

最终数据手册

英飞凌IKWH40N65EH7高速、低饱和电压 650 V TRENCHSTOP™ IGBT7 技术与快速软恢复发射极控制 7 二极管共同封装

特性

- $V_{CE} = 650\text{ V}$
- $I_C = 40\text{ A}$
- 低开关损耗
- 极低的集电极-发射极饱和电压 V_{CEsat}
- 非常柔软、快速恢复的反并联二极管
- 平滑切换
- 防潮性
- 针对硬开关、两电平和三电平拓扑进行了优化
- 完整的产品品类和 PSpice 模型：<http://www.infineon.com/igbt/>



潜在应用

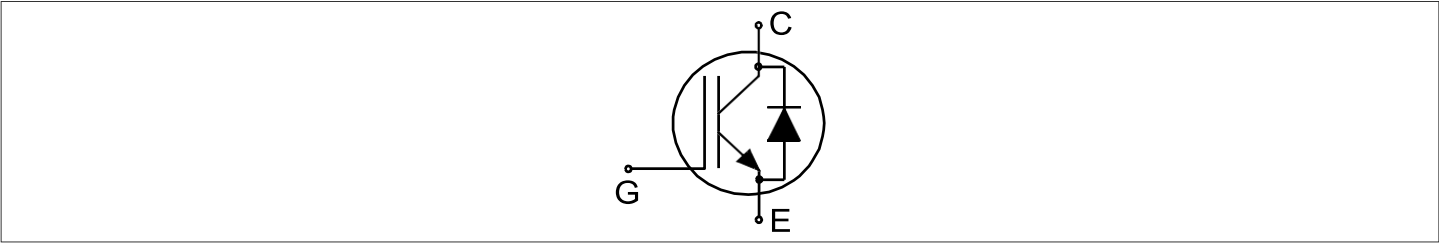
- 工业级不间断电源（UPS）
- 电动汽车充电桩
- 组串式逆变器
- 焊接

- Lead-free
- Green
- Halogen-free
- RoHS

产品验证

- 符合 JEDEC47/20/22 相关测试的工业应用要求

描述



Type	Package	Marking
IKWH40N65EH7	PG-TO247-3-STD-NN4.8	K40EEH7



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1 封装

1 封装

表 1 特征值

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Internal emitter inductance measured 5 mm (0.197 in.) from case	L_E			13		nH
Storage temperature	T_{stg}		-55		150	°C
Soldering temperature	T_{sold}	wave soldering 1.6 mm (0.063 in.) from case for 10 s			260	°C
Mounting torque	M	M3 screw, Maximum of mounting processes: 3			0.6	Nm
Thermal resistance, junction-ambient	$R_{th(j-a)}$				40	K/W
IGBT thermal resistance, junction-case	$R_{th(j-c)}$			0.54	0.71	K/W
Diode thermal resistance, junction-case	$R_{th(j-c)}$			0.72	0.94	K/W

2 IGBT

表 2 最大额定值

Parameter	Symbol	Note or test condition		Values	Unit
Collector-emitter voltage	V_{CE}	$T_{vj} \geq 25\text{ °C}$		650	V
DC collector current, limited by T_{vjmax}	I_C	limited by bondwire	$T_c = 25\text{ °C}$	80	A
			$T_c = 100\text{ °C}$	54	
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpulse}			160	A
Turn-off safe operating area		$V_{CE} \leq 650\text{ V}$, $t_p \leq 1\text{ }\mu\text{s}$, $T_{vj} \leq 175\text{ °C}$		160	A
Gate-emitter voltage	V_{GE}			± 20	V
Transient gate-emitter voltage	V_{GE}	$t_p \leq 10\text{ }\mu\text{s}$, $D < 0.01$		± 30	V
Power dissipation	P_{tot}		$T_c = 25\text{ °C}$	208	W
			$T_c = 100\text{ °C}$	103	

表 3 特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Collector-emitter saturation voltage	V_{CEsat}	$I_C = 40\text{ A}$, $V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$		1.4	1.65	V
			$T_{vj} = 175\text{ °C}$		1.6		
Gate-emitter threshold voltage	V_{GEth}	$I_C = 0.35\text{ mA}$, $V_{CE} = V_{GE}$		2.9	3.85	4.8	V
Zero gate-voltage collector current	I_{CES}	$V_{CE} = 650\text{ V}$, $V_{GE} = 0\text{ V}$	$T_{vj} = 25\text{ °C}$			10	μA
			$T_{vj} = 175\text{ °C}$		1200		
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0\text{ V}$, $V_{GE} = 20\text{ V}$				100	nA
Transconductance	g_{fs}	$I_C = 40\text{ A}$, $V_{CE} = 20\text{ V}$			56		S
Input capacitance	C_{ies}	$V_{CE} = 25\text{ V}$, $V_{GE} = 0\text{ V}$, $f = 100\text{ kHz}$			2016		pF
Output capacitance	C_{oes}	$V_{CE} = 25\text{ V}$, $V_{GE} = 0\text{ V}$, $f = 100\text{ kHz}$			70		pF
Reverse transfer capacitance	C_{res}	$V_{CE} = 25\text{ V}$, $V_{GE} = 0\text{ V}$, $f = 100\text{ kHz}$			8.6		pF
Gate charge	Q_G	$V_{CC} = 520\text{ V}$, $I_C = 40\text{ A}$, $V_{GE} = 15\text{ V}$			81		nC
Turn-on delay time	$t_{d(on)}$	$V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_{G(on)} = 12.5\text{ }\Omega$, $R_{G(off)} = 12.5\text{ }\Omega$	$T_{vj} = 25\text{ °C}$, $I_C = 40\text{ A}$		18		ns
			$T_{vj} = 175\text{ °C}$, $I_C = 40\text{ A}$		18		
Rise time (inductive load)	t_r	$V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_{G(on)} = 12.5\text{ }\Omega$, $R_{G(off)} = 12.5\text{ }\Omega$	$T_{vj} = 25\text{ °C}$, $I_C = 40\text{ A}$		25		ns
			$T_{vj} = 175\text{ °C}$, $I_C = 40\text{ A}$		28		
Turn-off delay time	$t_{d(off)}$	$V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_{G(on)} = 12.5\text{ }\Omega$, $R_{G(off)} = 12.5\text{ }\Omega$	$T_{vj} = 25\text{ °C}$, $I_C = 40\text{ A}$		141		ns
			$T_{vj} = 175\text{ °C}$, $I_C = 40\text{ A}$		167		
Fall time (inductive load)	t_f	$V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_{G(on)} = 12.5\text{ }\Omega$, $R_{G(off)} = 12.5\text{ }\Omega$	$T_{vj} = 25\text{ °C}$, $I_C = 40\text{ A}$		34		ns
			$T_{vj} = 175\text{ °C}$, $I_C = 40\text{ A}$		52		
Turn-on energy	E_{on}	$V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_{G(on)} = 12.5\text{ }\Omega$, $R_{G(off)} = 12.5\text{ }\Omega$	$T_{vj} = 25\text{ °C}$, $I_C = 40\text{ A}$		0.97		mJ
			$T_{vj} = 175\text{ °C}$, $I_C = 40\text{ A}$		1.52		

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3 二极管

表 3 (续) 特征值

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-off energy	E_{off}	$V_{\text{CC}} = 400 \text{ V}$, $V_{\text{GE}} = 0/15 \text{ V}$, $R_{\text{G(on)}} = 12.5 \Omega$, $R_{\text{G(off)}} = 12.5 \Omega$	$T_{\text{vj}} = 25 \text{ }^{\circ}\text{C}$, $I_{\text{C}} = 40 \text{ A}$	0.42		mJ
			$T_{\text{vj}} = 175 \text{ }^{\circ}\text{C}$, $I_{\text{C}} = 40 \text{ A}$	0.69		
Total switching energy	E_{ts}	$V_{\text{CC}} = 400 \text{ V}$, $V_{\text{GE}} = 0/15 \text{ V}$, $R_{\text{G(on)}} = 12.5 \Omega$, $R_{\text{G(off)}} = 12.5 \Omega$	$T_{\text{vj}} = 25 \text{ }^{\circ}\text{C}$, $I_{\text{C}} = 40 \text{ A}$	1.39		mJ
			$T_{\text{vj}} = 175 \text{ }^{\circ}\text{C}$, $I_{\text{C}} = 40 \text{ A}$	2.19		
Operating junction temperature	T_{vj}		-40		175	$^{\circ}\text{C}$

3 二极管

表 4 最大额定值

Parameter	Symbol	Note or test condition	Values	Unit
Diode forward current, limited by T_{vjmax}	I_{F}	$T_{\text{c}} = 25 \text{ }^{\circ}\text{C}$	76	A
		$T_{\text{c}} = 100 \text{ }^{\circ}\text{C}$	49	
Diode pulsed current, t_{p} limited by T_{vjmax}	I_{Fpulse}		160	A
Power dissipation	P_{tot}	$T_{\text{c}} = 25 \text{ }^{\circ}\text{C}$	158	W
		$T_{\text{c}} = 100 \text{ }^{\circ}\text{C}$	78	

表 5 特征值

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Diode forward voltage	V_{F}	$I_{\text{F}} = 40 \text{ A}$	$T_{\text{vj}} = 25 \text{ }^{\circ}\text{C}$	1.65	2	V
			$T_{\text{vj}} = 175 \text{ }^{\circ}\text{C}$	1.55		
Diode reverse recovery time	t_{rr}	$V_{\text{R}} = 400 \text{ V}$, $R_{\text{G(on)}} = 12.5 \Omega$	$T_{\text{vj}} = 25 \text{ }^{\circ}\text{C}$, $I_{\text{F}} = 40 \text{ A}$	74		ns
			$T_{\text{vj}} = 175 \text{ }^{\circ}\text{C}$, $I_{\text{F}} = 40 \text{ A}$	112		
Diode reverse recovery charge	Q_{rr}	$V_{\text{R}} = 400 \text{ V}$, $R_{\text{G(on)}} = 12.5 \Omega$	$T_{\text{vj}} = 25 \text{ }^{\circ}\text{C}$, $I_{\text{F}} = 40 \text{ A}$	0.9		μC
			$T_{\text{vj}} = 175 \text{ }^{\circ}\text{C}$, $I_{\text{F}} = 40 \text{ A}$	2.1		

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表 5 (续) 特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode peak reverse recovery current	I_{rrm}	$V_R = 400\text{ V}$, $R_{G(on)} = 12.5\ \Omega$	$T_{vj} = 25\text{ °C}$, $I_F = 40\text{ A}$		19.9		A
			$T_{vj} = 175\text{ °C}$, $I_F = 40\text{ A}$		29.8		
Diode peak rate of fall of reverse recovery current	di_{rr}/dt	$V_R = 400\text{ V}$, $R_{G(on)} = 12.5\ \Omega$	$T_{vj} = 25\text{ °C}$, $I_F = 40\text{ A}$		-1070		A/ μs
			$T_{vj} = 175\text{ °C}$, $I_F = 40\text{ A}$		-719		
Reverse recovery energy	E_{rec}	$V_R = 400\text{ V}$, $R_{G(on)} = 12.5\ \Omega$	$T_{vj} = 25\text{ °C}$, $I_F = 40\text{ A}$		0.16		mJ
			$T_{vj} = 175\text{ °C}$, $I_F = 40\text{ A}$		0.44		
Operating junction temperature	T_{vj}			-40		175	°C

注意：为了获得最佳的使用寿命和可靠性，英飞凌建议运行条件不超过本数据手册中所述最大额定值的80%。

除非另有规定，电气特性均为 $T_{vj} = 25\text{ °C}$ 。

动态测试电路，寄生电感 $L_\sigma = 8\text{ nH}$ ，寄生电容 $C_\sigma = 30\text{ pF}$ ，来自图E。能量损耗包括“拖尾”和二极管反向恢复。

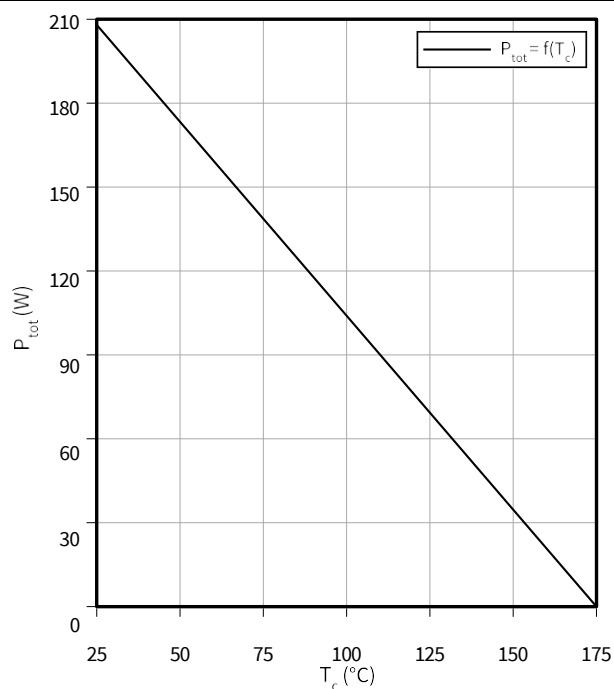
4 特征图

4 特性图

Power dissipation as a function of case temperature

$$P_{\text{tot}} = f(T_c)$$

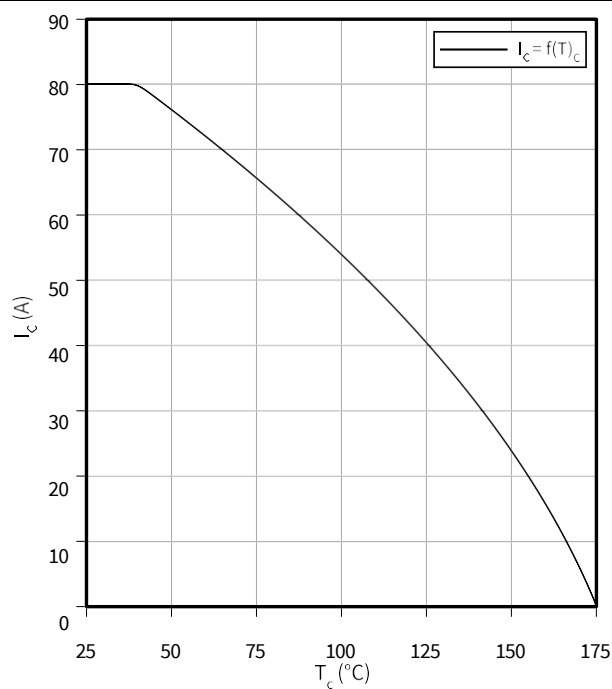
$$T_{vj} \leq 175^\circ\text{C}$$



Collector current as a function of case temperature

$$I_c = f(T_c)$$

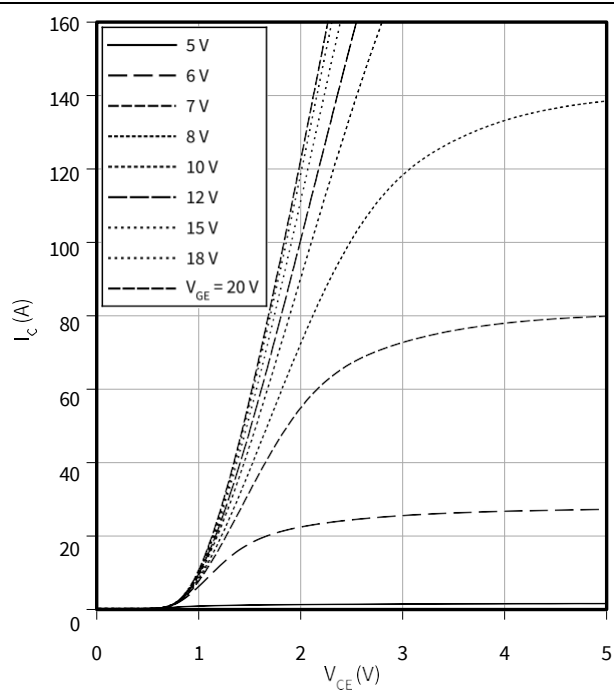
$$T_{vj} \leq 175^\circ\text{C}, V_{GE} \geq 15\text{ V}$$



Typical output characteristic

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

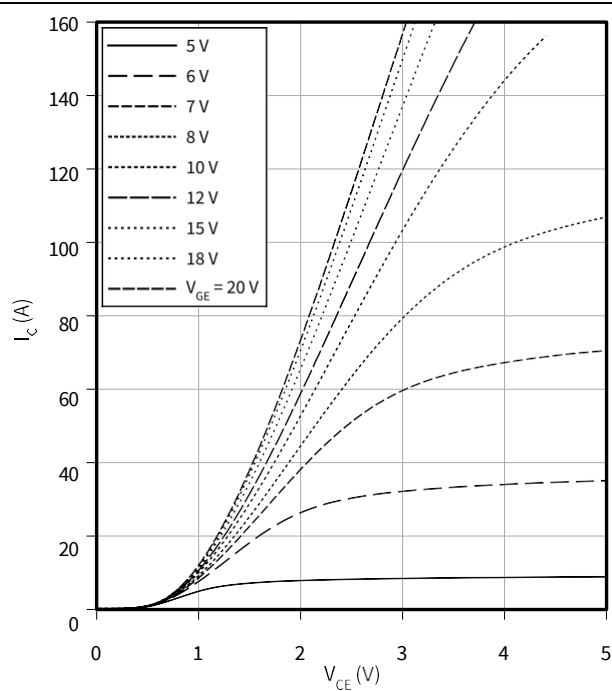
$$T_{vj} = 25^\circ\text{C}$$



Typical output characteristic

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

$$T_{vj} = 175^\circ\text{C}$$

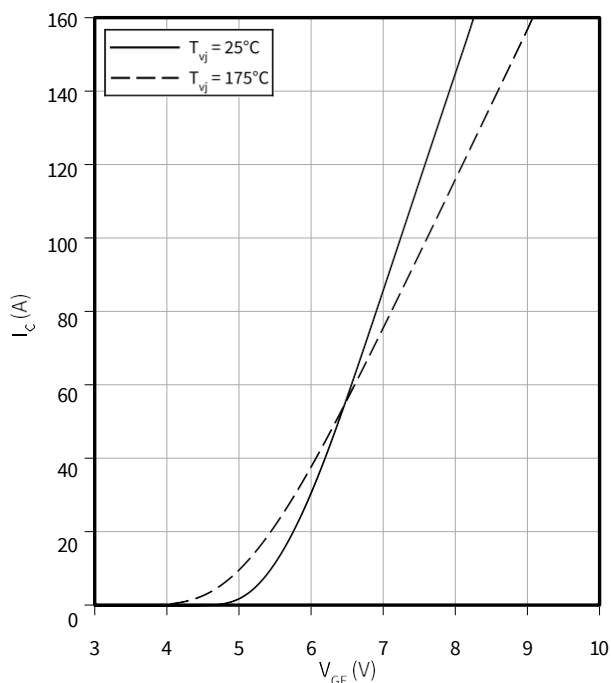


4 特征图

Typical transfer characteristic

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

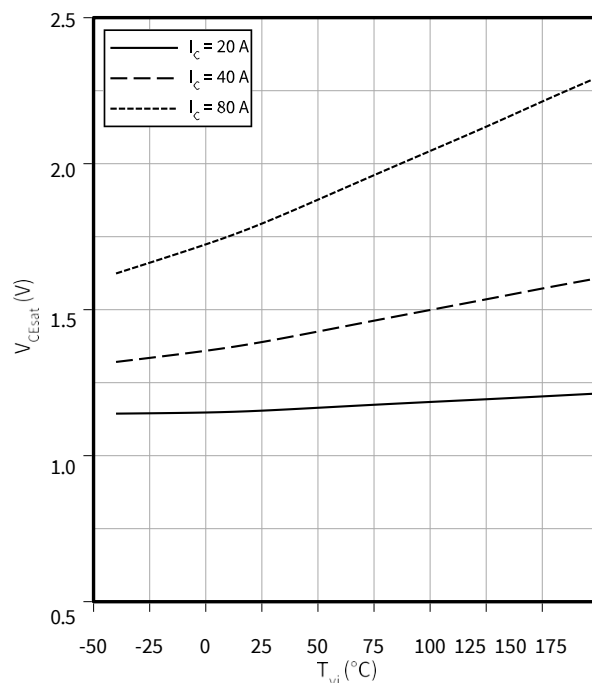
$$V_{CE} = 20 \text{ V}$$



Typical collector-emitter saturation voltage as a function of junction temperature

$$V_{CEsat} = f(T_{vj})$$

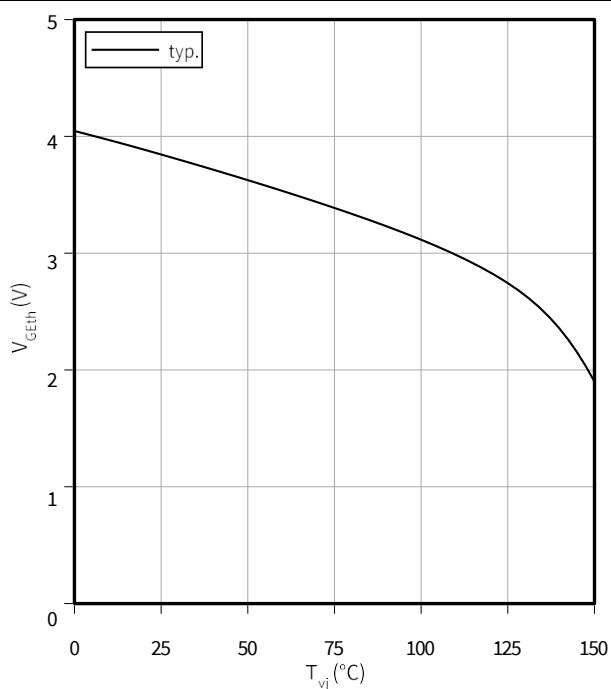
$$V_{GE} = 15 \text{ V}$$



Gate-emitter threshold voltage as a function of junction temperature

$$V_{GEth} = f(T_{vj})$$

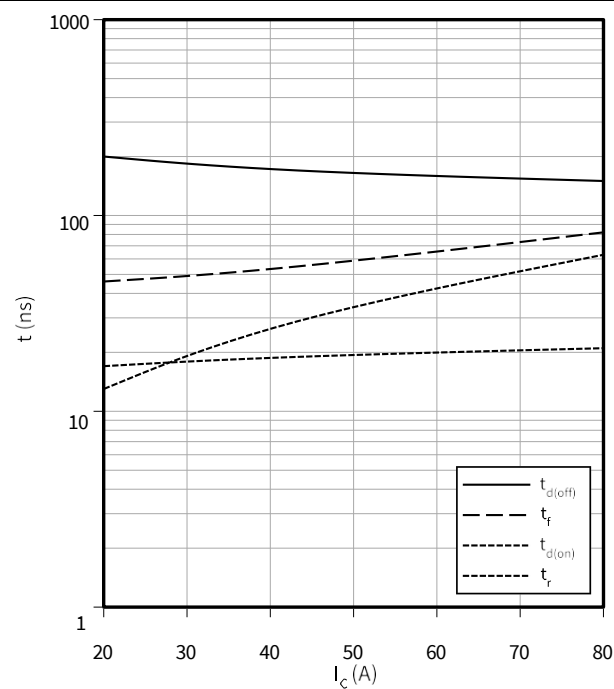
$$I_C = 0.35 \text{ mA}$$



Typical switching times as a function of collector current

$$t = f(I_C)$$

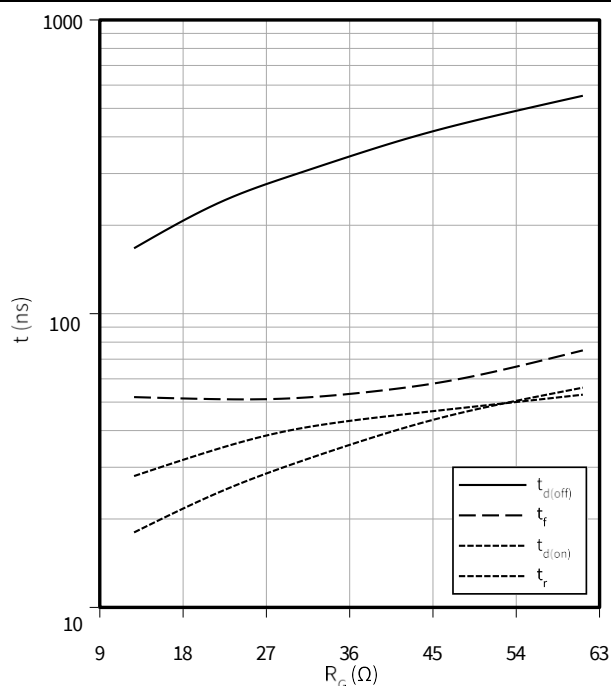
$$V_{CC} = 400 \text{ V}, T_{vj} = 175^\circ\text{C}, V_{GE} = 0/15 \text{ V}, R_G = 12.5 \Omega$$



4 特征图

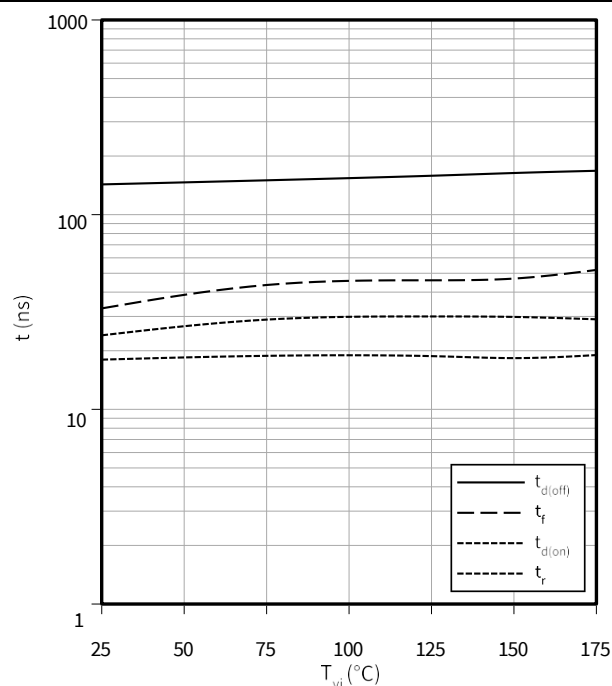
Typical switching times as a function of gate resistor

$$t = f(R_G)$$

 $I_C = 40\text{ A}$, $V_{CC} = 400\text{ V}$, $T_{vj} = 175\text{ }^\circ\text{C}$, $V_{GE} = 0/15\text{ V}$


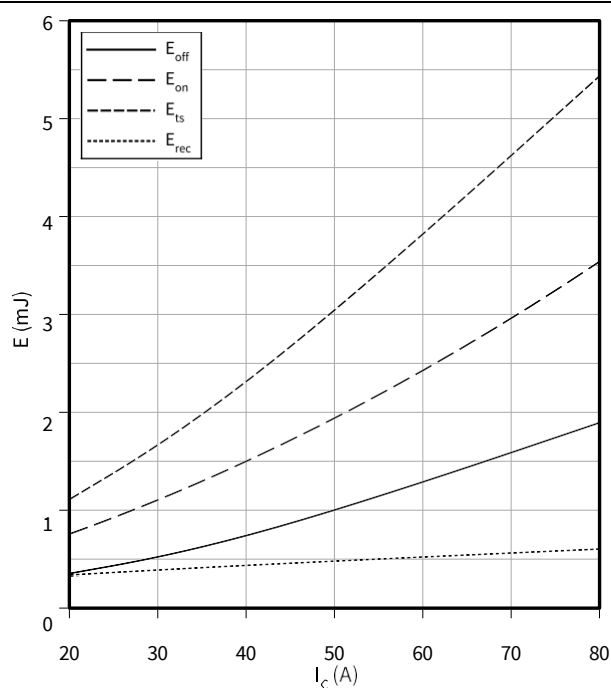
Typical switching times as a function of junction temperature

$$t = f(T_{vj})$$

 $I_C = 40\text{ A}$, $V_{CC} = 400\text{ V}$, $V_{GE} = 0/15\text{ V}$, $R_G = 12.5\text{ }\Omega$


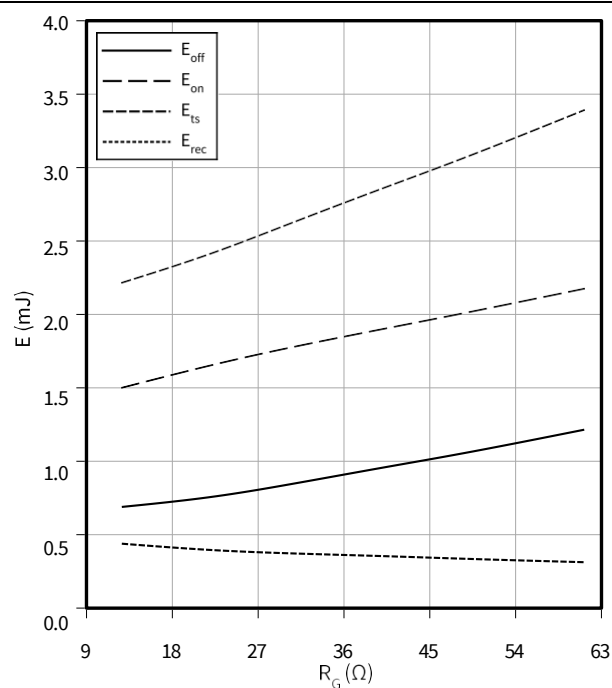
Typical switching energy losses as a function of collector current

$$E = f(I_C)$$

 $V_{CC} = 400\text{ V}$, $T_{vj} = 175\text{ }^\circ\text{C}$, $V_{GE} = 0/15\text{ V}$, $R_G = 12.5\text{ }\Omega$


Typical switching energy losses as a function of gate resistor

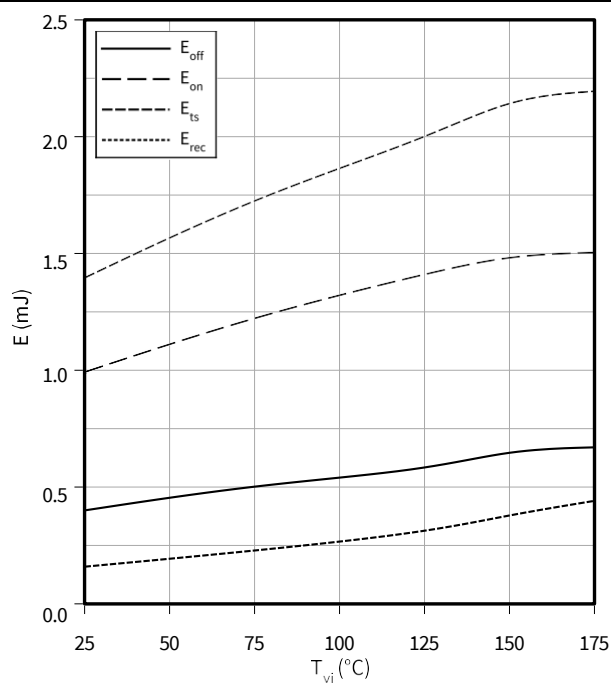
$$E = f(R_G)$$

 $I_C = 40\text{ A}$, $V_{CC} = 400\text{ V}$, $T_{vj} = 175\text{ }^\circ\text{C}$, $V_{GE} = 0/15\text{ V}$


4 特征图

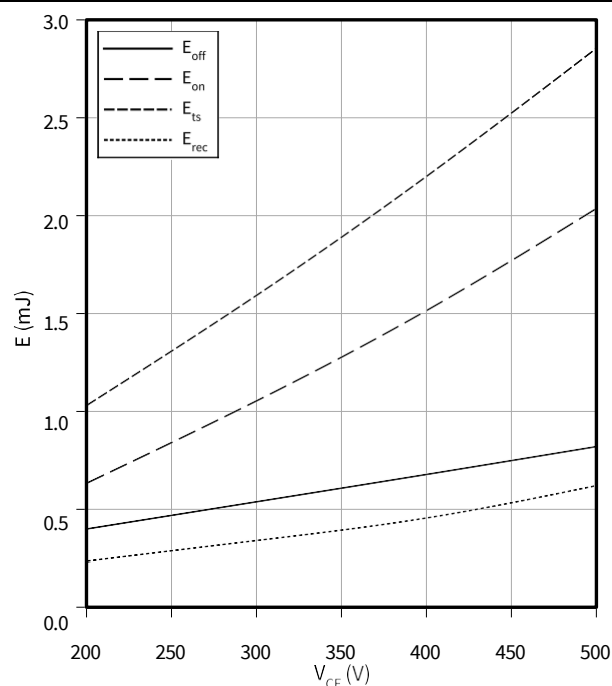
Typical switching energy losses as a function of junction temperature

$$E = f(T_{vj})$$

 $I_C = 40 \text{ A}, V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_G = 12.5 \Omega$


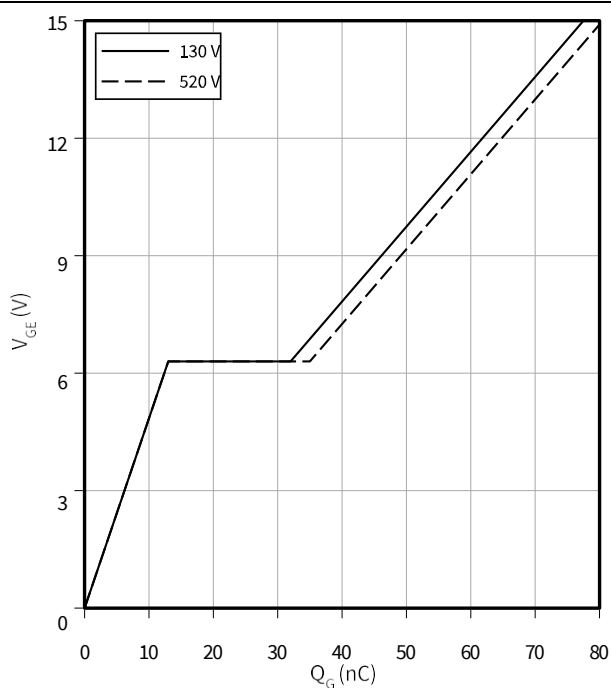
Typical switching energy losses as a function of collector emitter voltage

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

 $I_C = 40 \text{ A}, T_{vj} = 175 \text{ °C}, V_{GE} = 0/15 \text{ V}, R_G = 12.5 \Omega$


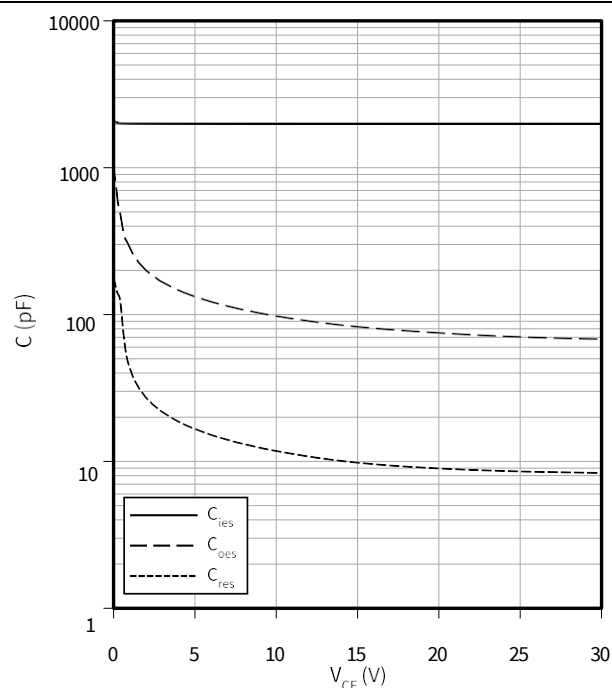
Typical gate charge

$$V_{GE} = f(Q_G)$$

 $I_C = 40 \text{ A}$


Typical capacitance as a function of collector-emitter voltage

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

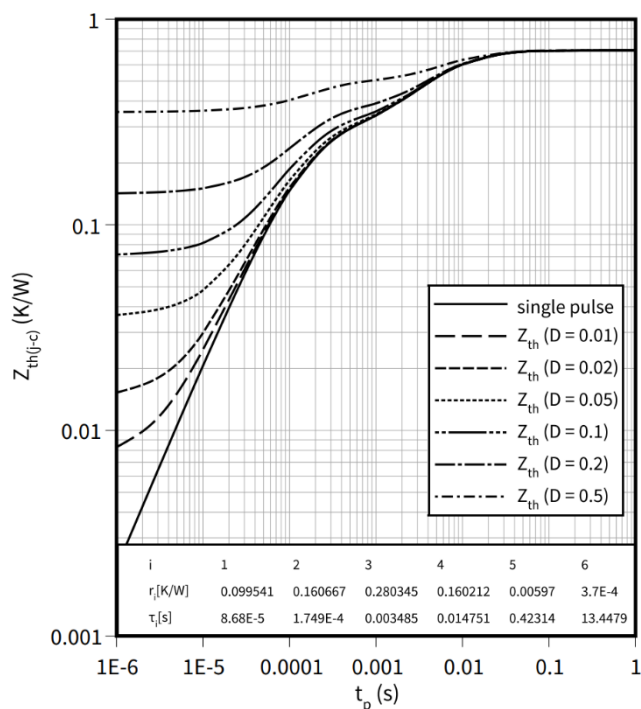
 $f = 100 \text{ kHz}, V_{GE} = 0 \text{ V}$


4 特征图

IGBT transient thermal impedance as a function of pulse width

$$Z_{th(j-c)} = f(t_p)$$

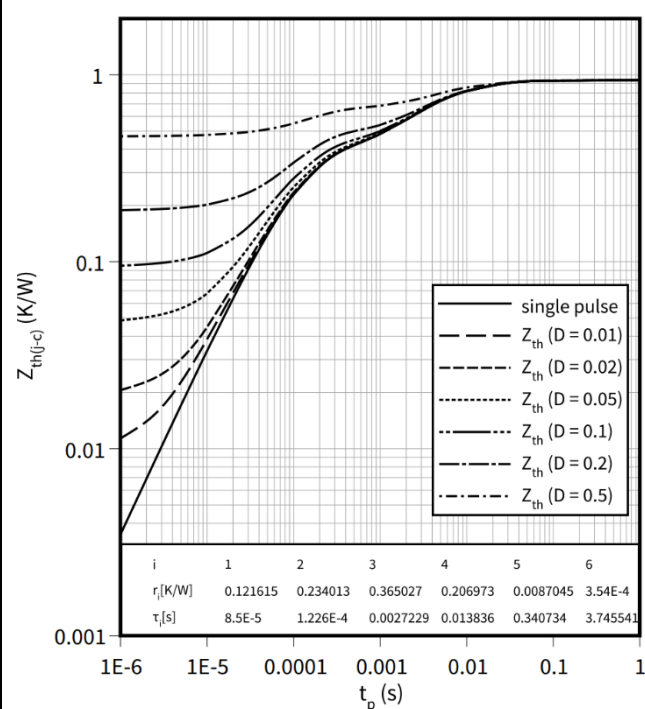
$$D = t_p / T$$



Diode transient thermal impedance as a function of pulse width

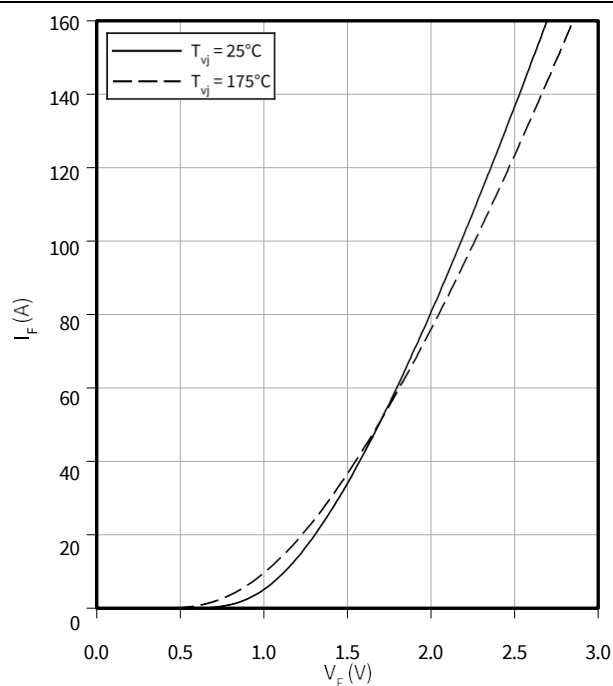
$$Z_{th(j-c)} = f(t_p)$$

$$D = t_p / T$$



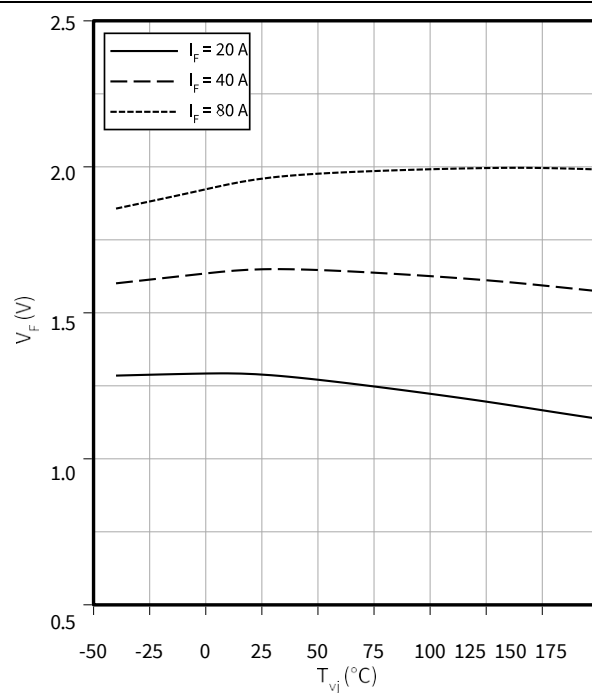
Typical diode forward current as a function of forward voltage

$$I_F = f(V_F)$$



Typical diode forward voltage as a function of junction temperature

$$V_F = f(T_{vj})$$

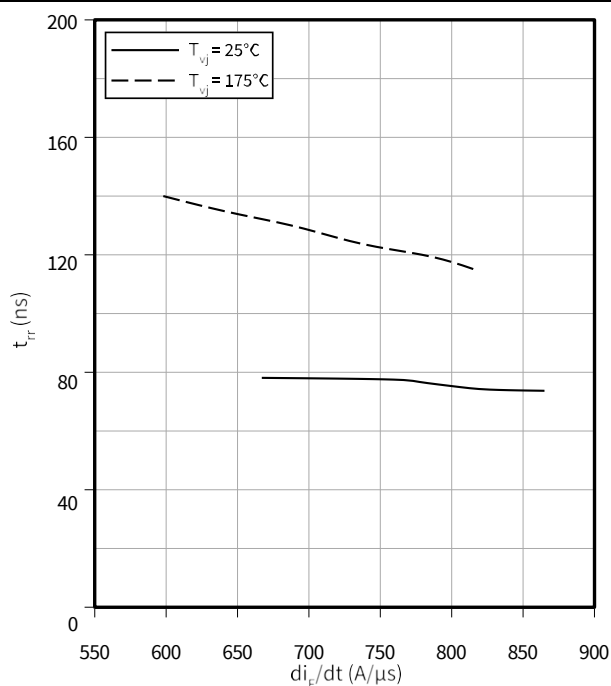


4 特征图

Typical reverse recovery time as a function of diode current slope

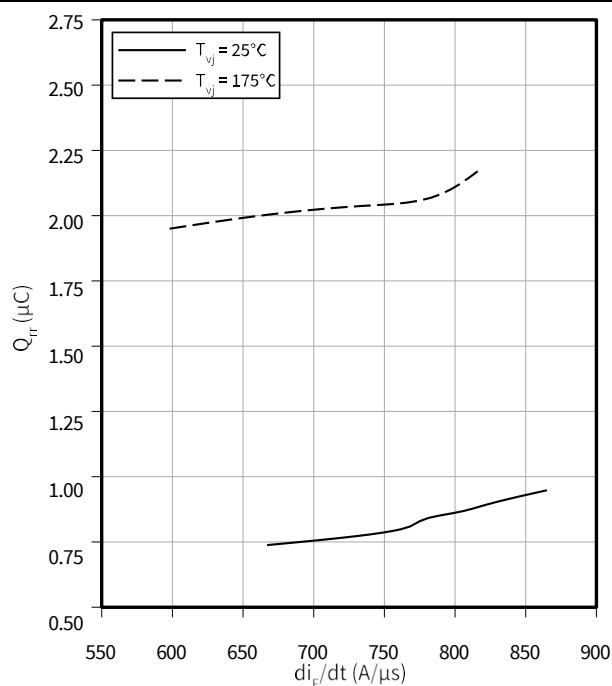
$$t_{rr} = f(di_F/dt)$$

$$I_F = 40 \text{ A}, V_R = 400 \text{ V}$$

**Typical reverse recovery charge as a function of diode current slope**

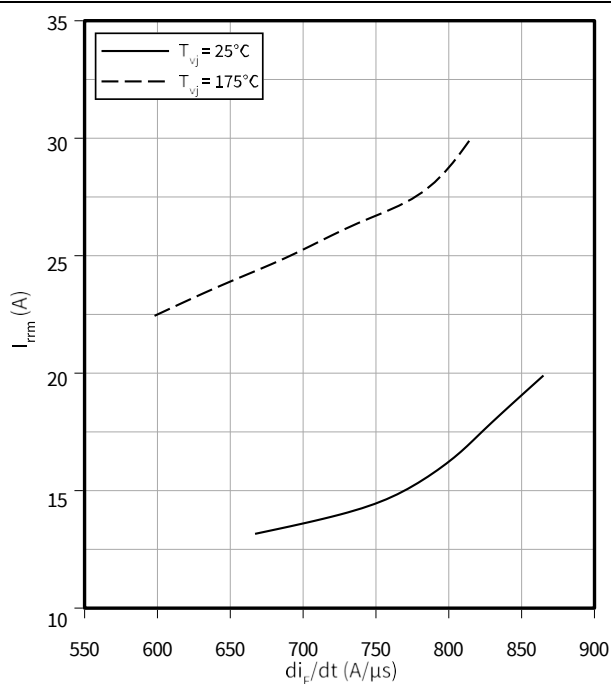
$$Q_{rr} = f(di_F/dt)$$

$$V_R = 400 \text{ V}, I_F = 40 \text{ A}$$

**Typical reverse recovery current as a function of diode current slope**

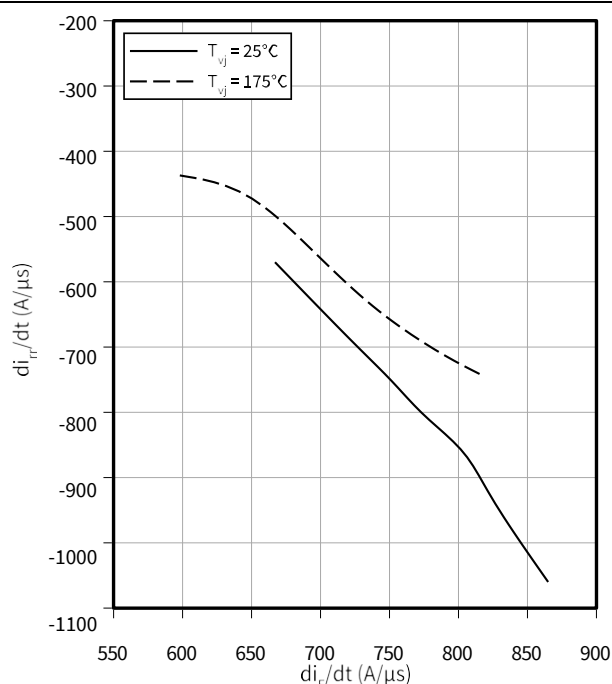
$$I_{rrm} = f(di_F/dt)$$

$$V_R = 400 \text{ V}, I_F = 40 \text{ A}$$

**Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**

$$di_{rr}/dt = f(di_F/dt)$$

$$V_R = 400 \text{ V}, I_F = 40 \text{ A}$$

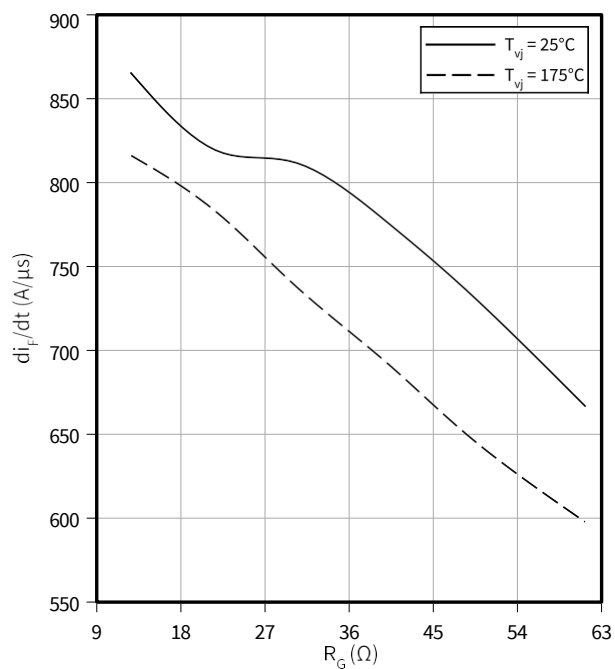


4 特征图

Typical diode current slope as a function of gate resistor

$$di_F/dt = f(R_G)$$

$$V_R = 400 \text{ V}, I_F = 40 \text{ A}$$



5 封装外形

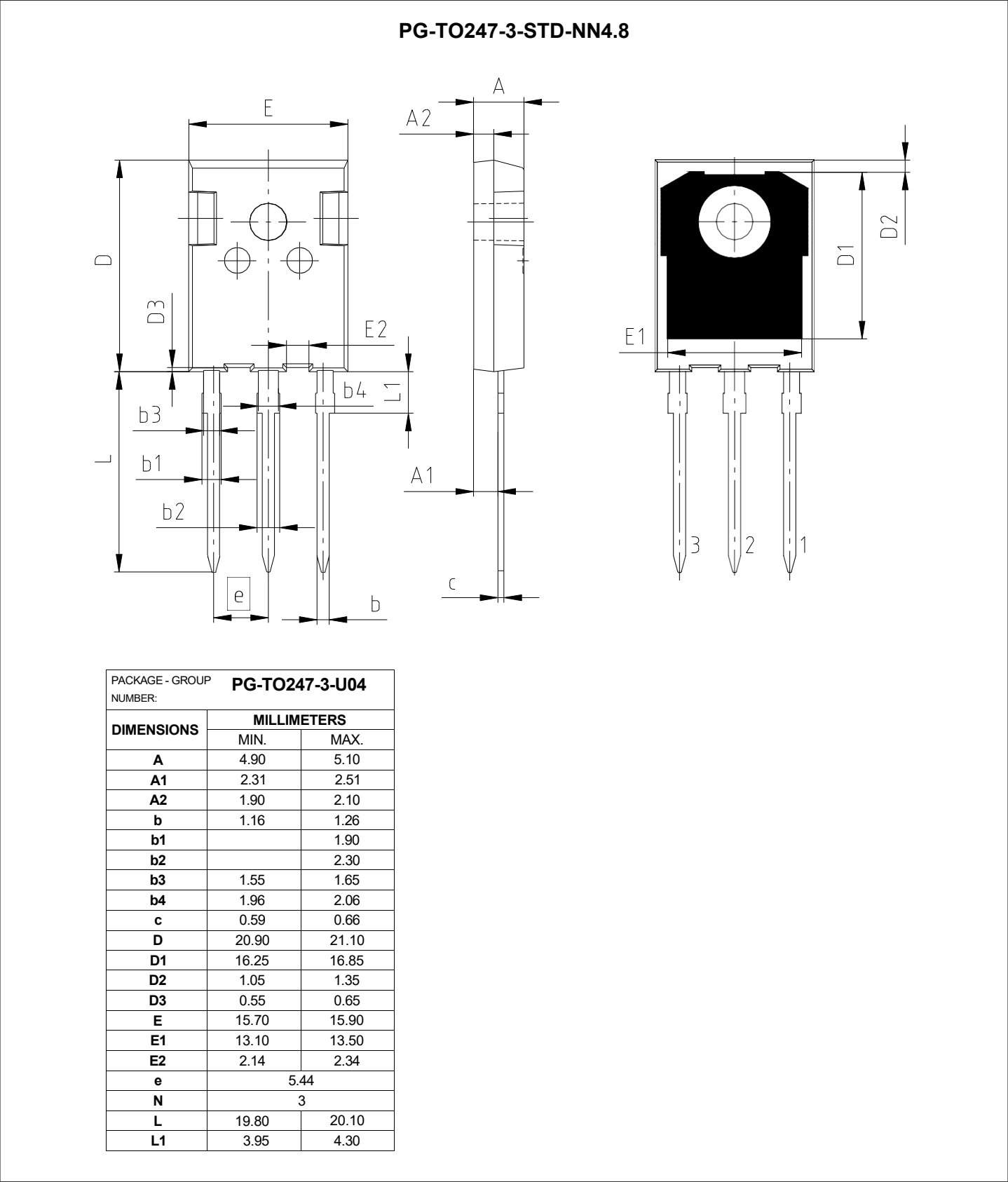


图 1

6 测试条件

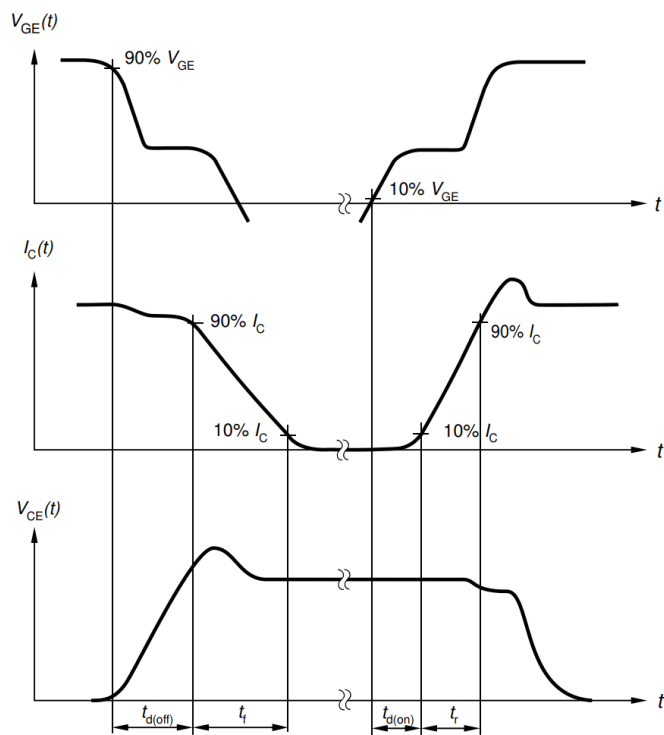


Figure A. Definition of switching times

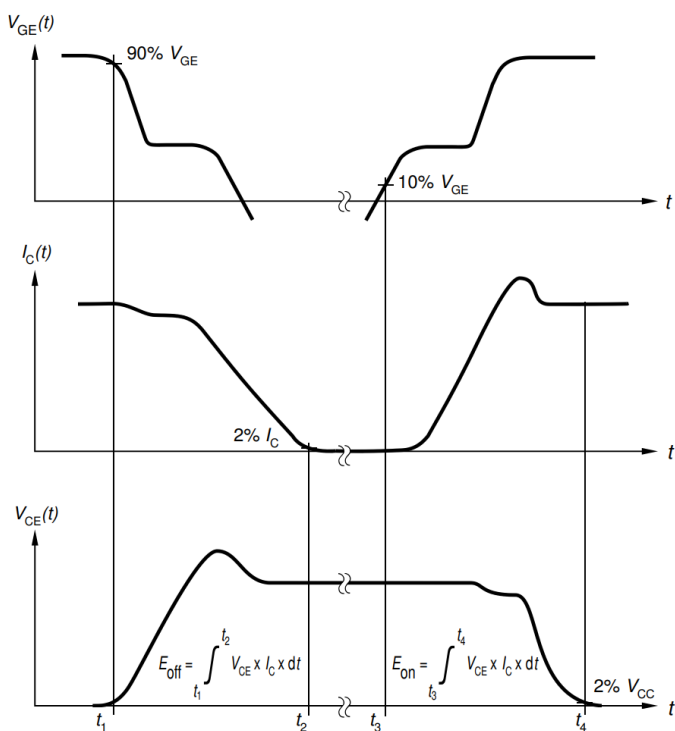


Figure B. Definition of switching losses

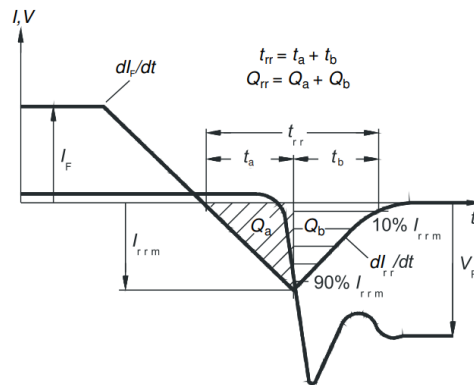


Figure C. Definition of diode switching characteristics

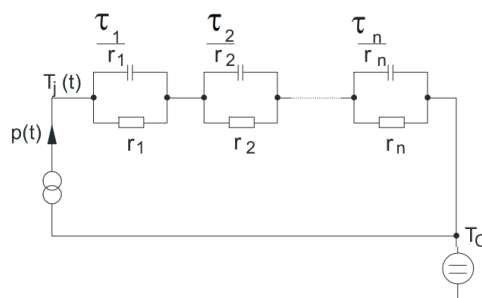


Figure D. Thermal equivalent circuit

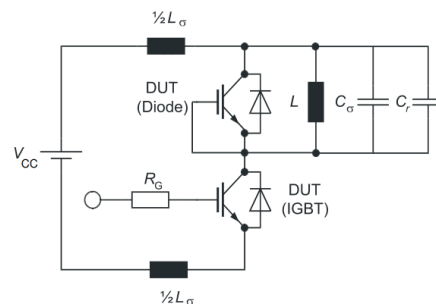


Figure E. **Dynamic test circuit**
 Parasitic inductance L_{σ} ,
 parasitic capacitor C_{σ} ,
 relief capacitor C_r ,
 (only for ZVT switching)

修订记录

Document revision	Date of release	Description of changes
1.00	2023-02-09	Final datasheet
1.10	2023-04-25	Correction of switching values in Table 3 Correction of diagram $V_{GE} = f(Q_G)$
1.20	2023-11-13	Update of E_{ts} temperature conditions in Table 3 Update of energy diagrams



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