

XHP™3 module with Trench/Fieldstop IGBT4 and emitter controlled 4 diode

Features

- Electrical features
 - $V_{CES} = 4500\text{ V}$
 - $I_{C\text{ nom}} = 450\text{ A} / I_{CRM} = 900\text{ A}$
 - High dynamic robustness
 - Low $V_{CE,sat}$
 - Trench IGBT 4
- Mechanical features
 - Package with CTI > 600
 - ALSiC base plate for increased thermal cycling capability
 - High creepage and clearance distances
 - Housing material compliant with the classification R23 (HL3) of the EN45545-2 “Fire protection of railway vehicles”
 - Package with enhanced insulation of 10.4 kV AC 60 s



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

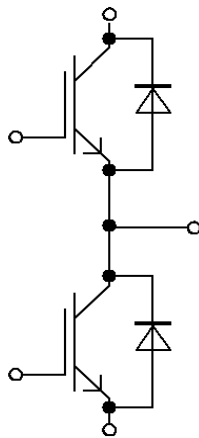


Table of contents

	Description	1
	Features	1
	Potential applications	1
	Product validation	1
	Table of contents	2
1	Package	3
2	IGBT, Inverter	3
3	Diode, Inverter	5
4	Characteristics diagrams	7
5	Circuit diagram	11
6	Package outlines	12
7	Module label code	13
	Revision history	14
	Disclaimer	15

1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 50 \text{ Hz}$, $t = 1 \text{ min}$	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	2900	V
Material of module baseplate			AlSiC	
Creepage distance	d_{Creep}	terminal to heatsink	53.0	mm
Creepage distance	d_{Creep}	terminal to terminal	53.0	mm
Clearance	d_{Clear}	terminal to heatsink	36.0	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	$R_{AA'+CC'}$	$T_C = 25\text{ }^{\circ}\text{C}$, per switch			0.33		mΩ
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C = 25\text{ }^{\circ}\text{C}$, per switch			0.42		mΩ
Storage temperature	T_{stg}			-40		150	°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	M3, Screw	0.9		1.1	Nm
			M8, Screw	8		10	
Weight	G				700		g

2 IGBT, Inverter

Table 3 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit
Collector-emitter voltage	V_{CES}	$T_{vj} = -40 \text{ °C}$	4300	V
		$T_{vj} = 25 \text{ °C}$	4500	
		$T_{vj} = 150 \text{ °C}$	4500	

(table continues...)

Table 3 (continued) Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Continuous DC collector current	I_{CDC}	$T_{vj\ max} = 150\ ^\circ\text{C}$	$T_C = 100\ ^\circ\text{C}$	450	A
Repetitive peak collector current	I_{CRM}	t_p limited by $T_{vj\ op}$		900	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	$V_{CE\ sat}$	$I_C = 450\ \text{A}, V_{GE} = 15\ \text{V}$	$T_{vj} = 25\ ^\circ\text{C}$		2.35	2.80	V
			$T_{vj} = 125\ ^\circ\text{C}$		2.85	3.40	
			$T_{vj} = 150\ ^\circ\text{C}$		2.95	3.50	
Gate threshold voltage	V_{GETh}	$I_C = 39\ \text{mA}, V_{CE} = V_{GE}, T_{vj} = 25\ ^\circ\text{C}$		5.5	6	6.5	V
Gate charge	Q_G	$V_{GE} = \pm 15\ \text{V}, V_{CC} = 2800\ \text{V}$			12.1		μC
Internal gate resistor	R_{Gint}	$T_{vj} = 25\ ^\circ\text{C}$			1.5		Ω
Input capacitance	C_{ies}	$f = 100\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$			76.6		nF
Reverse transfer capacitance	C_{res}	$f = 100\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$			1.4		nF
Collector-emitter cut-off current	I_{CES}	$V_{CE} = 4500\ \text{V}, V_{GE} = 0\ \text{V}$	$T_{vj} = 25\ ^\circ\text{C}$			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}	$I_C = 450\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 0.39\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$		0.500		μs
			$T_{vj} = 125\ ^\circ\text{C}$		0.550		
			$T_{vj} = 150\ ^\circ\text{C}$		0.560		
Rise time (inductive load)	t_r	$I_C = 450\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 0.39\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$		0.075		μs
			$T_{vj} = 125\ ^\circ\text{C}$		0.085		
			$T_{vj} = 150\ ^\circ\text{C}$		0.090		
Turn-off delay time (inductive load)	t_{doff}	$I_C = 450\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 22\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$		8.000		μs
			$T_{vj} = 125\ ^\circ\text{C}$		8.500		
			$T_{vj} = 150\ ^\circ\text{C}$		8.600		
Fall time (inductive load)	t_f	$I_C = 450\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 22\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$		1.300		μs
			$T_{vj} = 125\ ^\circ\text{C}$		2.350		
			$T_{vj} = 150\ ^\circ\text{C}$		2.700		
Turn-on time (resistive load)	t_{on_R}	$I_C = 500\ \text{A}, V_{CC} = 2000\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 0.39\ \Omega$	$T_{vj} = 25\ ^\circ\text{C}$	1.40			μs

(table continues...)

Table 4 (continued) Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-on energy loss per pulse	E_{on}	$I_C = 450\text{ A}$, $V_{CC} = 2800\text{ V}$, $L_\sigma = 75\text{ nH}$, $V_{GE} = \pm 15\text{ V}$, $R_{Gon} = 0.39\text{ }\Omega$, $di/dt = 4900\text{ A}/\mu\text{s}$ ($T_{vj} = 150\text{ }^\circ\text{C}$)	$T_{vj} = 25\text{ }^\circ\text{C}$	1000		mJ
			$T_{vj} = 125\text{ }^\circ\text{C}$	1540		
			$T_{vj} = 150\text{ }^\circ\text{C}$	1740		
Turn-off energy loss per pulse	E_{off}	$I_C = 450\text{ A}$, $V_{CC} = 2800\text{ V}$, $L_\sigma = 75\text{ nH}$, $V_{GE} = \pm 15\text{ V}$, $R_{Goff} = 22\text{ }\Omega$, $dv/dt = 1080\text{ V}/\mu\text{s}$ ($T_{vj} = 150\text{ }^\circ\text{C}$)	$T_{vj} = 25\text{ }^\circ\text{C}$	1810		mJ
			$T_{vj} = 125\text{ }^\circ\text{C}$	2390		
			$T_{vj} = 150\text{ }^\circ\text{C}$	2580		
SC data	I_{SC}	$V_{GE} \leq 15\text{ V}$, $V_{CC} = 3000\text{ V}$, $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$	$t_P \leq 10\text{ }\mu\text{s}$, $T_{vj} = 150\text{ }^\circ\text{C}$	2000		A
Thermal resistance, junction to case	R_{thJC}	per IGBT			26.1	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{K})$		27.1		K/kW
Temperature under switching conditions	$T_{vj\text{ op}}$		-40		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}	$T_{vj} = -40\text{ }^\circ\text{C}$	4300	V
		$T_{vj} = 25\text{ }^\circ\text{C}$	4500	
		$T_{vj} = 150\text{ }^\circ\text{C}$	4500	
Continuous DC forward current	I_F		450	A
Repetitive peak forward current	I_{FRM}	$t_P = 1\text{ ms}$	900	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
			$T_{vj} = 150\text{ }^\circ\text{C}$	
Maximum power dissipation	P_{RQM}	$T_{vj} = 150\text{ }^\circ\text{C}$	1500	kW
Minimum turn-on time	t_{onmin}		10	μs

Table 6 **Characteristic values**

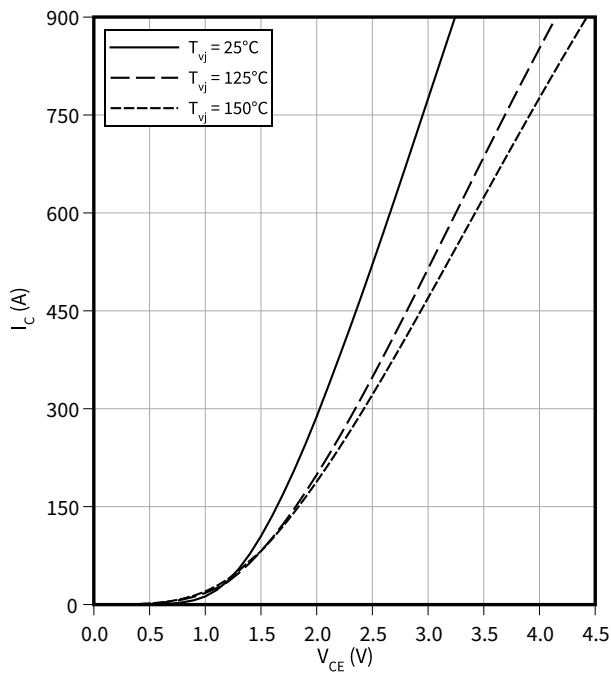
Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Forward voltage	V_F	$I_F = 450 \text{ A}$, $V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$	2.60	3.05	V
			$T_{vj} = 125 \text{ °C}$	2.50	2.95	
			$T_{vj} = 150 \text{ °C}$	2.45	2.90	
Peak reverse recovery current	I_{RM}	$V_{CC} = 2800 \text{ V}$, $I_F = 450 \text{ A}$, $V_{GE} = -15 \text{ V}$, $-di_F/dt = 4900 \text{ A}/\mu\text{s}$ ($T_{vj} = 150 \text{ °C}$)	$T_{vj} = 25 \text{ °C}$	925		A
			$T_{vj} = 125 \text{ °C}$	920		
			$T_{vj} = 150 \text{ °C}$	920		
Recovered charge	Q_r	$V_{CC} = 2800 \text{ V}$, $I_F = 450 \text{ A}$, $V_{GE} = -15 \text{ V}$, $-di_F/dt = 4900 \text{ A}/\mu\text{s}$ ($T_{vj} = 150 \text{ °C}$)	$T_{vj} = 25 \text{ °C}$	405		μC
			$T_{vj} = 125 \text{ °C}$	780		
			$T_{vj} = 150 \text{ °C}$	900		
Reverse recovery energy	E_{rec}	$V_{CC} = 2800 \text{ V}$, $I_F = 450 \text{ A}$, $V_{GE} = -15 \text{ V}$, $-di_F/dt = 4900 \text{ A}/\mu\text{s}$ ($T_{vj} = 150 \text{ °C}$)	$T_{vj} = 25 \text{ °C}$	690		mJ
			$T_{vj} = 125 \text{ °C}$	1400		
			$T_{vj} = 150 \text{ °C}$	1650		
Thermal resistance, junction to case	R_{thJC}	per diode			44.9	K/kW
Thermal resistance, case to heat sink	R_{thCH}	per diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot\text{K})$		19.8		K/kW
Temperature under switching conditions	$T_{vj\text{ op}}$		-40		150	°C

4 Characteristics diagrams

Output characteristic (typical), IGBT, Inverter

$I_C = f(V_{CE})$

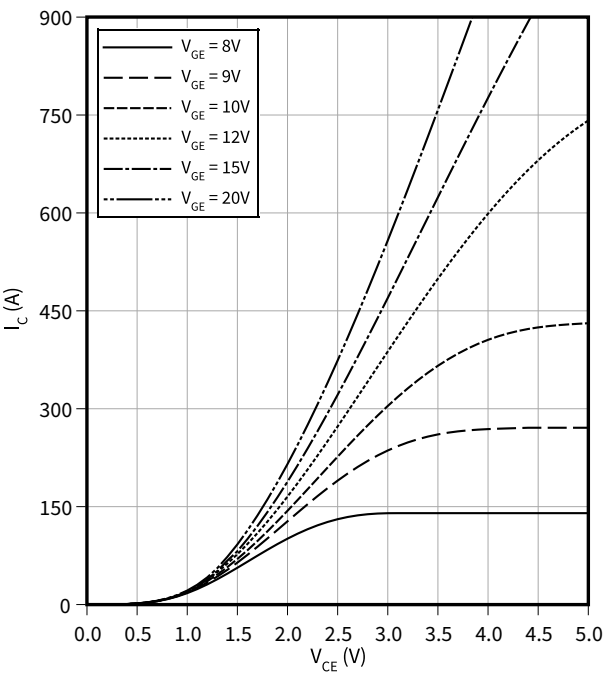
$V_{GE} = 15\text{ V}$



Output characteristic field (typical), IGBT, Inverter

$I_C = f(V_{CE})$

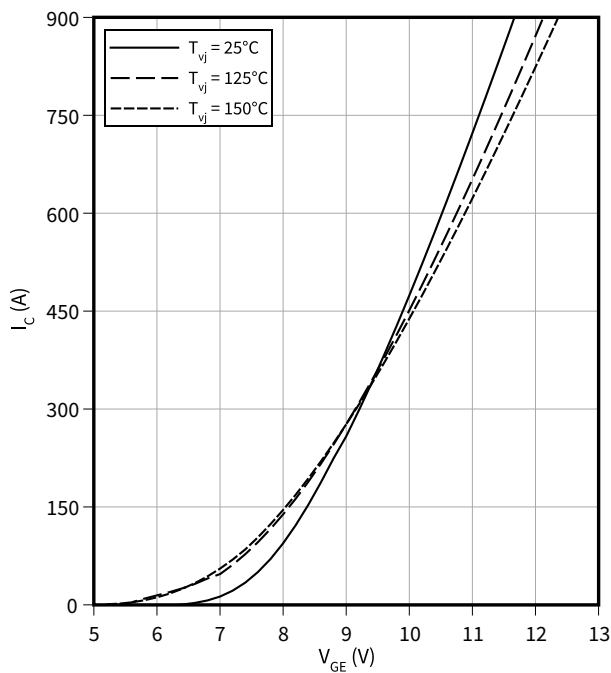
$T_{vj} = 150^\circ\text{C}$



Transfer characteristic (typical), IGBT, Inverter

$I_C = f(V_{GE})$

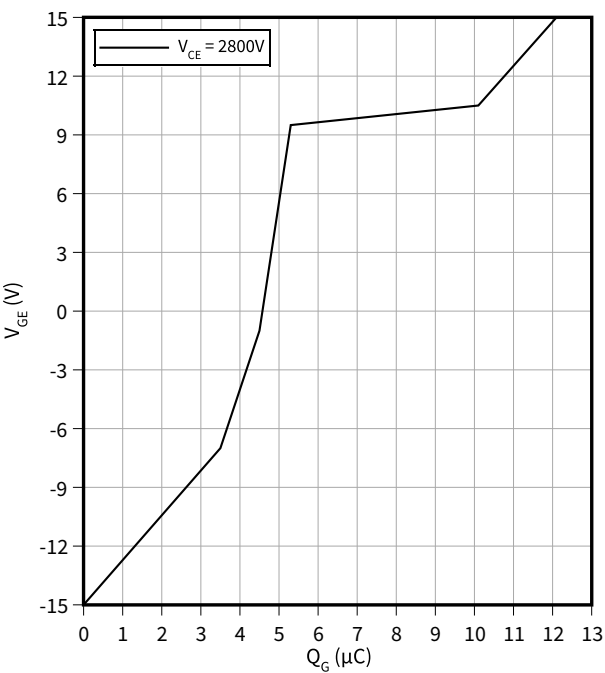
$V_{CE} = 20\text{ V}$



Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$

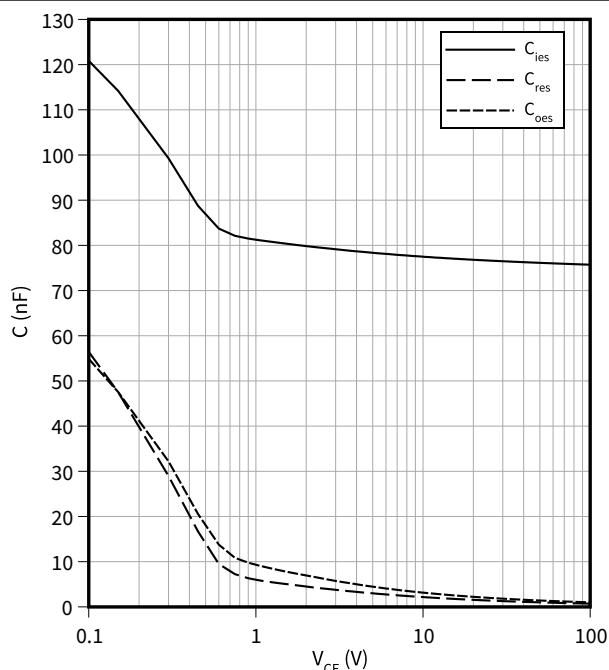
$I_C = 450\text{ A}, T_{vj} = 25^\circ\text{C}$



Capacity characteristic (typical), IGBT, Inverter

$$C = f(V_{CE})$$

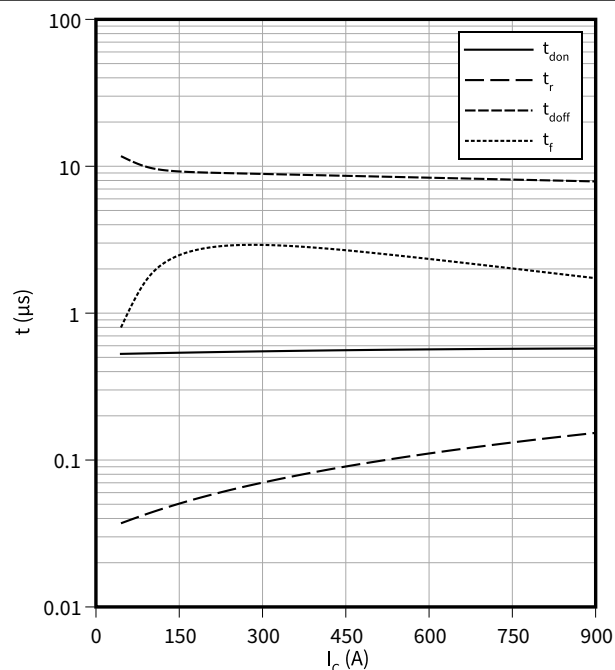
$f = 100 \text{ kHz}$, $V_{GE} = 0 \text{ V}$, $T_{vj} = 25 \text{ °C}$



Switching times (typical), IGBT, Inverter

$$t = f(I_C)$$

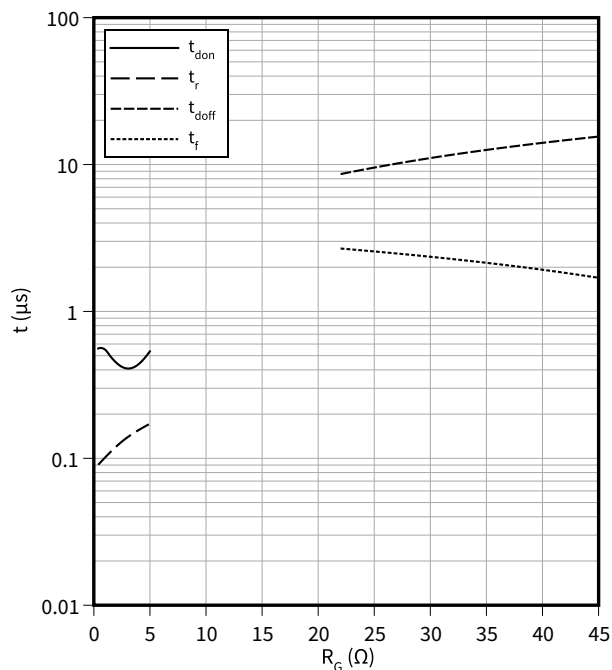
$R_{Goff} = 22 \text{ } \Omega$, $R_{Gon} = 0.39 \text{ } \Omega$, $V_{CC} = 2800 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$, $T_{vj} = 150 \text{ °C}$



Switching times (typical), IGBT, Inverter

$$t = f(R_G)$$

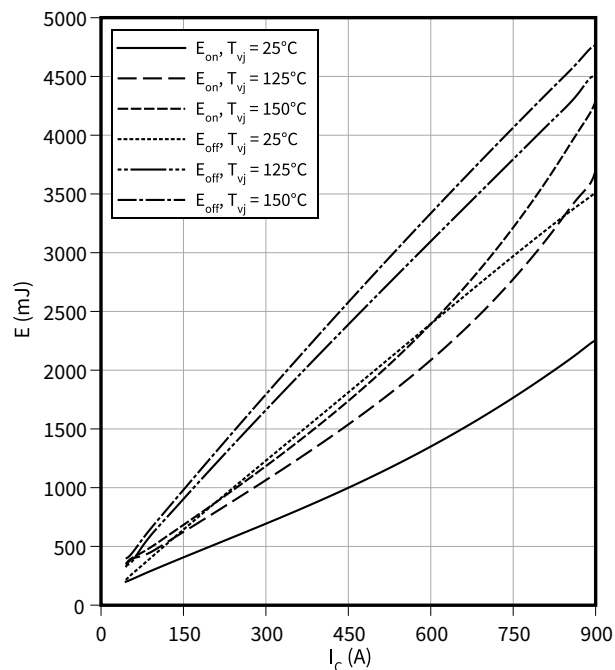
$I_C = 450 \text{ A}$, $V_{CC} = 2800 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$, $T_{vj} = 150 \text{ °C}$



Switching losses (typical), IGBT, Inverter

$$E = f(I_C)$$

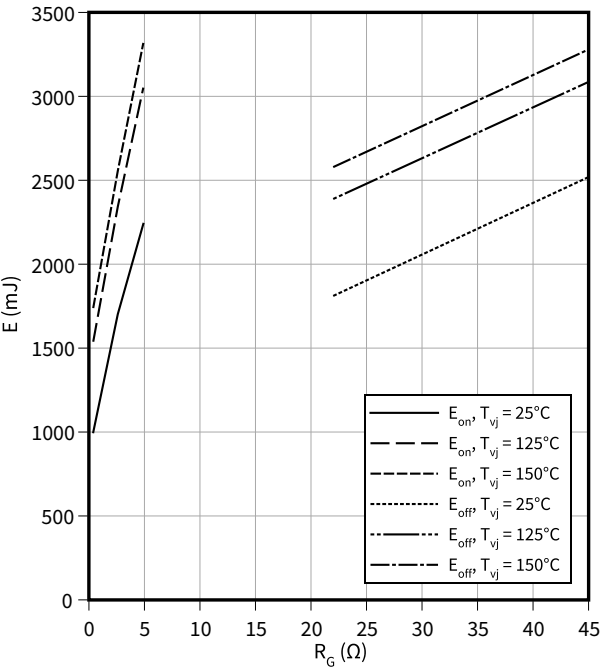
$R_{Goff} = 22 \text{ } \Omega$, $R_{Gon} = 0.39 \text{ } \Omega$, $V_{CC} = 2800 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$



4 Characteristics diagrams

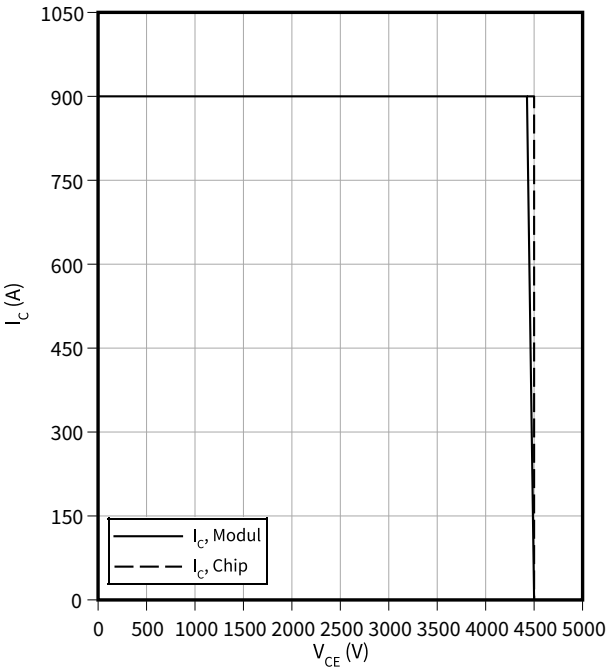
Switching losses (typical), IGBT, Inverter

$E = f(R_G)$
 $I_C = 450\text{ A}, V_{CC} = 2800\text{ V}, V_{GE} = \pm 15\text{ V}$



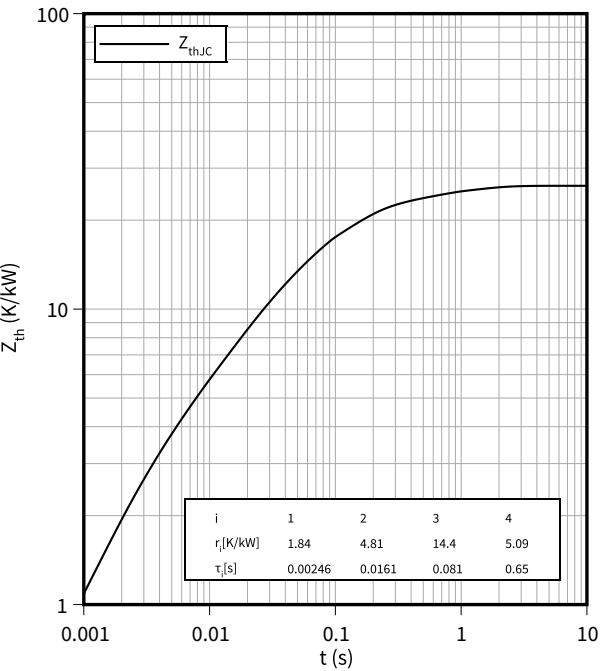
Reverse bias safe operating area (RBSOA), IGBT, Inverter

$I_C = f(V_{CE})$
 $R_{Goff} = 22\ \Omega, V_{GE} = \pm 15\text{ V}, T_{vj} = 150\text{ }^{\circ}\text{C}$



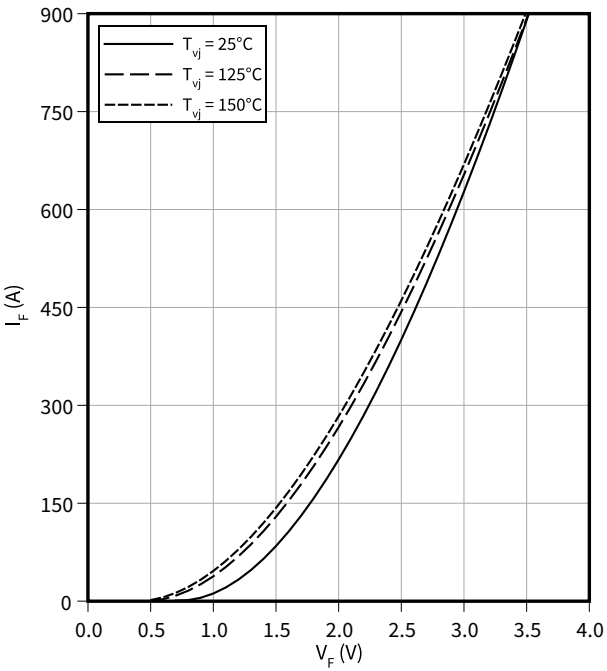
Transient thermal impedance, IGBT, Inverter

$Z_{th} = f(t)$



Forward characteristic (typical), Diode, Inverter

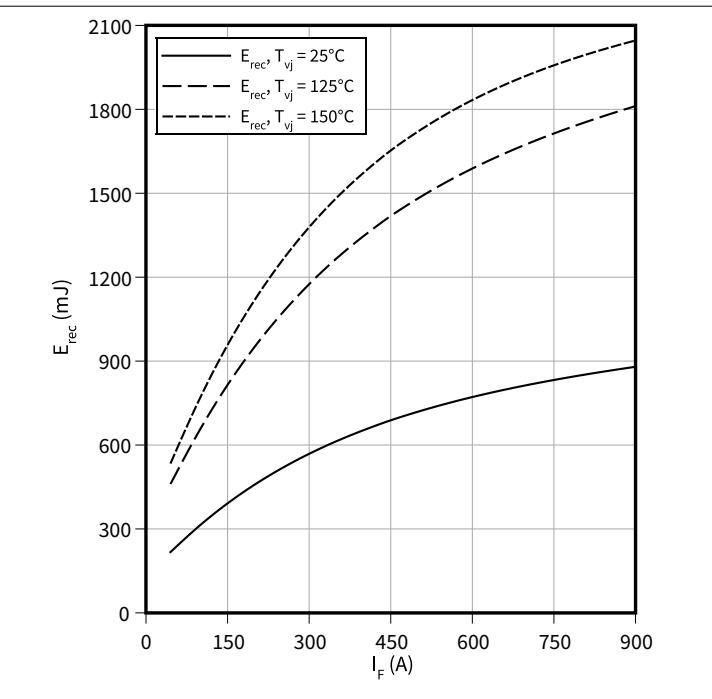
$I_F = f(V_F)$



4 Characteristics diagrams

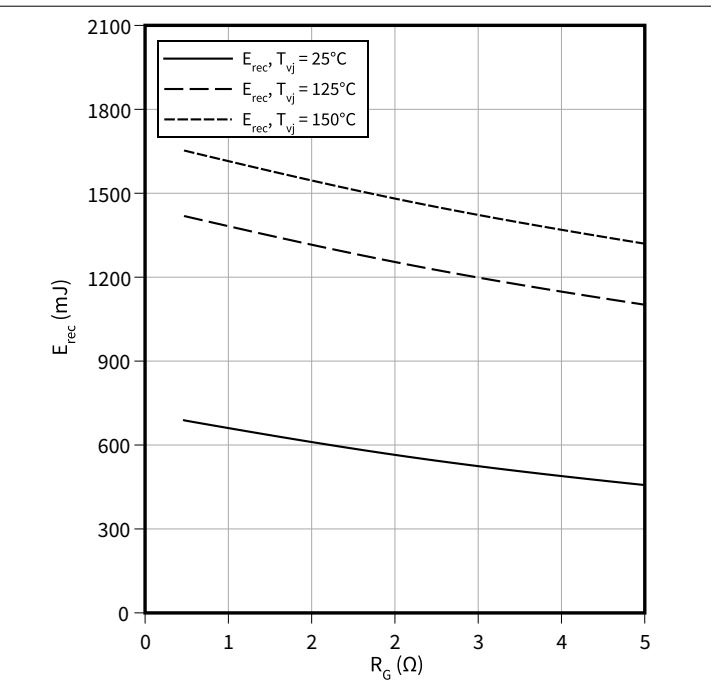
Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$
 $R_{Gon} = 0.39 \Omega, V_{CE} = 2800 V$



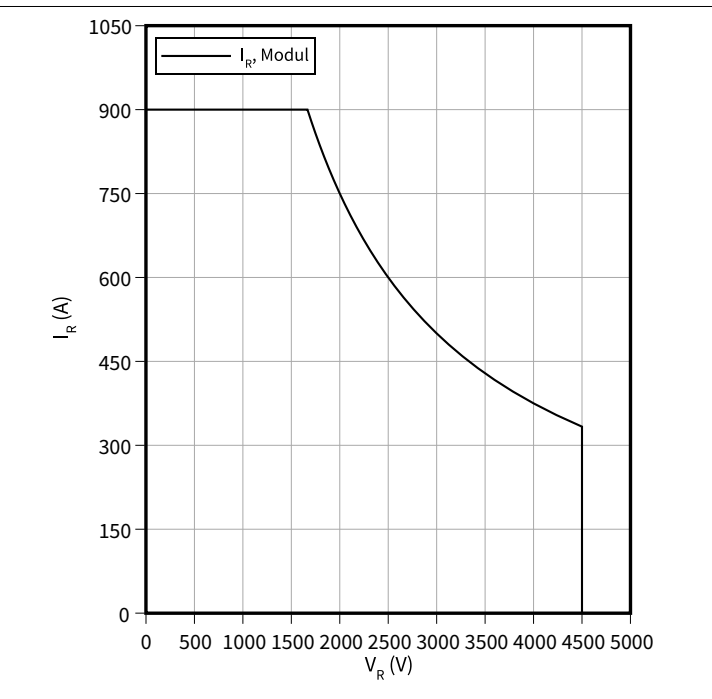
Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$
 $V_{CE} = 2800 V, I_F = 450 A$



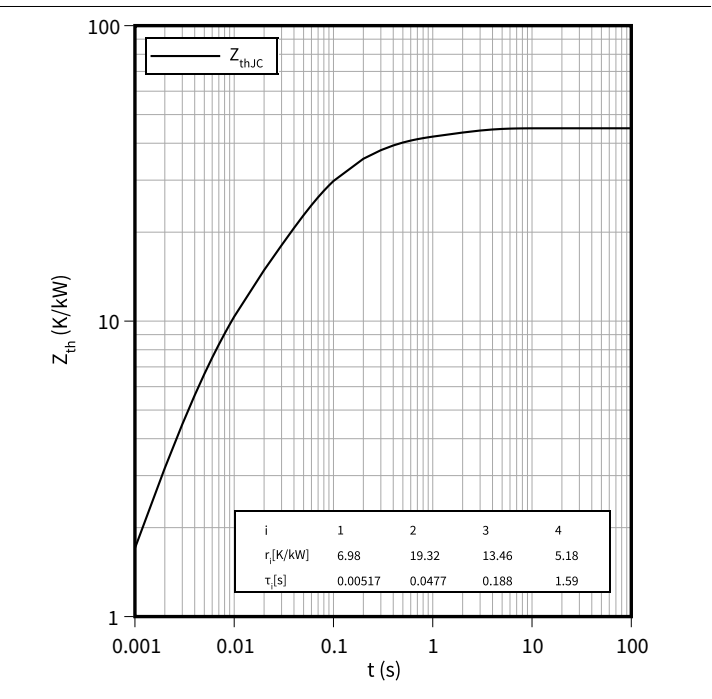
Safe operating area (SOA), Diode, Inverter

$I_R = f(V_R)$
 $T_{vj} = 150 \text{ °C}$



Transient thermal impedance, Diode, Inverter

$Z_{th} = f(t)$



5 **Circuit diagram**

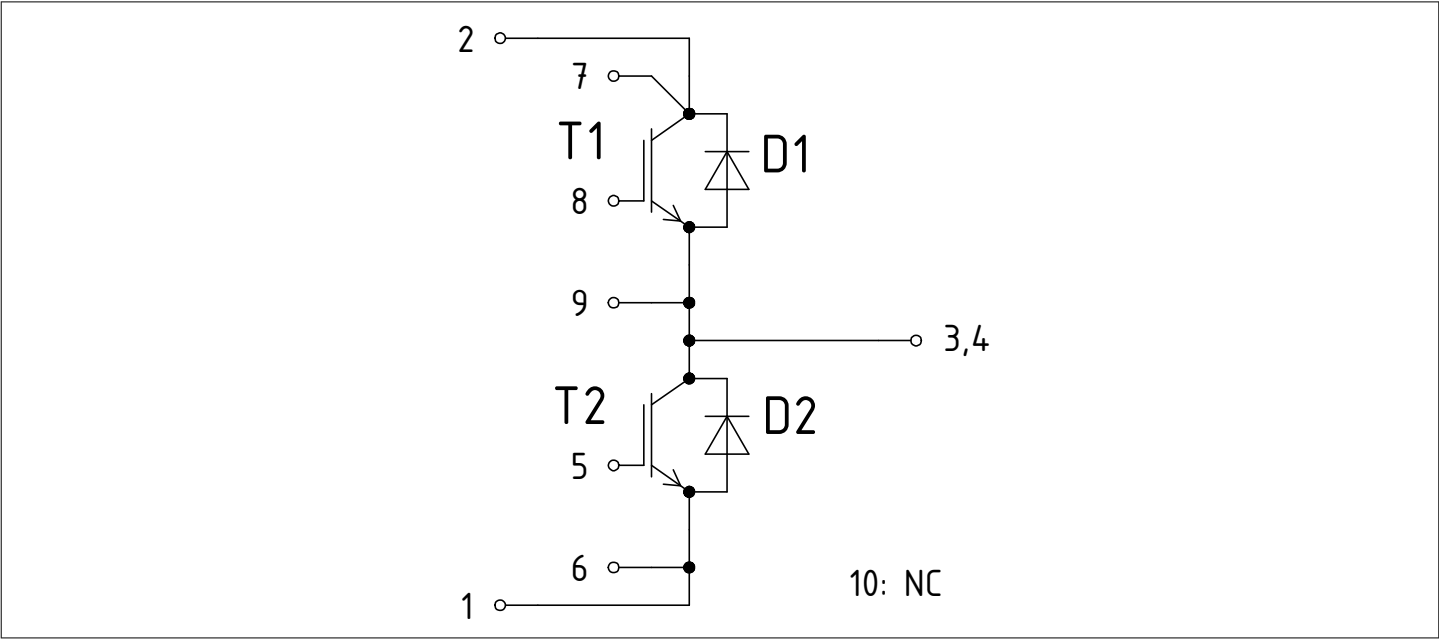


Figure 1

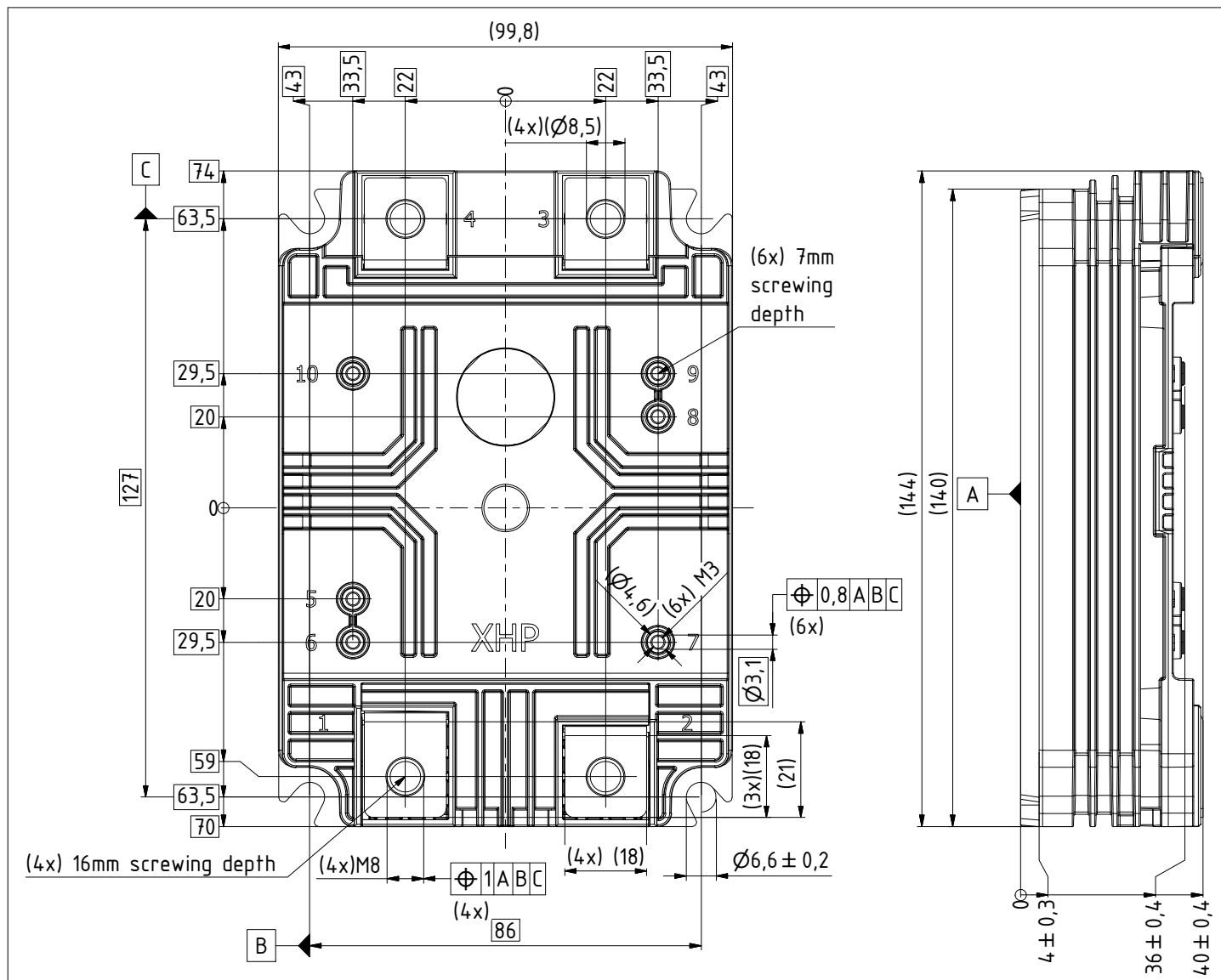


Figure 2

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
1.00	2023-06-15	Initial version

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