

BG25G12N10S4

□ General Description

BG25G12N10S4 is a cabinet and high integrated power module encapsulated by mini Pack that BYD has newly developed and designed. It highly combines convert circuit, breakdown circuit and invert circuit to make application circuit outside compact. It includes temperature detection function which can feedback quickly and output the analog temperature signal in real time.

□ 概述

BG25G12N10S4 是一款由比亚迪半导体设计开发的 mini 封装 PIM 模块 (Power Integrated Module)。该产品具有封装小、集成度高等优点；实现了三相变频电路、二极管桥接电路、制动电路的高度集成，能够紧凑地设计主电路。模块集成温度检测，可快速响应及温度实时输出。



封装类型: mini2

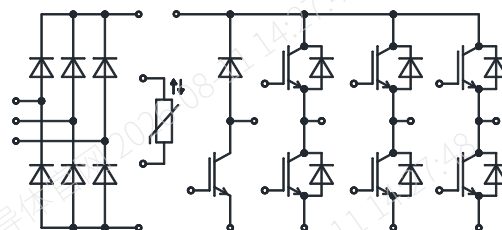
$V_{CE}=1200V$, $I_C=25A$

□ Key Features

- Very low thermal resistance due to using DBC
- The 4th technology of BYD IGBT chip
- low conduction and switching losses

□ 关键特性

- 采用陶瓷覆铜板 (DBC)，低热阻设计
- BYD 四代 IGBT 芯片技术
- 低导通和开关损耗



□ Applications

- Air conditioner
- Convert and servo controller
- Three-phase inverter for AC motor

□ 应用

- 空调
- 变频、伺服控制器
- 三相电机逆变器

BG25G12N10S4**IGBT, Inverter/ IGBT, 逆变器 T1 T2 T3 T4 T5 T6****● Maximum Rated Values/最大额定值**

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings	单位 Units
V_{CES}	Collector-emitter voltage 集电极-发射极电压	$T_{vj} = 25^{\circ}\text{C}$	1200	V
I_C	Collector current 连续集电极直流电流	$T_c = 100^{\circ}\text{C}, T_{vj} = 175^{\circ}\text{C}$	25	A
V_{GES}	Gate-emitter voltage 栅极-发射极峰值电压	$T_{vj} = 25^{\circ}\text{C}$	± 20	V
I_{CRM}	Repetitive peak collector current 集电极重复峰值电流	$T_p = 1\text{ms}$	50	A
t_{sc}	Short Circuit Withstand Time 短路耐受时间	$V_{CC} = 900\text{V}, V_{CE} \leq 1200\text{V},$ $V_{GE} \leq 15\text{V}, T_{vj} \leq 150^{\circ}\text{C}$	10	μs
P_{tot}	Total power dissipation 总耗散功率	$T_c = 25^{\circ}\text{C}, T_{vj} = 175^{\circ}\text{C}$	200	W

● Characteristics Values/特征值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings			单位 Units
			Min.	Typ.	Max.	
$V_{CE\ sat}$	Collector-Emitter Saturation Voltage 集电极-发射极饱和电压	$V_{GE} = 15\text{V}, I_C = 25\text{A}, T_{vj} = 25^{\circ}\text{C}$	-	2.1	2.3	V
		$V_{GE} = 15\text{V}, I_C = 25\text{A}, T_{vj} = 150^{\circ}\text{C}$	-	2.6	-	V
V_{GEth}	Gate threshold voltage 栅极阈值电压	$I_C = 0.8\text{mA}, V_{GE} = V_{CE}, T_{vj} = 25^{\circ}\text{C}$	5.0	5.8	7.0	V
Q_G	Gate charge 栅极电荷	$V_{GE} = -15\text{V} \dots +15\text{V}$	-	0.16	-	μC
R_{gint}	Internal gate resistance 内部栅极电阻	$T_{vj} = 25^{\circ}\text{C}$	-	12	-	Ω
C_{ies}	Input capacitance 输入电容	$f = 1\text{MHz}, T_{vj} = 25^{\circ}\text{C},$ $V_{CE} = 25\text{V}, V_{GE} = 0\text{V}$	-	1.4	-	nF
C_{res}	Reverse capacitance 反向传输电容	$f = 1\text{MHz}, T_{vj} = 25^{\circ}\text{C},$ $V_{CE} = 25\text{V}, V_{GE} = 0\text{V}$	-	0.05	-	nF
I_{CES}	Collector-emitter cut-off current 集电极-发射极截止电流	$V_{CE} = 1200\text{V}, V_{GE} = 0\text{V},$ $T_{vj} = 25^{\circ}\text{C}$	-	-	0.1	mA
I_{GES}	Gate-emitter leakage current 栅极-发射极漏电流	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}, T_{vj} = 25^{\circ}\text{C}$	-	-	200	nA



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RBSOA	Reverse biased safe operating area 反偏安全工作区	$V_{CC} = 800V, V_{CE} \leq 1200V,$ $V_{GE} = 20V, T_{vj} \leq 150^{\circ}C$		-	50	-	A	
$t_{d\ on}$	Turn-on delay time 开通延迟时间	$I_C = 25A,$ $V_{CE} = 600V,$ $V_{GE} = -8V...+15V,$ $R_G = 20\Omega$	$T_{vj} = 25^{\circ}C$	-	50.5	-	ns	
			$T_{vj} = 150^{\circ}C$	-	50.3	-	ns	
t_r	Rise time 上升时间		$T_{vj} = 25^{\circ}C$	-	48.1	-	ns	
			$T_{vj} = 150^{\circ}C$	-	56.4	-	ns	
$t_{d\ off}$	Turn-off delay time, 关断延迟时间		$T_{vj} = 25^{\circ}C$	-	159.6	-	ns	
			$T_{vj} = 150^{\circ}C$	-	198.8	-	ns	
t_f	Fall time 下降时间		$T_{vj} = 25^{\circ}C$	-	103.4	-	ns	
			$T_{vj} = 150^{\circ}C$	-	255.7	-	ns	
E_{on}	Turn-on energy loss 开通损耗能量		$T_{vj} = 25^{\circ}C$	-	2.6	-	mJ	
			$T_{vj} = 150^{\circ}C$	-	4.1	-	mJ	
E_{off}	Turn-off energy loss 关断损耗能量		$T_{vj} = 25^{\circ}C$	-	1.23	-	mJ	
			$T_{vj} = 150^{\circ}C$	-	2.00	-	mJ	

IGBT, Brake-Chopper/ IGBT, 制动-斩波器 T1

● Maximum Rated Values/最大额定值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings	单位 Units
V_{CES}	Collector-emitter voltage 集电极-发射极电压	$T_{vj} = 25^{\circ}C$	1200	V
I_C	Collector current 连续集电极直流电流	$T_c = 100^{\circ}C, T_{vj} = 175^{\circ}C$	25	A
V_{GES}	Gate-emitter voltage 栅极-发射极峰值电压	$T_{vj} = 25^{\circ}C$	± 20	V
I_{CRM}	Repetitive peak collector current 集电极重复峰值电流	$T_p = 1ms$	50	A
t_{sc}	Short Circuit Withstand Time 短路耐受时间	$V_{CC} = 900V, V_{CE} \leq 1200V,$ $V_{GE} \leq 15V, T_{vj} \leq 150^{\circ}C$	10	us
P_{tot}	Total power dissipation 总耗散功率	$T_c = 25^{\circ}C, T_{vj} = 175^{\circ}C$	200	W

● Characteristics Values/特征值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings			单位 Units
			Min.	Typ.	Max.	
$V_{CE sat}$	Collector-Emitter	$V_{GE} = 15V, I_C = 25A, T_{vj} = 25^{\circ}C$	-	2.1	2.3	V



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	Saturation Voltage 集电极-发射极饱和电压	$V_{GE} = 15V, I_C = 25A, T_{vj} = 150^{\circ}C$	-	2.6	-	V		
V_{GEth}	Gate threshold voltage 栅极阈值电压	$I_C = 0.8mA, V_{GE} = V_{CE}, T_{vj} = 25^{\circ}C$	5.0	5.8	7.0	V		
Q_G	Gate charge 栅极电荷	$V_{GE} = -15V \dots +15V$		0.16		μC		
R_{gint}	Internal gate resistance 内部栅极电阻	$T_{vj} = 25^{\circ}C$		12		Ω		
C_{ies}	Input capacitance 输入电容	$f = 1MHz, T_{vj} = 25^{\circ}C,$ $V_{CE} = 25V, V_{GE} = 0V$		1.4		nF		
C_{res}	Reverse capacitance 反向传输电容	$f = 1MHz, T_{vj} = 25^{\circ}C,$ $V_{CE} = 25V, V_{GE} = 0V$		0.05		nF		
I_{CES}	Collector-emitter cut-off current 集电极-发射极截止电流	$V_{CE} = 1200V, V_{GE} = 0V,$ $T_{vj} = 25^{\circ}C$	-	-	1.0	mA		
I_{GES}	Gate-emitter leakage current 栅极-发射极漏电流	$V_{CE} = 0V, V_{GE} = \pm 20V$ $T_{vj} = 25^{\circ}C$	-	-	400	nA		
RBSOA	Reverse biased safe operating area 反偏安全工作区	$V_{CC} = 900V, V_{CE} \leq 1200V,$ $V_{GE} = 20V, T_{vj} = 150^{\circ}C$	50	-	-	A		
$t_{d\ on}$	Turn-on delay time 开通延迟时间	$I_C = 25A,$ $V_{CE} = 600V,$ $V_{GE} = -8V\dots+15V,$ $R_G = 20\Omega$	$T_{vj} = 25^{\circ}C$	-	37	-	ns	
			$T_{vj} = 150^{\circ}C$	-	38	-	ns	
t_r	Rise time 上升时间		$T_{vj} = 25^{\circ}C$	-	15	-	ns	
			$T_{vj} = 150^{\circ}C$	-	17	-	ns	
$t_{d\ off}$	Turn-off delay time, 关断延迟时间		$T_{vj} = 25^{\circ}C$	-	220	-	ns	
			$T_{vj} = 150^{\circ}C$	-	305	-	ns	
t_f	Fall time 下降时间		$T_{vj} = 25^{\circ}C$	-	19	-	ns	
			$T_{vj} = 150^{\circ}C$	-	117	-	ns	
E_{on}	Turn-on energy loss 开通损耗能量		$T_{vj} = 25^{\circ}C$	-	1.67	-	mJ	
			$T_{vj} = 150^{\circ}C$	-	2.69	-	mJ	
E_{off}	Turn-off energy loss 关断损耗能量		$T_{vj} = 25^{\circ}C$	-	1.41	-	mJ	
			$T_{vj} = 150^{\circ}C$	-	2.54	-	mJ	



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□ Diode, Inverter /二极管, 逆变器 D1 D2 D3 D4 D5 D6

● Maximum Rated Values/最大额定值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings	单位 Units
V_{RRM}	Repetitive peak reverse voltage 反向重复峰值电压	$T_{vj} = 25^{\circ}\text{C}$	1200	V
I_F	Forward current of diode 连续正向直流电流	$T_C = 25^{\circ}\text{C}$	25	A
I_{FRM}	Repetitive peak forward current 正向重复峰值电流	$T_p = 1\text{ms}$	50	A
I^2t	I^2t - value I^2t -值	$V_R = 0\text{V}$, $t_p = 10\text{ms}$, $T_{vj} = 150^{\circ}\text{C}$	150	A^2S

● Characteristics Values/特征值

符号 Symbol	参数 Parameter	工作条件 Conditions		额定值 Ratings			单位 Units	
				Min.	Typ.	Max.		
V _F	Forward voltage 正向电压	I _F = 25A, V _{GE} = 0V	T _{vj} = 25°C	-	1.9	2.3	V	
			T _{vj} = 150°C	-	1.87	-	V	
I _{RM}	Peak reverse recovery current 反向恢复峰值电流	I _F = 25A, -di _F /dt = 1700A/μs (T _{vj} =150°C), V _R = 600V, V _{GE} = -8V...+15V, R _G = 20Ω	T _{vj} = 25°C	-	16.2	-	A	
			T _{vj} = 150°C	-	20.9	-	A	
Q _r	Recovered charge 恢复电荷		T _{vj} = 25°C	-	2.1	-	μC	
			T _{vj} = 150°C	-	4.3	-	μC	
E _{rec}	Reverse recovery energy 反向恢复损耗		T _{vj} = 25°C	-	0.85	-	mJ	
			T _{vj} = 150°C	-	1.6	-	mJ	

□ Diode, Brake-Chopper /二极管, 制动-斩波器 D1

● Maximum Rated Values/最大额定值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings	单位 Units
V_{RRM}	Repetitive peak reverse voltage 反向重复峰值电压	$T_{vj} = 25^{\circ}\text{C}$	1200	V
I_F	Forward current of diode 连续正向直流电流	$T_C = 25^{\circ}\text{C}$	25	A
I_{FRM}	Repetitive peak forward current 正向重复峰值电流	$T_p = 1\text{ms}$	50	A
I^2t	I^2t - value I^2t -值	$V_R = 0\text{V}$, $t_p = 10\text{ms}$, $T_{vj} = 150^{\circ}\text{C}$	110	A^2S



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● Characteristics Values/特征值

符号 Symbol	参数 Parameter	工作条件 Conditions		额定值 Ratings			单位 Units	
				Min.	Typ.	Max.		
V _F	Forward voltage 正向电压	I _F = 25A, V _{GE} = 0V	T _{vj} = 25°C	-	1.9	2.3	V	
			T _{vj} = 150°C	-	1.87	-	V	
I _{RM}	Peak reverse recovery current 反向恢复峰值电流	I _F = 25A, -di _F /dt = 500A/μs (T _{vj} =150°C), V _R = 600V, V _{GE} = -8V...+15V, R _G = 20Ω	T _{vj} = 25°C	-	16.2	-	A	
			T _{vj} = 150°C	-	20.9	-	A	
Q _r	Recovered charge 恢复电荷		T _{vj} = 25°C	-	0.7	-	μC	
			T _{vj} = 150°C	-	1.5	-	μC	
E _{rec}	Reverse recovery energy 反向恢复损耗		T _{vj} = 25°C	-	0.31	-	mJ	
			T _{vj} = 150°C	-	0.49	-	mJ	

□ Diode, Rectifier/二极管, 整流器 D1 D2 D3 D4 D5 D6

● Maximum Rated Values/最大额定值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings	单位 Units
V_{RRM}	Repetitive peak reverse voltage 反向重复峰值电压	$T_{vj} = 25^\circ C$	1600	V
I_{FRMSM}	Maximum RMS forward current per chip 最大正向均方根电流(每芯片)	$T_C = 100^\circ C$	25	A
I_{RMSM}	Maximum RMS current at rectifier output 最大整流器输出均方根电流	$T_C = 100^\circ C$	50	A
I_{FSM}	Surge forward current 正向浪涌电流	$T_p = 10ms$, $T_{vj} = 25^\circ C$	320	A
I^2t	I^2t - value I^2t -值	$T_p = 10ms$, $T_{vj} = 25^\circ C$	512	A^2S

● Characteristics Values/特征值

符号 Symbol	参数 Parameter	工作条件 Conditions	额定值 Ratings			单位 Units
			Min.	Typ.	Max.	
V_F	Forward voltage 正向电压	$T_{vj} = 150^\circ C$, $I_F = 25 A$	-	1	1.2	V
I_R	Peak reverse recovery current 反向恢复峰值电流	$T_{vj} = 150^\circ C$, $V_R = 1600 V$	-	0.5	1	mA

□ NTC-Thermistor/负温度系数热敏电阻



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Parameter	Symbol	Conditions	Values			Units
			Min.	Typ.	Max.	
Rated resistance 额定电阻值	R_{25}	$T_C = 25^{\circ}\text{C}$	-	5.0	-	k Ω
Deviation of R100 R100 偏差	$\Delta R/R$	$T_C = 100^{\circ}\text{C}$, $R_{100} = 493\Omega$	-5	-	5	%
Power dissipation 耗散功率	P_{25}	$T_C = 25^{\circ}\text{C}$	-	-	20	mW
B-value/B-值	$B_{25/50}$	$R_2 = R_{25}\exp[B_{25/50}(1/T_2 - 1/(298.15\text{K}))]$	-	3380	-	K
B-value/ B-值	$B_{25/80}$	$R_2 = R_{25}\exp[B_{25/80}(1/T_2 - 1/(298.15\text{K}))]$	-	3411	-	K
B-value/ B-值	$B_{25/100}$	$R_2 = R_{25}\exp[B_{25/100}(1/T_2 - 1/(298.15\text{K}))]$	-	3433	-	K

□ Module/模块

符号 Symbol	参数 Parameter	工作条件 Conditions		额定值 Ratings			单位 Units
				Min.	Typ.	Max.	
T_{vjmax}	Maximum junction temperature 最大结温	-	-	-	-	175	$^{\circ}\text{C}$
T_{vjop}	Temperature under switching conditions 工作结温	-	-	-40	-	150	$^{\circ}\text{C}$
T_{stg}	Storage temperature 储存温度	-	-	-40	-	125	$^{\circ}\text{C}$
T_{jop}	Module lead resistance, terminals - chip 模块引线电阻,端子-芯片	$T_C = 25^{\circ}\text{C}$, per switch 每个开关	$R_{CC'+EE'}$	-	5.0	-	m Ω
			$R_{AA'+CC'}$	-	6.0	-	m Ω
R_{thjc} IGBT	IGBT, thermal resistance, junction to case 结-外壳热阻	Per IGBT 单个 IGBT(T_1 T_2 T_3 T_4 T_5 T_6)		-	-	0.75	K/W
R_{thjc} Diode	Diode, thermal resistance, junction to case 结-外壳热阻	Per Diode 单个二极管(D_1 D_2 D_3 D_4 D_5 D_6)		-	-	0.38	K/W
V_{isol}	Isolation test voltage 绝缘测试电压	$f = 50\text{Hz}$, $t = 1\text{min.}$		-	2.5	-	KV
m	Weight 重量	-		-	39	-	g
-	Cree page distance 爬电距离	Terminal to terminal 端子到端子		-	6.3	-	mm



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-		Terminal to heatsink 端子到散热片	-	11.5	-	
-	Clearance distance in air 空气间隙	Terminal to terminal 端子到端子	-	5	-	
-		Terminal to heatsink 端子到散热片	-	10	-	
L _{sCE}	Stray inductance 杂散电感	-	-	37	-	nH
M ₁	Mounting torque for module mounting 模块的安装扭矩	Screw M4 M4 螺栓	2.0	-	2.3	N.m
-	Internal isolation 内部绝缘	Ceramics 陶瓷	Al ₂ O ₃			-
L x W x H	Dimensions 尺寸	-	62.8 x 56.7x 15.5			mm

Note: The typical reference values in the above parameters are based on laboratory test data under encapsulation conditions and are not to be used as a basis for production test acceptance.

注：以上参数中的典型参考值基于封装条件下实验室测试数据得出，不作为生产测试验收依据。

□ Characteristics Diagrams/特性曲线

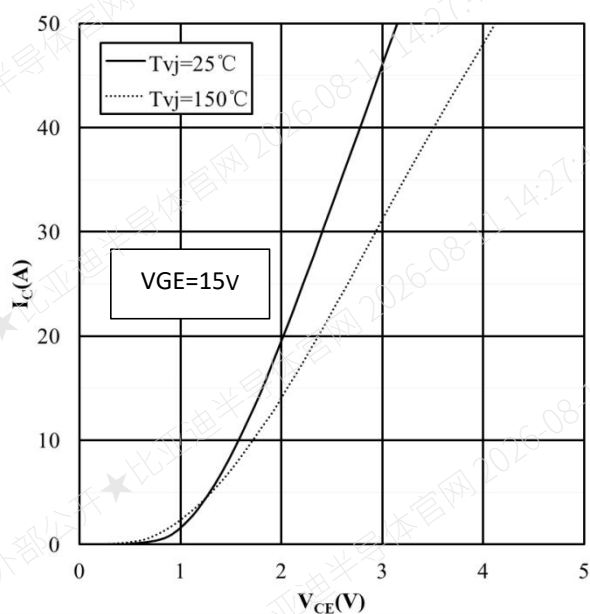


Fig.1 Typ. On-state Characteristics IGBT, Inverter

图 1 开通状态特性 IGBT, 逆变器

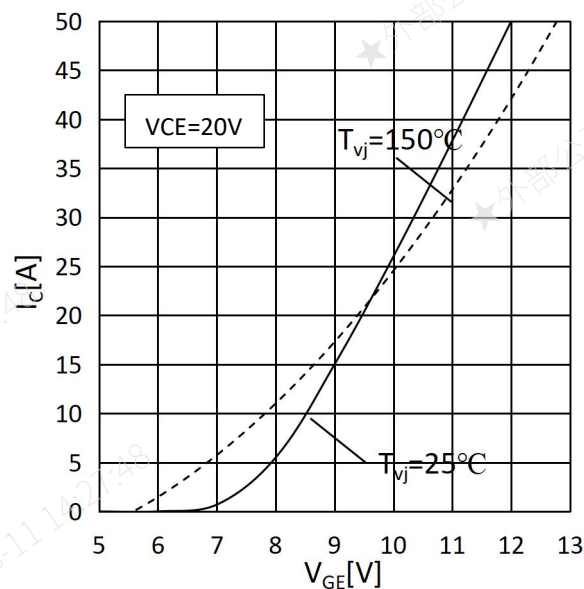


Fig.2 Typ. Transfer Characteristics

图 2 传输特性

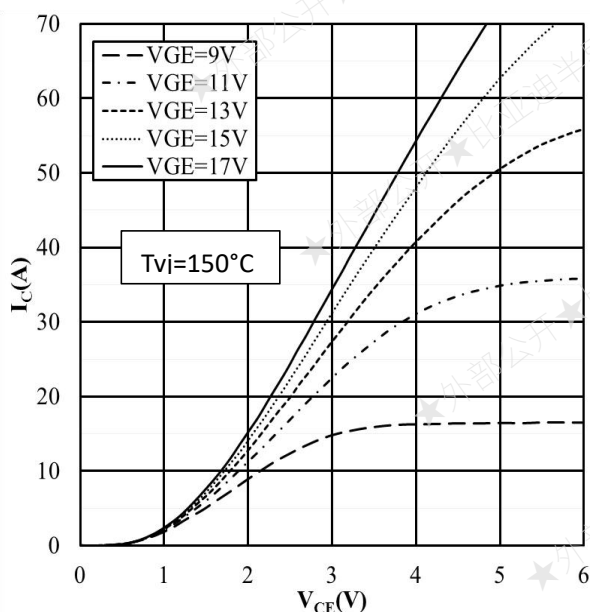


Fig.3 Typ. Output Characteristics

图 3 输出特性

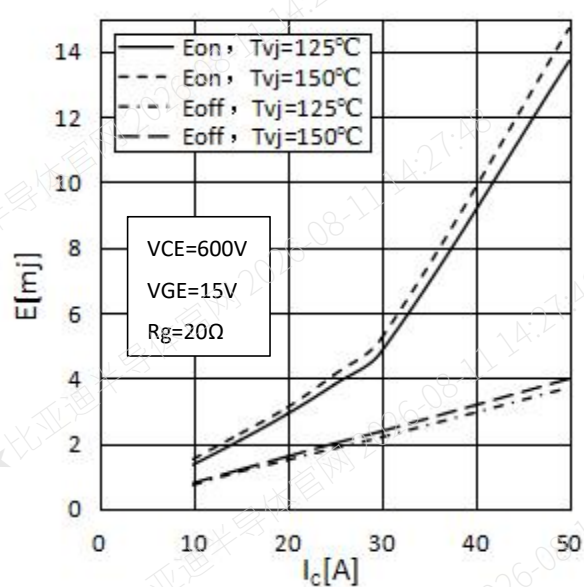


Fig.4 Switching Loss vs. Collector Current

图 4 开关损耗和集电极电流

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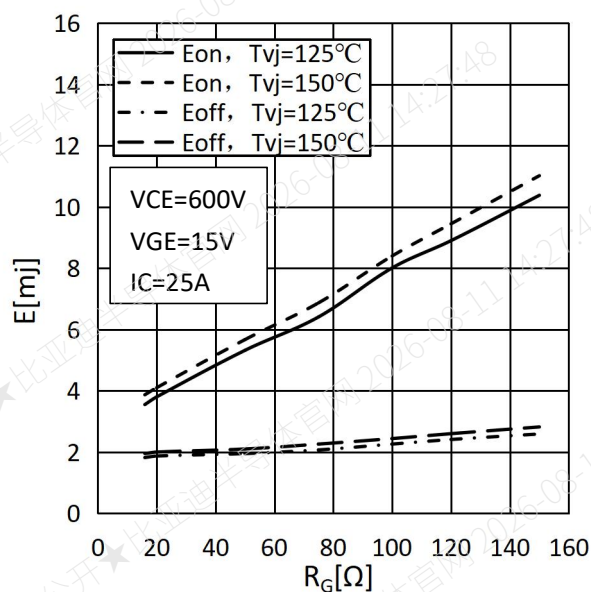


Fig.5 Switching Loss vs. Gate Resistor

图 5 开关损耗和门极电阻

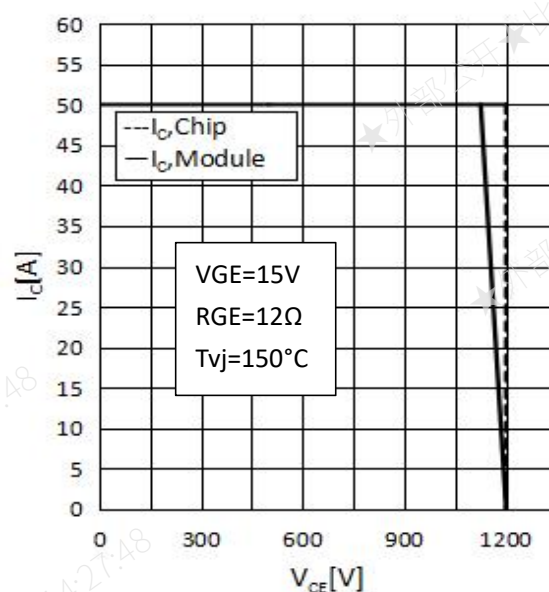


Fig.6 Reverse Bias Safe Operating Area

图 6 反偏安全工作区

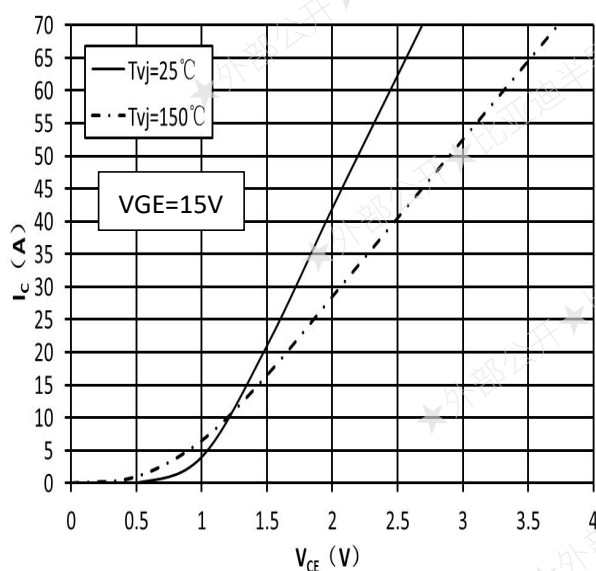


Fig.7 On-state Characteristics IGBT, Brake-Chopper

图 7 开通状态特性 IGBT, 制动-斩波器

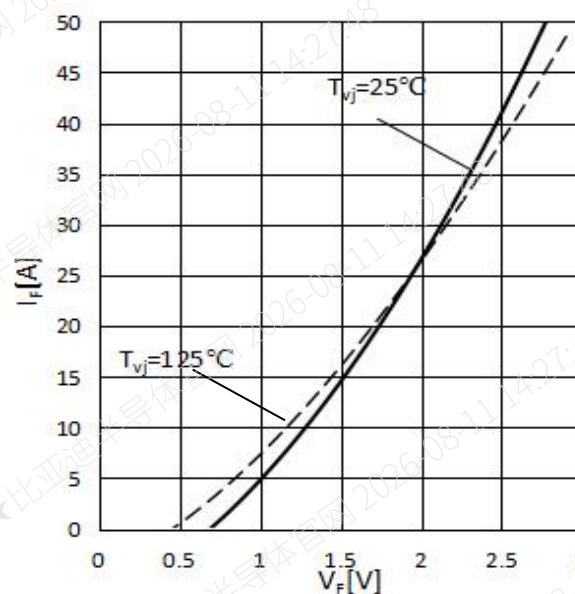


Fig.8 Diode, Inverted Forward Characteristics

图 8 逆变器二极管输出特性

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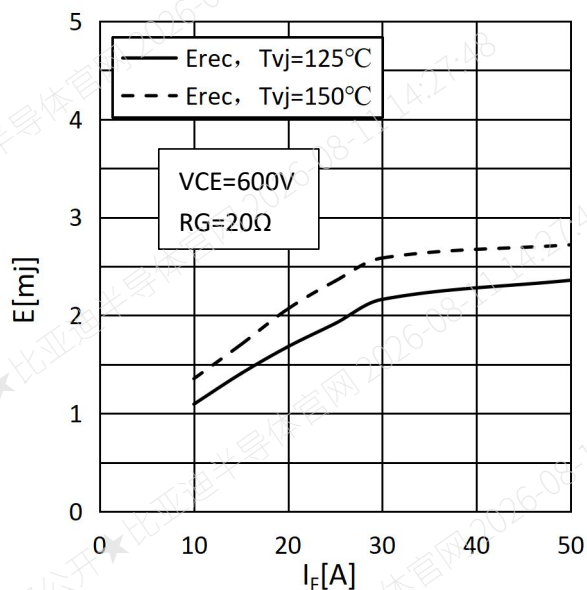


Fig.9 Reverse recovery Energy

图 9 反向恢复损耗

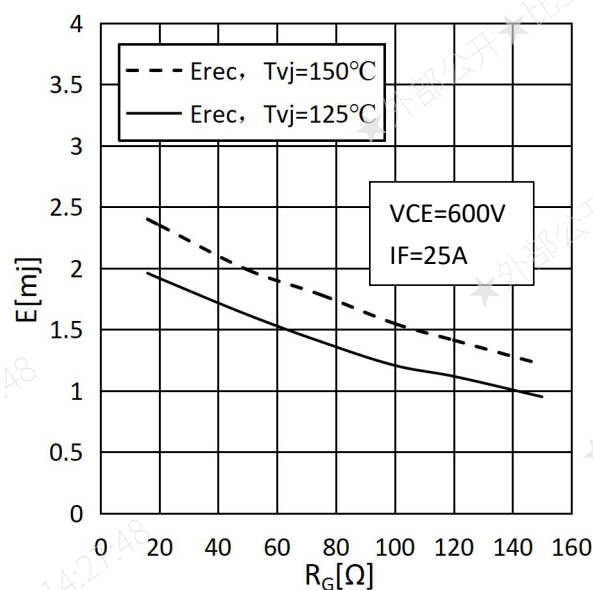


Fig.10 Reverse recovery Energy vs. Gate Resistor

图 10 反向恢复损耗与门极电阻关系

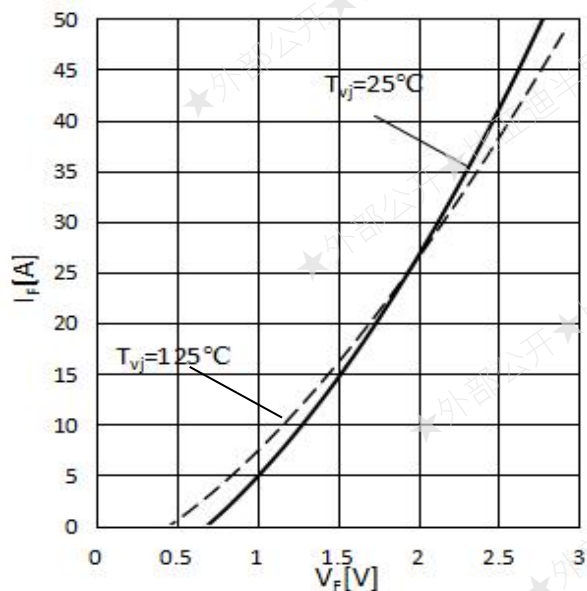


Fig.11 Diode, Brake-Chopperr Forward Characteristics

图 11 制动-斩波器二极管输出特性

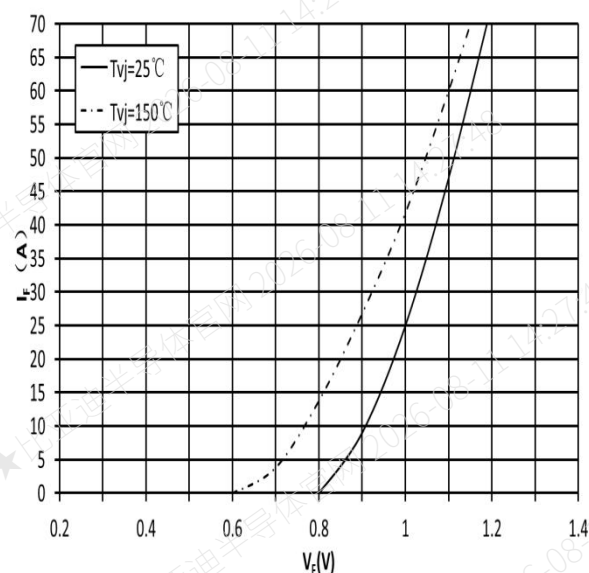


Fig.12 Diode, Rectifier Forward Characteristics

图 12 整流二极管输出特性

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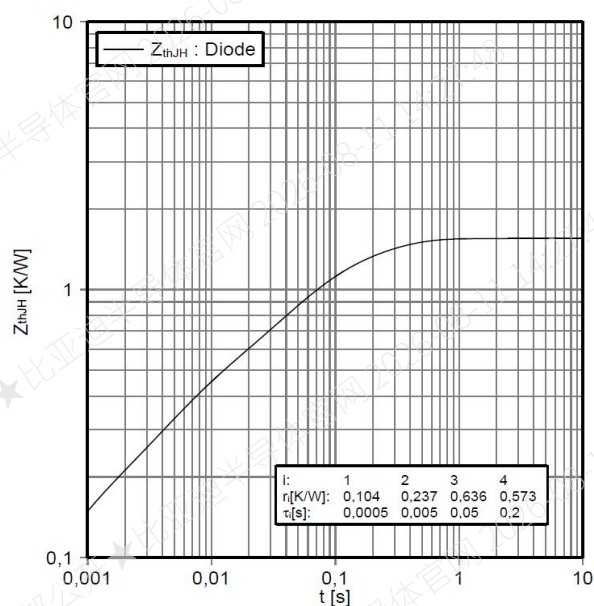


Fig.13 Typ. transient thermal impedance Diode ZthJC

图 13 典型的瞬态热阻抗 二极管,ZthJC

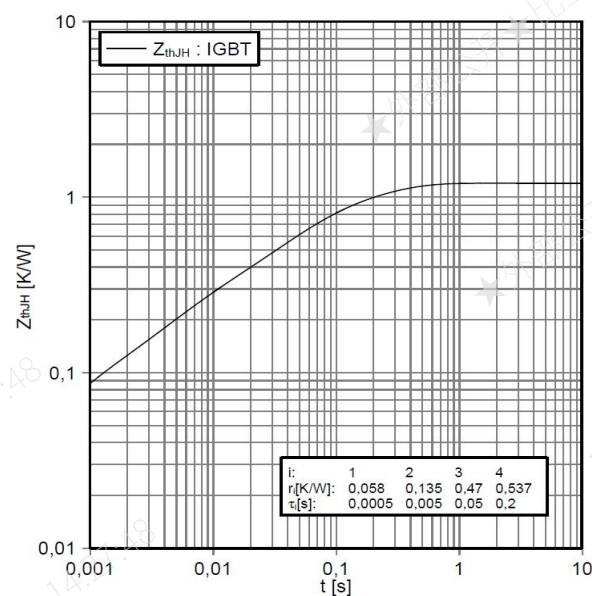


Fig.14 Typ. transient thermal impedance IGBT ZthJC

图 14 典型的瞬态热阻抗 IGBT, ZthJC

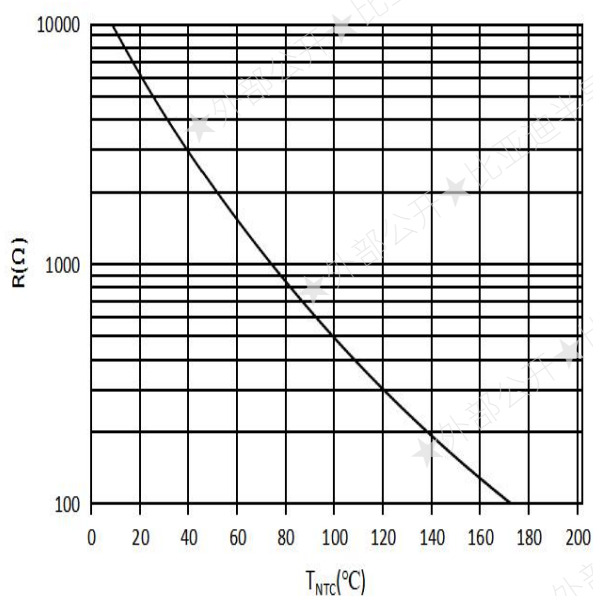
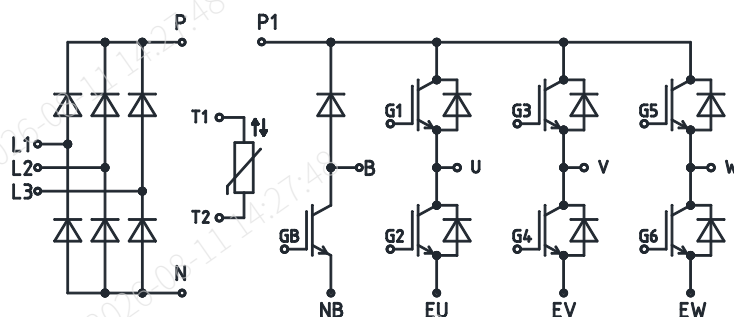


Fig.15 Typ. NTC-Temperature Characteristics

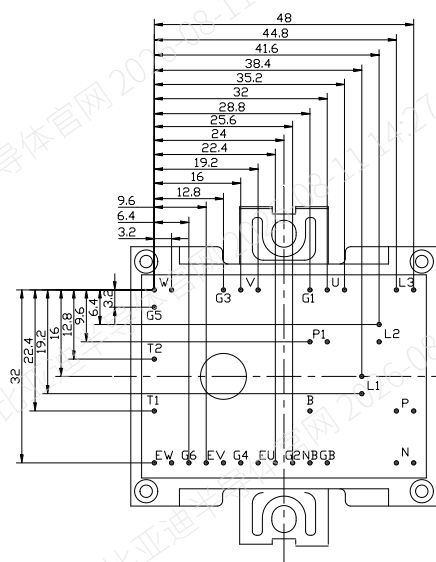
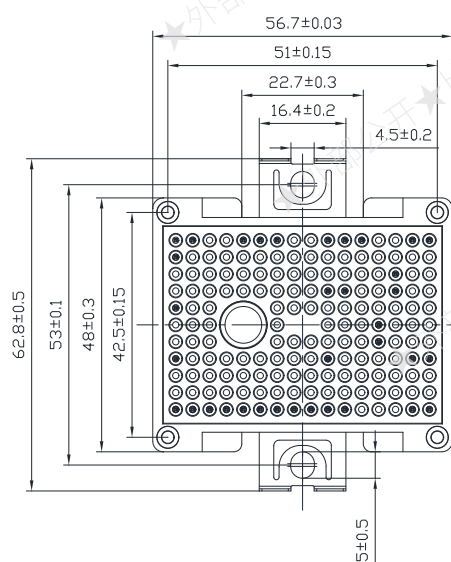
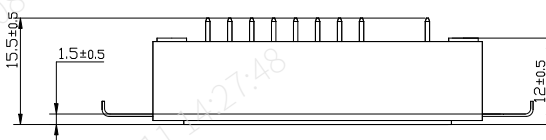
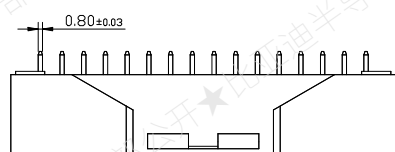
图 15 典型的 NTC 电阻-温度特性

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● Circuit Diagram/接线图



□ Package outlines/封装尺寸





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DISCLAIMER 免责声明

- Applications: This product is suitable for industrial electrical applications (including but not limited to: industrial motor drives, frequency converters, air conditioner, etc.)

使用范围：本产品适用于工业级电气应用（包括但不限于：工业电机驱动、变频器、空调等）

- Warranty Period: Unless otherwise agreed in the COOPERATION AGREEMENT Or Other WRITTEN DOCUMENTS, The warranty period for the product described in this specification is 12 months from the date of shipment.

质保期：除双方在合作协议或其他书面文件中另行约定外，本规格书所述产品质保期自出货起 12 个月。

- Special Instructions:

特别说明：

- Correct and Safety Use of Power Module: Unsuitable operation (such as electrical, mechanical stress and so on) may lead to damage of power modules. Please pay attention to the following descriptions and use this product according to the guidance.

功率模块安全正确的使用方法：不当的操作（如电应力、机械应力等）可能导致模块损毁。请注意以下介绍，并根据指导来使用本产品。

- During Transit: Tossing or dropping of a carton may damage devices inside. Devices exposed to moisture may result in failure. Special care should be taken during rainy or snowy weather to implement protective measures preventing the device from getting wet.

运输过程中：包装箱颠簸或坠落可能导致内部器件损毁；器件遇水受潮将导致故障失效。在雨雪天气尤其要注意保护器件防止淋湿。

- Storage: The temperature and humidity of the storage place should be $20\pm 5^{\circ}\text{C}$ and 30% ~ 60%RH respectively. The performance and reliability of devices may be jeopardized if devices are stored in an environment far above or below the range indicated above.

贮存：贮存地点温度与湿度应分别控制在 $20\pm 5^{\circ}\text{C}$ 和 30%~60%RH。如果贮存环境远高于或低于指示的变化范围，将危害器件的性能与可靠性。

- Prolonged Storage: When storing devices more than one year, dehumidifying measures should be provided for the storage place. When using devices after a long period of storage, please inspect them to ensure there are no scratches, dust, rust, or other defects on the surface.

长期贮存：当存储器件时间超过一年，贮存地点应当采取去湿措施。器件经过长期存放使用时，检查器件确保外观没有刮伤，灰尘，锈迹等。

- Operating Environment: Devices should not be exposed to water, organic solvents, corrosive gases, explosive gases, fine particles, or corrosive agents, since any of those can lead to a serious accident.

应用环境：器件不应当暴露在水，有机溶剂，腐蚀性气体、易燃易爆性气体，微尘，腐蚀性药剂中，上述任何一种情况都会导致严重事故。

- Anti-electrostatic Measures: Following precautions should be taken for gated devices to prevent static



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buildup which could damage the devices:

防静电措施：带栅极器件应采取以下预警来防止可以损毁器件的静电生成：

1. Static electricity of human bodies and cartons and/or excessive voltage applied across the gate to emitter may damage and rupture devices. Sense-emitter and temperature-sensor are also vulnerable to excessive voltage. The basis of anti-electrostatic is suppression of build-up and quick dissipation of the charged electricity.

门极与发射极间产生的人体静电、包装箱静电和过电压将损毁或击穿器件。采样发射极和温度传感器同样容易受到过压损毁。防静电底板可以抑制电荷生成并快速耗散。

2. Containers that are susceptible to static electricity should not be used for transit or for storage.

不要用易受静电影响的容器运输或贮存器件。

3. Signal terminals to emitter should be always shorted with a carbon cloth or the like until right before a module is used. Never touch the signal terminals with bare hands.

发射极信号端子应一直用碳纤维布或类似物短接直到模块使用前。任何情况下不要徒手碰触信号端子。

4. During the installation process, it is necessary to always maintain the equipment and the operator's body in contact with the ground after removing carbon fiber cloth or similar materials. It is advisable to cover the workstation and its surrounding floor with conductive mats and ground them.

安装过程中始终保持设备和操作人员的身体接触地面（移除碳纤维布或类似物后）。用导电垫覆盖工作地点及周围地板并使其接地。

5. Use soldering irons with grounded tips.

使用接地的烙铁头。

- Our Company is committed to enhancing product quality and stability. This specification serves solely to delineate technical product details.

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- **This product shall not be used in any equipment or applications requiring higher reliability or quality standards where failure could result in personal injury, death, or catastrophic events, including but not limited to nuclear control systems, aircraft/aviation components, maritime/rail transport equipment, traffic signaling devices, combustion control systems, medical equipment, or other safety-critical applications. Customers must procure genuine products exclusively through the Company or authorized channels, and utilize them strictly within legally permitted boundaries and under conditions expressly defined in this specification. The Company disclaims all liability for losses, damages, or injuries arising from non-compliance with these requirements.**

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