

Reverse-Conducting IGBT with monolithic body diode

Features

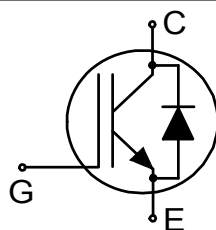
- $V_{CE} = 650\text{ V}$
- $I_C = 40\text{ A}$
- Powerful monolithic diode optimized for ZCS applications
- High ruggedness, temperature stable behavior
- Very low V_{CEsat} and low E_{off}
- Easy paralleling capability due to positive temperature coefficient in V_{CEsat}
- Low EMI
- Low electrical 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



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}			± 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}		$T_c = 25\text{ °C}$	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}	$V_{CE} = 650 \text{ V}$, $V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ °C}$			40	μA
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	$t_{d(on)}$	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		42		ns
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		42		
Rise time (inductive load)	t_r	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		18		ns
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		21		
Turn-off delay time	$t_{d(off)}$	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		432		ns
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		500		
Fall time (inductive load)	t_f	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		16		ns
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		10		
Turn-on energy	E_{on}	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		0.77		mJ
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		0.82		
Turn-off energy	E_{off}	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		0.16		mJ
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		0.24		
Total switching energy	E_{ts}	$V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 20 \text{ }\Omega$, $R_{Goff} = 20 \text{ }\Omega$, $L_\sigma = 70 \text{ nH}$, $C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ °C}$, $I_C = 20 \text{ A}$		0.93		mJ
			$T_{vj} = 175 \text{ °C}$, $I_C = 20 \text{ A}$		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		μC
			$T_{vj} = 175^{\circ}\text{C}$, $I_F = 20\text{ A}$, $-di_F/dt = 900\text{ A}/\mu\text{s}$		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}	$V_R = 400 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$, $I_F = 20 \text{ A}$, $-di_F/dt = 900 \text{ A}/\mu\text{s}$		27		A
			$T_{vj} = 175 \text{ }^\circ\text{C}$, $I_F = 20 \text{ A}$, $-di_F/dt = 900 \text{ A}/\mu\text{s}$		32		
Diode peak rate of fall of reverse recovery current	di_{rr}/dt	$V_R = 400 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$, $I_F = 20 \text{ A}$, $-di_F/dt = 900 \text{ A}/\mu\text{s}$		585		A/ μs
			$T_{vj} = 175 \text{ }^\circ\text{C}$, $I_F = 20 \text{ A}$, $-di_F/dt = 900 \text{ A}/\mu\text{s}$		1030		
Diode thermal resistance, junction to case	$R_{th(j-c)}$					2.85	K/W
Operating junction temperature	T_{vj}			-40		175	$^\circ\text{C}$

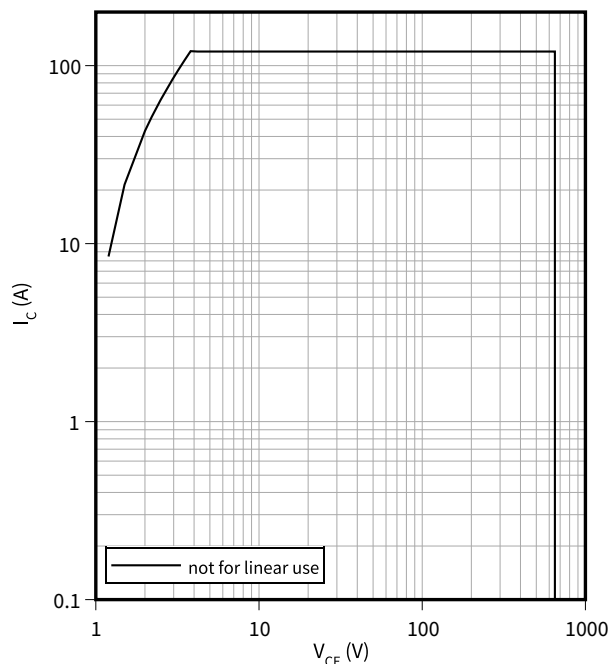
Note: For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

4 Characteristics diagrams

Reverse bias safe operating area

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

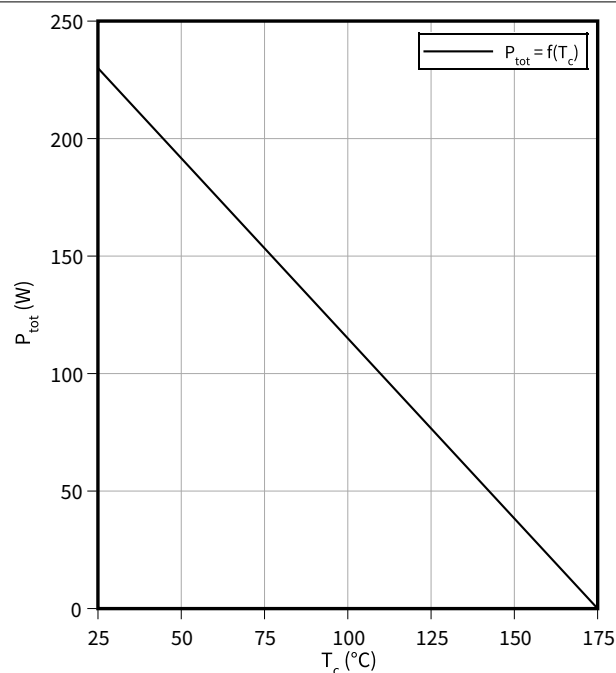
$$T_{vj} \leq 175\text{ °C}, V_{GE} = 15\text{ V}, T_c = 25\text{ °C}$$



Power dissipation as a function of case temperature

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

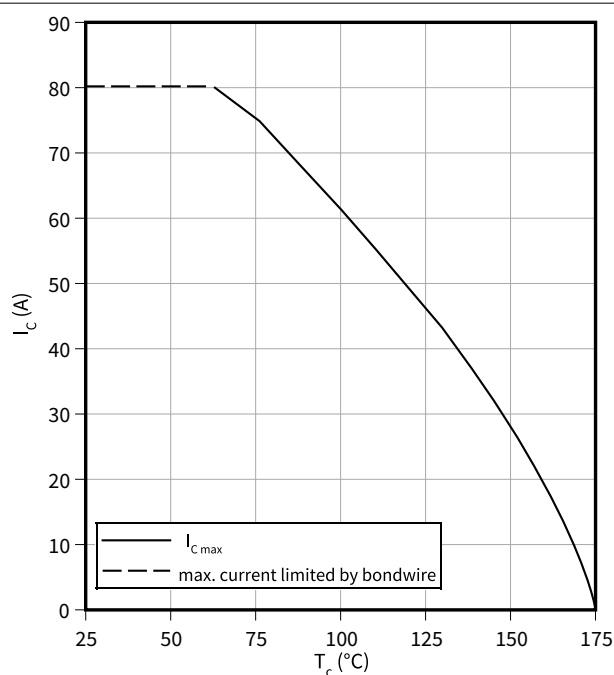
$$T_{vj} \leq 175\text{ °C}$$



Collector current as a function of case temperature

$$I_C = f(T_c)$$

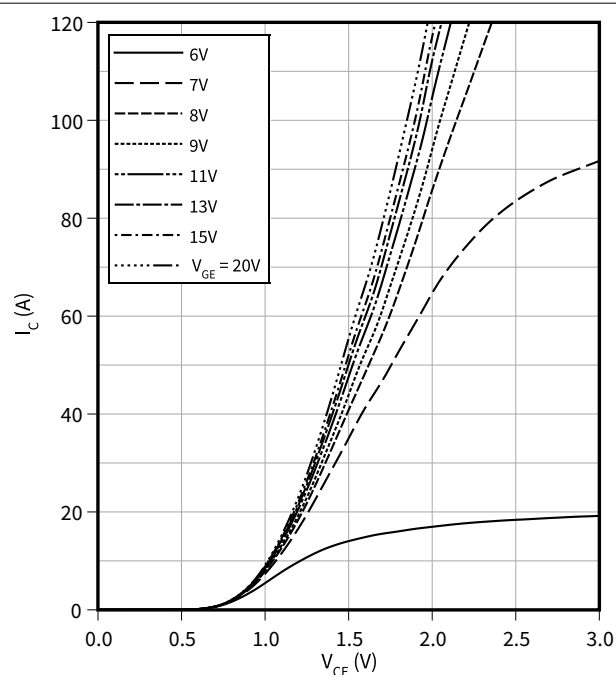
$$T_{vj} \leq 175\text{ °C}, V_{GE} \geq 15\text{ V}$$



Typical output characteristic

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

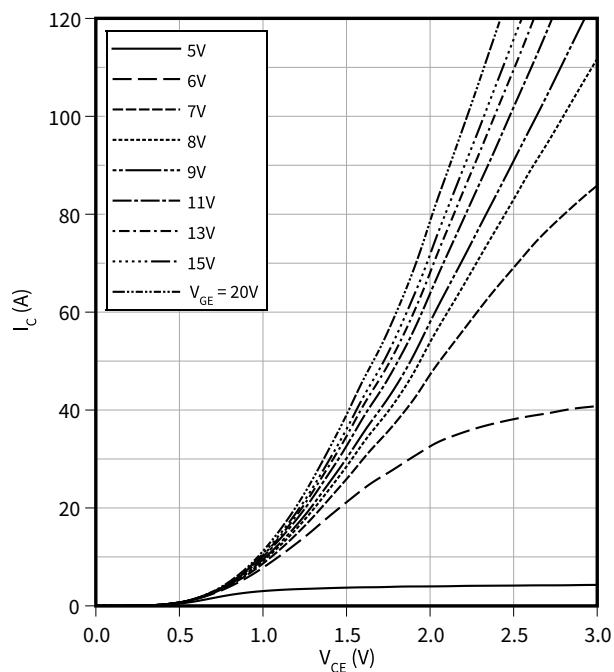
$$T_{vj} = 25\text{ °C}$$



4 Characteristics diagrams

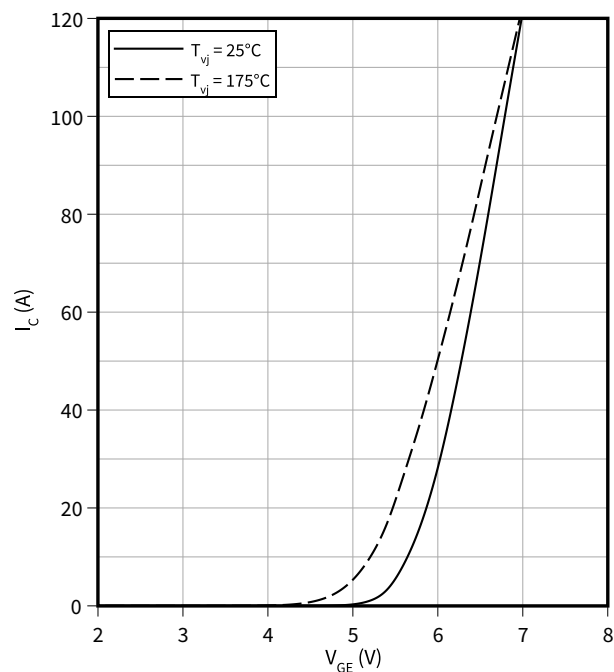
Typical output characteristic

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



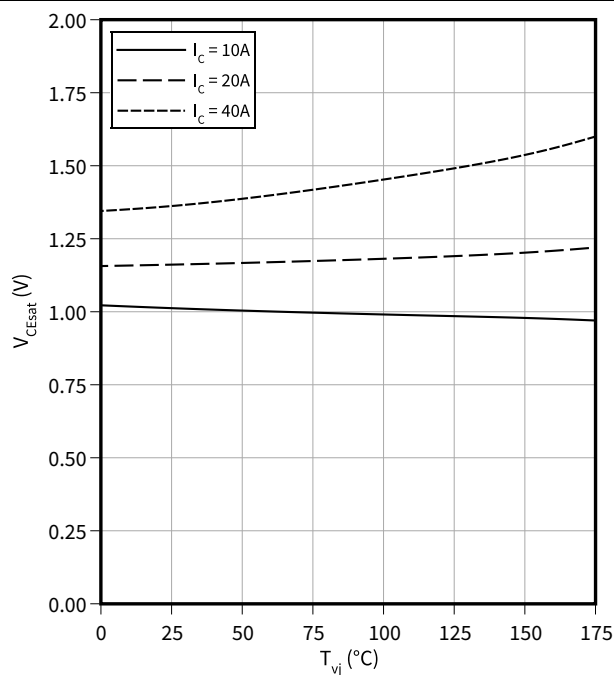
Typical transfer characteristic

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



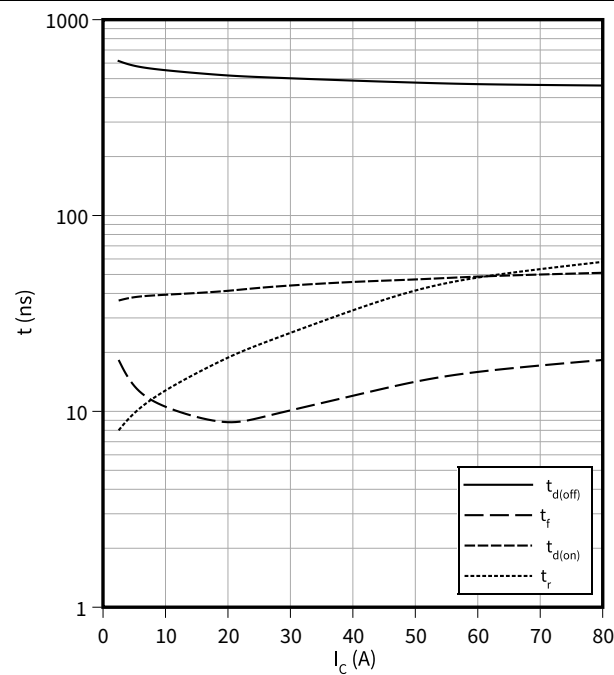
Typical collector-emitter saturation voltage as a function of junction temperature

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



Typical switching times as a function of collector current

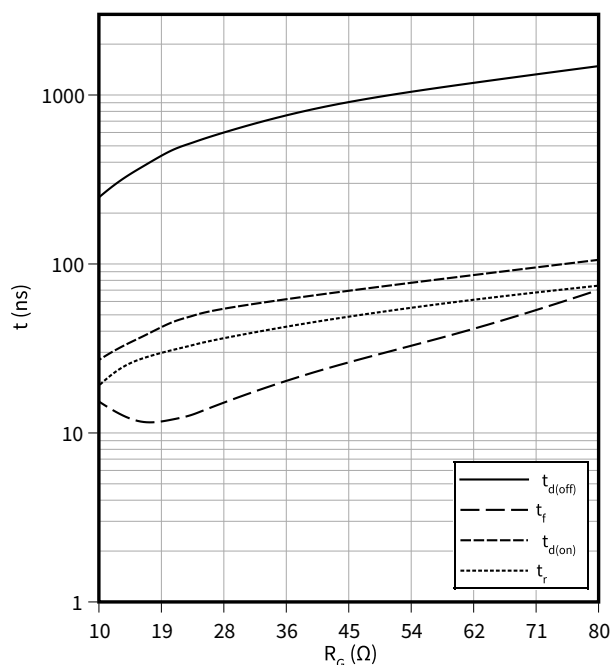
$t = f(I_C)$
 $V_{CC} = 400\text{ V}$, $T_{vj} = 175\text{ °C}$, $V_{GE} = 0/15\text{ V}$, $R_G = 20\text{ }\Omega$



Typical switching times as a function of gate resistor

$$t = f(R_G)$$

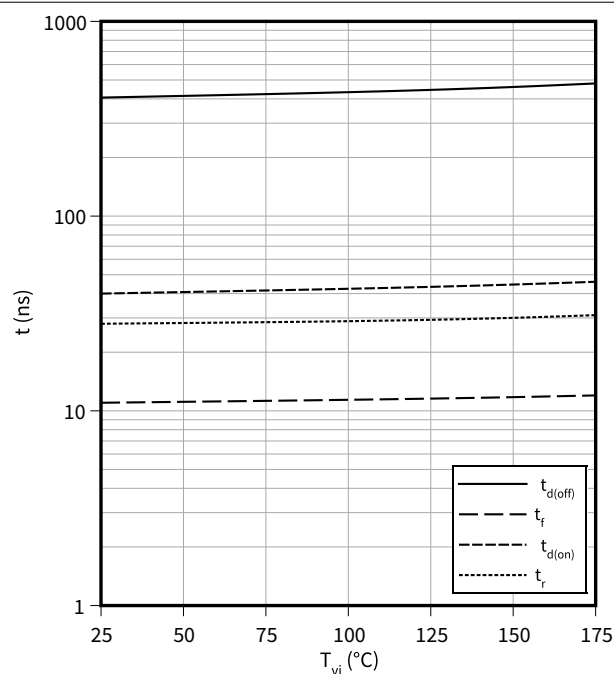
$I_C = 40 \text{ A}$, $V_{CC} = 400 \text{ V}$, $T_{vj} = 175 \text{ }^\circ\text{C}$, $V_{GE} = 0/15 \text{ V}$



Typical switching times as a function of junction temperature

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

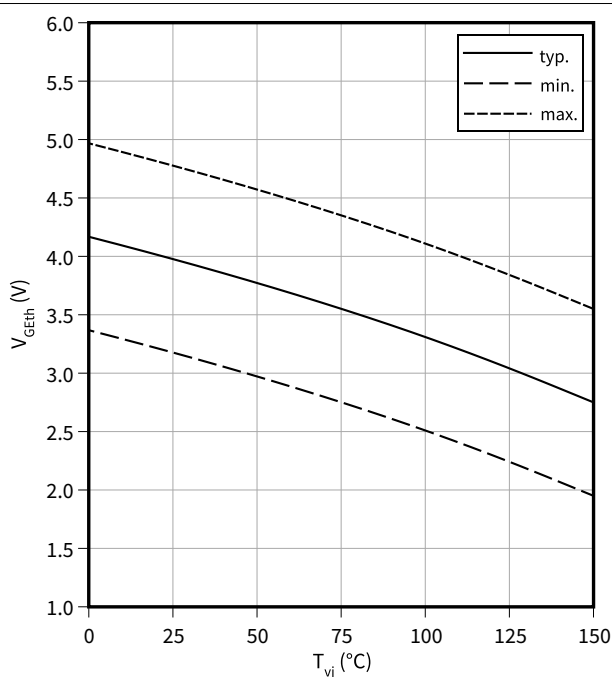
$I_C = 40 \text{ A}$, $V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_G = 20 \text{ }\Omega$



Gate-emitter threshold voltage as a function of junction temperature

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

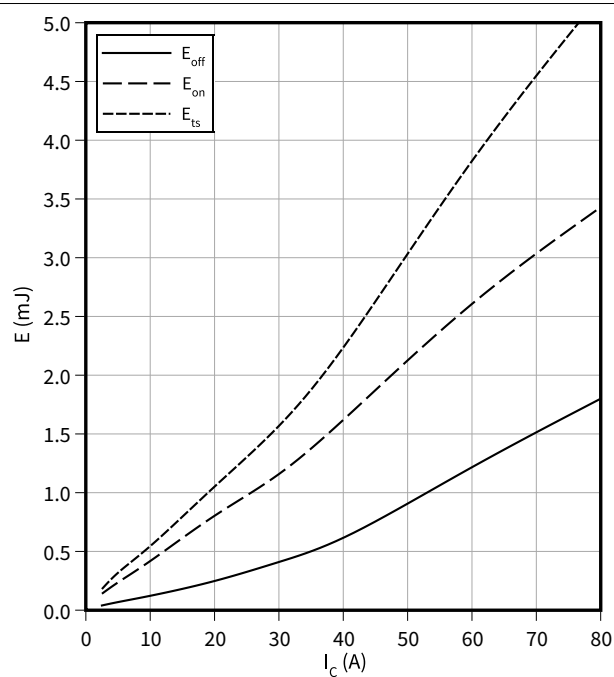
$I_C = 0.4 \text{ mA}$



Typical switching energy losses as a function of collector current

$$E = f(I_C)$$

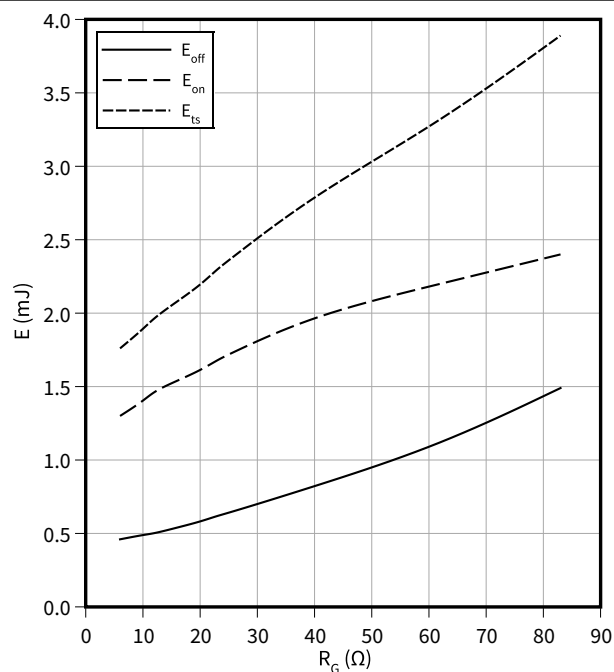
$V_{CC} = 400 \text{ V}$, $T_{vj} = 175 \text{ }^\circ\text{C}$, $V_{GE} = 0/15 \text{ V}$, $R_G = 20 \text{ }\Omega$



Typical switching energy losses as a function of gate resistor

$$E = f(R_G)$$

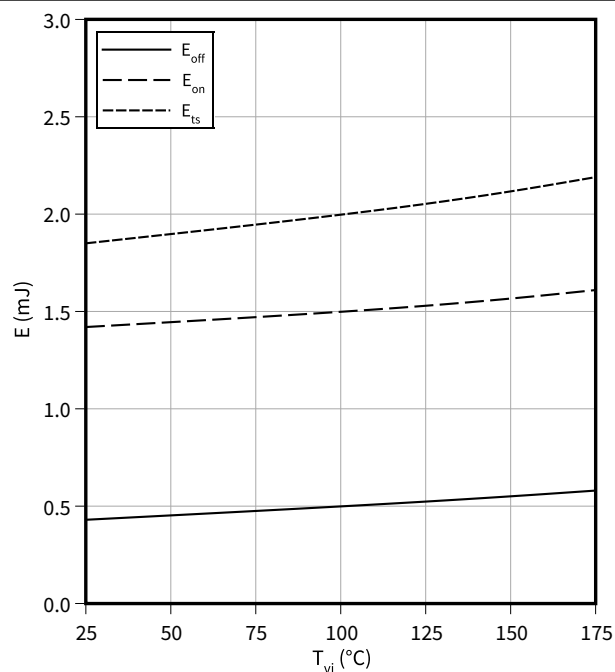
$I_C = 40 \text{ A}$, $V_{CC} = 400 \text{ V}$, $T_{vj} = 175 \text{ °C}$, $V_{GE} = 0/15 \text{ V}$



Typical switching energy losses as a function of junction temperature

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

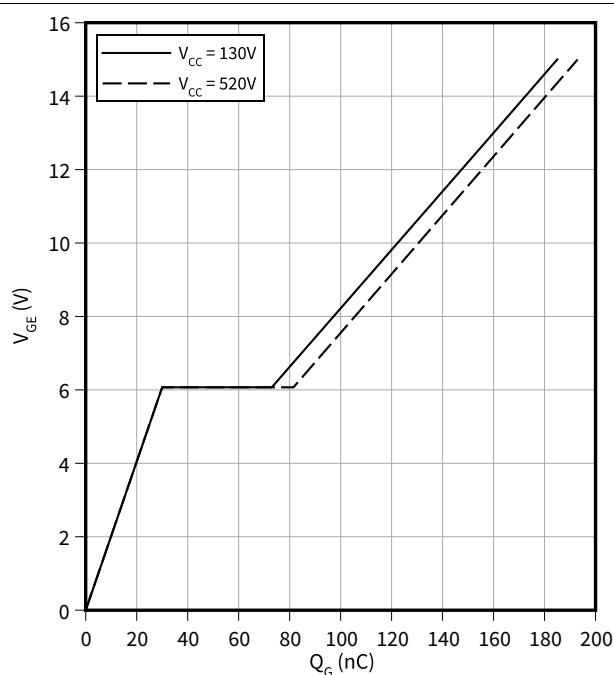
$I_C = 40 \text{ A}$, $V_{CC} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_G = 20 \text{ Ω}$



Typical gate charge

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

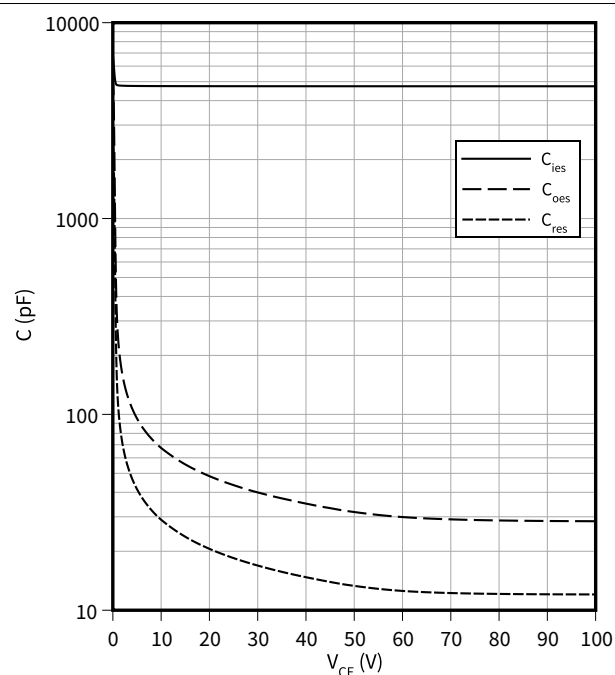
$I_C = 40 \text{ A}$



Typical capacitance as a function of collector-emitter voltage

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

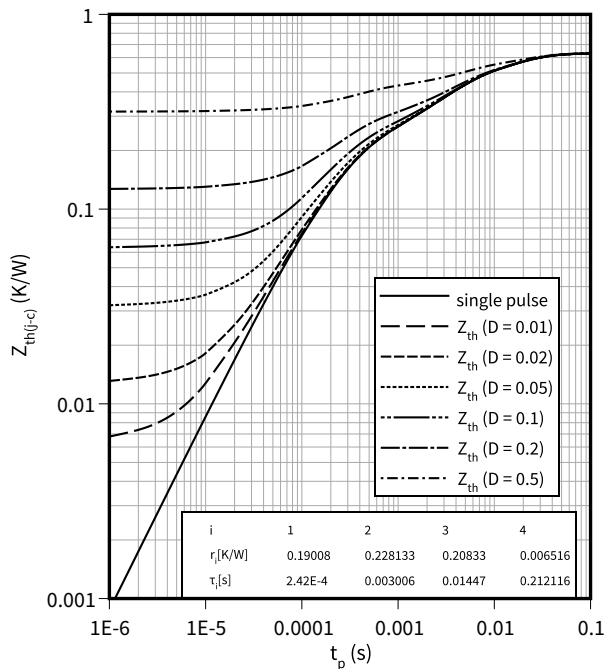
$f = 1000 \text{ kHz}$, $V_{GE} = 0 \text{ V}$



4 Characteristics diagrams

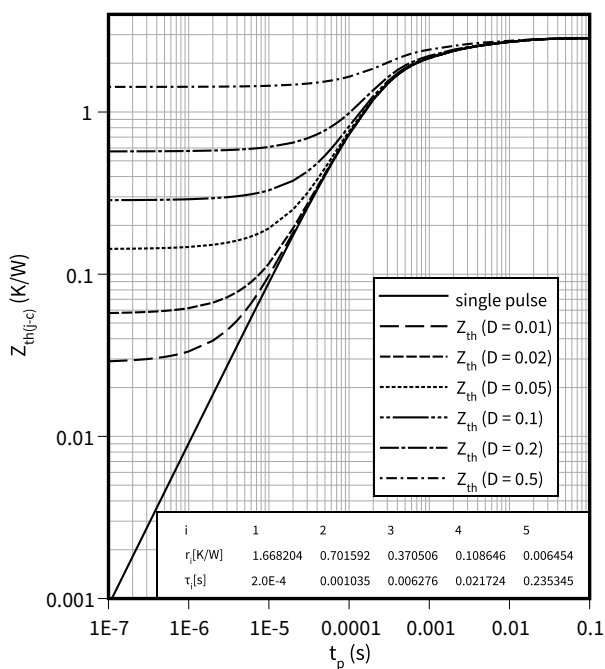
IGBT transient thermal impedance as a function of pulse width

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



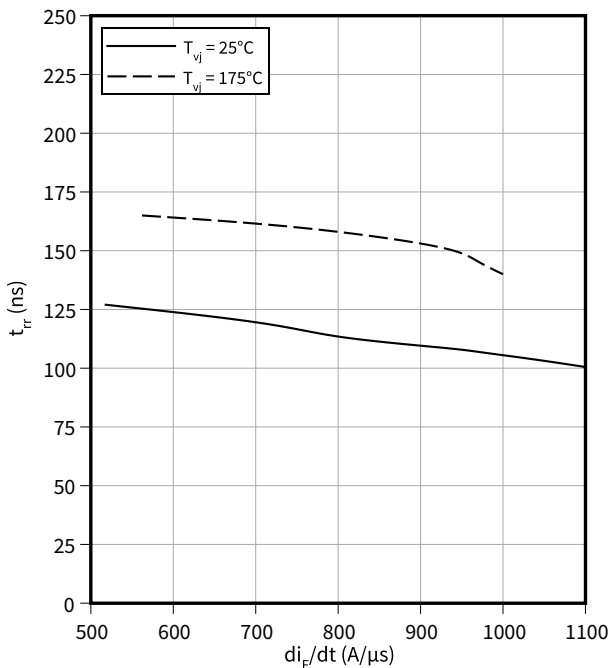
Diode transient thermal impedance as a function of pulse width

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



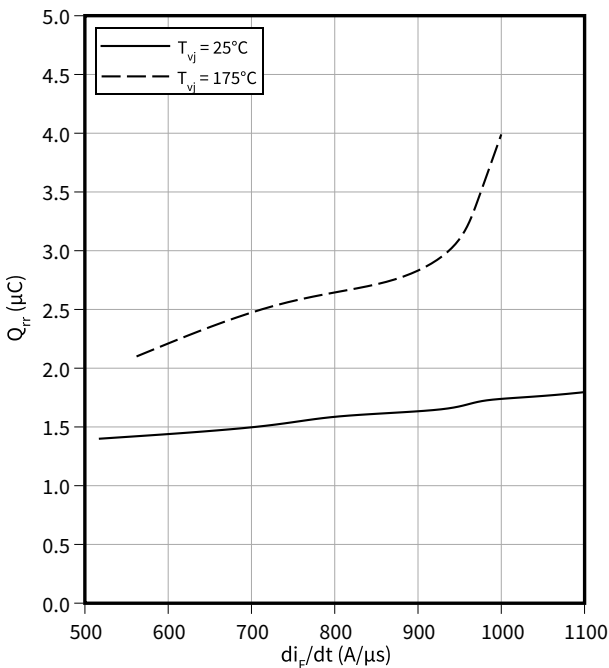
Typical reverse recovery time as a function of diode current slope

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



Typical reverse recovery charge as a function of diode current slope

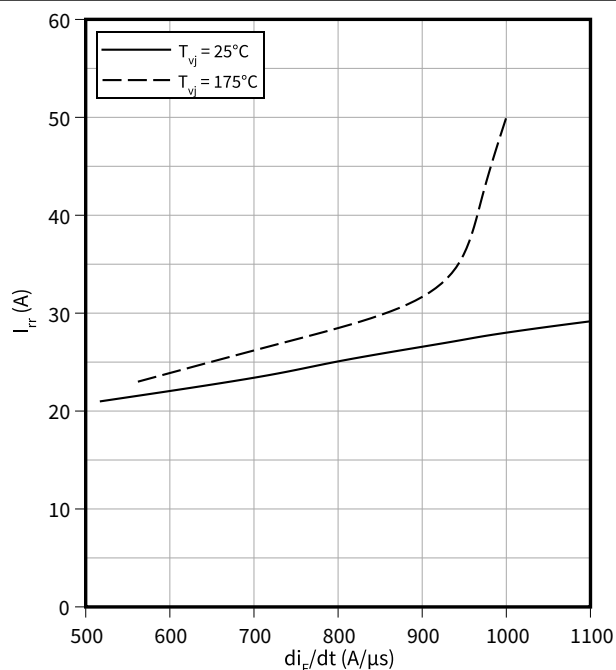
$Q_{rr} = f(di_F/dt)$
 $V_R = 400\text{ V}, I_F = 20\text{ A}$



Typical reverse recovery current as a function of diode current slope

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

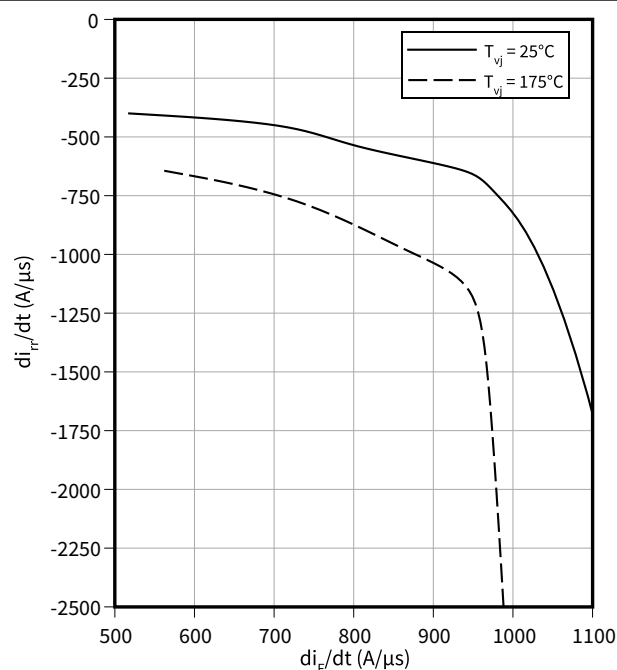
$V_R = 400 \text{ V}$, $I_F = 20 \text{ A}$



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

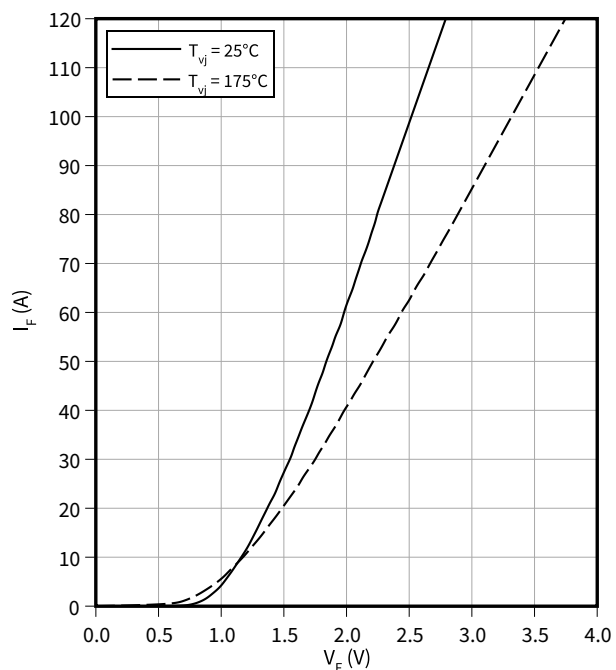
$$di_{rr}/dt = f(di_F/dt)$$

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



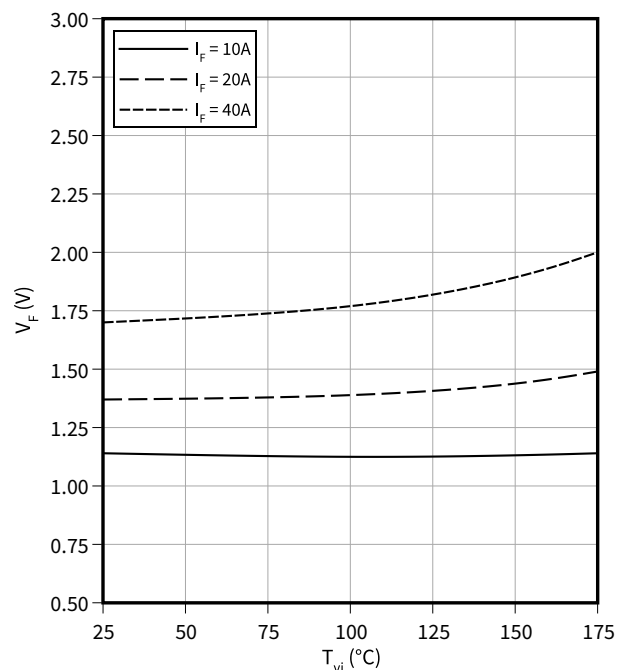
Typical diode forward current as a function of forward voltage

$$I_F = f(V_F)$$



Typical diode forward voltage as a function of junction temperature

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



5 Package outlines

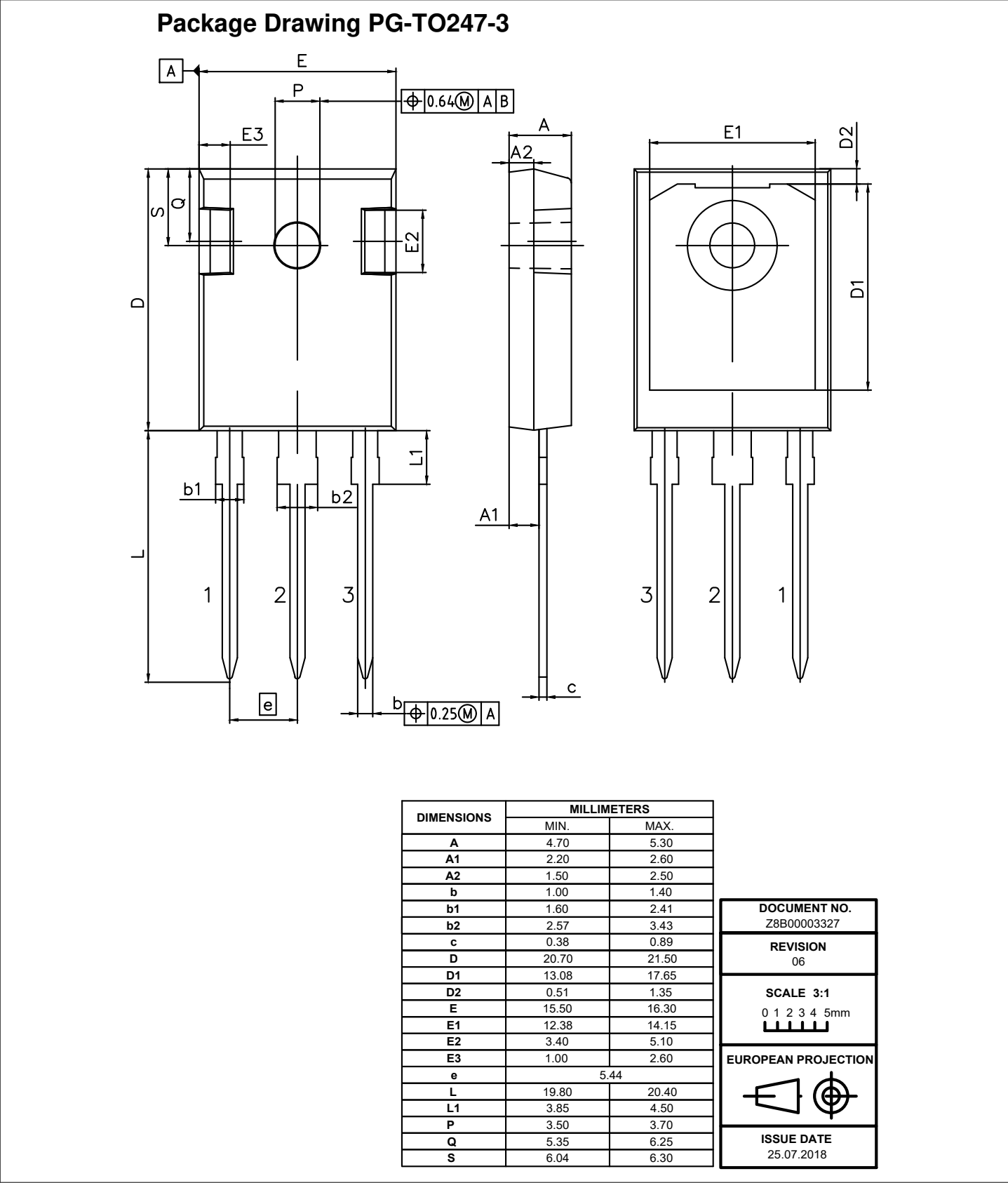


Figure 1

6 Testing conditions

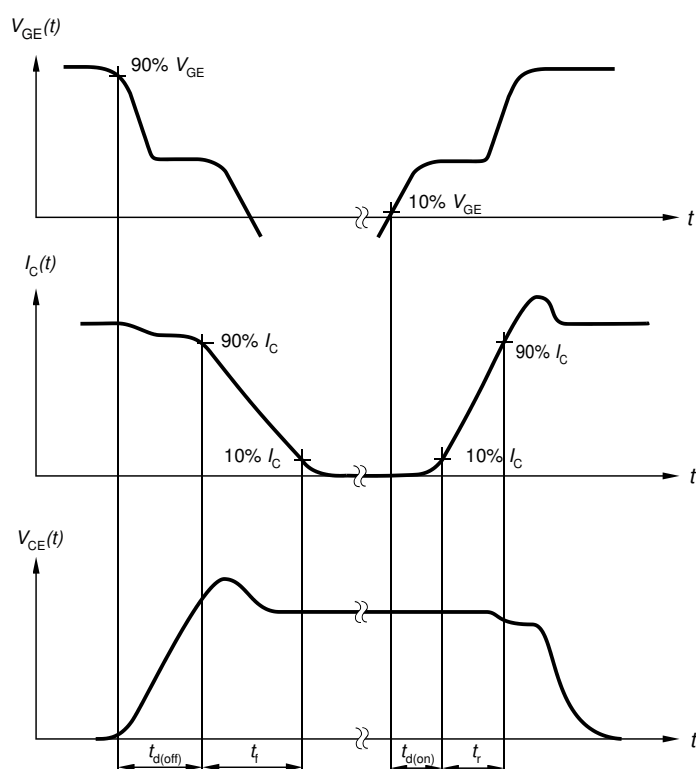


Figure A. Definition of switching times

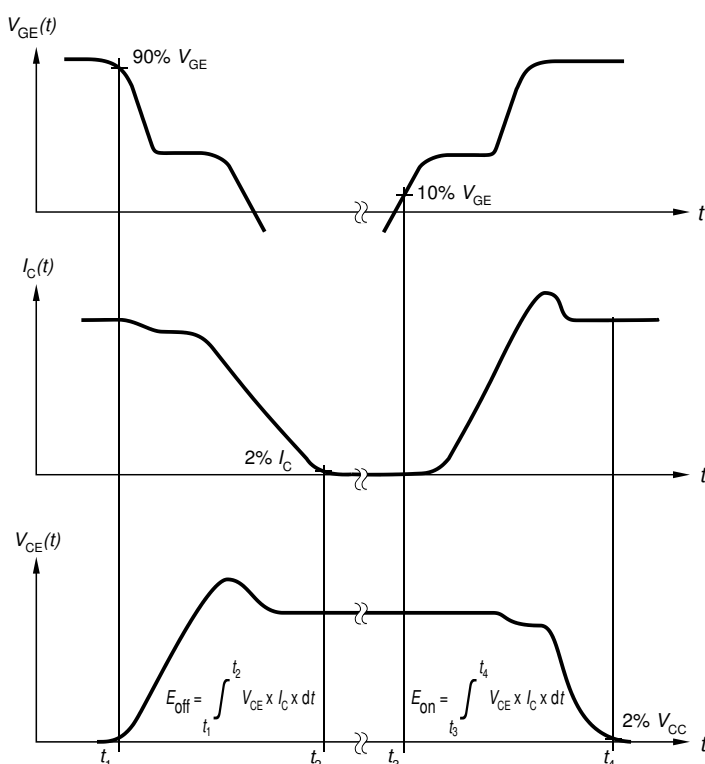


Figure B. Definition of switching losses

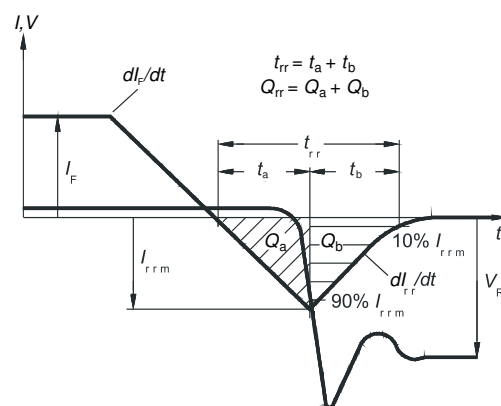


Figure C. Definition of diode switching characteristics

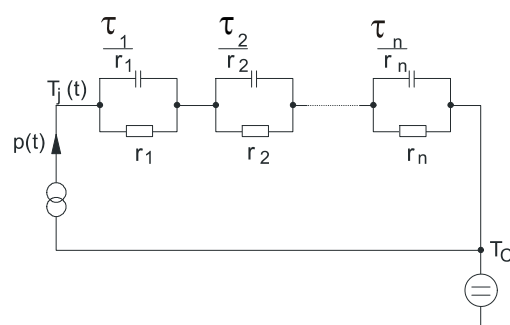


Figure D. Thermal equivalent circuit

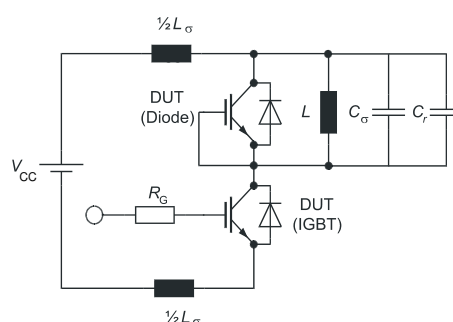


Figure E. **Dynamic test circuit**
Parasitic inductance L_σ ,
parasitic capacitor C_σ ,
relief capacitor C_r ,
(only for ZVT switching)

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"

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