

## 具有单片体二极管的反向传导 IGBT

### 特性

- $V_{CE} = 650\text{ V}$
- $I_C = 40\text{ A}$
- 针对 ZCS 应用优化的强大单片二极管
- 高稳健性、温度稳定性
- 极低的  $V_{CEsat}$  和低的  $E_{off}$
- 由于  $V_{CEsat}$  具有正温度系数，因此易于并联
- 低电磁干扰
- 电气参数对温度的依赖性较低
- 符合 JESD-022 目标应用要求
- 无铅镀层；符合 RoHS 标准
- 完整的产品品类和 PSpice 模型：<http://www.infineon.com/igbt/>



### 潜在应用

- 焊接
- 功率因数校正
- ZCS - 转换器



Lead-free



Green

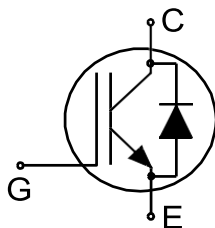


Halogen-free



RoHS

### 描述



Type	Package	Marking
IKW40N65WR5	PG-TO247-3	K40EWR5

本数据手册的原文使用英文撰写。为方便起见，英飞凌提供了译文；由于翻译过程中可能使用了自动化工具，英飞凌不保证译文的准确性。为确认准确性，请务必访问 [infineon.com](http://www.infineon.com) 参考最新的英文版本（控制文档）。

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## 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	$R_{th(j-c)}$				0.65	K/W
Diode thermal resistance, junction-case	$R_{th(j-c)}$				2.85	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
			$T_c = 130\text{ °C}$	40	
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpulse}$		120	A	
Turn-off safe operating area		$V_{CE} \leq 650\text{ V}, T_{vj} \leq 175\text{ °C}$	120	A	
Gate-emitter voltage	$V_{GE}$		$\pm 20$	V	
Transient gate-emitter voltage	$V_{GE}$	$t_p \leq 10\text{ }\mu\text{s}, D < 0.01$	$\pm 30$	V	
Power dissipation	$P_{tot}$	$T_c = 25\text{ °C}$	230	W	
		$T_c = 100\text{ °C}$	115		

**表3 特征值**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Collector-emitter breakdown voltage	$V_{BRCES}$	$I_C = 0.2 \text{ mA}, V_{GE} = 0 \text{ V}$	650			V
Collector-emitter saturation voltage	$V_{CESat}$	$I_C = 40 \text{ A}, V_{GE} = 15 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$	1.4	1.8	V
			$T_{vj} = 175 \text{ }^\circ\text{C}$	1.65		
Gate-emitter threshold voltage	$V_{GETh}$	$I_C = 0.4 \text{ mA}, V_{CE} = V_{GE}$	3.2	4	4.8	V
Zero gate-voltage collector current	$I_{CES}$	$V_{CE} = 650 \text{ V}, V_{GE} = 0 \text{ V}$			40	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0 \text{ V}, V_{GE} = 20 \text{ V}$			100	nA
Transconductance	$g_{fs}$	$I_C = 40 \text{ A}, V_{CE} = 20 \text{ V}$		55		S
Input capacitance	$C_{ies}$	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 1000 \text{ kHz}$		4755		pF
Output capacitance	$C_{oes}$	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 1000 \text{ kHz}$		45		pF
Reverse transfer capacitance	$C_{res}$	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 1000 \text{ kHz}$		20		pF
Gate charge	$Q_G$	$V_{CC} = 520 \text{ V}, I_C = 40 \text{ A}, V_{GE} = 15 \text{ V}$		193		nC
Turn-on delay time	$t_{d(on)}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{G(on)} = 20 \text{ } \Omega, R_{G(off)} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	42		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	42		
Rise time (inductive load)	$t_r$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{G(on)} = 20 \text{ } \Omega, R_{G(off)} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	18		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	21		
Turn-off delay time	$t_{d(off)}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{G(on)} = 20 \text{ } \Omega, R_{G(off)} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	432		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	500		
Fall time (inductive load)	$t_f$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{G(on)} = 20 \text{ } \Omega, R_{G(off)} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	16		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	10		
Turn-on energy	$E_{on}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{G(on)} = 20 \text{ } \Omega, R_{G(off)} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	0.77		mJ
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$	0.82		

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**表 3** (续) 特征值

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Turn-off energy	$E_{off}$	$V_{CC} = 400\text{ V}$ , $V_{GE} = 0/15\text{ V}$ , $R_{G(on)} = 20\ \Omega$ , $R_{G(off)} = 20\ \Omega$ , $L_{\sigma} = 70\text{ nH}$ , $C_{\sigma} = 30\text{ pF}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$ , $I_C = 20\text{ A}$		0.16		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$ , $I_C = 20\text{ A}$		0.24		
Total switching energy	$E_{ts}$	$V_{CC} = 400\text{ V}$ , $V_{GE} = 0/15\text{ V}$ , $R_{G(on)} = 20\ \Omega$ , $R_{G(off)} = 20\ \Omega$ , $L_{\sigma} = 70\text{ nH}$ , $C_{\sigma} = 30\text{ pF}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$ , $I_C = 20\text{ A}$		0.93		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$ , $I_C = 20\text{ A}$		1.06		
Operating junction temperature	$T_{vj}$		-40		175	$^{\circ}\text{C}$	

注： 电气特性，在  $T_{vj} = 25^{\circ}\text{C}$  条件下测得，除非另有规定。

### 3 二极管

**表4** 最大额定值

Parameter	Symbol	Note or test condition	Values	Unit	
Repetitive peak reverse voltage	$V_{RRM}$	$T_{vj} \geq 25\text{ }^{\circ}\text{C}$	650	V	
Diode forward current, limited by $T_{vjmax}$	$I_F$	limited by bondwire	$T_c = 25\text{ }^{\circ}\text{C}$	32	A
			$T_c = 100\text{ }^{\circ}\text{C}$	19	
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpulse}$		120	A	

**表5** 特征值

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Diode forward voltage	$V_F$	$I_F = 20\text{ A}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		1.4	1.9	V
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		1.5		
Diode reverse recovery time	$t_{rr}$	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		112		ns
			$T_{vj} = 175\text{ }^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		153		

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**表 5** (续) 特征值

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode reverse recovery charge	$Q_{rr}$	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		1.65		$\mu\text{C}$
			$T_{vj} = 175\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		2.8		
Diode peak reverse recovery current	$I_{rrm}$	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		27		A
			$T_{vj} = 175\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		32		
Diode peak rate of fall of reverse recovery current	$di_{rr}/dt$	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		585		$\text{A}/\mu\text{s}$
			$T_{vj} = 175\text{ °C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$		1030		
Operating junction temperature	$T_{vj}$			-40		175	$^{\circ}\text{C}$

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%。

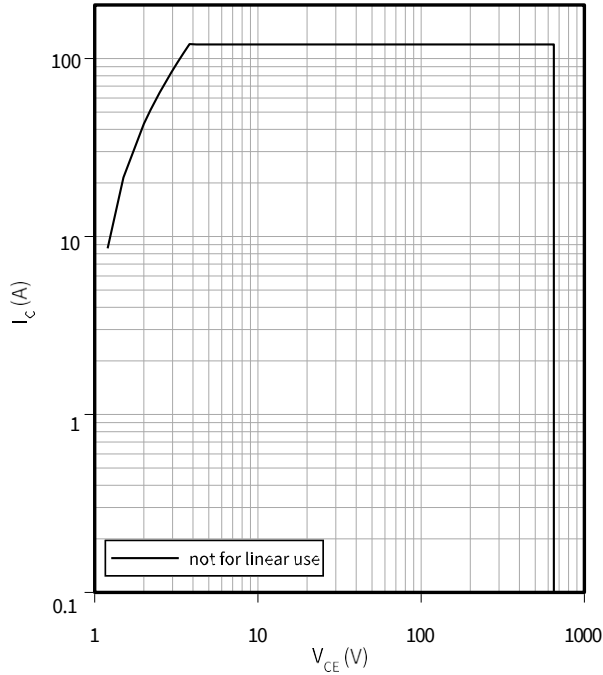
4 特性图

4 特性图

**Reverse bias safe operating area**

$I_C = f(V_{CE})$

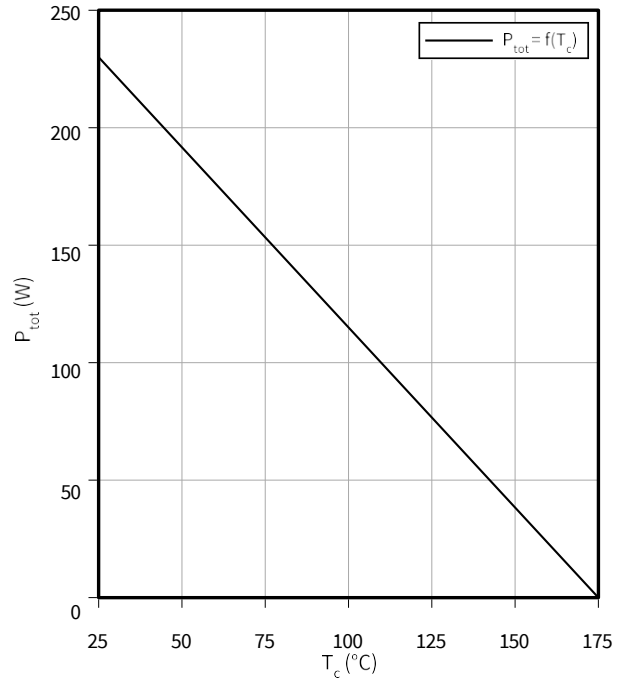
$T_{vj} \leq 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 15\text{ V}$ ,  $T_c = 25\text{ }^\circ\text{C}$



**Power dissipation as a function of case temperature**

$P_{tot} = f(T_c)$

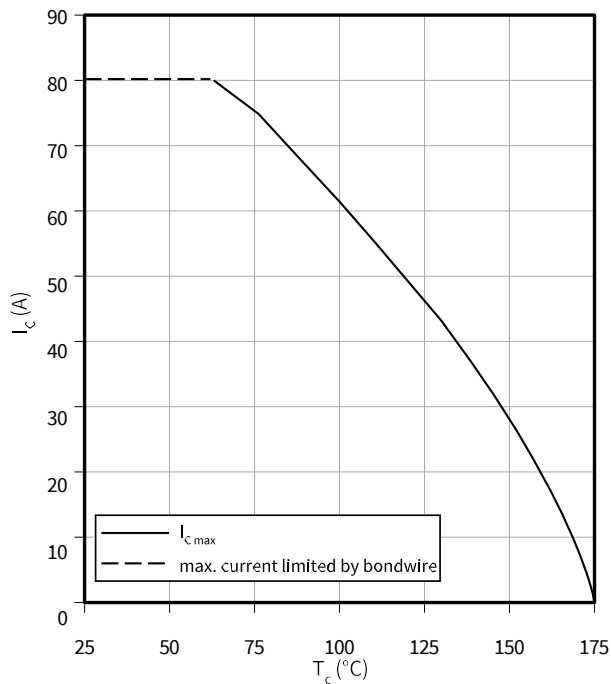
$T_{vj} \leq 175\text{ }^\circ\text{C}$



**Collector current as a function of case temperature**

$I_C = f(T_c)$

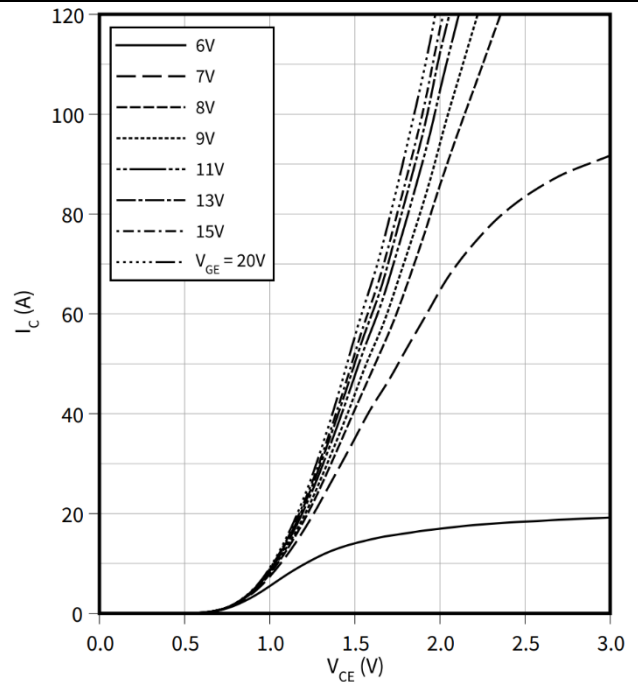
$T_{vj} \leq 175\text{ }^\circ\text{C}$ ,  $V_{GE} \geq 15\text{ V}$



**Typical output characteristic**

$I_C = f(V_{CE})$

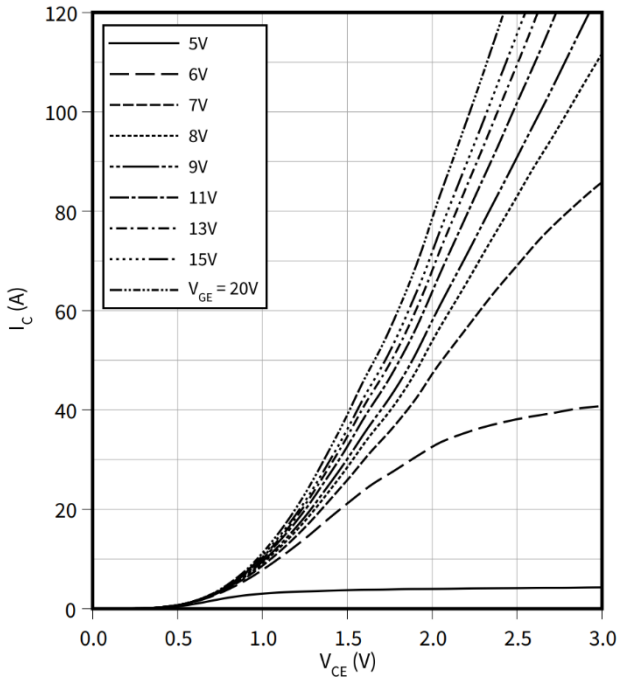
$T_{vj} = 25\text{ }^\circ\text{C}$



4 特性图

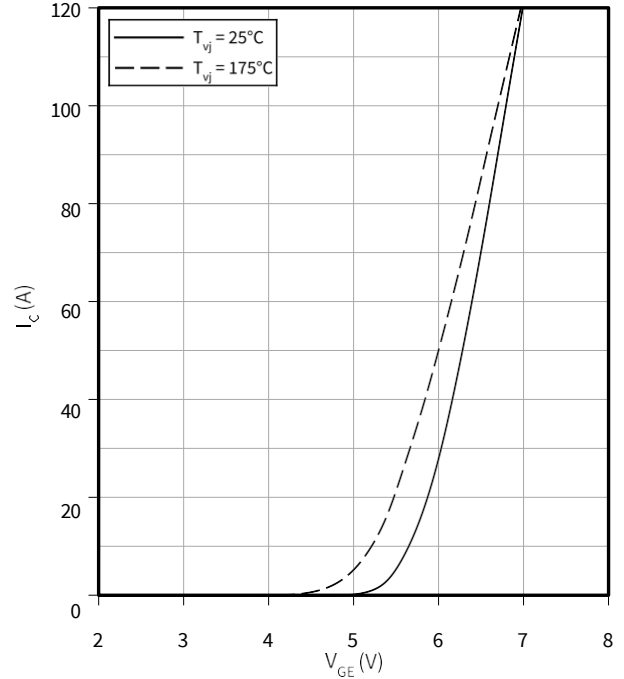
**Typical output characteristic**

$I_C = f(V_{CE})$   
 $T_{vj} = 175^\circ\text{C}$



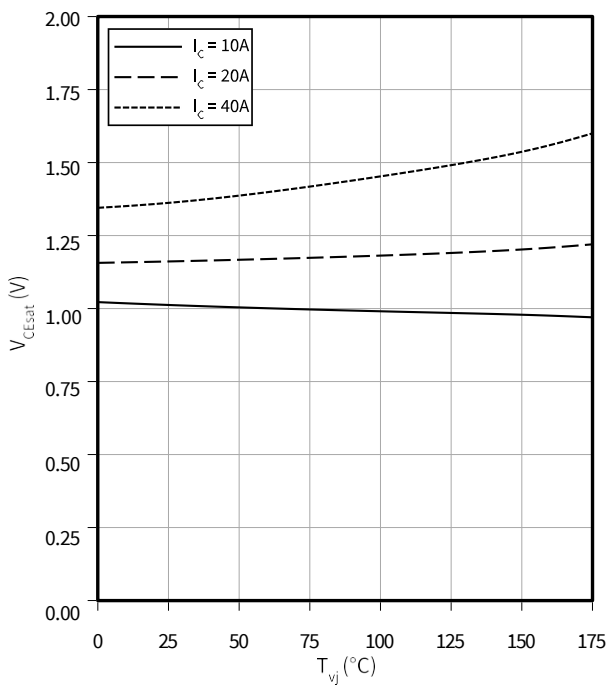
**Typical transfer characteristic**

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



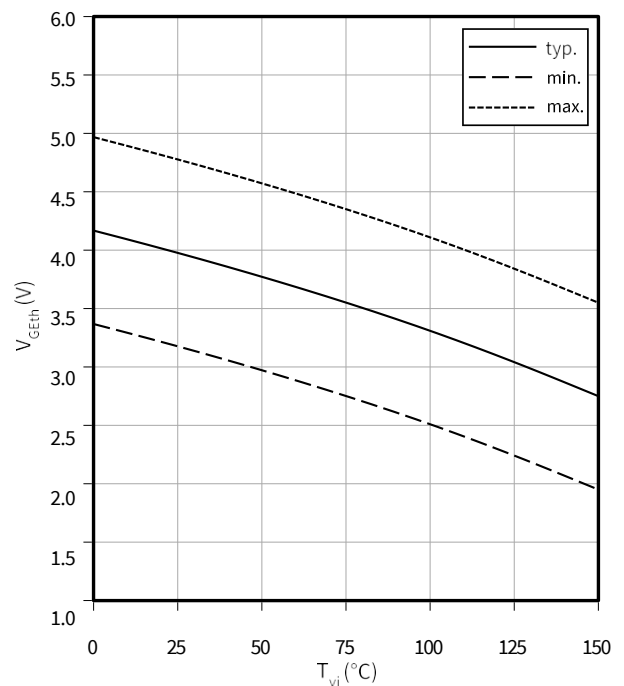
**Typical collector-emitter saturation voltage as a function of junction temperature**

$V_{CEsat} = f(T_{vj})$   
 $V_{GE} = 15\text{ V}$



**Gate-emitter threshold voltage as a function of junction temperature**

$V_{GEth} = f(T_{vj})$   
 $I_C = 0.4\text{ mA}$

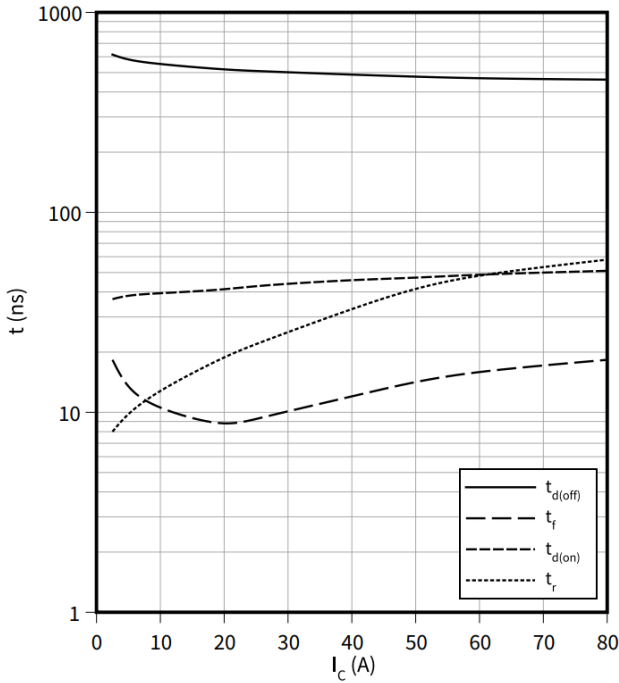


4 特性图

**Typical switching times as a function of collector current**

$t = f(I_C)$

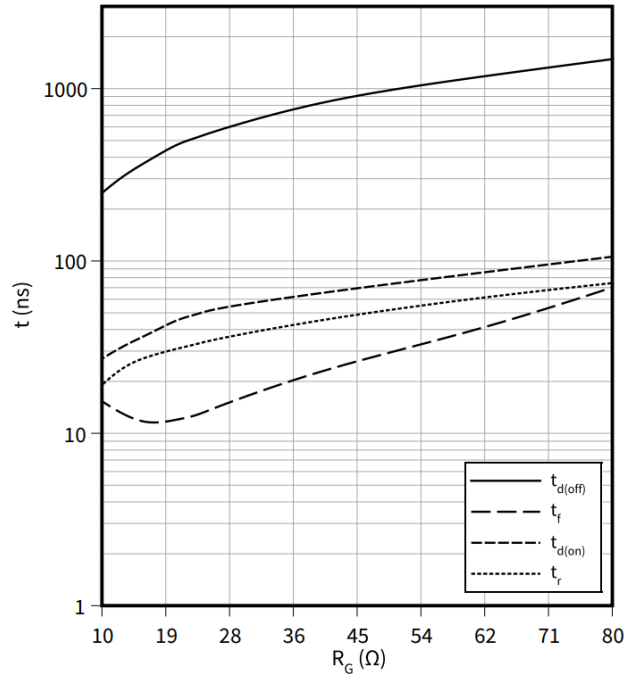
$V_{CC} = 400\text{ V}$ ,  $T_{vj} = 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_G = 20\text{ }\Omega$



**Typical switching times as a function of gate resistor**

$t = f(R_G)$

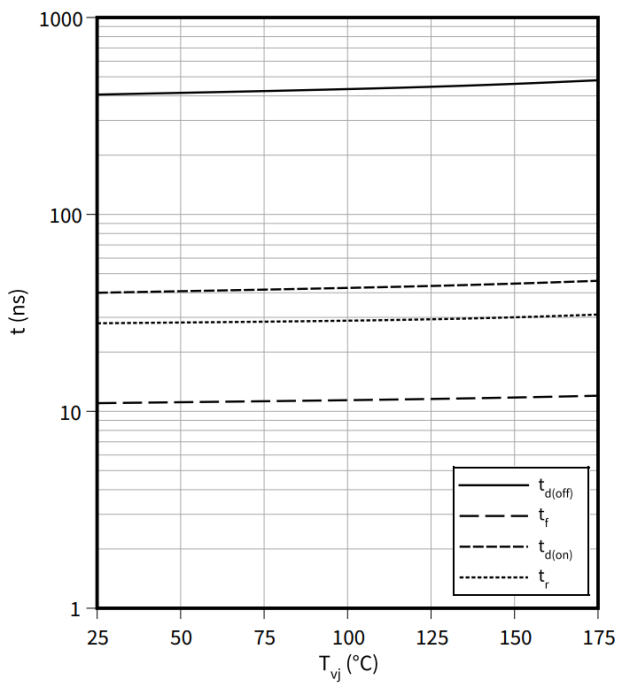
$I_C = 40\text{ A}$ ,  $V_{CC} = 400\text{ V}$ ,  $T_{vj} = 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$



**Typical switching times as a function of junction temperature**

$t = f(T_{vj})$

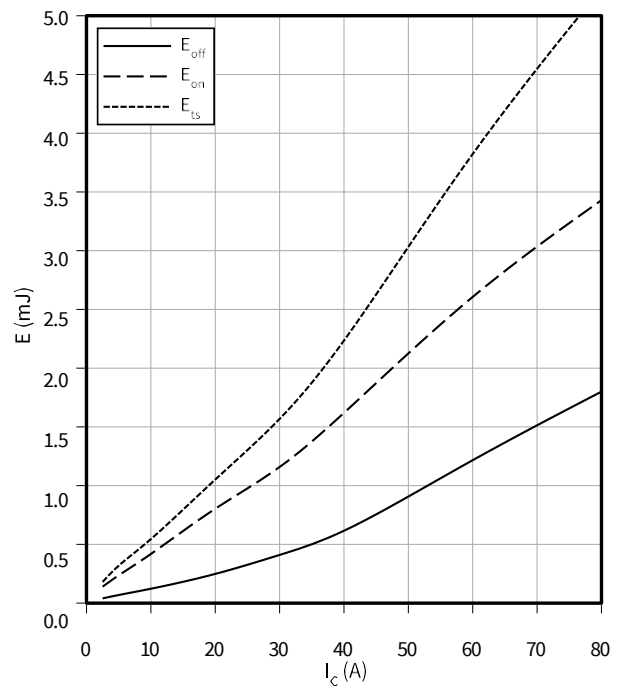
$I_C = 40\text{ A}$ ,  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_G = 20\text{ }\Omega$



**Typical switching energy losses as a function of collector current**

$E = f(I_C)$

$V_{CC} = 400\text{ V}$ ,  $T_{vj} = 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_G = 20\text{ }\Omega$

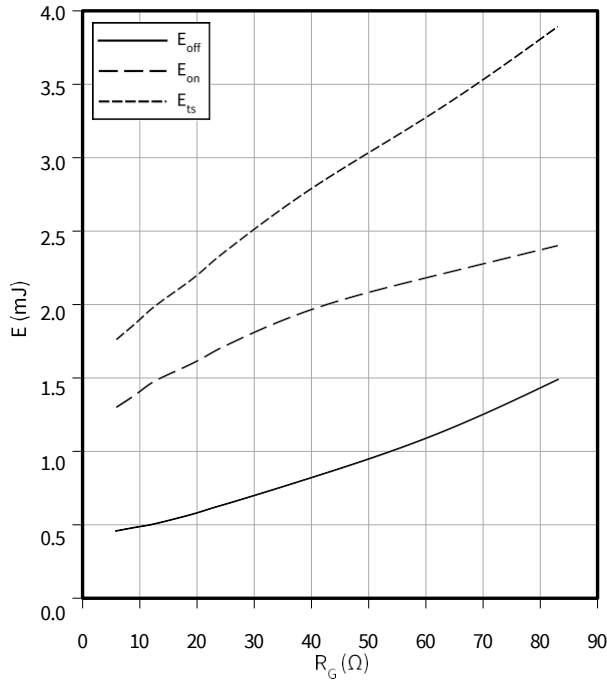


4 特性图

**Typical switching energy losses as a function of gate resistor**

$E = f(R_G)$

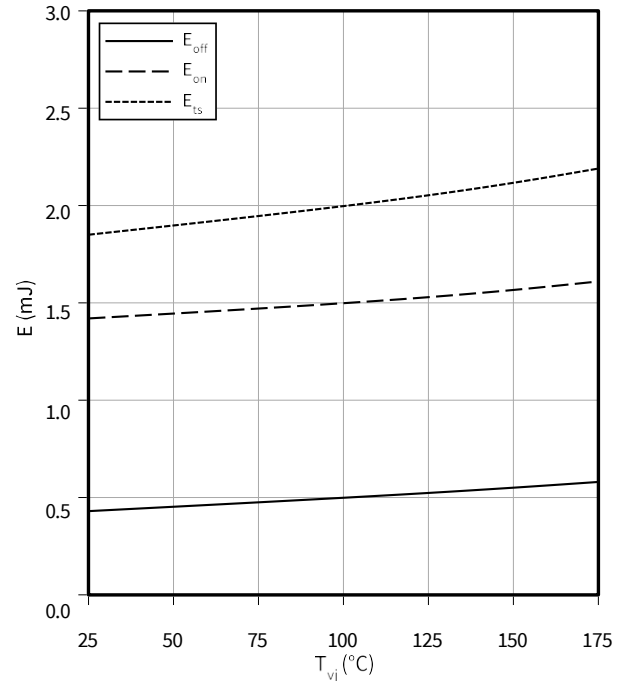
$I_C = 40\text{ A}$ ,  $V_{CC} = 400\text{ V}$ ,  $T_{vj} = 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$



**Typical switching energy losses as a function of junction temperature**

$E = f(T_{vj})$

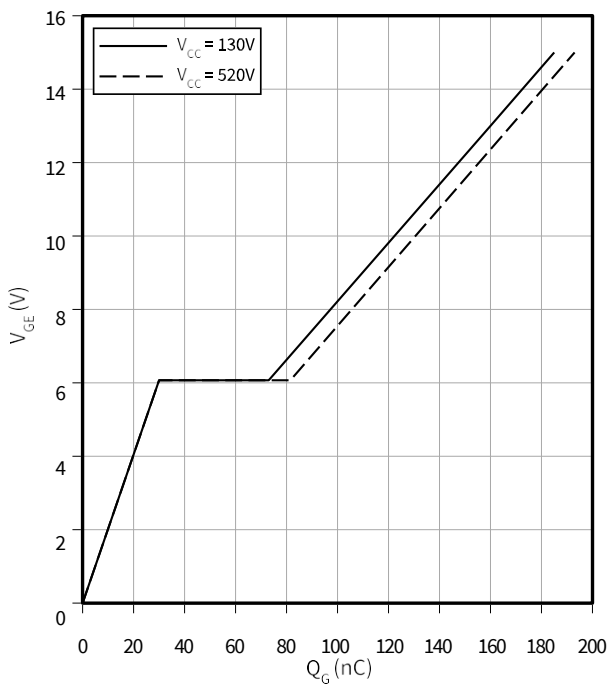
$V_{CC} = 400\text{ V}$ ,  $I_C = 40\text{ A}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_G = 20\text{ }\Omega$



**Typical gate charge**

$V_{GE} = f(Q_G)$

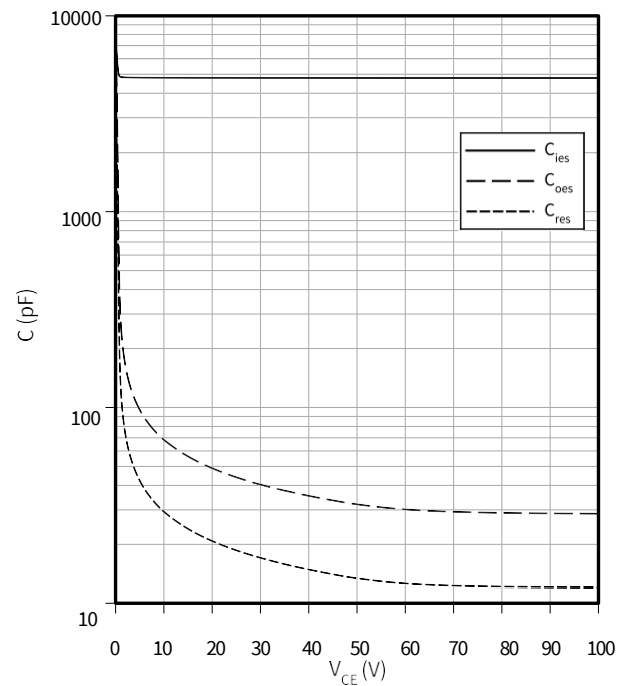
$I_C = 40\text{ A}$



**Typical capacitance as a function of collector-emitter voltage**

$C = f(V_{CE})$

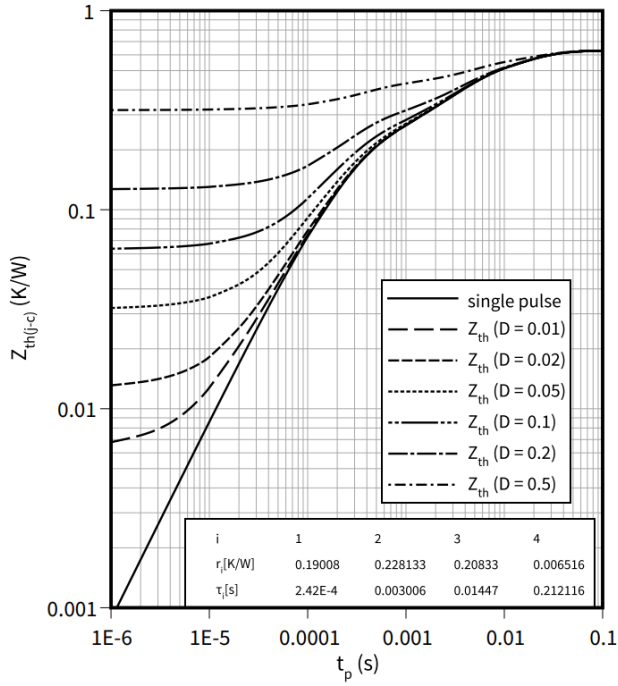
$f = 1000\text{ kHz}$ ,  $V_{GE} = 0\text{ V}$



4 特性图

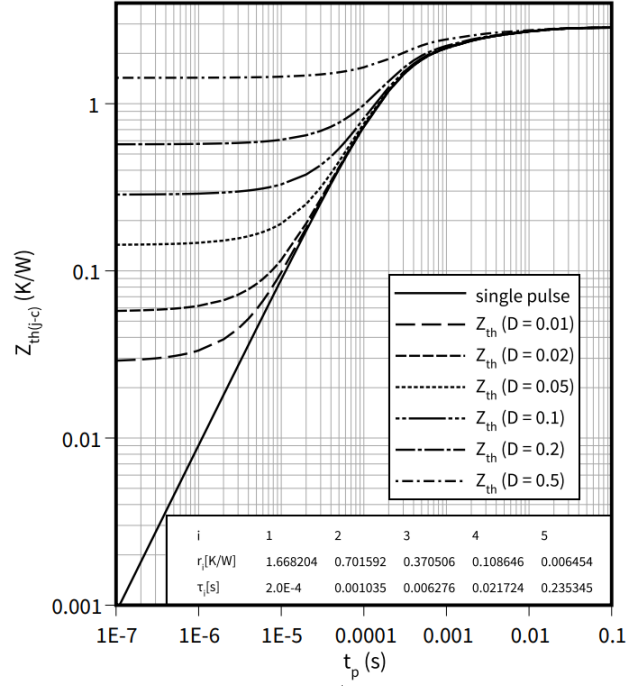
**IGBT transient thermal impedance as a function of pulse width**

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



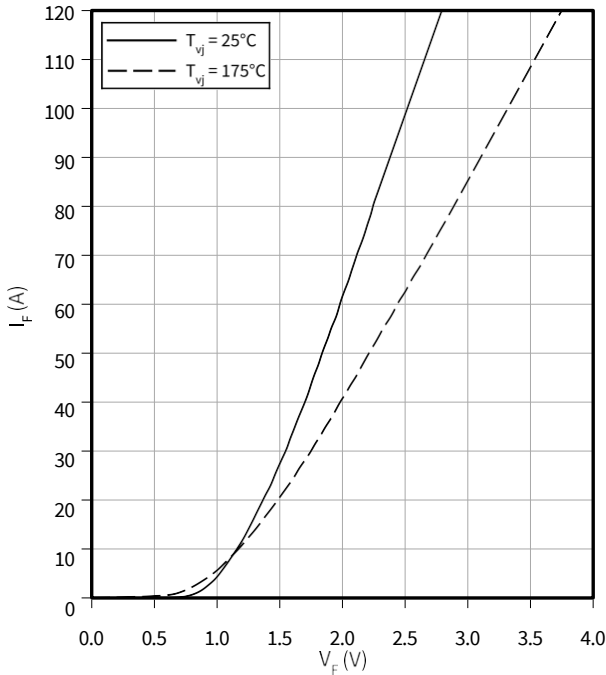
**Diode transient thermal impedance as a function of pulse width**

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



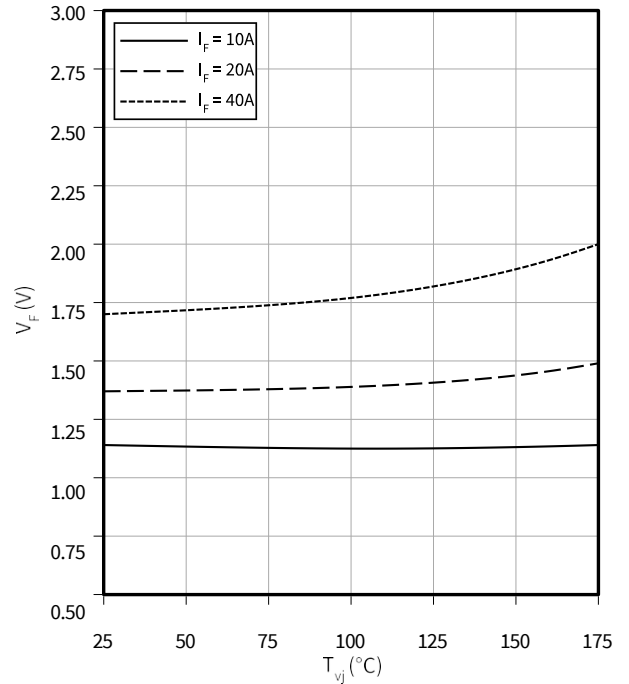
**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$



**Typical diode forward voltage as a function of junction temperature**

$V_F = f(T_{vj})$

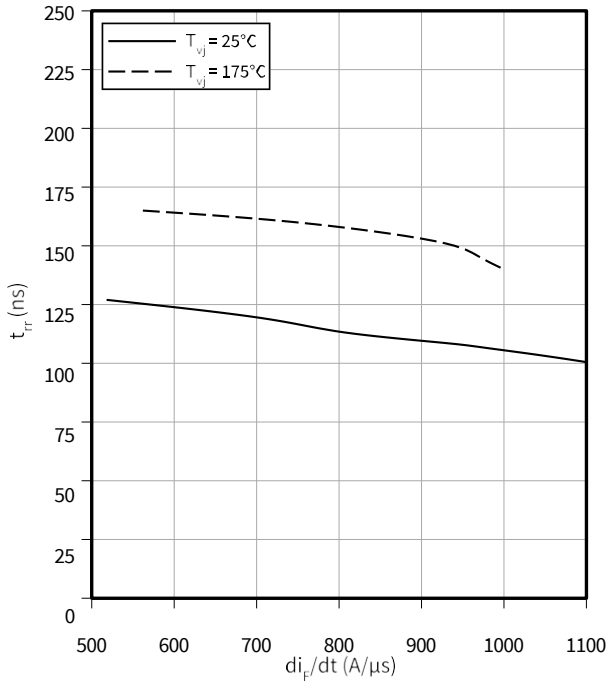


4 特性图

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

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

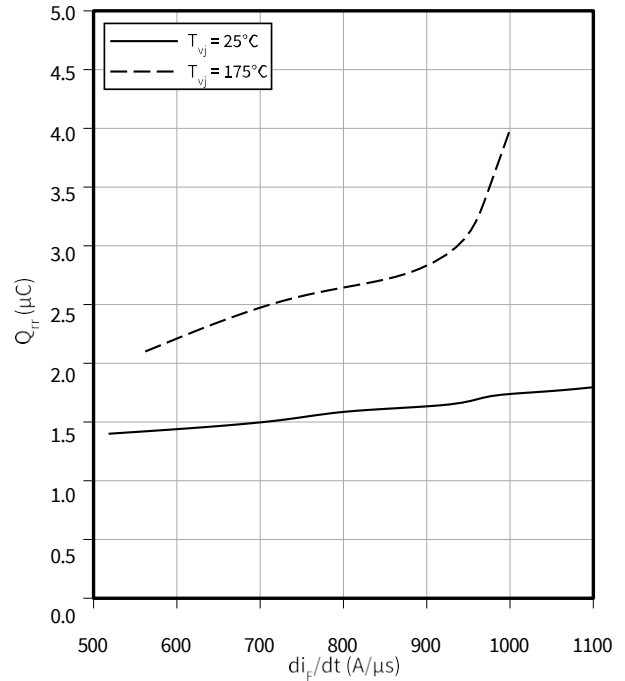
$V_R = 400\text{ V}, I_F = 20\text{ A}$



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

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

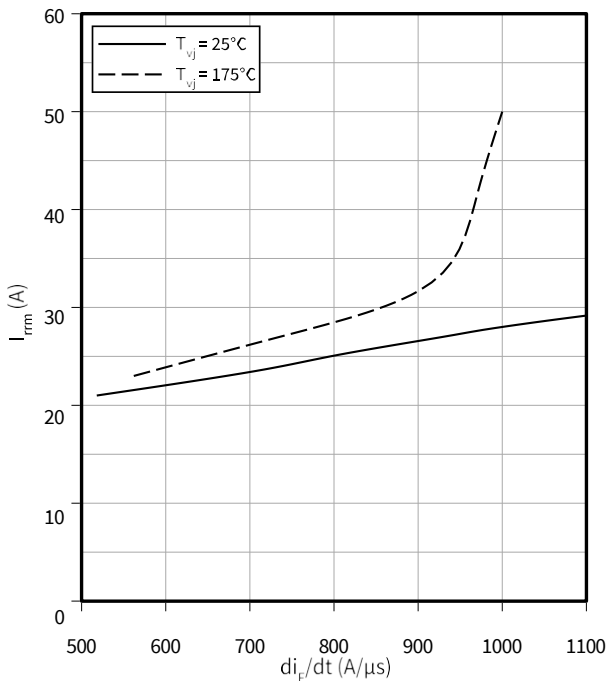
$V_R = 400\text{ V}, I_F = 20\text{ A}$



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

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

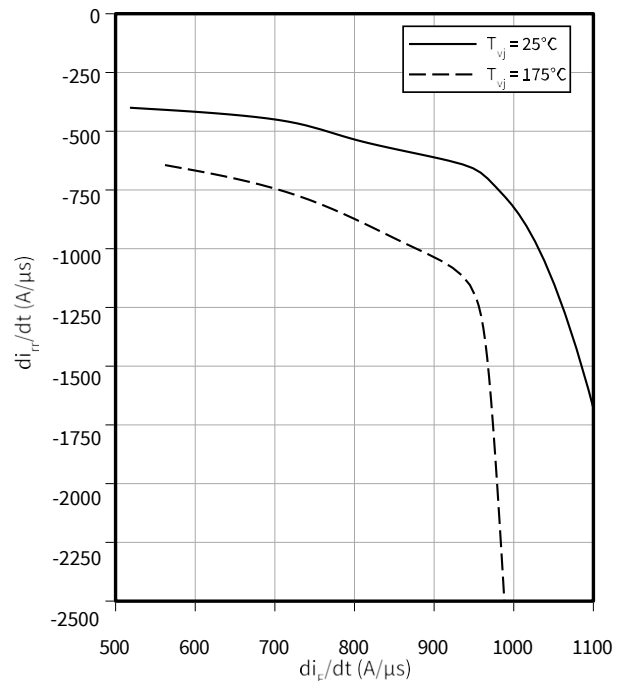
$V_R = 400\text{ V}, I_F = 20\text{ A}$



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

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

$V_R = 400\text{ V}, I_F = 20\text{ A}$



5 封装外形

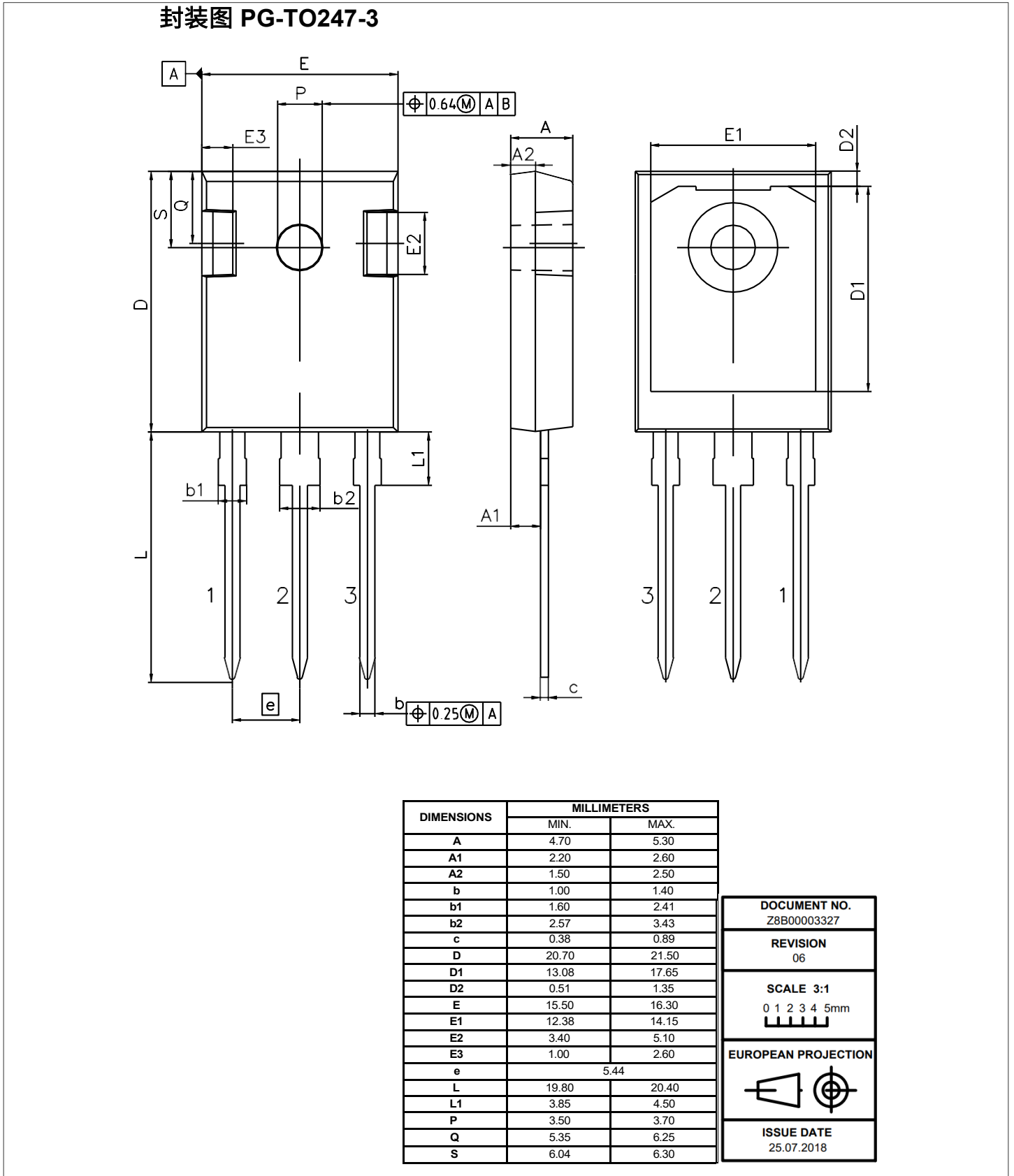


图 1

**6 测试条件**

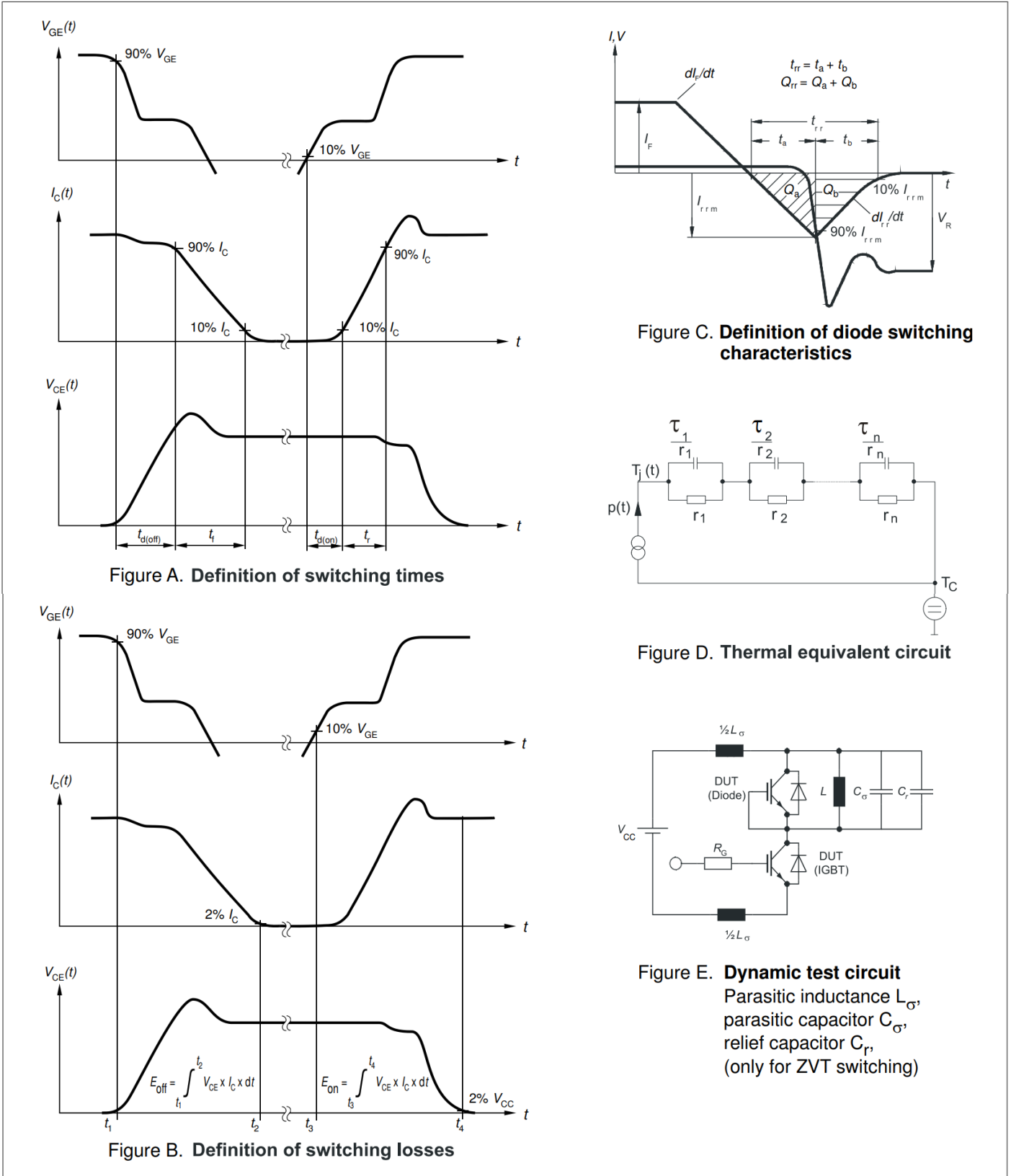


图 2

## 修订记录

Document revision	Date of release	Description of changes
V1.1	2014-12-05	Preliminary data sheet
V1.2	2015-03-27	New dynamic parameters and graphs
V1.3	2015-05-12	New dynamic parameters
V2.1	2015-12-10	Final data sheet
n/a	2020-11-30	Datasheet migrated to a new system with a new layout and new revision number schema: target or preliminary datasheet = 0.xy; final datasheet = 1.xy
1.10	2022-03-08	Added transient gate-emitter voltage Updated diagram $E = f(I_c)$
1.20	2022-05-13	Transient gate-emitter voltage $V_{GE}$ added in table “Maximum rated values” of IGBT Update of diagram “Typical switching energy losses as a function of collector current”, $E = f(I_c)$ “Forward bias safe operating area” diagram renamed to “Reverse bias safe operating area”
1.30	2023-06-06	Power dissipation conditions on page 3 updated Editorial changes



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版本 2025-10-15

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德国 Neubiberg 85579

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