

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

### Features

- Electrical features
  - $V_{CES} = 6500\text{ V}$
  - $I_{C\text{nom}} = 500\text{ A} / I_{CRM} = 1000\text{ A}$
  - 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 CTI > 600
  - Package with enhanced insulation of 10.4 kV AC 60 s



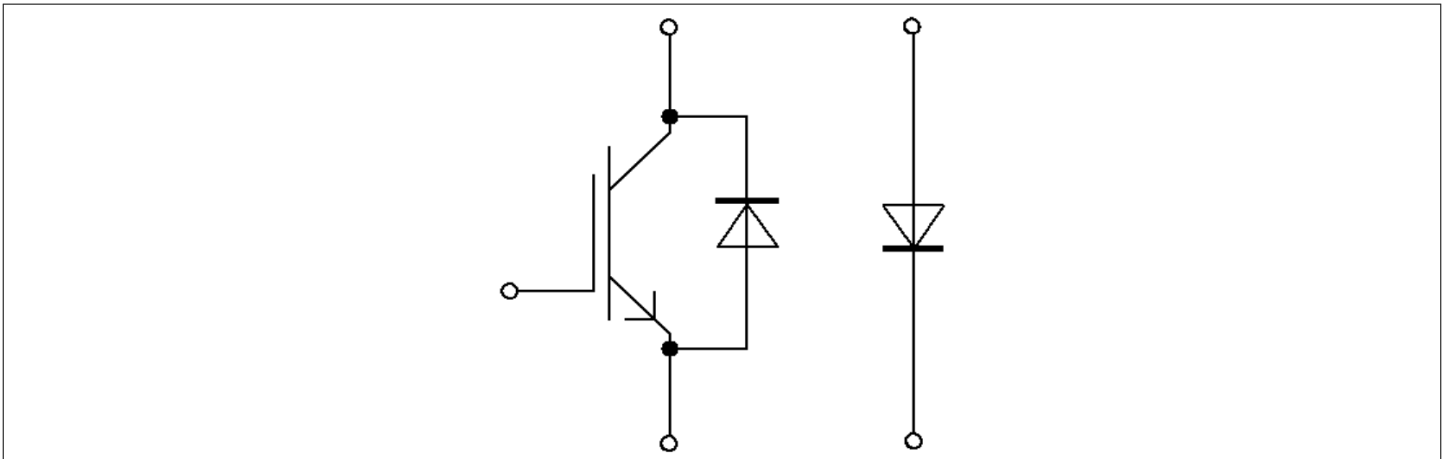
### Potential applications

- Chopper applications
- Medium-voltage converters
- Traction drives

### 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	$L_{SCE}$			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	$G$			1400		g	

## 2 IGBT, Brake-Chopper

**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	$I_{CDC}$	$T_{vj\ max} = 150\ ^\circ C$ $T_C = 80\ ^\circ C$	500	A
Repetitive peak collector current	$I_{CRM}$	$t_p = 1\ ms$	1000	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	$V_{CE\ sat}$	$I_C = 500\ A, V_{GE} = 15\ V$	$T_{vj} = 25\ ^\circ C$	3.00	3.40	V
			$T_{vj} = 125\ ^\circ C$	3.70	4.20	
Gate threshold voltage	$V_{GEth}$	$I_C = 70\ mA, V_{CE} = V_{GE}, T_{vj} = 25\ ^\circ C$	5.40	6	6.60	V
Gate charge	$Q_G$	$V_{GE} = \pm 15\ V, V_{CE} = 3600\ V$		20		$\mu C$
Internal gate resistor	$R_{Gint}$	$T_{vj} = 25\ ^\circ C$		1.1		$\Omega$
Input capacitance	$C_{ies}$	$f = 1000\ kHz, T_{vj} = 25\ ^\circ C, V_{CE} = 25\ V, V_{GE} = 0\ V$		135		nF
Reverse transfer capacitance	$C_{res}$	$f = 1000\ kHz, T_{vj} = 25\ ^\circ C, V_{CE} = 25\ V, V_{GE} = 0\ V$		2.1		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)	$t_{don}$	$I_C = 500\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Gon} = 1.5\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.640		$\mu s$
			$T_{vj} = 125\ ^\circ C$	0.650		
Rise time (inductive load)	$t_r$	$I_C = 500\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Gon} = 1.5\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.180		$\mu s$
			$T_{vj} = 125\ ^\circ C$	0.200		
Turn-off delay time (inductive load)	$t_{doff}$	$I_C = 500\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Goff} = 10\ \Omega$	$T_{vj} = 25\ ^\circ C$	7.300		$\mu s$
			$T_{vj} = 125\ ^\circ C$	7.600		
Fall time (inductive load)	$t_f$	$I_C = 500\ A, V_{CE} = 3600\ V, V_{GE} = \pm 15\ V, R_{Goff} = 10\ \Omega$	$T_{vj} = 25\ ^\circ C$	0.400		$\mu s$
			$T_{vj} = 125\ ^\circ C$	0.500		
Turn-on time (resistive load)	$t_{on\_R}$	$I_C = 500\ A, V_{CE} = 2000\ V, V_{GE} = \pm 15\ V, R_{Gon} = 1.5\ \Omega$	1.62			$\mu s$
Turn-on energy loss per pulse	$E_{on}$	$I_C = 500\ A, V_{CE} = 3600\ V, L_\sigma = 280\ nH, V_{GE} = \pm 15\ V, R_{Gon} = 1.5\ \Omega, di/dt = 2000\ A/\mu s (T_{vj} = 125\ ^\circ C)$	$T_{vj} = 25\ ^\circ C$	2800		mJ
			$T_{vj} = 125\ ^\circ C$	4300		
Turn-off energy loss per pulse	$E_{off}$	$I_C = 500\ A, V_{CE} = 3600\ V, L_\sigma = 280\ nH, V_{GE} = \pm 15\ V, R_{Goff} = 10\ \Omega$	$T_{vj} = 25\ ^\circ C$	2400		mJ
			$T_{vj} = 125\ ^\circ C$	2800		

(table continues...)

**Table 4 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
SC data	$I_{SC}$	$V_{GE} \leq 15 \text{ V}$ , $V_{CC} = 4500 \text{ V}$ , $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$	$t_p \leq 10 \mu\text{s}$ , $T_{vj} \leq 125 \text{ }^\circ\text{C}$		3000		A
Thermal resistance, junction to case	$R_{thJC}$	per IGBT			13.1		K/kW
Thermal resistance, case to heat sink	$R_{thCH}$	per IGBT, $\lambda_{grease} = 1 \text{ W}/(\text{m}^2\text{K})$		13.0			K/kW
Temperature under switching conditions	$T_{vjop}$		-50		125		$^\circ\text{C}$

### 3 Diode, Brake-Chopper

**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	$I_F$		500	A	
Repetitive peak forward current	$I_{FRM}$	$t_p = 1 \text{ ms}$	1000	A	
$I^2t$ - value	$I^2t$	$t_p = 10 \text{ ms}$ , $V_R = 0 \text{ V}$	$T_{vj} = 125 \text{ }^\circ\text{C}$	210	$\text{kA}^2\text{s}$
Maximum power dissipation	$P_{RQM}$	$T_{vj} = 125 \text{ }^\circ\text{C}$	2000	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	$V_F$	$I_F = 500 \text{ A}$ , $V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		3.00	3.50	V
			$T_{vj} = 125 \text{ }^\circ\text{C}$		2.95	3.50	
Peak reverse recovery current	$I_{RM}$	$V_R = 3600 \text{ V}$ , $I_F = 500 \text{ A}$ , $V_{GE} = -15 \text{ V}$ , $-di_F/dt = 2000 \text{ A}/\mu\text{s}$ ( $T_{vj} = 125 \text{ }^\circ\text{C}$ )	$T_{vj} = 25 \text{ }^\circ\text{C}$		730		A
			$T_{vj} = 125 \text{ }^\circ\text{C}$		800		
Recovered charge	$Q_r$	$V_R = 3600 \text{ V}$ , $I_F = 500 \text{ A}$ , $V_{GE} = -15 \text{ V}$ , $-di_F/dt = 2000 \text{ A}/\mu\text{s}$ ( $T_{vj} = 125 \text{ }^\circ\text{C}$ )	$T_{vj} = 25 \text{ }^\circ\text{C}$		570		$\mu\text{C}$
			$T_{vj} = 125 \text{ }^\circ\text{C}$		1050		

(table continues...)

**Table 6 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Reverse recovery energy	$E_{rec}$	$V_R = 3600\text{ V}, I_F = 500\text{ A}, V_{GE} = -15\text{ V}, -di_F/dt = 2000\text{ A}/\mu\text{s} (T_{vj} = 125\text{ }^\circ\text{C})$	$T_{vj} = 25\text{ }^\circ\text{C}$	930		mJ
			$T_{vj} = 125\text{ }^\circ\text{C}$	2000		
Thermal resistance, junction to case	$R_{thJC}$	per diode			28.0	K/kW
Thermal resistance, case to heat sink	$R_{thCH}$	per diode, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{K})$		21.0		K/kW
Temperature under switching conditions	$T_{vj\text{op}}$		-50		125	$^\circ\text{C}$

## 4 Diode, Reverse

**Table 7 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	$I_F$		500	A	
Repetitive peak forward current	$I_{FRM}$	$t_p = 1\text{ ms}$	1000	A	
$I^2t$ - value	$I^2t$	$t_p = 10\text{ ms}, V_R = 0\text{ V}$	$T_{vj} = 125\text{ }^\circ\text{C}$	210	$\text{kA}^2\text{s}$
Maximum power dissipation	$P_{RQM}$	$T_{vj} = 125\text{ }^\circ\text{C}$	2000	kW	
Minimum turn-on time	$t_{onmin}$		10	$\mu\text{s}$	

**Table 8 Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	$V_F$	$I_F = 500\text{ A}, V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ }^\circ\text{C}$	3.00	3.50	V
			$T_{vj} = 125\text{ }^\circ\text{C}$	2.95	3.50	
Peak reverse recovery current	$I_{RM}$	$V_R = 3600\text{ V}, I_F = 500\text{ A}, V_{GE} = -15\text{ V}, -di_F/dt = 2000\text{ A}/\mu\text{s} (T_{vj} = 125\text{ }^\circ\text{C})$	$T_{vj} = 25\text{ }^\circ\text{C}$	730		A
			$T_{vj} = 125\text{ }^\circ\text{C}$	800		
Recovered charge	$Q_r$	$V_R = 3600\text{ V}, I_F = 500\text{ A}, V_{GE} = -15\text{ V}, -di_F/dt = 2000\text{ A}/\mu\text{s} (T_{vj} = 125\text{ }^\circ\text{C})$	$T_{vj} = 25\text{ }^\circ\text{C}$	570		$\mu\text{C}$
			$T_{vj} = 125\text{ }^\circ\text{C}$	1050		

(table continues...)

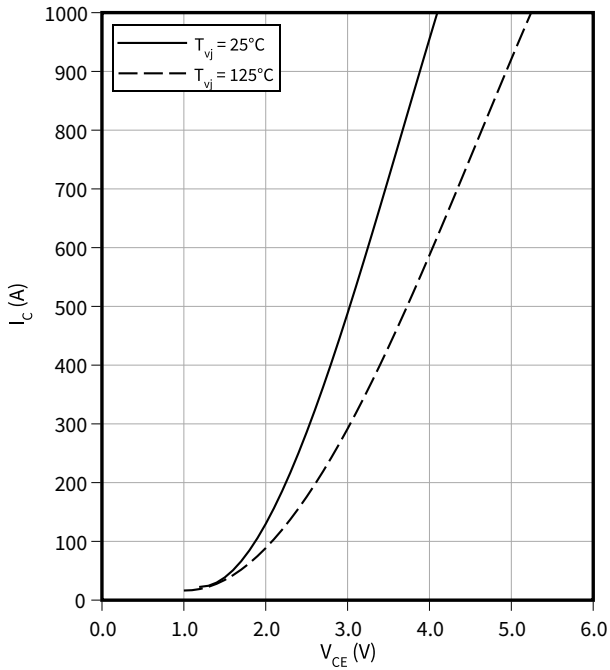
**Table 8 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Reverse recovery energy	$E_{rec}$	$V_R = 3600\text{ V}$ , $I_F = 500\text{ A}$ , $V_{GE} = -15\text{ V}$ , $-di_F/dt =$ $2000\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ }^\circ\text{C}$ )	$T_{vj} = 25\text{ }^\circ\text{C}$	930		mJ
			$T_{vj} = 125\text{ }^\circ\text{C}$	2000		
Thermal resistance, junction to case	$R_{thJC}$	per diode			28.0	K/kW
Thermal resistance, case to heat sink	$R_{thCH}$	per diode, $\lambda_{grease} = 1\text{ W}/(\text{m}^*\text{K})$		16.0		K/kW
Temperature under switching conditions	$T_{vjop}$		-50		125	$^\circ\text{C}$

## 5 Characteristics diagrams

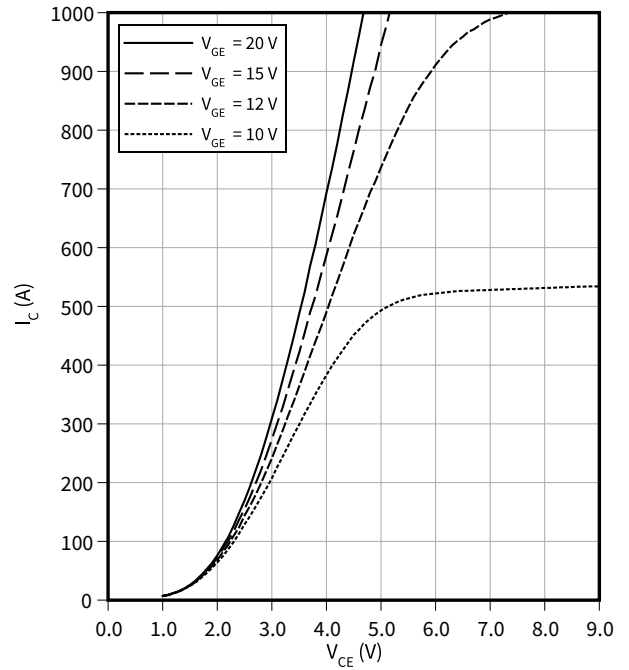
**output characteristic (typical), IGBT, Brake-Chopper**

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



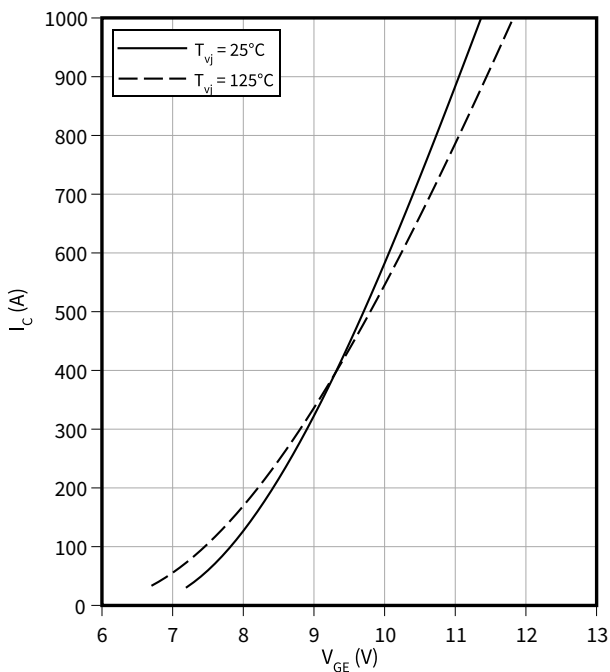
**output characteristic (typical), IGBT, Brake-Chopper**

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



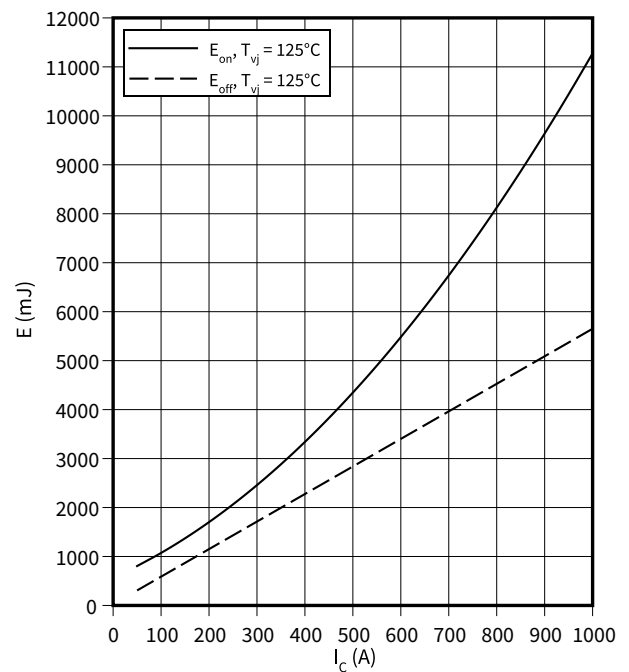
**transfer characteristic (typical), IGBT, Brake-Chopper**

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



**switching losses (typical), IGBT, Brake-Chopper**

$E = f(I_C)$   
 $R_{Goff} = 10 \text{ } \Omega$ ,  $R_{Gon} = 1.5 \text{ } \Omega$ ,  $V_{CE} = 3600 \text{ V}$ ,  $V_{GE} = \pm 15 \text{ V}$



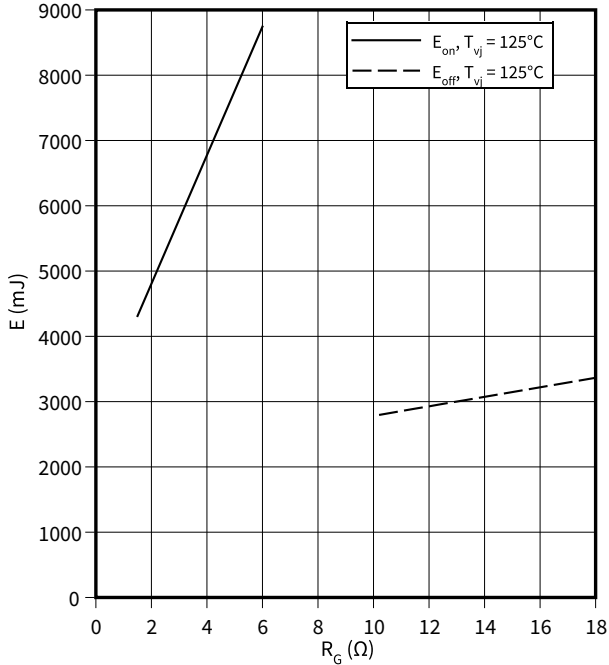


5 Characteristics diagrams

**switching losses (typical), IGBT, Brake-Chopper**

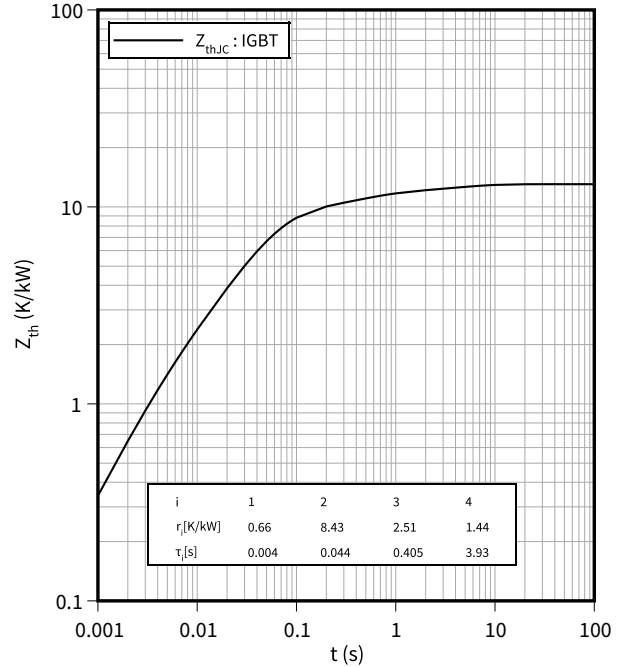
$E = f(R_G)$

$I_C = 500 \text{ A}$ ,  $V_{CE} = 3600 \text{ V}$ ,  $V_{GE} = \pm 15 \text{ V}$



**transient thermal impedance, IGBT, Brake-Chopper**

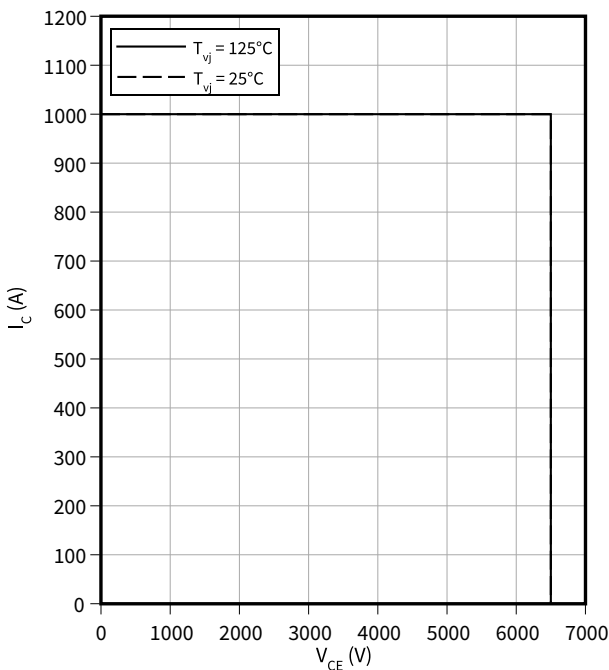
$Z_{th} = f(t)$



**reverse bias safe operating area (RBSOA), IGBT, Brake-Chopper**

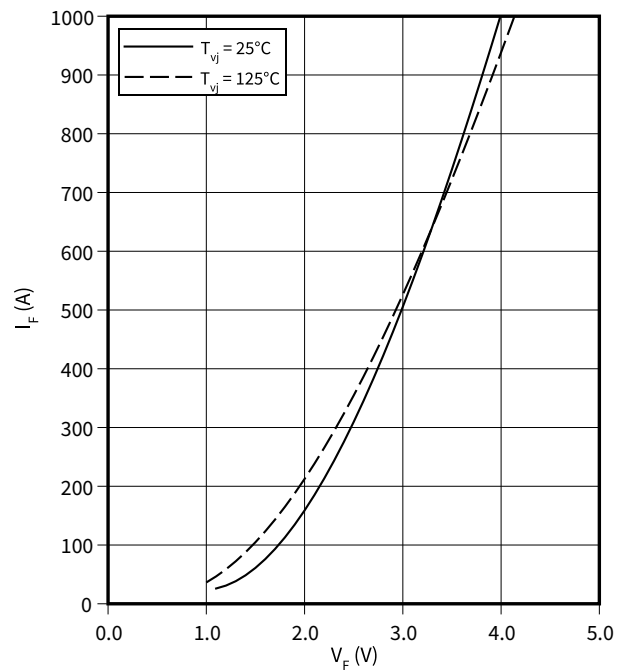
$I_C = f(V_{CE})$

$R_{Goff} = 10 \Omega$ ,  $V_{GE} = \pm 15 \text{ V}$ ,  $T_{vj} = 125 \text{ °C}$



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

$I_F = f(V_F)$

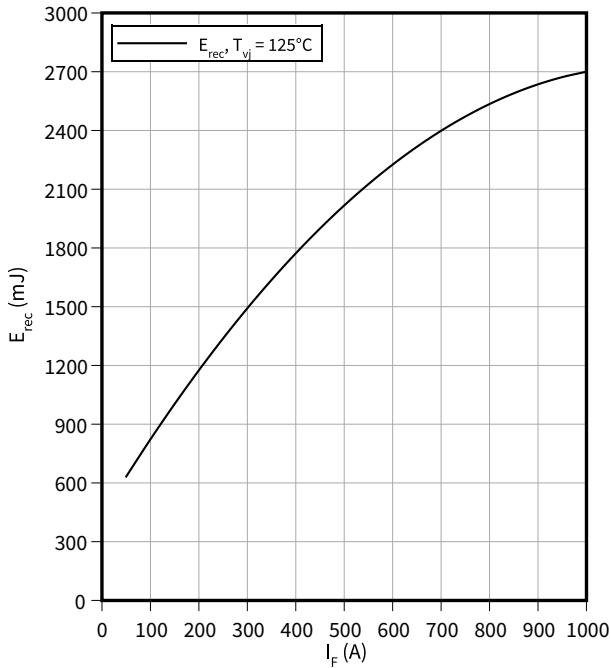


5 Characteristics diagrams

**switching losses (typical), Diode, Brake-Chopper**

$E_{rec} = f(I_F)$

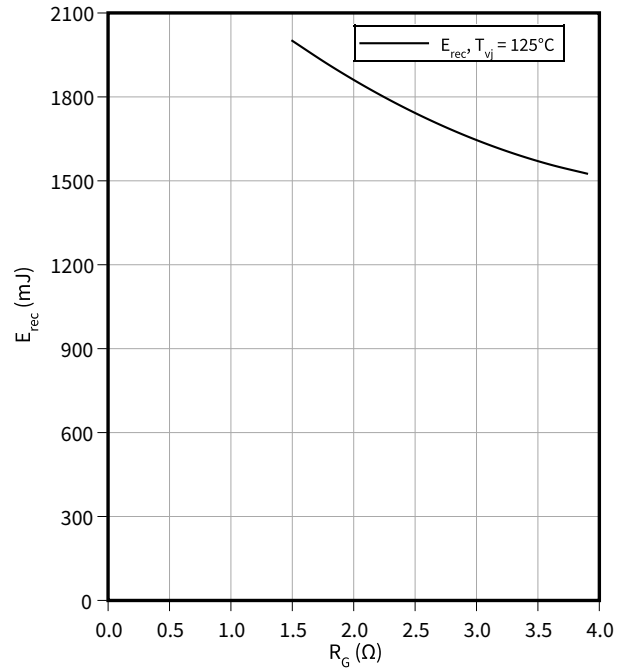
$V_{CE} = 3600\text{ V}$ ,  $R_{Gon} = R_{Gon}(IGBT)$



**switching losses (typical), Diode, Brake-Chopper**

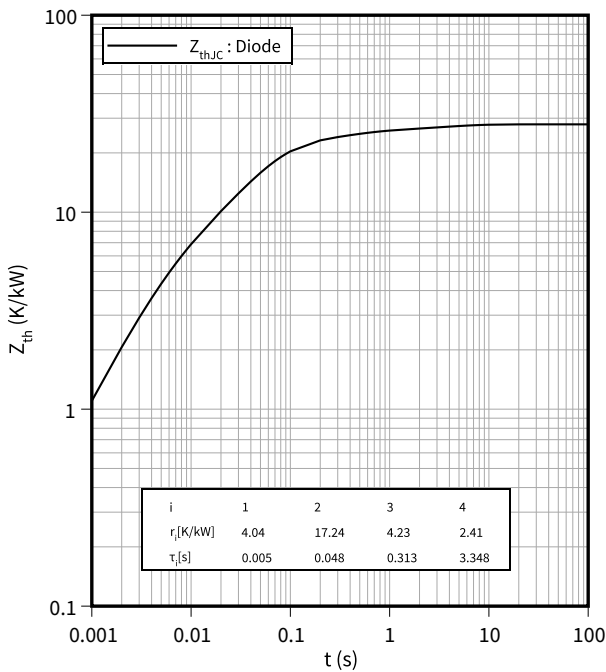
$E_{rec} = f(R_G)$

$V_{CE} = 3600\text{ V}$ ,  $I_F = 500\text{ A}$



**transient thermal impedance , Diode, Brake-Chopper**

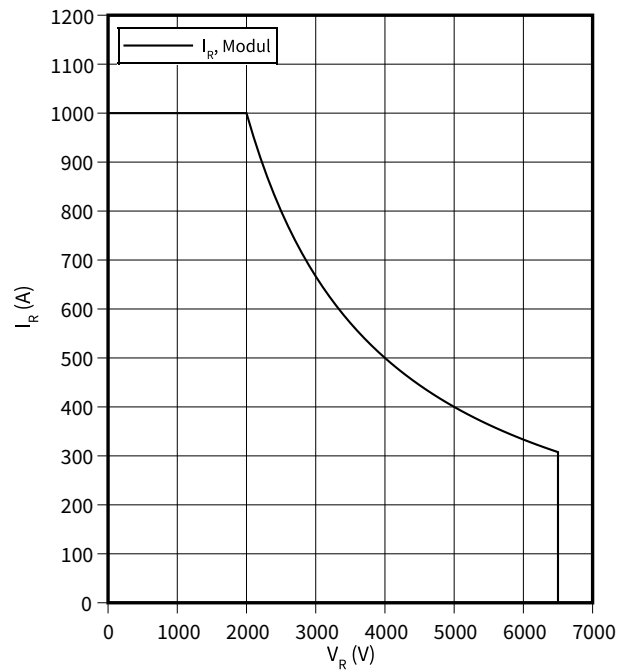
$Z_{th} = f(t)$



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

$I_R = f(V_R)$

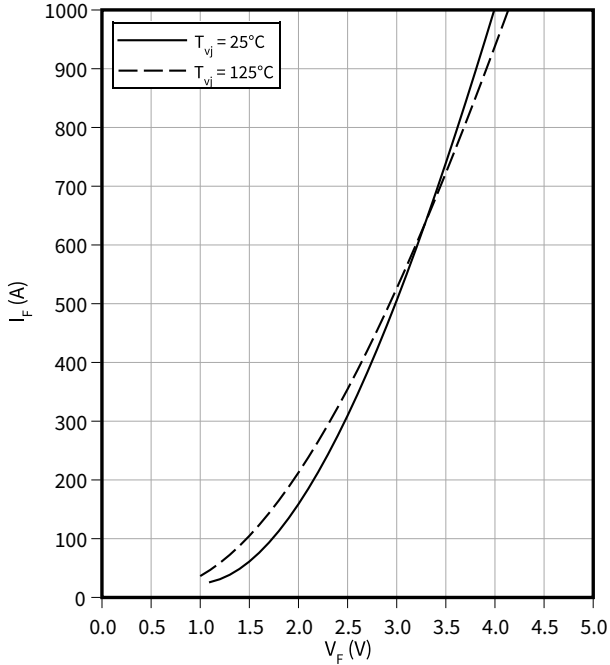
$T_{vj} = 125\text{ °C}$



5 Characteristics diagrams

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

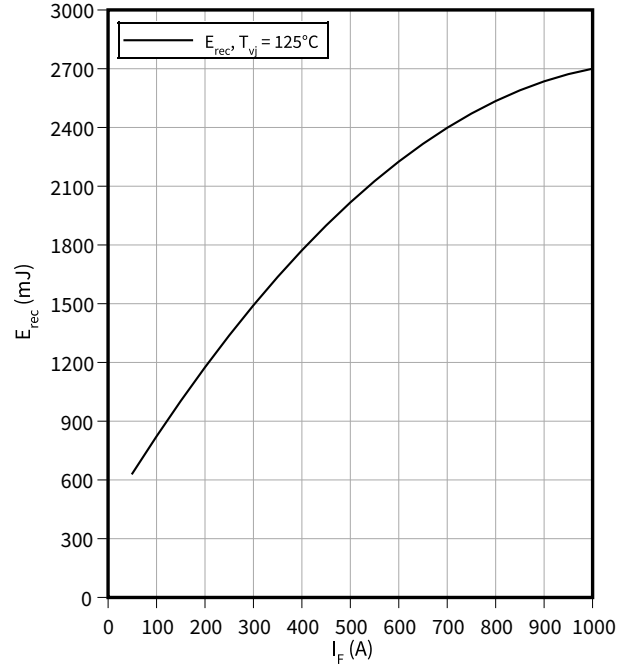
$I_F = f(V_F)$



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

$E_{rec} = f(I_F)$

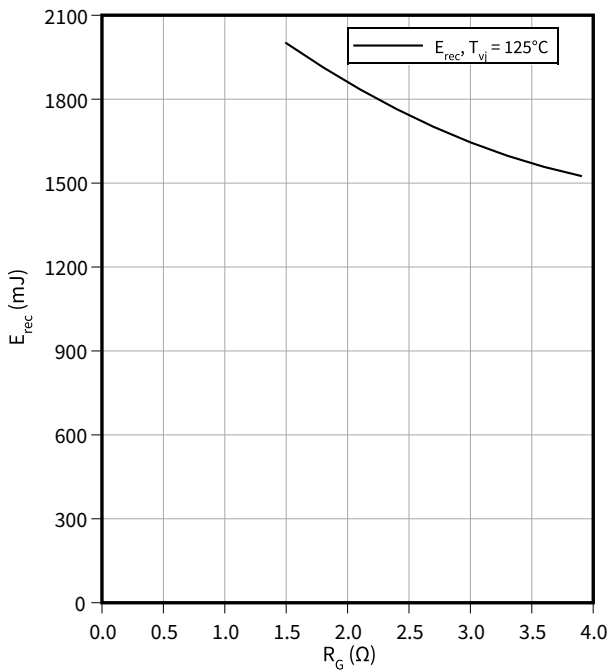
$V_{CE} = 3600 \text{ V}, R_{Gon} = R_{Gon}(IGBT)$



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

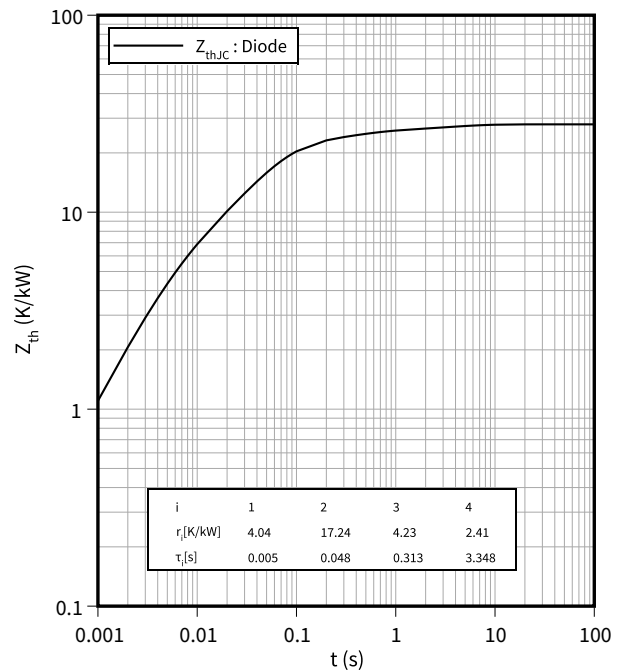
$E_{rec} = f(R_G)$

$V_{CE} = 3600 \text{ V}, I_F = 500 \text{ A}$



**transient thermal impedance , Diode, Reverse**

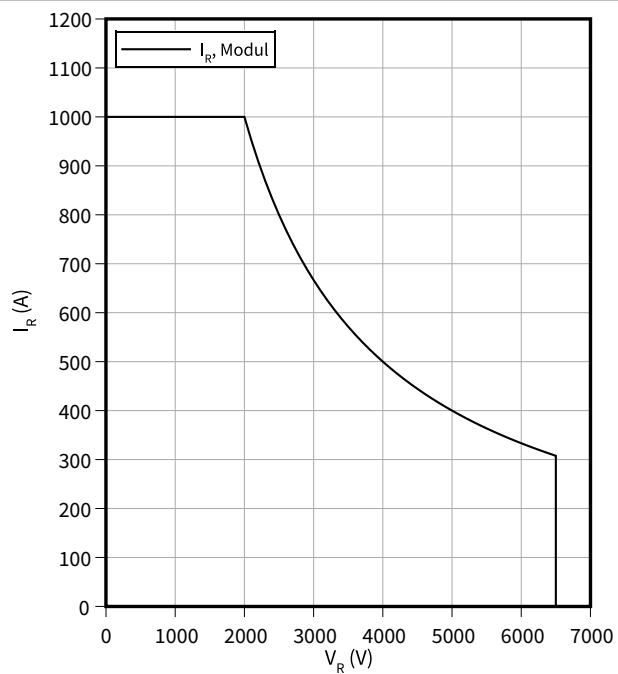
$Z_{th} = f(t)$



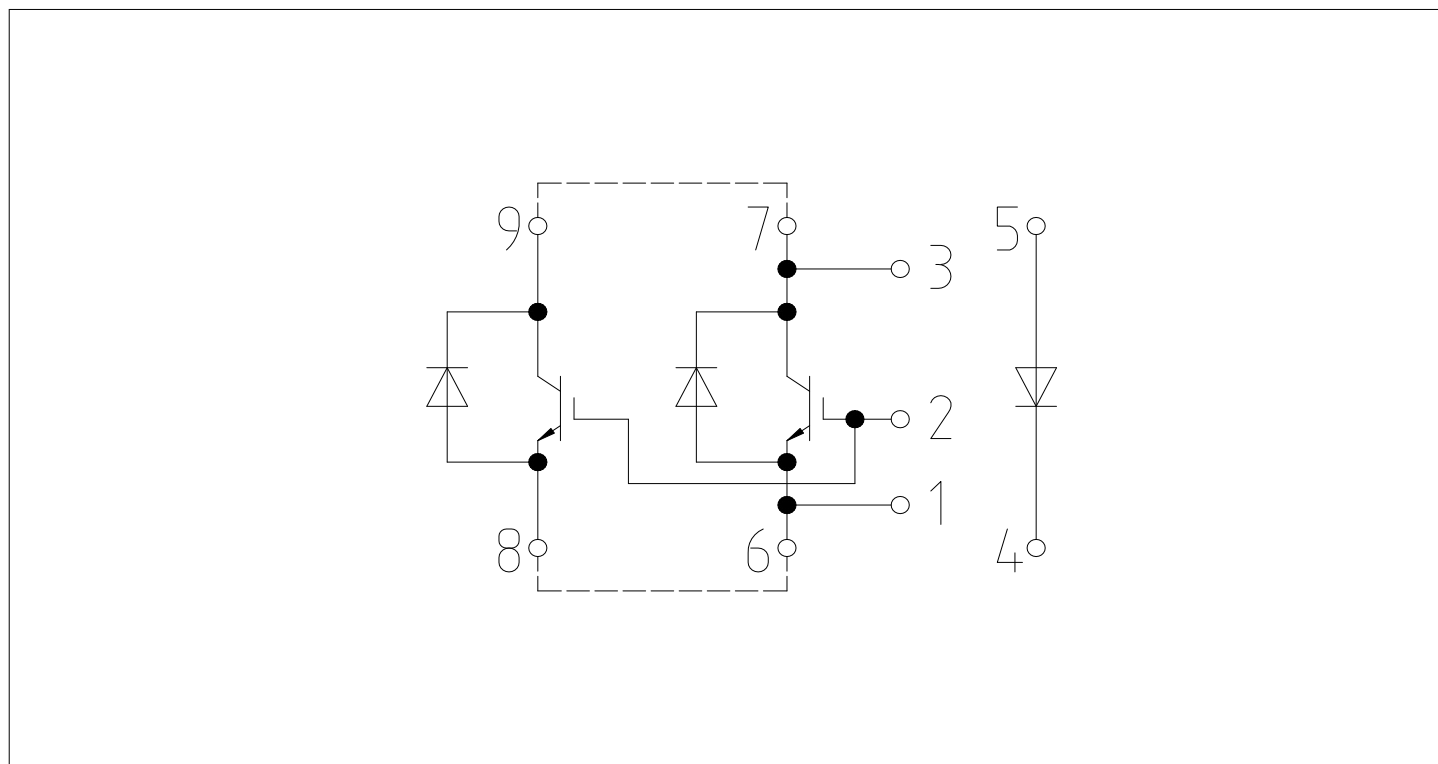
**safe operation area (SOA), Diode, Reverse**

$$I_R = f(V_R)$$

$$T_{vj} = 125\text{ °C}$$





## 6 Circuit diagram



**Figure 1**



## 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

**Figure 3**

## Revision history

Document revision	Date of release	Description of changes
V2.0	2012-08-07	Preliminary datasheet
V2.1	2013-05-07	Preliminary datasheet
V3.0	2014-06-16	Final datasheet
V3.1	2016-08-30	Final datasheet
V3.2	2018-01-15	Final datasheet
V3.3	2019-09-06	Final datasheet
V3.4	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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