



**THE DATASHEET OF  
FF400R07A01E3S6XKSA2**



Double Side Cooled Module

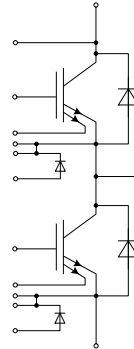
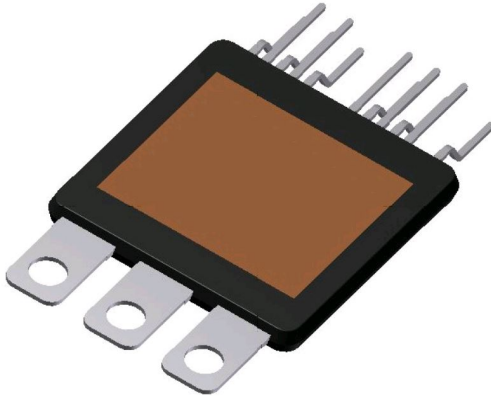
FF400R07A01E3\_S6

Final Data Sheet

V3.4, 2020-04-15

Automotive High Power

### 1 Features / Description



$V_{CES} = 700 \text{ V}$   
 $I_C = 400 \text{ A}$

#### Typical Applications

- Automotive Applications
- Hybrid Electrical Vehicles (H)EV

#### Electrical Features

- Increased Blocking Voltage Capability to 700V
- Integrated Current Sensor
- Integrated Temperature Sensor
- Low Inductive Design
- Low Switching Losses
- $T_{vj \text{ op}} = 150^\circ\text{C}$
- Short-time extended Operation Temperature  
 $T_{vj \text{ op}} = 175^\circ\text{C}$

#### Mechanical Features

- 2.5kV AC 1min Insulation
- Double sided cooling
- Compact design
- RoHS compliant

#### Description

The HybridPACK™ DSC S1 is a very compact half-bridge module targeting hybrid and electric vehicles.

The module is based on Infineon's long-term experience developing IGBT power modules and Trench-Field-Stop IGBTs including matching diodes with enhanced softness. Additionally, on-die integrated current sensor and temperature sensor allow precise monitoring of IGBT state. These features enable enhanced protection and intelligent control of the system.

The innovative and small package is designed for Double Sided Cooling (DSC) with superior thermal performance. The low stray inductance and increased blocking voltage support the design of systems with a very high efficiency. Furthermore, new material combinations and assembly technologies enable best thermal and electrical performance at highest reliability and mechanical robustness.

Product Name	Ordering Code
FF400R07A01E3_S6	SP001661226

## 2 IGBT, Inverter

### 2.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Collector-emitter voltage	$T_{vj} = 25^{\circ}\text{C}$	$V_{CES}$	700	V
Continuous DC collector current	$T_C = 75^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	$I_{C\text{ nom}}$	400	A
Repetitive peak collector current	$t_P = 1\text{ ms}$	$I_{CRM}$	800	A
Total power dissipation	$T_C = 25^{\circ}\text{C}, T_{vj\text{ max}} = 175^{\circ}\text{C}$	$P_{tot}$	1500	W
Gate-emitter peak voltage		$V_{GES}$	+/-20	V

### 2.2 Characteristic Values

Parameter	Conditions	Symbol	min. typ. max.			Unit	
Collector-emitter saturation voltage	$I_C = 400\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 400\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 400\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$V_{CE\text{ sat}}$	1.65 1.90 2.00	2.30	V	
Gate threshold voltage	$I_C = 4.85\text{ mA}, V_{CE} = V_{GE}$	$T_{vj} = 25^{\circ}\text{C}$	$V_{GE\text{ th}}$	5.00	5.80	6.50	V
Gate charge	$V_{GE} = -15\text{ V} \dots 15\text{ V}$		$Q_G$	2.90		$\mu\text{C}$	
Internal gate resistor		$T_{vj} = 25^{\circ}\text{C}$	$R_{G\text{ int}}$	0.0		$\Omega$	
Input capacitance	$f = 1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	$C_{ies}$	18.0		nF	
Reverse transfer capacitance	$f = 1\text{ MHz}, V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	$C_{res}$	0.50		nF	
Collector-emitter cut-off current	$V_{CE} = 450\text{ V}, V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$	$I_{CES}$		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	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Gon} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ on}}$	0.06 0.06 0.06		$\mu\text{s}$	
Rise time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Gon} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_r$	0.08 0.08 0.08		$\mu\text{s}$	
Turn-off delay time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Goff} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{d\text{ off}}$	0.43 0.44 0.48		$\mu\text{s}$	
Fall time, inductive load	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Goff} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$t_f$	0.04 0.04 0.05		$\mu\text{s}$	
Turn-on energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = -8/+15\text{ V}$ $R_{Gon} = 3.6\ \Omega$ $di/dt = 5.1\text{ kA}/\mu\text{s}$ ( $T_{vj} = 150^{\circ}\text{C}$ )	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{on}$	5.70 7.40 7.90		mJ	
Turn-off energy loss per pulse	$I_C = 400\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = -8/+15\text{ V}$ $R_{Goff} = 3.6\ \Omega$ $du/dt = 3.0\text{ kV}/\mu\text{s}$ ( $T_{vj} = 150^{\circ}\text{C}$ )	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{off}$	14.5 16.5 18.0		mJ	
SC data	$V_{GE} \leq 15\text{ V}, V_{CC} = 360\text{ V}$ $V_{CE\text{ max}} = V_{CES} - L_{SCE} \cdot di/dt$ $t_P \leq 6\ \mu\text{s}, T_{vj} = 150^{\circ}\text{C}$		$I_{SC}$	1900		A	
Thermal resistance, junction to case	per IGBT		$R_{th\text{ JC}}$		0.100 <sup>1)</sup>	K/W	
Thermal resistance, case to heatsink	per IGBT $\lambda_{\text{Paste}} = 1\text{ W}/(\text{m}\cdot\text{K})$ / $\lambda_{\text{grease}} = 1\text{ W}/(\text{m}\cdot\text{K})$ Clamping Force $F = 700\text{ N}$		$R_{th\text{ CH}}$		0.140 <sup>1)</sup>	K/W	
Temperature under switching conditions	$t_{op}$ continuous for 18s within a period of 600s, occurrence maximum 200 times over lifetime		$T_{vj\text{ op}}$	-40 150	150 175	$^{\circ}\text{C}$	

<sup>1)</sup> with double sided cooling, evaluation according to HybridPack™ DSC application note

### 3 Diode, Inverter

#### 3.1 Maximum Rated Values

Parameter	Conditions	Symbol	Value	Unit
Repetitive peak reverse voltage	$T_{vj} = 25^{\circ}\text{C}$	$V_{RRM}$	700	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	$V_R = 0 \text{ V}$ , $t_P = 10 \text{ ms}$ , $T_{vj} = 125^{\circ}\text{C}$	$I^2t$	9000	$\text{A}^2\text{s}$

#### 3.2 Characteristic Values

Parameter	Conditions	Symbol	min. typ. max.			Unit
Forward voltage	$I_F = 400 \text{ A}$ , $V_{GE} = 0 \text{ V}$ $I_F = 400 \text{ A}$ , $V_{GE} = 0 \text{ V}$ $I_F = 400 \text{ A}$ , $V_{GE} = 0 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$V_F$	1.95 1.84 1.80	2.55	V
Peak reverse recovery current	$I_F = 400 \text{ A}$ , $-di_F/dt = 5000 \text{ A}/\mu\text{s}$ ( $T_{vj} = 150^{\circ}\text{C}$ ) $V_R = 300 \text{ V}$ $V_{GE} = -8 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$I_{RM}$	135 210 220		A
Recovered charge	$I_F = 400 \text{ A}$ , $-di_F/dt = 5000 \text{ A}/\mu\text{s}$ ( $T_{vj} = 150^{\circ}\text{C}$ ) $V_R = 300 \text{ V}$ $V_{GE} = -8 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$Q_r$	12.0 23.0 27.0		$\mu\text{C}$
Reverse recovery energy	$I_F = 400 \text{ A}$ , $-di_F/dt = 5000 \text{ A}/\mu\text{s}$ ( $T_{vj} = 150^{\circ}\text{C}$ ) $V_R = 300 \text{ V}$ $V_{GE} = -8 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$E_{rec}$	2.80 5.80 6.60		mJ
Thermal resistance, junction to case	per diode	$R_{thJC}$			0.150 <sup>1)</sup>	K/W
Thermal resistance, case to heatsink	per diode $\lambda_{\text{Paste}} = 1 \text{ W}/(\text{m}\cdot\text{K})$ / $\lambda_{\text{grease}} = 1 \text{ W}/(\text{m}\cdot\text{K})$ Clamping Force $F = 700\text{N}$	$R_{thCH}$		0.200 <sup>1)</sup>		K/W
Temperature under switching conditions	$t_{op}$ continuous for 18s within a period of 600s, occurrence maximum 200 times over lifetime	$T_{vj op}$	-40 150		150 175	$^{\circ}\text{C}$

### 4 Module

Parameter	Conditions	Symbol	Value	Unit	
Isolation test voltage	RMS, $f = 50 \text{ Hz}$ , $t = 1 \text{ min.}$	$V_{ISOL}$	2.5	kV	
Material of module baseplate			Cu		
Internal isolation	basic insulation (class 1, IEC 61140)		$\text{Al}_2\text{O}_3$		
Creepage distance	terminal to heatsink terminal to terminal	$d_{\text{Creep}}$	3.5	mm	
Clearance	terminal to heatsink terminal to terminal	$d_{\text{Clear}}$	3.5	mm	
Comperative tracking index		CTI	> 600		
			min. typ. max.		
Stray inductance module		$L_{sCE}$	15	nH	
Storage temperature		$T_{\text{stg}}$	-40	125	$^{\circ}\text{C}$
Terminal connection torque	Screw M5	M	-		Nm
Mounting force per clamp		F	-	900	N
Weight		G	30		g

### 5 Temperature Sensor

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Forward voltage	$I_{TS} = 1.00 \text{ mA}$ , $T_{vj} = 150^{\circ}\text{C}$ $I_{TS} = 1.00 \text{ mA}$ , $T_{vj} = 25^{\circ}\text{C}$	$V_{TS}$		2.120 2.910		V

<sup>1)</sup> with double sided cooling, evaluation according to HybridPack™ DSC application note

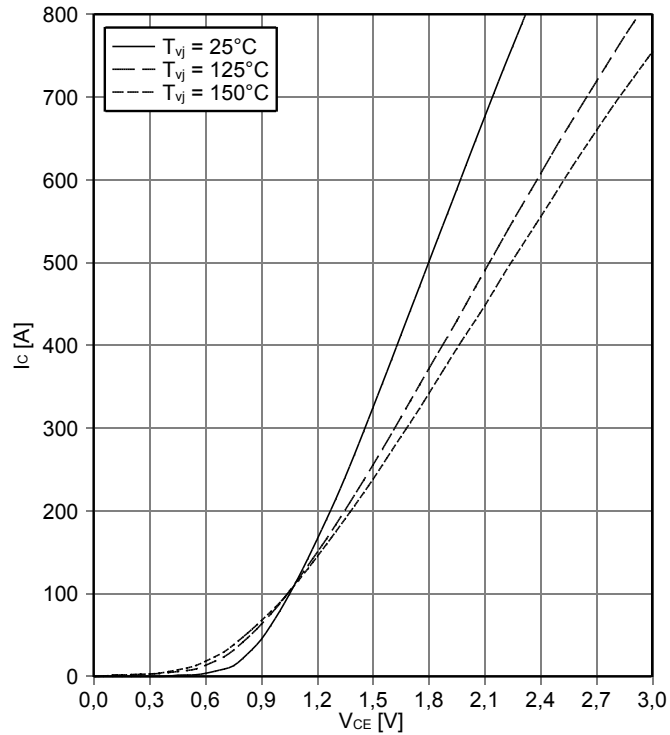
## 6 Current Sensor

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Output voltage	$V_{CE} = 2.35 \text{ V}$ , $I_C = 800 \text{ A}$ $R_{\text{sense}} = 1.60 \text{ } \Omega$ , $T_{vj} = 25^\circ\text{C}$ $V_{GE} = 15 \text{ V}$	$V_{\text{sense}}$		0.64		V

## 7 Characteristics Diagrams

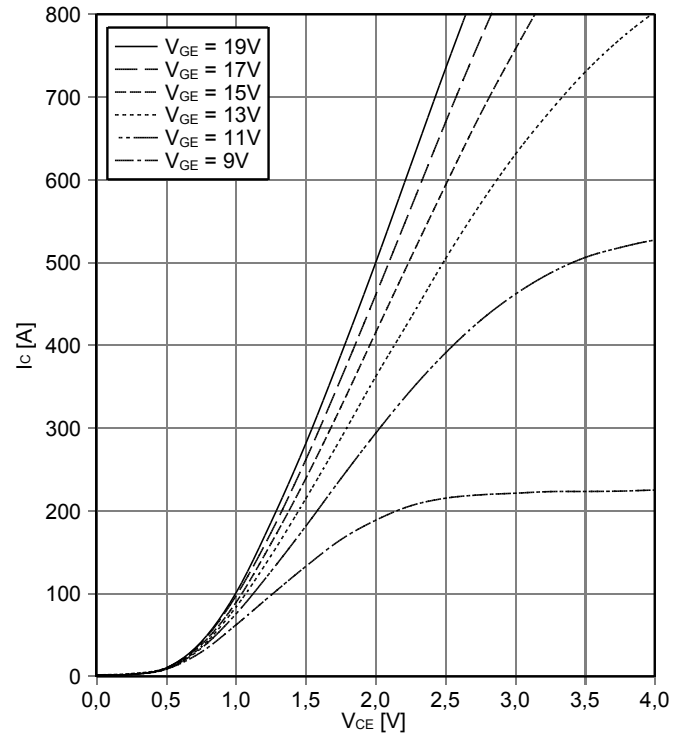
**output characteristic IGBT, Inverter (typical)**

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



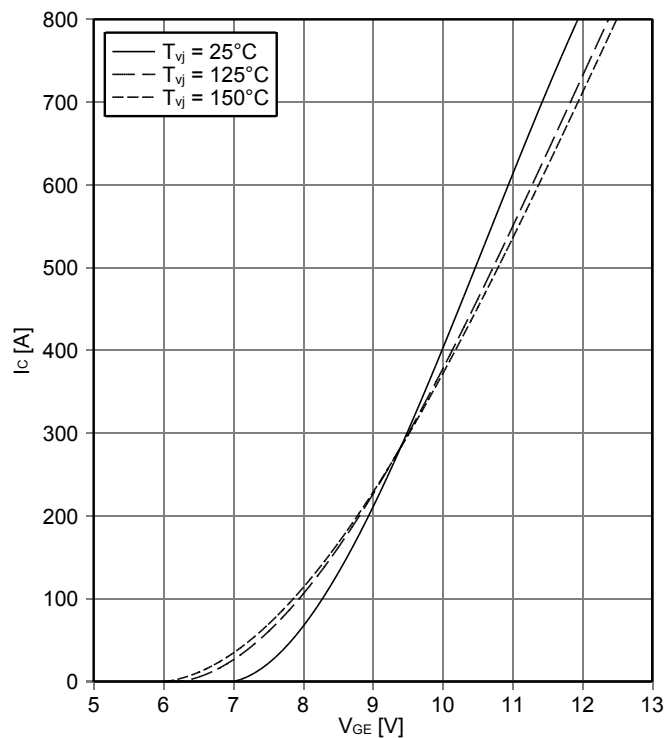
**output characteristic IGBT, Inverter (typical)**

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



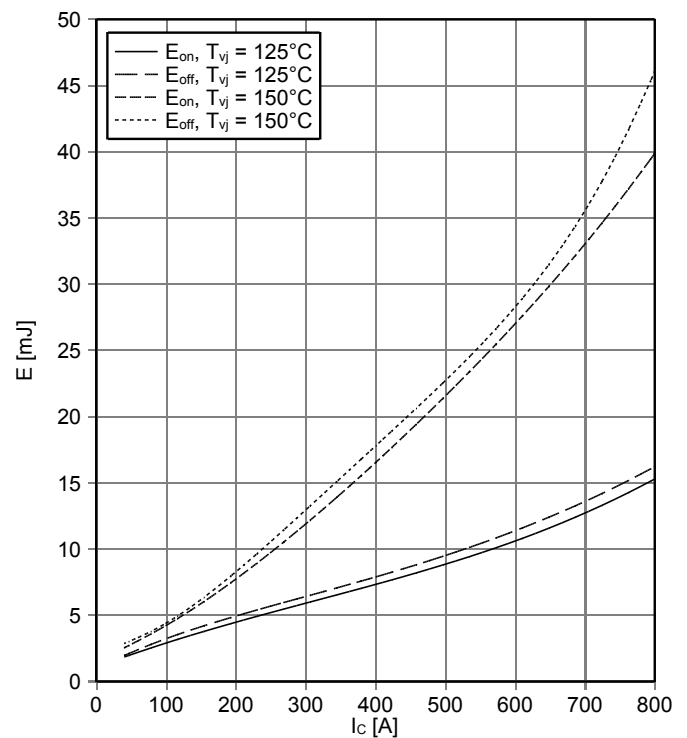
**transfer characteristic IGBT, Inverter (typical)**

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



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

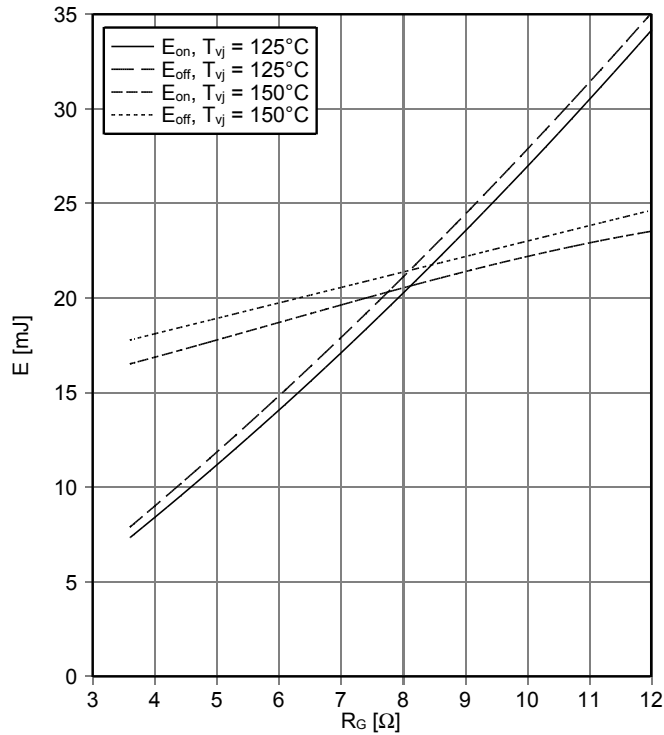
$E_{on} = f(I_C)$ ,  $E_{off} = f(I_C)$   
 $V_{GE} = -8 / +15\text{ V}$ ,  $R_{Gon} = 3.6\ \Omega$ ,  $R_{Goff} = 3.6\ \Omega$ ,  $V_{CE} = 300\text{ V}$



### switching losses IGBT, Inverter (typical)

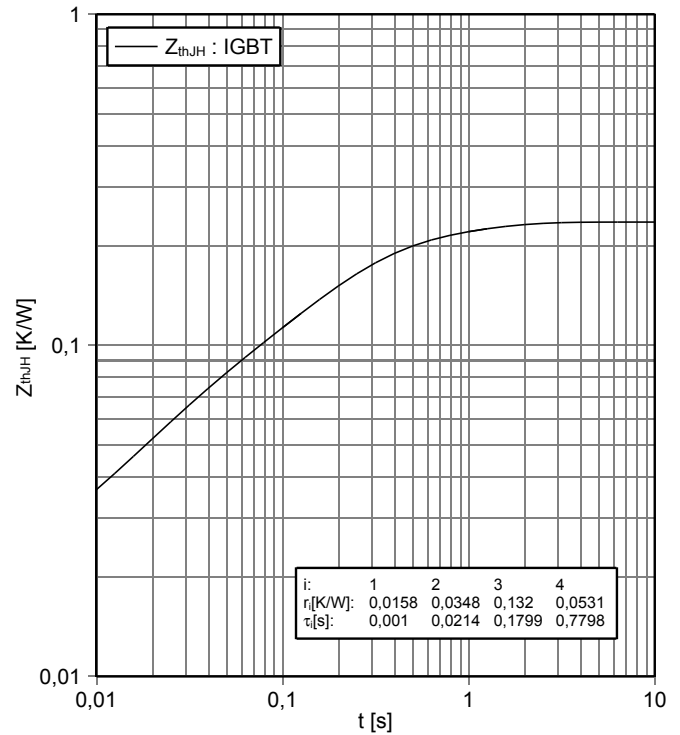
$$E_{on} = f(R_G), E_{off} = f(R_G)$$

$V_{GE} = -8 / +15 \text{ V}, I_C = 400 \text{ A}, V_{CE} = 300 \text{ V}$



### transient thermal impedance IGBT, Inverter

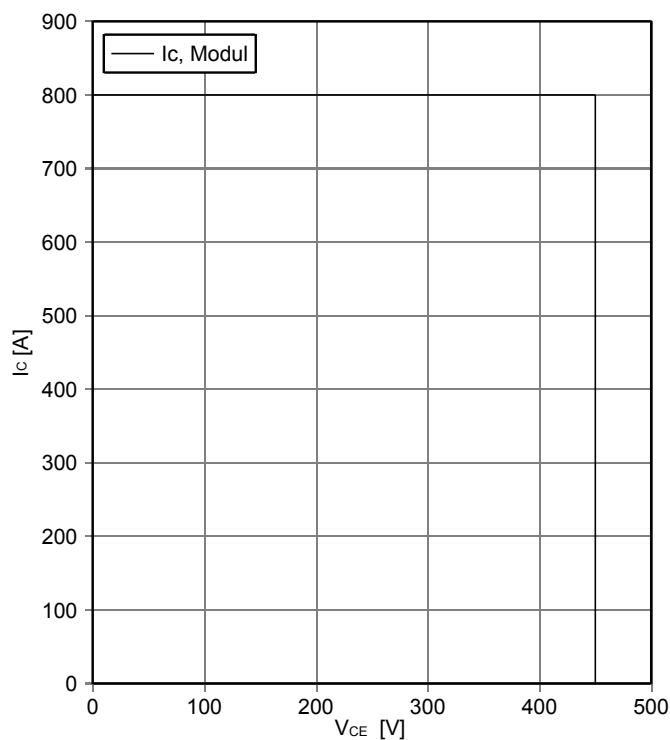
$$Z_{thJH} = f(t)$$



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

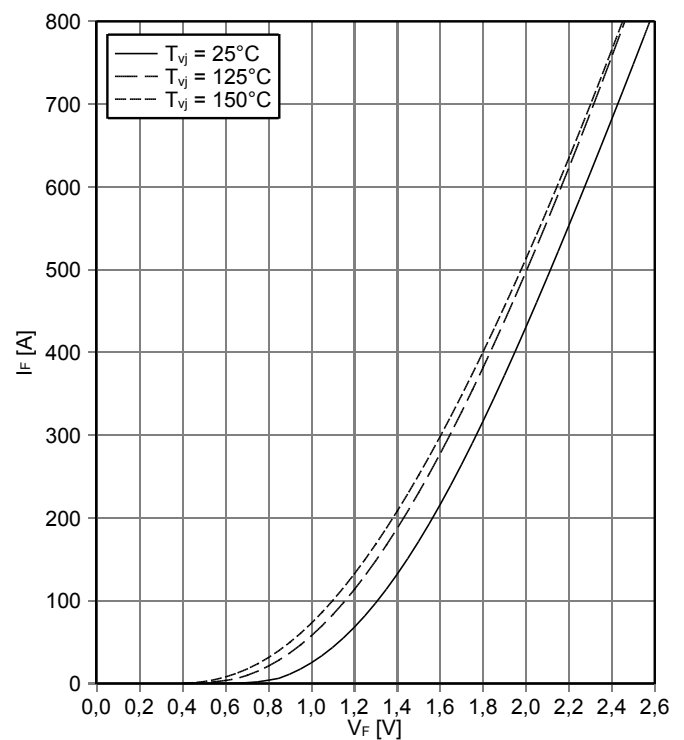
$$I_C = f(V_{CE})$$

$V_{GE} = \pm 15 \text{ V}, R_{Goff} = 3.6 \Omega, T_{vj} = 150^\circ\text{C}$



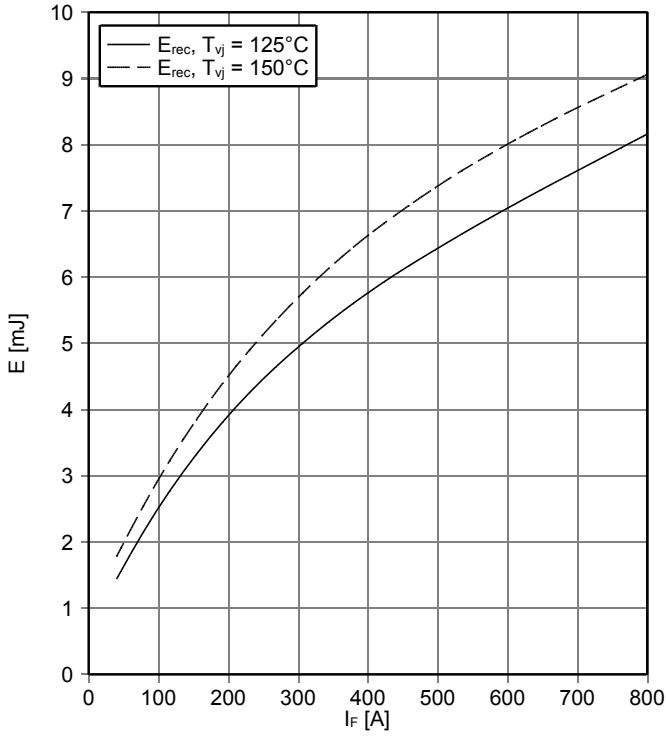
### forward characteristic of Diode, Inverter (typical)

$$I_F = f(V_F)$$



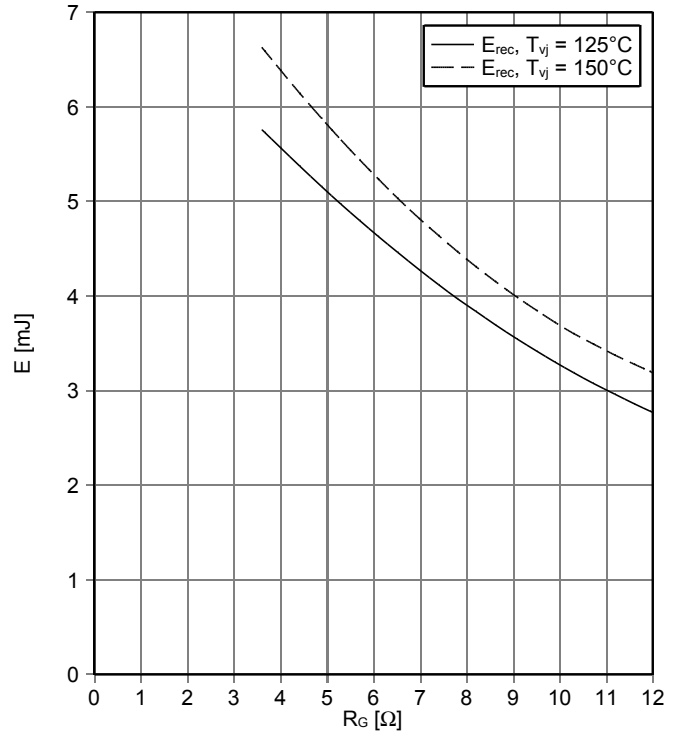
### switching losses Diode, Inverter (typical)

$E_{rec} = f(I_F)$   
 $R_{Gon} = 3.6 \Omega, V_{CE} = 300 V$



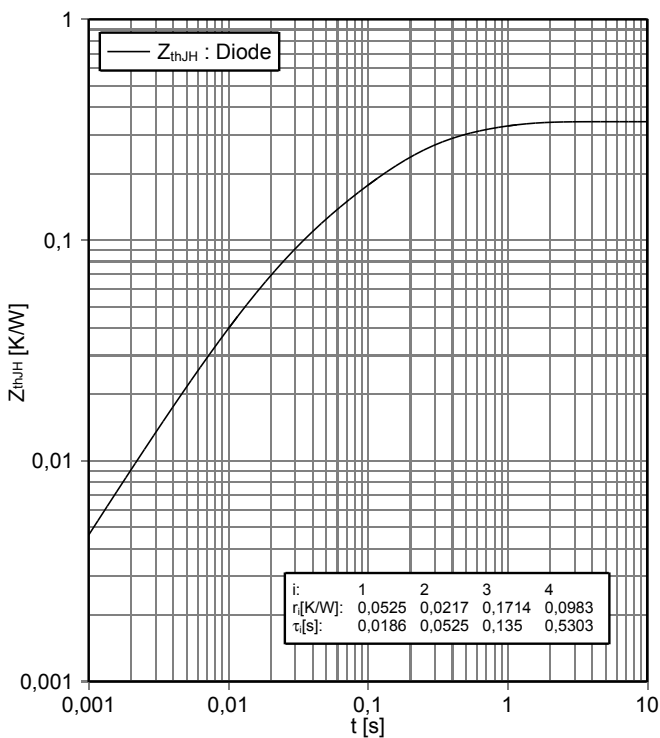
### switching losses Diode, Inverter (typical)

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

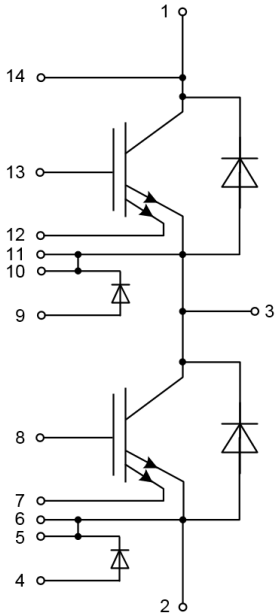


### transient thermal impedance Diode, Inverter

$Z_{thJH} = f(t)$

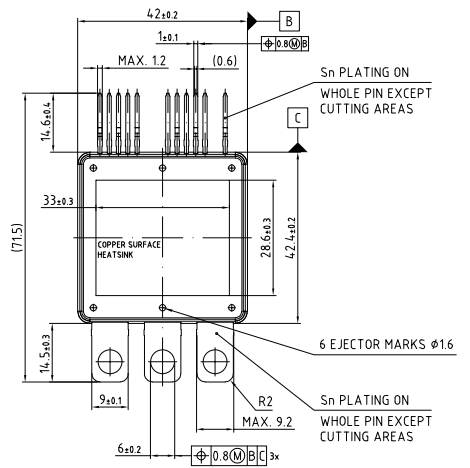
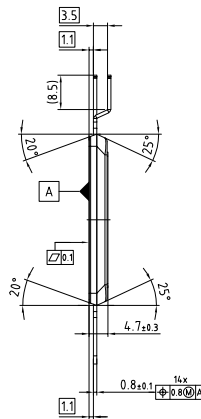
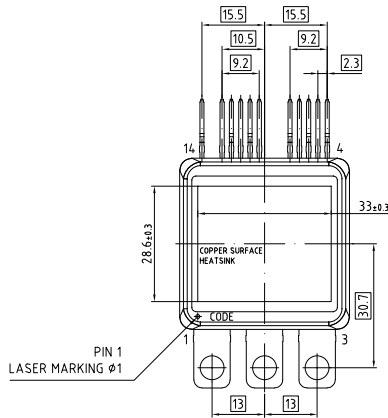
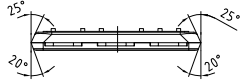


## 8 Circuit diagram



Pin Number	Symbol	I/O	Function
1	P	DC Supply (+)	Positive Supply
2	N	DC Supply (-)	Negative Supply
3	U	AC Output	U Phase Output
4	T+L	Input	Temperature Sensor Plus Low Side
5	T-L	Output	Temperature Sensor Minus Low Side
6	EL	Output	IGBT Emitter Output Low Side
7	CSL	Output	IGBT Current Sensor Output Low Side
8	GL	Input	Gate Input Low Side
9	T+H	Input	Temperature Sensor Plus High Side
10	T-H	Output	Temperature Sensor Minus High Side
11	EH	Output	IGBT Emitter Output High Side
12	CSH	Output	IGBT Current Sensor output High Side
13	GH	Input	Gate Input High Side
14	PS	Output	P-Terminal Voltage Sensing / IGBT Collector Output

## 9 Package outlines



Drawing: Z8B0017254.2 POL 000 09	Drawing according to ISO 8015	General tolerances: ISO 2768-mK
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## Revision History

Major changes since previous revision

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### Revision History

Reference	Date	Description
V1.0	2015-03-26	Initial Version
V1.1	2015-04-07	Extension of target data
V2.0	2016-02-02	Update of target data
V3.0	2016-11-07	Final Datasheet
V3.1	2016-11-08	Change of product name in description
V3.2	2016-12-13	Changes in description
V3.3	2017-07-28	Update mechanical drawing
V3.4	2020-04-15	Correction of package outlines

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