

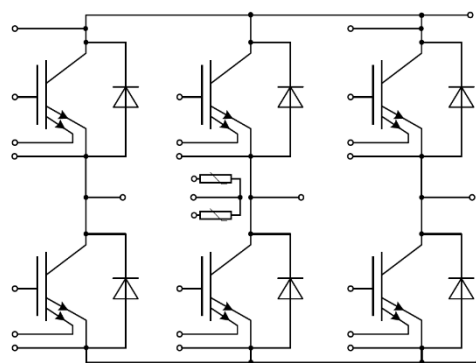
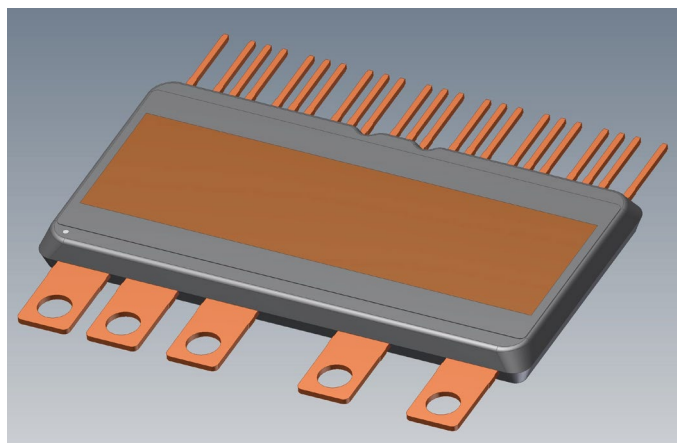
英飞凌双面冷却模块

FS200R07A02E3_S6

最终数据手册

V3.1, 2019-10-11

1 特点/描述


 $V_{CES} = 700\text{ V}$
 $I_C = 200\text{ A}$

典型应用

- 汽车应用
- (混合) 电动汽车 (H)EV

电气特性

- 阻断电压能力提升至700V
- 集成电流传感器
- 低杂散电感设计
- $T_{vj\text{ op}} = 150^\circ\text{C}$

机械特性

- 2.5kV AC 1分钟绝缘
- 双面冷却
- 紧凑型设计
- 符合 RoHS 要求
- 集成NTC温度传感器

描述

英飞凌 HybridPACK™DSC L 是一款非常紧凑的六相全桥模块,专为混合动力和电动汽车设计。该模块基于英飞凌在开发IGBT功率模块和沟槽场截止型IGBT (含具有增强软恢复特性的匹配二极管) 方面的长期经验。此外,芯片上集成的电流传感器和模块温度传感器 (2个 NTC) 可支持对 IGBT 状态的监测。这些功能可实现增强型短路保护,并实现系统的智能控制。

双面冷却 (DSC) 技术的采用,实现了极度紧凑的封装设计。这项新的装配技术在确保高可靠性和机械稳健性的同时,还能提升热性能和电气性能。

此外,该模块可与其他现有的双面冷却封装 (例如 HybridPACK™DSC S) 组合使用,将单逆变器扩展为双逆变器配置。

Product Name	Ordering Code
FS200R07A02E3_S6	SP001661220

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2 IGBT、逆变器

2.1 最大额定值

Parameter	Conditions	Symbol	Value	Unit
Collector-emitter voltage	$T_{vj} = 25^{\circ}\text{C}$	V_{CES}	700	V
Continuous DC collector current	$T_C = 65^{\circ}\text{C}, T_{vj\max} = 150^{\circ}\text{C}$	$I_{C\text{ nom}}$	200	A
Repetitive peak collector current	$t_P = 1\text{ ms}$	I_{CRM}	400	A
Total power dissipation	$T_C = 25^{\circ}\text{C}, T_{vj\max} = 150^{\circ}\text{C}$	P_{tot}	694	W
Gate-emitter peak voltage		V_{GES}	+/-20	V

2.2 特征值

			min.	typ.	max.	
Collector-emitter saturation voltage	$I_C = 200\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 200\text{ A}, V_{GE} = 15\text{ V}$ $I_C = 200\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$V_{CE\text{ sat}}$		1.45 1.60 1.70	2.25 V
Gate threshold voltage	$I_C = 3.70\text{ mA}, V_{CE} = V_{GE}$	$T_{vj} = 25^{\circ}\text{C}$	V_{GEth}	5.00	5.80	6.50 V
Gate charge	$V_{GE} = -15\text{ V} \dots 15\text{ V}$		Q_G		2.20	μC
Internal gate resistor		$T_{vj} = 25^{\circ}\text{C}$	R_{Gint}		2.0	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}		13.5	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}		0.36	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	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Gon} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_{don}		0.13 0.14 0.15	μs
Rise time, inductive load	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Gon} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_r		0.07 0.07 0.07	μs
Turn-off delay time, inductive load	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Goff} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_{doff}		0.48 0.52 0.53	μs
Fall time, inductive load	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}$ $V_{GE} = -8/+15\text{ V}$ $R_{Goff} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_f		0.03 0.04 0.04	μs
Turn-on energy loss per pulse	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = -8/+15\text{ V}, di/dt = 3000\text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $T_{vj} = 125^{\circ}\text{C}$ $R_{Gon} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{on}		3.90 4.90 5.10	mJ
Turn-off energy loss per pulse	$I_C = 200\text{ A}, V_{CE} = 300\text{ V}, L_S = 25\text{ nH}$ $V_{GE} = -8/+15\text{ V}, du/dt = 2500\text{ V}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ $T_{vj} = 125^{\circ}\text{C}$ $R_{Goff} = 3.6\ \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{off}		6.80 8.20 8.50	mJ
SC data	$V_{GE} \leq 15\text{ V}, V_{CC} = 360\text{ V}$ $V_{CEmax} = V_{CES} - L_{SCE} \cdot di/dt$ $t_P \leq 6\ \mu\text{s}, T_{vj} = 150^{\circ}\text{C}$		I_{sc}		1700	A
Thermal resistance, junction to case	per IGBT Clamping Force $F = 700\text{ N}$		R_{thJC}			0.180 ¹⁾ 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_{thCH}		0.170 ¹⁾	K/W
Temperature under switching conditions	$t_{op\text{ continuous}}$	$T_{vj\text{ op}}$	-40		150	$^{\circ}\text{C}$

3 二极管、逆变器

3.1 最大额定值

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	200	A
Repetitive peak forward current	$t_P = 1\text{ ms}$	I_{FRM}	400	A
I^2t - value	$V_R = 0\text{ V}$, $t_P = 10\text{ ms}$, $T_{vj} = 125^{\circ}\text{C}$	I^2t	1800	A^2s

3.2 特征值

			min.	typ.	max.	
Forward voltage	$I_F = 200\text{ A}$, $V_{GE} = 0\text{ V}$ $I_F = 200\text{ A}$, $V_{GE} = 0\text{ V}$ $I_F = 200\text{ A}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	V_F	1.60 1.50 1.50	2.55	V
Peak reverse recovery current	$I_F = 200\text{ A}$, $-di_F/dt = 2900\text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_{GE} = -8\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $V_R = 300\text{ V}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	I_{RM}	96.0 130 140		A
Recovered charge	$I_F = 200\text{ A}$, $-di_F/dt = 2900\text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_{GE} = -8\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $V_R = 300\text{ V}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	Q_r	7.20 13.5 16.0		μC
Reverse recovery energy	$I_F = 200\text{ A}$, $-di_F/dt = 2900\text{ A}/\mu\text{s}$ ($T_{vj} = 150^{\circ}\text{C}$) $V_{GE} = -8\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $V_R = 300\text{ V}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{rec}	1.70 3.30 3.80		mJ
Thermal resistance, junction to case	per diode Clamping Force $F = 700\text{ N}$		R_{thJC}		0.280 ¹⁾	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}	0.270 ¹⁾		K/W
Temperature under switching conditions	t_{op} continuous	$T_{vj\text{ op}}$	-40		150	$^{\circ}\text{C}$

4 模块

Parameter	Conditions	Symbol	Value			Unit
Isolation test voltage	RMS, f = 50 Hz, t = 1min	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 terminal to terminal	d _{Creep}	2.8			mm
Clearance	terminal to heatsink terminal to terminal	d _{Clear}	2.4			mm
Comperative tracking index		CTI	> 600			
			min.	typ.	max.	
Stray inductance module		L _{SCE}		20		nH
Storage temperature		T _{stg}	-40		125	°C
Terminal connection torque	Screw M5	M		-		Nm
Mounting force per clamp		F	400	-	750	N
Weight		G		72		g

5 电流传感器

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Output voltage	$V_{CE} = 1.95\text{ V}$, $I_C = 400\text{ A}$ $R_{\text{sense}} = 1.60\text{ }\Omega$, $T_{vj} = 25^{\circ}\text{C}$ $V_{GE} = 15\text{ V}$	V_{sense}		0.26		V

6 NTC-热敏电阻

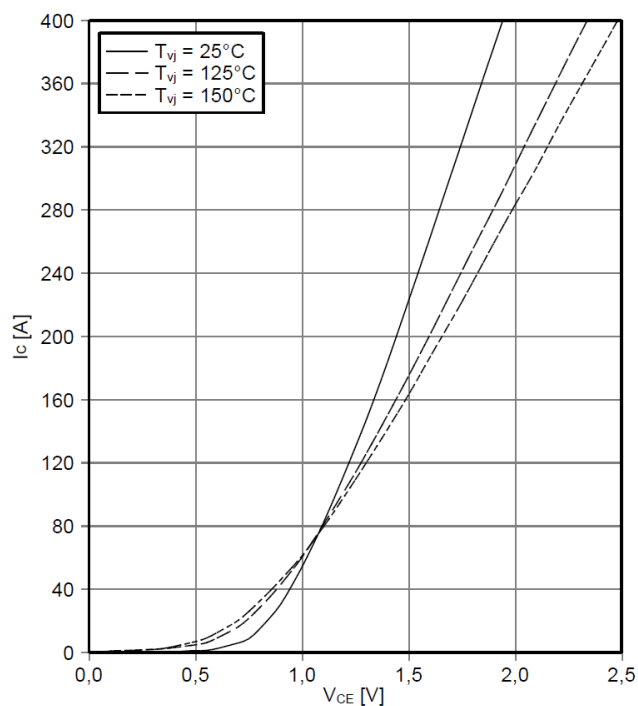
Parameter	Conditions	Symbol	min. typ. max.			Unit
Rated resistance	$T_C = 25^\circ\text{C}$	R_{25}		5.00		$\text{k}\Omega$
Deviation of R_{100}	$T_C = 100^\circ\text{C}, R_{100} = 493 \Omega$	$\Delta R/R$	-5		5	%
Power dissipation	$T_C = 25^\circ\text{C}$	P_{25}			20.0	mW
B-value	$R_2 = R_{25} \exp [B_{25/50}(1/T_2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

根据应用笔记标定

7 特性图

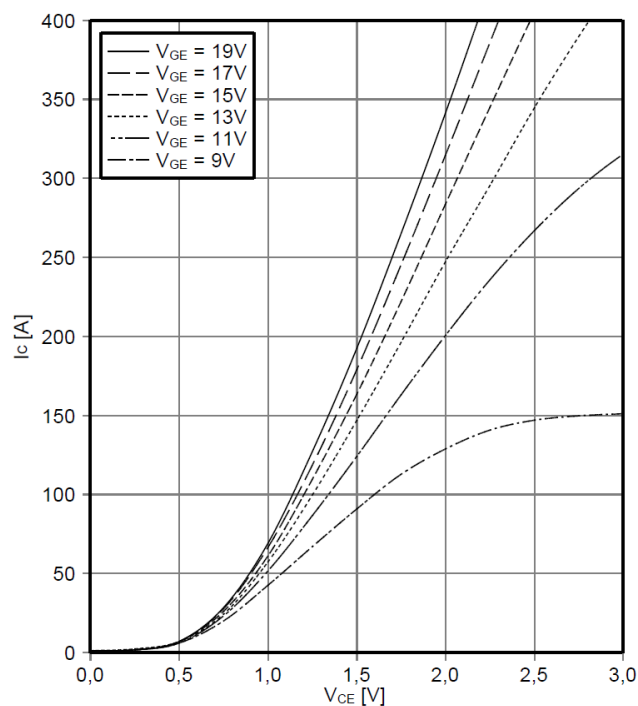
output characteristic IGBT, Inverter (typical)

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



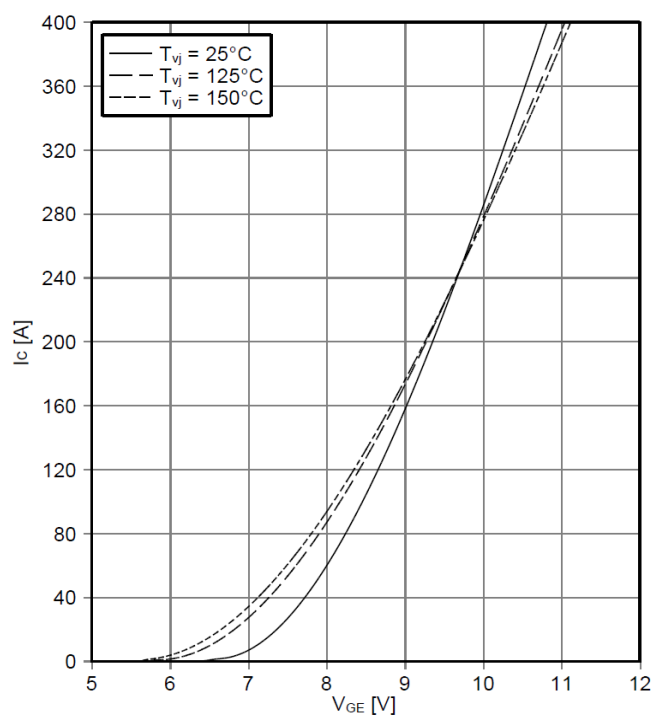
output characteristic IGBT, Inverter (typical)

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



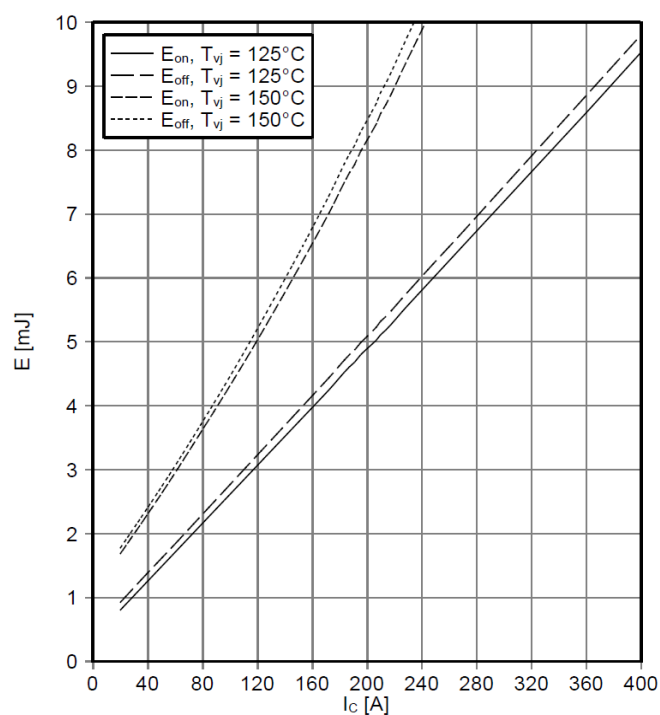
transfer characteristic IGBT, Inverter (typical)

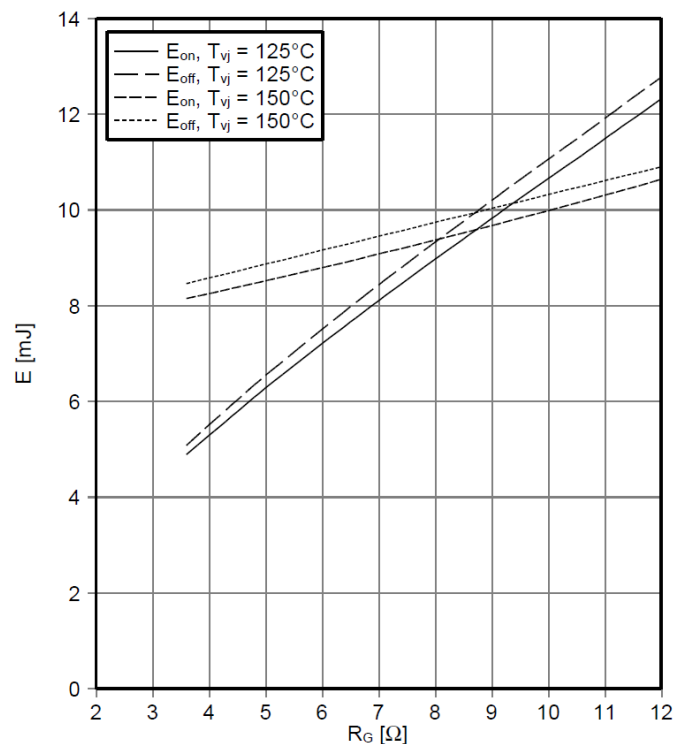
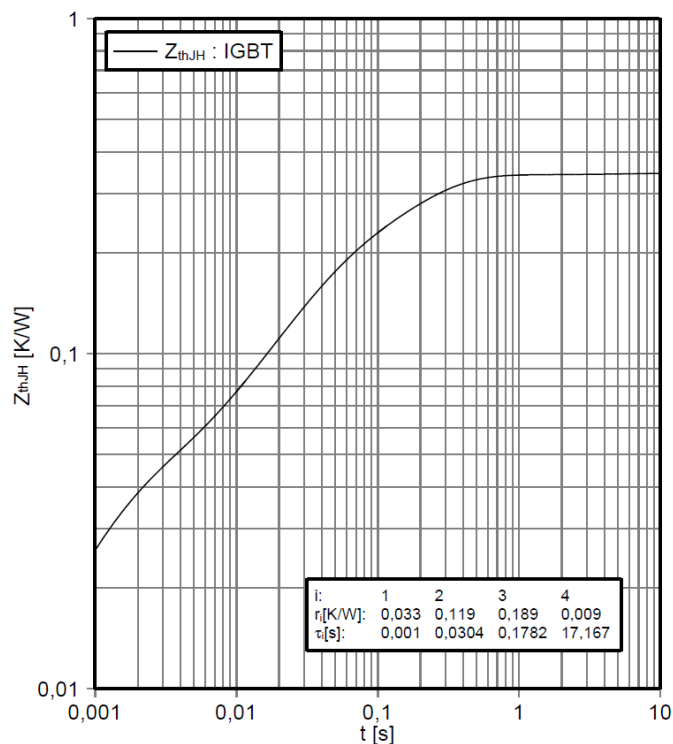
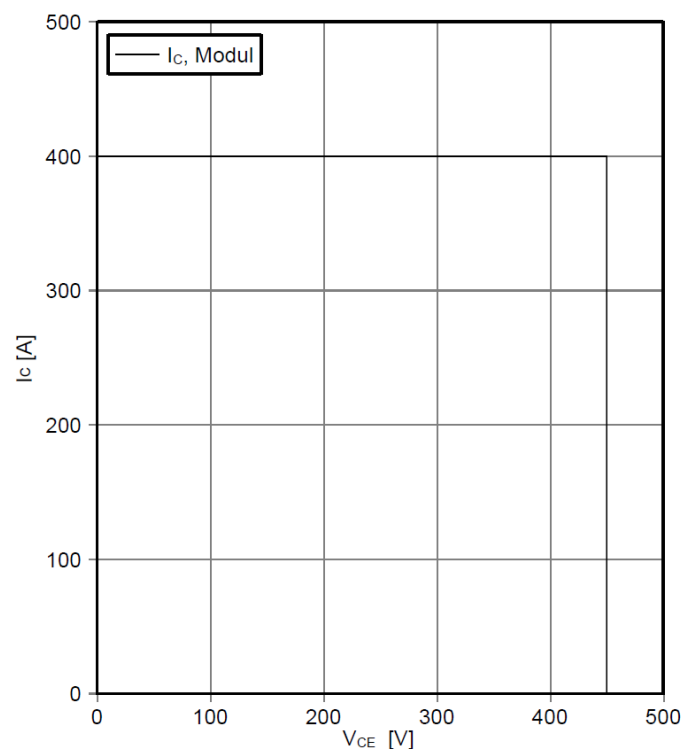
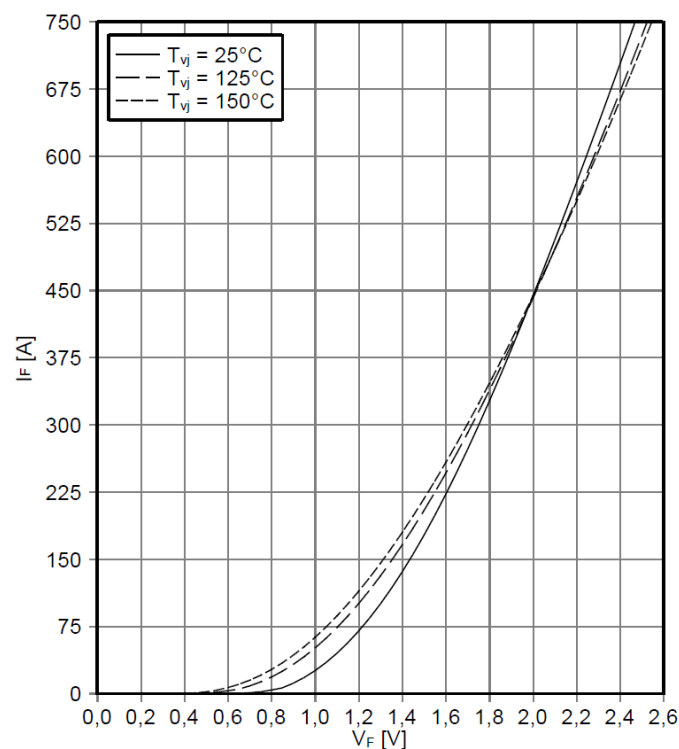
$I_C = f(V_{GE})$
 $V_{CE} = 20 \text{ V}$



switching losses IGBT, Inverter (typical)

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

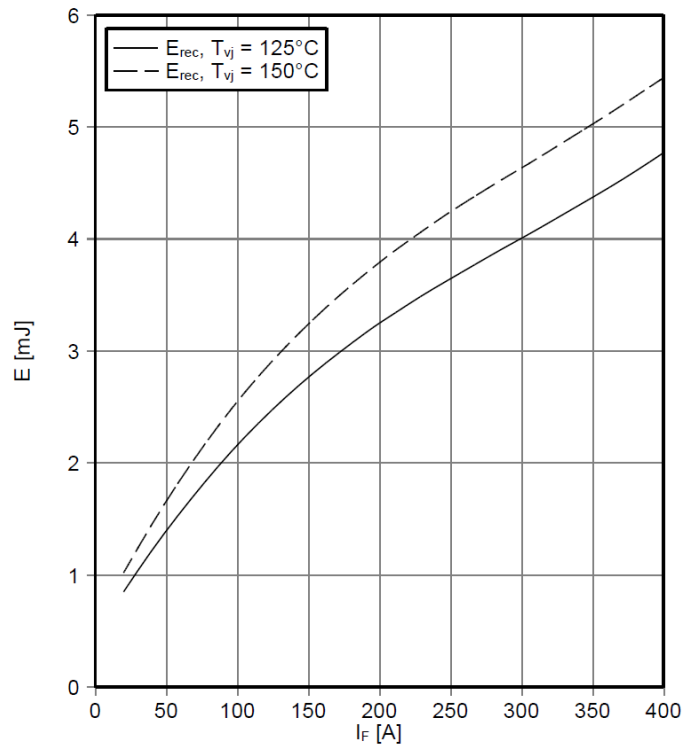


switching losses IGBT, Inverter (typical)
 $E_{on} = f(R_G), E_{off} = f(R_G)$
 $V_{GE} = -8 / +15 \text{ V}, I_C = 200 \text{ A}, V_{CE} = 300 \text{ V}$

transient thermal impedance IGBT, Inverter
 $Z_{thJH} = f(t)$

reverse bias safe operating area IGBT, Inverter (RBSOA)
 $I_C = f(V_{CE})$
 $V_{GE} = -8 / +15 \text{ V}, R_{Goff} = 3.6 \Omega, T_{vj} = 150^\circ\text{C}$

forward characteristic of Diode, Inverter (typical)
 $I_F = f(V_F)$


switching losses Diode, Inverter (typical)

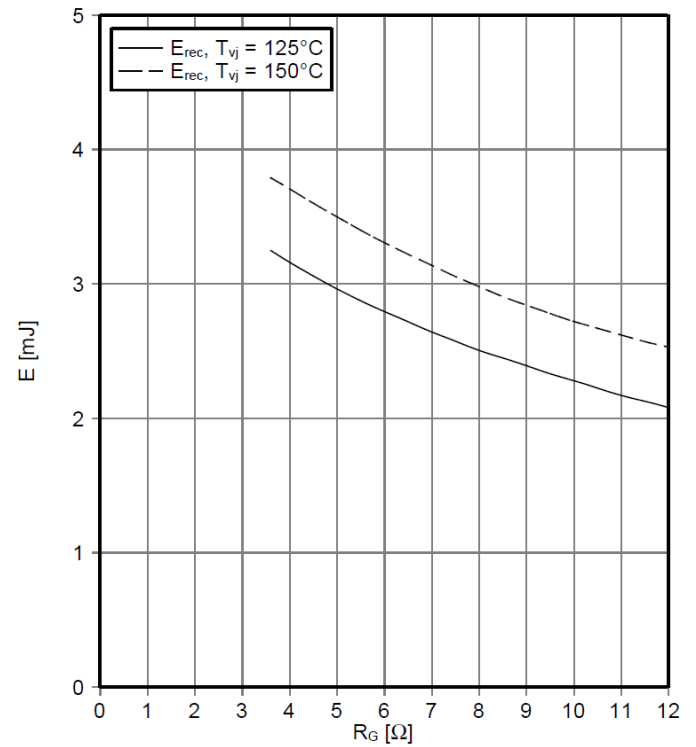
$$E_{\text{rec}} = f(I_F)$$

$$R_{\text{Gon}} = 3.6 \, \Omega, V_{\text{CE}} = 300 \, \text{V}$$

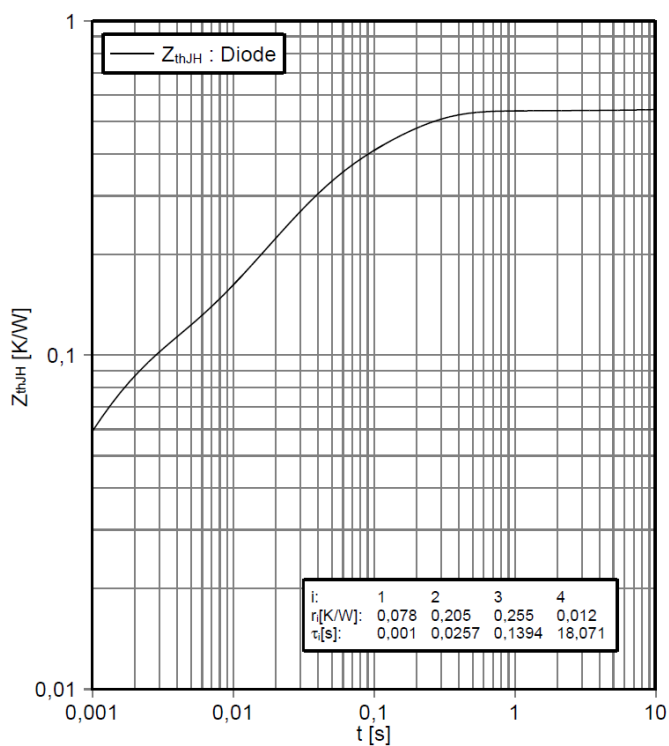

switching losses Diode, Inverter (typical)

$$E_{\text{rec}} = f(R_G)$$

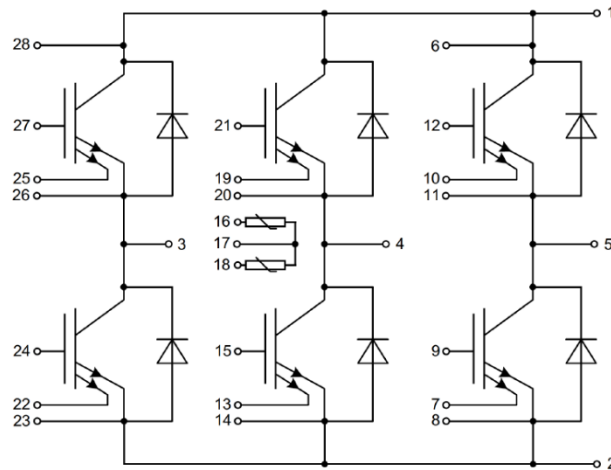
$$I_F = 200 \, \text{A}, V_{\text{CE}} = 300 \, \text{V}$$


transient thermal impedance Diode, Inverter

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



8 电路图



Pin Number	Symbol	I/O	Function
1	P	DC Supply (+)	P ositive Supply
2	N	DC Supply (-)	Negative Supply
3	U	AC Output	U P hase Output
4	V	AC Output	V P hase Output
5	W	AC Output	W P hase Output
6	P S	Output	P Terminal Voltage Sensing (IGBT Collector)
7	CS6	Output	IGBT Current Sensor System 6
8	E 6	Output	IGBT Emitter Output System 6
9	G6	Input	Gate Input System 6
10	CS5	Output	IGBT Current Sensor System 5
11	E 5	Output	IGBT Emitter Output System 5
12	G5	Input	Gate Input System 5
13	CS4	Output	IGBT Current Sensor System 4
14	E 4	Output	IGBT Emitter Output System 4
15	G4	Input	Gate Input System 4
16	T1	Output	NTC 1 +(Bottom DCB)
17	TG	Ground	NTC Ground
18	T2	Output	NTC 2 +(Top DCB)
19	CS3	Output	IGBT Current Sensor System 3
20	E 3	Output	IGBT Emitter Output System 3
21	G3	Input	Gate Input System 3
22	CS2	Output	IGBT Current Sensor System 2
23	E 2	Output	IGBT Emitter Output System 2
24	G2	Input	Gate Input System 2
25	CS2	Output	IGBT Current Sensor System 1
26	E 1	Output	IGBT Emitter Output System 1
27	G1	Input	Gate Input System 1
28	P S	Output	P Terminal Voltage Sensing (IGBT Collector)

10 标签代码

10.1 模块代码

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		

10.2 包装代码

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			

修订记录

自上次修订以来的主要变化

Revision History

Reference	Date	Description
V1.0	2015-07-31	-
V3.0	2016-12-13	final datasheet
V3.1	2019-10-11	Change of ordering code number

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