

Final datasheet**Highly insulated module with Trench/Fieldstop IGBT4 and emitter controlled 4 diode****Features**

- Electrical features
 - $V_{CES} = 6500 \text{ V}$
 - $I_{C \text{ nom}} = 1000 \text{ A} / I_{CRM} = 2000 \text{ A}$
 - Low $V_{CE, \text{sat}}$
- Mechanical features
 - Extended storage temperature down to $T_{\text{stg}} = -55 \text{ }^{\circ}\text{C}$
 - Package with enhanced insulation of 10.4 kV AC 60 s
 - High creepage and clearance distances
 - Package with CTI > 600
 - AlSiC base plate for increased thermal cycling capability

**Potential applications**

- Medium-voltage converters
- Traction
- Power transmission and distribution

Product validation

- Qualified for industrial applications according to the relevant tests of IEC 60747, 60749 and 60068

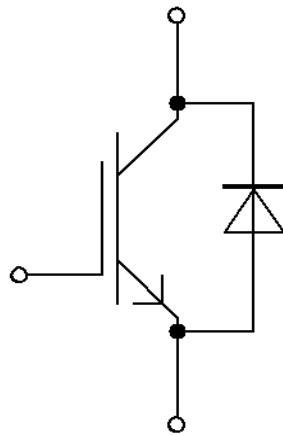
Description

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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 50 \text{ Hz}$, $t = 60 \text{ s}$	10.4	kV
Partial discharge extinction voltage	V_{isol}	RMS, $f = 50 \text{ Hz}$, Q_{PD} typ. 10 pC	5.1	kV
DC stability	$V_{CE(D)}$	$T_{vj} = 25 \text{ °C}$, 100 Fit	3800	V
Material of module baseplate			AlSiC	
Internal isolation		basic insulation (class 1, IEC 61140)	AlN	
Creepage distance	$d_{Creep \text{ nom}}$	terminal to baseplate, nom.	64.0	mm
Creepage distance	$d_{Creep \text{ nom}}$	terminal to terminal, nom.	56.0	mm
Clearance	$d_{Clear \text{ nom}}$	terminal to baseplate, nom.	40.0	mm
Clearance	$d_{Clear \text{ nom}}$	terminal to terminal, nom.	26.0	mm
Comparative tracking index	CTI		> 600	

Table 2 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Stray inductance module	L_{sCE}				18		nH
Module lead resistance, terminals - chip	$R_{AA'+CC'}$	$T_C = 25\text{ }^{\circ}\text{C}$, per switch			0.075		mΩ
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C = 25\text{ }^{\circ}\text{C}$, per switch			0.095		mΩ
Storage temperature	T_{stg}			-55		125	°C
Mounting torque for module mounting	M	- Mounting according to valid application note	M6, Screw	4.25		5.75	Nm
Terminal connection torque	M	- Mounting according to valid application note	M4, Screw	1.8		2.1	Nm
			M8, Screw	8		10	
Weight	G				1400		g

2 IGBT, Inverter

Table 3 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Collector-emitter voltage	V_{CES}		$T_{vj} = -50\text{ °C}$	5900	V
			$T_{vj} = 25\text{ °C}$	6500	
			$T_{vj} = 135\text{ °C}$	6500	
Continuous DC collector current	I_{CDC}	$T_{vj\text{ max}} = 135\text{ °C}$	$T_C = 100\text{ °C}$	1000	A
Repetitive peak collector current	I_{CRM}	t_p limited by $T_{vj\text{ op}}$		2000	A
Gate-emitter peak voltage	V_{GES}			± 20	V

Table 4 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Collector-emitter saturation voltage	$V_{CE\text{ sat}}$	$I_C = 1000\text{ A}$, $V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$		2.85	3.25	V
			$T_{vj} = 125\text{ °C}$		3.55		
			$T_{vj} = 135\text{ °C}$		3.60	4.10	
Gate threshold voltage	V_{GEth}	$I_C = 130\text{ mA}$, $V_{CE} = V_{GE}$, $T_{vj} = 25\text{ °C}$		5.45	6.1	6.55	V
Gate charge	Q_G	$V_{GE} = \pm 15\text{ V}$, $V_{CC} = 3600\text{ V}$, $T_{vj} = 25\text{ °C}$			42		μC
Internal gate resistor	R_{Gint}	$T_{vj} = 25\text{ °C}$			0.84		Ω
Input capacitance	C_{ies}	$f = 100\text{ kHz}$, $T_{vj} = 25\text{ °C}$, $V_{CE} = 25\text{ V}$, $V_{GE} = 0\text{ V}$			245		nF
Reverse transfer capacitance	C_{res}	$f = 100\text{ kHz}$, $T_{vj} = 25\text{ °C}$, $V_{CE} = 25\text{ V}$, $V_{GE} = 0\text{ V}$			4.2		nF
Collector-emitter cut-off current	I_{CES}	$V_{CE} = 6500\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$			5	mA
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0\text{ V}$, $V_{GE} = 20\text{ V}$, $T_{vj} = 25\text{ °C}$				400	nA
Turn-on delay time (inductive load)	t_{don}	$I_C = 1000\text{ A}$, $V_{CC} = 3600\text{ V}$, $V_{GE} = \pm 15\text{ V}$, $R_{Gon} = 0.68\text{ }\Omega$	$T_{vj} = 25\text{ °C}$		1.110		μs
			$T_{vj} = 125\text{ °C}$		1.200		
			$T_{vj} = 135\text{ °C}$		1.220		
Rise time (inductive load)	t_r	$I_C = 1000\text{ A}$, $V_{CC} = 3600\text{ V}$, $V_{GE} = \pm 15\text{ V}$, $R_{Gon} = 0.68\text{ }\Omega$	$T_{vj} = 25\text{ °C}$		0.150		μs
			$T_{vj} = 125\text{ °C}$		0.170		
			$T_{vj} = 135\text{ °C}$		0.170		
Turn-off delay time (inductive load)	t_{doff}	$I_C = 1000\text{ A}$, $V_{CC} = 3600\text{ V}$, $V_{GE} = \pm 15\text{ V}$, $R_{Goff} = 9.1\text{ }\Omega$	$T_{vj} = 25\text{ °C}$		10.200		μs
			$T_{vj} = 125\text{ °C}$		10.630		
			$T_{vj} = 135\text{ °C}$		10.690		

(table continues...)

Table 4 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Fall time (inductive load)	t_f	$I_C = 1000 \text{ A}$, $V_{CC} = 3600 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$, $R_{Goff} = 9.1 \Omega$	$T_{vj} = 25 \text{ }^\circ\text{C}$	0.680		μs
			$T_{vj} = 125 \text{ }^\circ\text{C}$	1.680		
			$T_{vj} = 135 \text{ }^\circ\text{C}$	1.820		
Turn-on time (resistive load)	t_{on_R}	$I_C = 500 \text{ A}$, $V_{CC} = 2000 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$, $R_{Gon} = 0.68 \Omega$	$T_{vj} = 25 \text{ }^\circ\text{C}$	2.10		μs
Turn-on energy loss per pulse	E_{on}	$I_C = 1000 \text{ A}$, $V_{CC} = 3600 \text{ V}$, $L_\sigma = 150 \text{ nH}$, $V_{GE} = \pm 15 \text{ V}$, $R_{Gon} = 0.68 \Omega$, $di/dt = 4530 \text{ A}/\mu\text{s}$ ($T_{vj} = 135 \text{ }^\circ\text{C}$)	$T_{vj} = 25 \text{ }^\circ\text{C}$	5400		mJ
			$T_{vj} = 125 \text{ }^\circ\text{C}$	7950		
			$T_{vj} = 135 \text{ }^\circ\text{C}$	8350		
Turn-off energy loss per pulse	E_{off}	$I_C = 1000 \text{ A}$, $V_{CC} = 3600 \text{ V}$, $L_\sigma = 150 \text{ nH}$, $V_{GE} = \pm 15 \text{ V}$, $R_{Goff} = 9.1 \Omega$, $dv/dt = 1330 \text{ V}/\mu\text{s}$ ($T_{vj} = 135 \text{ }^\circ\text{C}$)	$T_{vj} = 25 \text{ }^\circ\text{C}$	5550		mJ
			$T_{vj} = 125 \text{ }^\circ\text{C}$	6750		
			$T_{vj} = 135 \text{ }^\circ\text{C}$	6900		
SC data	I_{SC}	$V_{GE} \leq 15 \text{ V}$, $V_{CC} = 4500 \text{ V}$, $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$	$t_p \leq 10 \mu\text{s}$, $T_{vj} = 135 \text{ }^\circ\text{C}$	4900		A
Thermal resistance, junction to case	R_{thJC}	per IGBT			7.70	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per IGBT, $\lambda_{grease} = 1 \text{ W}/(\text{m} \cdot \text{K})$		3.60		K/kW
Temperature under switching conditions	$T_{vj\ op}$		-50		135	$^\circ\text{C}$
Temperature under overload switching conditions	$T_{vj\ over}$	Overload, cumulative max. 4000s			150	$^\circ\text{C}$

3 Diode, Inverter

Table 5 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Repetitive peak reverse voltage	V_{RRM}	$T_{vj} = -50 \text{ }^\circ\text{C}$	5900	V
		$T_{vj} = 25 \text{ }^\circ\text{C}$	6500	
		$T_{vj} = 135 \text{ }^\circ\text{C}$	6500	
Continuous DC forward current	I_F		1000	A
Repetitive peak forward current	I_{FRM}	$t_p = 1 \text{ ms}$	2000	A
I^2t - value	I^2t	$t_p = 10 \text{ ms}$, $V_R = 0 \text{ V}$	$T_{vj} = 125 \text{ }^\circ\text{C}$	kA^2s
			$T_{vj} = 135 \text{ }^\circ\text{C}$	

(table continues...)

Table 5 (continued) Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Maximum power dissipation	P_{RQM}	$T_{vj} = 135\text{ °C}$	3600	kW
Minimum turn-on time	t_{onmin}		10	μs

Table 6 Characteristic values

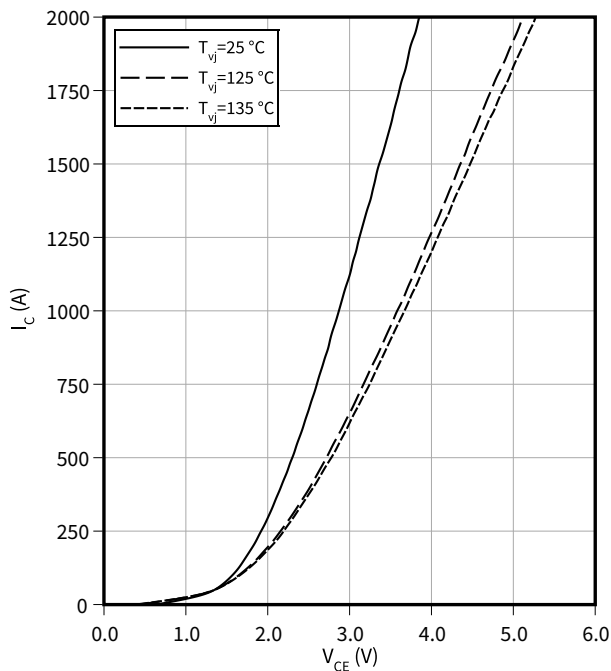
Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	$I_F = 1000\text{ A}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$	2.65	3.20	V
			$T_{vj} = 125\text{ °C}$	2.45		
			$T_{vj} = 135\text{ °C}$	2.40	2.95	
Peak reverse recovery current	I_{RM}	$V_{CC} = 3600\text{ V}$, $I_F = 1000\text{ A}$, $V_{GE} = -15\text{ V}$, $-di_F/dt = 4530\text{ A}/\mu\text{s}$ ($T_{vj} = 135\text{ °C}$)	$T_{vj} = 25\text{ °C}$	1800		A
			$T_{vj} = 125\text{ °C}$	1850		
			$T_{vj} = 135\text{ °C}$	1850		
Recovered charge	Q_r	$V_{CC} = 3600\text{ V}$, $I_F = 1000\text{ A}$, $V_{GE} = -15\text{ V}$, $-di_F/dt = 4530\text{ A}/\mu\text{s}$ ($T_{vj} = 135\text{ °C}$)	$T_{vj} = 25\text{ °C}$	1300		μC
			$T_{vj} = 125\text{ °C}$	2550		
			$T_{vj} = 135\text{ °C}$	2700		
Reverse recovery energy	E_{rec}	$V_{CC} = 3600\text{ V}$, $I_F = 1000\text{ A}$, $V_{GE} = -15\text{ V}$, $-di_F/dt = 4530\text{ A}/\mu\text{s}$ ($T_{vj} = 135\text{ °C}$)	$T_{vj} = 25\text{ °C}$	2600		mJ
			$T_{vj} = 125\text{ °C}$	5600		
			$T_{vj} = 135\text{ °C}$	5950		
Thermal resistance, junction to case	R_{thJC}	per diode			12.8	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{K})$		6.80		K/kW
Temperature under switching conditions	$T_{vj\text{ op}}$		-50		135	$^{\circ}\text{C}$

4 Characteristics diagrams

Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

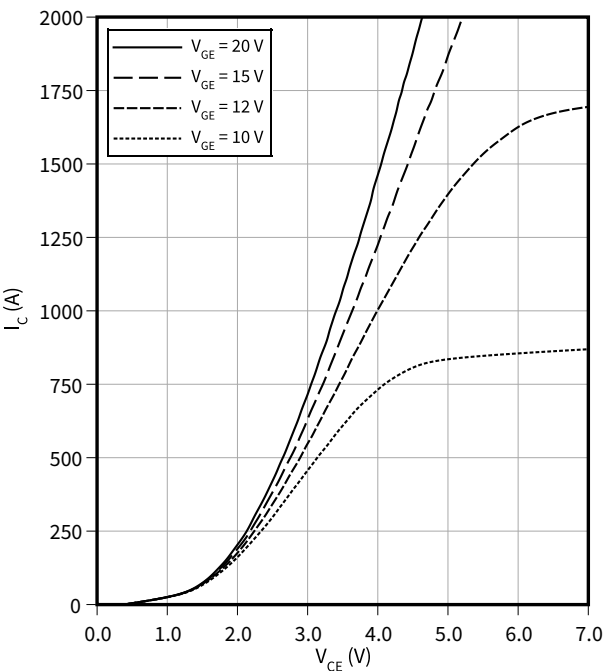
$V_{GE} = 15\text{ V}$



Output characteristic field (typical), IGBT, Inverter

$I_C = f(V_{CE})$

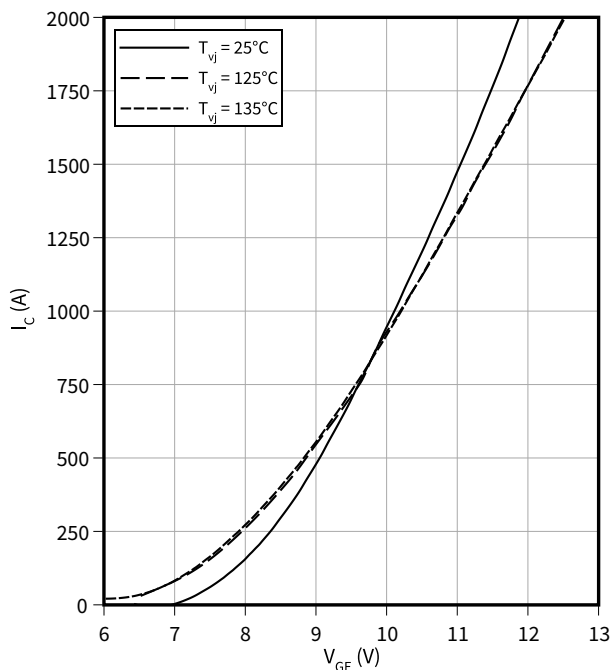
$T_{vj} = 135\text{ }^{\circ}\text{C}$



Transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$

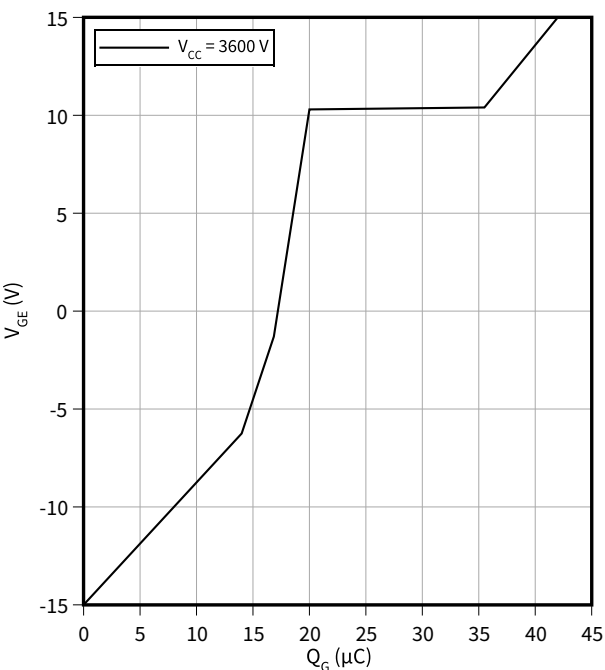
$V_{CE} = 20\text{ V}$



Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$

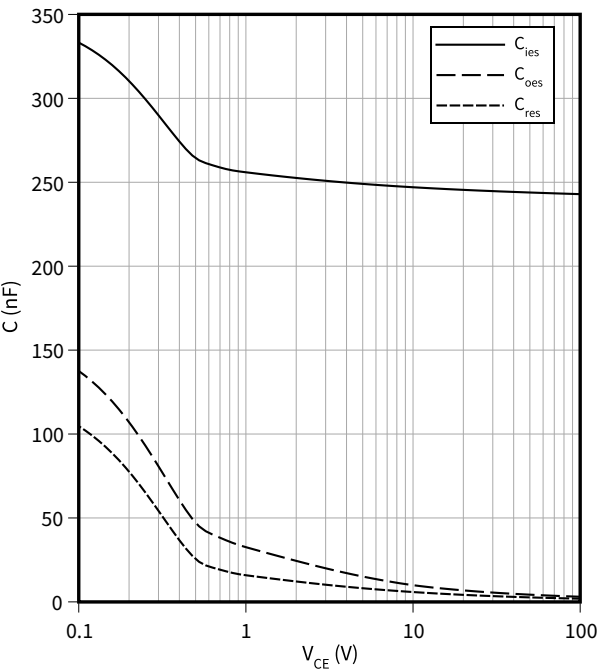
$I_C = 1000\text{ A}, T_{vj} = 25\text{ }^{\circ}\text{C}$



4 Characteristics diagrams

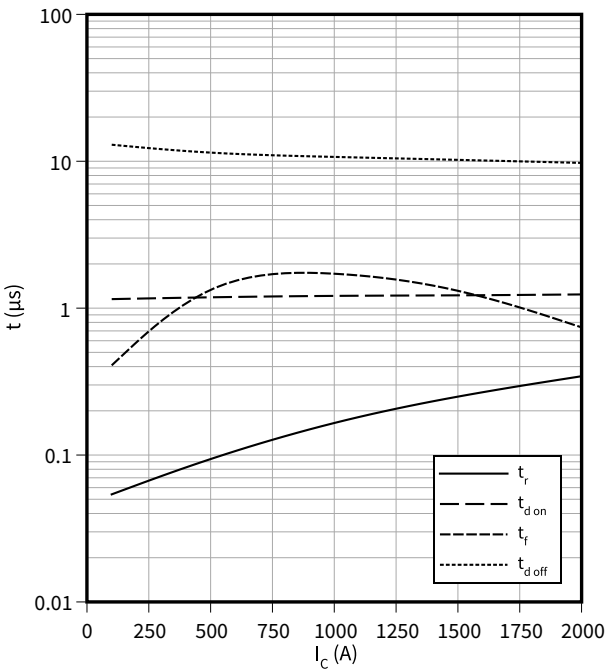
Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$
 $f = 100\text{ kHz}$, $V_{GE} = 0\text{ V}$, $T_{vj} = 25\text{ °C}$



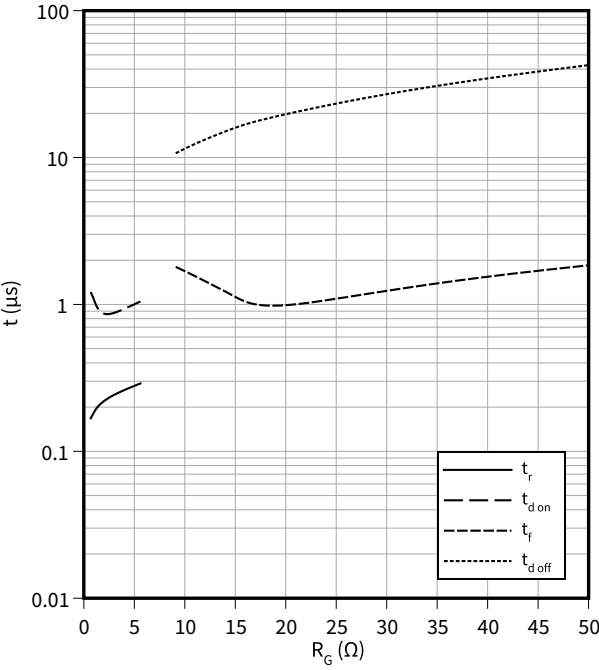
Switching times (typical), IGBT, Inverter

$t = f(I_C)$
 $R_{Goff} = 9.1\text{ }\Omega$, $R_{Gon} = 0.68\text{ }\Omega$, $V_{GE} = \pm 15\text{ V}$, $V_{CC} = 3600\text{ V}$, $T_{vj} = 135\text{ °C}$



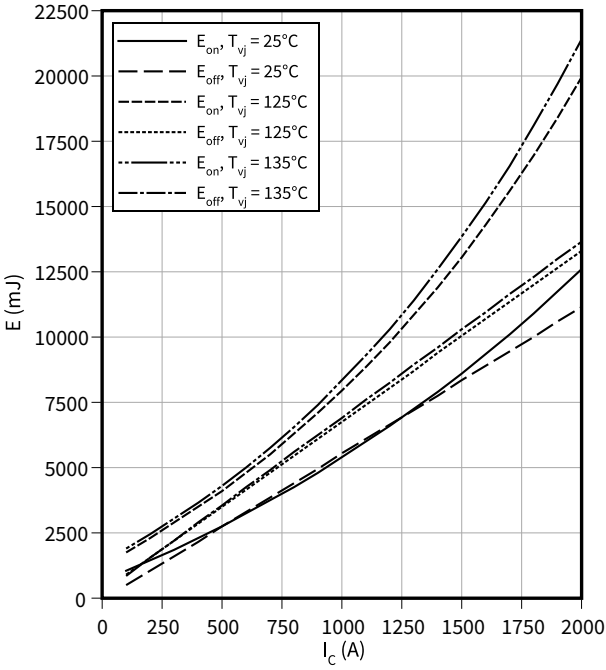
Switching times (typical), IGBT, Inverter

$t = f(R_G)$
 $V_{GE} = \pm 15\text{ V}$, $I_C = 1000\text{ A}$, $V_{CC} = 3600\text{ V}$, $T_{vj} = 135\text{ °C}$



Switching losses (typical), IGBT, Inverter

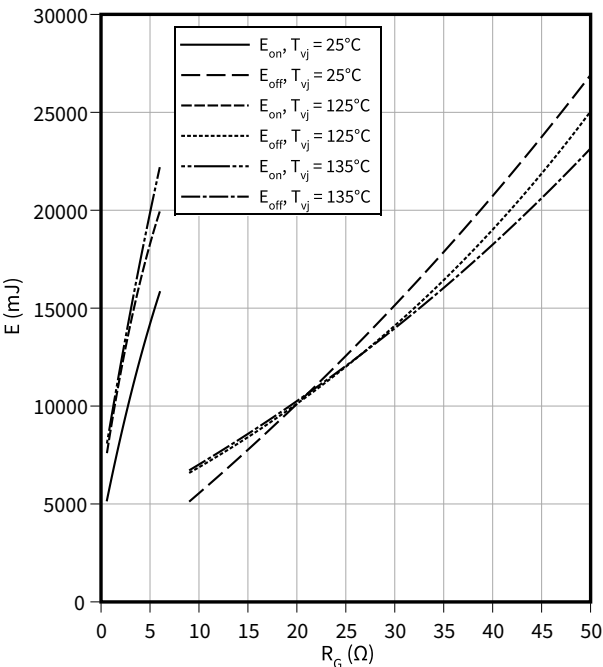
$E = f(I_C)$
 $V_{CC} = 3600\text{ V}$, $R_{Goff} = 9.1\text{ }\Omega$, $R_{Gon} = 0.68\text{ }\Omega$, $V_{GE} = \pm 15\text{ V}$



4 Characteristics diagrams

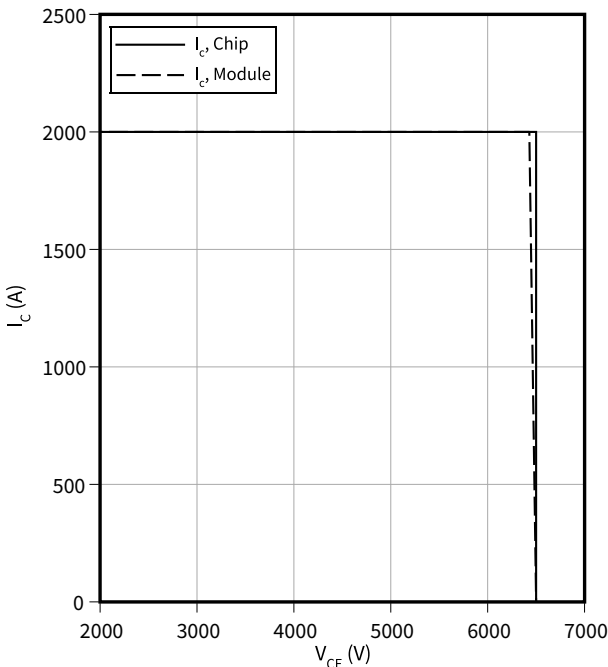
Switching losses (typical), IGBT, Inverter

$E = f(R_G)$
 $V_{GE} = \pm 15\text{ V}, I_C = 1000\text{ A}, V_{CC} = 3600\text{ V}$



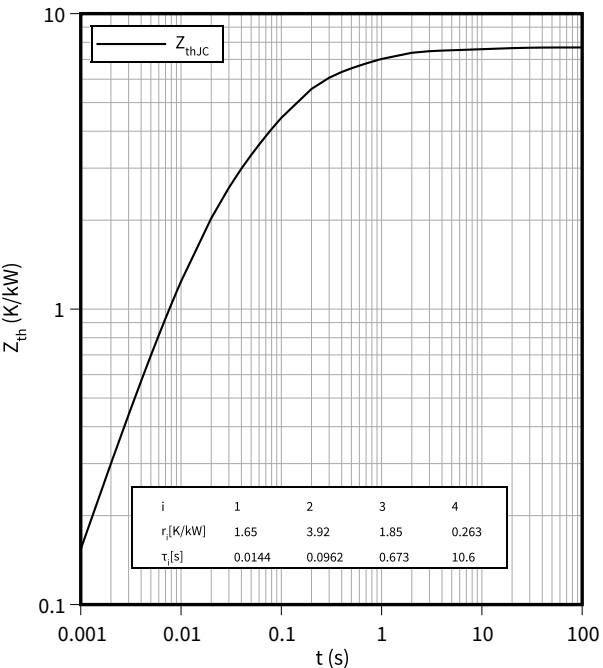
Reverse bias safe operating area (RBSOA), IGBT, Inverter

$I_C = f(V_{CE})$
 $R_{Goff} \geq 9.1\ \Omega, V_{GE} = \pm 15\text{ V}, T_{vj} = 135\text{ }^{\circ}\text{C}$



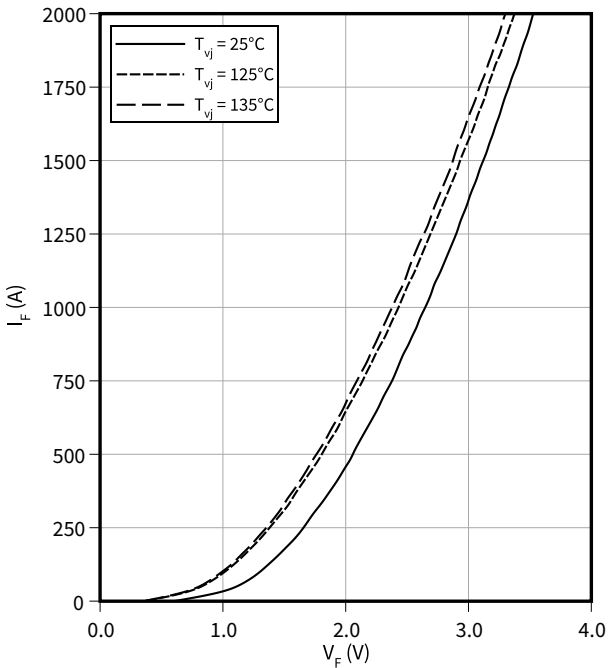
Transient thermal impedance, IGBT, Inverter

$Z_{th} = f(t)$



Forward characteristic (typical), Diode, Inverter

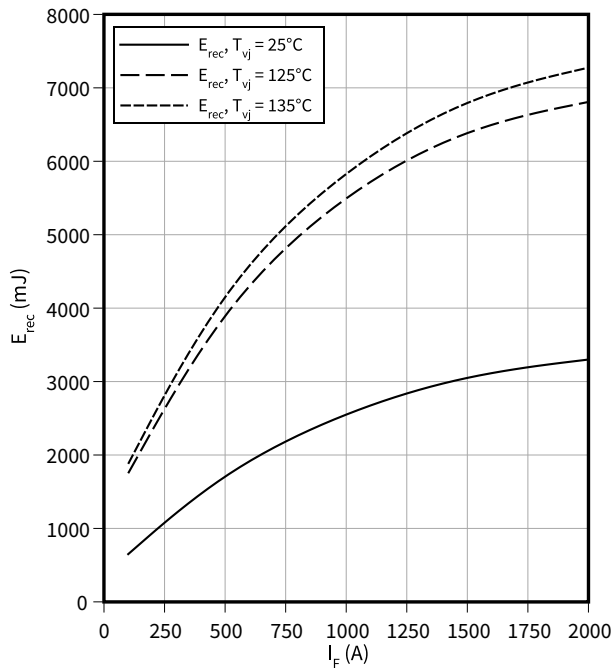
$I_F = f(V_F)$



4 Characteristics diagrams

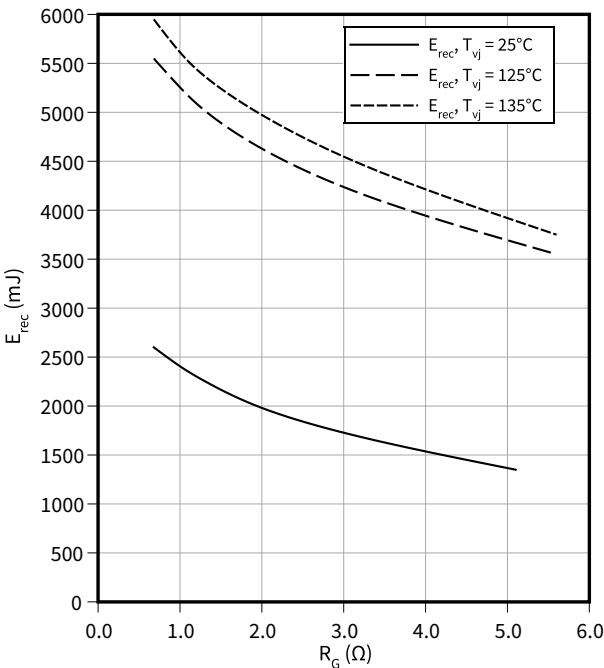
Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$
 $R_{Gon} = R_{Gon}(IGBT) , V_{CC} = 3600\text{ V}$



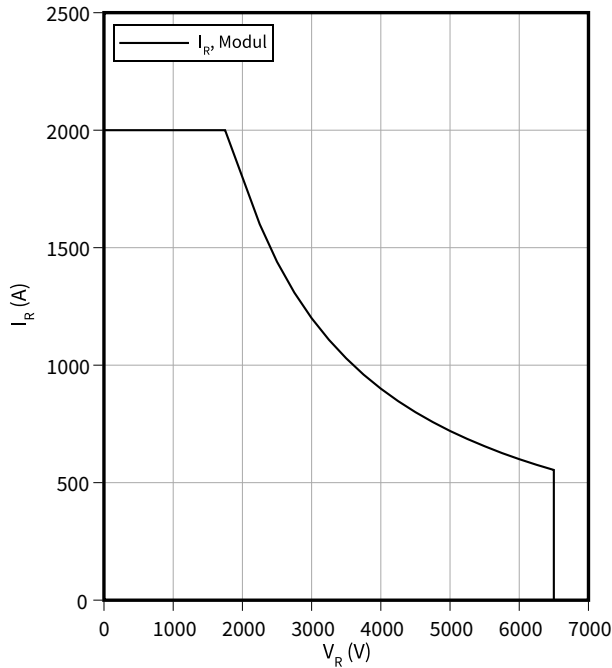
Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$
 $I_F = 1000\text{ A}, V_{CC} = 3600\text{ V}$



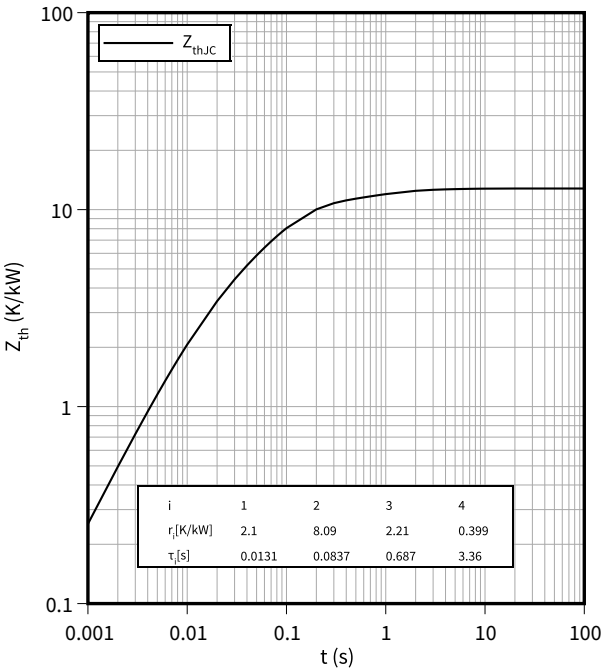
Safe operating area (SOA), Diode, Inverter

$I_R = f(V_R)$
 $T_{vj} = 135\text{ °C}$



Transient thermal impedance, Diode, Inverter

$Z_{th} = f(t)$



5 **Circuit diagram**

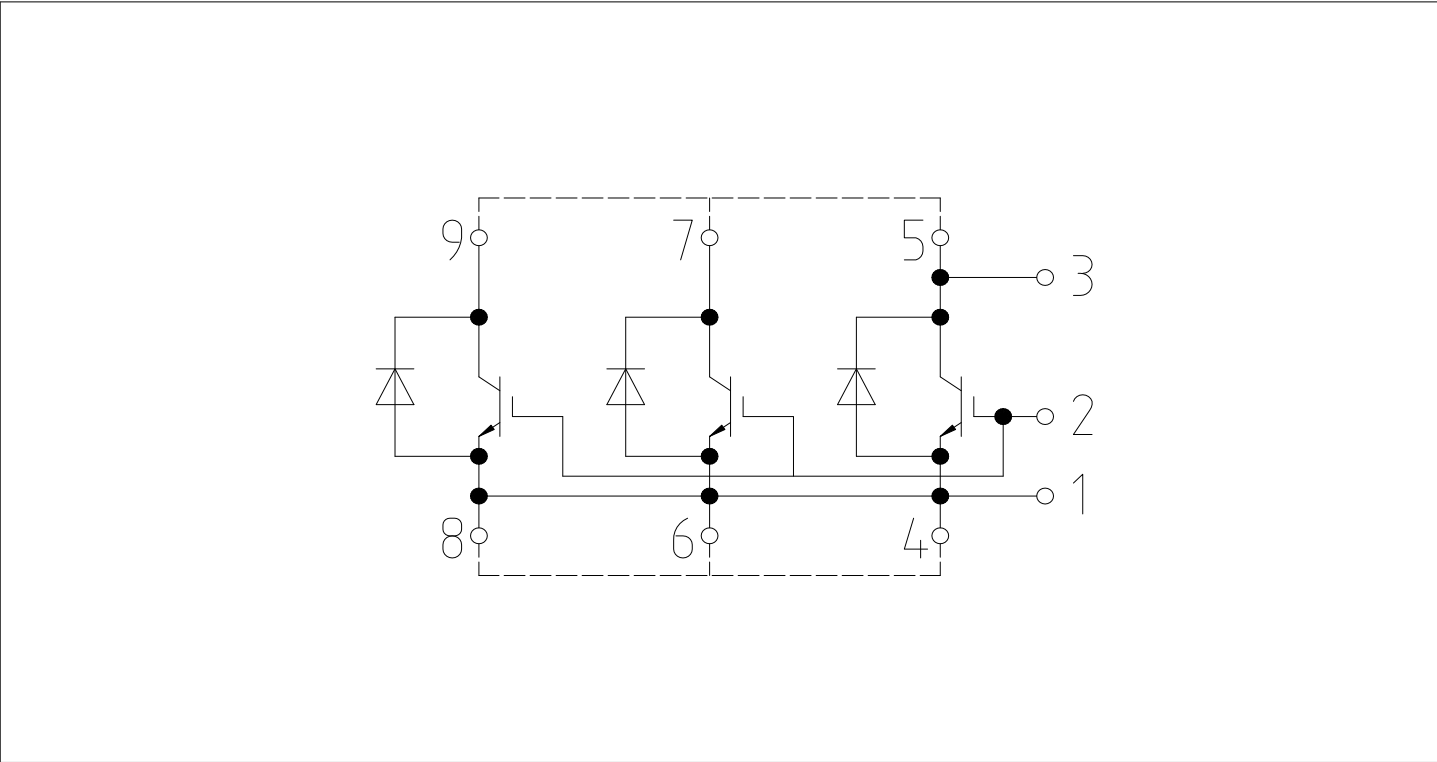


Figure 1

6 Package outlines

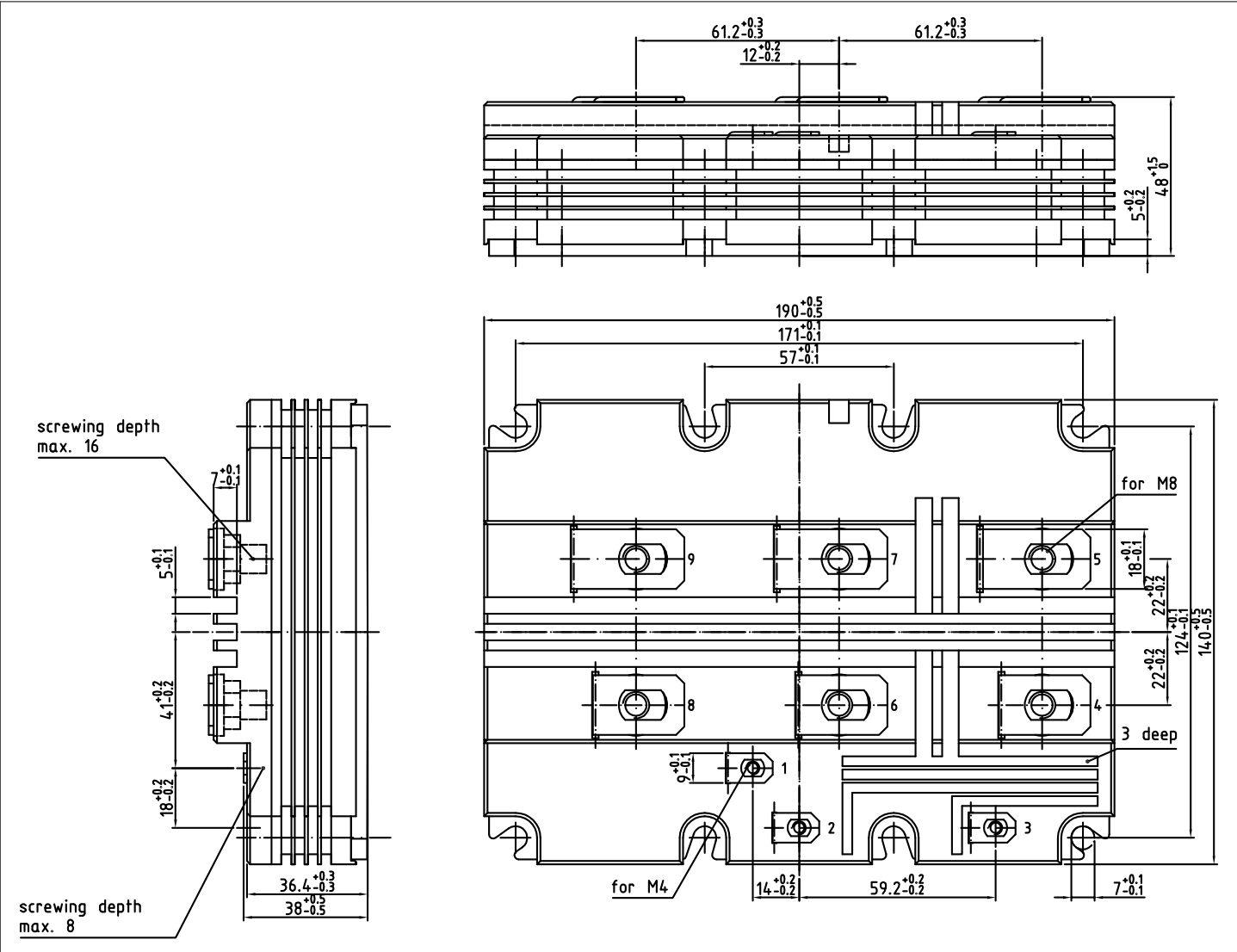


Figure 2

7 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		

Figure 3

Revision history

Document revision	Date of release	Description of changes
V1.0	2018-11-02	Target datasheet
V1.1	2018-11-07	Target datasheet
n/a	2020-09-01	Datasheet migrated to a new system with a new layout and new revision number schema: target or preliminary datasheet = 0.xy; final datasheet = 1.xy
0.20	2022-12-22	Target datasheet
0.30	2023-03-16	Target datasheet
0.40	2023-12-04	Preliminary datasheet
1.00	2024-03-27	Final datasheet
1.10	2024-07-25	Final datasheet
1.20	2024-11-28	Final datasheet
1.21	2024-12-09	Final datasheet

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Edition 2024-12-09

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference
IFX-AAAY124-009

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