

A large, stylized white graphic consisting of a thick, curved line that forms a partial circle, with a smaller circle attached to its upper left side, resembling a stylized 'C' or a power symbol.

HybridPACK™ 1 Module

FS400R07A1E3

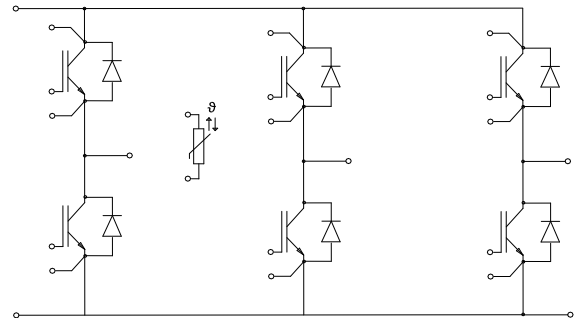
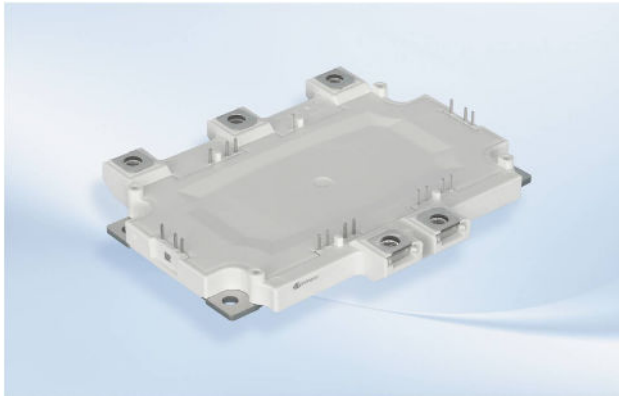
Final Data Sheet

V3.4, 2018-08-09

Automotive High Power

1 Features / Description

HybridPACK™ 1 module with Trench/Fieldstop IGBT3 and Emitter Controlled 3 diode and NTC



$V_{CES} = 650V$
 $I_{C\ nom} = 400A$

Typical Applications

- Automotive Applications
- Hybrid Electrical Vehicles (H)EV
- Commercial Agriculture Vehicles
- Motor Drives
- Optimized for automotive applications with DC link voltages up to 420 V

Electrical Features

- Low Switching Losses
- Low V_{CESat}
- $T_{vj\ op} = 150^{\circ}C$
- V_{CESat} with positive Temperature Coefficient

Mechanical Features

- 2.5kV AC 1min Insulation
- Al_2O_3 Substrate with Low Thermal Resistance
- High mechanical robustness
- Integrated NTC temperature sensor
- Copper Base Plate
- RoHS compliant

Description

Infineon®'s HybridPACK™ 1 is an automotive qualified power module designed for electric vehicle applications for a power range up to 20–30kW. Designed for a 150°C junction operation temperature, the module accommodates a 3-phase Six-Pack configuration of Trench-Field-Stop IGBT3 and matching emitter controlled diodes.

The HybridPACK™ 1 power module is built on Infineon's long time experience in the development of IGBT power modules, intense research efforts of new material combinations and assembly technologies. HybridPACK™ 1 is suitable for air or liquid cooling. The copper base plate combined with high-performance ceramic substrate and Infineon's enhanced wire-bonding process provides unparalleled thermal and power cycling capability and highest reliability for mild hybrid inverter or generator applications. For a compact design the driver stage PCB can easily be soldered on top of the module. All power connections are realized with screw terminals.

Product Name	Ordering Code
FS400R07A1E3	SP000663446

2 IGBT, Inverter

2.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Collector-emitter voltage	$T_{vj} = 25^{\circ}\text{C}$	V_{CES}	650	V
Continuous DC collector current	$T_C = 65^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$ $T_C = 25^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	$I_{C\text{ nom}}$ I_C	400 500	A A
Repetitive peak collector current	$t_P = 1\text{ ms}$	I_{CRM}	800	A
Total power dissipation	$T_C = 25^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	P_{tot}	1250	W
Gate-emitter peak voltage		V_{GES}	+/-20	V

2.2 Characteristic Values

Parameter	Conditions	Symbol	min. typ. max.			Unit	
Collector-emitter saturation voltage	$I_C = 400\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 400\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 400\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$V_{CE\text{ sat}}$		1.45 1.60 1.70	1.90 V	
Gate threshold voltage	$I_C = 6.40\text{ mA}, V_{CE} = V_{GE}$	$T_{vj} = 25^{\circ}\text{C}$	$V_{GE\text{ th}}$	4.90	5.80	6.50	V
Gate charge	$V_{GE} = -15\text{ V} \dots 15\text{ V}$		Q_G		4.30		μC
Internal gate resistor		$T_{vj} = 25^{\circ}\text{C}$	R_{Gint}		1.0		Ω
Input capacitance	$f = 1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	C_{ies}		26.0		nF
Reverse transfer capacitance	$f = 1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	C_{res}		0.76		nF
Collector-emitter cut-off current	$V_{CE} = 650\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	I_{CES}			1.0	mA
Gate-emitter leakage current	$V_{CE} = 0\text{ V}, V_{GE} = 20\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	I_{GES}			400	nA
Turn-on delay time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Gon} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ on}}$		0.10 0.11 0.12		μs
Rise time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Gon} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_r		0.08 0.08 0.08		μs
Turn-off delay time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ off}}$		0.46 0.50 0.50		μs
Fall time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_f		0.05 0.07 0.08		μs
Turn-on energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = \pm 15\text{ V}, di/dt = 5500\text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $R_{Gon} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{on}		2.90 4.20 4.50		mJ
Turn-off energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = \pm 15\text{ V}, du/dt = 3000\text{ V}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{off}		13.0 16.0 17.0		mJ
SC data	$V_{GE} \leq 15\text{ V}, V_{CC} = 360\text{ V}$ $V_{CE\text{ max}} = V_{CES} - L_{SCE} \cdot di/dt$	$t_P \leq 8\ \mu\text{s}, T_{vj} = 25^{\circ}\text{C}$ $t_P \leq 6\ \mu\text{s}, T_{vj} = 150^{\circ}\text{C}$	I_{SC}		2800 2000		A
Thermal resistance, junction to case	per IGBT		R_{thJC}			0.120	K/W
Thermal resistance, case to heatsink	per IGBT $\lambda_{\text{Paste}} = 1\text{ W}/(\text{m}\cdot\text{K}) / \lambda_{\text{grease}} = 1\text{ W}/(\text{m}\cdot\text{K})$		R_{thCH}		0.080		K/W
Temperature under switching conditions	t_{op} continuous		$T_{vj\text{ op}}$	-40		150	$^{\circ}\text{C}$

3 Diode, Inverter

3.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Repetitive peak reverse voltage	$T_{vj} = 25^{\circ}\text{C}$	V_{RRM}	650	V
Continuous DC forward current		I_F	400	A
Repetitive peak forward current	$t_P = 1 \text{ ms}$	I_{FRM}	800	A
I^2t - value	$V_R = 0 \text{ V}$, $t_P = 10 \text{ ms}$, $T_{vj} = 125^{\circ}\text{C}$ $V_R = 0 \text{ V}$, $t_P = 10 \text{ ms}$, $T_{vj} = 150^{\circ}\text{C}$	I^2t	8800 8500	A^2s A^2s

3.2 Characteristic Values

Parameter	Conditions	Symbol	Value			Unit
			min.	typ.	max.	
Forward voltage	$I_F = 400 \text{ A}$, $V_{GE} = 0 \text{ V}$ $I_F = 400 \text{ A}$, $V_{GE} = 0 \text{ V}$ $I_F = 400 \text{ A}$, $V_{GE} = 0 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	V_F	1.55 1.50 1.45	1.95	V
Peak reverse recovery current	$I_F = 400 \text{ A}$, $-di_F/dt = 5500 \text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	I_{RM}	210 280 300		A
Recovered charge	$I_F = 400 \text{ A}$, $-di_F/dt = 5500 \text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	Q_r	18.0 30.0 34.0		μC
Reverse recovery energy	$I_F = 400 \text{ A}$, $-di_F/dt = 5500 \text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{rec}	3.60 7.25 8.30		mJ
Thermal resistance, junction to case	per diode		R_{thJC}		0.200	K/W
Thermal resistance, case to heatsink	per diode $\lambda_{Paste} = 1 \text{ W}/(\text{m}\cdot\text{K})$ / $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot\text{K})$		R_{thCH}	0.085		K/W
Temperature under switching conditions	t_{op} continuous		$T_{vj op}$	-40	150	$^{\circ}\text{C}$

4 NTC-Thermistor

Parameter	Conditions	Symbol	Value			Unit
			min.	typ.	max.	
Rated resistance	$T_C = 25^{\circ}\text{C}$	R_{25}		5.00		$\text{k}\Omega$
Deviation of R_{100}	$T_C = 100^{\circ}\text{C}$, $R_{100} = 493 \Omega$	$\Delta R/R$	5		5	%
Power dissipation	$T_C = 25^{\circ}\text{C}$	P_{25}			20.0	mW
B-value	$R_2 = R_{25} \exp [B_{25/50}(1/T_2 - 1/(298,15 \text{ K}))]$	$B_{25/50}$		3375		K
B-value	$R_2 = R_{25} \exp [B_{25/80}(1/T_2 - 1/(298,15 \text{ K}))]$	$B_{25/80}$		3411		K
B-value	$R_2 = R_{25} \exp [B_{25/100}(1/T_2 - 1/(298,15 \text{ K}))]$	$B_{25/100}$		3433		K

Specification according to the valid application note.

5 Module

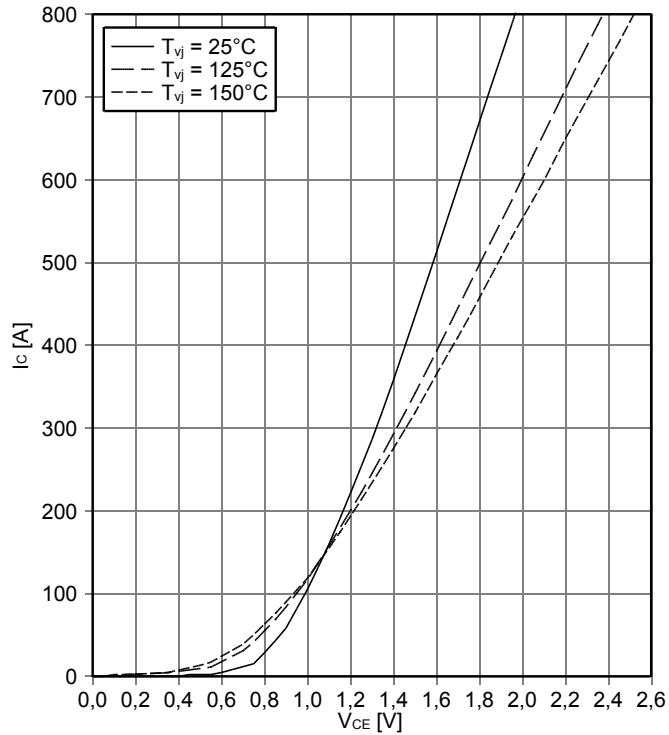
Parameter	Conditions	Symbol	Value			Unit
Isolation test voltage	RMS, f = 50 Hz, t = 1 min.	V_{ISOL}	2.5			kV
Material of module baseplate			Cu			
Internal isolation	basic insulation (class 1, IEC 61140)		Al ₂ O ₃			
Creepage distance	terminal to heatsink	d_{Creep}	12.0			mm
	terminal to terminal		6.1			
Clearance	terminal to heatsink	d_{Clear}	12.0			mm
	terminal to terminal		6.1			
Comperative tracking index		CTI	> 200			
			min.	typ.	max.	
Stray inductance module		L_{sCE}		30		nH
Module lead resistance, terminals - chip	$T_C = 25\text{ °C}$, per switch	$R_{CC+EE'}$		1.00		mΩ
Storage temperature		T_{stg}	-40		125	°C
Mounting torque for modul mounting	Screw M5 baseplate to heatsink	M	3.00		6.00	Nm
Terminal connection torque	Screw M6	M	3.0	-	6.0	Nm
Weight		G		485		g

Der Kollektor-Dauergleichstrom / Dioden-Dauergleichstrom ist durch die Lastanschlüsse begrenzt.
 DC-collector current / diode forward current limited by power terminals.

6 Characteristics Diagrams

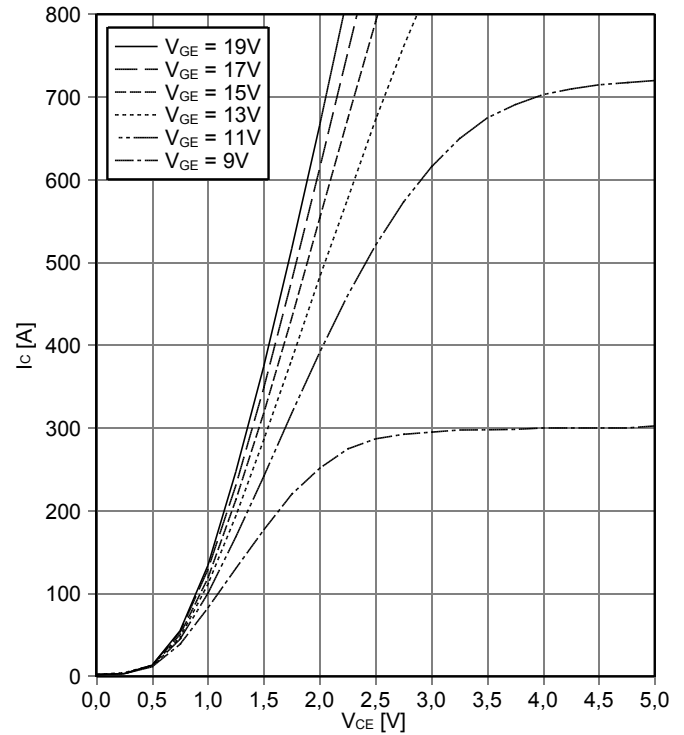
output characteristic IGBT, Inverter (typical)

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



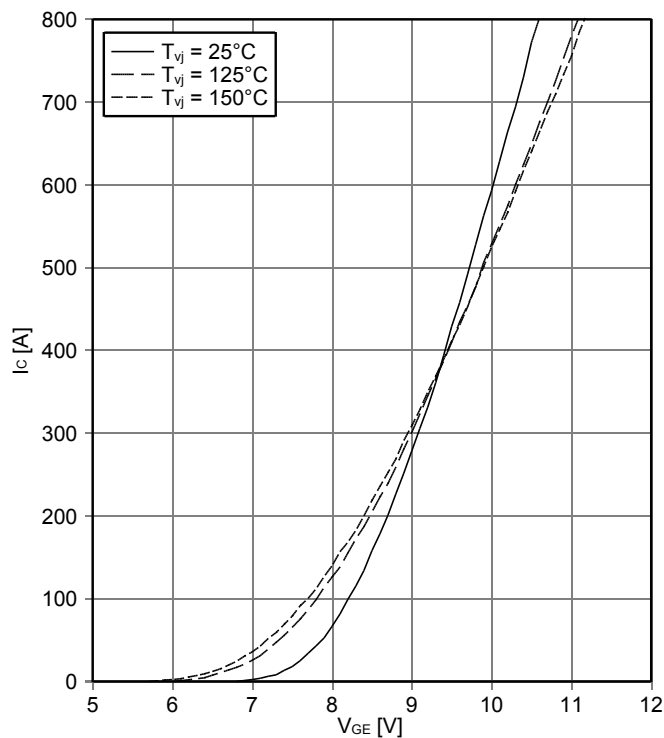
output characteristic IGBT, Inverter (typical)

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



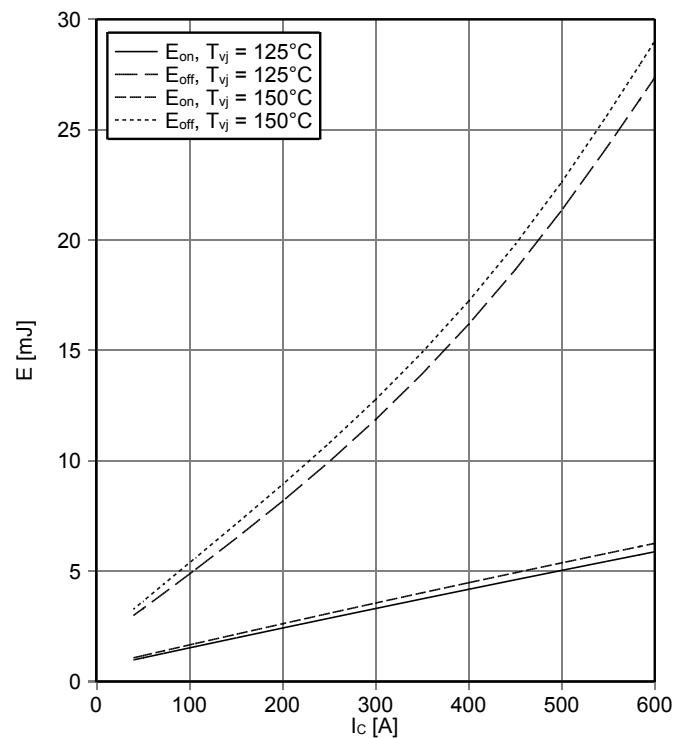
transfer characteristic IGBT, Inverter (typical)

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



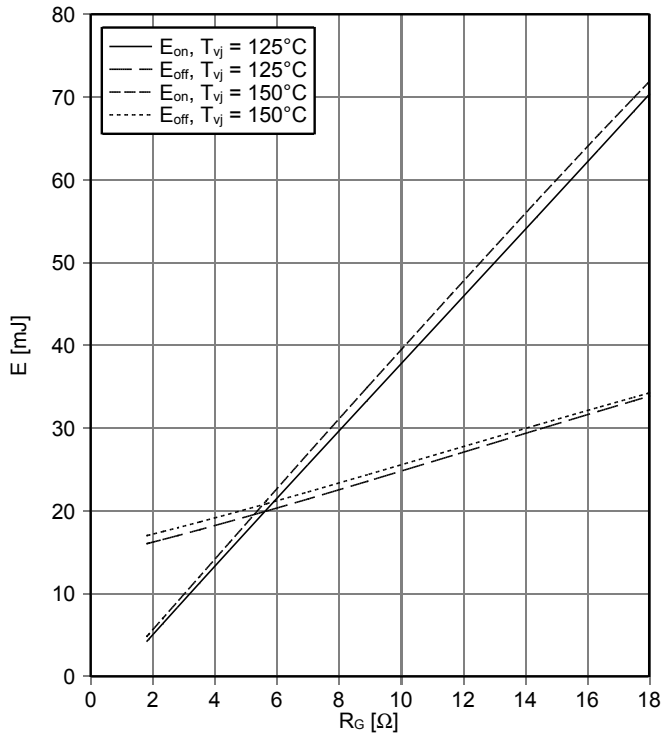
switching losses IGBT, Inverter (typical)

$E_{on} = f(I_C)$, $E_{off} = f(I_C)$
 $V_{GE} = \pm 15\text{ V}$, $R_{Gon} = 1.8\ \Omega$, $R_{Goff} = 1.8\ \Omega$, $V_{CE} = 300\text{ V}$



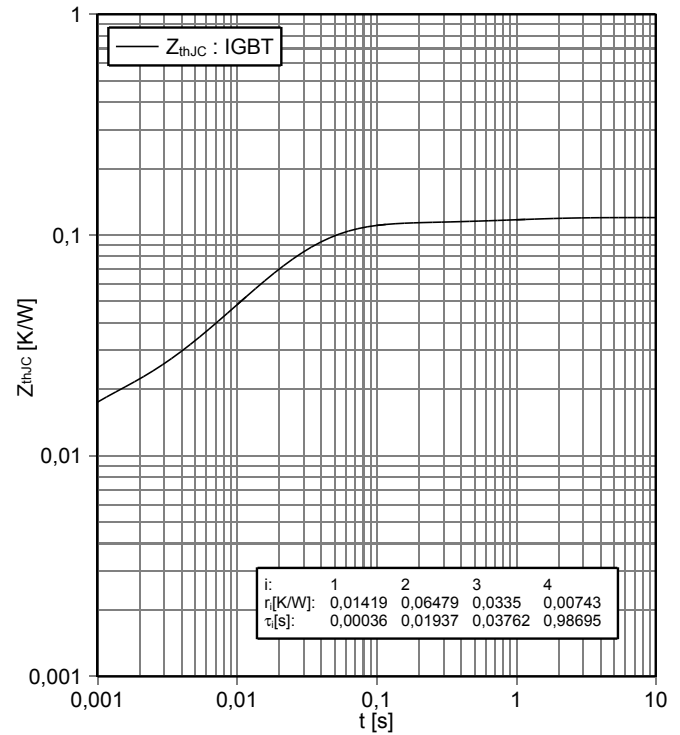
switching losses IGBT, Inverter (typical)

$E_{on} = f(R_G), E_{off} = f(R_G)$
 $V_{GE} = \pm 15\text{ V}, I_C = 400\text{ A}, V_{CE} = 300\text{ V}$



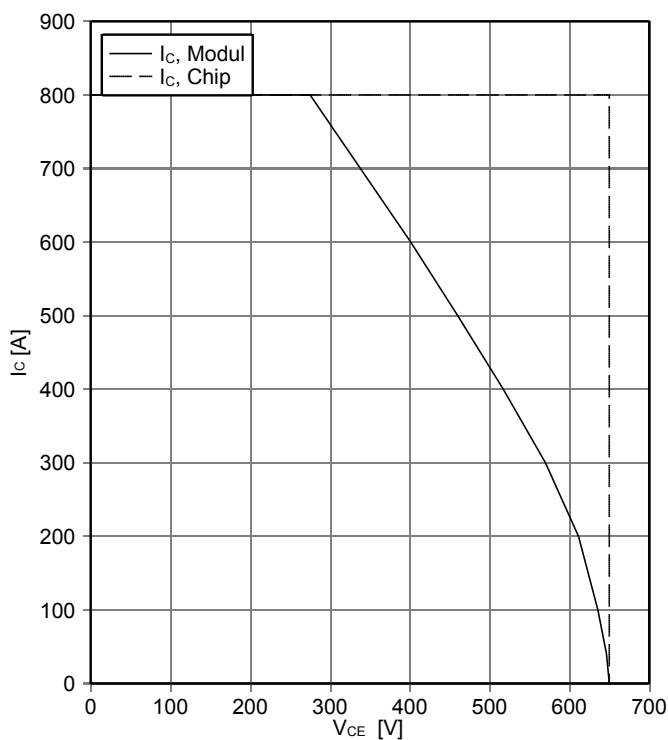
transient thermal impedance IGBT, Inverter

$Z_{thJC} = f(t)$



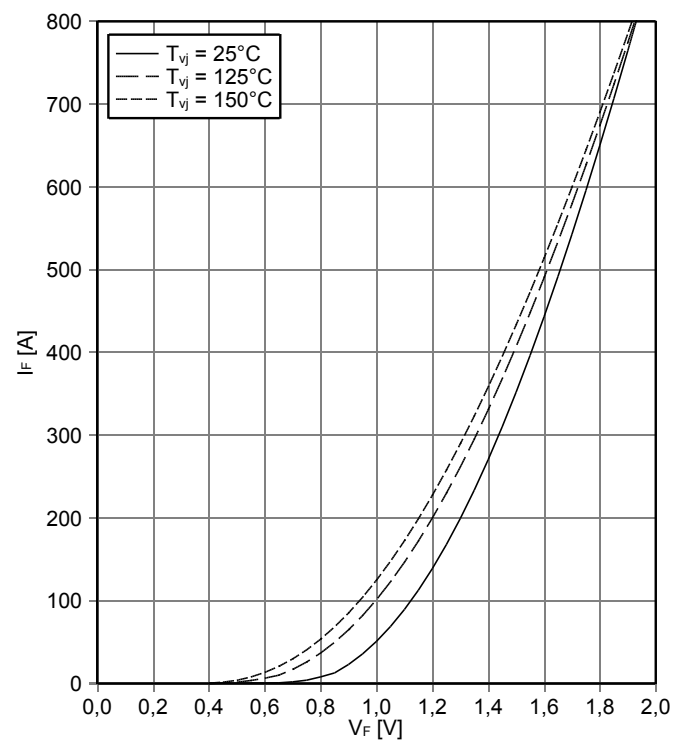
reverse bias safe operating area IGBT, Inverter (RBSOA)

$I_C = f(V_{CE})$
 $V_{GE} = \pm 15\text{ V}, R_{Goff} = 1.8\ \Omega, T_{vj} = 150^\circ\text{C}$



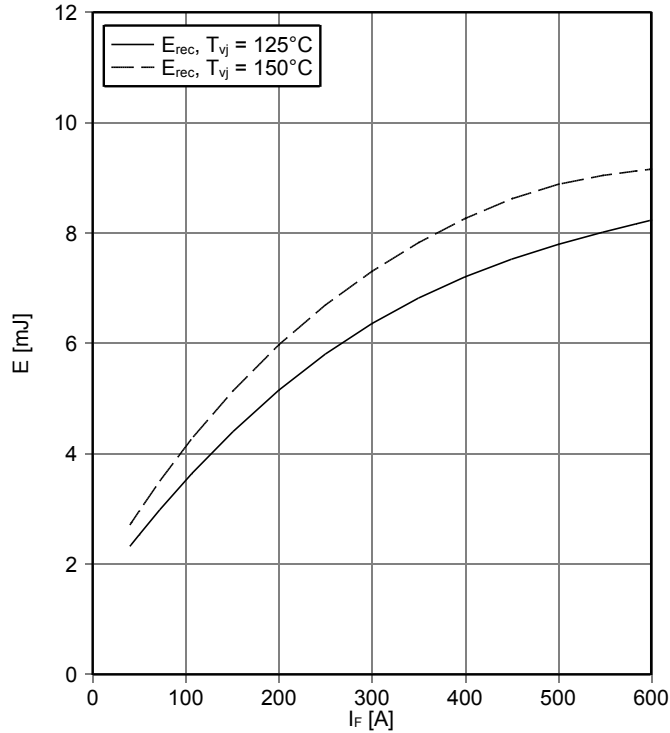
forward characteristic of Diode, Inverter (typical)

$I_F = f(V_F)$



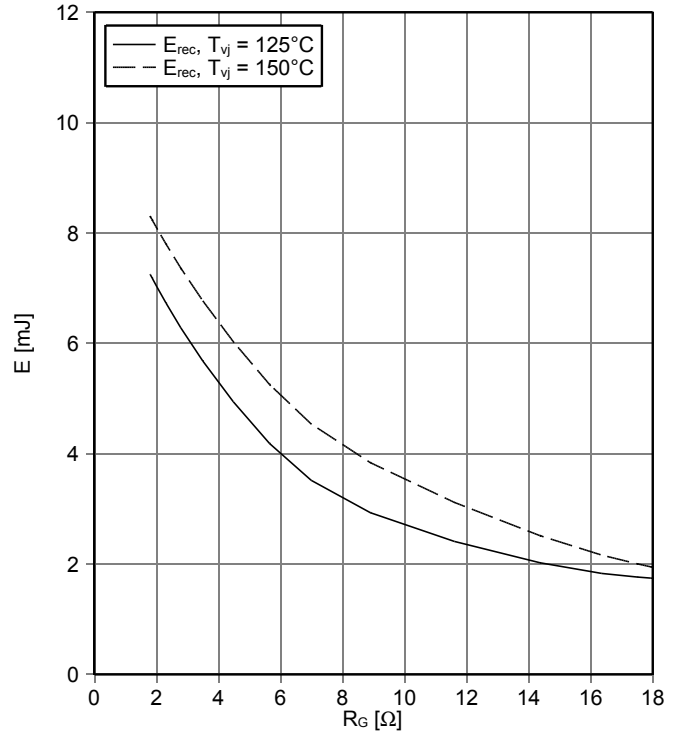
switching losses Diode, Inverter (typical)

$E_{rec} = f(I_F)$
 $R_{Gon} = 1.8 \Omega, V_{CE} = 300 V$



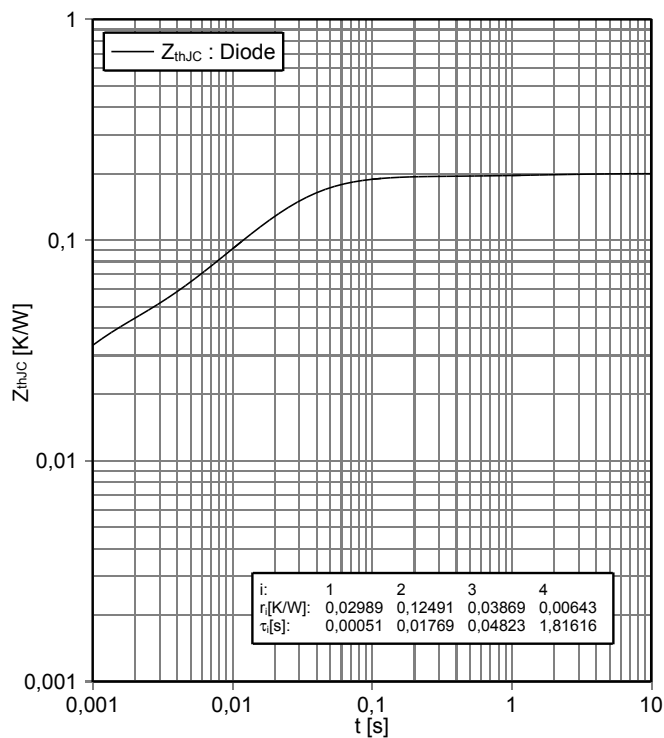
switching losses Diode, Inverter (typical)

$E_{rec} = f(R_G)$
 $I_F = 400 A, V_{CE} = 300 V$



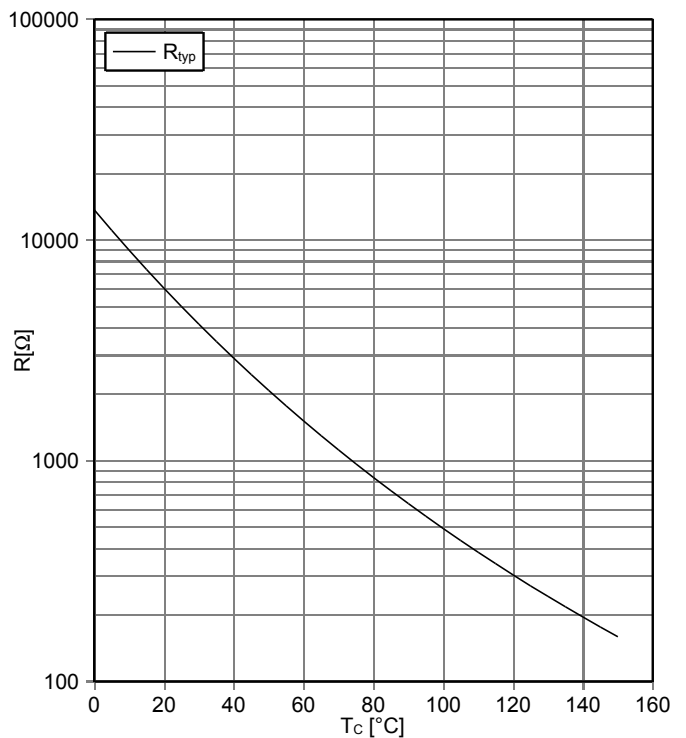
transient thermal impedance Diode, Inverter

$Z_{thJC} = f(t)$

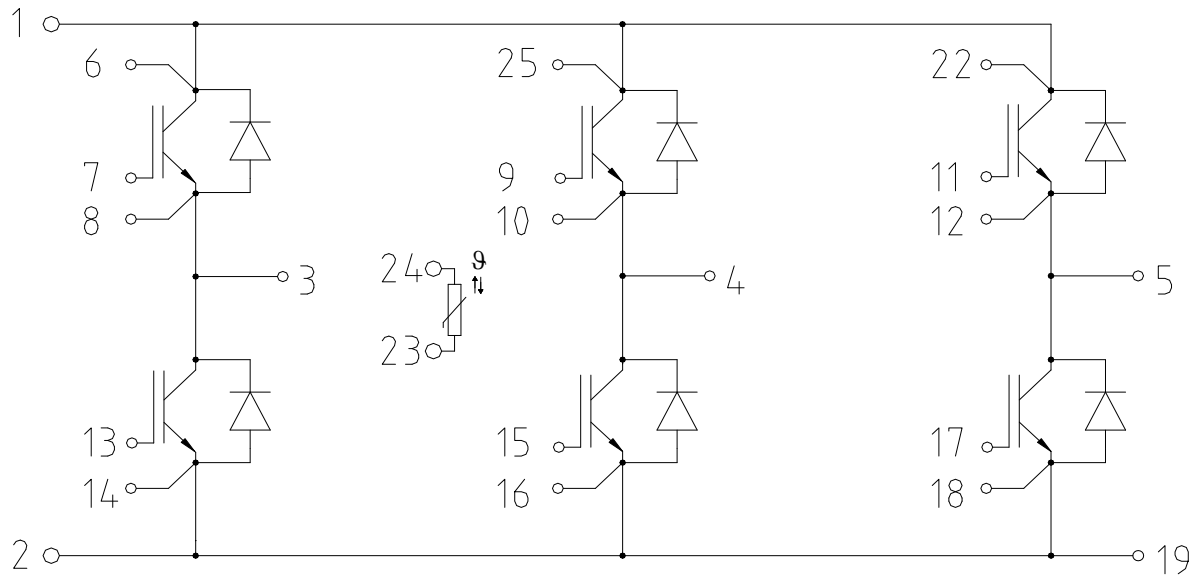


NTC-Thermistor-temperature characteristic (typical)

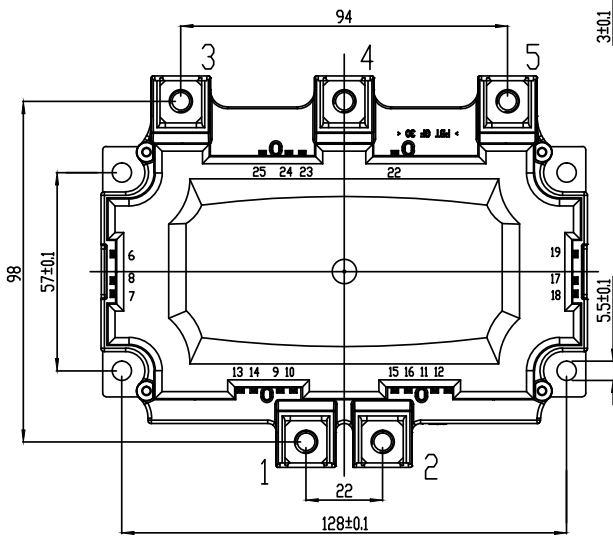
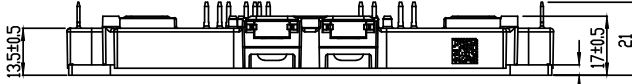
$R = f(T)$



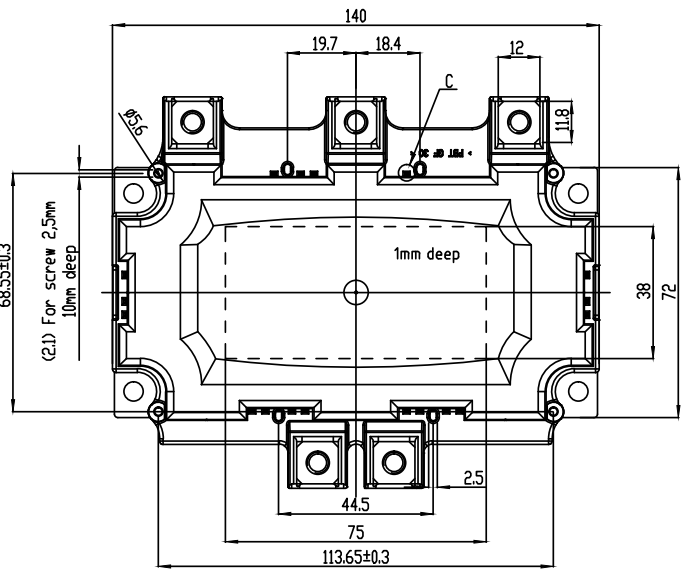
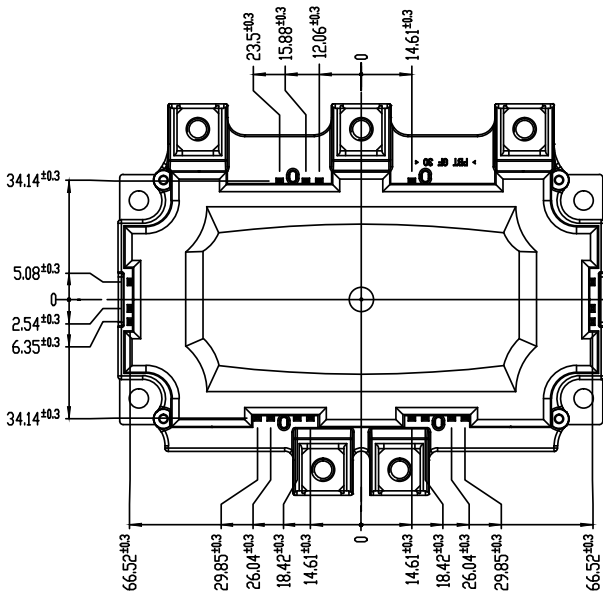
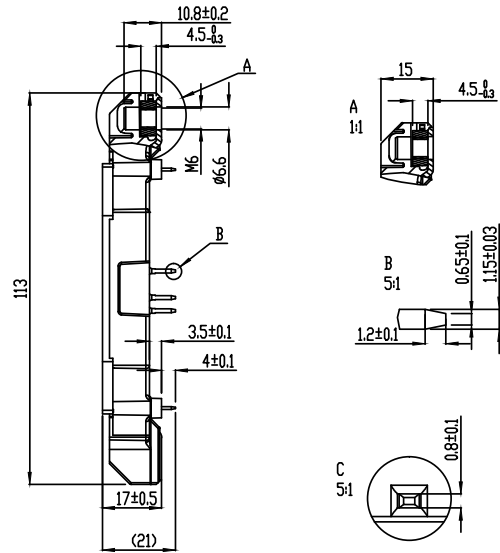
7 Circuit diagram



8 Package outlines




All dimensions are to be measured in the mounted condition




9 Label Codes

9.1 Module Code

Code Format	Data Matrix		
Encoding	ASCII Text		
Symbol Size	16x16		
Standard	IEC24720 and IEC16022		
Code Content	Content Module Serial Number Module Material Number Production Order Number Datecode (Production Year) Datecode (Production Week)	Digit 1 - 5 6 - 11 12 - 19 20 - 21 22 - 23	Example (below) 71549 142846 55054991 15 30
Example	 71549142846550549911530		

9.2 Packing Code

Code Format	Code128			
Encoding	Code Set A			
Symbol Size	34 digits			
Standard	IEC8859-1			
Code Content	Content Backend Construction Number Production Lot Number Serial Number Date Code Box Quantity	Identifier X 1T S 9D Q	Digit 2 - 9 12 - 19 21 - 25 28 - 31 33 - 34	Example (below) 95056609 2X0003E0 754389 1139 15
Example	 X950566091T2X0003E0S754389D1139Q15			

Revision History

Major changes since previous revision

Revision History

Reference	Date	Description
V1.0	2009-08-26	Initial Version
V1.1	2009-10-14	target data
V2.0	2009-11-19	preliminary data
V3.0	2010-04-21	final data
V3.1	2012-02-29	final data
V3.2	2016-11-08	new datasheet format
V3.3	2017-03-07	-
V3.4	2018-08-09	update of "Terms & Conditions of usage"

Terms & Conditions of usage

Edition 2018-08-01

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