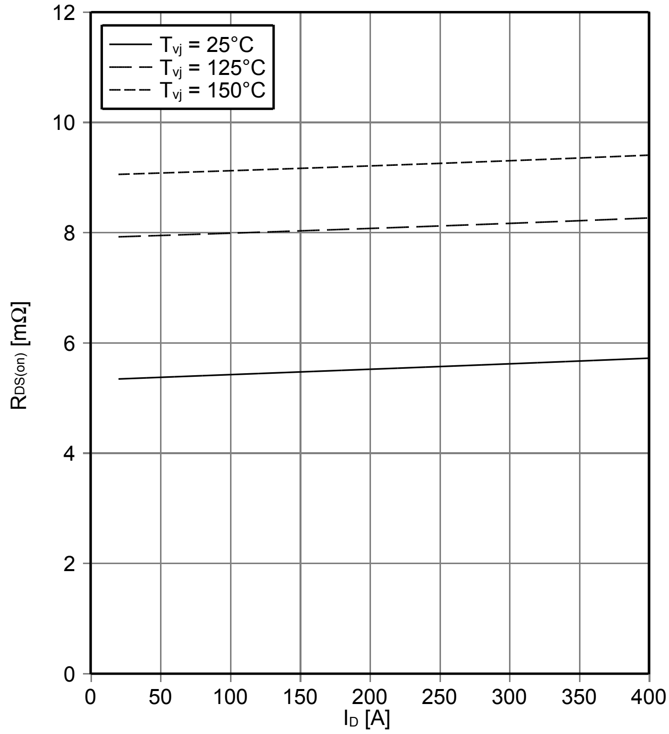
transfer characteristic MOSFET (typical)
$I_D = f(V_{GS})$
$V_{DS} = 20$ V



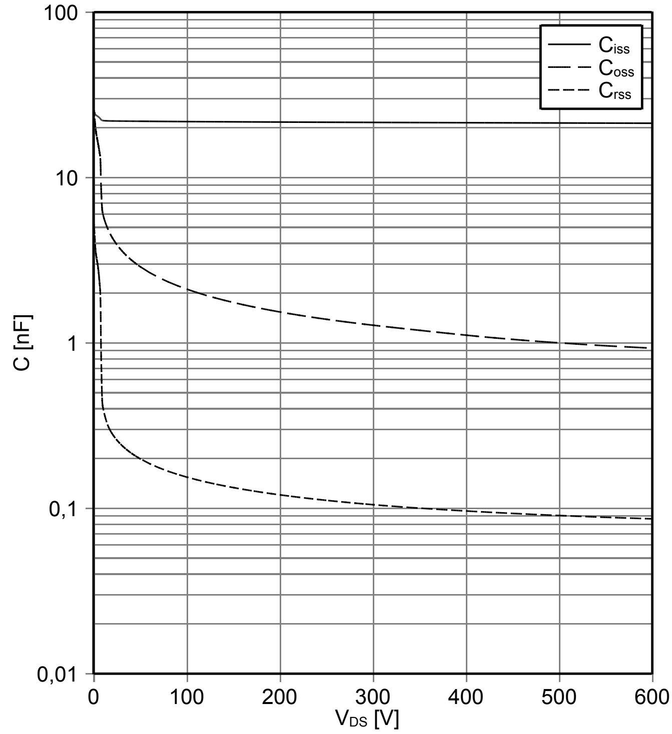
drain source on-resistance MOSFET (typical)
$R_{DS(on)} = f(T_j)$
$I_{DS} = 200A$



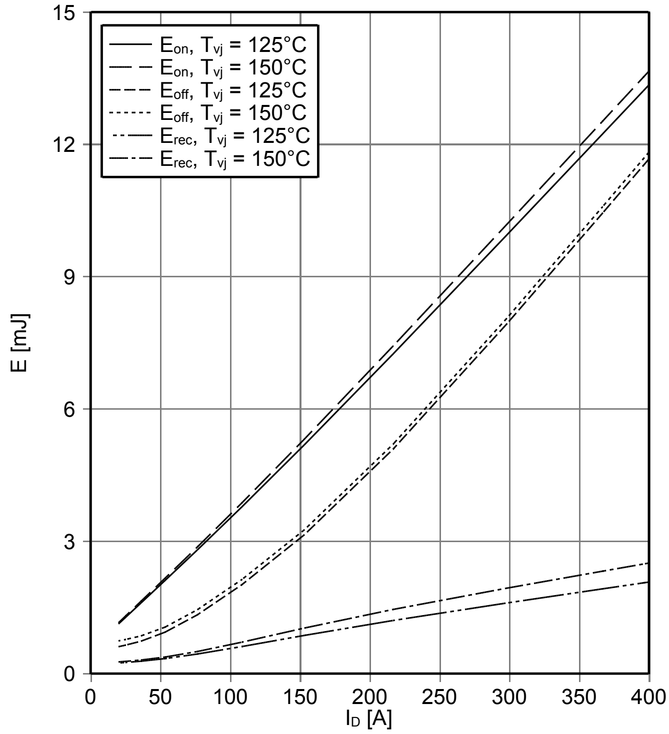
drain source on-resistance MOSFET (typical)
$R_{DS(on)} = f(I_D)$
V_{GS} = 15 V



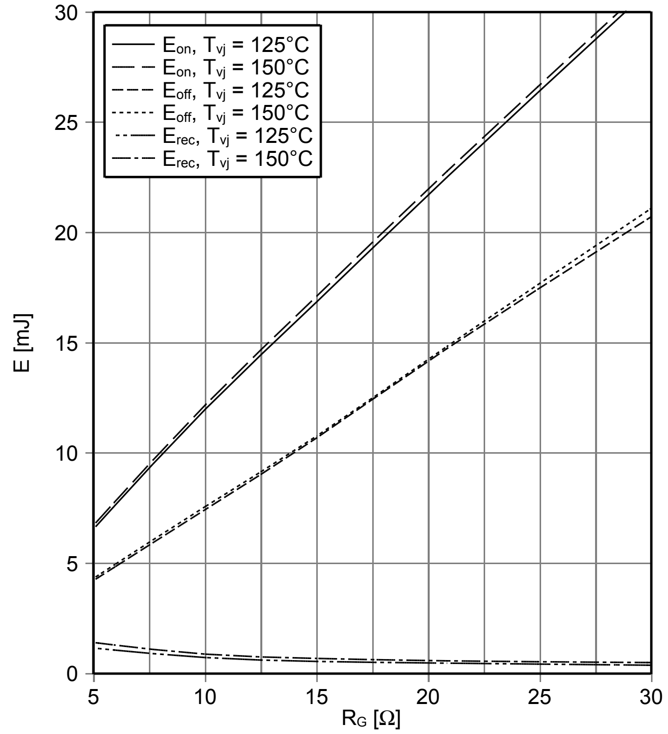
capacity characteristic MOSFET (typical)
$C = f(V_{DS})$
V_{GS} = 0 V, T_{vj} = 25°C, f = 1 MHz



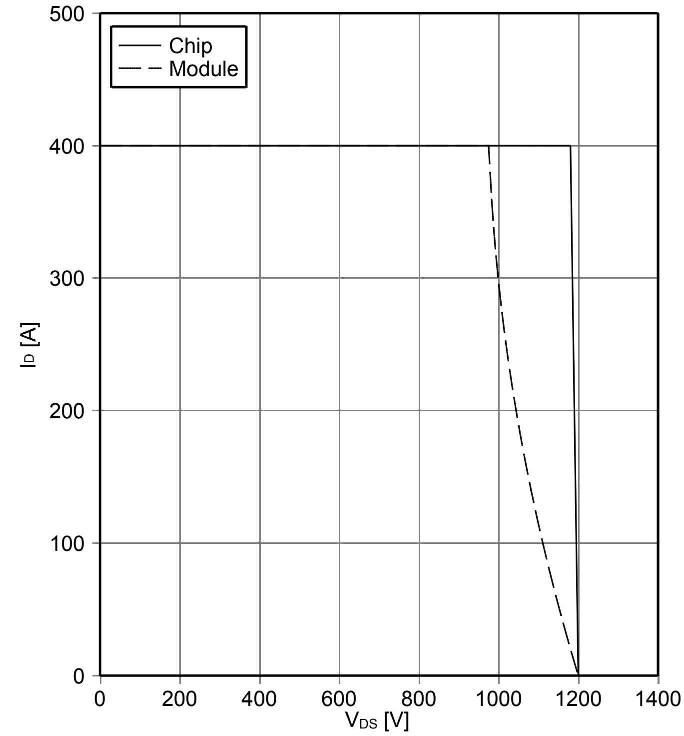
switching losses MOSFET (typical)
$E_{on} = f(I_D)$, $E_{off} = f(I_D)$, $E_{rec} = f(I_D)$
V_{GS} = +15 V / -5 V, $R_{Gon} = R_{Goff}$ = 5.1 Ω, V_{DS} = 600 V



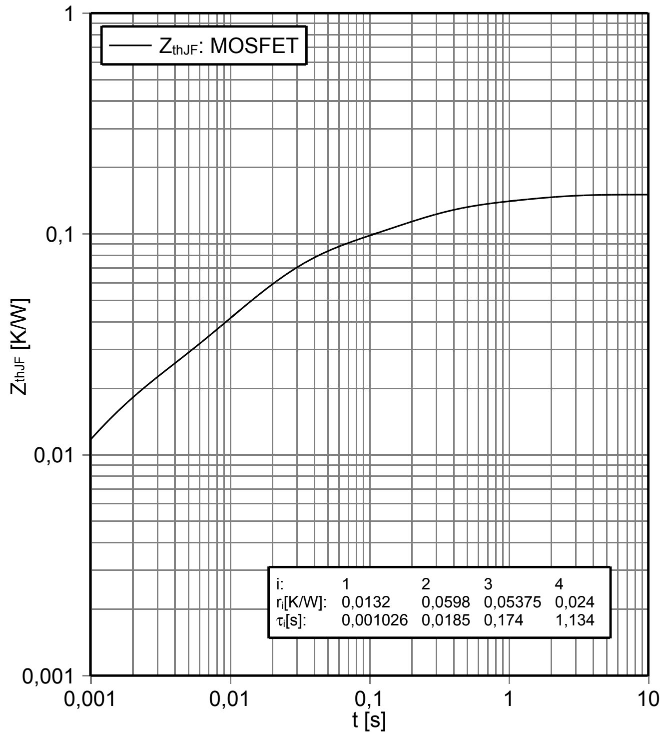
switching losses MOSFET (typical)
$E_{on} = f(R_G)$, $E_{off} = f(R_G)$, $E_{rec} = f(R_G)$
V_{GS} = +15 V / -5 V, I_D = 200 A, V_{DS} = 600 V



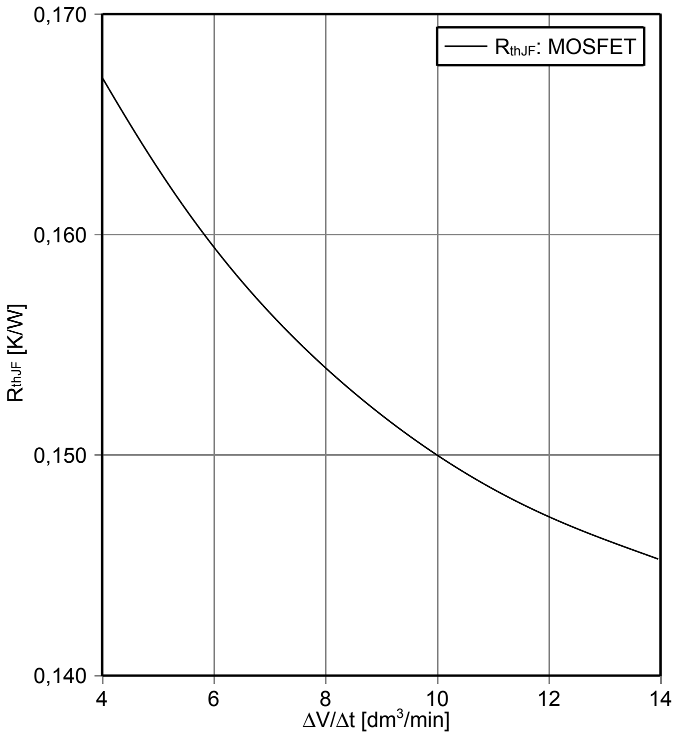
reverse bias safe operating area MOSFET (RBSOA)
$I_D = f(V_{DS})$
$V_{GS} = +15\ V\ /\ -5\ V$, $R_{Goff} = 5.1\ \Omega$, $T_{vj} = 150°C$



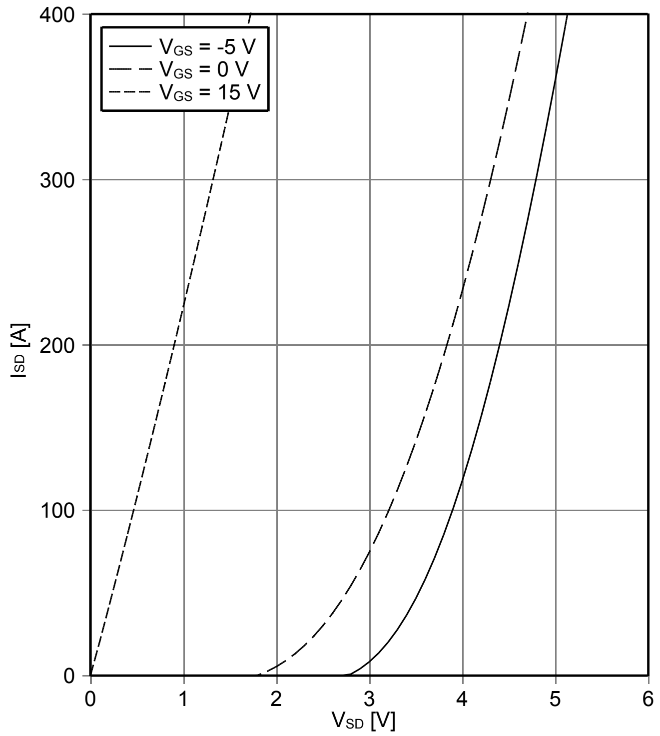
transient thermal impedance MOSFET
$Z_{thJF} = f(t)$ (typical)



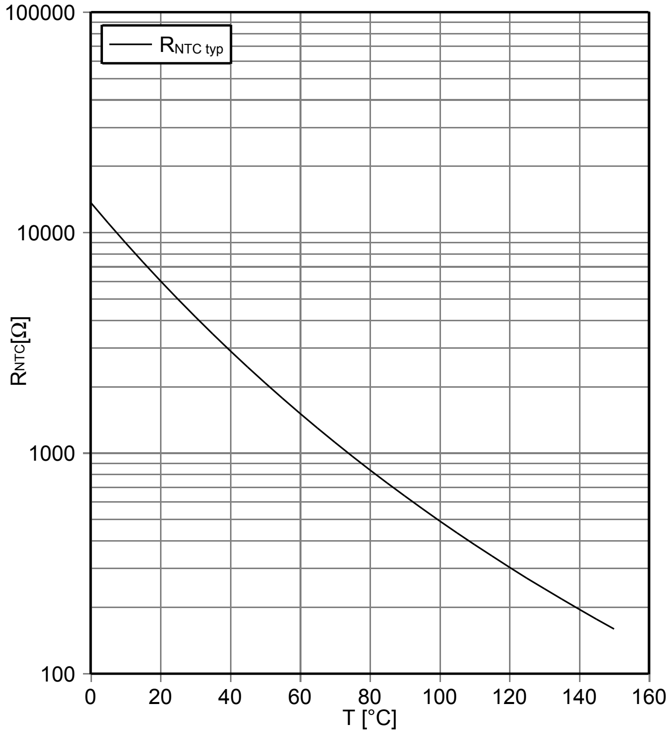
thermal impedance MOSFET
$R_{thJF} = f(\Delta V/\Delta t)$ (typical)
$T_F = 75°C$, cooling fluid = 50% water / 50% ethylenglycol



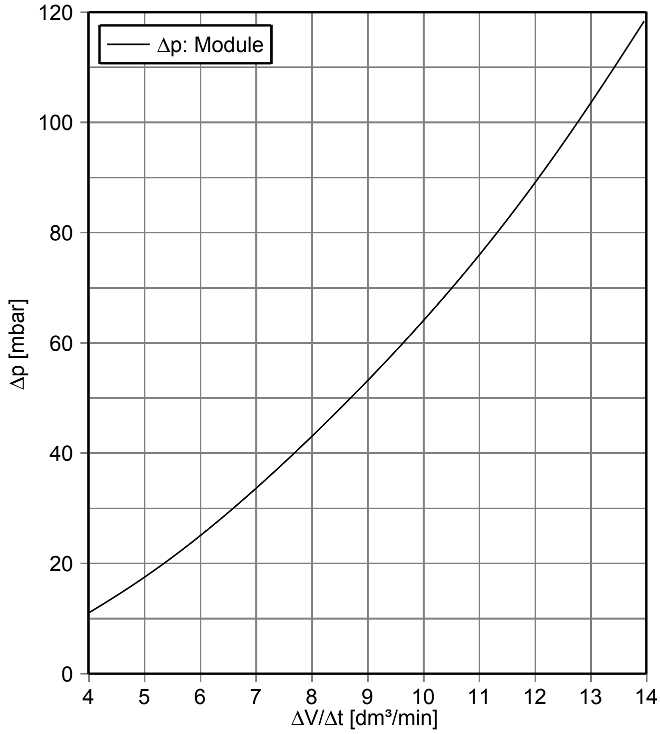
forward characteristic MOSFET body diode (typical)
$I_{SD} = f(V_{SD})$
$T_j = 25°C$



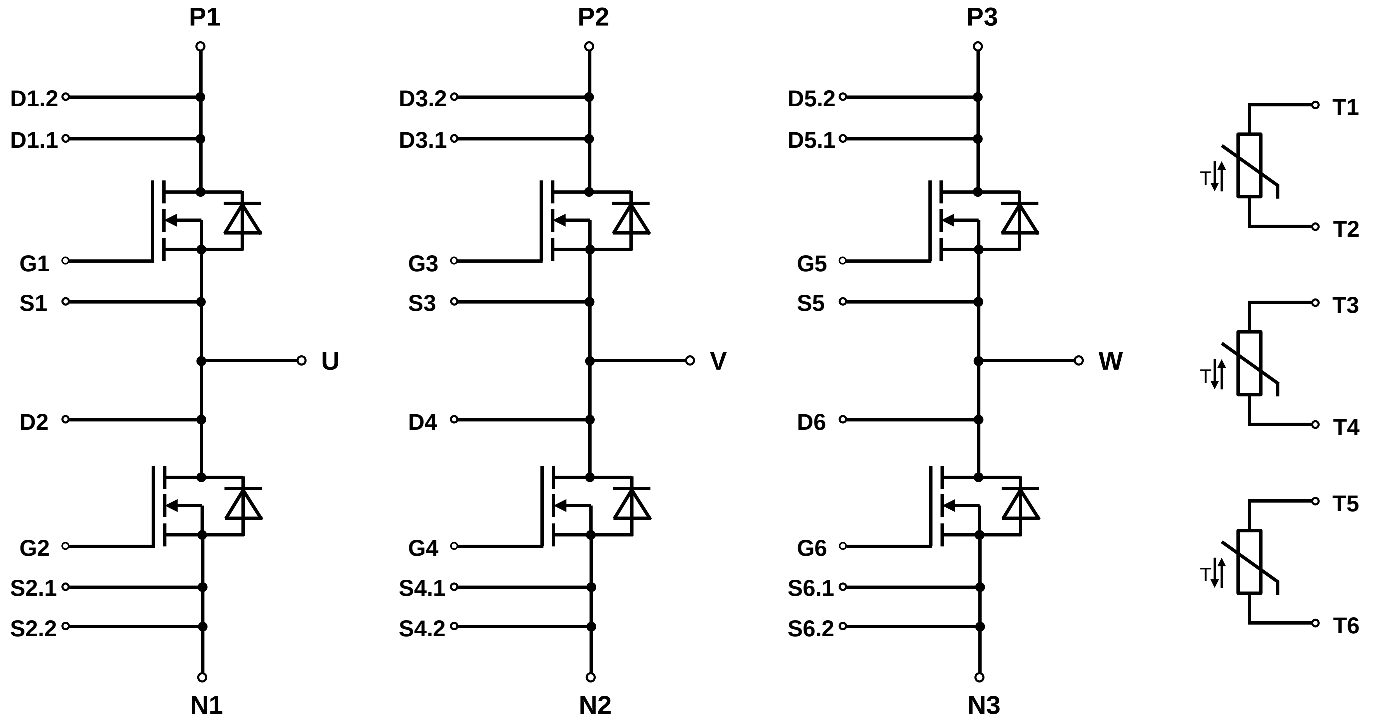
NTC-Thermistor-temperature characteristic (typical)
$R_{NTC} = f(T)$



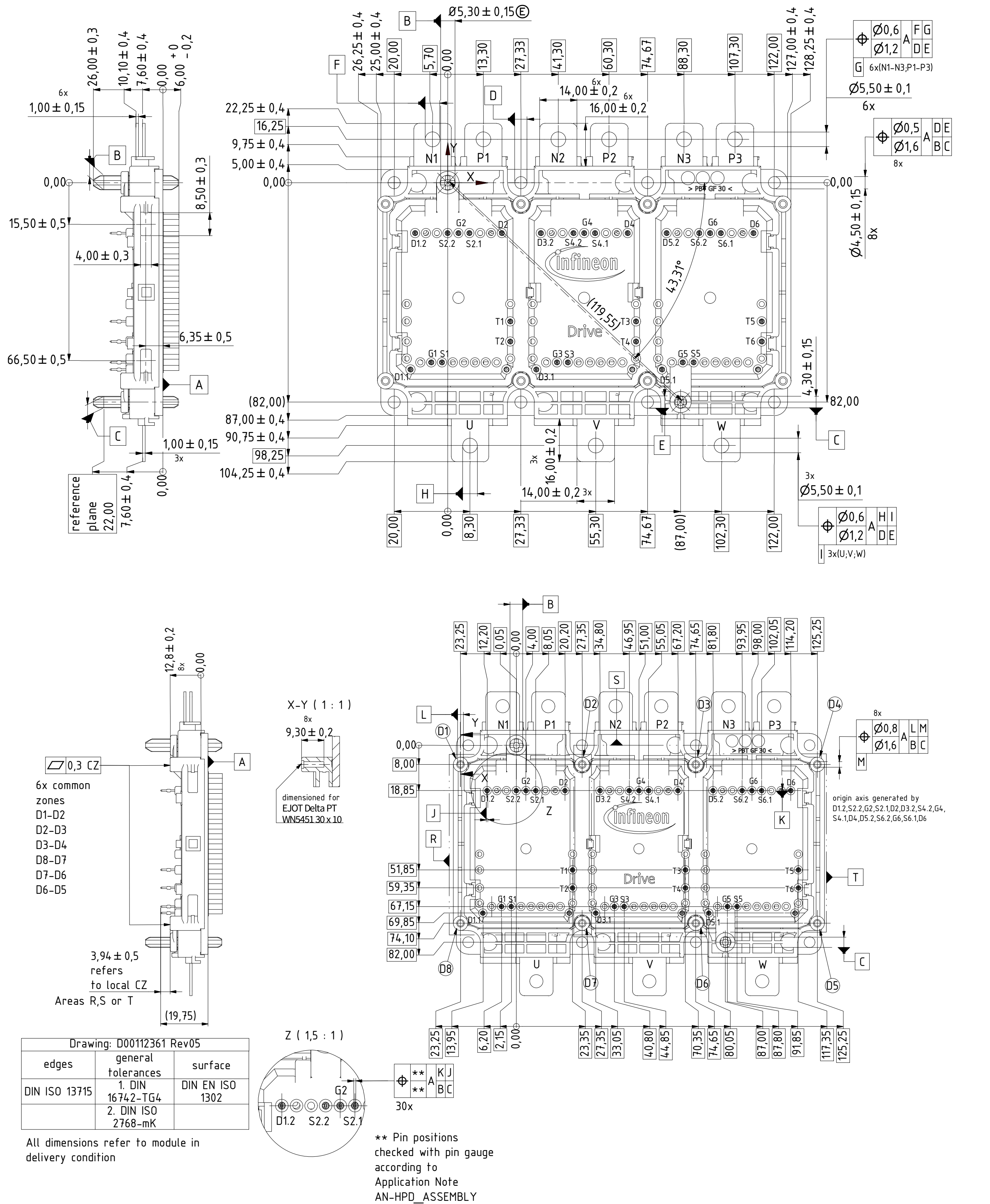
pressure drop in cooling circuit
$\Delta p = f(\Delta V/\Delta t)$, cooler design according to AN-HPD-ASSEMBLY
$T_f = 75°C$; 50% water / 50% ethylenglycol



7 Circuit diagram



8 Package outlines



9 Label Codes

9.1 Module Code

Code Format	Data Matrix		
Encoding	ASCII Text		
Symbol Size	16x16		
Standard	IEC24720 and IEC16022		
Code Content	**Content** Module Serial Number Module Material Number Production Order Number Datecode (Production Year) Datecode (Production Week)	**Digit** 1 - 5 6 - 11 12 - 19 20 - 21 22 - 23	**Example (below)** 71549 142846 55054991 15 30
Example	71549142846550549911530		

9.2 Packing Code

Code Format	Code128			
Encoding	Code Set A			
Symbol Size	34 digits			
Standard	IEC8859-1			
Code Content	**Content** Backend Construction Number 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 (below)** 95056609 2X0003E0 754389 1139 15
Example	X950566091T2X0003E0S754389D1139Q15			

Revision History

Major changes since previous revision

Revision History		
Reference	**Date**	**Description**
V1.0	2019-09-13	Target Datasheet
V2.0	2020-04-02	Preliminary Data Sheet
V3.0	2020-06-26	-
V3.1	2020-09-17	Final datasheet, correction of module weight

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