

Highly insulated module with Trench/Fieldstop IGBT3 and emitter controlled 3 diode

Features

- Electrical features
 - $V_{CES} = 6500\text{ V}$
 - $I_{C\text{nom}} = 250\text{ A} / I_{CRM} = 500\text{ A}$
 - LOW $V_{CE,sat}$
- Mechanical features
 - ALSiC base plate for increased thermal cycling capability
 - Extended storage temperature down to $T_{stg} = -55\text{ °C}$
 - High creepage and clearance distances
 - Package with enhanced insulation of 10.4 kV AC 60 s
 - Package with CTI > 600



Potential applications

- Traction drives
- Medium-voltage converters

Product validation

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

Description

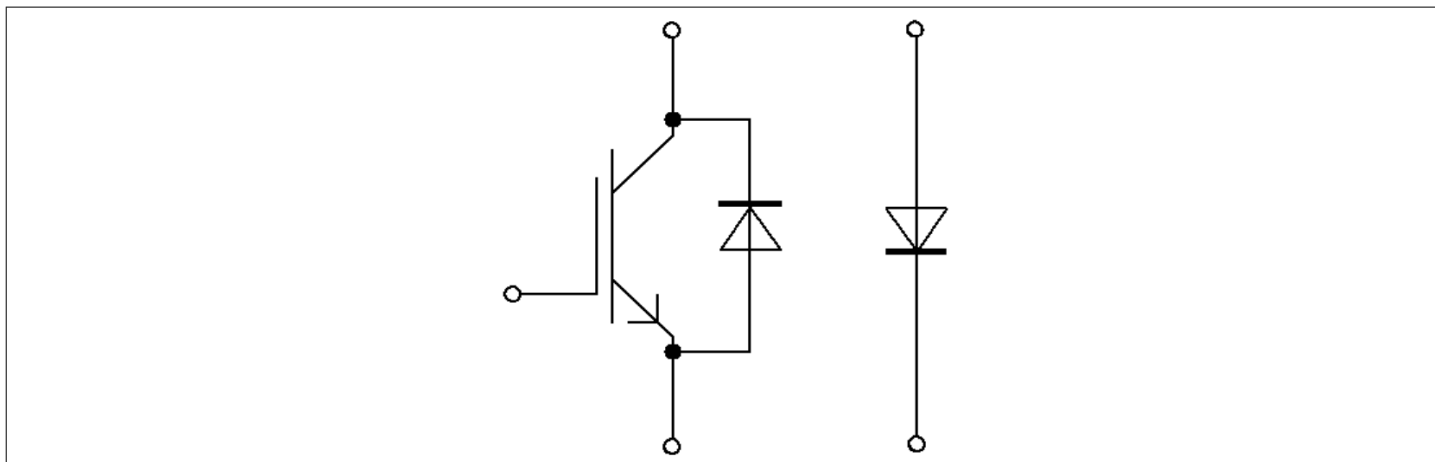


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1 Package

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	$V_{CE(D)}$	$T_{vj}=25^{\circ}\text{C}$, 100 Fit	3800	V
Material of module baseplate			AlSiC	
Internal isolation		basic insulation (class 1, IEC 61140)	AlN	
Creepage distance	d_{Creep}	terminal to heatsink	64.0	mm
Creepage distance	d_{Creep}	terminal to terminal	56.0	mm
Clearance	d_{Clear}	terminal to heatsink	40.0	mm
Clearance	d_{Clear}	terminal to terminal	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}			25		nH	
Module lead resistance, terminals - chip	$R_{AA'+CC'}$	$T_C=25^{\circ}\text{C}$, per switch		0.36		mΩ	
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C=25^{\circ}\text{C}$, per switch		0.36		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			1000		g	

2 IGBT, Inverter

Table 3 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit	
Collector-emitter voltage	V_{CES}		$T_{vj} = -50^{\circ}\text{C}$	5900	V
			$T_{vj} = 25^{\circ}\text{C}$	6500	
			$T_{vj} = 125^{\circ}\text{C}$	6500	

(table continues...)

Table 3 (continued) Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Continuous DC collector current	I_{CDC}	$T_{vj\ max} = 150\ ^\circ C$ $T_C = 80\ ^\circ C$	250	A
Repetitive peak collector current	I_{CRM}	$t_P = 1\ ms$	500	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	$V_{CE\ sat}$	$I_C = 250\ A, V_{GE} = 15\ V$	$T_{vj} = 25\ ^\circ C$	3.00	3.40	V
			$T_{vj} = 125\ ^\circ C$	3.70	4.20	
Gate threshold voltage	V_{GETh}	$I_C = 35\ mA, V_{CE} = V_{GE}, T_{vj} = 25\ ^\circ C$	5.40	6	6.60	V
Gate charge	Q_G	$V_{GE} = \pm 15\ V, V_{CE} = 3600\ V$		10		μC
Internal gate resistor	R_{Gint}	$T_{vj} = 25\ ^\circ C$		2.3		Ω
Input capacitance	C_{ies}	$f = 1000\ kHz, T_{vj} = 25\ ^\circ C, V_{CE} = 25\ V, V_{GE} = 0\ V$		69		nF
Reverse transfer capacitance	C_{res}	$f = 1000\ kHz, T_{vj} = 25\ ^\circ C, V_{CE} = 25\ V, V_{GE} = 0\ V$		1.05		nF
Collector-emitter cut-off current	I_{CES}	$V_{CE} = 6500\ V, V_{GE} = 0\ V$ $T_{vj} = 25\ ^\circ C$			5	mA
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0\ V, V_{GE} = 20\ V, T_{vj} = 25\ ^\circ C$			400	nA
Turn-on delay time (inductive load)	t_{don}	$I_C = 250\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Gon} = 3\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.640		μs
			$T_{vj} = 125\ ^\circ C$	0.650		
Rise time (inductive load)	t_r	$I_C = 250\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Gon} = 3\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.180		μs
			$T_{vj} = 125\ ^\circ C$	0.200		
Turn-off delay time (inductive load)	t_{doff}	$I_C = 250\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Goff} = 20\ \Omega$	$T_{vj} = 25\ ^\circ C$	7.300		μs
			$T_{vj} = 125\ ^\circ C$	7.600		
Fall time (inductive load)	t_f	$I_C = 250\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Goff} = 20\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.400		μs
			$T_{vj} = 125\ ^\circ C$	0.500		
Turn-on time (resistive load)	t_{on_R}	$I_C = 500\ A, V_{CE} = 2000\ V, V_{GE} = \pm 15\ V, R_{Gon} = 3\ \Omega$	1.91			μs
Turn-on energy loss per pulse	E_{on}	$I_C = 250\ A, V_{CE} = 3600\ V, L_\sigma = 280\ nH, V_{GE} = \pm 15\ V, R_{Gon} = 3\ \Omega$	$T_{vj} = 25\ ^\circ C$	1400		mJ
			$T_{vj} = 125\ ^\circ C$	2200		
Turn-off energy loss per pulse	E_{off}	$I_C = 250\ A, V_{CE} = 3600\ V, L_\sigma = 280\ nH, V_{GE} = \pm 15\ V, R_{Goff} = 20\ \Omega$	$T_{vj} = 25\ ^\circ C$	1200		mJ
			$T_{vj} = 125\ ^\circ C$	1400		
SC data	I_{SC}	$V_{GE} \leq 15\ V, V_{CC} = 4500\ V, V_{CEmax} = V_{CES} - L_{sCE} * di/dt$	$t_P \leq 10\ \mu s, T_{vj} \leq 125\ ^\circ C$	1500		A

(table continues...)

Table 4 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Thermal resistance, junction to case	R_{thJC}	per IGBT			26.1	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per IGBT, $\lambda_{grease} = 1 \text{ W}/(\text{m}^2\text{K})$		26.4		K/kW
Temperature under switching conditions	$T_{vj\text{op}}$		-50		125	°C

3 Diode, Inverter

Table 5 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit	
Repetitive peak reverse voltage	V_{RRM}		$T_{vj} = -50 \text{ °C}$	5900	V
			$T_{vj} = 25 \text{ °C}$	6500	
			$T_{vj} = 125 \text{ °C}$	6500	
Continuous DC forward current	I_F		250	A	
Repetitive peak forward current	I_{FRM}	$t_P = 1 \text{ ms}$	500	A	
I^2t - value	I^2t	$t_P = 10 \text{ ms}, V_R = 0 \text{ V}$	$T_{vj} = 125 \text{ °C}$	52	kA^2s
Maximum power dissipation	P_{RQM}	$T_{vj} = 125 \text{ °C}$	1000	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	$I_F = 250 \text{ A}, V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$	3.00	3.50	V
			$T_{vj} = 125 \text{ °C}$	2.95	3.50	
Peak reverse recovery current	I_{RM}	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	370		A
			$T_{vj} = 125 \text{ °C}$	400		
Recovered charge	Q_r	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	290		μC
			$T_{vj} = 125 \text{ °C}$	540		
Reverse recovery energy	E_{rec}	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	470		mJ
			$T_{vj} = 125 \text{ °C}$	1000		

(table continues...)

Table 6 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Thermal resistance, junction to case	R_{thJC}	per diode			55.8	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}^2\text{K})$		42.0		K/kW
Temperature under switching conditions	$T_{vj\text{op}}$		-50		125	°C

4 Diode, Brake-Chopper

Table 7 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit	
Repetitive peak reverse voltage	V_{RRM}		$T_{vj} = -50 \text{ °C}$	5900	V
			$T_{vj} = 25 \text{ °C}$	6500	
			$T_{vj} = 125 \text{ °C}$	6500	
Continuous DC forward current	I_F		250	A	
Repetitive peak forward current	I_{FRM}	$t_p = 1 \text{ ms}$	500	A	
I^2t - value	I^2t	$t_p = 10 \text{ ms}, V_R = 0 \text{ V}$	$T_{vj} = 125 \text{ °C}$	52	kA^2s
Maximum power dissipation	P_{RQM}	$T_{vj} = 125 \text{ °C}$	1000	kW	
Minimum turn-on time	t_{onmin}		10	μs	

Table 8 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	$I_F = 250 \text{ A}, V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$	3.00	3.50	V
			$T_{vj} = 125 \text{ °C}$	2.95	3.50	
Peak reverse recovery current	I_{RM}	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	370		A
			$T_{vj} = 125 \text{ °C}$	400		
Recovered charge	Q_r	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	290		μC
			$T_{vj} = 125 \text{ °C}$	540		
Reverse recovery energy	E_{rec}	$V_R = 3600 \text{ V}, I_F = 250 \text{ A}, V_{GE} = -15 \text{ V}, -di_F/dt = 1000 \text{ A}/\mu\text{s} (T_{vj} = 125 \text{ °C})$	$T_{vj} = 25 \text{ °C}$	470		mJ
			$T_{vj} = 125 \text{ °C}$	1000		

(table continues...)

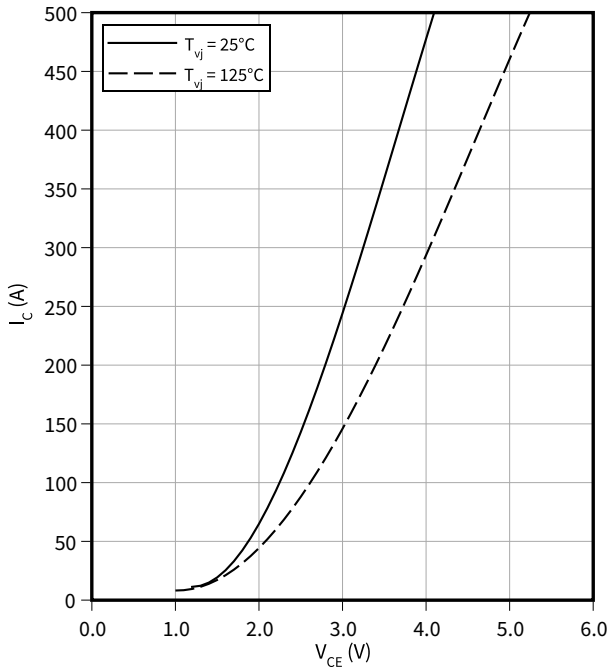
Table 8 (continued) **Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Thermal resistance, junction to case	R_{thJC}	per diode			55.8	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}^2\text{K})$		42.0		K/kW
Temperature under switching conditions	$T_{vj op}$		-50		125	°C

5 Characteristics diagrams

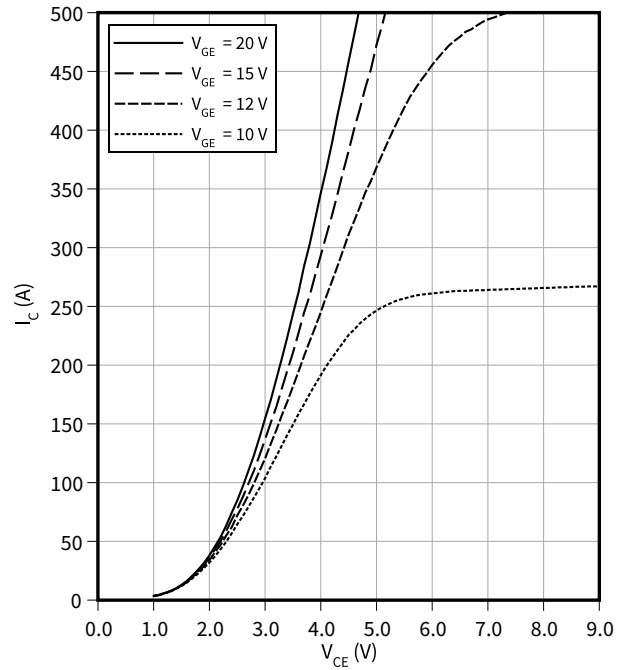
output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$
 $V_{GE} = 15 \text{ V}$



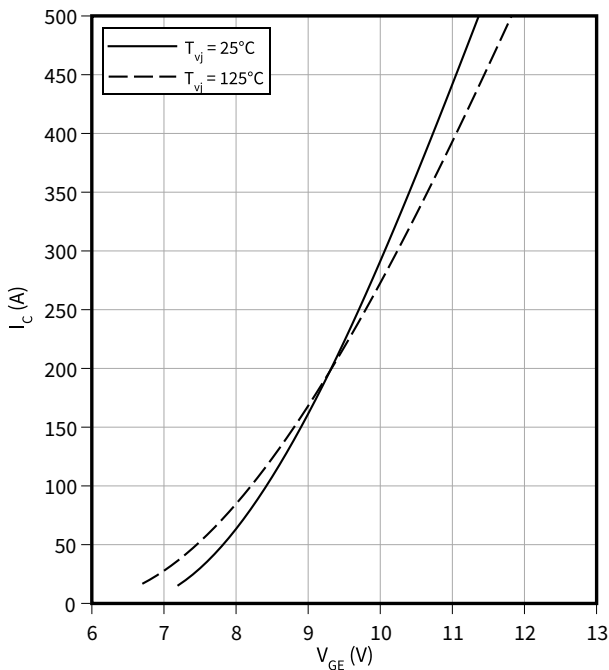
output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$
 $T_{vj} = 125 \text{ °C}$



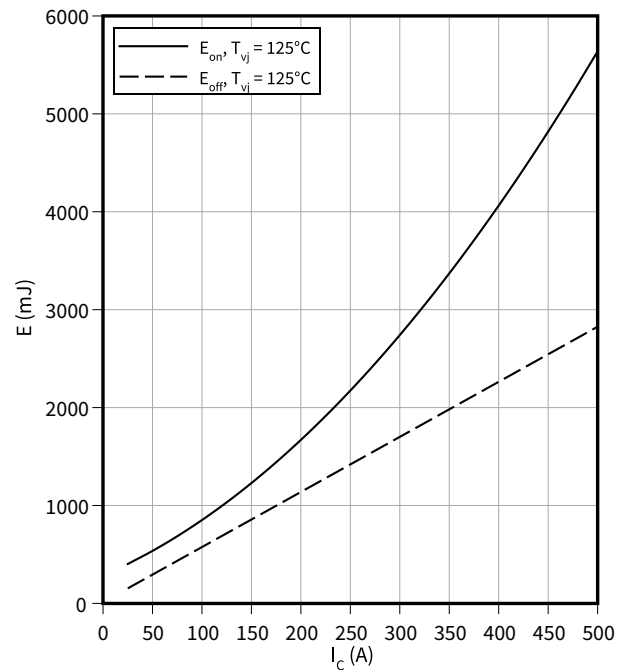
transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$
 $V_{CE} = 20 \text{ V}$



switching losses (typical), IGBT, Inverter

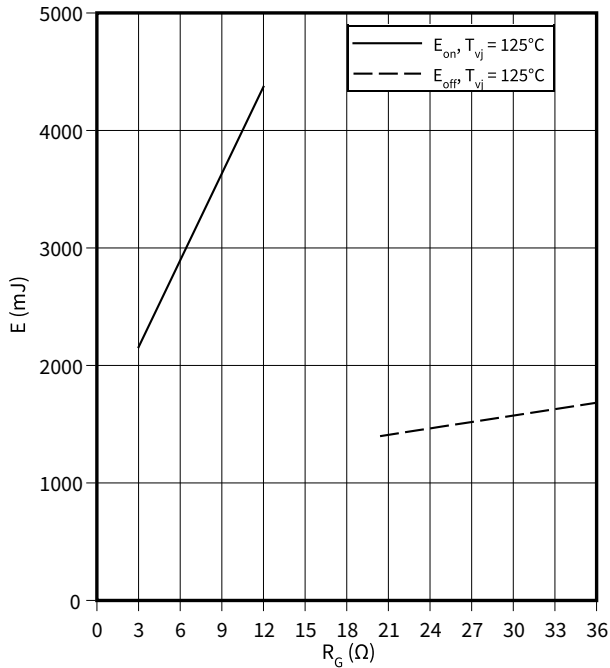
$E = f(I_C)$
 $R_{Goff} = 20 \text{ } \Omega$, $R_{Gon} = 3 \text{ } \Omega$, $V_{CE} = 3600 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$



switching losses (typical), IGBT, Inverter

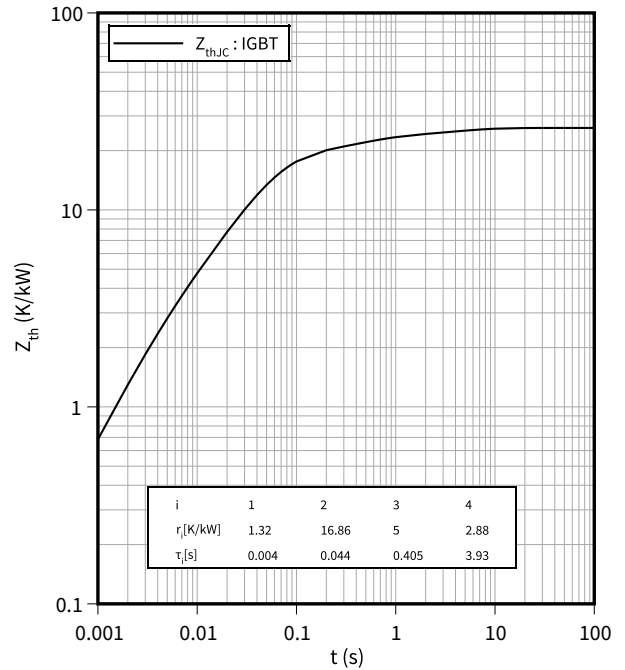
$E = f(R_G)$

$I_C = 250 \text{ A}$, $V_{CE} = 3600 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$



transient thermal impedance , IGBT, Inverter

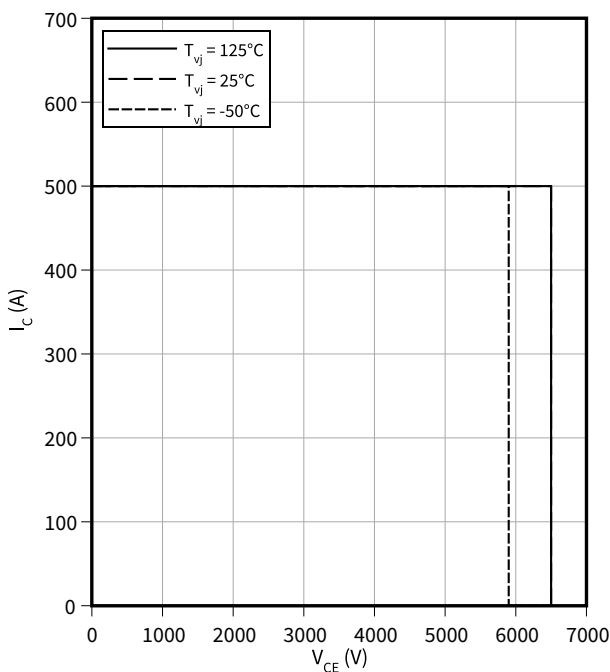
$Z_{th} = f(t)$



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

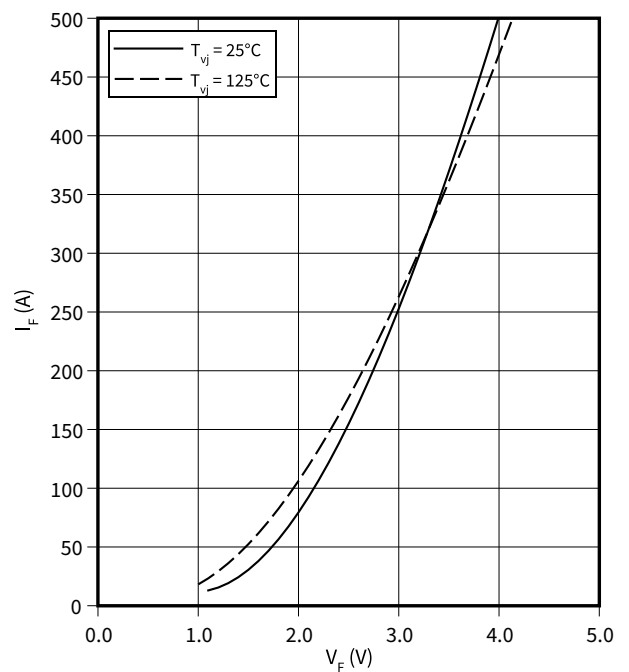
$I_C = f(V_{CE})$

$R_{Goff} = 20 \Omega$, $V_{GE} = \pm 15 \text{ V}$



forward characteristic of (typical), Diode, Inverter

$I_F = f(V_F)$

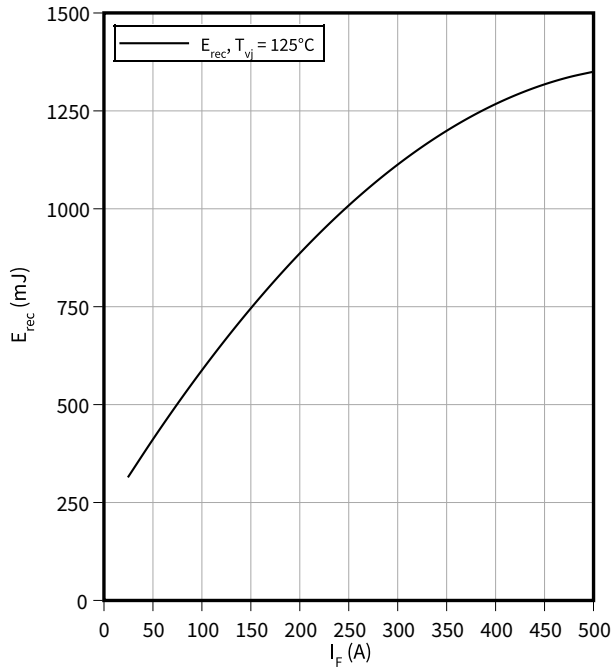


5 Characteristics diagrams

switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

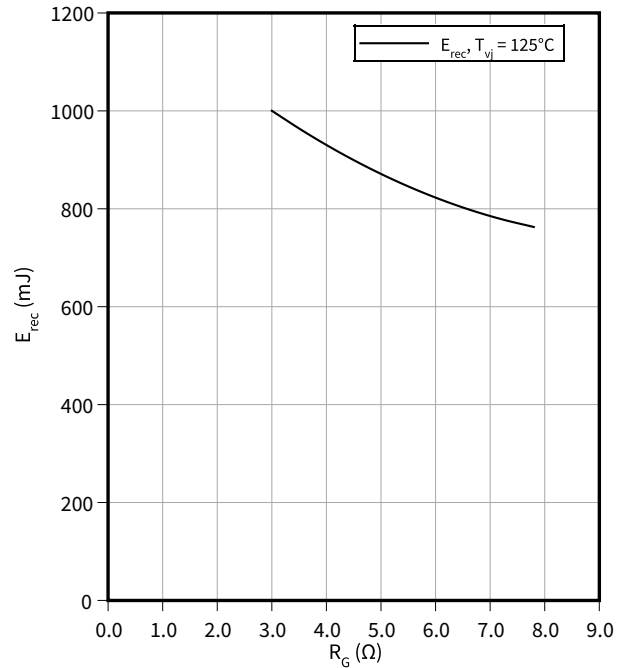
$V_{CE} = 3600\text{ V}, R_{Gon} = R_{Gon}(IGBT)$



switching losses (typical), Diode, Inverter

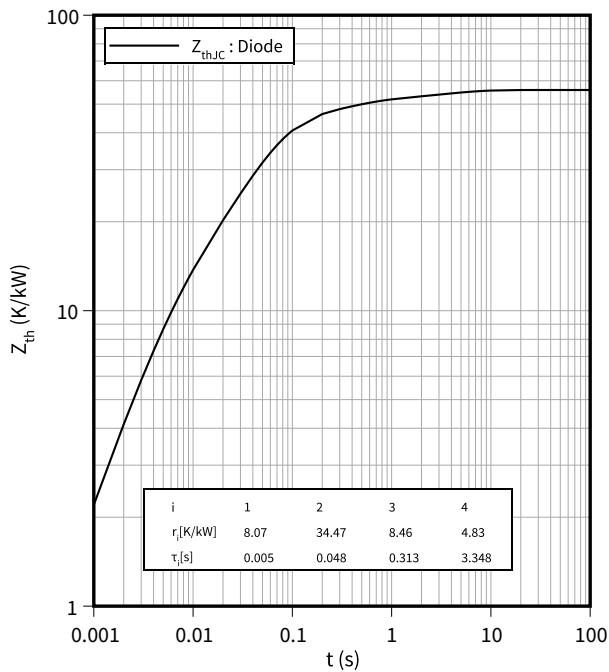
$E_{rec} = f(R_G)$

$V_{CE} = 3600\text{ V}, I_F = 250\text{ A}$



transient thermal impedance , Diode, Inverter

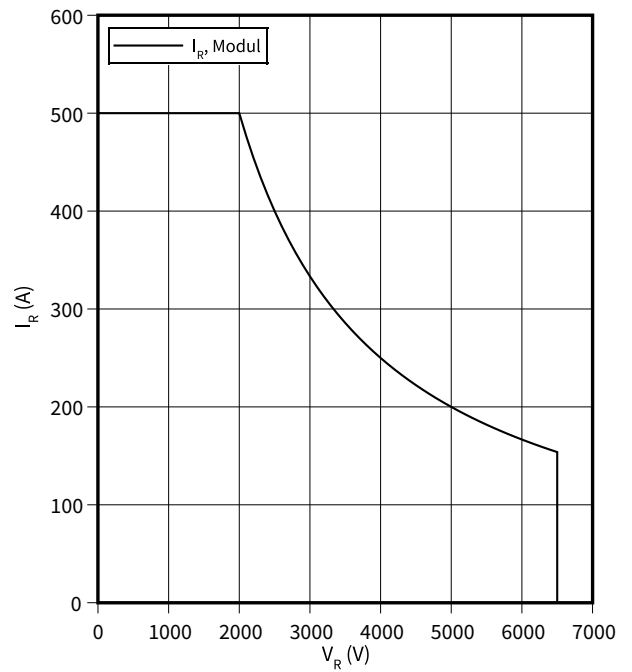
$Z_{th} = f(t)$



safe operation area (SOA), Diode, Inverter

$I_R = f(V_R)$

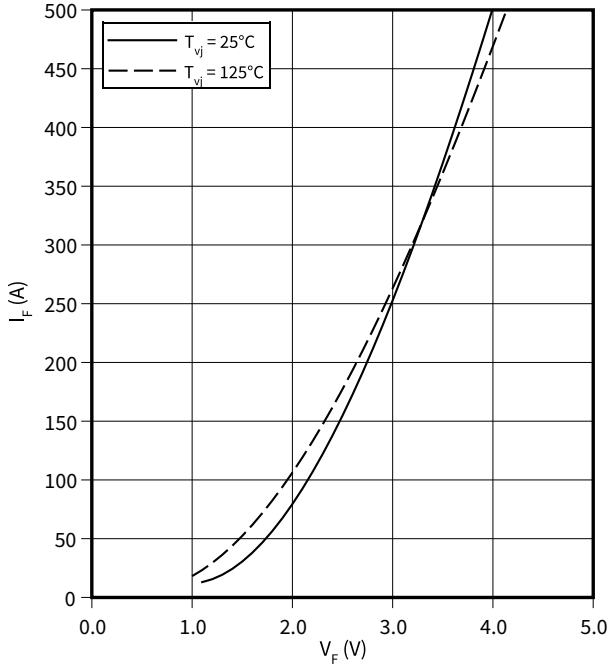
$T_{vj} = 125\text{ °C}$



5 Characteristics diagrams

forward characteristic of (typical), Diode, Brake-Chopper

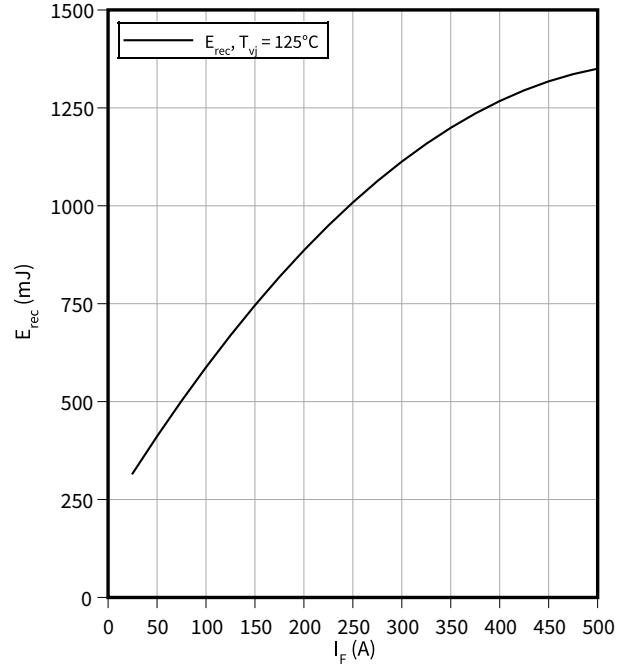
$I_F = f(V_F)$



switching losses (typical), Diode, Brake-Chopper

$E_{rec} = f(I_F)$

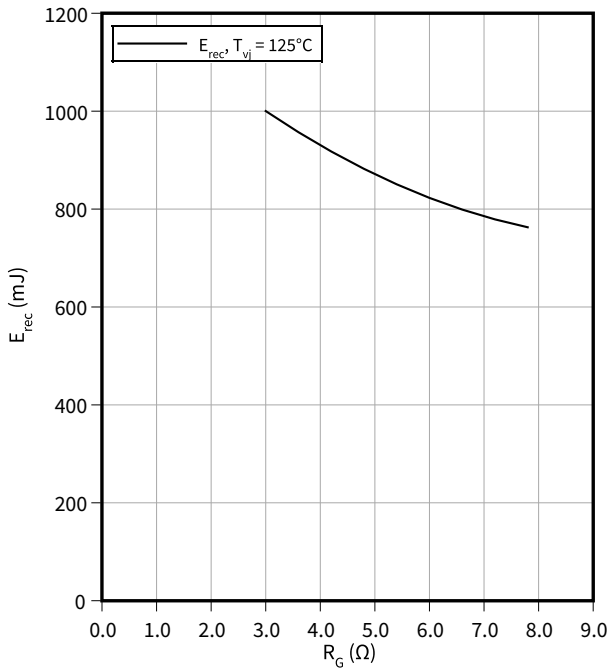
$V_{CE} = 3600 \text{ V}, R_{Gon} = R_{Gon}(IGBT)$



switching losses (typical), Diode, Brake-Chopper

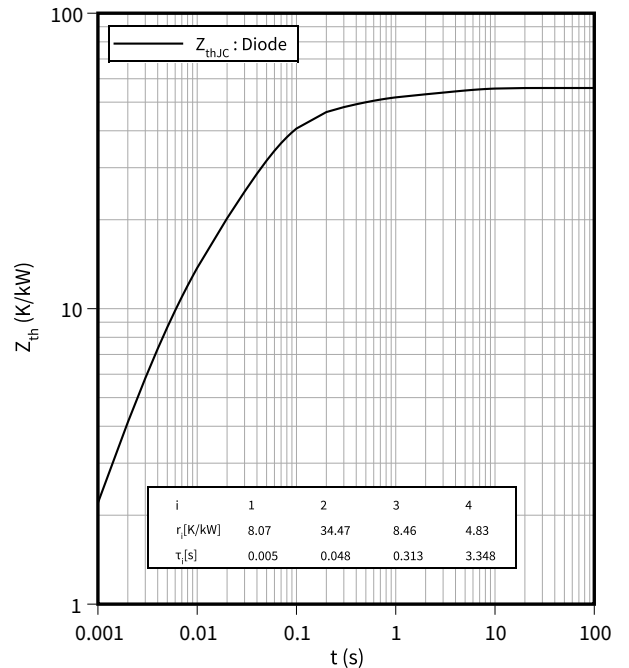
$E_{rec} = f(R_G)$

$V_{CE} = 3600 \text{ V}, I_F = 250 \text{ A}$



transient thermal impedance, Diode, Brake-Chopper

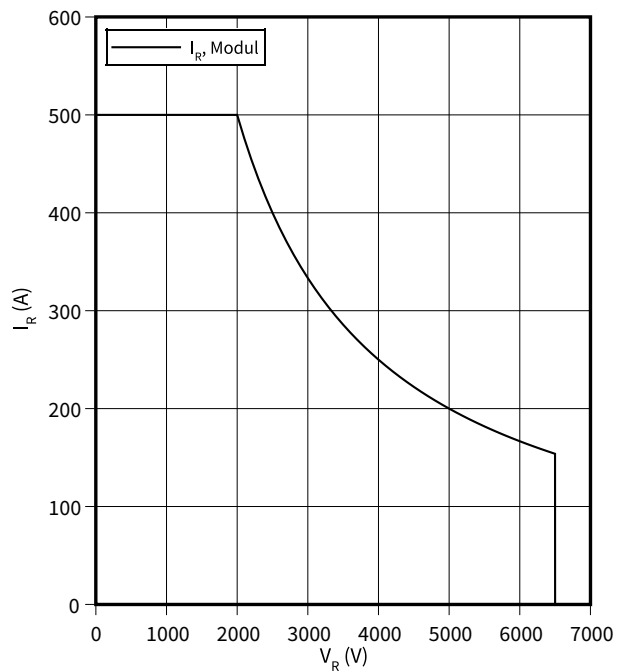
$Z_{th} = f(t)$



safe operation area (SOA), Diode, Brake-Chopper

$$I_R = f(V_R)$$

$$T_{vj} = 125\text{ °C}$$



6 Circuit diagram

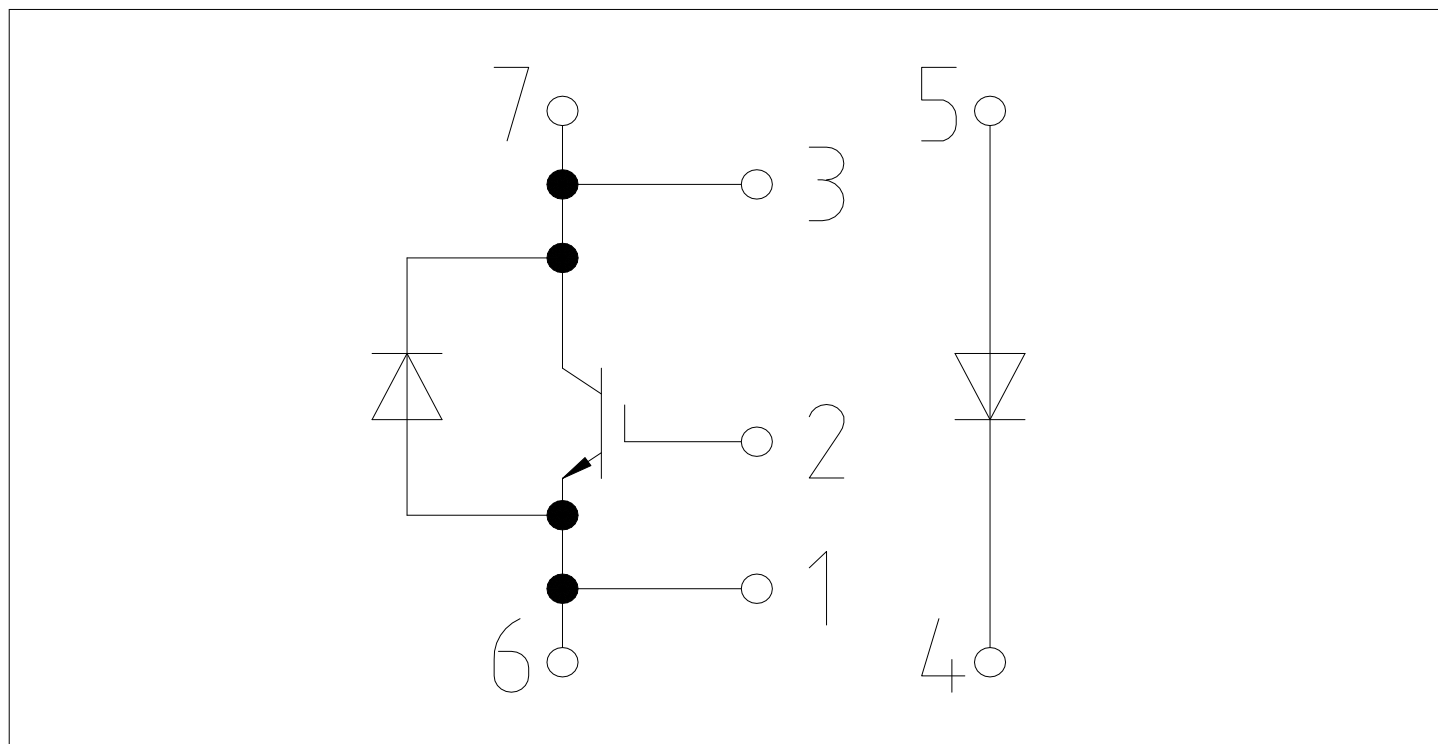


Figure 1

7 Package outlines

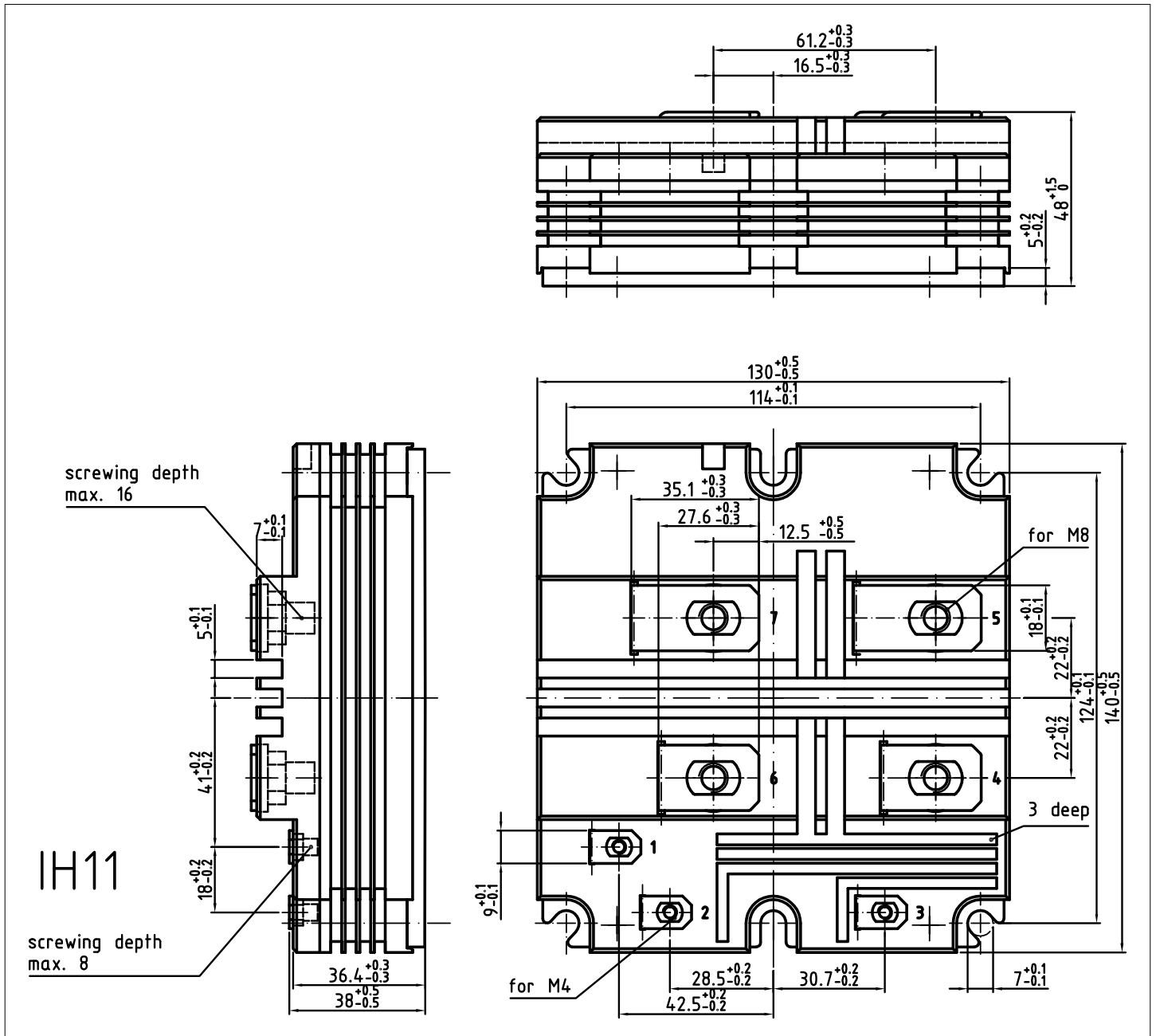


Figure 2

8 Module label code


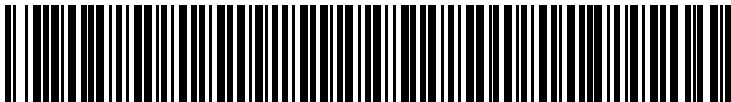
Module label code			
Code format	Data Matrix	Barcode Code128	
Encoding	ASCII text	Code Set A	
Symbol size	16x16	23 digits	
Standard	IEC24720 and IEC16022	IEC8859-1	
Code content	<i>Content</i>	<i>Digit</i>	<i>Example</i>
	Module serial number	1 - 5	71549
	Module material number	6 - 11	142846
	Production order number	12 - 19	55054991
	Date code (production year)	20 - 21	15
	Date code (production week)	22 - 23	30
Example	 		
	71549142846550549911530		71549142846550549911530

Figure 3

Revision history

Document revision	Date of release	Description of changes
V1.0	2012-07-13	Target datasheet
V2.0	2012-07-16	Preliminary datasheet
V2.1	2012-12-03	Preliminary datasheet
V3.0	2014-06-16	Final datasheet
V3.1	2018-01-15	Final datasheet
V3.2	2019-09-06	Final datasheet
V3.3	2020-05-06	Final 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
1.10	2021-11-05	Final datasheet

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[FD401R17KF6C_B2](#) [FD-DF80R12W1H3_B52](#) [FF200R06YE3](#) [FF300R12KE4_E](#) [FF450R12ME4P](#) [FF600R12IP4V](#) [FP10R06W1E3_B11](#)
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[FZ1800R17KF4](#) [DD250S65K3](#) [DF1000R17IE4](#) [DF1000R17IE4D_B2](#) [DF1400R12IP4D](#) [DF200R12PT4_B6](#) [DF400R07PE4R_B6](#)
[BSM75GB120DN2_E3223c-Se](#) [F3L300R12ME4_B22](#) [F3L75R07W2E3_B11](#) [F4-50R12KS4_B11](#) [F475R07W1H3B11ABOMA1](#)
[FD1400R12IP4D](#) [FD200R12PT4_B6](#) [FD800R33KF2C-K](#) [FF1200R17KP4_B2](#) [FF300R17KE3_S4](#) [FF300R17ME4_B11](#) [FF401R17KF6C_B2](#)
[FF650R17IE4D_B2](#) [FF900R12IP4D](#) [FF900R12IP4DV](#) [STGIF7CH60TS-L](#) [FP50R07N2E4_B11](#) [FS100R07PE4](#) [FS150R07N3E4_B11](#)
[FS150R17N3E4](#) [FS150R17PE4](#) [FS225R12KE4](#)