

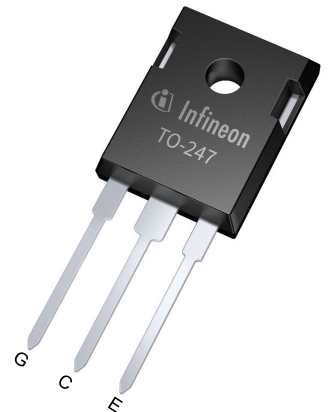
**Reverse-Conducting IGBT with monolithic body diode**

**Features**

- $V_{CE} = 650\text{ V}$
- $I_C = 40\text{ A}$
- Powerful monolithic diode optimized for ZCS applications
- High ruggedness, temperature stable behavior
- Very low  $V_{CEsat}$  and low  $E_{off}$
- Easy paralleling capability due to positive temperature coefficient in  $V_{CEsat}$
- Low EMI
- Low electrical parameters depending (dependence) on temperature
- Qualified according to JESD-022 for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>

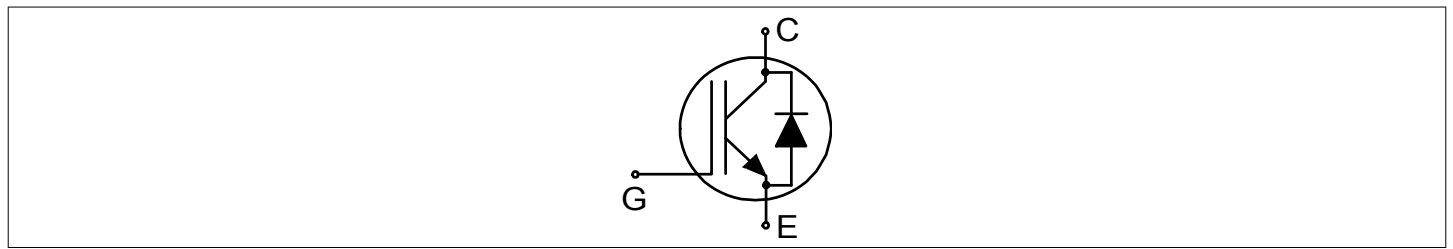
**Potential applications**

- Welding
- PFC
- ZCS - converters



- Lead-Free
- Green
- Halogen-Free
- RoHS

**Description**



Type	Package	Marking
IKW40N65WR5	PG-TO247-3	K40EWR5

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## 1 Package

**Table 1** Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Internal emitter inductance measured 5 mm (0.197 in.) from case	$L_E$			13.0		nH
Storage temperature	$T_{stg}$		-55		150	°C
Soldering temperature		wave soldering 1.6 mm (0.063 in.) from case for 10 s			260	°C
Mounting torque	$M$	M3 screw Maximum of mounting process: 3			0.6	Nm
Thermal resistance, junction-ambient	$R_{th(j-a)}$				40	K/W

## 2 IGBT

**Table 2** Maximum rated values

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
			$T_c = 130\text{ °C}$	115	

**Table 3** Characteristic values

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	$V_{CEsat}$	$I_C = 40\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.4	1.8	V
			$T_{vj} = 175\text{ °C}$	1.65		
Gate-emitter threshold voltage	$V_{GEth}$	$I_C = 0.4\text{ mA}, V_{CE} = V_{GE}$	3.2	4	4.8	V

(table continues...)  
Datasheet

**Table 3 (continued) Characteristic values**

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Zero gate-voltage collector current	$I_{CES}$	$V_{CE} = 650 \text{ V}, V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$			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	$Q_G$	$I_C = 40 \text{ A}, V_{GE} = 15 \text{ V}, V_{CC} = 520 \text{ V}$			193		nC
Turn-on delay time	$t_{d(on)}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		42		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		42		
Rise time (inductive load)	$t_r$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		18		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		21		
Turn-off delay time	$t_{d(off)}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		432		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		500		
Fall time (inductive load)	$t_f$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		16		ns
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		10		
Turn-on energy	$E_{on}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		0.77		mJ
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		0.82		
Turn-off energy	$E_{off}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		0.16		mJ
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		0.24		
Total switching energy	$E_{ts}$	$V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_{Gon} = 20 \text{ } \Omega, R_{Goff} = 20 \text{ } \Omega, L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		0.93		mJ
			$T_{vj} = 175 \text{ }^\circ\text{C}, I_C = 20 \text{ A}$		1.06		

(table continues...)

**Table 3 (continued) Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
IGBT thermal resistance, junction to case	$R_{th(j-c)}$				0.65	K/W
Operating junction temperature	$T_{vj}$		-40		175	°C

Note: Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified.

### 3 Diode

**Table 4 Maximum rated values**

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

**Table 5 Characteristic values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Diode forward voltage	$V_F$	$I_F = 20\text{ A}$	$T_{vj} = 25^{\circ}\text{C}$	1.4	1.9	V
			$T_{vj} = 175^{\circ}\text{C}$	1.5		
Diode reverse recovery time	$t_{rr}$	$V_R = 400\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$	112		ns
			$T_{vj} = 175^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$	153		
Diode reverse recovery charge	$Q_{rr}$	$V_R = 400\text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$	1.65		$\mu\text{C}$
			$T_{vj} = 175^{\circ}\text{C}$ , $I_F = 20\text{ A}$ , $-di_F/dt = 900\text{ A}/\mu\text{s}$	2.8		

(table continues...)

**Table 5 (continued) Characteristic values**

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
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
					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		A/ $\mu\text{s}$
					1030		
Diode thermal resistance, junction to case	$R_{th(j-c)}$					2.85	K/W
Operating junction temperature	$T_{vj}$			-40		175	°C

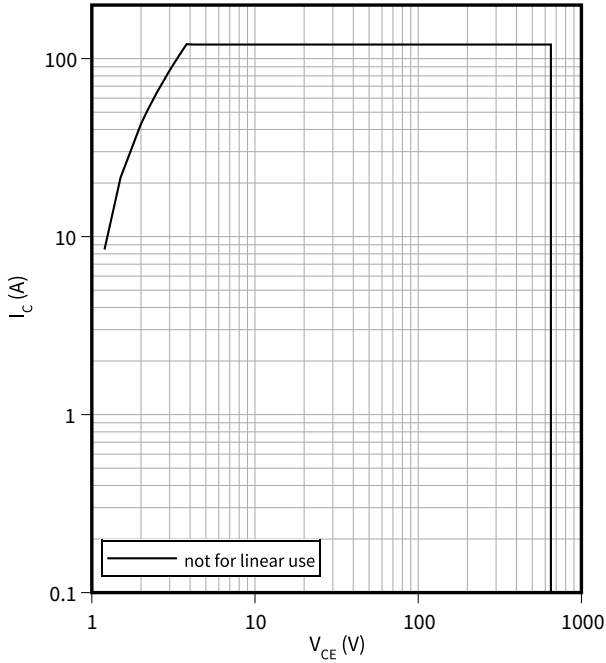
*Note: For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.*

## 4 Characteristics diagrams

### Reverse bias safe operating area

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

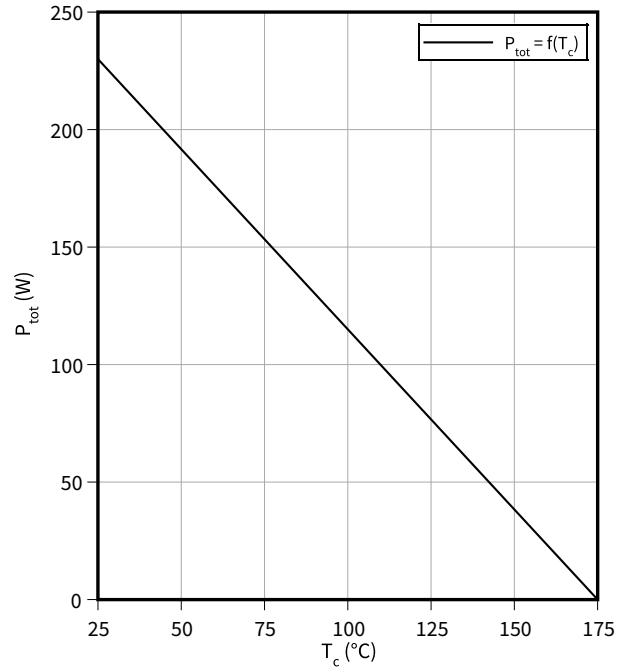
$$T_{vj} \leq 175\text{ °C}, V_{GE} = 15\text{ V}, T_c = 25\text{ °C}$$



### Power dissipation as a function of case temperature

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

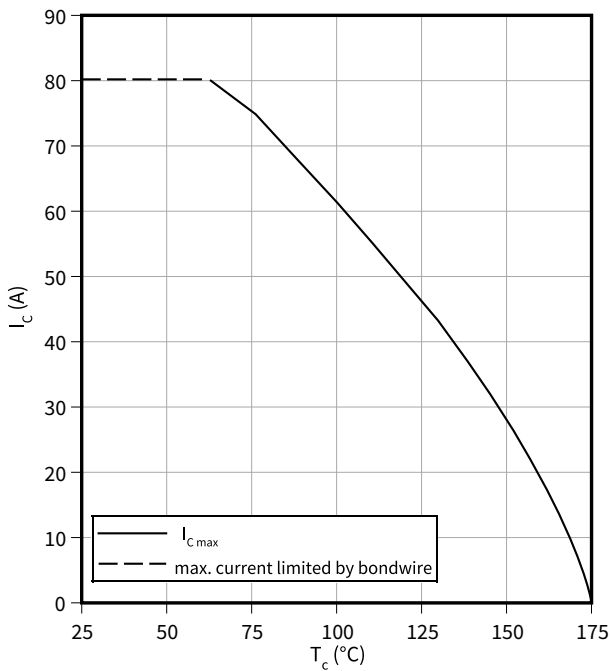
$$T_{vj} \leq 175\text{ °C}$$



### Collector current as a function of case temperature

$$I_C = f(T_c)$$

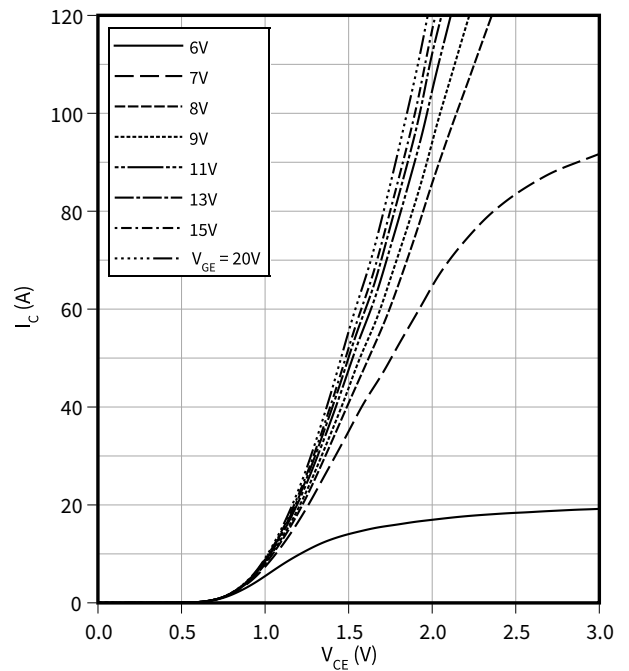
$$T_{vj} \leq 175\text{ °C}, V_{GE} \geq 15\text{ V}$$



### Typical output characteristic

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

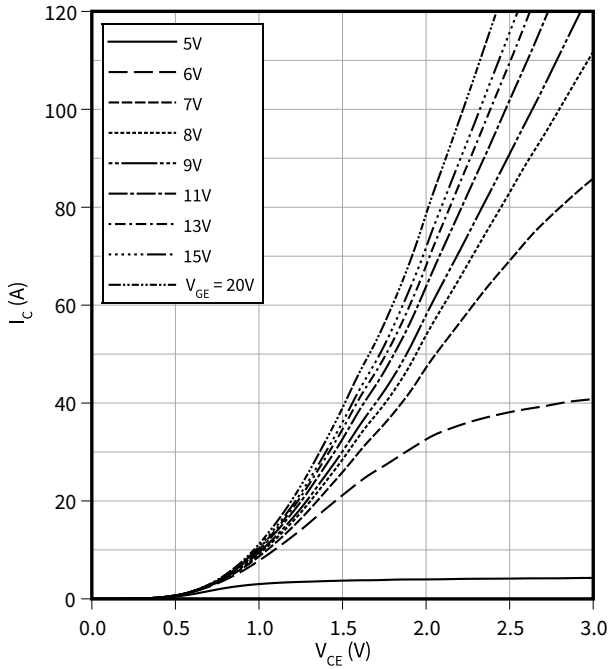
$$T_{vj} = 25\text{ °C}$$



4 Characteristics diagrams

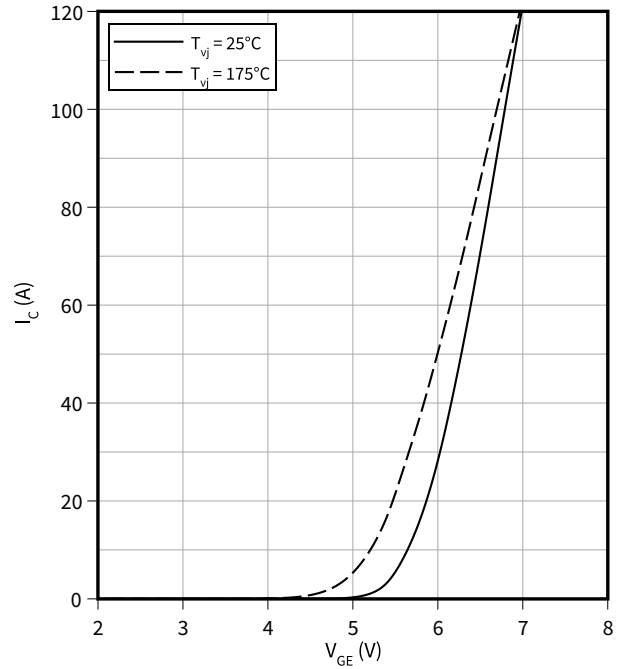
**Typical output characteristic**

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



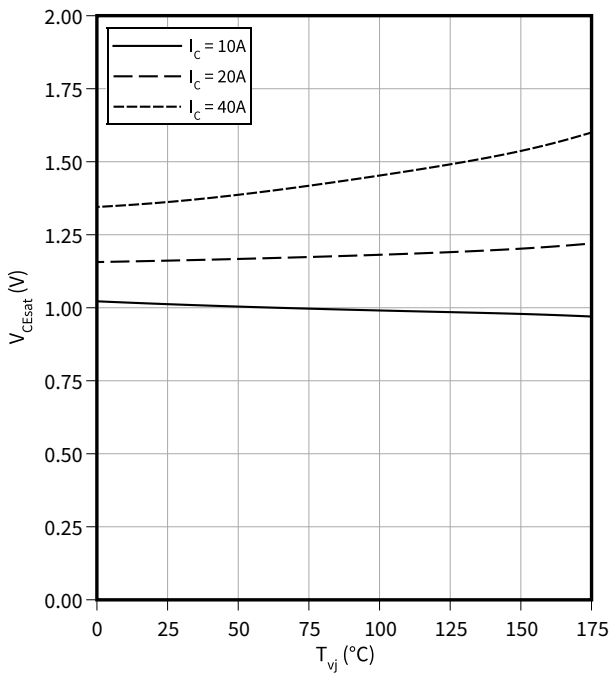
**Typical transfer characteristic**

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



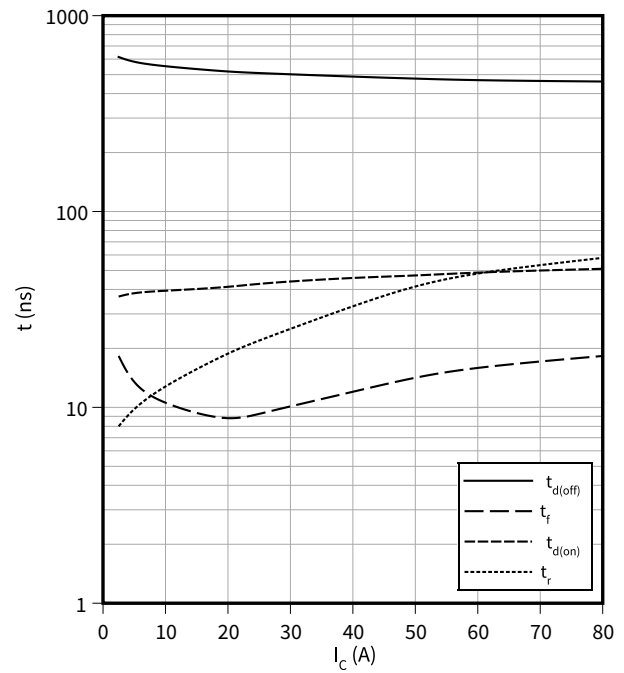
**Typical collector-emitter saturation voltage as a function of junction temperature**

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



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

$t = f(I_C)$   
 $V_{CC} = 400\text{ V}, T_{vj} = 175\text{ °C}, V_{GE} = 0/15\text{ V}, R_G = 20\text{ }\Omega$



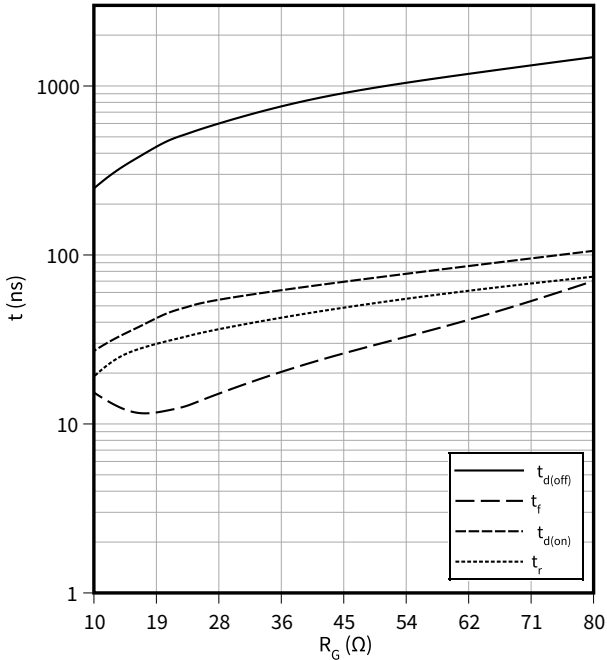


4 Characteristics diagrams

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

$t = f(R_G)$

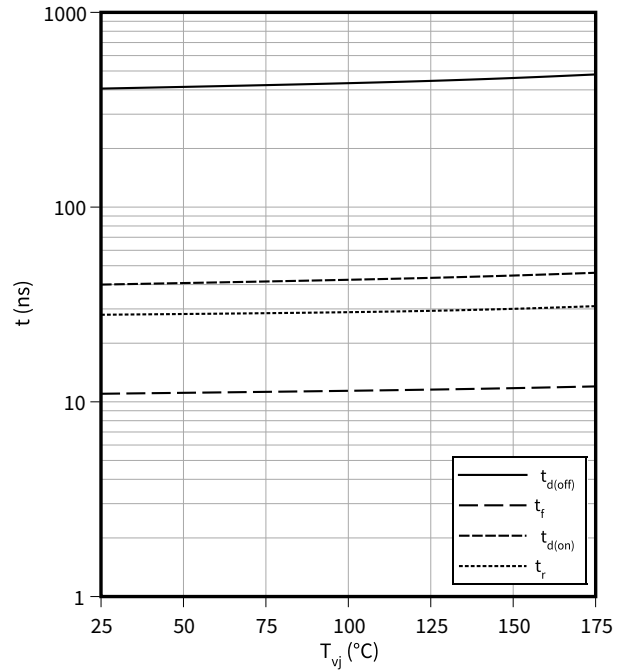
$I_C = 40 \text{ A}, V_{CC} = 400 \text{ V}, T_{vj} = 175 \text{ }^\circ\text{C}, V_{GE} = 0/15 \text{ V}$



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

$t = f(T_{vj})$

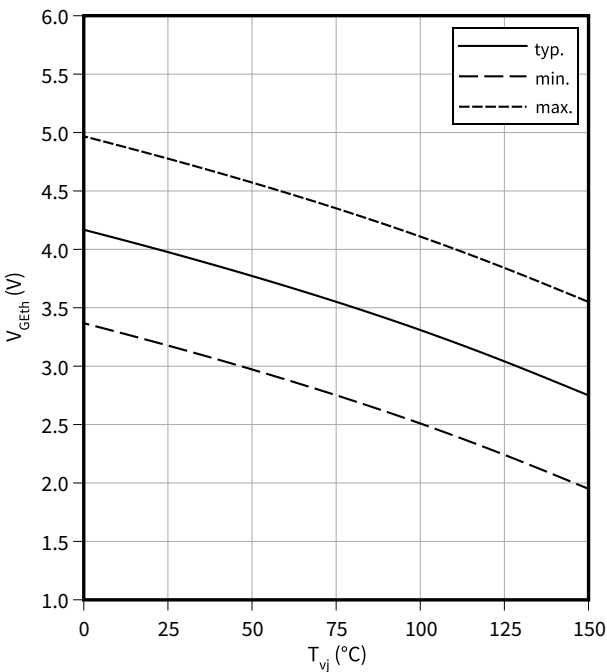
$I_C = 40 \text{ A}, V_{CC} = 400 \text{ V}, V_{GE} = 0/15 \text{ V}, R_G = 20 \text{ } \Omega$



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

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

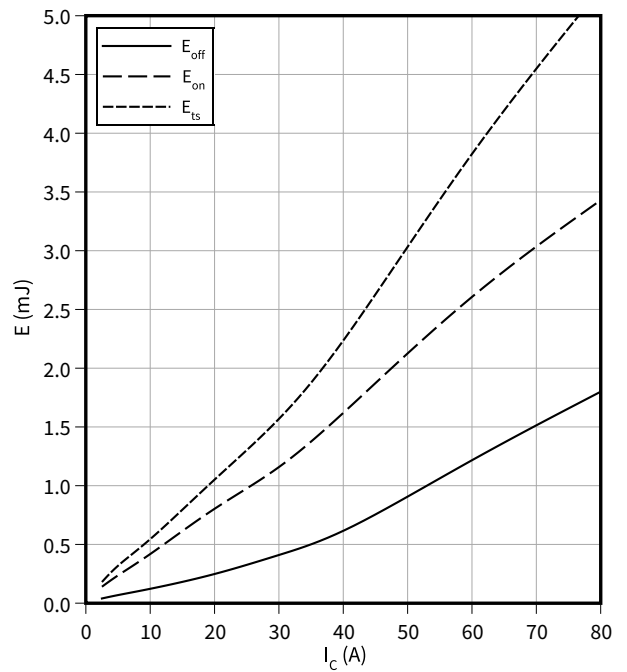
$I_C = 0.4 \text{ mA}$



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

$E = f(I_C)$

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

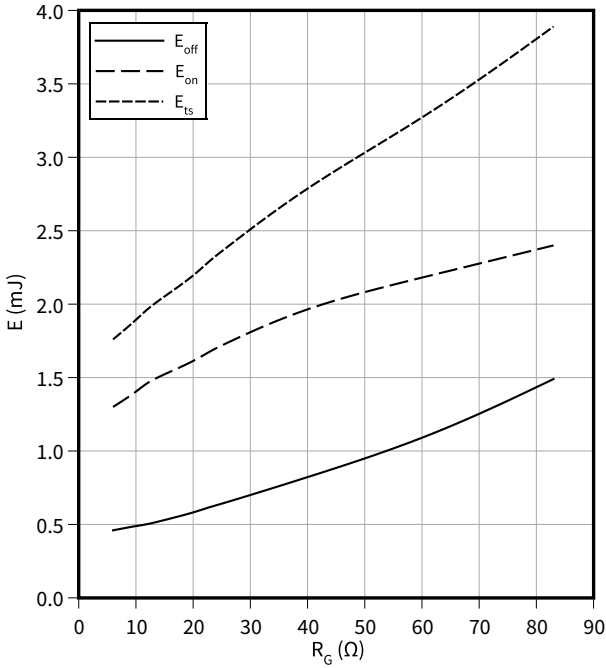


4 Characteristics diagrams

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

$E = f(R_G)$

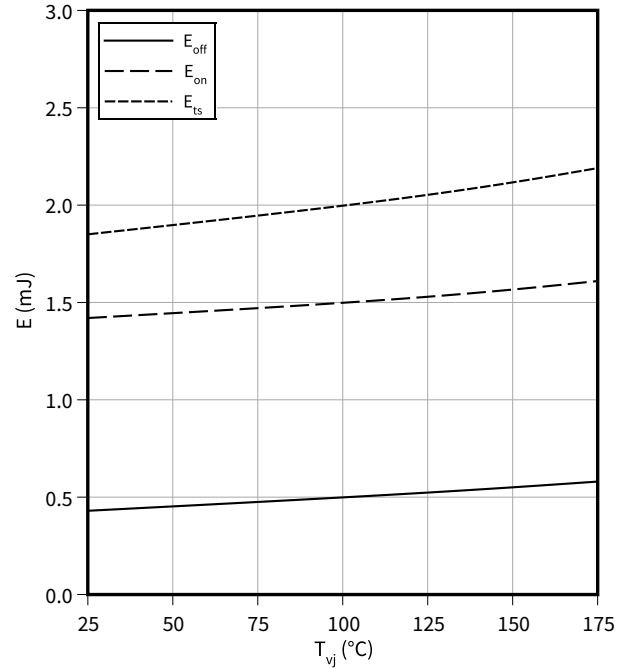
$I_C = 40\text{ A}$ ,  $V_{CC} = 400\text{ V}$ ,  $T_{vj} = 175\text{ °C}$ ,  $V_{GE} = 0/15\text{ V}$



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

$E = f(T_{vj})$

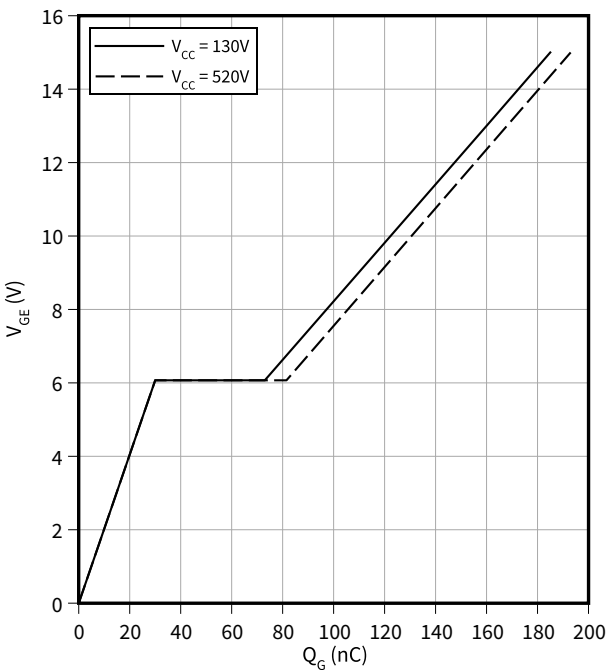
$I_C = 40\text{ A}$ ,  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_G = 20\text{ Ω}$



**Typical gate charge**

$V_{GE} = f(Q_G)$

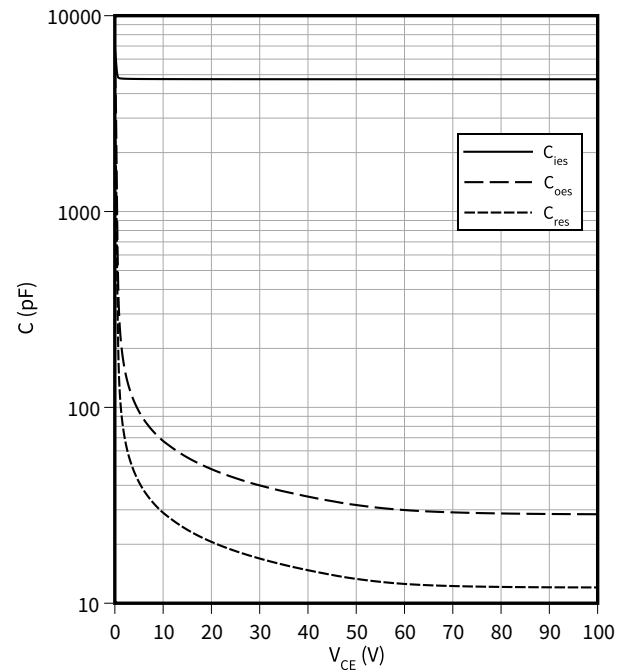
$I_C = 40\text{ A}$



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

$C = f(V_{CE})$

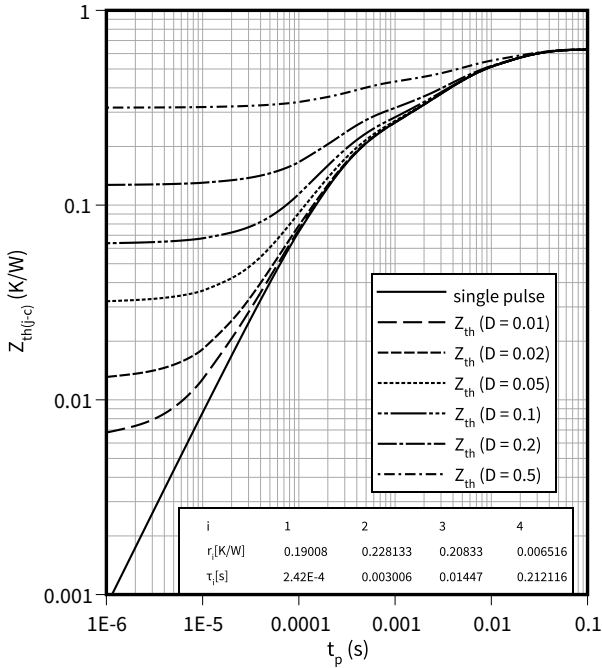
$f = 1000\text{ kHz}$ ,  $V_{GE} = 0\text{ V}$



4 Characteristics diagrams

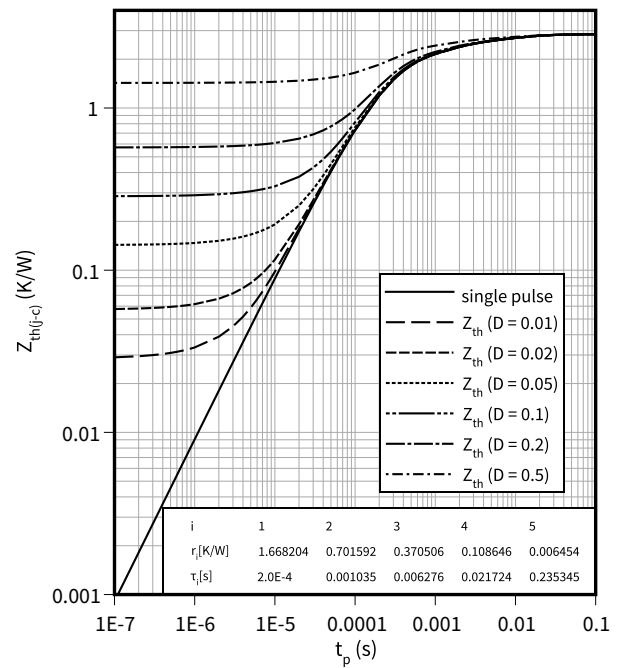
**IGBT transient thermal impedance as a function of pulse width**

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



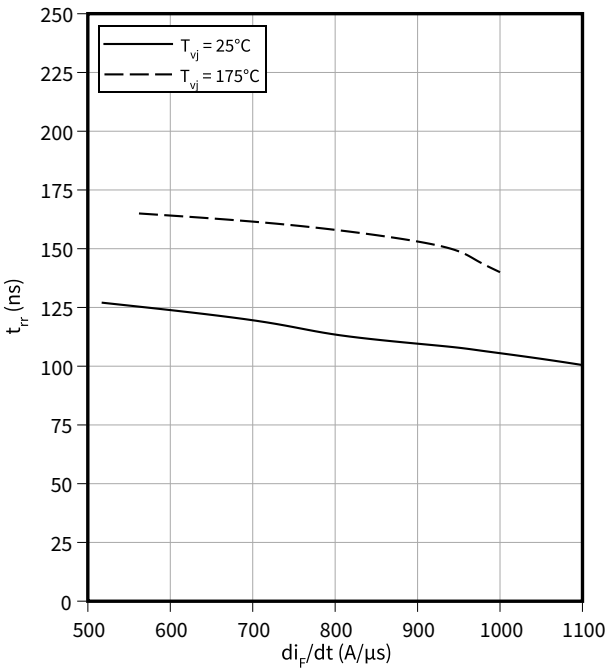
**Diode transient thermal impedance as a function of pulse width**

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



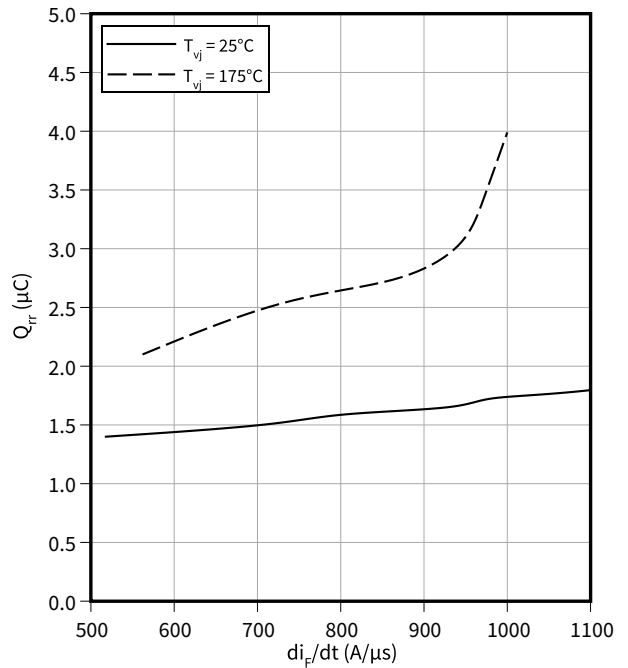
**Typical reverse recovery time as a function of diode current slope**

$t_{rr} = f(di_F/dt)$   
 $V_R = 400\text{ V}, I_F = 20\text{ A}$



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

$Q_{rr} = f(di_F/dt)$   
 $V_R = 400\text{ V}, I_F = 20\text{ A}$

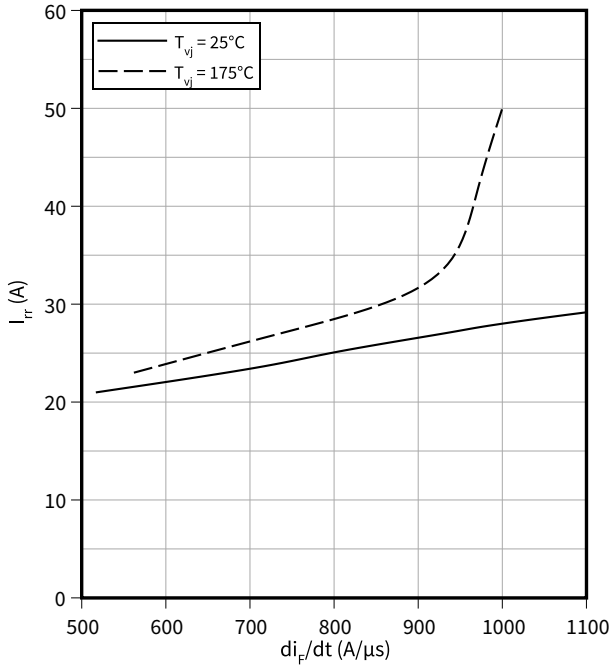


4 Characteristics diagrams

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

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

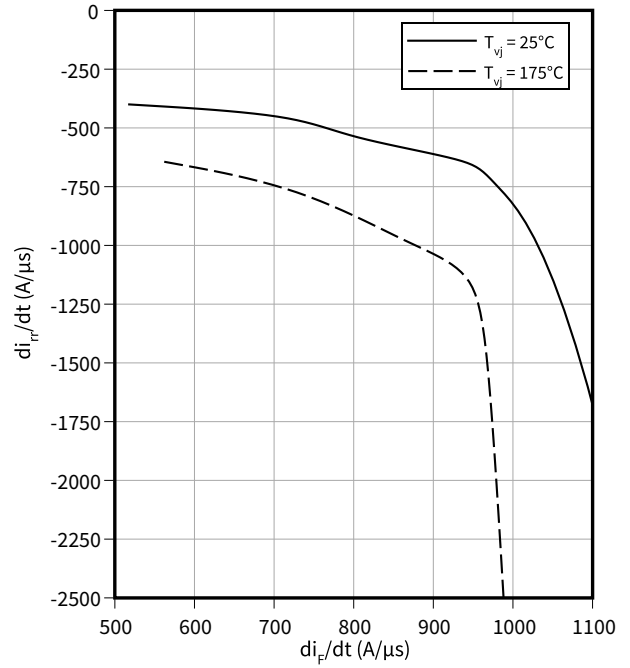
$V_R = 400\text{ V}, I_F = 20\text{ A}$



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

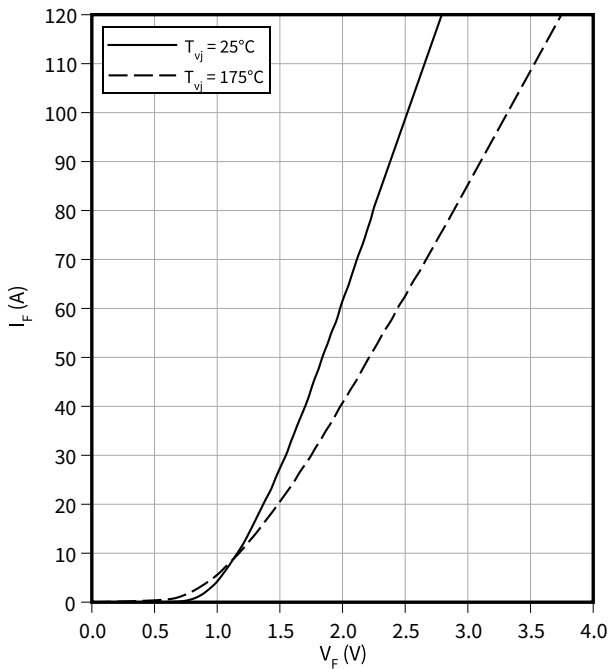
$di_{rr}/dt = f(di_F/dt)$

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



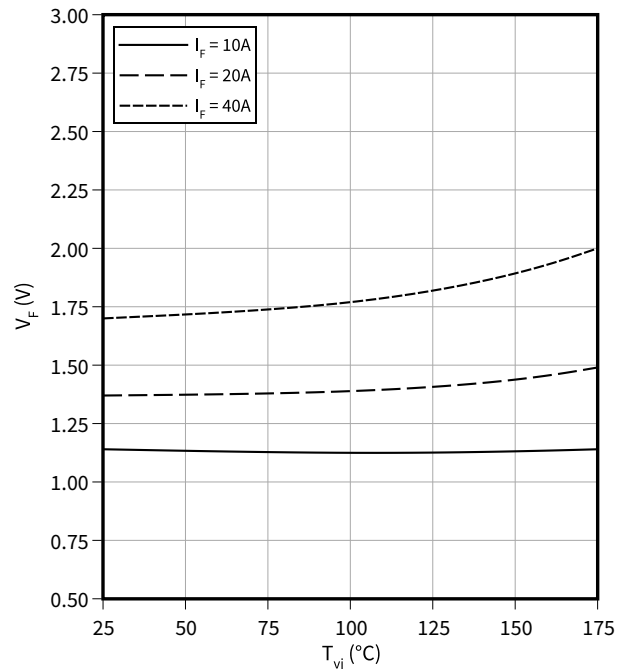
**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$

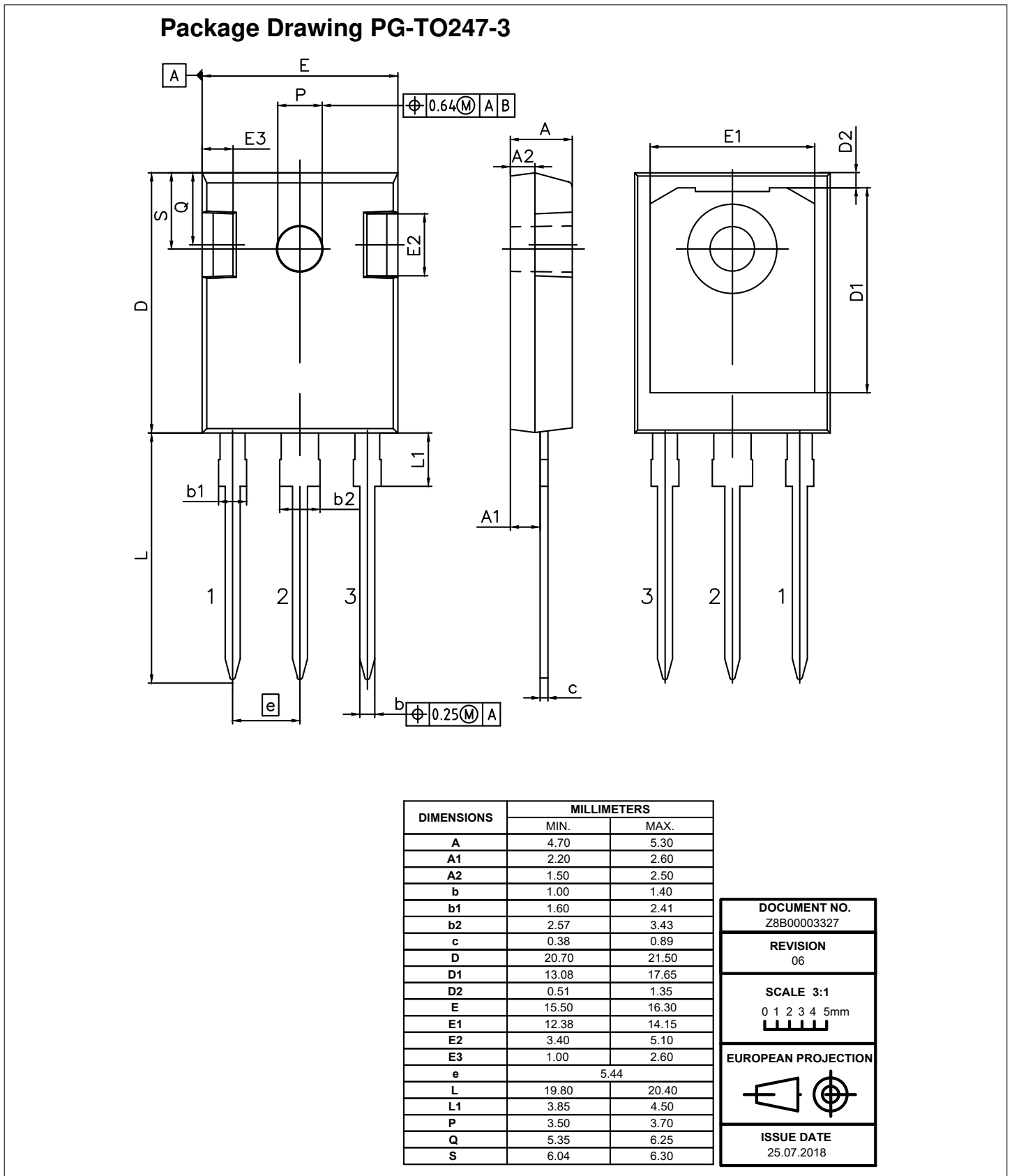


**Typical diode forward voltage as a function of junction temperature**

$V_F = f(T_{vj})$

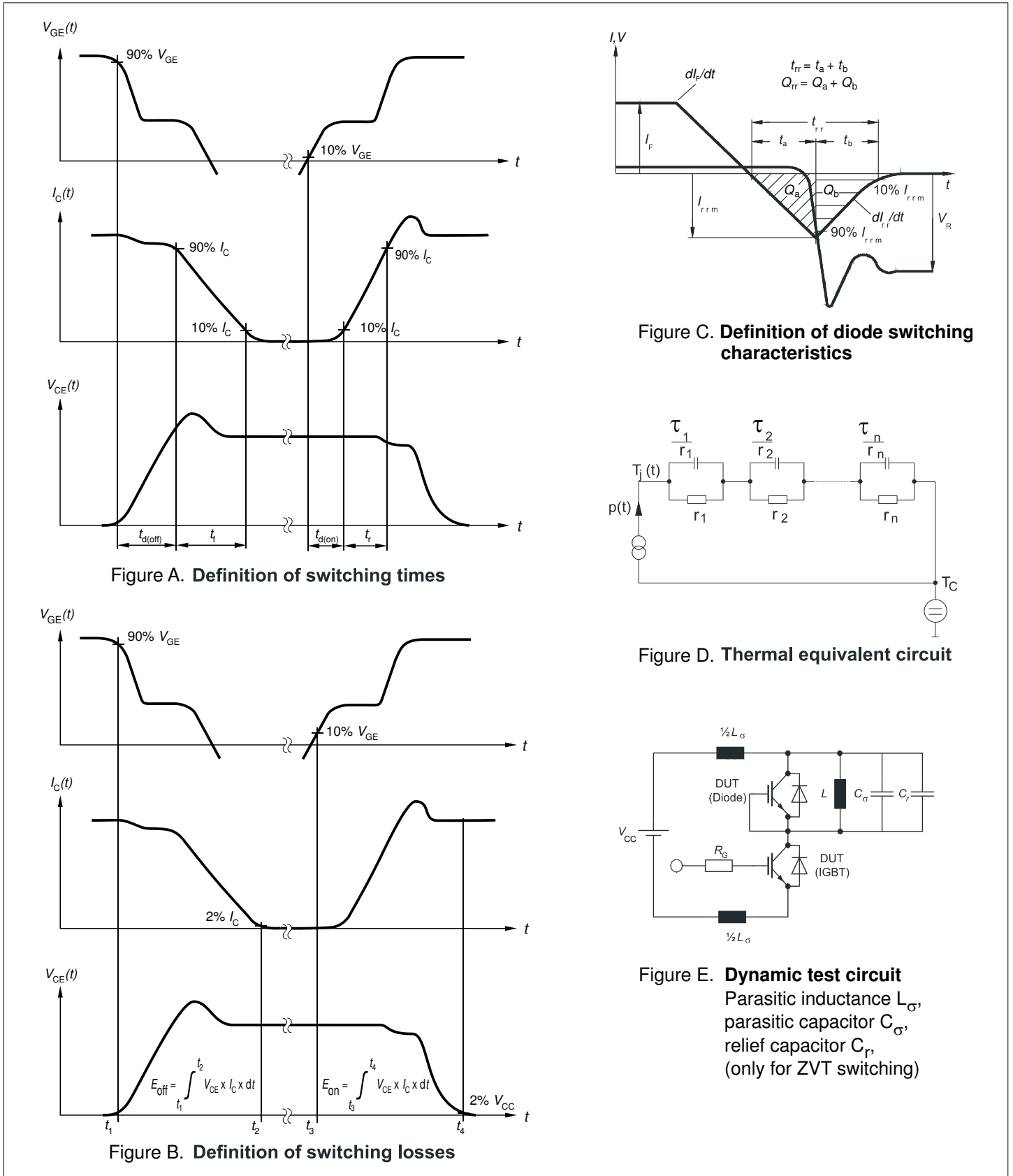


**5 Package outlines**



**Figure 1**

## 6 Testing conditions



**Figure 2**

## Revision history

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”