

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

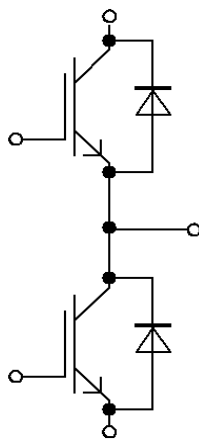


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1 Package

Table 1 Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, $f = 50$ Hz, $t = 1$ min	10.4	kV
Partial discharge extinction voltage	V_{isol}	RMS, $f = 50$ Hz, Q_{PD} typ. 10 pC	5.1	kV
DC stability	$V_{CE(D)}$	$T_{vj} = 25$ °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	$R_{AA'+CC'}$	$T_C = 25$ °C, per switch		0.33		mΩ	
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C = 25$ °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}	$T_{vj} = -40$ °C	4300	V
		$T_{vj} = 25$ °C	4500	
		$T_{vj} = 150$ °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}	$I_C = 450\text{ A}, V_{CC} = 2800\text{ V}, L_\sigma = 75\text{ nH}, V_{GE} = \pm 15\text{ V}, R_{Gon} = 0.39\ \Omega, di/dt = 4900\text{ A}/\mu\text{s} (T_{vj} = 150\text{ }^\circ\text{C})$	$T_{vj} = 25\text{ }^\circ\text{C}$	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}	$I_C = 450\text{ A}, V_{CC} = 2800\text{ V}, L_\sigma = 75\text{ nH}, V_{GE} = \pm 15\text{ V}, R_{Goff} = 22\ \Omega, dv/dt = 1080\text{ V}/\mu\text{s} (T_{vj} = 150\text{ }^\circ\text{C})$	$T_{vj} = 25\text{ }^\circ\text{C}$	1810		mJ
			$T_{vj} = 125\text{ }^\circ\text{C}$	2390		
			$T_{vj} = 150\text{ }^\circ\text{C}$	2580		
SC data	I_{SC}	$V_{GE} \leq 15\text{ V}, V_{CC} = 3000\text{ V}, V_{CEmax} = V_{CES} - L_{SCE} * di/dt$	$t_p \leq 10\ \mu\text{s}, T_{vj} = 150\text{ }^\circ\text{C}$	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	$T_{vj\ op}$		-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	$t_p = 10\text{ ms}, V_R = 0\text{ V}$	$T_{vj} = 125\text{ }^\circ\text{C}$	87.4	kA ² s
			$T_{vj} = 150\text{ }^\circ\text{C}$	79.9	
Maximum power dissipation	P_{RQM}		$T_{vj} = 150\text{ }^\circ\text{C}$	1500	kW
Minimum turn-on time	t_{onmin}			10	μs

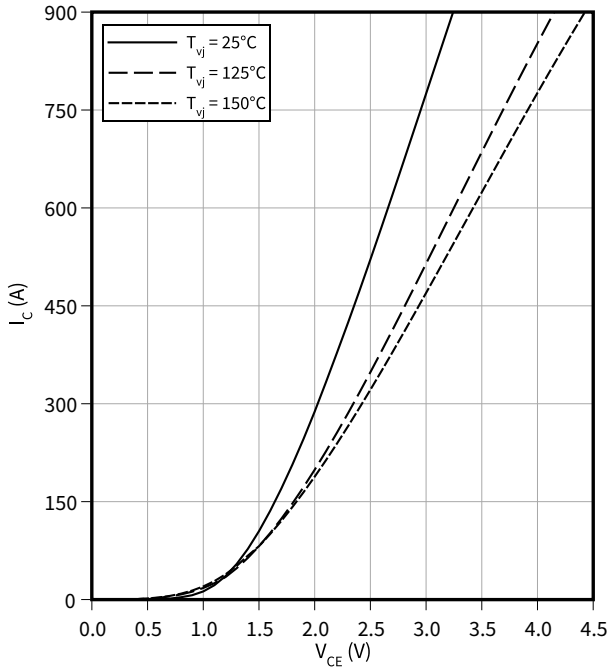
Table 6 Characteristic values

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	$T_{vj op}$		-40		150	$^{\circ}\text{C}$	

4 Characteristics diagrams

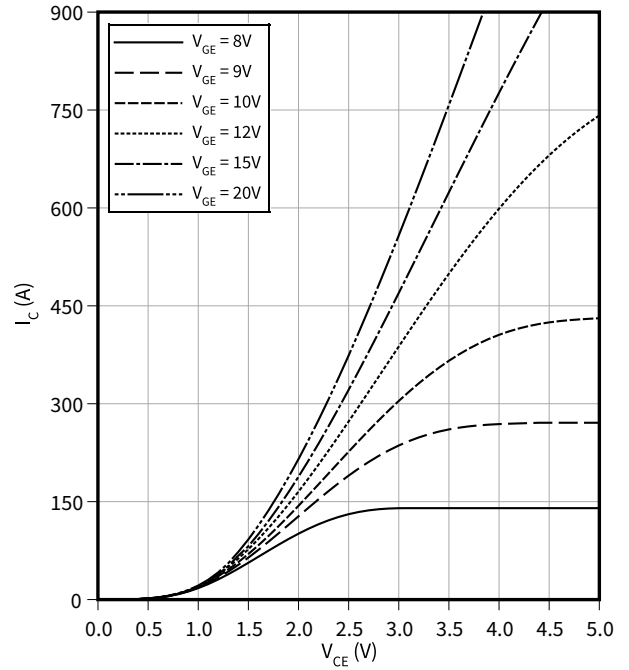
Output characteristic (typical), IGBT, Inverter

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



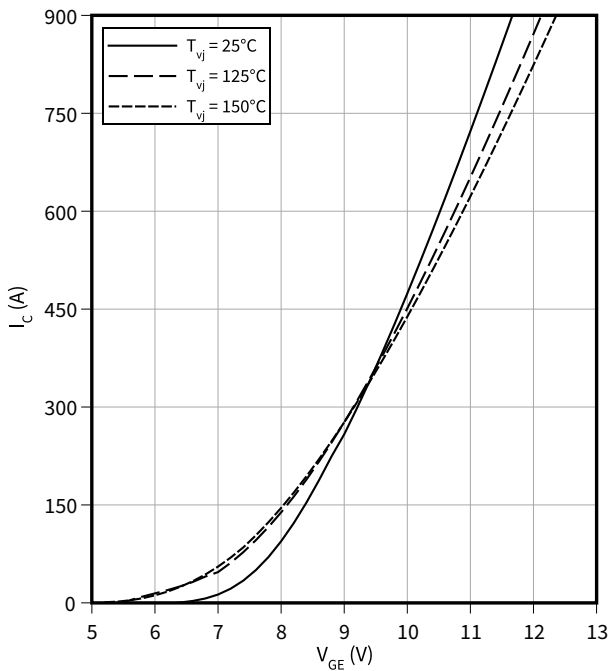
Output characteristic field (typical), IGBT, Inverter

$I_C = f(V_{CE})$
 $T_{vj} = 150\text{ °C}$



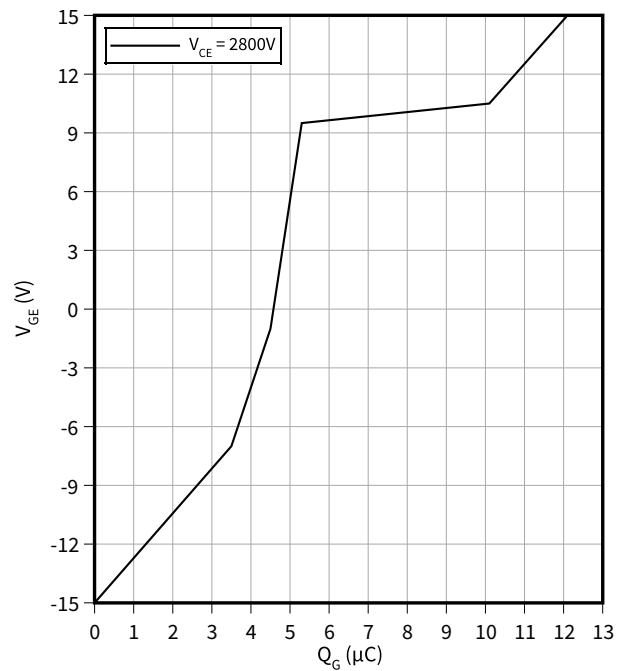
Transfer characteristic (typical), IGBT, Inverter

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



Gate charge characteristic (typical), IGBT, Inverter

$V_{GE} = f(Q_G)$
 $I_C = 450\text{ A}, T_{vj} = 25\text{ °C}$

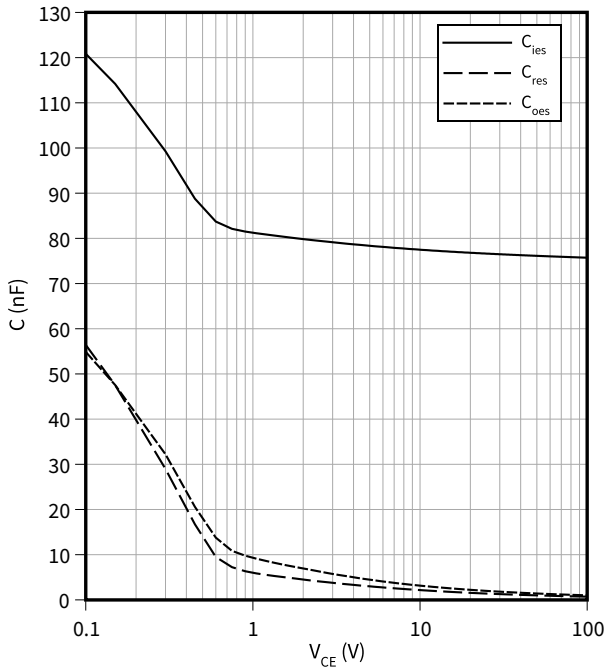


4 Characteristics diagrams

Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$

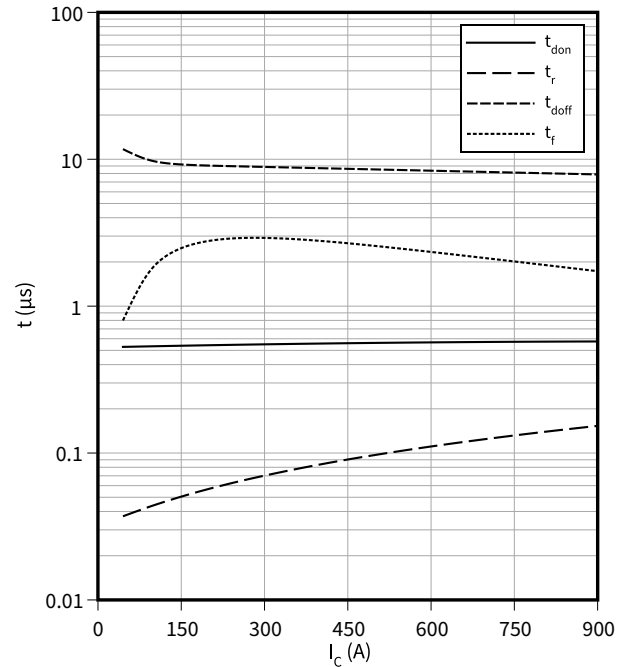
$f = 100 \text{ kHz}, V_{GE} = 0 \text{ V}, T_{vj} = 25 \text{ }^\circ\text{C}$



Switching times (typical), IGBT, Inverter

$t = f(I_C)$

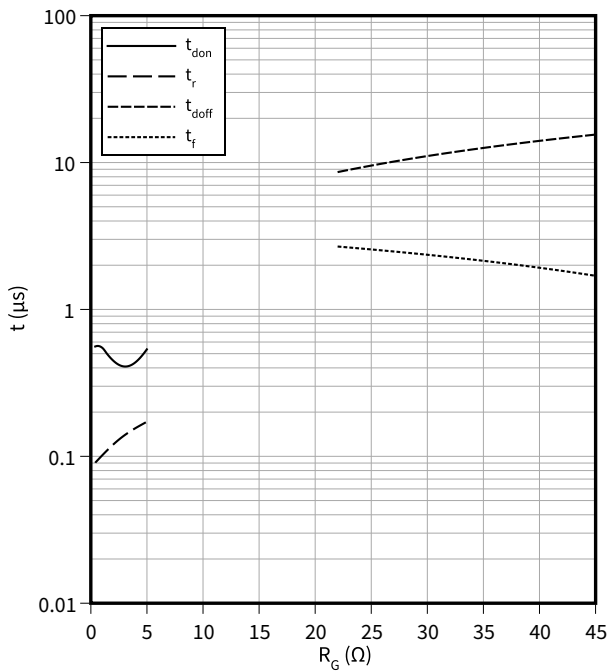
$R_{Goff} = 22 \text{ } \Omega, R_{Gon} = 0.39 \text{ } \Omega, V_{CC} = 2800 \text{ V}, V_{GE} = \pm 15 \text{ V}, T_{vj} = 150 \text{ }^\circ\text{C}$



Switching times (typical), IGBT, Inverter

$t = f(R_G)$

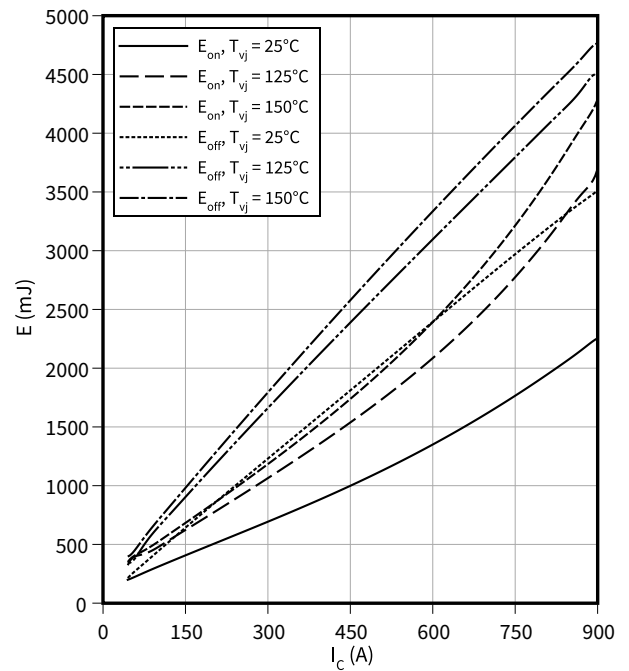
$I_C = 450 \text{ A}, V_{CC} = 2800 \text{ V}, V_{GE} = \pm 15 \text{ V}, T_{vj} = 150 \text{ }^\circ\text{C}$



Switching losses (typical), IGBT, Inverter

$E = f(I_C)$

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

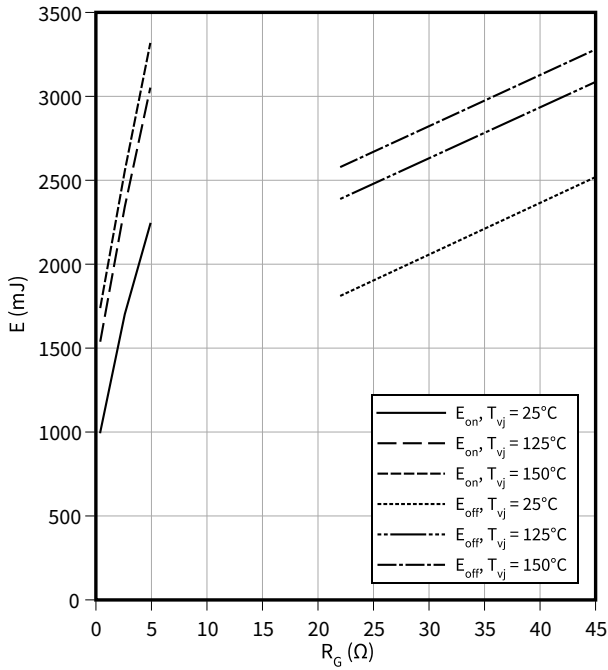


4 Characteristics diagrams

Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

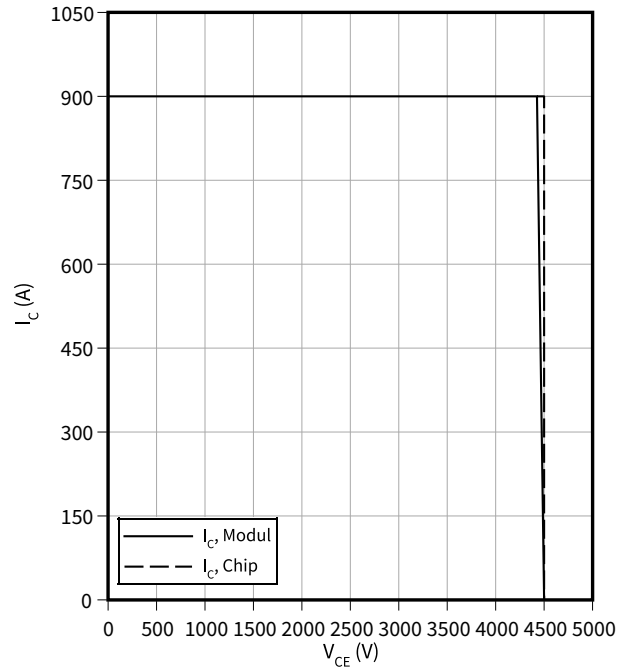
$I_C = 450 \text{ A}$, $V_{CC} = 2800 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$



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

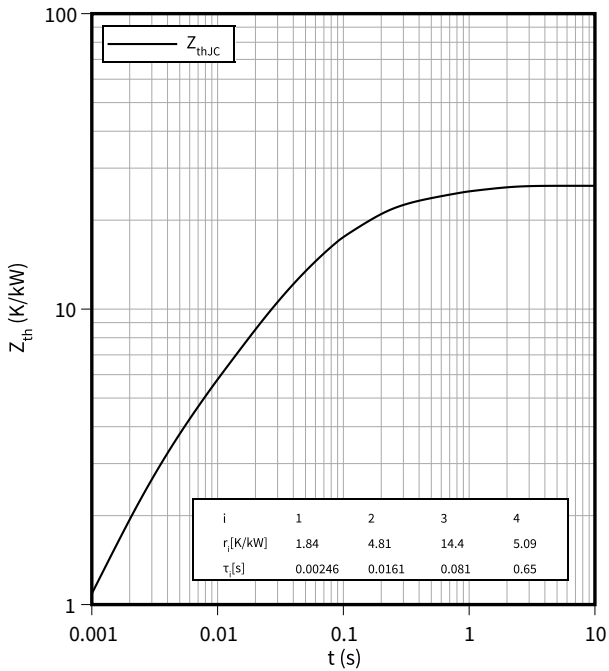
$I_C = f(V_{CE})$

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



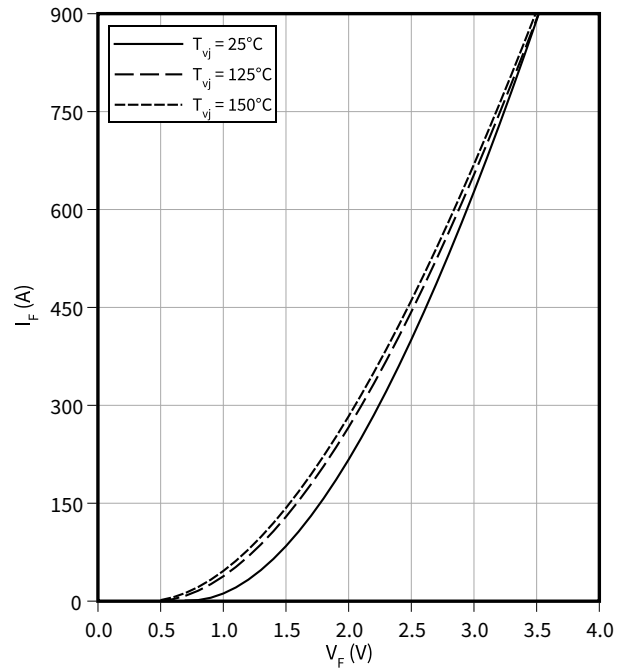
Transient thermal impedance, IGBT, Inverter

$Z_{th} = f(t)$



Forward characteristic (typical), Diode, Inverter

$I_F = f(V_F)$

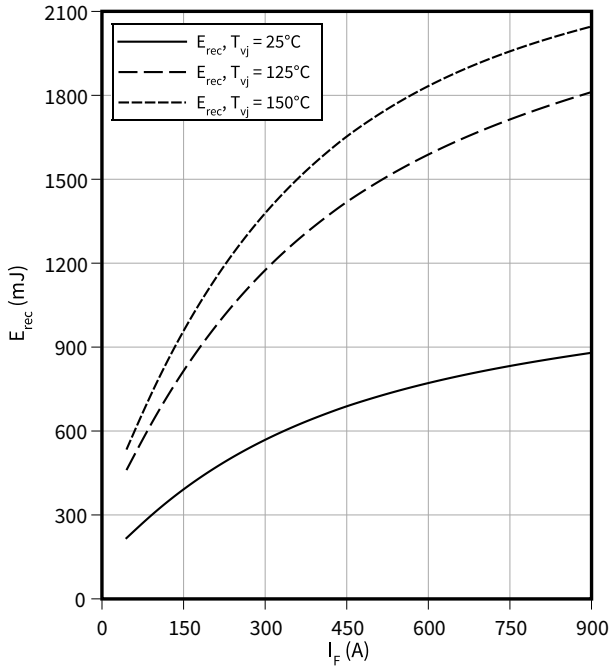


4 Characteristics diagrams

Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

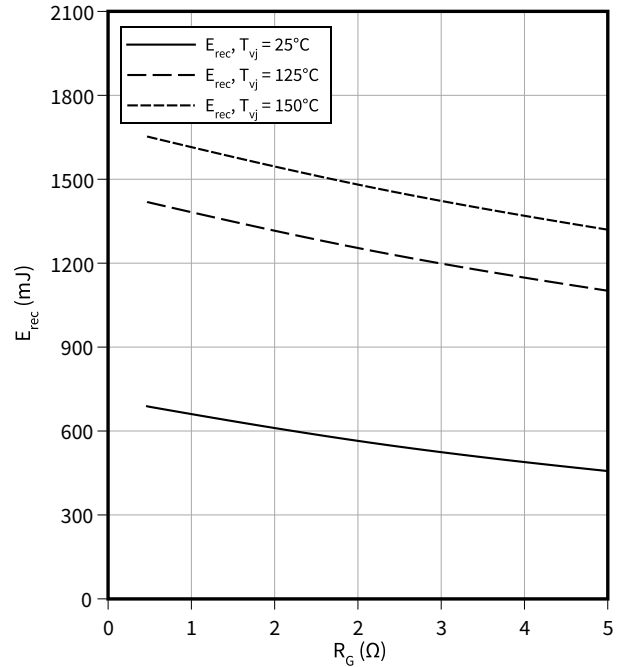
$R_{Gon} = 0.39 \Omega, V_{CE} = 2800 V$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

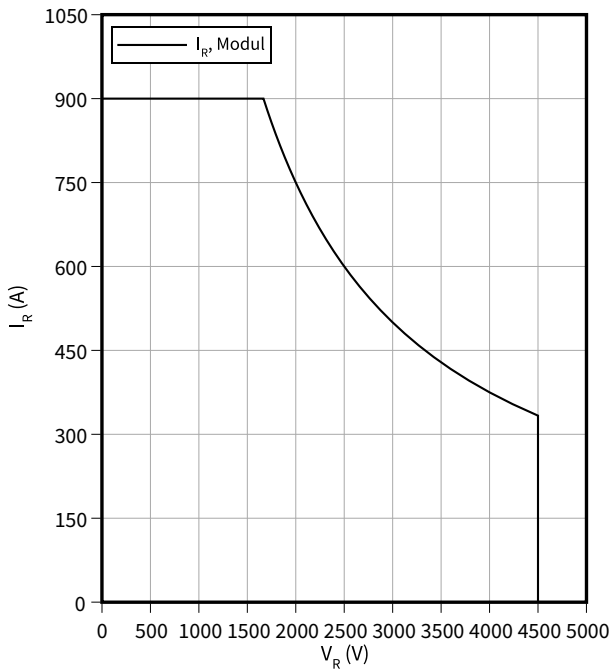
$V_{CE} = 2800 V, I_F = 450 A$



Safe operating area (SOA), Diode, Inverter

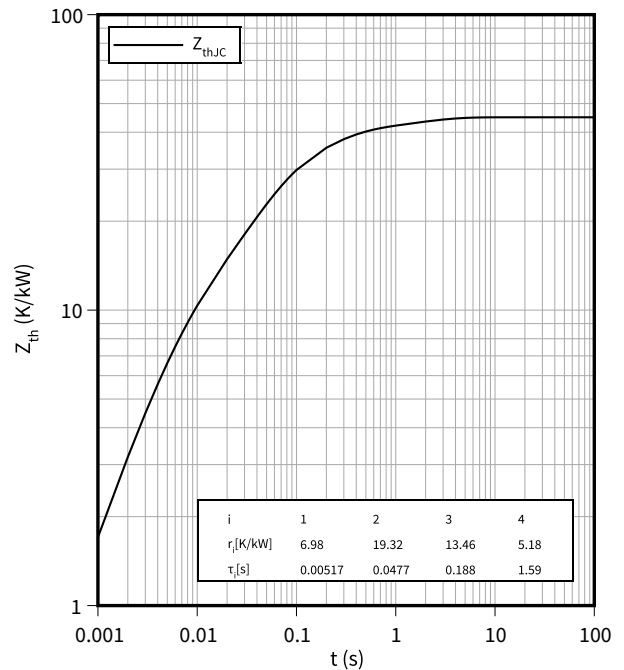
$I_R = f(V_R)$

$T_{vj} = 150 \text{ °C}$



Transient thermal impedance, Diode, Inverter

$Z_{th} = f(t)$



5 Circuit diagram

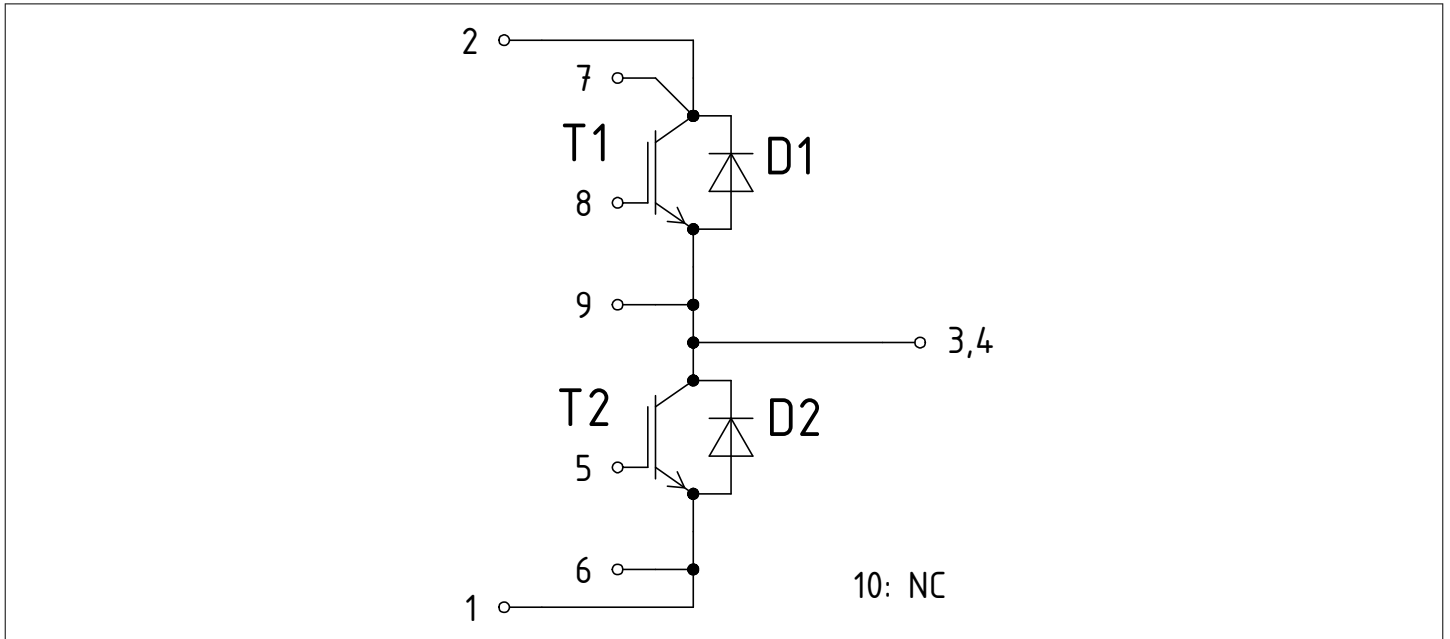


Figure 1

6 Package outlines

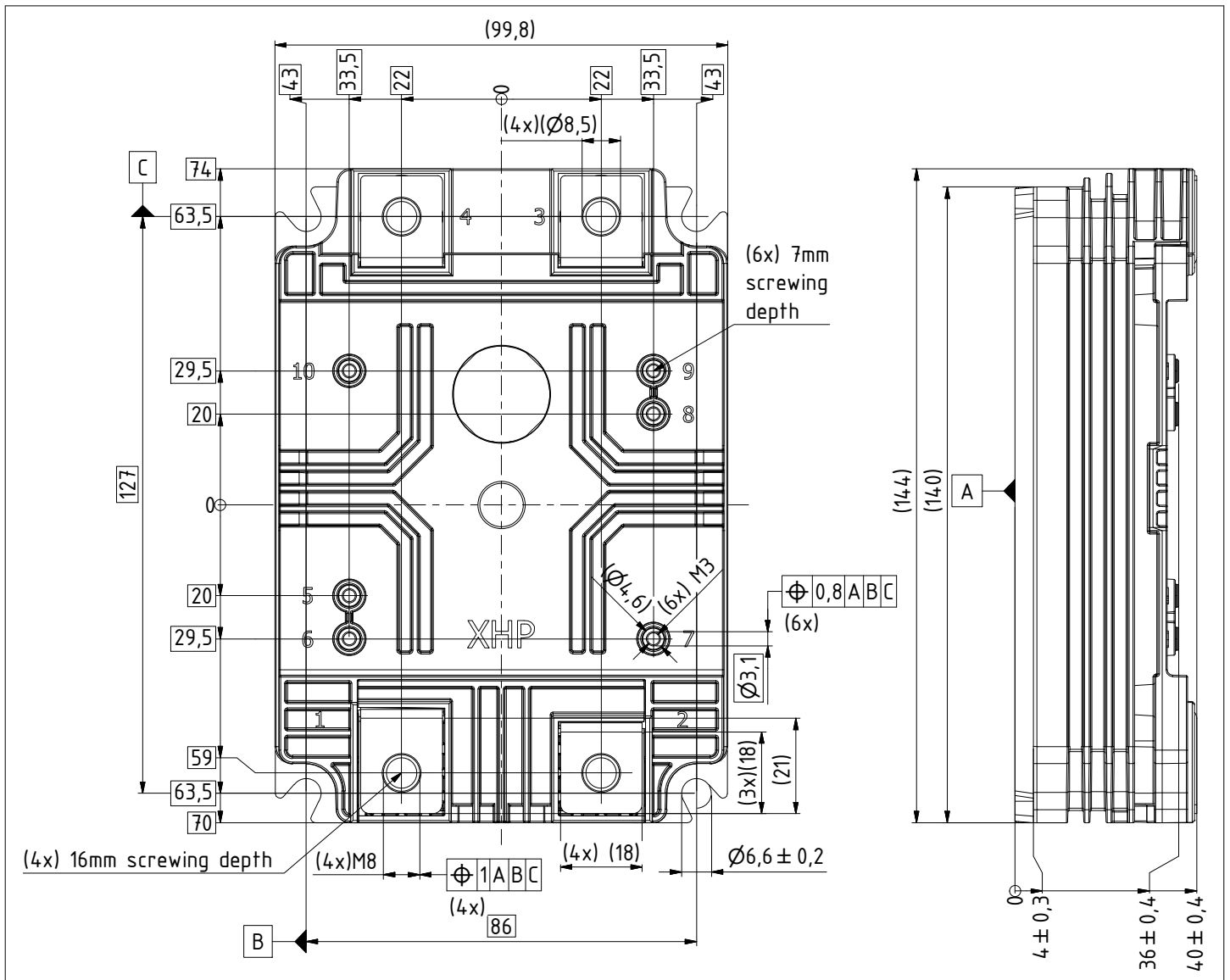


Figure 2

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			
	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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