

# NI3000S45S1K1

4500V 3000A IGBT 模块, 压接 封装, 内置续流二极管  
4500V 3000A IGBT Module, Press-pack Package, with FWD

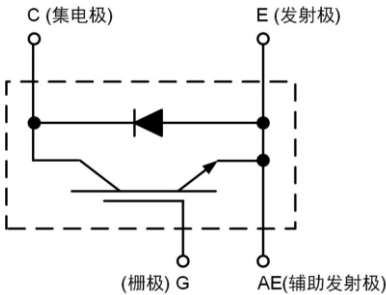
## 特点 Features

- 4500V 平面栅及场截止结构  
4500V Planar Gate & Field Stop Structure
- 高鲁棒性  
High Robustness
- 高可靠性  
High Reliability
- 正温度系数  
Positive Temperature Coefficient
- 高短路耐量  
High Short Circuit Capability



## 应用 Applications

- 柔性直流输电  
HVDC flexible system
- 海上风电  
Offshore wind power generation



## 最大额定值 Maximum Rated Values\*1

| 参数 Parameter                        | 符号 Symbol     | 条件 Conditions                                                                        | 数值 Value | 单位 Unit     |
|-------------------------------------|---------------|--------------------------------------------------------------------------------------|----------|-------------|
| 集电极-发射极电压 Collector-Emitter Voltage | $V_{CES}$     | $V_{GE}=0V, T_{vj}=25^{\circ}C$                                                      | 4500     | V           |
| 集电极电流 DC Collector Current          | $I_C$         | $T_C=100^{\circ}C, T_{vj}=125^{\circ}C$                                              | 3000     | A           |
| 集电极峰值电流 Peak Collector Current      | $I_{CM}$      | $t_p=1ms$                                                                            | 6000     | A           |
| 栅极-发射极电压 Gate-Emitter Voltage       | $V_{GES}$     |                                                                                      | $\pm 20$ | V           |
| 总耗散功耗 Total Power Dissipation       | $P_{tot}$     | $T_C=25^{\circ}C, T_{vj}=125^{\circ}C$                                               | 31200    | W           |
| 额定正向工作电流 DC Forward Current         | $I_F$         |                                                                                      | 3000     | A           |
| 正向峰值电流 Peak Forward Current         | $I_{FRM}$     | $t_p=1ms$                                                                            | 6000     | A           |
| 浪涌电流 Surge Current                  | $I_{FSM}$     | $V_R=0V, T_{vj}=125^{\circ}C,$<br>$t_p=10ms, half\text{-}sinewave$                   | 21000    | A           |
| IGBT短路耐量 IGBT Short Circuit SOA     | $t_{psc}$     | $V_{CC}=3400V, V_{CEM\ CHIP}\leq 4500V$<br>$V_{GE}\leq 15V, T_{vj}\leq 125^{\circ}C$ | 10       | $\mu s$     |
| 最高结温 Maximum Junction Temperature   | $T_{vj(max)}$ |                                                                                      | 125      | $^{\circ}C$ |
| 工作结温 Junction Operating Temperature | $T_{vj(op)}$  |                                                                                      | -40~125  | $^{\circ}C$ |
| 环境温度 Case temperature               | $T_C$         |                                                                                      | -40~125  | $^{\circ}C$ |
| 存储温度范围 Storage Temperature          | $T_{stg}$     |                                                                                      | -40~70   | $^{\circ}C$ |
| 安装压力 Mounting force                 | $F_M$         |                                                                                      | 90~130   | kN          |

\*1 根据IEC 60747，最大额定值表明会使器件造成损伤的条件边界

IGBT特征值 IGBT Characteristic Values\*2

| 参数<br>Parameter                                       | 符号<br>Symbol  | 条件<br>Conditions                                                                                                         |                       | 数值 Value |       |      | 单位<br>Unit |
|-------------------------------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------|----------|-------|------|------------|
|                                                       |               |                                                                                                                          |                       | Min.     | Typ.  | Max. |            |
| 集电极-发射极反向击穿电压<br>Collector-Emitter Breakdown Voltage  | $V_{(BR)CES}$ | $V_{GE}=0V, I_C=10mA, T_{vj}=25^{\circ}C$                                                                                |                       | 4500     |       |      | V          |
| 集电极-发射极饱和电压*3<br>Collector-Emitter Saturation Voltage | $V_{CE(sat)}$ | $I_C=3000A, V_{GE}=15V$                                                                                                  | $T_{vj}=25^{\circ}C$  |          | 2.65  | 3.05 | V          |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 3.35  | 3.85 | V          |
| 集电极-发射极截止电流<br>Collector-Emitter Cut-off Current      | $I_{CES}$     | $V_{CE}=4500V, V_{GE}=0V$                                                                                                | $T_{vj}=25^{\circ}C$  |          |       | 1    | mA         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 20    | 100  | mA         |
| 栅极-发射极漏电流<br>Gate-Emitter Leakage Current             | $I_{GES}$     | $V_{CE}=0V, V_{GE}=\pm 20V, T_{vj}=125^{\circ}C$                                                                         |                       | -500     |       | 500  | nA         |
| 栅极-发射极开启电压<br>Gate-Emitter Threshold Voltage          | $V_{GE(th)}$  | $I_C=480mA, V_{CE}=V_{GE}, T_{vj}=25^{\circ}C$                                                                           |                       | 6.7      |       | 7.7  | V          |
| 栅极电荷<br>Gate Charge                                   | $Q_G$         | $I_C=3000A, V_{CE}=2800V, V_{GE}=-15V\sim+15V$                                                                           |                       |          | 15    |      | $\mu C$    |
| 输入电容<br>Input Capacitance                             | $C_{ies}$     | $V_{CE}=25V, V_{GE}=0V, f=100kHz, T_{vj}=25^{\circ}C$                                                                    |                       |          | 310   |      | nF         |
| 输出电容<br>Output Capacitance                            | $C_{oes}$     |                                                                                                                          |                       |          | 22    |      | nF         |
| 反向传输电容<br>Reverse Transfer Capacitance                | $C_{res}$     |                                                                                                                          |                       |          | 8     |      | nF         |
| 内置栅极电阻<br>Internal Gate Resistance                    | $R_{Gint}$    |                                                                                                                          |                       |          | 0     |      | $\Omega$   |
| 开通延迟时间<br>Turn-on Delay Time                          | $t_{d(on)}$   | $I_C=3000A, V_{CE}=2800V, V_{GE}=\pm 15V, R_{Gon}=1.5\Omega, R_{Goff}=10\Omega, C_{ge}=330nF, L_s=140nH, Inductive Load$ | $T_{vj}=25^{\circ}C$  |          | 1360  |      | ns         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 1000  |      | ns         |
| 上升时间<br>Rise Time                                     | $t_r$         |                                                                                                                          | $T_{vj}=25^{\circ}C$  |          | 580   |      | ns         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 530   |      | ns         |
| 关断延迟时间<br>Turn-off Delay Time                         | $t_{d(off)}$  |                                                                                                                          | $T_{vj}=25^{\circ}C$  |          | 4250  |      | ns         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 5000  |      | ns         |
| 下降时间<br>Fall Time                                     | $t_f$         |                                                                                                                          | $T_{vj}=25^{\circ}C$  |          | 1040  |      | ns         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 1900  |      | ns         |
| 开通损耗<br>Turn-on Switching Energy                      | $E_{on}$      |                                                                                                                          | $T_{vj}=25^{\circ}C$  |          | 15800 |      | mJ         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 19300 |      | mJ         |
| 关断损耗<br>Turn-off Switching Energy                     | $E_{off}$     |                                                                                                                          | $T_{vj}=25^{\circ}C$  |          | 14400 |      | mJ         |
|                                                       |               |                                                                                                                          | $T_{vj}=125^{\circ}C$ |          | 17500 |      | mJ         |
| 短路电流<br>Short Circuit Current                         | $I_{SC}$      | $V_{GE}\leq 15V, t_{psc}\leq 10\mu s, V_{CC}=3400V, T_{vj}=125^{\circ}C, V_{CEM CHIP}\leq 4500V$                         |                       |          | 12600 |      | A          |

\*2 IGBT特征值遵从IEC 60747-9

\*3  $V_{CE(sat)}$ 值为芯片值

二极管特征值 Diode Characteristic Values\*3

| 参数<br>Parameter                        | 符号<br>Symbol     | 条件<br>Conditions                                                                                                                                                                   |                        | 数值 Value |      |      | 单位<br>Unit |  |
|----------------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------|------|------|------------|--|
|                                        |                  |                                                                                                                                                                                    |                        | Min.     | Typ. | Max. |            |  |
| 正向电压*4<br>Forward Voltage              | V <sub>F</sub>   | I <sub>F</sub> =3000A                                                                                                                                                              | T <sub>vj</sub> =25°C  |          | 2.70 |      | V          |  |
|                                        |                  |                                                                                                                                                                                    | T <sub>vj</sub> =125°C |          | 3.10 |      | V          |  |
| 反向恢复电流<br>Reverse Recovery Current     | I <sub>rr</sub>  | I <sub>F</sub> =3000A,<br>V <sub>R</sub> =2800V,<br>di <sub>F</sub> /dt=-2500A/μs,<br>V <sub>GE</sub> =15V,<br>R <sub>Gon</sub> =1.5Ω,<br>L <sub>S</sub> =140nH,<br>Inductive load | T <sub>vj</sub> =25°C  |          | 1690 |      | A          |  |
|                                        |                  |                                                                                                                                                                                    | T <sub>vj</sub> =125°C |          | 2750 |      | A          |  |
| 反向恢复电荷<br>Reverse Recovery Charge      | Q <sub>rr</sub>  |                                                                                                                                                                                    | T <sub>vj</sub> =25°C  |          | 3000 |      | uC         |  |
|                                        |                  |                                                                                                                                                                                    | T <sub>vj</sub> =125°C |          | 3950 |      | uC         |  |
| 反向恢复时间<br>Reverse Recovery Time        | t <sub>rr</sub>  |                                                                                                                                                                                    | T <sub>vj</sub> =25°C  |          | 1.80 |      | us         |  |
|                                        |                  |                                                                                                                                                                                    | T <sub>vj</sub> =125°C |          | 2.20 |      | us         |  |
| 反向恢复损耗<br>Reverse Recovery Energy Loss | E <sub>rec</sub> |                                                                                                                                                                                    | T <sub>vj</sub> =25°C  |          | 4000 |      | mJ         |  |
|                                        |                  |                                                                                                                                                                                    | T <sub>vj</sub> =125°C |          | 6300 |      | mJ         |  |

\*3 二极管特征值遵从IEC 60747-2

\*4 V<sub>F</sub>值为芯片值

封装特性 Package Properties\*5

| 参数<br>Parameter                                         | 符号<br>Symbol         | 条件<br>Condition                                      | 数值 Value |        |        | 单位<br>Unit |
|---------------------------------------------------------|----------------------|------------------------------------------------------|----------|--------|--------|------------|
|                                                         |                      |                                                      | Min      | Typ.   | Max    |            |
| IGBT 结-壳热阻<br>IGBT Thermal Resistance: Junction to Case | R <sub>th(J-C)</sub> |                                                      |          |        | 0.0032 | K/W        |
| 二极管 结-壳热阻<br>Diode Thermal Resistance: Junction to Case | R <sub>th(J-C)</sub> |                                                      |          |        | 0.0061 | K/W        |
| IGBT接触热阻<br>IGBT Thermal Resistance: Case to Heatsink   | R <sub>th(C-H)</sub> | Heatsink flatness :<br>Complete module area < 100 μm |          | 0.0007 |        | K/W        |
| 二极管接触热阻<br>Diode Thermal Resistance: Case to Heatsink   | R <sub>th(C-H)</sub> | Each submodule area < 20 μm<br>Roughness : < 1.6 μm  |          | 0.0015 |        | K/W        |
| 相对漏电起痕指数<br>Comparative Tracking Index                  | CTI                  |                                                      | 600      |        |        |            |

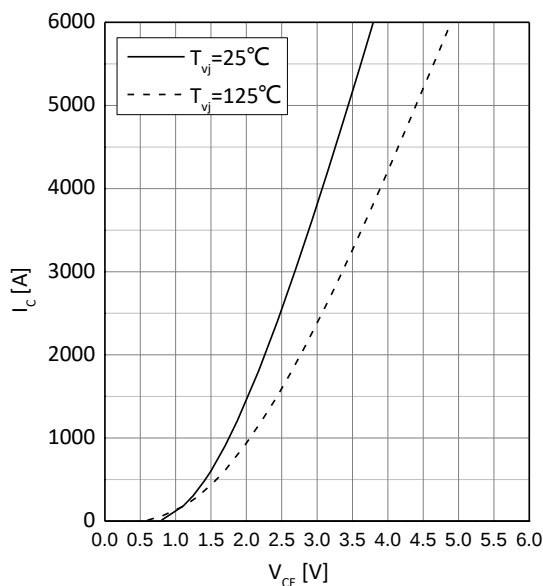
\*5 封装特性遵从IEC 60747-15、IEC 60270

机械特性 Package Properties

| 参数<br>Parameter                     | 符号<br>Symbol   | 条件<br>Condition                            |                  | Min                  | Typ. | Max | 单位<br>Unit |
|-------------------------------------|----------------|--------------------------------------------|------------------|----------------------|------|-----|------------|
| 尺寸<br>Dimensions                    | L x W x H      | Typical                                    | device clamped   | 237.3 x 235.1 x 28.7 |      |     | mm         |
|                                     |                |                                            | device unclamped | 237.3 x 235.1 x 31.5 |      |     | mm         |
| 表面爬电距离<br>Surface creepage distance | d <sub>a</sub> | according to IEC 60664-1<br>and EN 50124-1 |                  | 40                   |      |     | mm         |
| 空气电气间隙<br>Clearance distance in air | d <sub>s</sub> | according to IEC 60664-1<br>and EN 50124-1 |                  | 23                   |      |     | mm         |
| 模块重量<br>Module Weight               | G              |                                            |                  |                      | 4180 |     | g          |

### 输出特性典型曲线

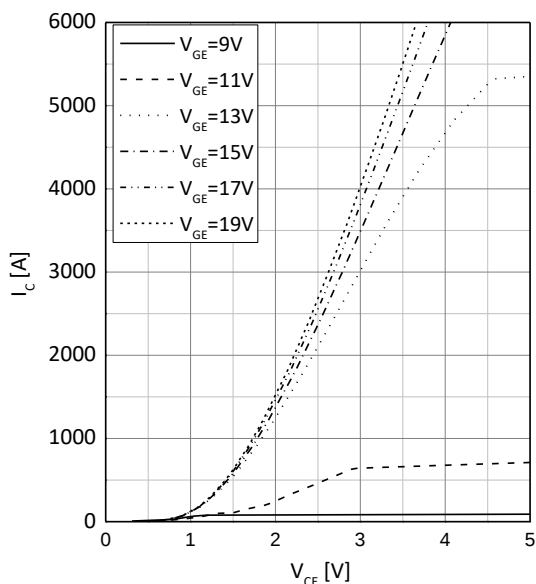
Typical output characteristics,chip level



### 输出特性典型曲线

Typical output characteristics,chip level

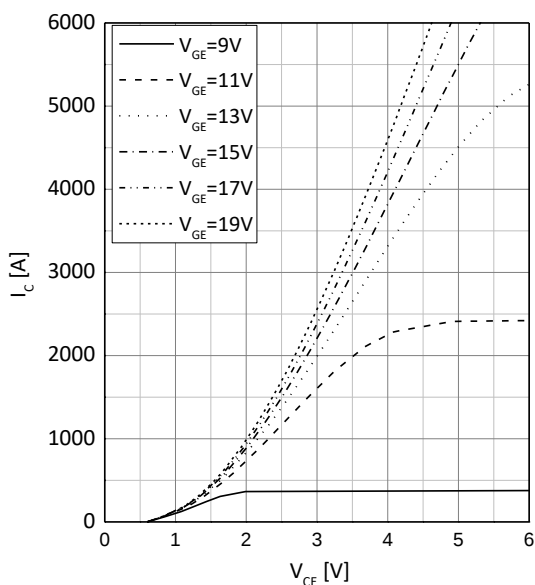
$$I_c = f(V_{CE}), T_{vj} = 25^{\circ}\text{C}$$



### 输出特性典型曲线

Typical output characteristics,chip level

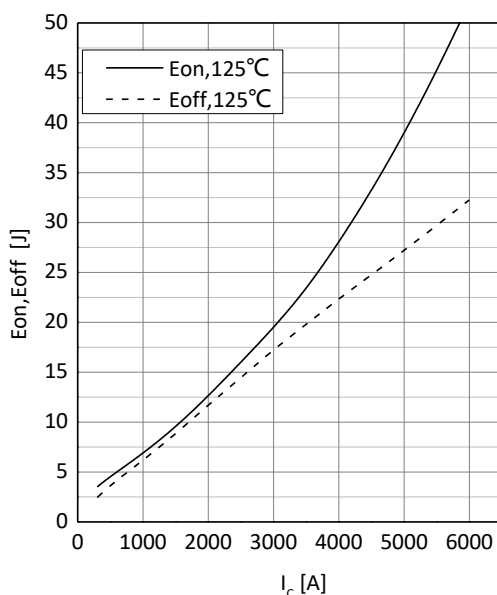
$$I_c = f(V_{CE}), T_{vj} = 125^{\circ}\text{C}$$



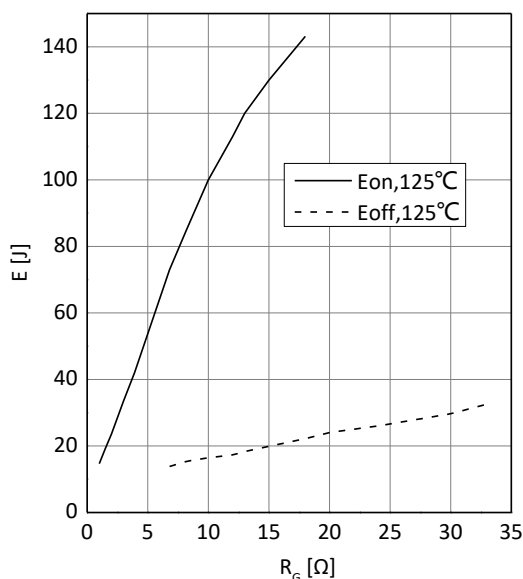
### 开关损耗 IGBT

Switching losses IGBT

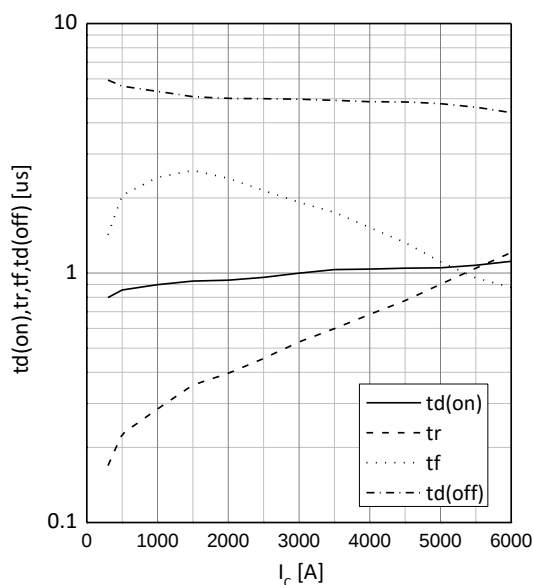
$$E = f(I_c), V_{GE} = \pm 15\text{V}, R_{Gon} = 1.5\Omega, R_{Goff} = 10\Omega, C_{ge} = 330\text{nF}, V_{CE} = 2800\text{V}$$



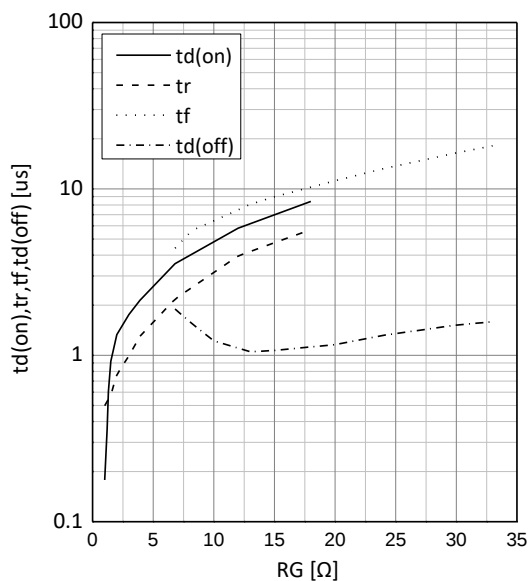
**开关损耗IGBT**  
**Switching losses IGBT**  
 **$V_{GE}=\pm 15V, I_C=3000A, C_{ge}=330nF, V_{CE}=2800V$**



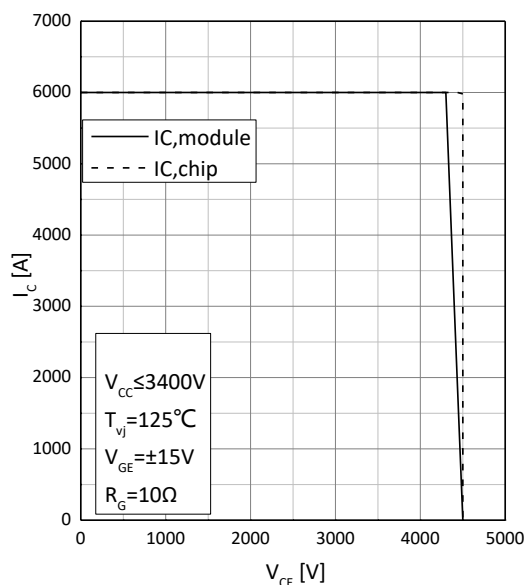
**开关时间与集电极电流关系曲线**  
**Typical switching time per pulse vs. collector current**



**开关时间与门极电阻关系曲线**  
**Typical switching time per pulse vs. gate resistor**

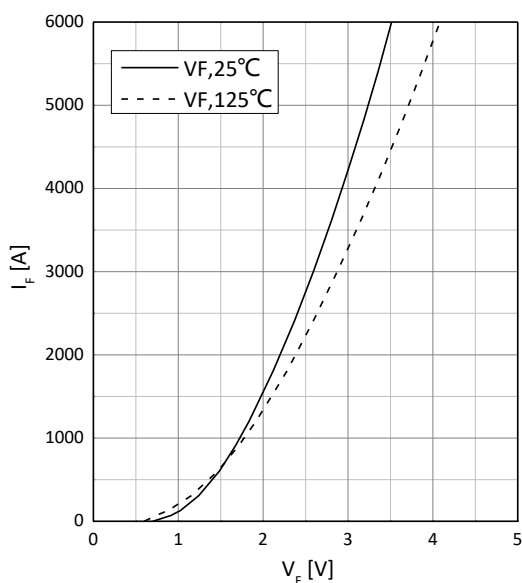


**反偏安全工作区**  
**Turn-off safe operating area (RBSOA)**  
 **$V_{GE}=\pm 15V, R_{Goff}=10\Omega, T_{vj}=125^\circ C$**



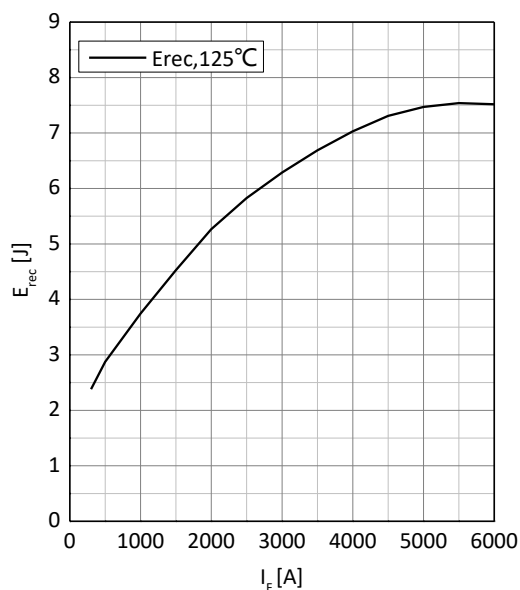
## 二极管正向偏压特性曲线

Typical diode forward characteristic, chip level



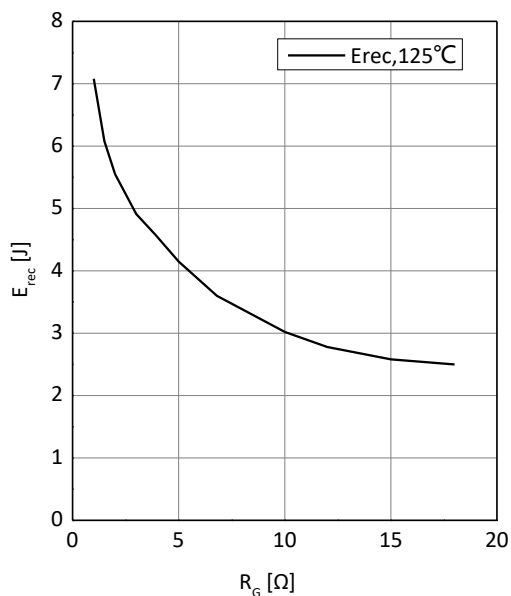
## 反向恢复损耗与二极管电流关系曲线

Typical reverse recovery characteristics vs. forward current



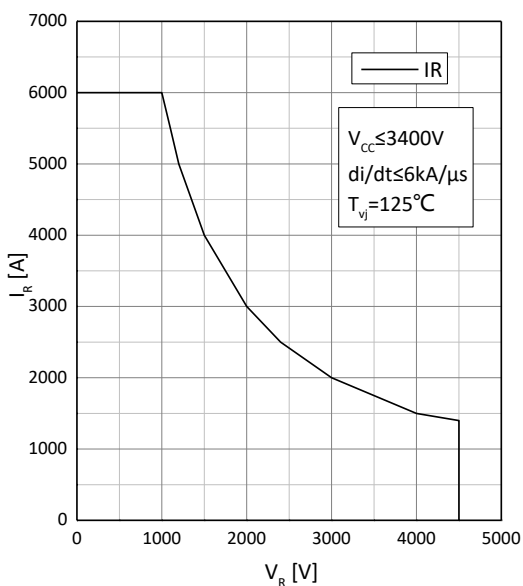
## 反向恢复损耗与门极电阻的关系曲线

Typical switching energies per pulse vs. gate resistor



## 二极管安全工作区

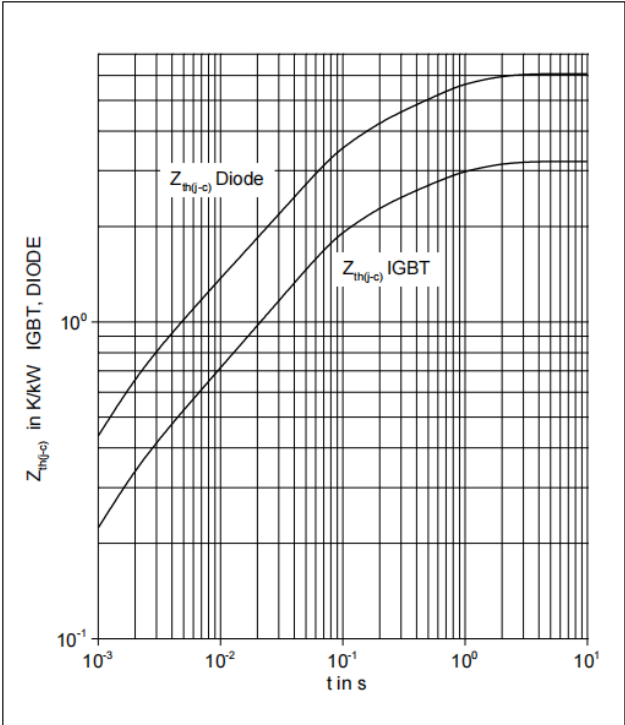
safe operating area diode (RROSA)



瞬态热阻抗

Transient thermal impedance

ZthJC = f (t)



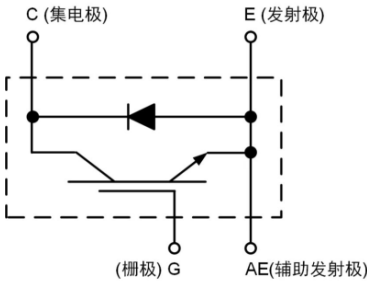
Analytical function for transient thermal impedance:

$$Z_{th(j-c)}(t) = \sum_{i=1}^n R_i (1 - e^{-t/\tau_i})$$

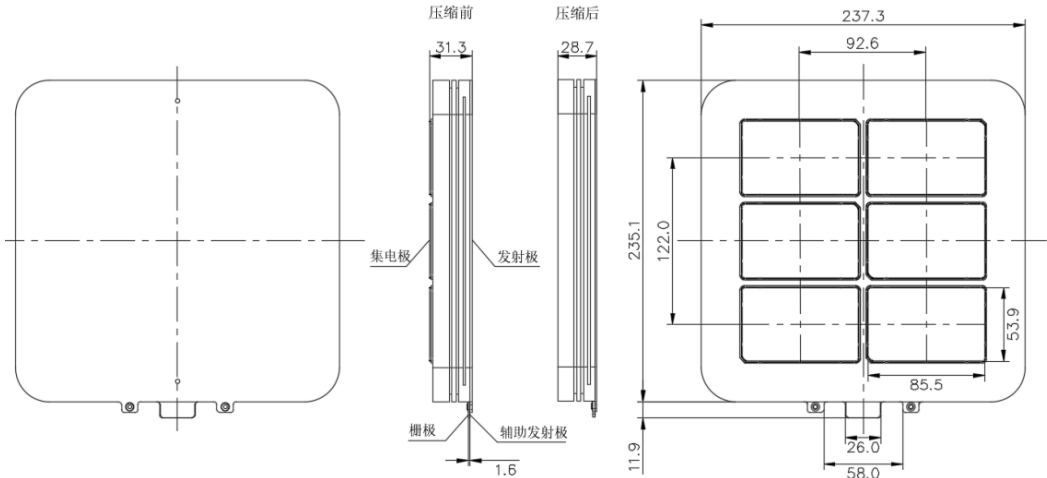
|                        |       |       |       |       |   |
|------------------------|-------|-------|-------|-------|---|
| i                      | 1     | 2     | 3     | 4     | 5 |
| R <sub>i</sub> in K/kW | 1.200 | 1.490 | 0.269 | 0.246 |   |
| τ <sub>i</sub> in s    | 0.581 | 0.059 | 0.006 | 0.001 |   |

|                        |       |       |       |       |  |
|------------------------|-------|-------|-------|-------|--|
| R <sub>i</sub> in K/kW | 2.409 | 2.639 | 0.535 | 0.485 |  |
| τ <sub>i</sub> in s    | 0.584 | 0.059 | 0.006 | 0.001 |  |

接线图



封装尺寸



| 版本Version | 日期Date     | 描述Description |
|-----------|------------|---------------|
| A1        | 2023-03-28 | 初版            |
| A2        | 2024-02-22 | 正式版           |