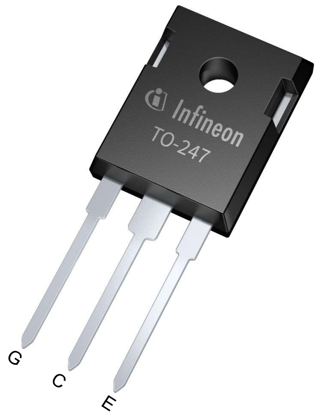
High speed 5 IGBT in TRENCHSTOP™ 5 technology co-packed with full-rated RAPID 1 fast and soft antiparallel diode



Lead-free
Green
Halogen-free
RoHS

Features

- V_{CE} = 650 V
- I_C = 50 A
- Best-in-class efficiency in hard switching and resonant topologies
- Plug and play replacement of previous generation IGBTs
- 650 V breakdown voltage
- Low gate charge Q_G
- IGBT co-packed with full-rated RAPID 1 fast and soft antiparallel diode
- Maximum junction temperature T_{vjmax} = 175°C
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models: http://www.infineon.com/igbt/

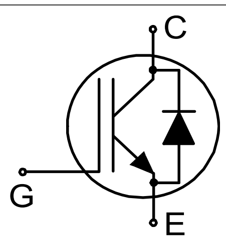
Potential applications

- Uninterruptible power supplies
- Solar converters
- Welding converters
- Mid to high range switching frequency converters

Description

Package pin definition:

• Pin G - gate
• Pin C & backside - collector
• Pin E - emitter



Type	Package	Marking
IKW50N65EH5	PG-TO247-3	K50EEH5

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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		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 process: 3			0.6	Nm
Thermal resistance, junction-ambient	$R_{th(j-a)}$				40	K/W
IGBT thermal resistance, junction-case	$R_{th(j-c)}$				0.55	K/W
Diode thermal resistance, junction-case	$R_{th(j-c)}$				0.63	K/W

2 IGBT

Table 2 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Collector-emitter voltage	V_{CE}	$T_{vj} \geq 25$ °C		650	V
DC collector current, limited by T_{vjmax}	I_C	limited by bondwire	$T_c = 25$ °C	80	A
			$T_c = 100$ °C	50	
Pulsed collector current, t_p limited by T_{vjmax} 1)	I_{Cpulse}			200	A
Turn-off safe operating area 1)		$V_{CE} \leq 650$ V, $t_p = 1$ μs, $T_{vj} \leq 175$ °C		200	A
Gate-emitter voltage	V_{GE}			±20	V
Transient gate-emitter voltage	V_{GE}	$t_p \leq 10$ μs, $D < 0.01$		±30	V
Power dissipation	P_{tot}		$T_c = 25$ °C	275	W
			$T_c = 100$ °C	138	

1) Defined by design. Not subject to production test.

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 mA, V_{GE} = 0 V		650			V
Collector-emitter saturation voltage	V_{CEsat}	I_C = 50 A, V_{GE} = 15 V	T_{vj} = 25 °C		1.65	2.1	V
			T_{vj} = 125 °C		1.85		
			T_{vj} = 175 °C		1.95		
Gate-emitter threshold voltage	V_{GEth}	I_C = 0.5 mA, V_{CE} = V_{GE}		3.2	4	4.8	V
Zero gate-voltage collector current	I_{CES}	V_{CE} = 650 V, V_{GE} = 0 V	T_{vj} = 25 °C		1	50	µA
			T_{vj} = 175 °C		2000		
Gate-emitter leakage current	I_{GES}	V_{CE} = 0 V, V_{GE} = 20 V				100	nA
Transconductance	g_{fs}	I_C = 50 A, V_{CE} = 20 V			62		S
Input capacitance	C_{ies}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			3000		pF
Output capacitance	C_{oes}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			90		pF
Reverse transfer capacitance	C_{res}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			12		pF
Gate charge	Q_G	I_C = 50 A, V_{GE} = 15 V, V_{CC} = 520 V			120		nC
Turn-on delay time	$t_{d(on)}$	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		25		ns
			T_{vj} = 25 °C, I_C = 25 A		24		
			T_{vj} = 150 °C, I_C = 50 A		24		
			T_{vj} = 150 °C, I_C = 25 A		23		
Rise time (inductive load)	t_r	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		29		ns
			T_{vj} = 25 °C, I_C = 25 A		12		
			T_{vj} = 150 °C, I_C = 50 A		30		
			T_{vj} = 150 °C, I_C = 25 A		14		

(table continues...)

Table 3 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Turn-off delay time	$t_{d(off)}$	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		172		ns
			T_{vj} = 25 °C, I_C = 25 A		173		
			T_{vj} = 150 °C, I_C = 50 A		190		
			T_{vj} = 150 °C, I_C = 25 A		203		
Fall time (inductive load)	t_f	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		35		ns
			T_{vj} = 25 °C, I_C = 25 A		15		
			T_{vj} = 150 °C, I_C = 50 A		30		
			T_{vj} = 150 °C, I_C = 25 A		20		
Turn-on energy	E_{on}	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		1.5		mJ
			T_{vj} = 25 °C, I_C = 25 A		0.57		
			T_{vj} = 150 °C, I_C = 50 A		2		
			T_{vj} = 150 °C, I_C = 25 A		0.95		
Turn-off energy	E_{off}	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		0.5		mJ
			T_{vj} = 25 °C, I_C = 25 A		0.16		
			T_{vj} = 150 °C, I_C = 50 A		0.6		
			T_{vj} = 150 °C, I_C = 25 A		0.25		

(table continues...)

Table 3 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Total switching energy	E_{ts}	V_{CC} = 400 V, V_{GE} = 15 V, R_{Gon} = 12 Ω, R_{Goff} = 12 Ω	T_{vj} = 25 °C, I_C = 50 A		2		mJ
			T_{vj} = 25 °C, I_C = 25 A		0.73		
			T_{vj} = 150 °C, I_C = 50 A		2.6		
			T_{vj} = 150 °C, I_C = 25 A		1.2		
Operating junction temperature	T_{vj}			-40		175	°C

3 Diode

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition		Values	Unit
Repetitive peak reverse voltage	V_{RRM}	T_{vj} ≥ 25 °C		650	V
Diode forward current, limited by T_{vjmax}	I_F	limited by bondwire	T_c = 25 °C	80	A
			T_c = 100 °C	50	
Diode pulsed current, t_p limited by T_{vjmax} [1)]	I_{Fpulse}			200	A

1) Defined by design. Not subject to production test.

Table 5 Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode forward voltage	V_F	I_F = 50 A	T_{vj} = 25 °C		1.35	1.7	V
			T_{vj} = 125 °C		1.33		
			T_{vj} = 175 °C		1.3		

(table continues...)

Table 5 (continued) Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode reverse recovery time	t_{rr}	V_R = 400 V	T_{vj} = 25 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		81		ns
			T_{vj} = 25 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		56		
			T_{vj} = 150 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		108		
			T_{vj} = 150 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		98		
Diode reverse recovery charge	Q_{rr}	V_R = 400 V	T_{vj} = 25 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		1.1		µC
			T_{vj} = 25 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		0.7		
			T_{vj} = 150 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		2.6		
			T_{vj} = 150 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		1.8		
Diode peak reverse recovery current	I_{rrm}	V_R = 400 V	T_{vj} = 25 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		17		A
			T_{vj} = 25 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		19.7		
			T_{vj} = 150 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		36		
			T_{vj} = 150 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		28.8		

(table continues...)

Table 5 (continued) Characteristic values

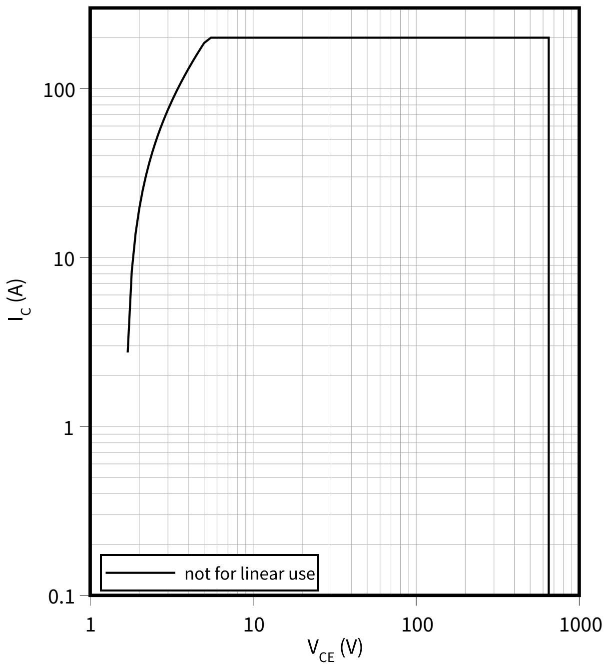
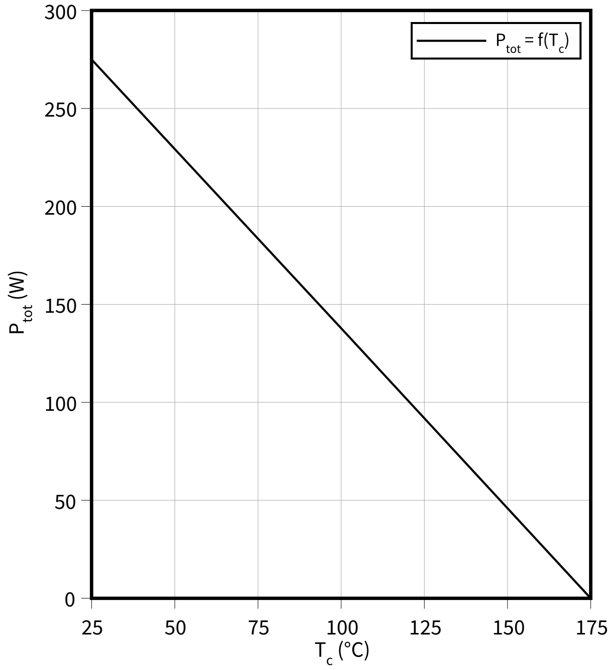
Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode peak rate of fall of reverse recovery current	di_{rr}/dt	V_R = 400 V	T_{vj} = 25 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		1000		A/µs
			T_{vj} = 25 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		1500		
			T_{vj} = 150 °C, I_F = 50 A, $-di_F/dt$ = 1000 A/µs		2000		
			T_{vj} = 150 °C, I_F = 25 A, $-di_F/dt$ = 1000 A/µs		1500		
Operating junction temperature	T_{vj}			-40		175	°C

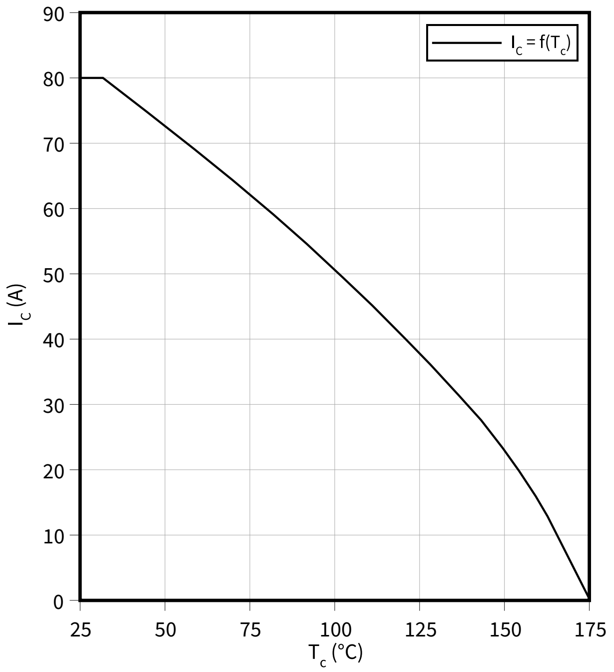
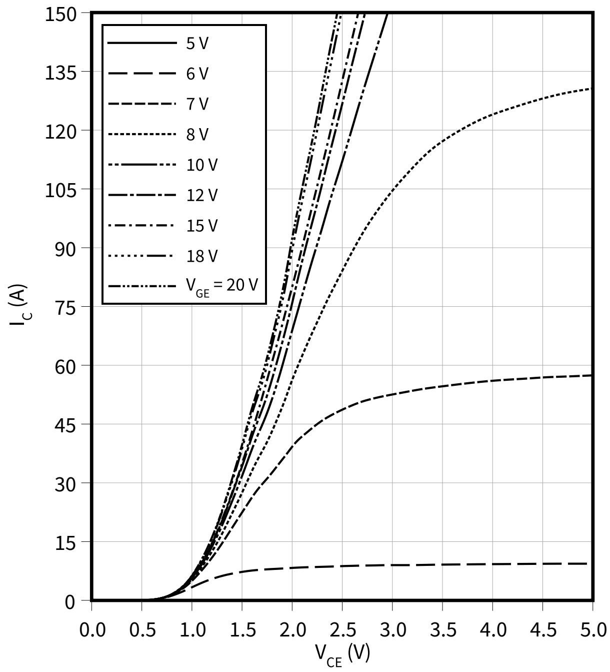
Note: *For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.*

Electrical Characteristic at T_{vj} = 25°C, unless otherwise specified.

Dynamic test circuit, parasitic inductance L_σ = 30nH, parasitic capacitor C_σ = 25 pF from Fig. E. Energy losses include "tail" and diode reverse recovery.

4 Characteristics diagrams

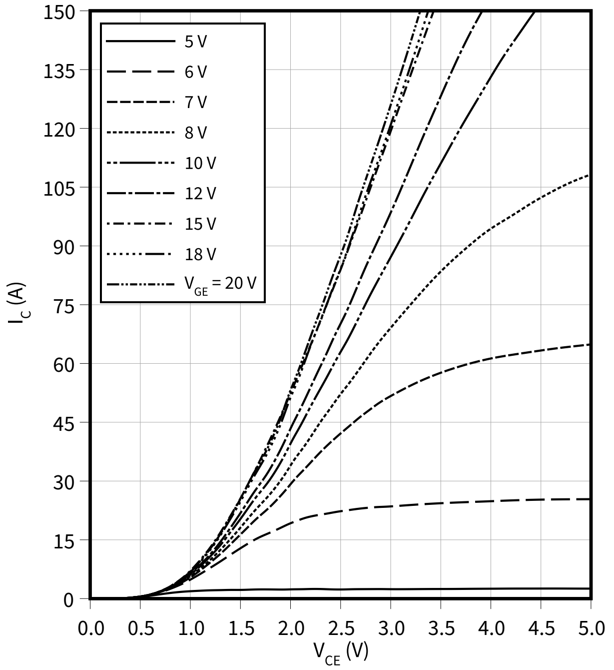
Forward bias safe operating area $I_C = f(V_{CE})$ $D = 0$, $T_{vj} \leq 175$ °C, $V_{GE} = 15$ V, $t_p = 1$ μs, $T_c = 25$ °C	**Power dissipation as a function of case temperature** $P_{tot} = f(T_c)$ $T_{vj} \leq 175$ °C
	

Collector current as a function of case temperature $I_C = f(T_c)$ $T_{vj} \leq 175$ °C, $V_{GE} \geq 15$ V	**Typical output characteristic** $I_C = f(V_{CE})$ $T_{vj} = 25$ °C
	

Typical output characteristic

$I_C = f(V_{CE})$

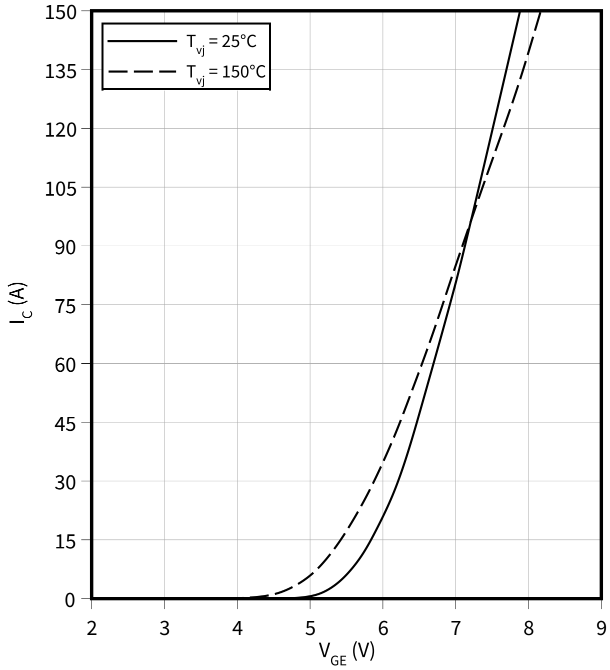
$T_{vj} = 150\ °C$



Typical transfer characteristic

$I_C = f(V_{GE})$

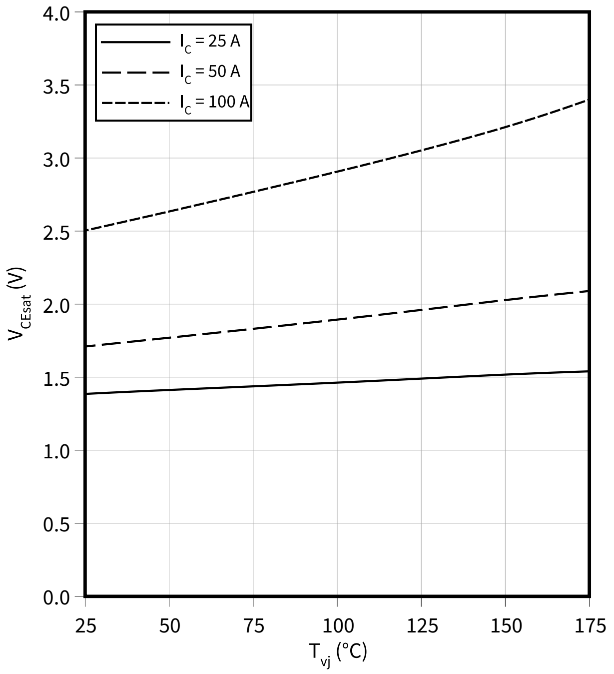
$V_{CE} = 20\ V$



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

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

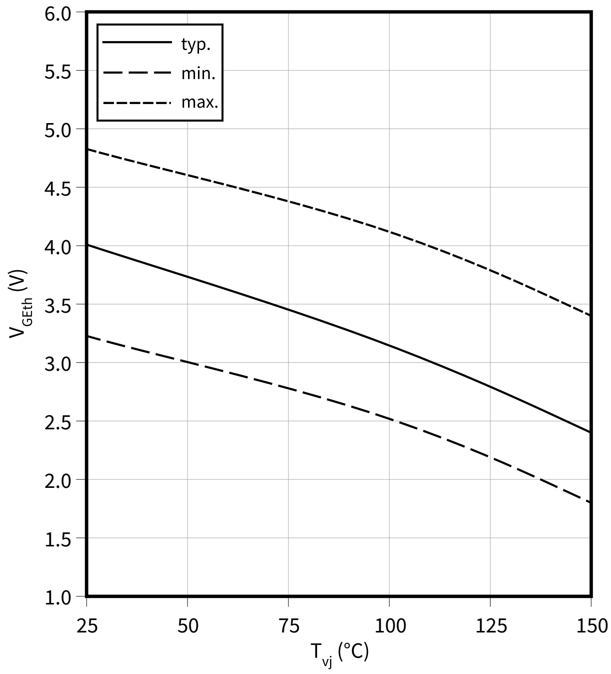
$V_{GE} = 15\ V$



Gate-emitter threshold voltage as a function of junction temperature

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

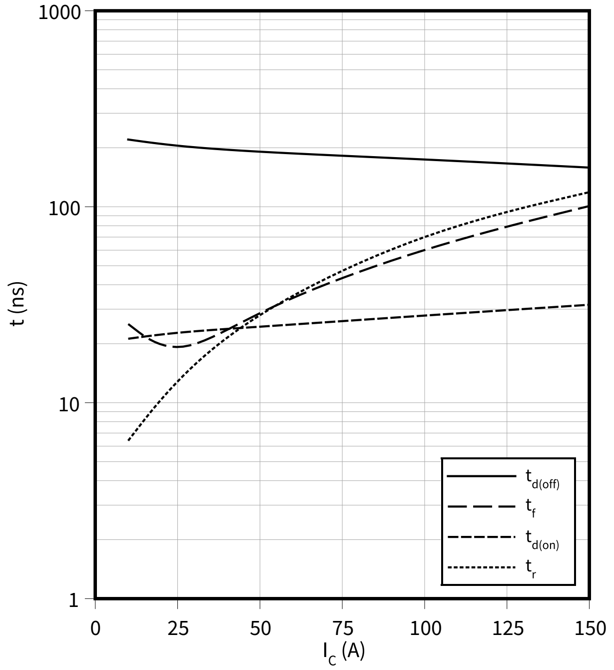
$I_C = 0.5\ mA$



Typical switching times as a function of collector current

$t = f(I_C)$

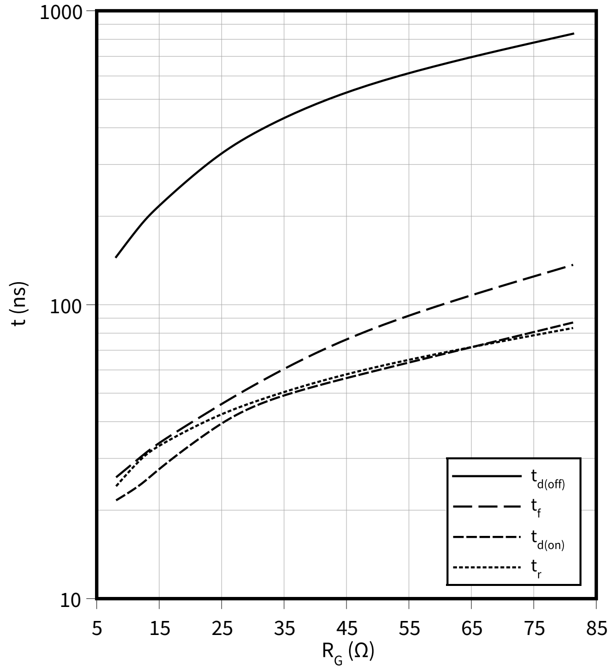
$V_{CC} = 400$ V, $T_{vj} = 150$ °C, $V_{GE} = 0/15$ V, $R_G = 12$ Ω



Typical switching times as a function of gate resistor

$t = f(R_G)$

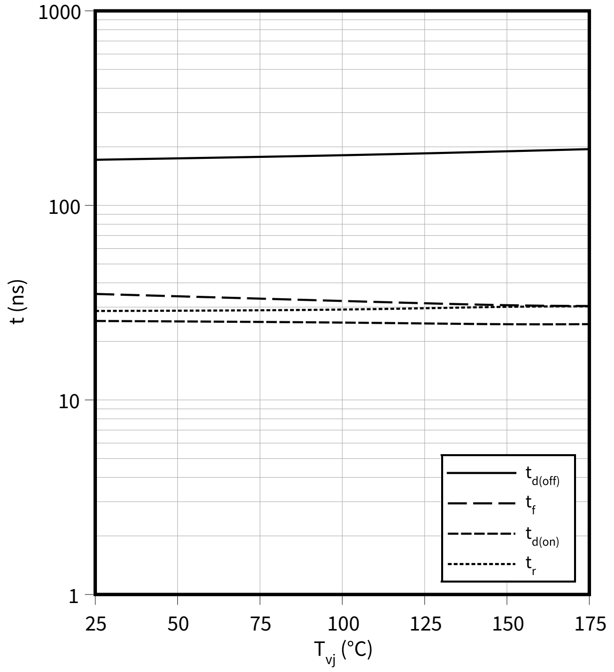
$I_C = 50$ A, $V_{CC} = 400$ V, $T_{vj} = 150$ °C, $V_{GE} = 0/15$ V



Typical switching times as a function of junction temperature

$t = f(T_{vj})$

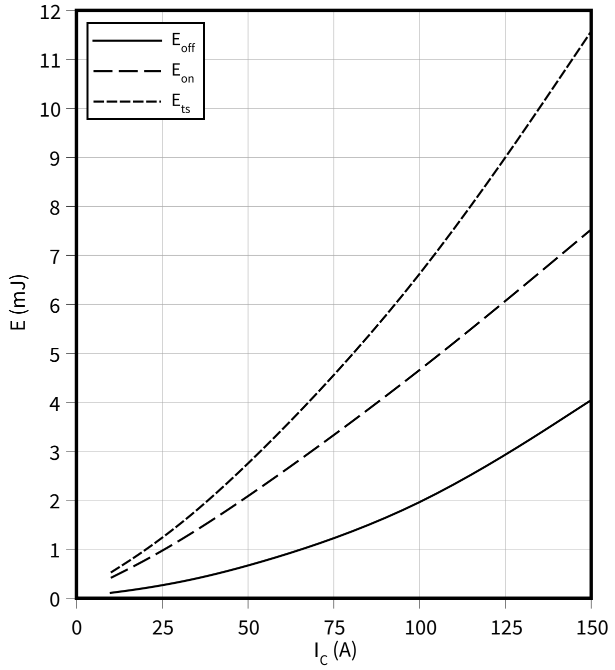
$I_C = 50$ A, $V_{CC} = 400$ V, $V_{GE} = 0/15$ V, $R_G = 12$ Ω



Typical switching energy losses as a function of collector current

$E = f(I_C)$

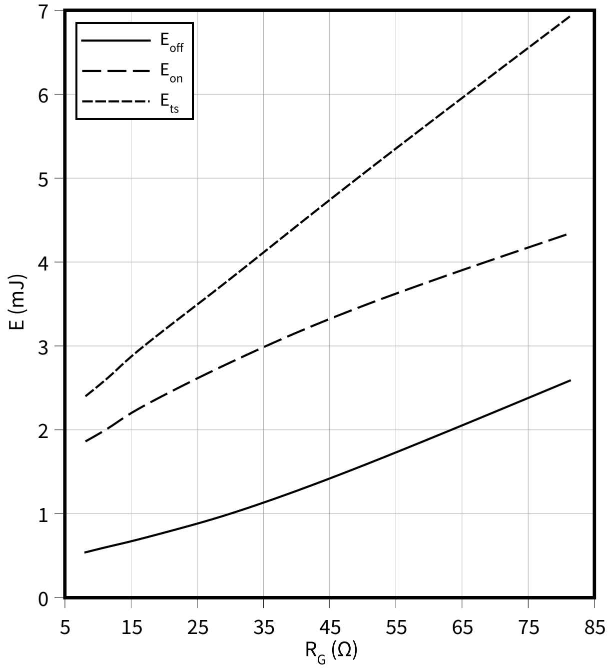
$V_{CC} = 400$ V, $T_{vj} = 150$ °C, $V_{GE} = 0/15$ V, $R_G = 12$ Ω



Typical switching energy losses as a function of gate resistor

$E = f(R_G)$

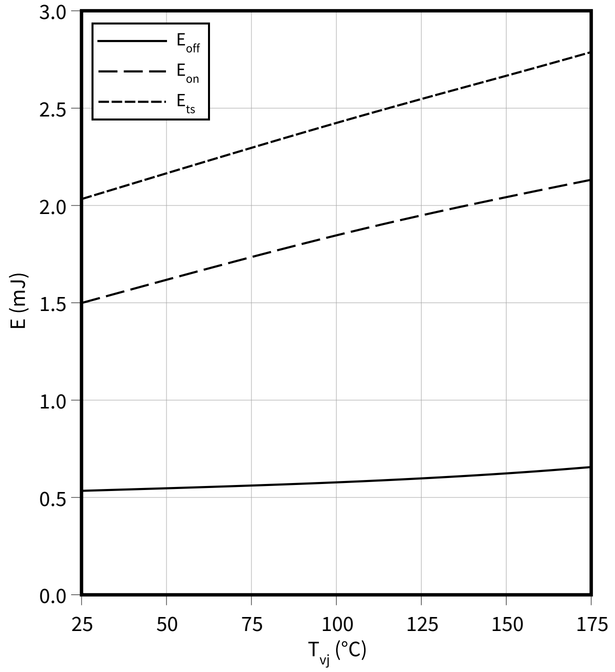
$I_C = 50$ A, $V_{CC} = 400$ V, $T_{vj} = 150$ °C, $V_{GE} = 0/15$ V



Typical switching energy losses as a function of junction temperature

$E = f(T_{vj})$

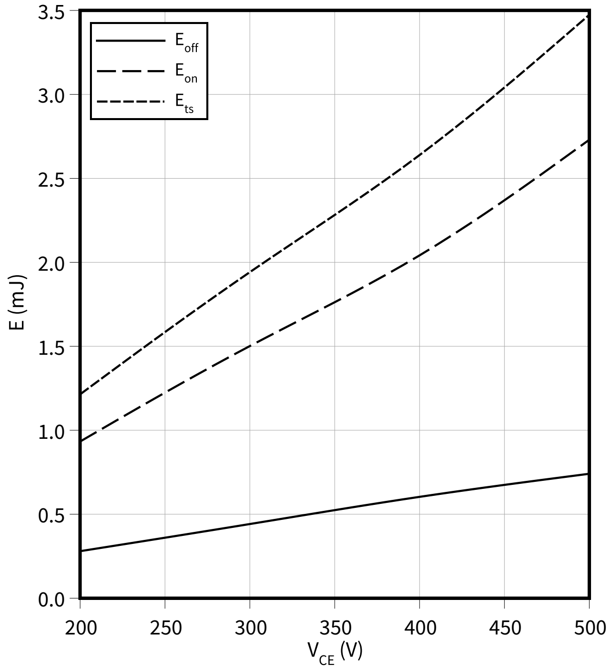
$I_C = 50$ A, $V_{CC} = 400$ V, $V_{GE} = 0/15$ V, $R_G = 12$ Ω



Typical switching energy losses as a function of collector emitter voltage

$E = f(V_{CE})$

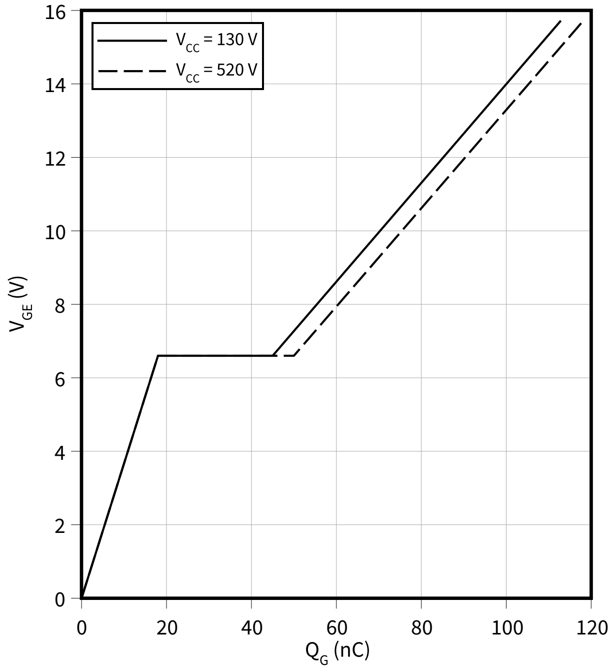
$I_C = 50$ A, $T_{vj} = 150$ °C, $V_{GE} = 0/15$ V, $R_G = 12$ Ω



Typical gate charge

$V_{GE} = f(Q_G)$

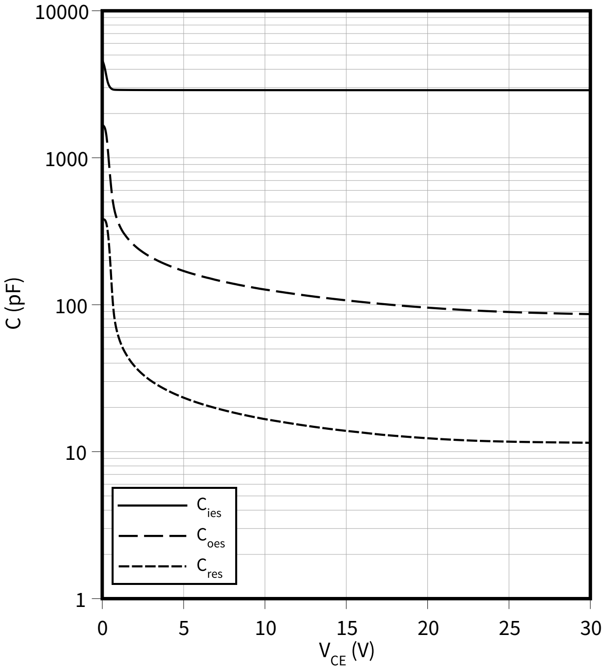
$I_C = 50$ A



Typical capacitance as a function of collector-emitter voltage

$C = f(V_{CE})$

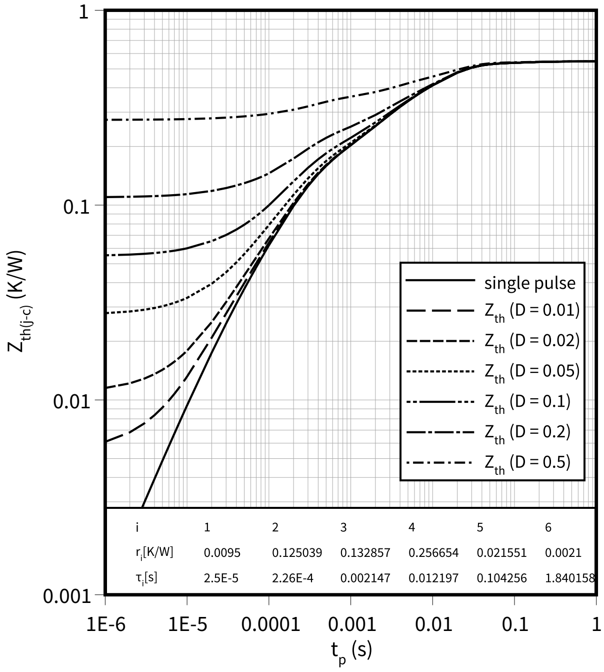
$f = 1000$ kHz, $V_{GE} = 0$ V



IGBT transient thermal impedance as a function of pulse width

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

$D = t_p/T$

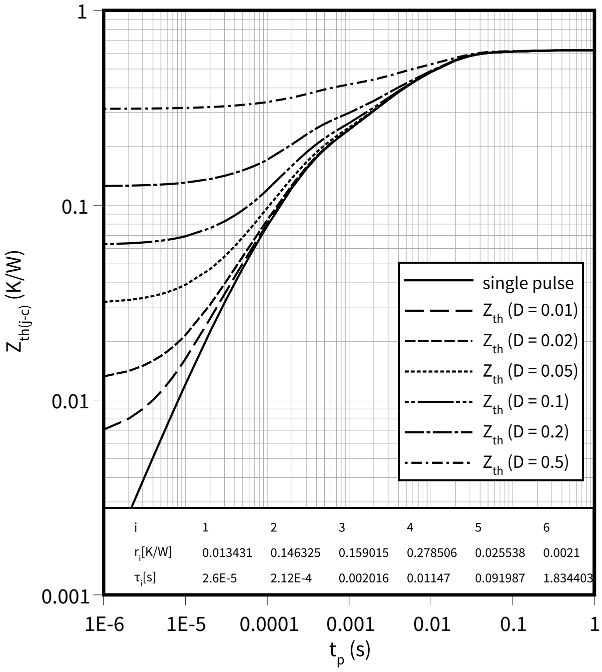


i	1	2	3	4	5	6
r_i[K/W]	0.0095	0.125039	0.132857	0.256654	0.021551	0.0021
τ_i[s]	2.5E-5	2.26E-4	0.002147	0.012197	0.104256	1.840158

Diode transient thermal impedance as a function of pulse width

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

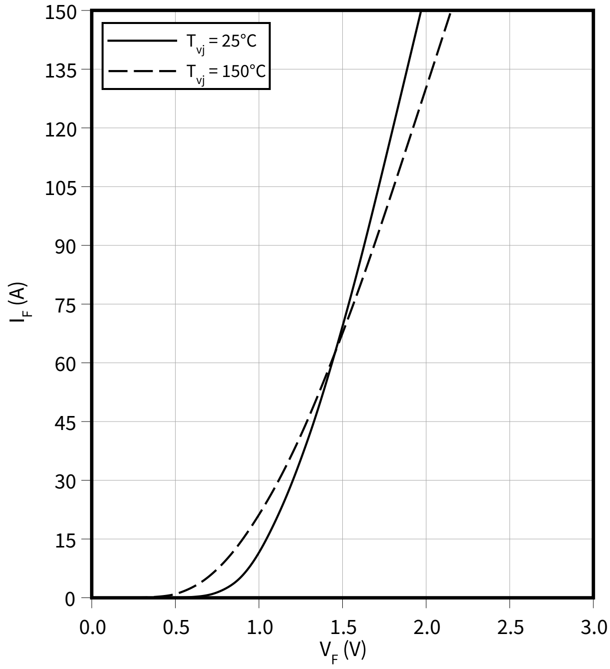
$D = t_p/T$



i	1	2	3	4	5	6
r_i[K/W]	0.013431	0.146325	0.159015	0.278506	0.025538	0.0021
τ_i[s]	2.6E-5	2.12E-4	0.002016	0.01147	0.091987	1.834403

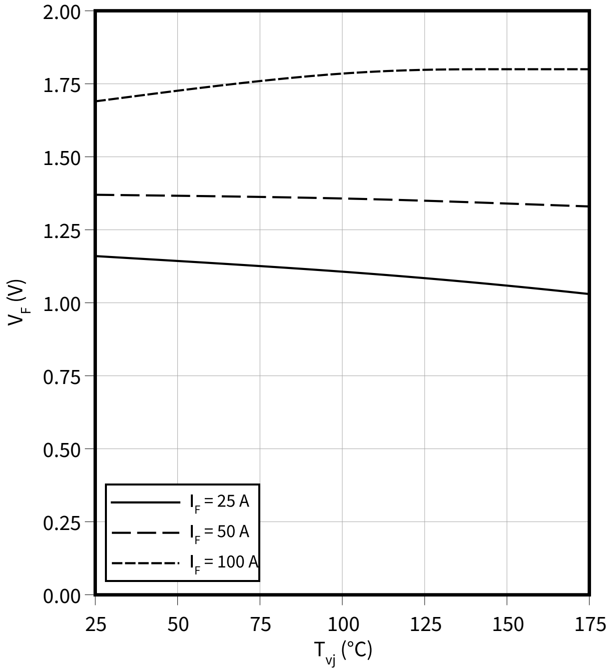
Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



Typical diode forward voltage as a function of junction temperature

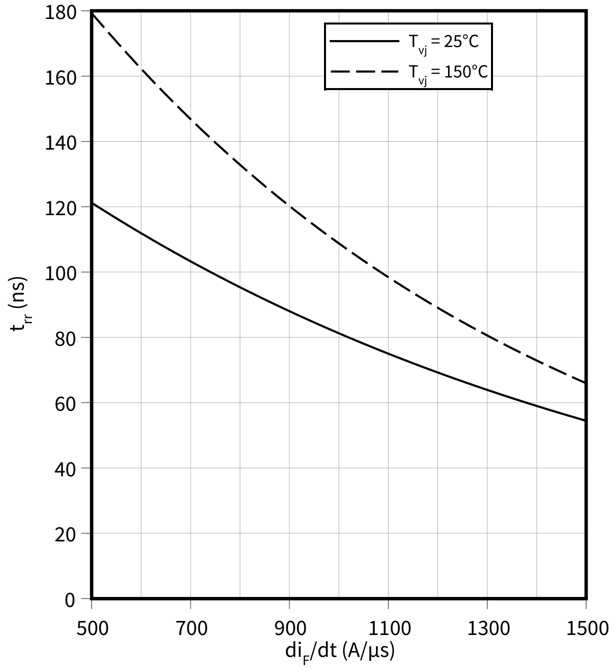
$V_F = f(T_{vj})$



Typical reverse recovery time as a function of diode current slope

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

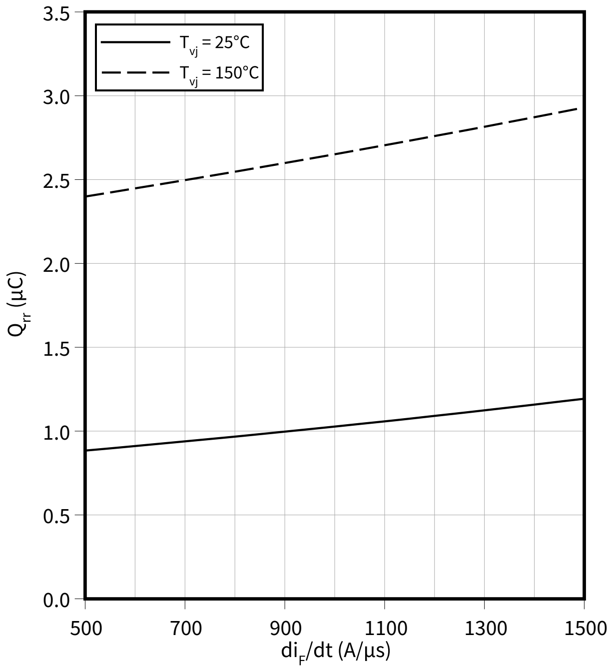
$V_R = 400$ V, $I_F = 50$ A



Typical reverse recovery charge as a function of diode current slope

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

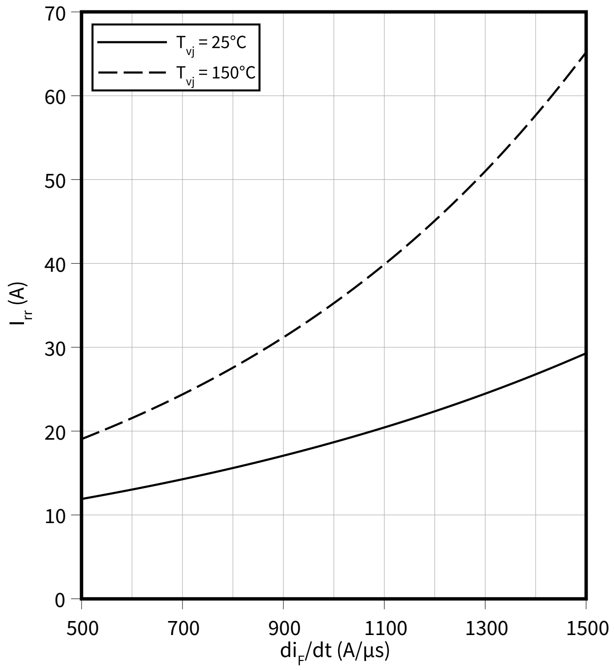
$V_R = 400$ V, $I_F = 50$ A



Typical reverse recovery current as a function of diode current slope

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

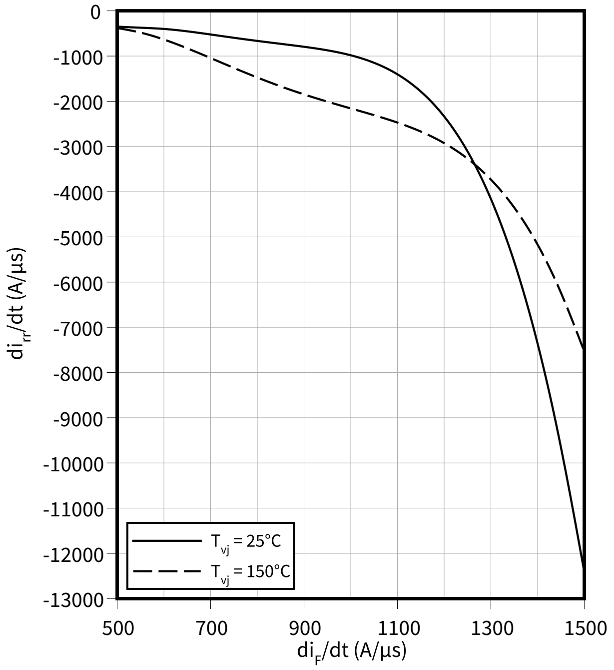
$V_R = 400$ V, $I_F = 50$ A



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

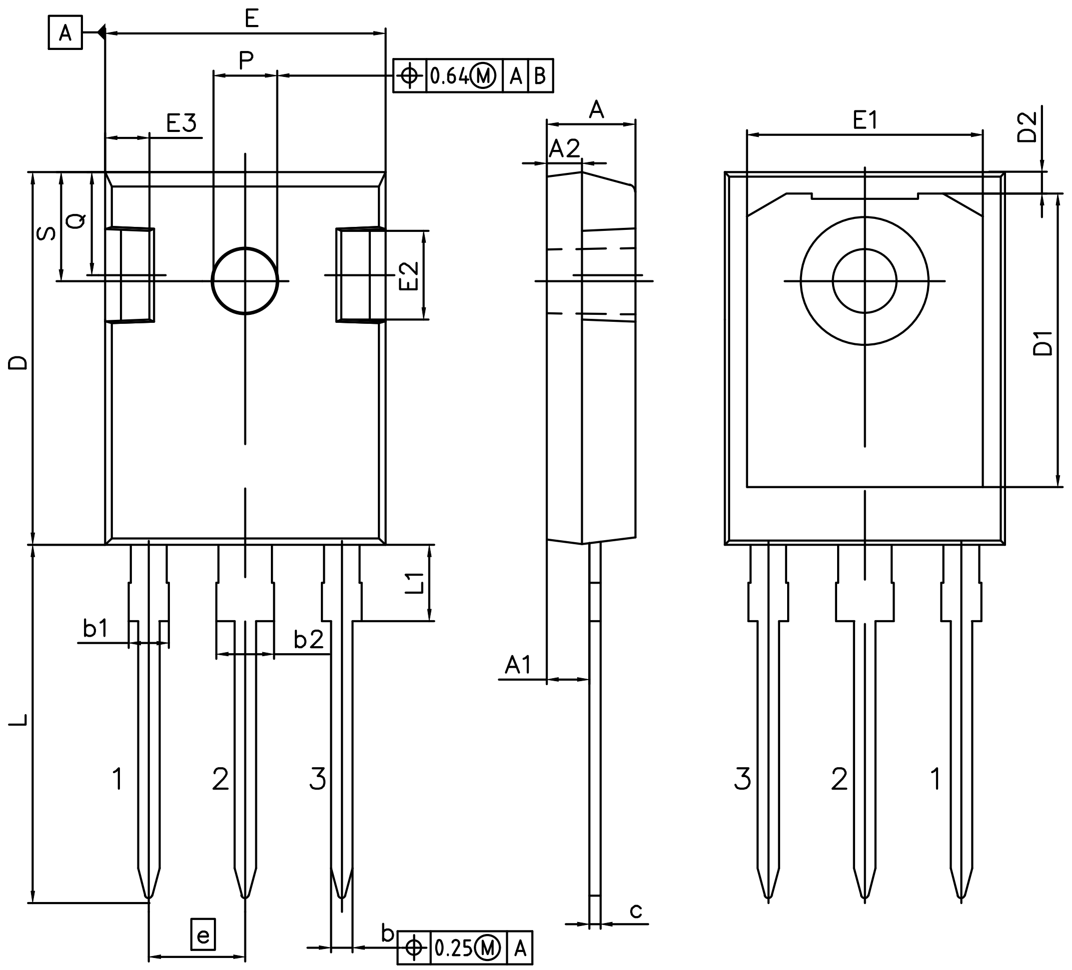
$di_{rr}/dt = f(di_F/dt)$

$V_R = 400$ V, $I_F = 50$ A



5 Package outlines

Package Drawing PG-TO247-3



DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	4.70	5.30
A1	2.20	2.60
A2	1.50	2.50
b	1.00	1.40
b1	1.60	2.41
b2	2.57	3.43
c	0.38	0.89
D	20.70	21.50
D1	13.08	17.65
D2	0.51	1.35
E	15.50	16.30
E1	12.38	14.15
E2	3.40	5.10
E3	1.00	2.60
e	5.44	
L	19.80	20.40
L1	3.85	4.50
P	3.50	3.70
Q	5.35	6.25
S	6.04	6.30

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06

SCALE 3:1
0 1 2 3 4 5mm

EUROPEAN PROJECTION

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Figure 1

6 Testing conditions

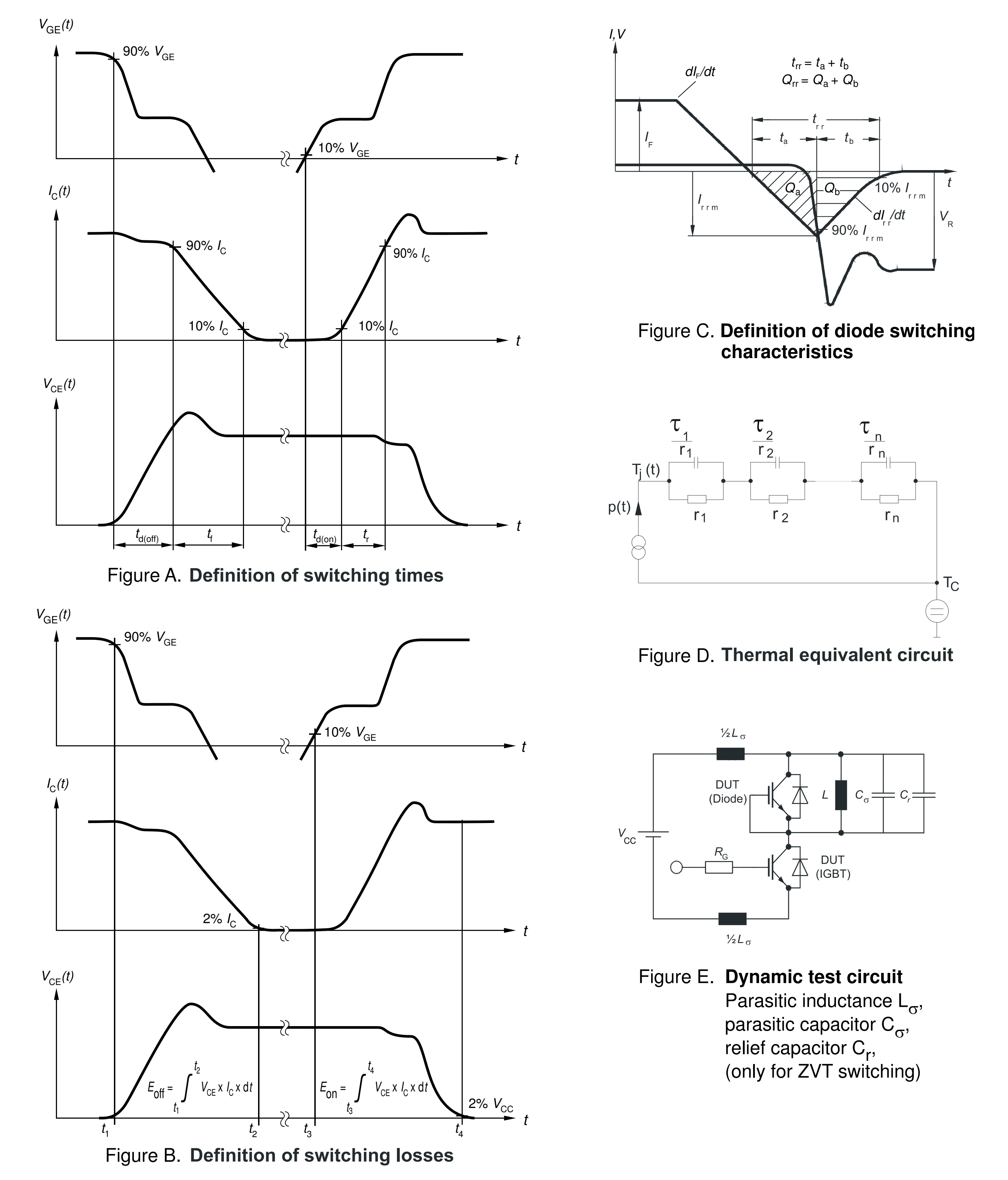

Figure A. **Definition of switching times**

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)

Figure 2

Revision history

Document revision	Date of release	Description of changes
V2.1	2015-05-20	Final data sheet
V2.2	2017-07-27	Correction Fig.1
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	2022-11-09	Correction of diagram: “Typical switching energy losses as a function of collector emitter voltage”