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

Features

- Electrical features
  - V_{CES} = 4500 V
  - $I_{C\ nom}$ = 450 A / I_{CRM} = 900 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

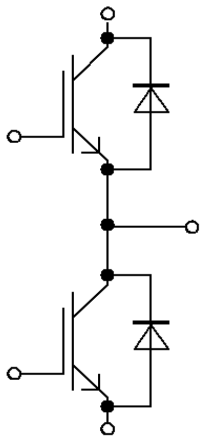
Potential applications

- 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 °C	T_C = 100 °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 A, V_{GE} = 15 V	T_{vj} = 25 °C		2.35	2.80	V
			T_{vj} = 125 °C		2.85	3.40	
			T_{vj} = 150 °C		2.95	3.50	
Gate threshold voltage	V_{GEth}	I_C = 39 mA, V_{CE} = V_{GE}, T_{vj} = 25 °C		5.5	6	6.5	V
Gate charge	Q_G	V_{GE} = ±15 V, V_{CC} = 2800 V			12.1		µC
Internal gate resistor	R_{Gint}	T_{vj} = 25 °C			1.5		Ω
Input capacitance	C_{ies}	f = 100 kHz, T_{vj} = 25 °C, V_{CE} = 25 V, V_{GE} = 0 V			76.6		nF
Reverse transfer capacitance	C_{res}	f = 100 kHz, T_{vj} = 25 °C, V_{CE} = 25 V, V_{GE} = 0 V			1.4		nF
Collector-emitter cut-off current	I_{CES}	V_{CE} = 4500 V, V_{GE} = 0 V	T_{vj} = 25 °C			5	mA
Gate-emitter leakage current	I_{GES}	V_{CE} = 0 V, V_{GE} = 20 V, T_{vj} = 25 °C				400	nA
Turn-on delay time (inductive load)	t_{don}	I_C = 450 A, V_{CC} = 2800 V, V_{GE} = ±15 V, R_{Gon} = 0.39 Ω	T_{vj} = 25 °C		0.500		µs
			T_{vj} = 125 °C		0.550		
			T_{vj} = 150 °C		0.560		
Rise time (inductive load)	t_r	I_C = 450 A, V_{CC} = 2800 V, V_{GE} = ±15 V, R_{Gon} = 0.39 Ω	T_{vj} = 25 °C		0.075		µs
			T_{vj} = 125 °C		0.085		
			T_{vj} = 150 °C		0.090		
Turn-off delay time (inductive load)	t_{doff}	I_C = 450 A, V_{CC} = 2800 V, V_{GE} = ±15 V, R_{Goff} = 22 Ω	T_{vj} = 25 °C		8.000		µs
			T_{vj} = 125 °C		8.500		
			T_{vj} = 150 °C		8.600		
Fall time (inductive load)	t_f	I_C = 450 A, V_{CC} = 2800 V, V_{GE} = ±15 V, R_{Goff} = 22 Ω	T_{vj} = 25 °C		1.300		µs
			T_{vj} = 125 °C		2.350		
			T_{vj} = 150 °C		2.700		
Turn-on time (resistive load)	t_{on_R}	I_C = 500 A, V_{CC} = 2000 V, V_{GE} = ±15 V, R_{Gon} = 0.39 Ω	T_{vj} = 25 °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 A, V_{CC} = 2800 V, L_σ = 75 nH, V_{GE} = ±15 V, R_{Gon} = 0.39 Ω, di/dt = 4900 A/µs (T_{vj} = 150 °C)	T_{vj} = 25 °C		1000		mJ
			T_{vj} = 125 °C		1540		
			T_{vj} = 150 °C		1740		
Turn-off energy loss per pulse	E_{off}	I_C = 450 A, V_{CC} = 2800 V, L_σ = 75 nH, V_{GE} = ±15 V, R_{Goff} = 22 Ω, dv/dt = 1080 V/µs (T_{vj} = 150 °C)	T_{vj} = 25 °C		1810		mJ
			T_{vj} = 125 °C		2390		
			T_{vj} = 150 °C		2580		
SC data	I_{SC}	V_{GE} ≤ 15 V, V_{CC} = 3000 V, V_{CEmax}=V_{CES}-L_{sCE}*di/dt	t_P ≤ 10 µs, T_{vj}=150 °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, λ_{grease} = 1 W/(m·K)			27.1		K/kW
Temperature under switching conditions	$T_{vj\ op}$			-40		150	°C

3 Diode, Inverter

Table 5 **Maximum rated values**

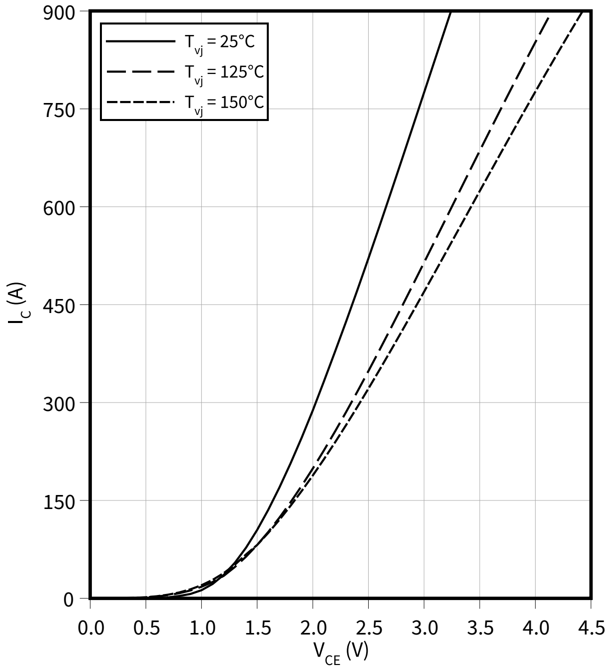
Parameter	Symbol	Note or test condition		Values	Unit
Repetitive peak reverse voltage	V_{RRM}		T_{vj} = -40 °C	4300	V
			T_{vj} = 25 °C	4500	
			T_{vj} = 150 °C	4500	
Continuous DC forward current	I_F			450	A
Repetitive peak forward current	I_{FRM}	t_P = 1 ms		900	A
I^2t - value	I^2t	t_P = 10 ms, V_R = 0 V	T_{vj} = 125 °C	87.4	kA^2s
			T_{vj} = 150 °C	79.9	
Maximum power dissipation	P_{RQM}		T_{vj} = 150 °C	1500	kW
Minimum turn-on time	t_{onmin}			10	µs

Table 6 **Characteristic values**

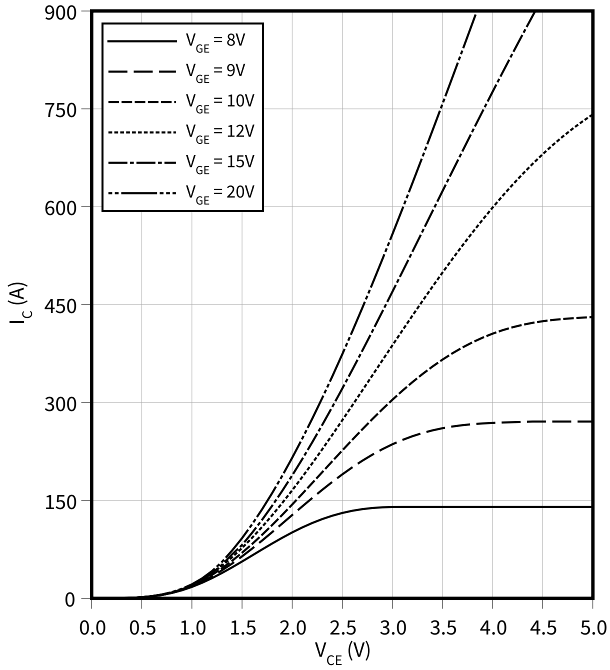
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Forward voltage	V_F	I_F = 450 A, V_{GE} = 0 V	T_{vj} = 25 °C		2.60	3.05	V
			T_{vj} = 125 °C		2.50	2.95	
			T_{vj} = 150 °C		2.45	2.90	
Peak reverse recovery current	I_{RM}	V_{CC} = 2800 V, I_F = 450 A, V_{GE} = -15 V, -di_F/dt = 4900 A/µs (T_{vj} = 150 °C)	T_{vj} = 25 °C		925		A
			T_{vj} = 125 °C		920		
			T_{vj} = 150 °C		920		
Recovered charge	Q_r	V_{CC} = 2800 V, I_F = 450 A, V_{GE} = -15 V, -di_F/dt = 4900 A/µs (T_{vj} = 150 °C)	T_{vj} = 25 °C		405		µC
			T_{vj} = 125 °C		780		
			T_{vj} = 150 °C		900		
Reverse recovery energy	E_{rec}	V_{CC} = 2800 V, I_F = 450 A, V_{GE} = -15 V, -di_F/dt = 4900 A/µs (T_{vj} = 150 °C)	T_{vj} = 25 °C		690		mJ
			T_{vj} = 125 °C		1400		
			T_{vj} = 150 °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, λ_{grease} = 1 W/(m·K)			19.8		K/kW
Temperature under switching conditions	$T_{vj\ op}$			-40		150	°C

4 Characteristics diagrams

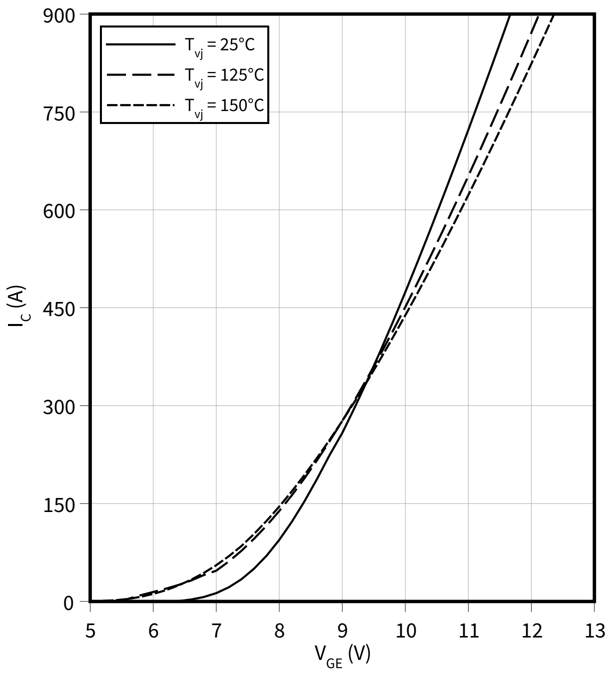
Output characteristic (typical), IGBT, Inverter
$I_C = f(V_{CE})$
$V_{GE} = 15\ V$



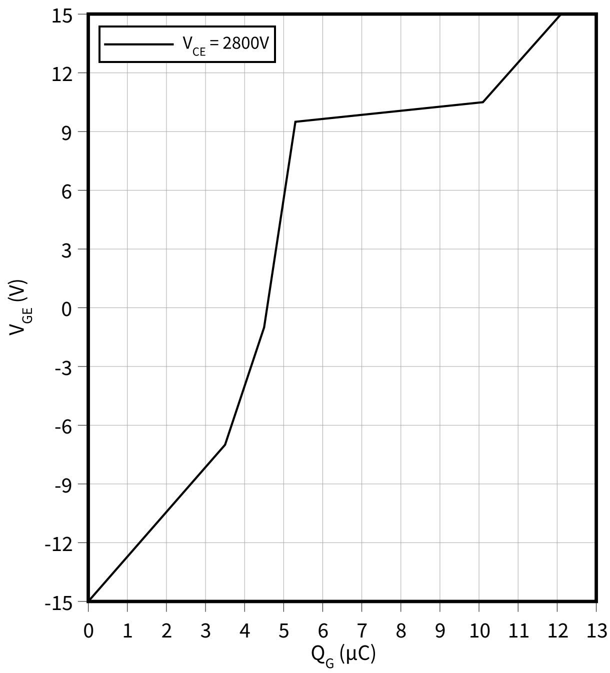
Output characteristic field (typical), IGBT, Inverter
$I_C = f(V_{CE})$
$T_{vj} = 150\ °C$



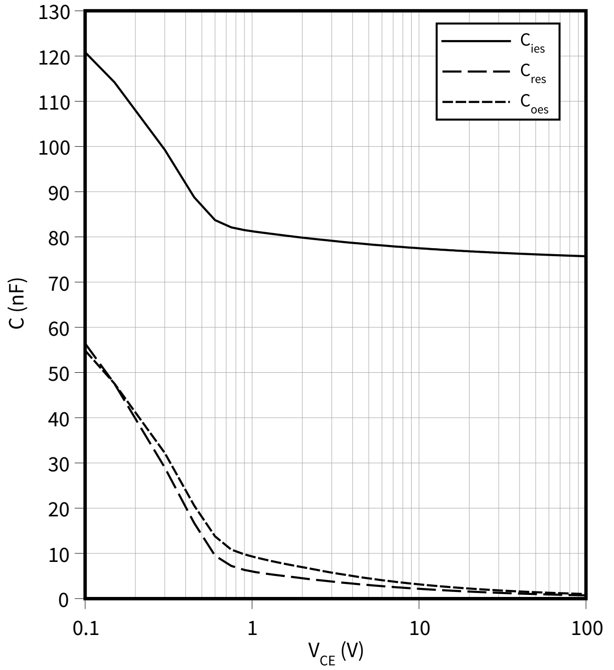
Transfer characteristic (typical), IGBT, Inverter
$I_C = f(V_{GE})$
$V_{CE} = 20\ V$



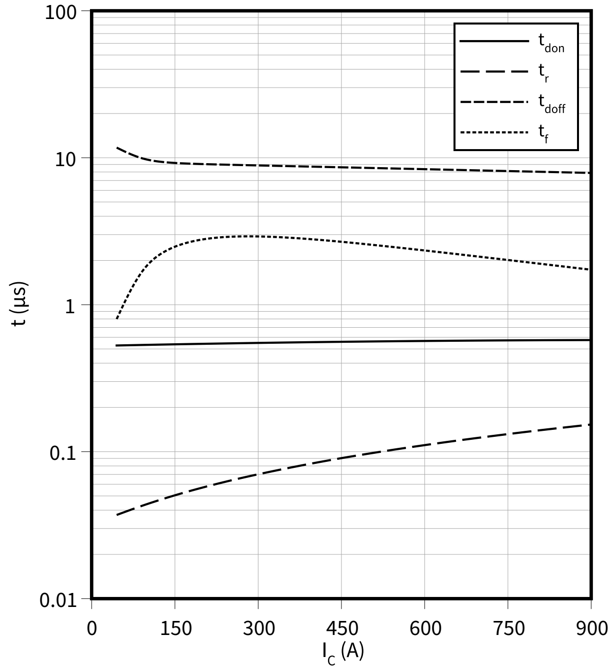
Gate charge characteristic (typical), IGBT, Inverter
$V_{GE} = f(Q_G)$
$I_C = 450\ A$, $T_{vj} = 25\ °C$



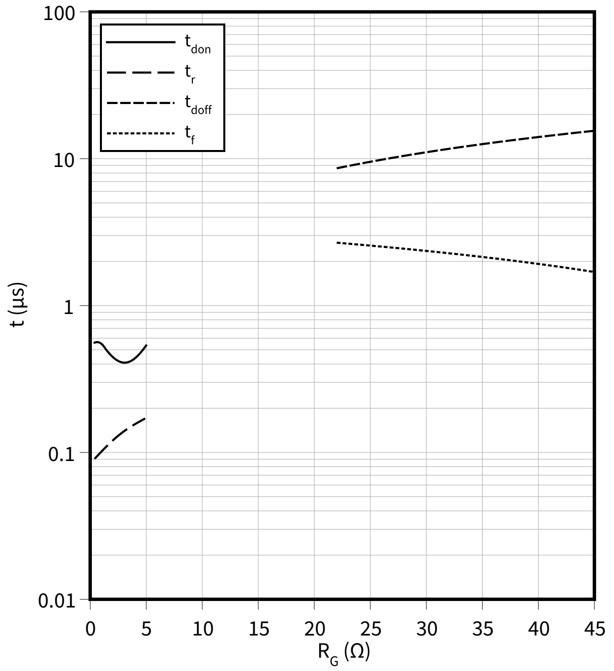
Capacity characteristic (typical), IGBT, Inverter
$C = f(V_{CE})$
$f = 100\ kHz$, $V_{GE} = 0\ V$, $T_{vj} = 25\ °C$



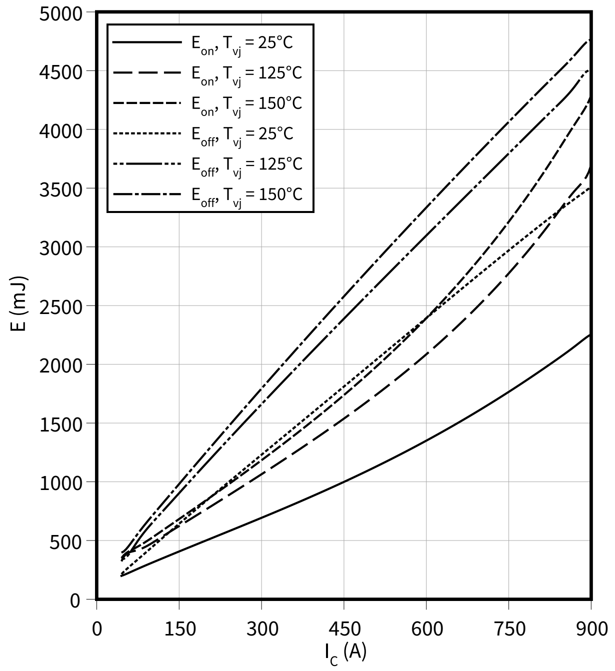
Switching times (typical), IGBT, Inverter
$t = f(I_C)$
$R_{Goff} = 22\ \Omega$, $R_{Gon} = 0.39\ \Omega$, $V_{CC} = 2800\ V$, $V_{GE} = \pm 15\ V$, $T_{vj} = 150\ °C$



Switching times (typical), IGBT, Inverter
$t = f(R_G)$
$I_C = 450\ A$, $V_{CC} = 2800\ V$, $V_{GE} = \pm 15\ V$, $T_{vj} = 150\ °C$



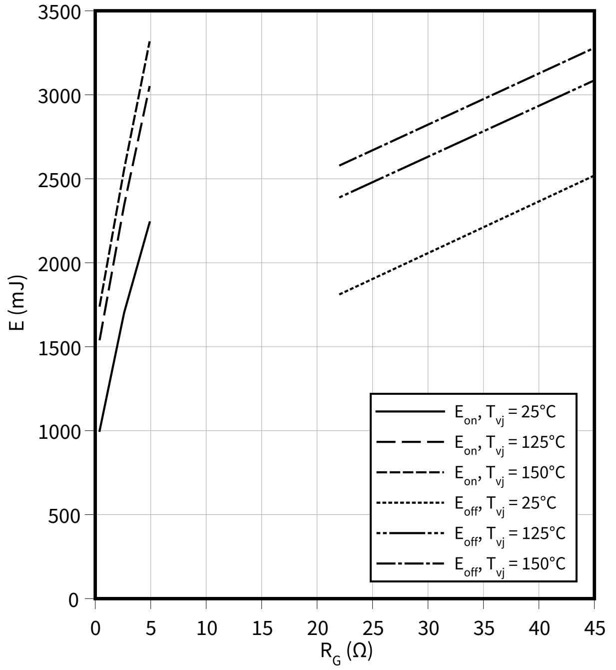
Switching losses (typical), IGBT, Inverter
$E = f(I_C)$
$R_{Goff} = 22\ \Omega$, $R_{Gon} = 0.39\ \Omega$, $V_{CC} = 2800\ V$, $V_{GE} = \pm 15\ V$



Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

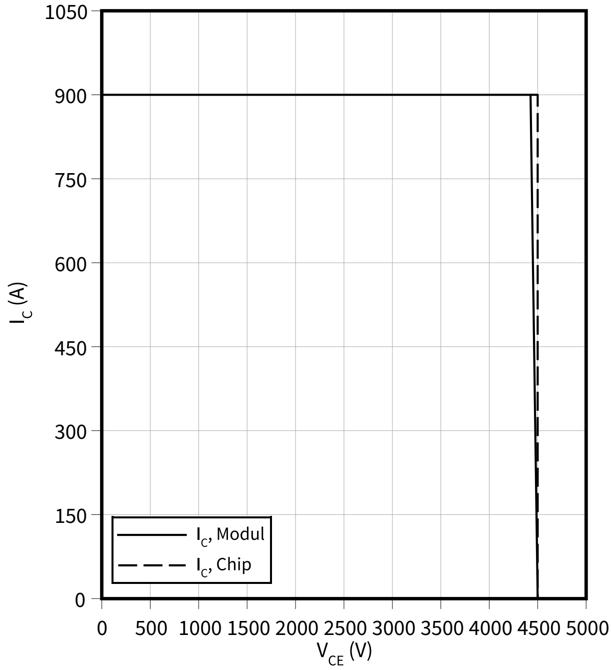
$I_C = 450$ A, $V_{CC} = 2800$ V, $V_{GE} = \pm 15$ V



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

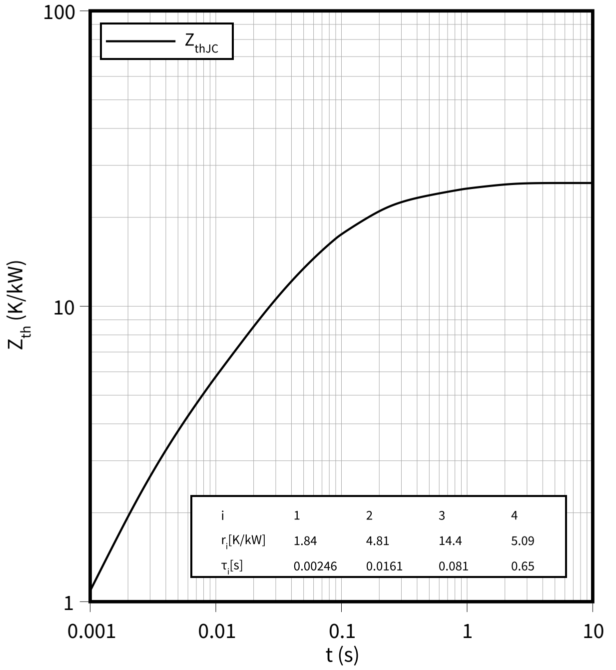
$I_C = f(V_{CE})$

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



Transient thermal impedance, IGBT, Inverter

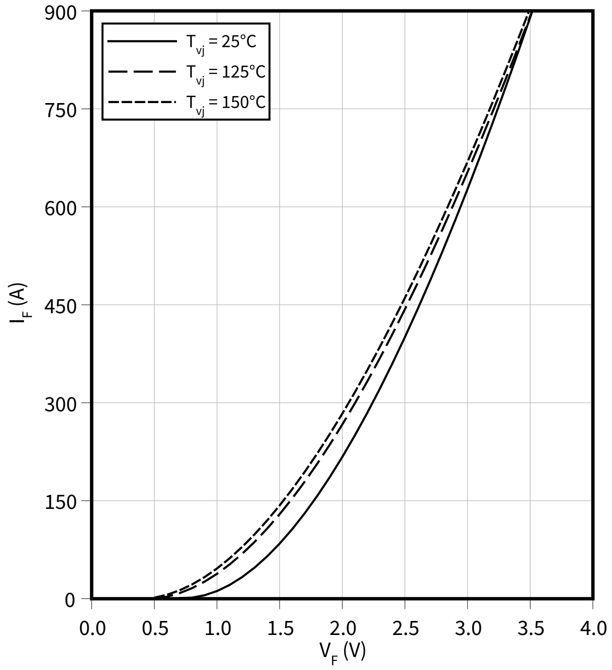
$Z_{th} = f(t)$



i	1	2	3	4
r_i[K/kW]	1.84	4.81	14.4	5.09
τ_i[s]	0.00246	0.0161	0.081	0.65

Forward characteristic (typical), Diode, Inverter

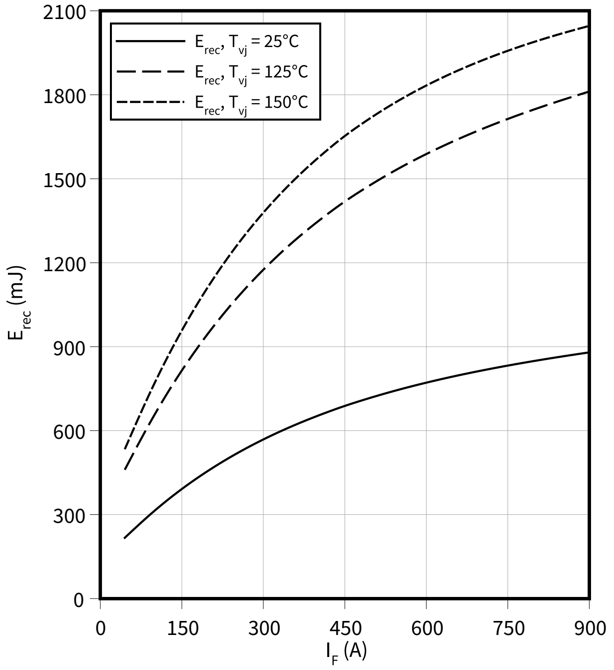
$I_F = f(V_F)$



Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

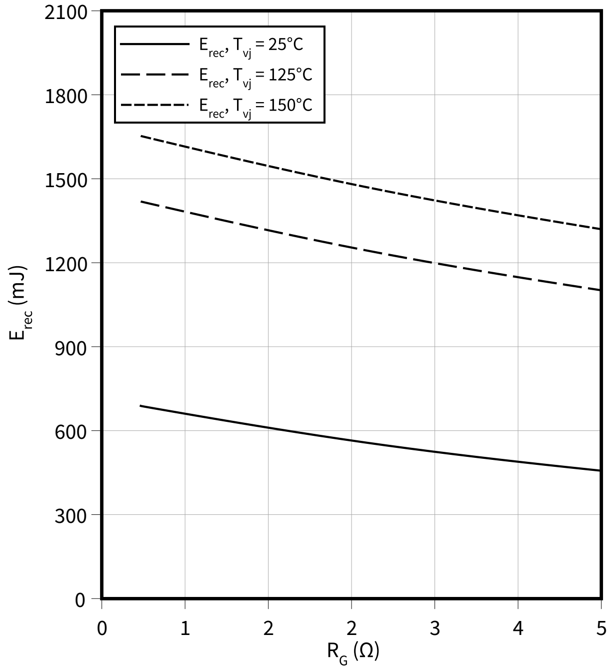
$R_{Gon} = 0.39\ \Omega$, $V_{CE} = 2800$ V



Switching losses (typical), Diode, Inverter

$E_{rec} = f(R_G)$

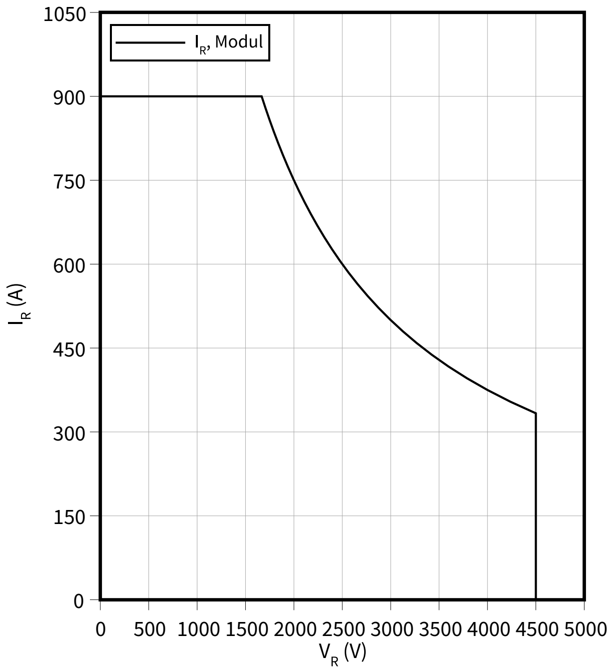
$V_{CE} = 2800$ V, $I_F = 450$ A



Safe operating area (SOA), Diode, Inverter

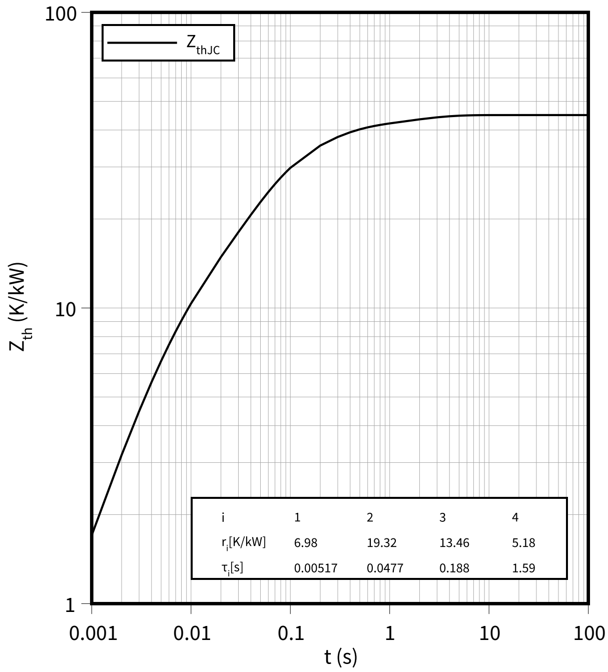
$I_R = f(V_R)$

$T_{vj} = 150$ °C



Transient thermal impedance, Diode, Inverter

$Z_{th} = f(t)$



5 Circuit diagram

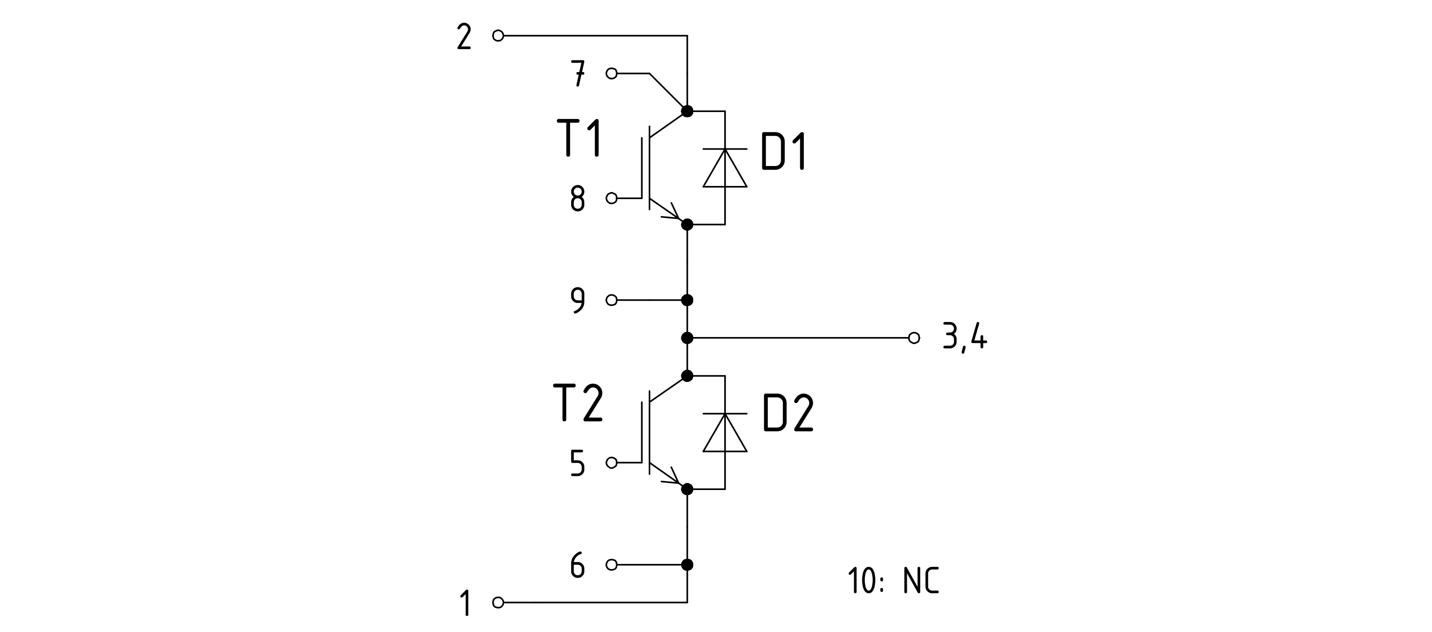


Figure 1

6 Package outlines

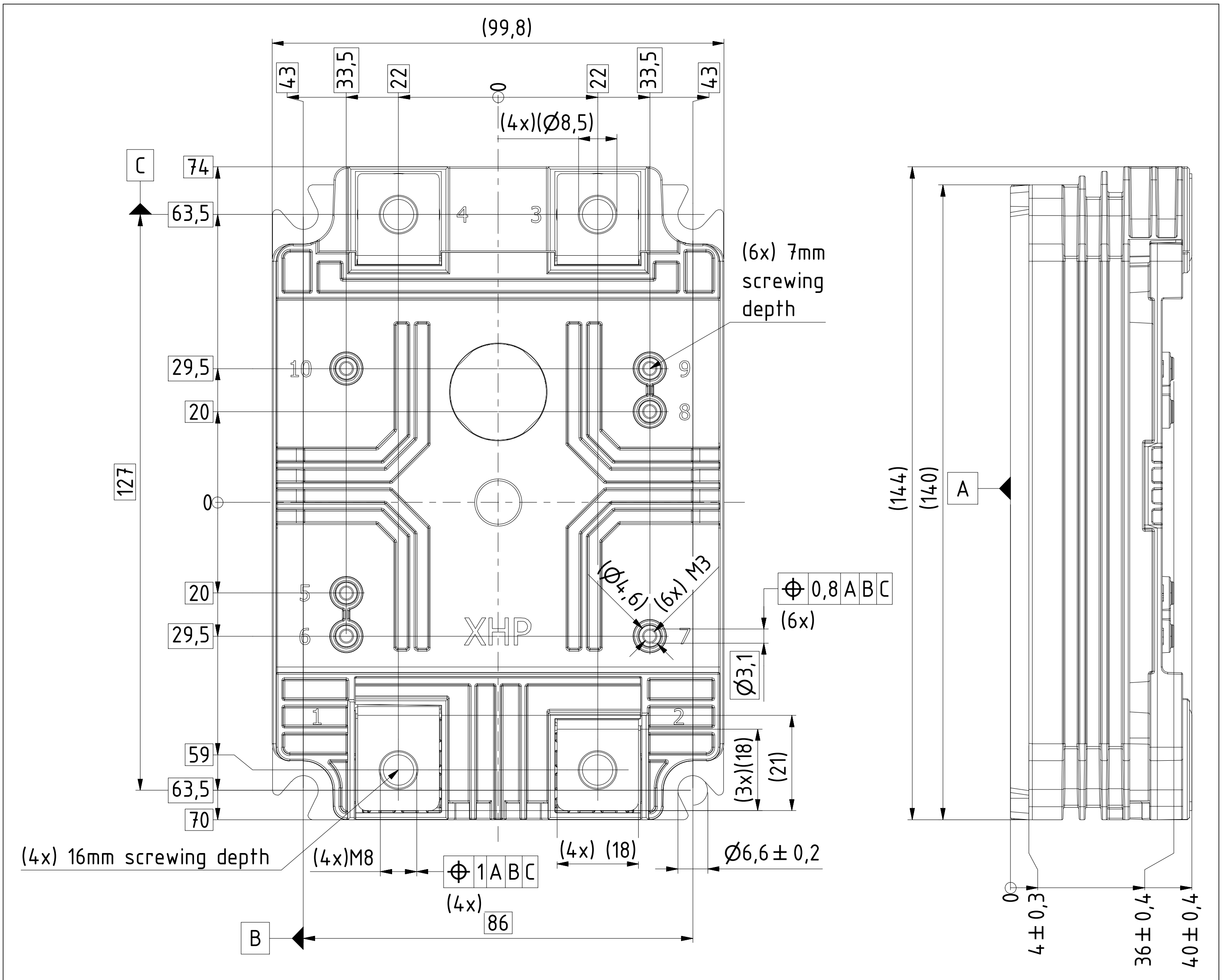


Figure 2

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* Module serial number Module material number Production order number Date code (production year) Date code (production week)	*Digit* 1 – 5 6 - 11 12 - 19 20 – 21 22 – 23	*Example* 71549 142846 55054991 15 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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