

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

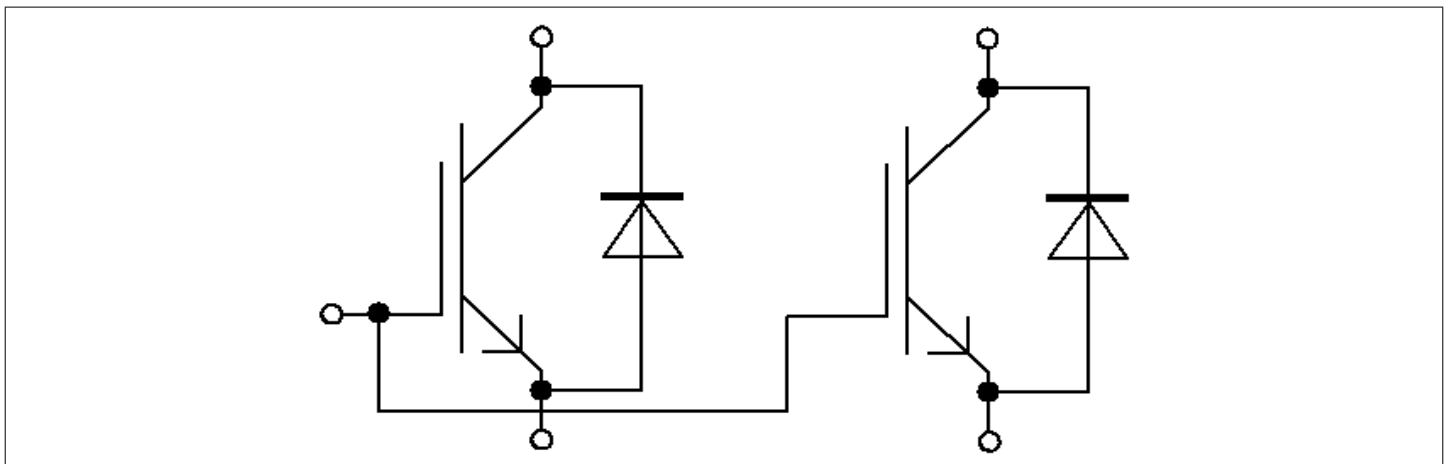
- Electrical features
  - $V_{CES} = 6500\text{ V}$
  - $I_{C\text{nom}} = 400\text{ A} / I_{CRM} = 800\text{ A}$
  - Low  $V_{CE,\text{sat}}$
- Mechanical features
  - Extended storage temperature down to  $T_{\text{stg}} = -55\text{ °C}$
  - High creepage and clearance distances
  - Package with CTI > 600
  - Package with enhanced insulation of 10.4 kV AC 60 s
  - AlSiC base plate for increased thermal cycling capability

**Potential applications**

- Medium-voltage converters
- Traction drives

**Product validation**

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

**Description**

## Table of contents

	<b>Description</b> .....	1
	<b>Features</b> .....	1
	<b>Potential applications</b> .....	1
	<b>Product validation</b> .....	1
	<b>Table of contents</b> .....	2
<b>1</b>	<b>Package</b> .....	3
<b>2</b>	<b>IGBT, Inverter</b> .....	3
<b>3</b>	<b>Diode, Inverter</b> .....	5
<b>4</b>	<b>Characteristics diagrams</b> .....	7
<b>5</b>	<b>Circuit diagram</b> .....	10
<b>6</b>	<b>Package outlines</b> .....	11
<b>7</b>	<b>Module label code</b> .....	12
	<b>Revision history</b> .....	13
	<b>Disclaimer</b> .....	14

## 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	$L_{sCE}$			20		nH	
Module lead resistance, terminals - chip	$R_{AA'+CC'}$	$T_C=25^{\circ}\text{C}$ , per switch		0.18		mΩ	
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C=25^{\circ}\text{C}$ , per switch		0.18		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	$I_{CDC}$	$T_{vj\ max} = 150\ ^\circ\text{C}$ $T_C = 80\ ^\circ\text{C}$	400	A
Repetitive peak collector current	$I_{CRM}$	$t_p = 1\ \text{ms}$	800	A
Gate-emitter peak voltage	$V_{GES}$		$\pm 20$	V

**Table 4 Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Collector-emitter saturation voltage	$V_{CE\ sat}$	$I_C = 400\ \text{A}, V_{GE} = 15\ \text{V}$	$T_{vj} = 25\ ^\circ\text{C}$	3.00	3.40	V
			$T_{vj} = 125\ ^\circ\text{C}$	3.70		
Gate threshold voltage	$V_{GEth}$	$I_C = 70\ \text{mA}, V_{CE} = V_{GE}, T_{vj} = 25\ ^\circ\text{C}$	5.40	6	6.60	V
Gate charge	$Q_G$	$V_{GE} = \pm 15\ \text{V}, V_{CE} = 3600\ \text{V}$		17		$\mu\text{C}$
Internal gate resistor	$R_{Gint}$	$T_{vj} = 25\ ^\circ\text{C}$		1.1		$\Omega$
Input capacitance	$C_{ies}$	$f = 1000\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$		110		nF
Reverse transfer capacitance	$C_{res}$	$f = 1000\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$		1.7		nF
Collector-emitter cut-off current	$I_{CES}$	$V_{CE} = 6500\ \text{V}, V_{GE} = 0\ \text{V}$ $T_{vj} = 25\ ^\circ\text{C}$			5	mA
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\ \text{V}, V_{GE} = 20\ \text{V}, T_{vj} = 25\ ^\circ\text{C}$			400	nA
Turn-on delay time (inductive load)	$t_{don}$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1.9\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	0.640		$\mu\text{s}$
			$T_{vj} = 125\ ^\circ\text{C}$	0.650		
Rise time (inductive load)	$t_r$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1.9\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	0.180		$\mu\text{s}$
			$T_{vj} = 125\ ^\circ\text{C}$	0.200		
Turn-off delay time (inductive load)	$t_{doff}$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 13\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	7.300		$\mu\text{s}$
			$T_{vj} = 125\ ^\circ\text{C}$	7.600		
Fall time (inductive load)	$t_f$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 13\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	0.400		$\mu\text{s}$
			$T_{vj} = 125\ ^\circ\text{C}$	0.500		
Turn-on time (resistive load)	$t_{on\_R}$	$I_C = 500\ \text{A}, V_{CE} = 2000\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1.9\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	1.55		$\mu\text{s}$
Turn-on energy loss per pulse	$E_{on}$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, L_\sigma = 280\ \text{nH}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1.9\ \Omega, di/dt = 1600\ \text{A}/\mu\text{s} (T_{vj} = 125\ ^\circ\text{C})$	$T_{vj} = 25\ ^\circ\text{C}$	2250		mJ
			$T_{vj} = 125\ ^\circ\text{C}$	3450		
Turn-off energy loss per pulse	$E_{off}$	$I_C = 400\ \text{A}, V_{CE} = 3600\ \text{V}, L_\sigma = 280\ \text{nH}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 13\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	2000		mJ
			$T_{vj} = 125\ ^\circ\text{C}$	2250		

(table continues...)

**Table 4 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
SC data	$I_{SC}$	$V_{GE} \leq 15 \text{ V}$ , $V_{CC} = 4500 \text{ V}$ , $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$	$t_P \leq 10 \mu\text{s}$ , $T_{vj} \leq 125 \text{ }^\circ\text{C}$		2400		A
Thermal resistance, junction to case	$R_{thJC}$	per IGBT			15.0		K/kW
Thermal resistance, case to heat sink	$R_{thCH}$	per IGBT, $\lambda_{grease} = 1 \text{ W}/(\text{m}^2\text{K})$		13.8			K/kW
Temperature under switching conditions	$T_{vjop}$		-50		125		$^\circ\text{C}$

### 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	
			$T_{vj} = 125 \text{ }^\circ\text{C}$	6500	
Continuous DC forward current	$I_F$		400	A	
Repetitive peak forward current	$I_{FRM}$	$t_P = 1 \text{ ms}$	800	A	
$I^2t$ - value	$I^2t$	$t_P = 10 \text{ ms}$ , $V_R = 0 \text{ V}$	$T_{vj} = 125 \text{ }^\circ\text{C}$	130	$\text{kA}^2\text{s}$
Maximum power dissipation	$P_{RQM}$	$T_{vj} = 125 \text{ }^\circ\text{C}$	1600	kW	
Minimum turn-on time	$t_{onmin}$		10	$\mu\text{s}$	

**Table 6 Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Forward voltage	$V_F$	$I_F = 400 \text{ A}$ , $V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		3.00	3.50	V
			$T_{vj} = 125 \text{ }^\circ\text{C}$		2.95		
Peak reverse recovery current	$I_{RM}$	$V_R = 3600 \text{ V}$ , $I_F = 400 \text{ A}$ , $V_{GE} = -15 \text{ V}$ , $-di_F/dt = 1600 \text{ A}/\mu\text{s}$ ( $T_{vj} = 125 \text{ }^\circ\text{C}$ )	$T_{vj} = 25 \text{ }^\circ\text{C}$		600		A
			$T_{vj} = 125 \text{ }^\circ\text{C}$		670		
Recovered charge	$Q_r$	$V_R = 3600 \text{ V}$ , $I_F = 400 \text{ A}$ , $V_{GE} = -15 \text{ V}$ , $-di_F/dt = 1600 \text{ A}/\mu\text{s}$ ( $T_{vj} = 125 \text{ }^\circ\text{C}$ )	$T_{vj} = 25 \text{ }^\circ\text{C}$		470		$\mu\text{C}$
			$T_{vj} = 125 \text{ }^\circ\text{C}$		870		

(table continues...)

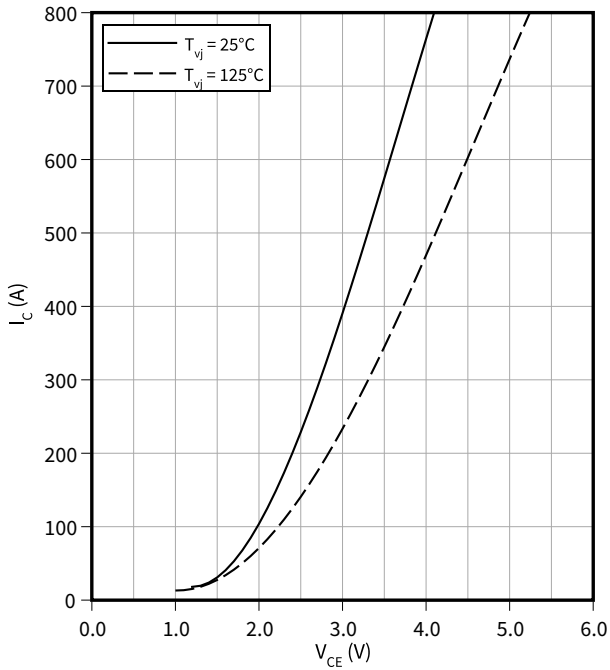
**Table 6 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Reverse recovery energy	$E_{rec}$	$V_R = 3600\text{ V}$ , $I_F = 400\text{ A}$ , $V_{GE} = -15\text{ V}$ , $-di_F/dt =$ $1600\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ }^\circ\text{C}$ )				mJ	
			$T_{vj} = 25\text{ }^\circ\text{C}$		740		
			$T_{vj} = 125\text{ }^\circ\text{C}$		1600		
Thermal resistance, junction to case	$R_{thJC}$	per diode			33.0	K/kW	
Thermal resistance, case to heat sink	$R_{thCH}$	per diode, $\lambda_{grease} = 1\text{ W}/(\text{m}^*\text{K})$		21.6		K/kW	
Temperature under switching conditions	$T_{vj\text{op}}$		-50		125	$^\circ\text{C}$	

## 4 Characteristics diagrams

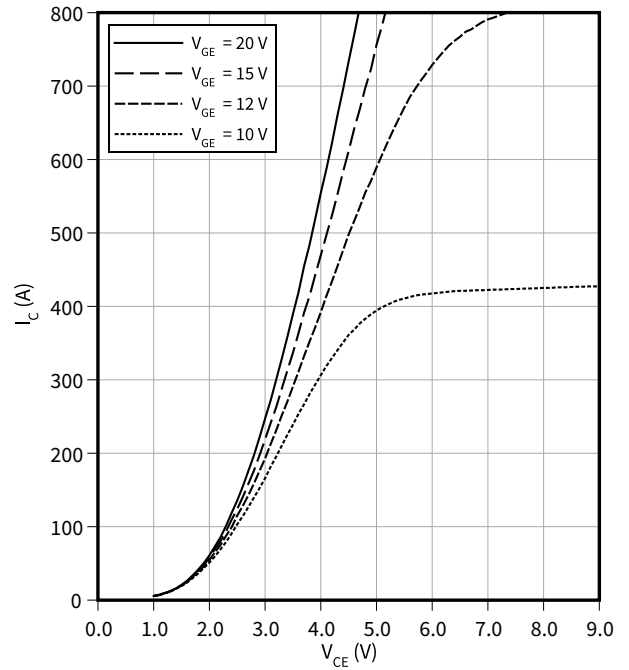
**output characteristic (typical), IGBT, Inverter**

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



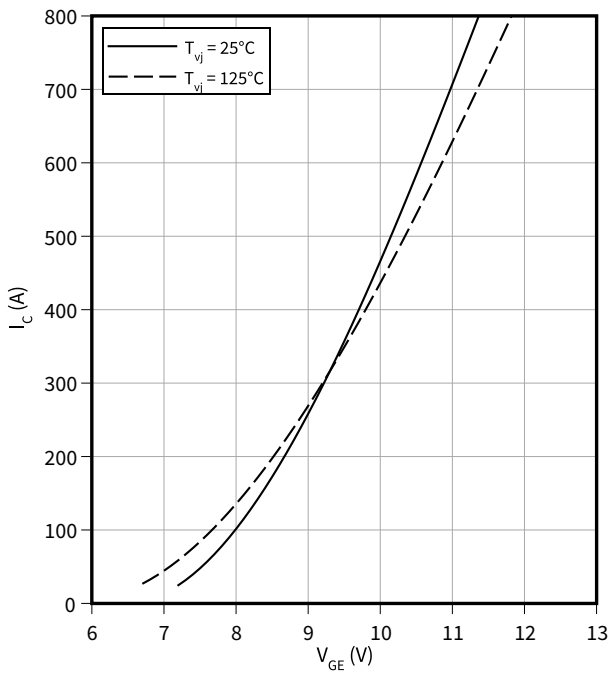
**output characteristic (typical), IGBT, Inverter**

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



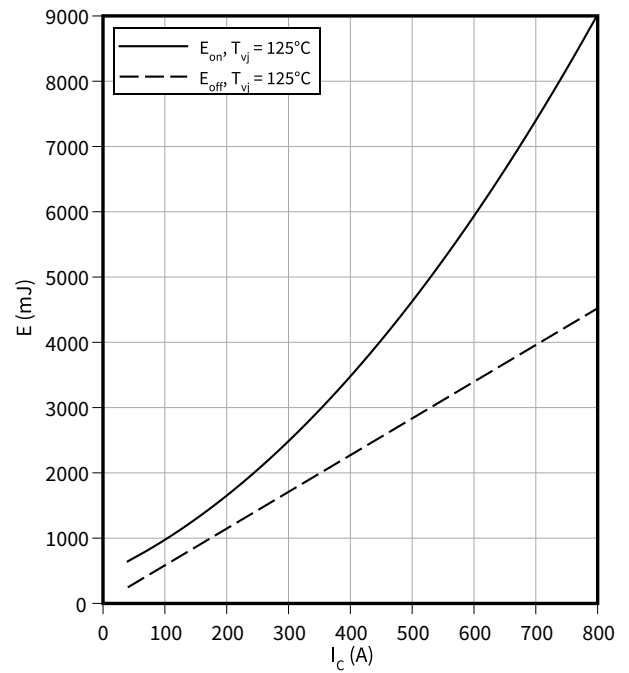
**transfer characteristic (typical), IGBT, Inverter**

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



**switching losses (typical), IGBT, Inverter**

$E = f(I_C)$   
 $R_{Goff} = 13 \text{ } \Omega$ ,  $R_{Gon} = 1.9 \text{ } \Omega$ ,  $V_{CE} = 3600 \text{ V}$ ,  $V_{GE} = \pm 15 \text{ V}$

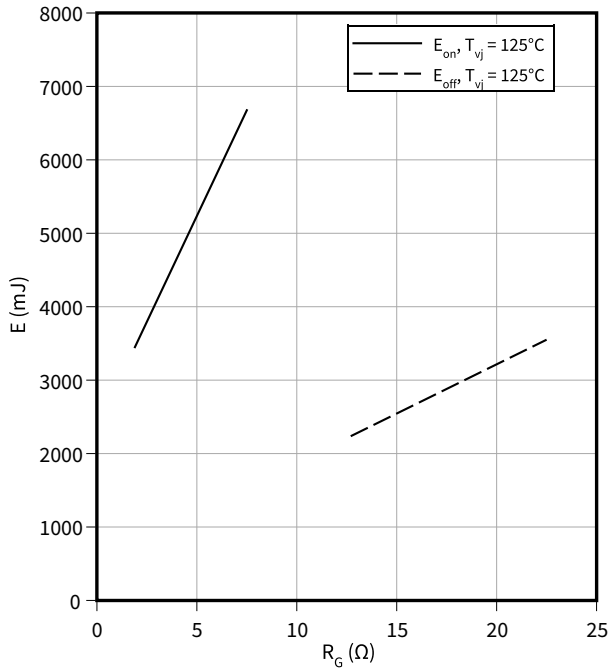


4 Characteristics diagrams

**switching losses (typical), IGBT, Inverter**

$E = f(R_G)$

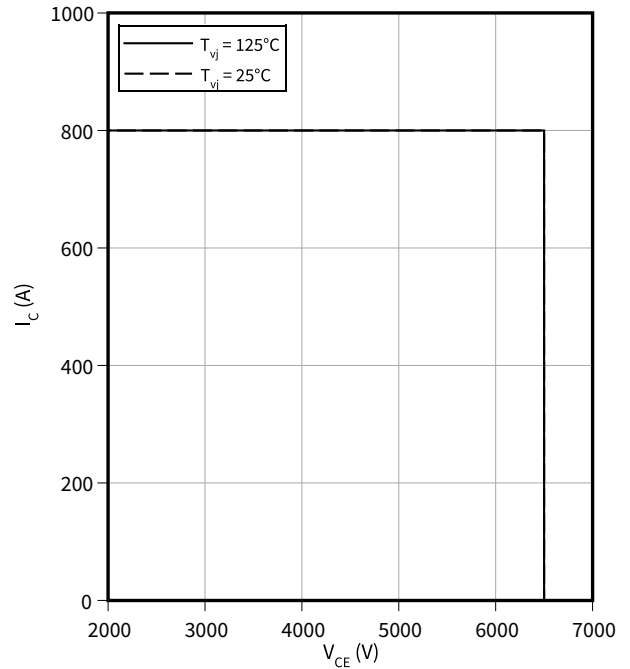
$I_C = 400 \text{ A}$ ,  $V_{CE} = 3600 \text{ V}$ ,  $V_{GE} = \pm 15 \text{ V}$



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

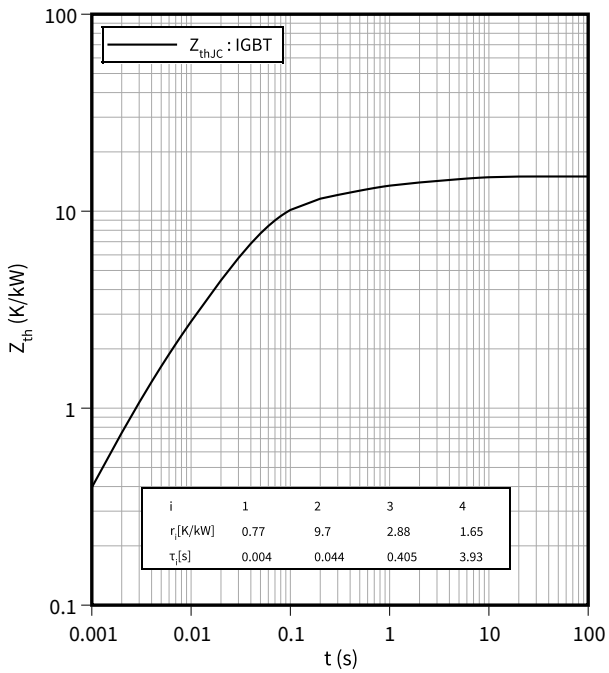
$I_C = f(V_{CE})$

$R_{Goff} = 13 \text{ } \Omega$ ,  $V_{GE} = \pm 15 \text{ V}$



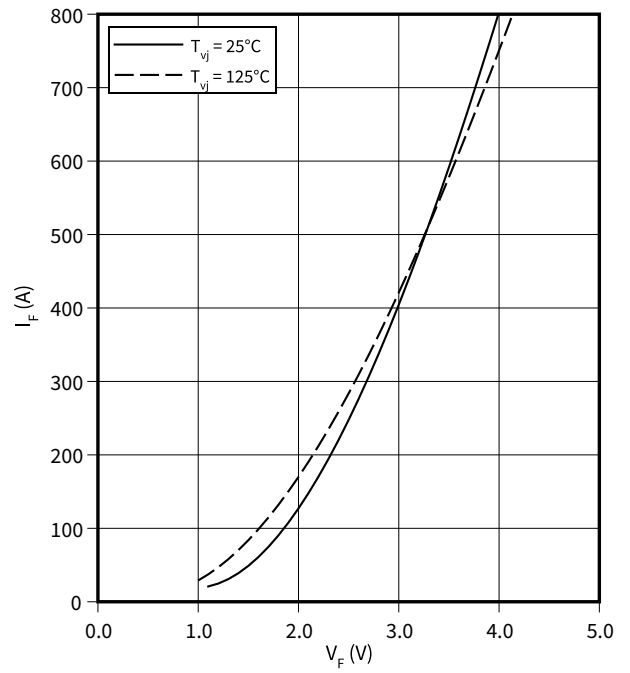
**transient thermal impedance, IGBT, Inverter**

$Z_{th} = f(t)$



**forward characteristic of (typical), Diode, Inverter**

$I_F = f(V_F)$



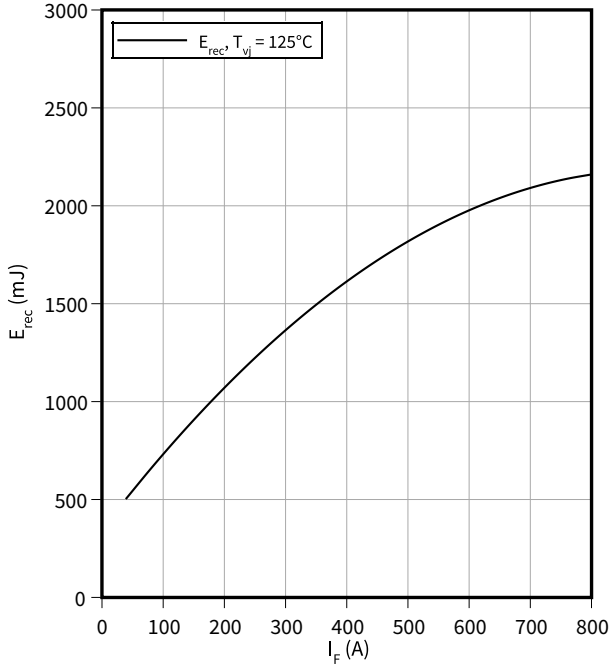


4 Characteristics diagrams

**switching losses (typical), Diode, Inverter**

$E_{rec} = f(I_F)$

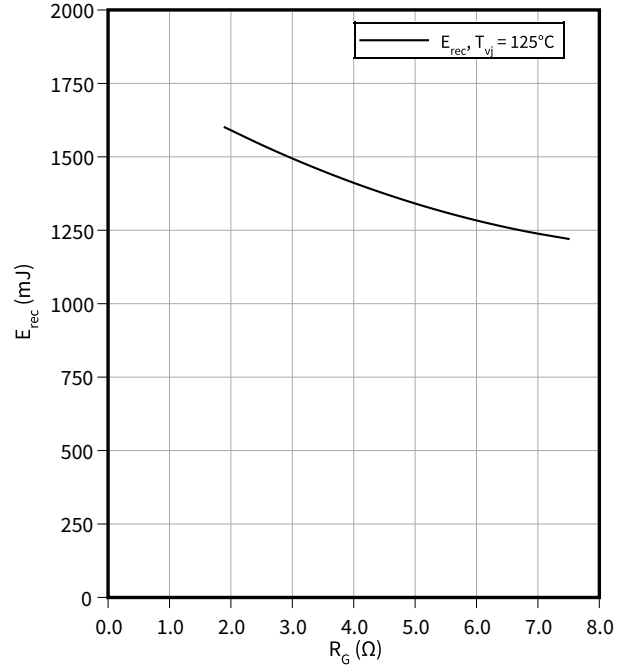
$V_{CE} = 3600 \text{ V}, R_{Gon} = R_{Gon}(IGBT)$



**switching losses (typical), Diode, Inverter**

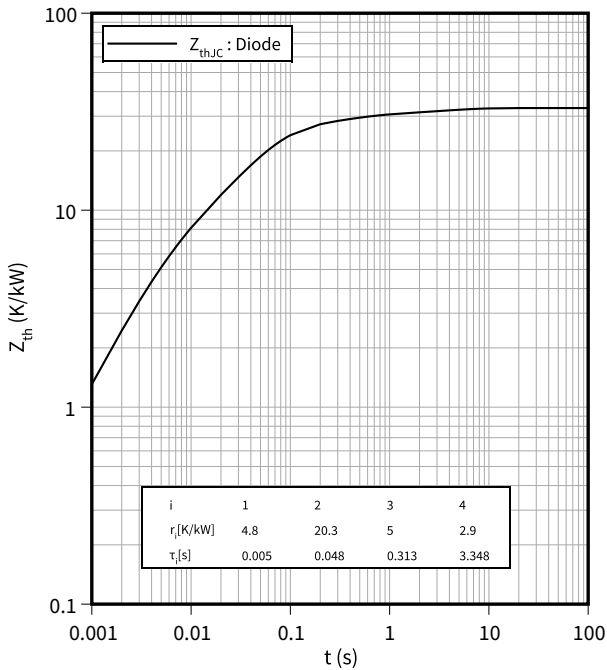
$E_{rec} = f(R_G)$

$V_{CE} = 3600 \text{ V}, I_F = 400 \text{ A}$



**transient thermal impedance , Diode, Inverter**

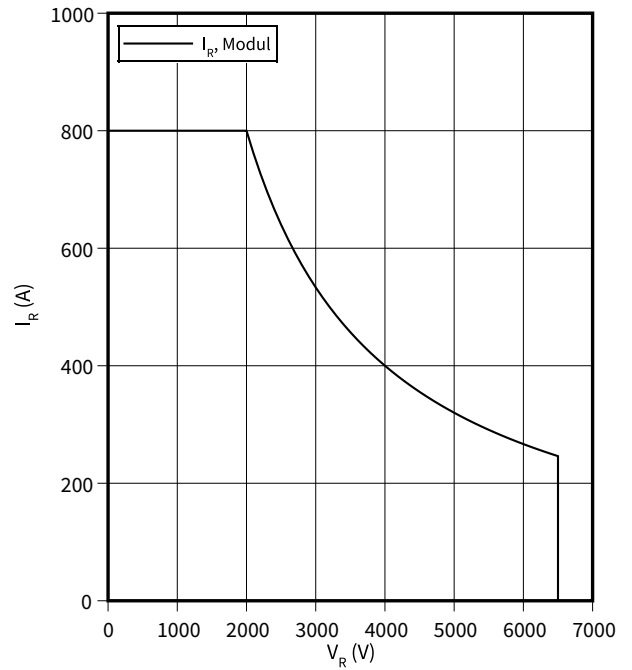
$Z_{th} = f(t)$



**safe operation area (SOA), Diode, Inverter**

$I_R = f(V_R)$

$T_{vj} = 125 \text{ °C}$



## 5 Circuit diagram

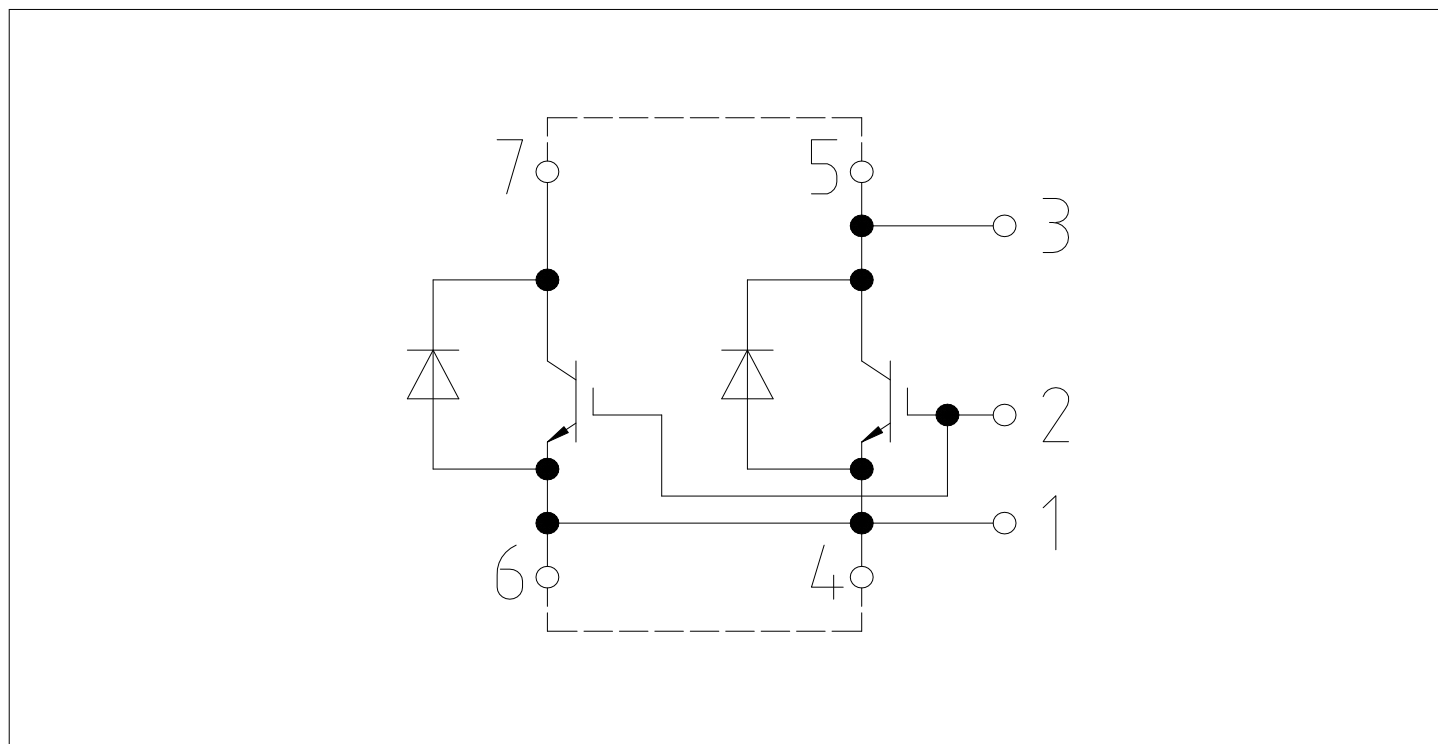


Figure 1

6 Package outlines

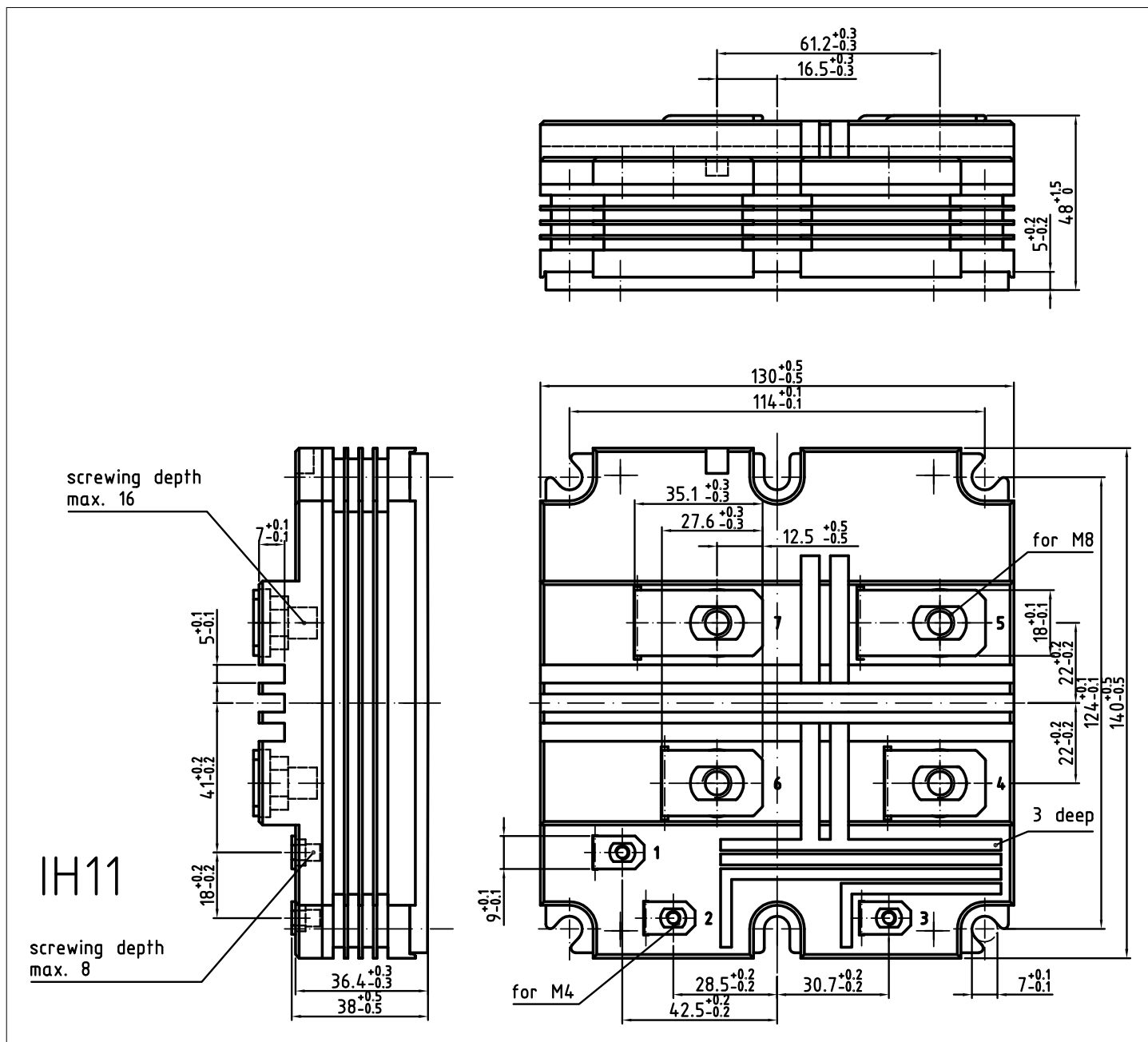




Figure 2

## 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	<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	2012-02-06	Target datasheet
V1.1	2012-03-06	Target datasheet
V2.0	2012-05-02	Preliminary datasheet
V2.1	2012-06-25	Preliminary datasheet
V3.0	2018-01-15	Final datasheet
V3.1	2019-09-06	Final datasheet
V3.2	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	2021-10-27	Final datasheet

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**Document reference**

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