

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

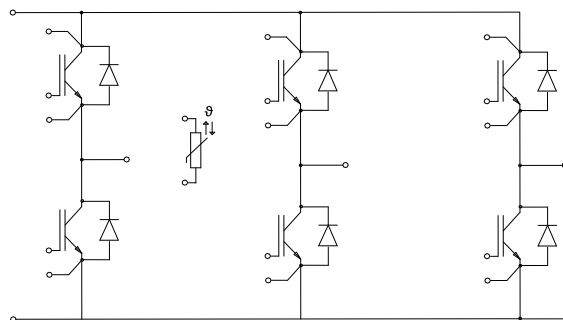
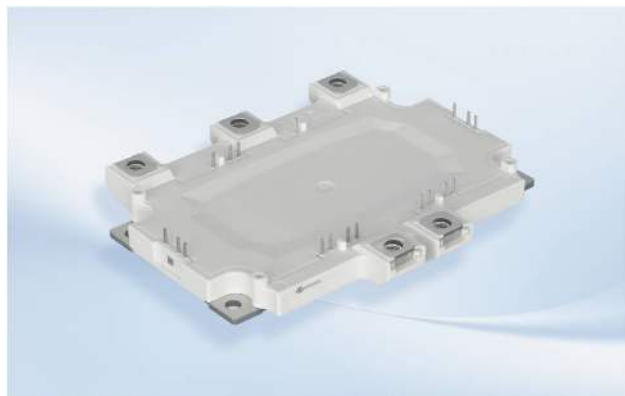
Final Data Sheet

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		$\mu\text{C}$
Internal gate resistor		$T_{vj} = 25^{\circ}\text{C}$	$R_{Gint}$		1.0		$\Omega$
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		$\mu\text{s}$
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		$\mu\text{s}$
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		$\mu\text{s}$
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		$\mu\text{s}$
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	$\text{A}^2\text{s}$ $\text{A}^2\text{s}$

#### 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		$\mu\text{C}$
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

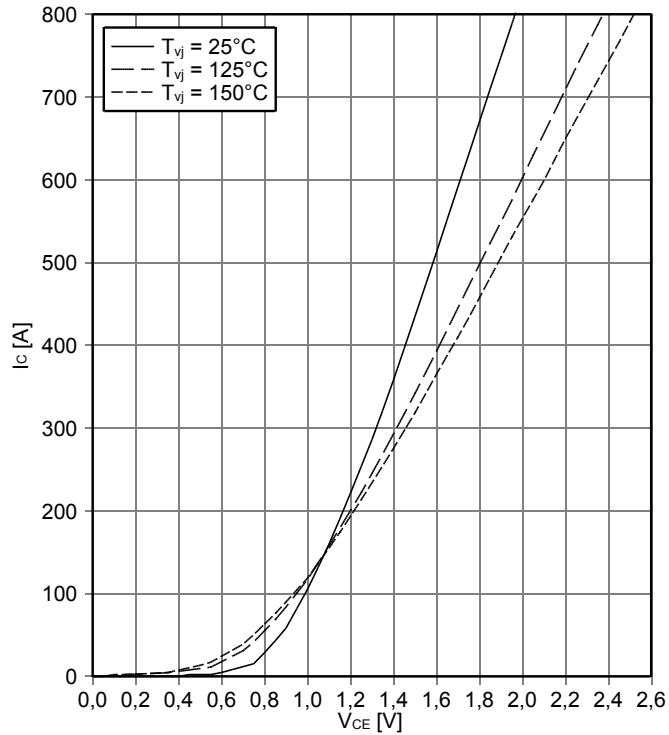
Parameter	Conditions	Symbol	Value			Unit
Isolation test voltage	RMS, f = 50 Hz, t = 1 min.	$V_{ISOL}$	2.5			kV
Material of module baseplate			Cu			
Internal isolation	basic insulation (class 1, IEC 61140)		Al <sub>2</sub> O <sub>3</sub>			
Creepage distance	terminal to heatsink	$d_{Creep}$	12.0			mm
	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

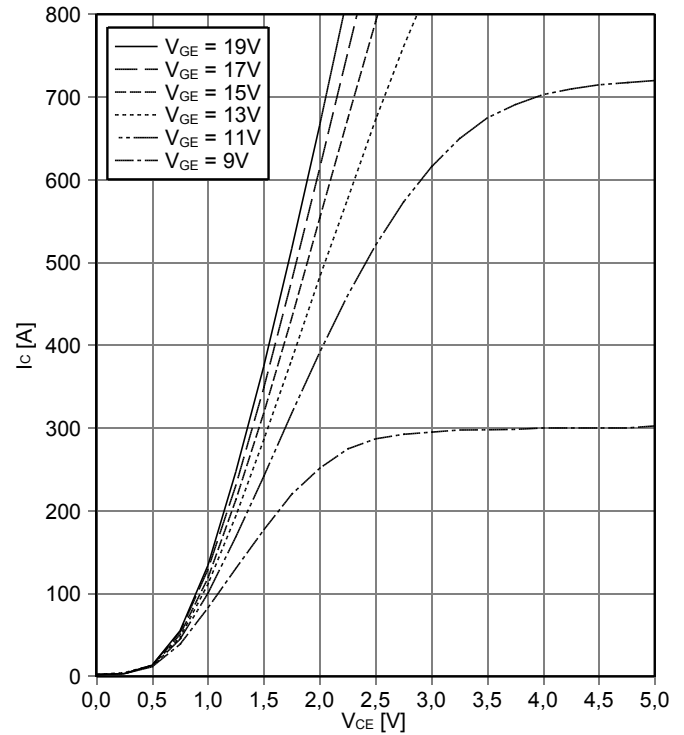
**output characteristic IGBT, Inverter (typical)**

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



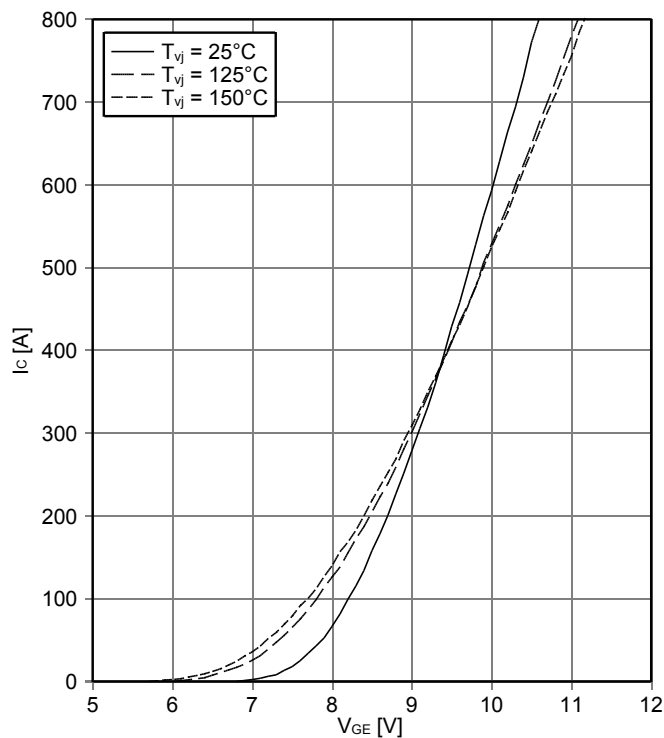
**output characteristic IGBT, Inverter (typical)**

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



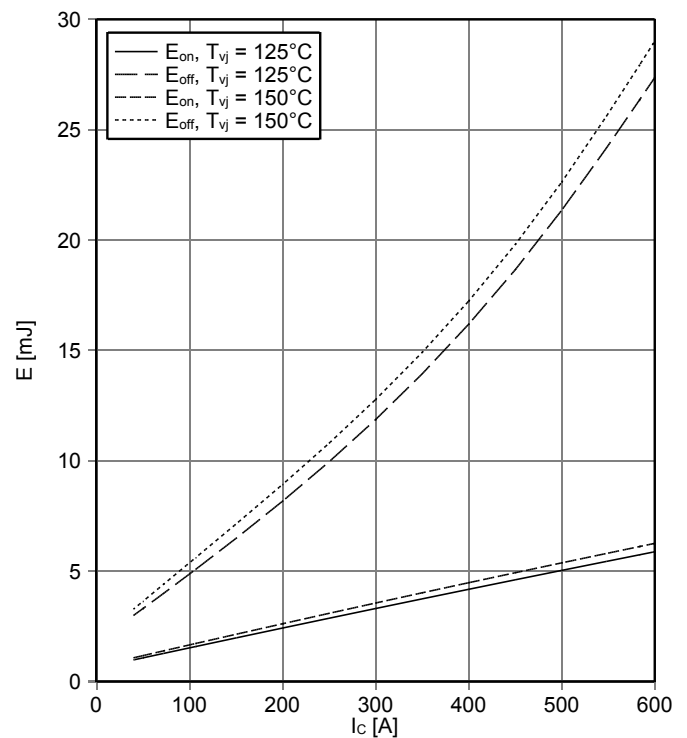
**transfer characteristic IGBT, Inverter (typical)**

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



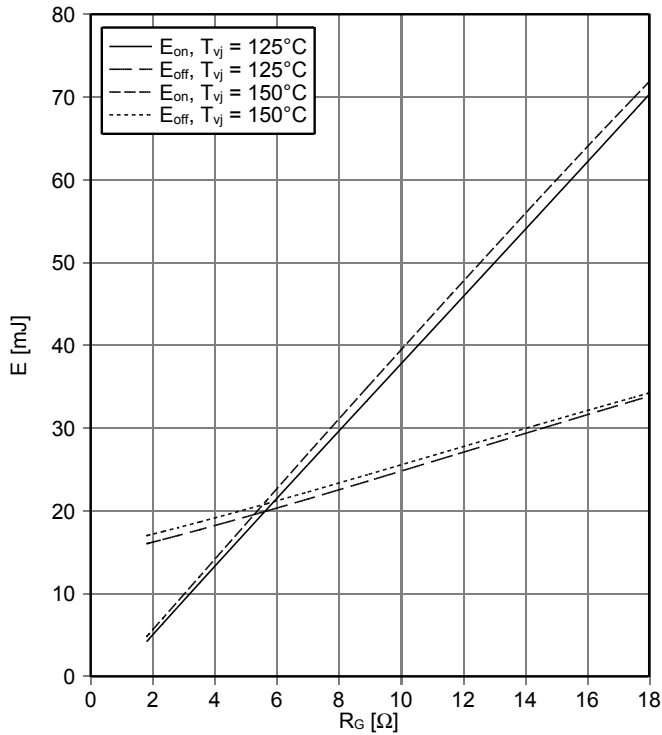
**switching losses IGBT, Inverter (typical)**

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



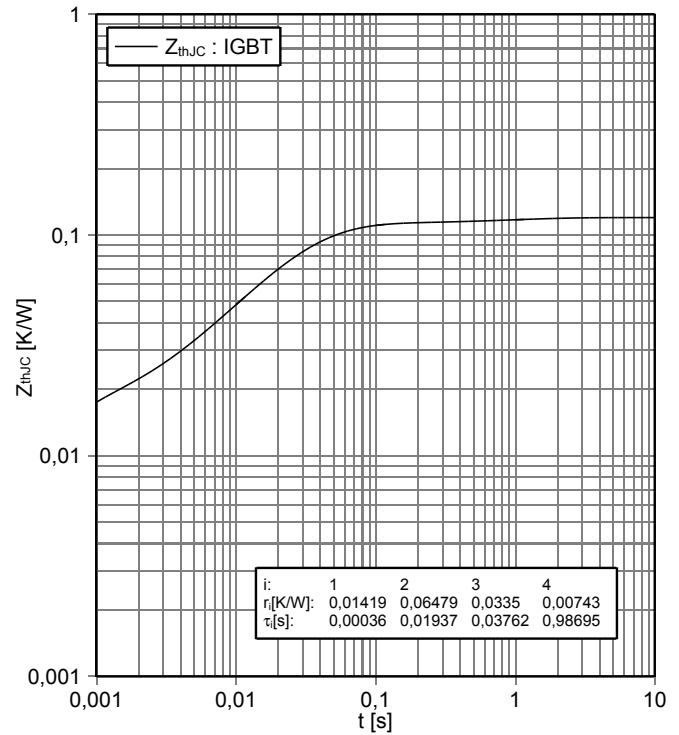
**switching losses IGBT, Inverter (typical)**

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



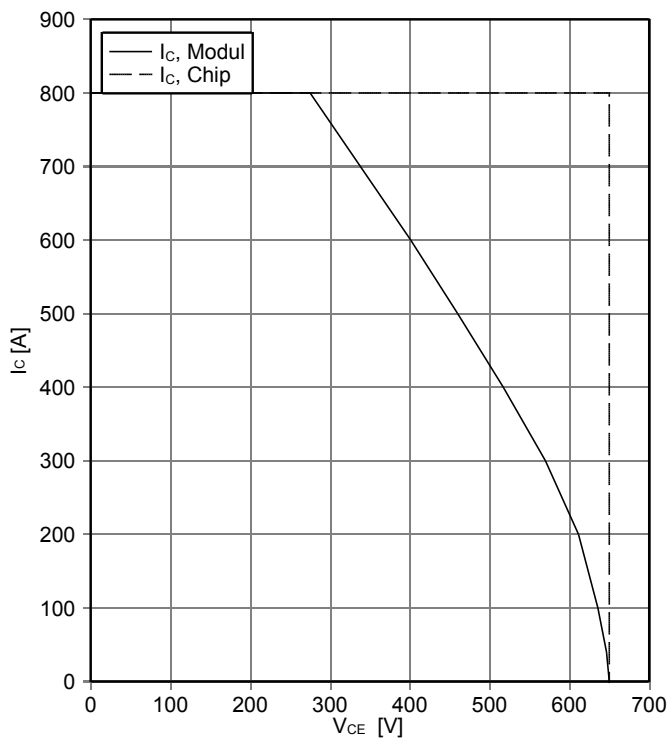
**transient thermal impedance IGBT, Inverter**

$Z_{thJC} = f(t)$



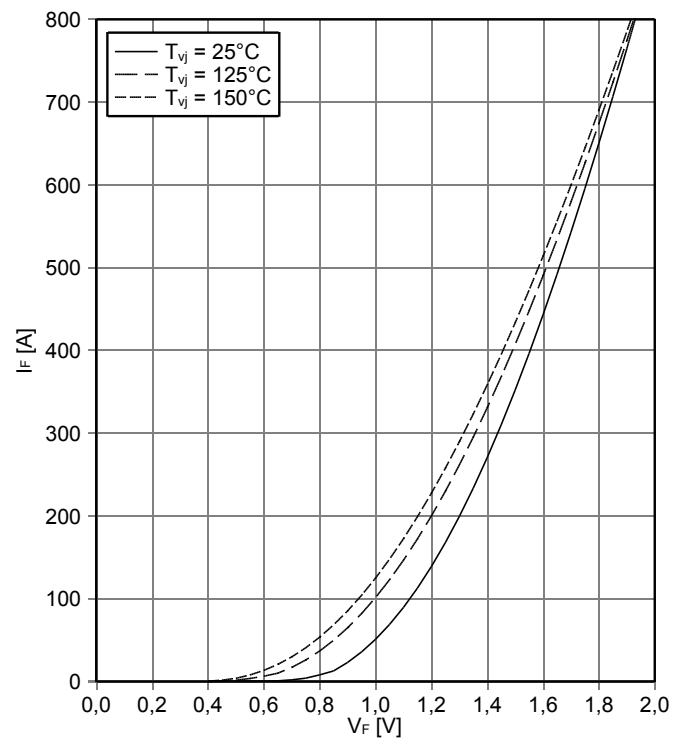
**reverse bias safe operating area IGBT, Inverter (RBSOA)**

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



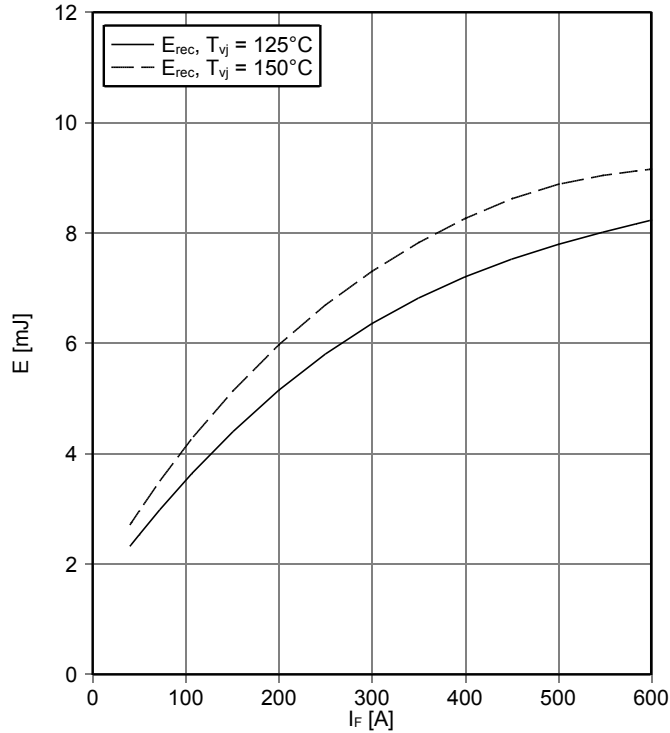
**forward characteristic of Diode, Inverter (typical)**

$I_F = f(V_F)$



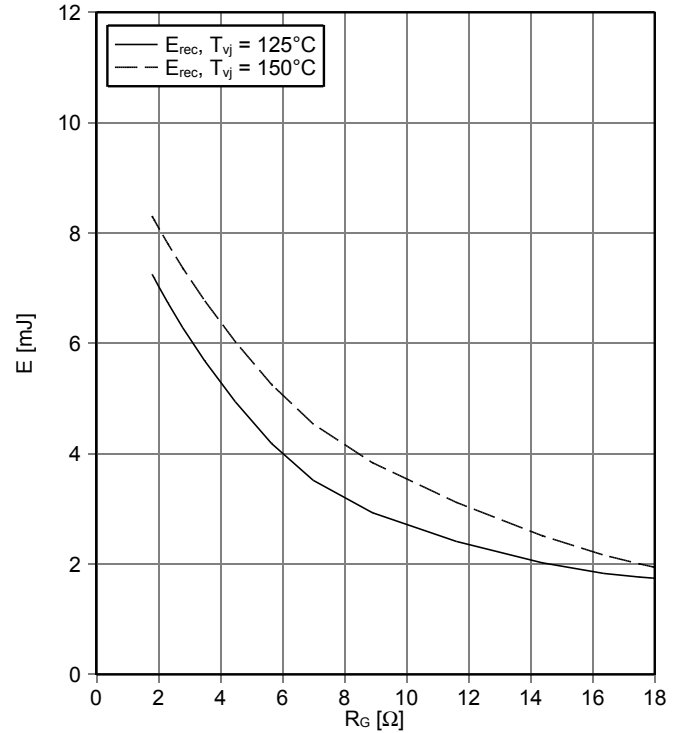
**switching losses Diode, Inverter (typical)**

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



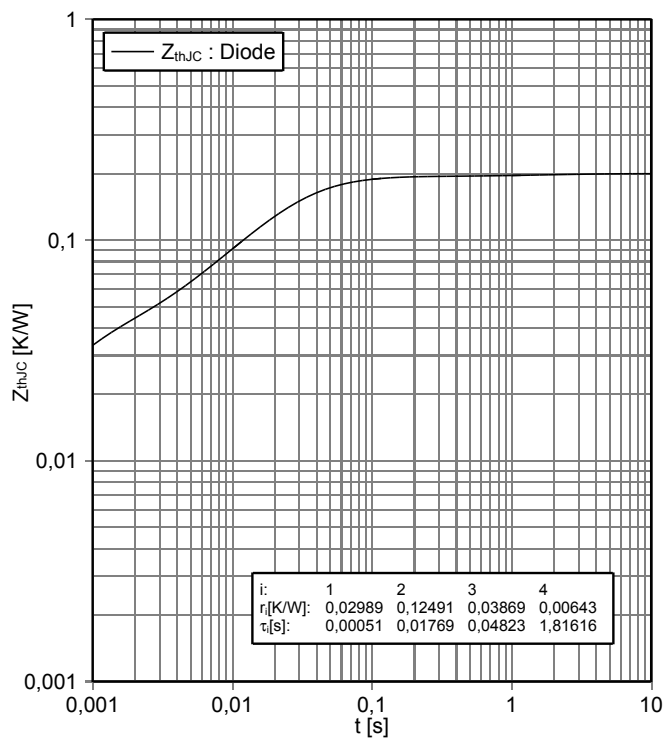
**switching losses Diode, Inverter (typical)**

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



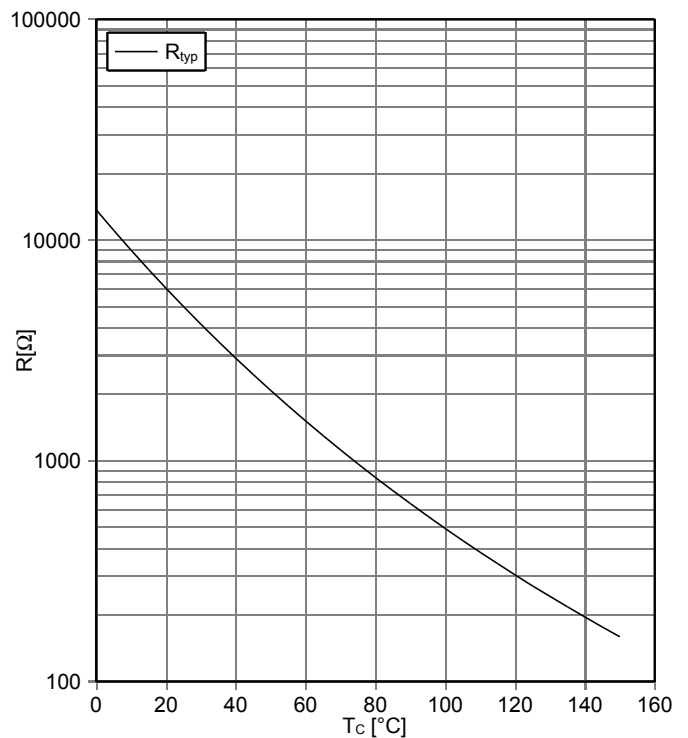
**transient thermal impedance Diode, Inverter**

$Z_{thJC} = f(t)$



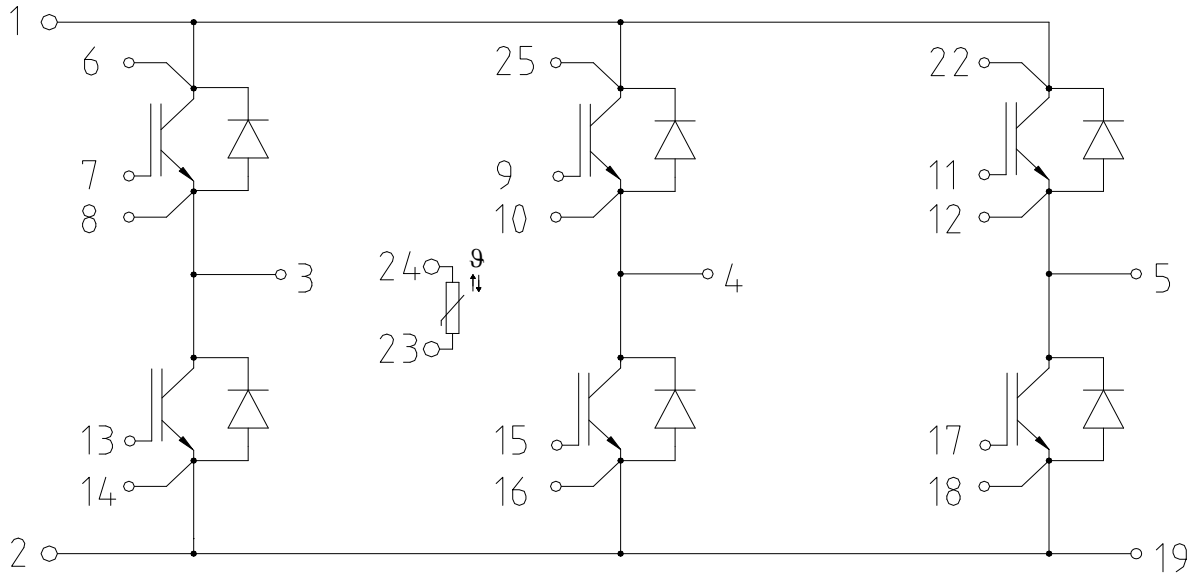
**NTC-Thermistor-temperature characteristic (typical)**

$R = f(T)$

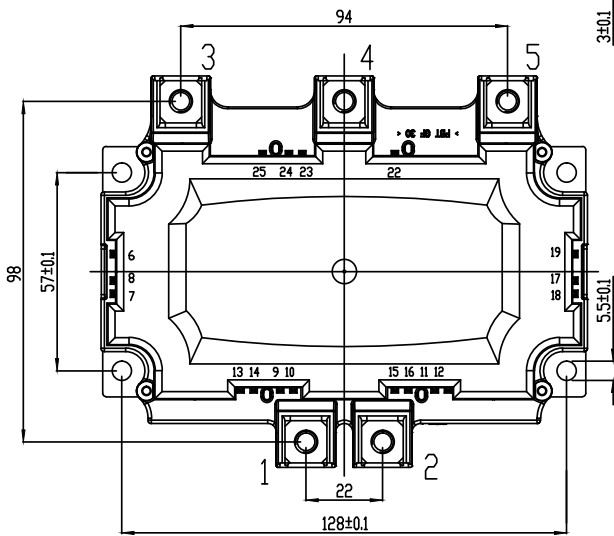
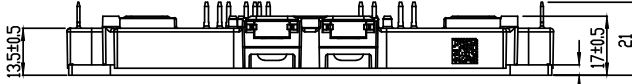




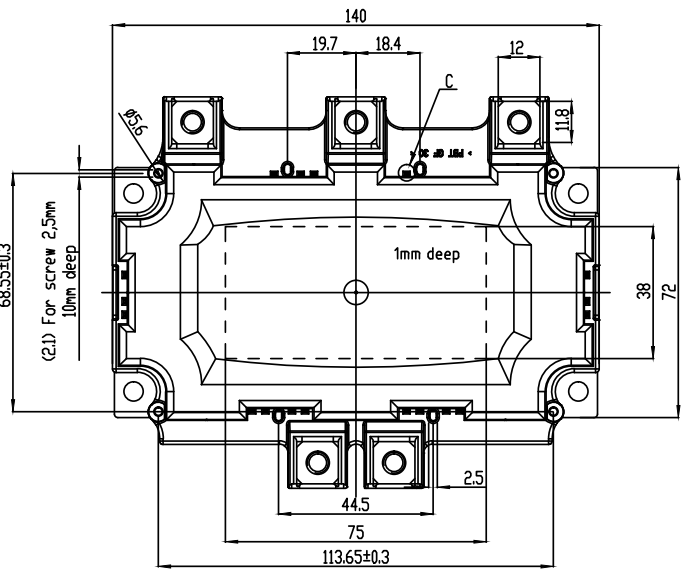
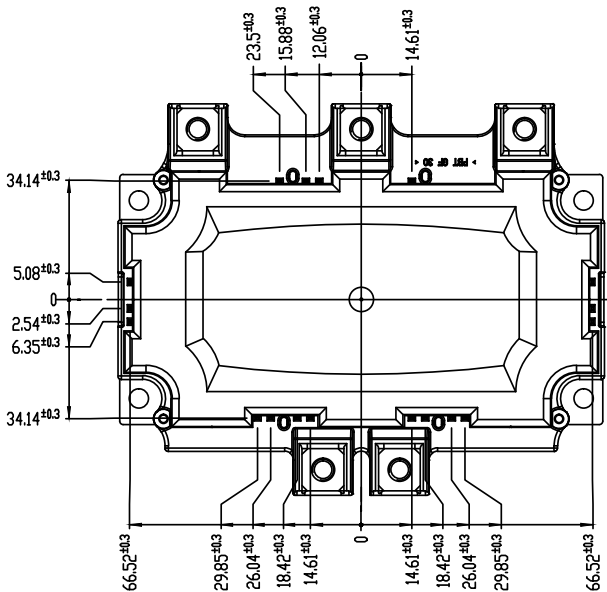
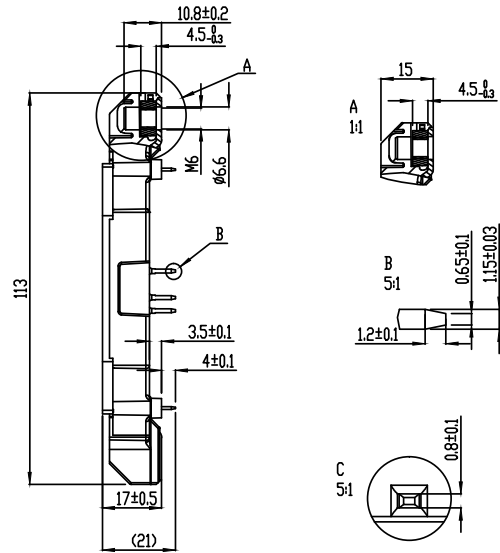
**7 Circuit diagram**



**8 Package outlines**




All dimensions are to be measured in the mounted condition




## 9 Label Codes

### 9.1 Module Code

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

### 9.2 Packing Code

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

## Revision History

Major changes since previous revision

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### 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"

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Edition 2018-08-01

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**81726 Munich, Germany**  
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Last update

2011-11-11

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