

# HybridPACK™ DC6 Module

FS400R07A3E3\_H6

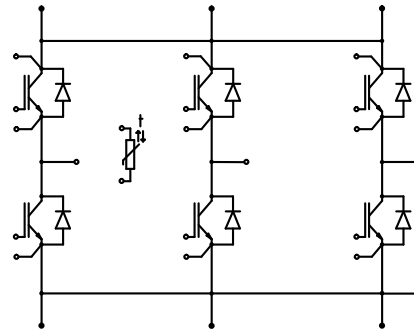
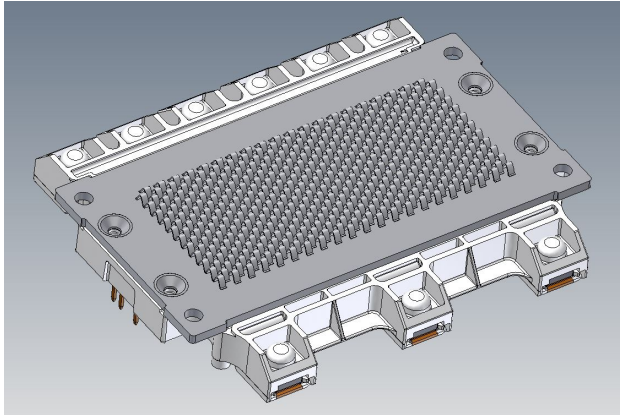
Final Data Sheet

V3.0, 2018-03-26

Automotive High Power

## 1 Features / Description

HybridPACK™ DC6 module with Trench/Fieldstop IGBT3 and Emitter Controlled 3 diode and NTC



$V_{CES} = 700V$   
 $I_{C\ nom} = 400A$

### Typical Applications

- Automotive Applications
- Hybrid Electrical Vehicles (H)EV
- Commercial Agriculture Vehicles
- Motor Drives

### Electrical Features

- Low Switching Losses
- Low  $V_{CEsat}$
- $T_{vj\ op} = 150^{\circ}C$
- $V_{CEsat}$  with positive Temperature Coefficient
- Increased blocking voltage capability to 705V

### Mechanical Features

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

### Description

Infineon's HybridPACK™ DC6 with ribbon bonded cooling structures is a variant of the HybridPACK™ 1 power module family with increased continuous current capability and a reduced stray inductance. Like all HybridPACK™ 1 products the HybridPACK™ DC6 with ribbon bonds is an automotive qualified power module designed for electric vehicle applications. Designed for a 150°C junction operation temperature, with a 30 hour limited 175°C capacity the module accommodates a 3-phase Six-Pack configuration of Trench-Field-Stop IGBT3 and matching emitter controlled diodes. The HybridPACK™ DC6 power module family 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™ DC6 with ribbon bonds is suitable for direct 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
FS400R07A3E3_H6	SP001632430

## 2 IGBT, Inverter

### 2.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Collector-emitter voltage	$T_{vj} = 25^{\circ}\text{C}$	$V_{CES}$	705	V
Continuous DC collector current	$T_F = 75^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$ $T_F = 25^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	$I_{C\text{ nom}}$ $I_C$	400 <sup>1)</sup> 500 <sup>1)</sup>	A A
Repetitive peak collector current	$t_p = 1\text{ ms}$	$I_{CRM}$	800	A
Total power dissipation	$T_F = 25^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	$P_{tot}$	811	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	1.70	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		$T_{vj} = 25^{\circ}\text{C}$	$R_{G\text{ int}}$		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	$V_{CE} = 705\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	$I_{CES}$			0.1	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	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Gon} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ on}}$		0.12 0.12 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	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ off}}$		0.36 0.40 0.40		$\mu\text{s}$
Fall time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = \pm 15\text{ V}$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_f$		0.02 0.03 0.03		$\mu\text{s}$
Turn-on energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = \pm 15\text{ V}, di/dt = 5500\text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $R_{Gon} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{on}$		5.10 6.80 7.30		mJ
Turn-off energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = \pm 15\text{ V}, du/dt = 3000\text{ V}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $R_{Goff} = 1.8\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{off}$		9.10 12.0 12.5		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 cooling fluid	per IGBT; $\Delta V/\Delta t = 10\text{ dm}^3/\text{min}$		$R_{thJF}$		0.170	0.185	K/W
Temperature under switching conditions	$t_{op}$ continuous		$T_{vj\text{ op}}$	-40		150	$^{\circ}\text{C}$

<sup>1)</sup> DC-collector current limited by power terminals.

### 3 Diode, Inverter

#### 3.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Repetitive peak reverse voltage	$T_{vj} = 25^{\circ}\text{C}$	$V_{RRM}$	705	V
Continuous DC forward current		$I_F$	400 <sup>1)</sup>	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	$I_F = 400 \text{ A}, -di_F/dt = 5500 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$I_{RM}$	205 295 305		A
Recovered charge	$I_F = 400 \text{ A}, -di_F/dt = 5500 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$Q_r$	15.0 32.0 34.0		$\mu\text{C}$
Reverse recovery energy	$I_F = 400 \text{ A}, -di_F/dt = 5500 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $V_R = 300 \text{ V}$ $V_{GE} = -15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{rec}$	3.35 6.90 8.10		mJ
Thermal resistance, junction to cooling fluid	per diode; $\Delta V/\Delta t = 10 \text{ dm}^3/\text{min}$	$R_{thJF}$		0.270	0.300	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.

<sup>1)</sup> DC-collector current limited by power terminals.

## 5 Module

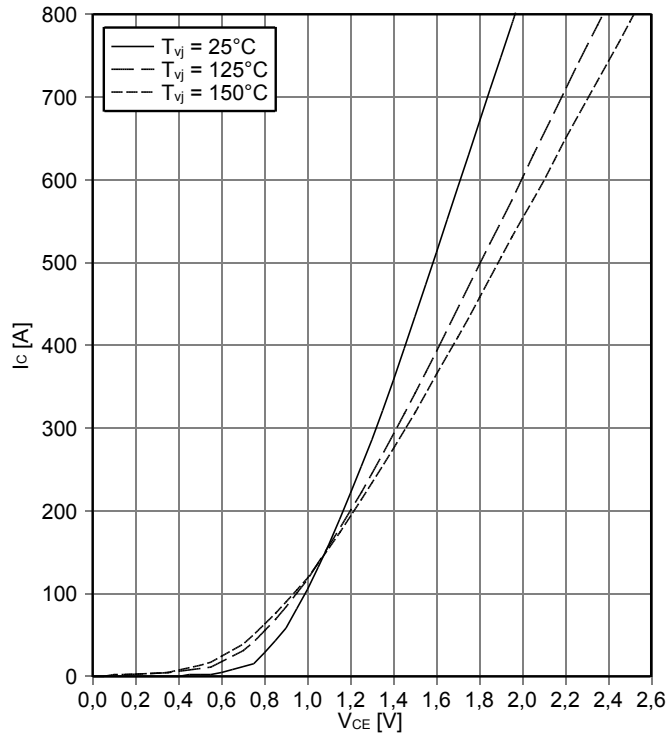
Parameter	Conditions	Symbol	Value			Unit
			min.	typ.	max.	
Isolation test voltage	RMS, f = 50 Hz, t = 1 min.	$V_{ISOL}$	2.5			kV
Maximum RMS module terminal current	$T_F = 25^\circ\text{C}$ , $T_{Ct} = 150^\circ\text{C}$	$I_{IRMS}$	320 <sup>1)</sup>			A
Material of module baseplate			Cu			
Internal 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			
Pressure drop in cooling circuit	$\Delta V/\Delta t = 10.0 \text{ dm}^3/\text{min}$ ; $T_F = 25^\circ\text{C}$	$\Delta p$		100		mbar
Maximum pressure in cooling circuit		p			2.0	bar
Stray inductance module		$L_{sCE}$		15		nH
Module lead resistance, terminals - chip	$T_F = 25^\circ\text{C}$ , 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		515		g

<sup>1)</sup> DC-collector current limited by internal busbar

## 6 Characteristics Diagrams

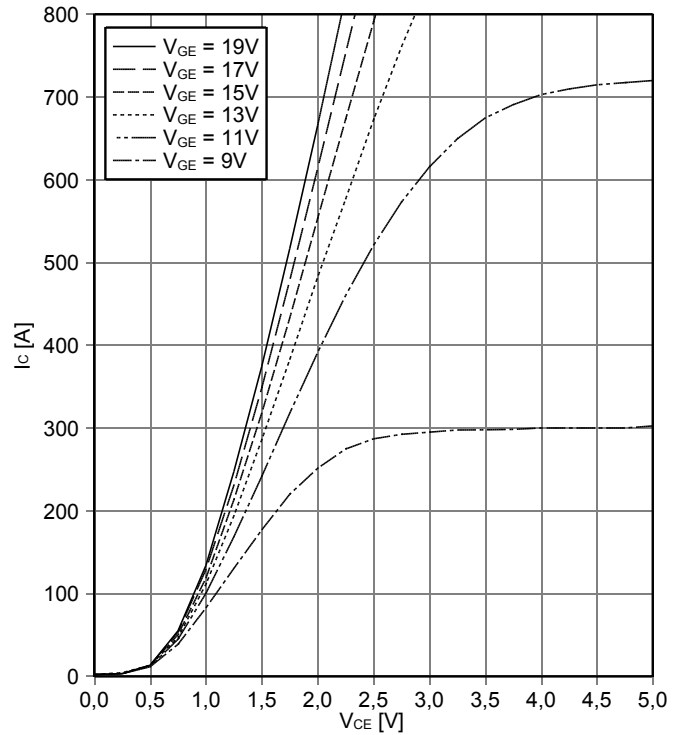
output characteristic IGBT, Inverter (typical)

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



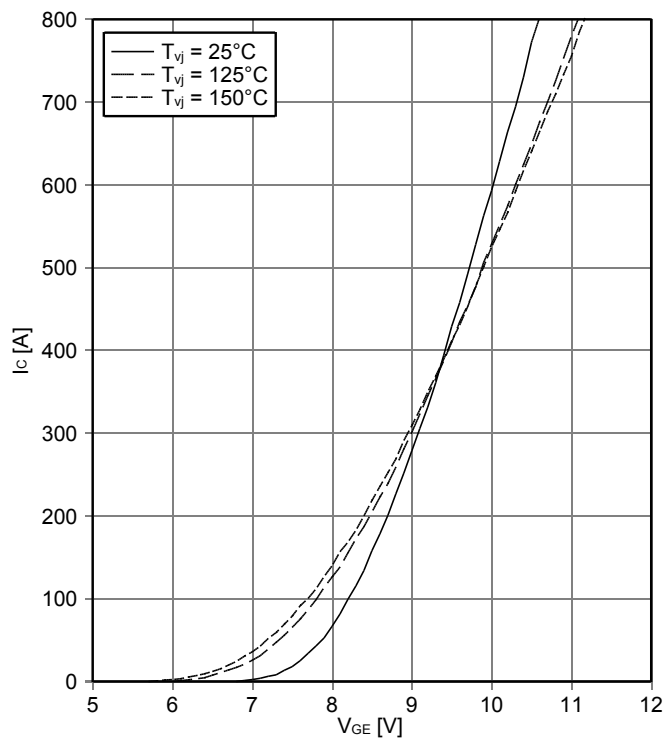
output characteristic IGBT, Inverter (typical)

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



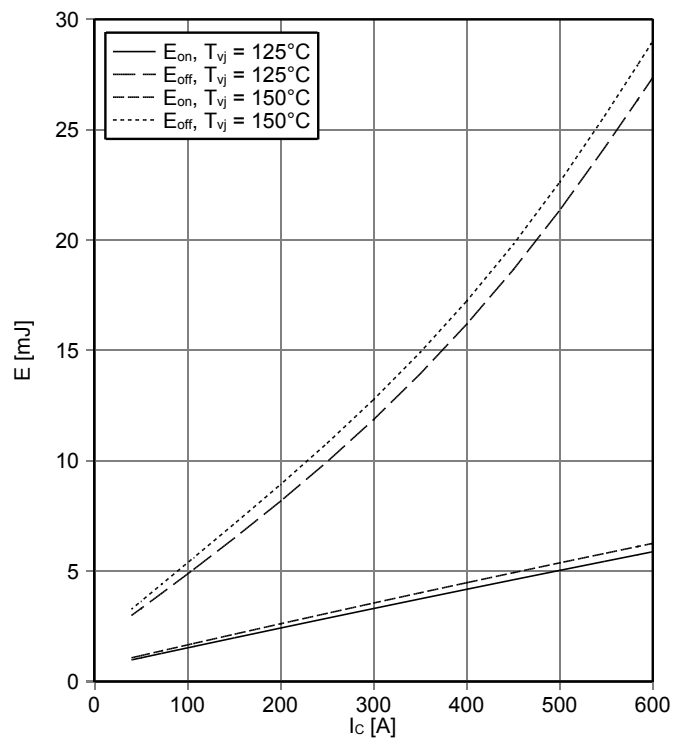
transfer characteristic IGBT, Inverter (typical)

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



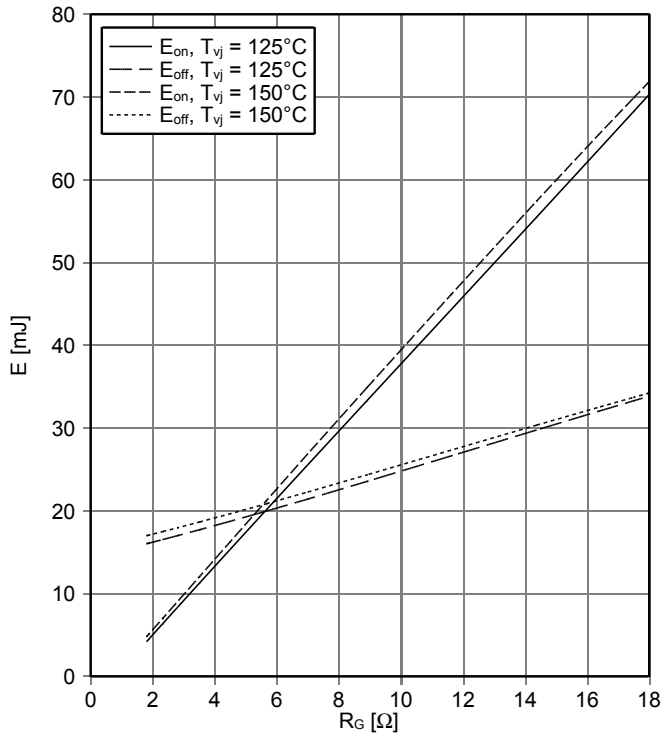
switching losses IGBT, Inverter (typical)

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



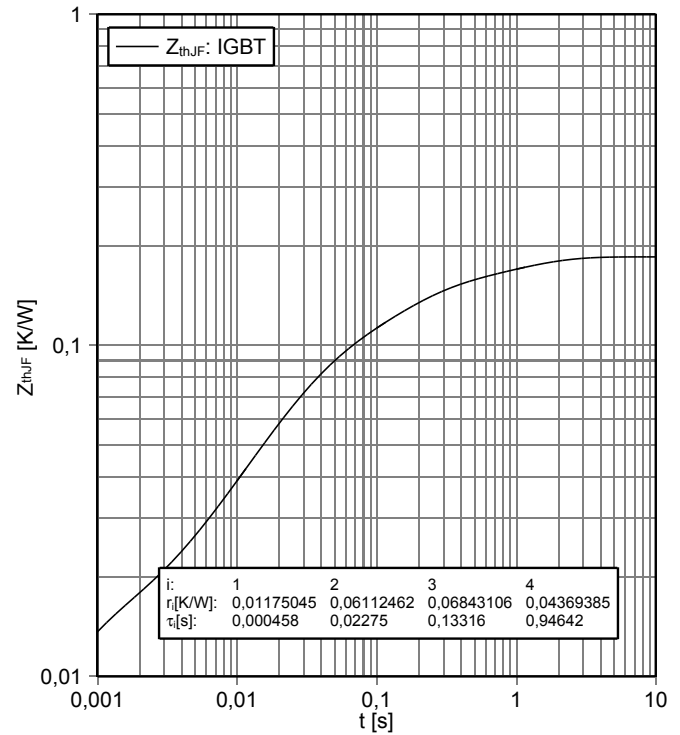
**switching losses IGBT, Inverter (typical)**

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



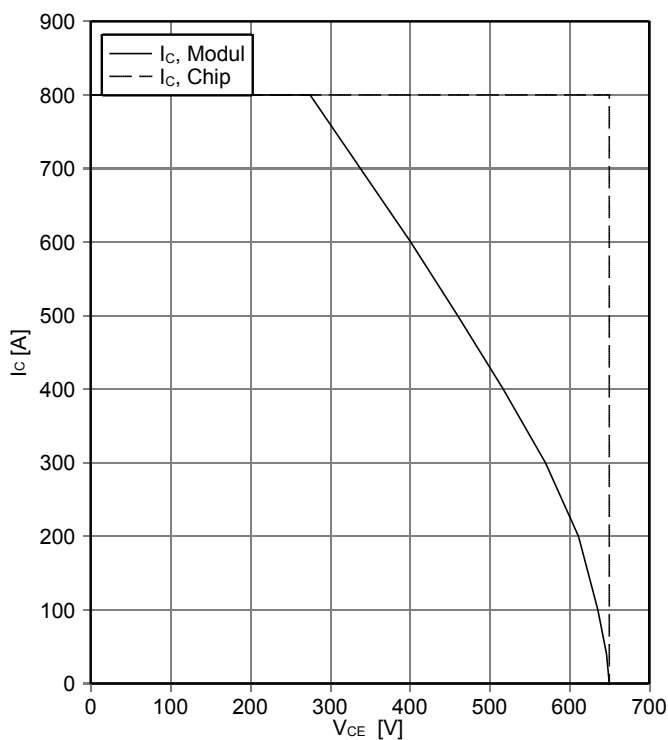
**transient thermal impedance IGBT, Inverter**

$Z_{thJF} = f(t) (\Delta V/\Delta t = 10\text{ dm}^3/\text{min})$



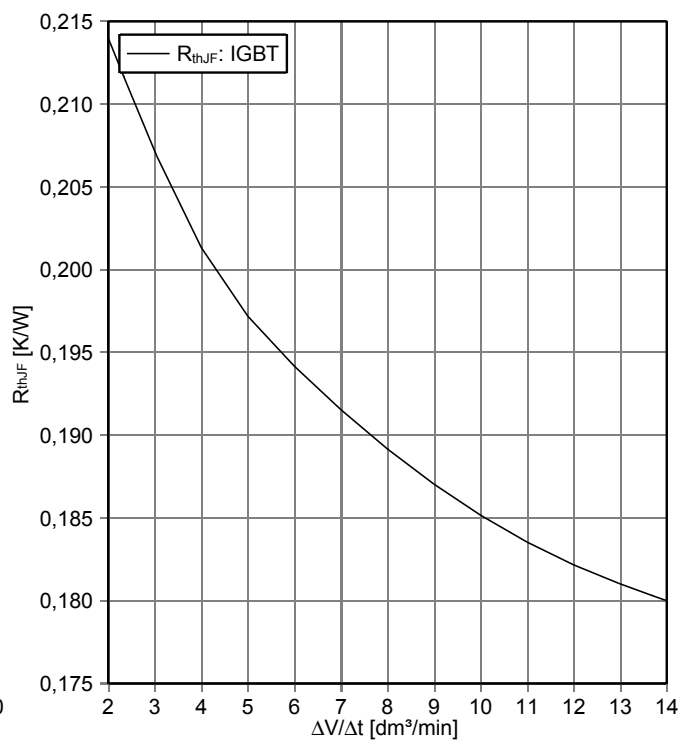
**reverse bias safe operating area IGBT, Inverter (RBSOA)**

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



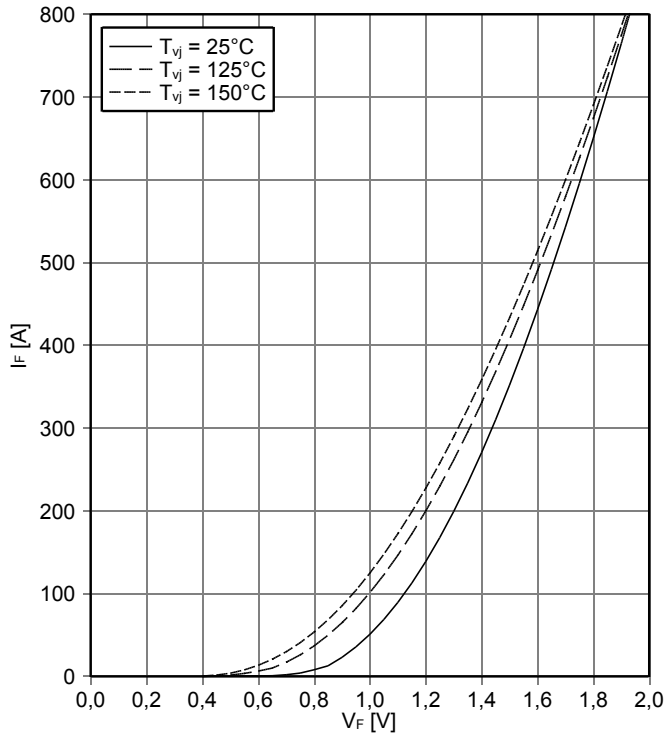
**thermal impedance IGBT, Inverter**

$R_{thJF} = f(\Delta V/\Delta t)$   
cooling fluid = 50% water/50% ethylenglycol



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

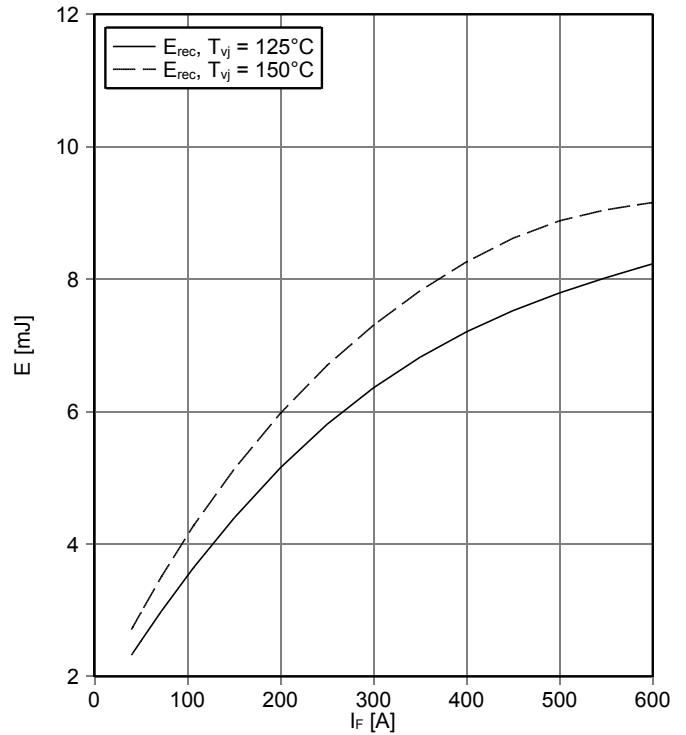
$I_F = f(V_F)$



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

$E_{rec} = f(I_F)$

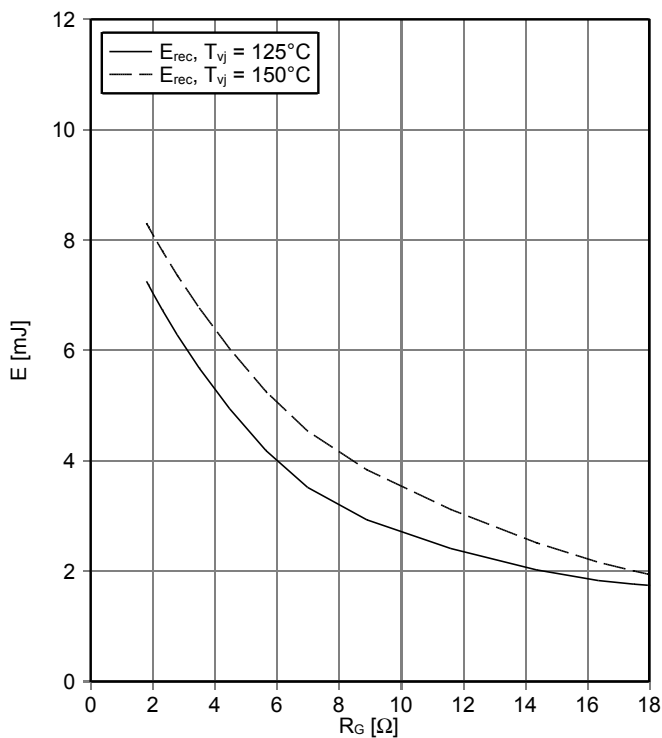
$R_{Gon} = 1.8 \Omega, V_{CE} = 300 \text{ V}$



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

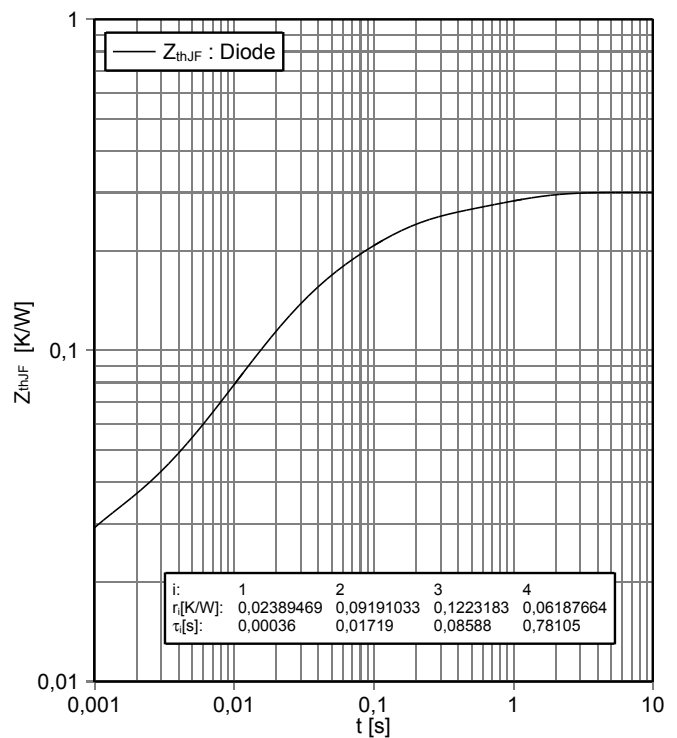
$E_{rec} = f(R_G)$

$I_F = 400 \text{ A}, V_{CE} = 300 \text{ V}$



**transient thermal impedance Diode, Inverter**

$Z_{thJF} = f(t) (\Delta V/\Delta t = 10 \text{ dm}^3/\text{min})$

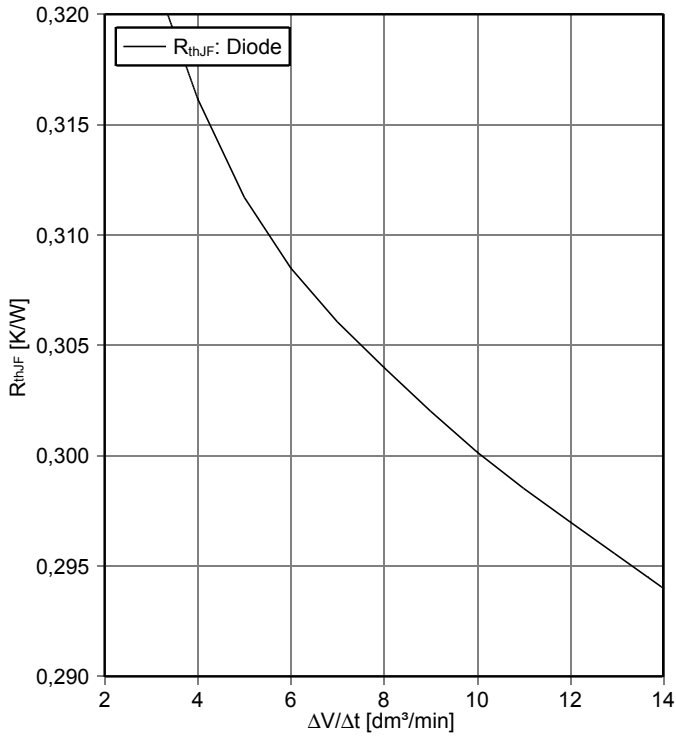




**thermal impedance Diode, Inverter**

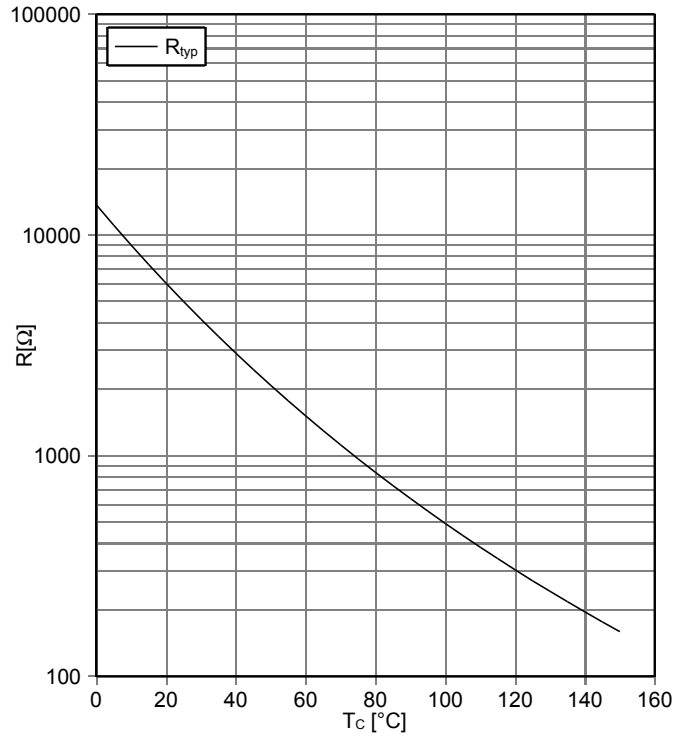
$R_{thJF} = f(\Delta V/\Delta t)$

cooling fluid = 50% water/50% ethylenglycol

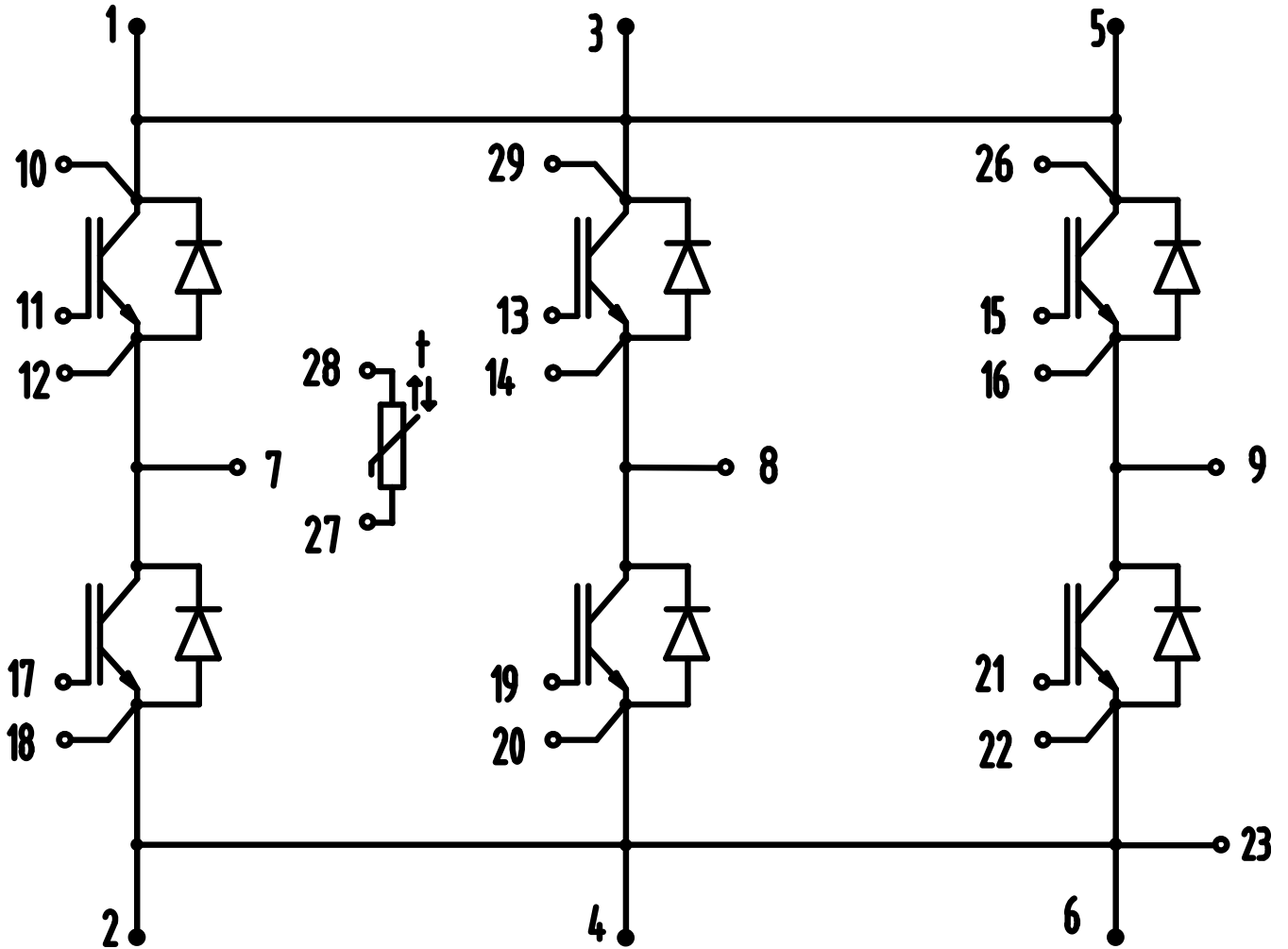


**NTC-Thermistor-temperature characteristic (typical)**

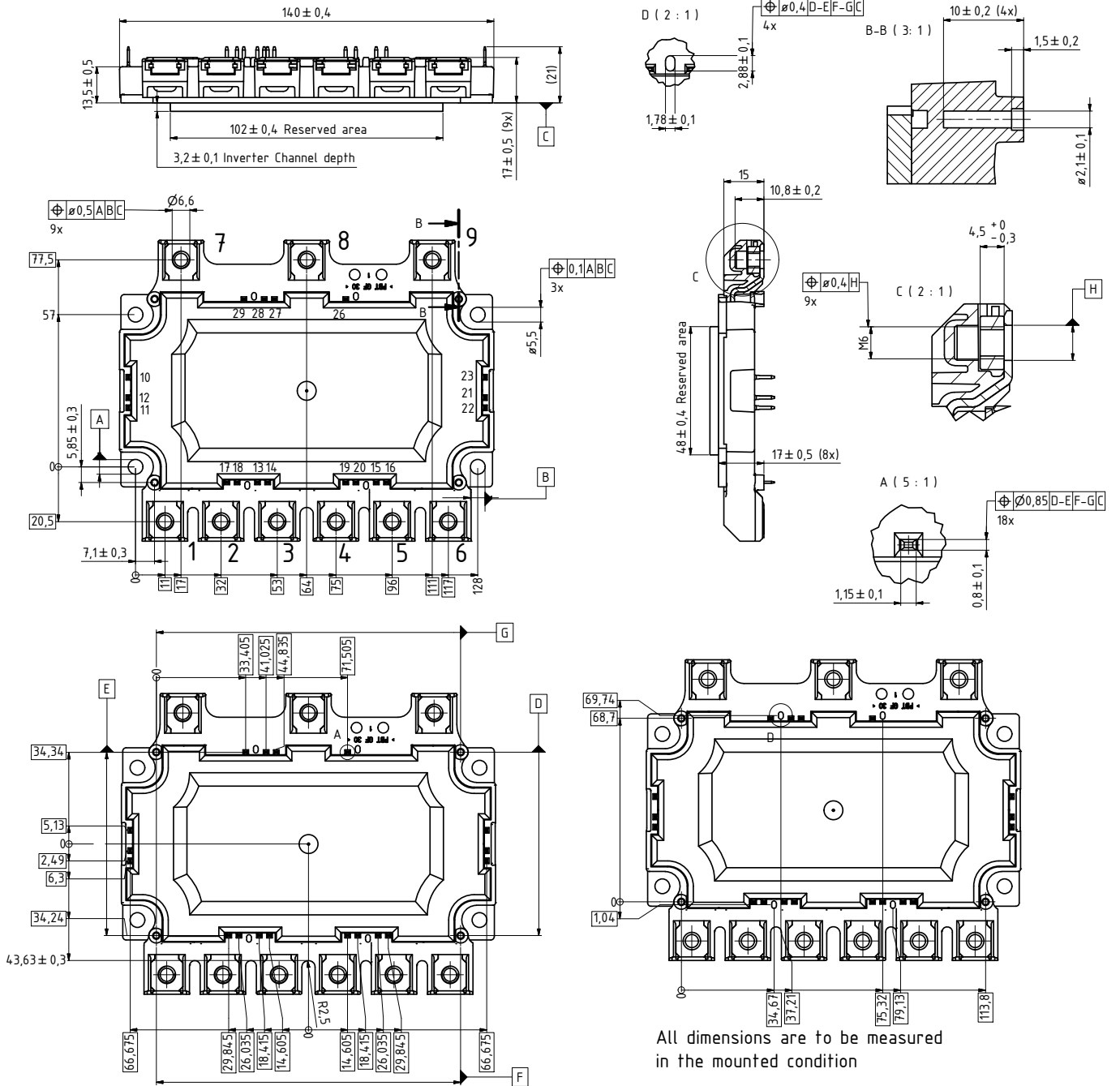
$R = f(T)$



7 Circuit diagram




### 8 Package outlines




## 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	2017-04-06	-
V2.0	2018-01-15	-
V3.0	2018-03-26	Final datasheet

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