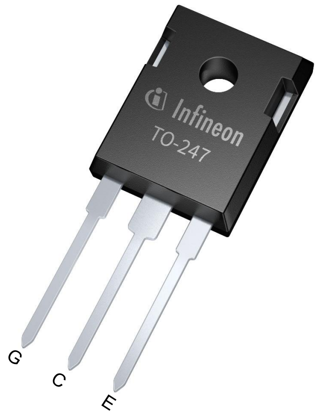
Reverse-Conducting IGBT with monolithic body diode



Features

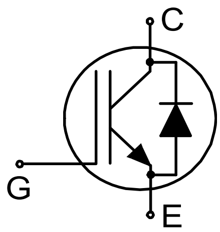
- V_{CE} = 650 V
- I_C = 40 A
- Powerful monolithic diode optimized for ZCS applications
- High ruggedness, temperature stable behavior
- Very low V_{CEsat} and low E_{off}
- Easy paralleling capability due to positive temperature coefficient in V_{CEsat}
- Low EMI
- Low electrical parameters depending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

Table of contents

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 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

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
			$T_c = 130$ °C	40	
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpulse}			120	A
Turn-off safe operating area		$V_{CE} \leq 650$ V, $T_{vj} \leq 175$ °C		120	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	230	W
			$T_c = 100$ °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 mA, V_{GE} = 0 V		650			V
Collector-emitter saturation voltage	V_{CEsat}	I_C = 40 A, V_{GE} = 15 V	T_{vj} = 25 °C		1.4	1.8	V
			T_{vj} = 175 °C		1.65		
Gate-emitter threshold voltage	V_{GEth}	I_C = 0.4 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			40	µA
Gate-emitter leakage current	I_{GES}	V_{CE} = 0 V, V_{GE} = 20 V				100	nA
Transconductance	g_{fs}	I_C = 40 A, V_{CE} = 20 V			55		S
Input capacitance	C_{ies}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			4755		pF
Output capacitance	C_{oes}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			45		pF
Reverse transfer capacitance	C_{res}	V_{CE} = 25 V, V_{GE} = 0 V, f = 1000 kHz			20		pF
Gate charge	Q_G	V_{CC} = 520 V, I_C = 40 A, V_{GE} = 15 V			193		nC
Turn-on delay time	$t_{d(on)}$	V_{CC} = 400 V, V_{GE} = 0/15 V, $R_{G(on)}$ = 20 Ω, $R_{G(off)}$ = 20 Ω, $L_σ$ = 70 nH, $C_σ$ = 30 pF	T_{vj} = 25 °C, I_C = 20 A		42		ns
			T_{vj} = 175 °C, I_C = 20 A		42		
Rise time (inductive load)	t_r	V_{CC} = 400 V, V_{GE} = 0/15 V, $R_{G(on)}$ = 20 Ω, $R_{G(off)}$ = 20 Ω, $L_σ$ = 70 nH, $C_σ$ = 30 pF	T_{vj} = 25 °C, I_C = 20 A		18		ns
			T_{vj} = 175 °C, I_C = 20 A		21		
Turn-off delay time	$t_{d(off)}$	V_{CC} = 400 V, V_{GE} = 0/15 V, $R_{G(on)}$ = 20 Ω, $R_{G(off)}$ = 20 Ω, $L_σ$ = 70 nH, $C_σ$ = 30 pF	T_{vj} = 25 °C, I_C = 20 A		432		ns
			T_{vj} = 175 °C, I_C = 20 A		500		
Fall time (inductive load)	t_f	V_{CC} = 400 V, V_{GE} = 0/15 V, $R_{G(on)}$ = 20 Ω, $R_{G(off)}$ = 20 Ω, $L_σ$ = 70 nH, $C_σ$ = 30 pF	T_{vj} = 25 °C, I_C = 20 A		16		ns
			T_{vj} = 175 °C, I_C = 20 A		10		
Turn-on energy	E_{on}	V_{CC} = 400 V, V_{GE} = 0/15 V, $R_{G(on)}$ = 20 Ω, $R_{G(off)}$ = 20 Ω, $L_σ$ = 70 nH, $C_σ$ = 30 pF	T_{vj} = 25 °C, I_C = 20 A		0.77		mJ
			T_{vj} = 175 °C, I_C = 20 A		0.82		

(table continues...)

Table 3 **(continued) Characteristic values**

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

Note: *Electrical Characteristic, at T_{vj} = 25°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} ≥ 25 °C		650	V
Diode forward current, limited by T_{vjmax}	I_F	limited by bondwire	T_c = 25 °C	32	A
			T_c = 100 °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 A	T_{vj} = 25 °C		1.4	1.9	V
			T_{vj} = 175 °C		1.5		
Diode reverse recovery time	t_{rr}	V_R = 400 V	T_{vj} = 25 °C, I_F = 20 A, $-di_F/dt$ = 900 A/µs		112		ns
			T_{vj} = 175 °C, I_F = 20 A, $-di_F/dt$ = 900 A/µs		153		

(table continues...)

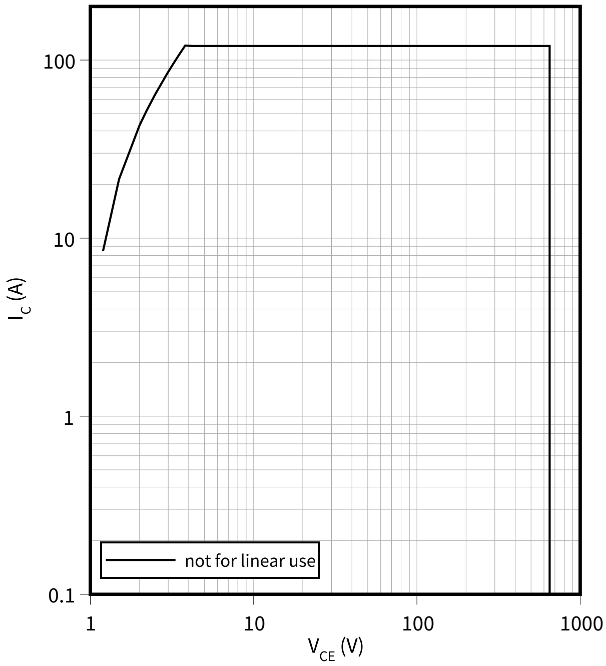
Table 5 (continued) Characteristic values

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

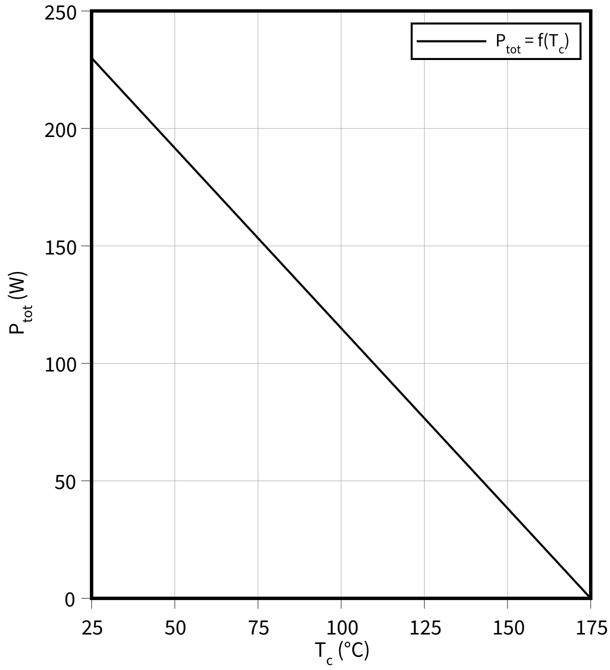
Note: *For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.*

4 Characteristics diagrams

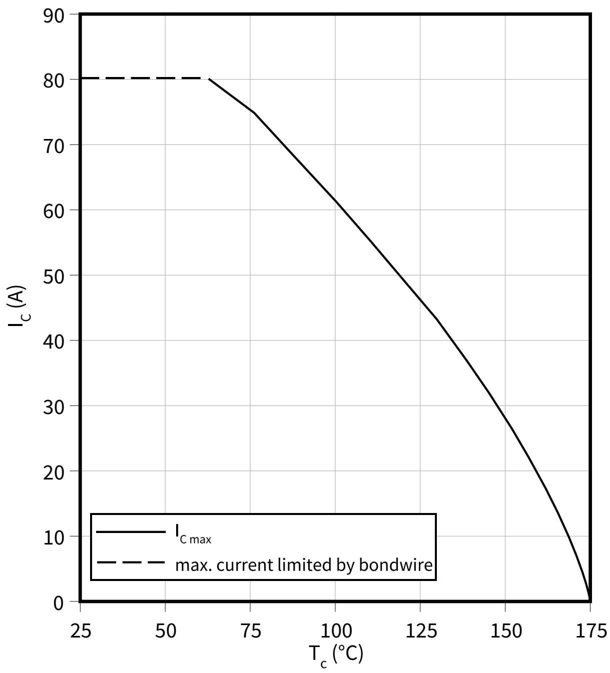
Reverse bias safe operating area
$I_C = f(V_{CE})$
$T_{vj} \leq 175$ °C, $V_{GE} = 15$ V, $T_c = 25$ °C



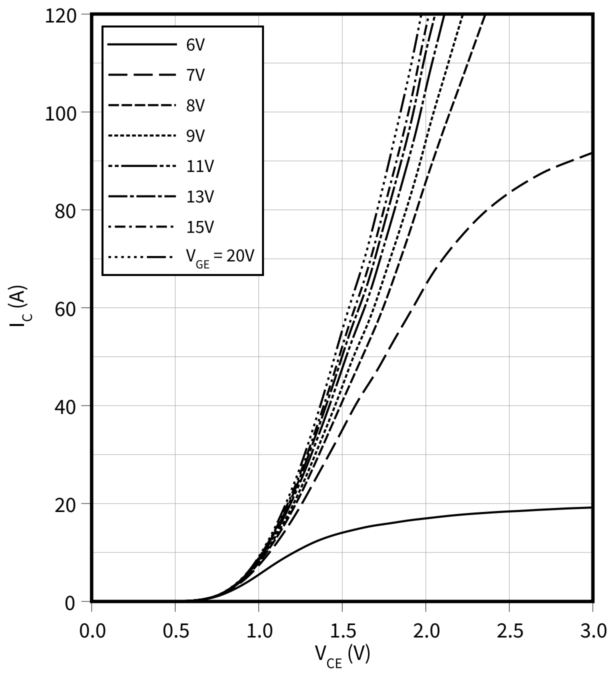
Power dissipation as a function of case temperature
$P_{tot} = f(T_c)$
$T_{vj} \leq 175$ °C



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



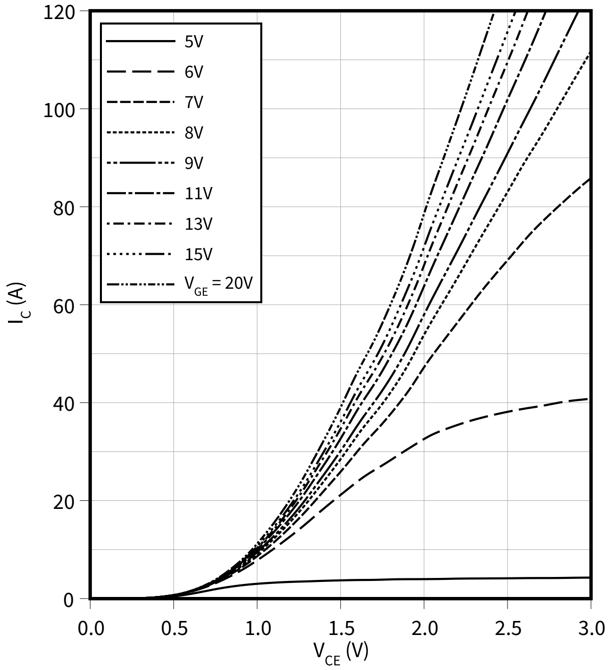
Typical output characteristic
$I_C = f(V_{CE})$
$T_{vj} = 25$ °C



Typical output characteristic

$I_C = f(V_{CE})$

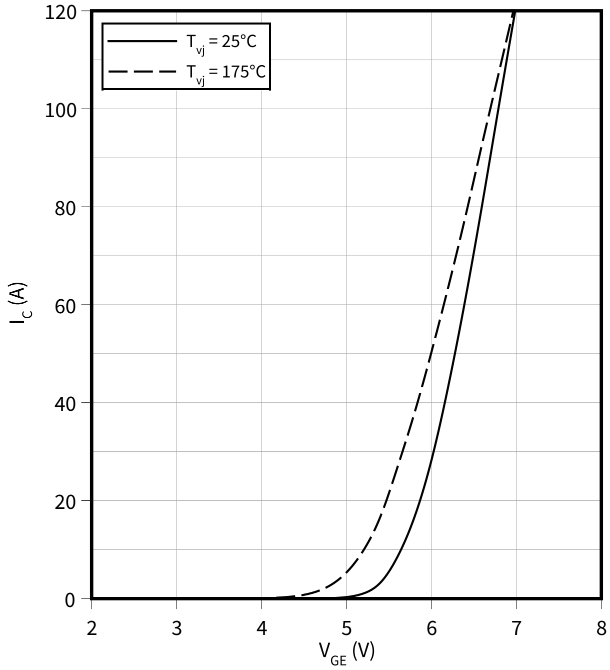
$T_{vj} = 175\ °C$



Typical transfer characteristic

$I_C = f(V_{GE})$

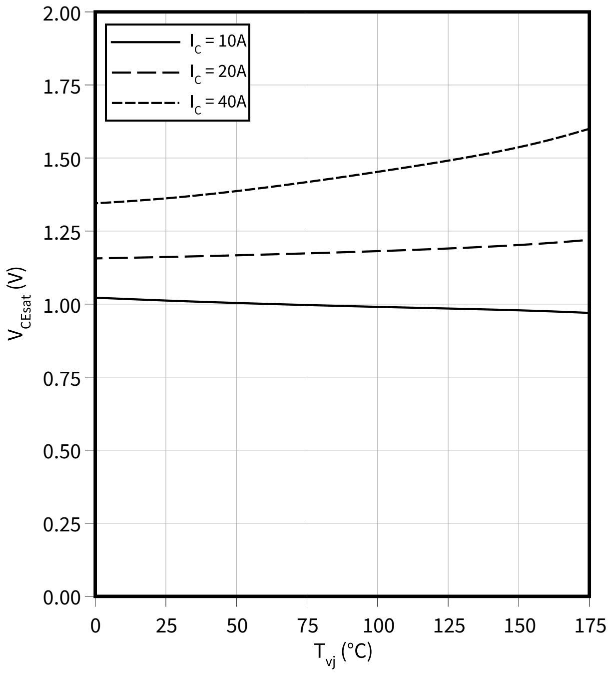
$V_{CE} = 20\ V$



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

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

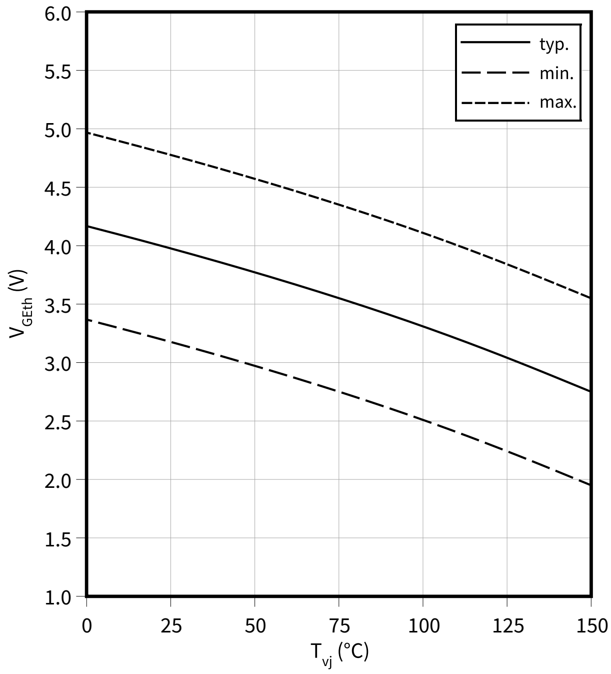
$V_{GE} = 15\ V$



Gate-emitter threshold voltage as a function of junction temperature

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

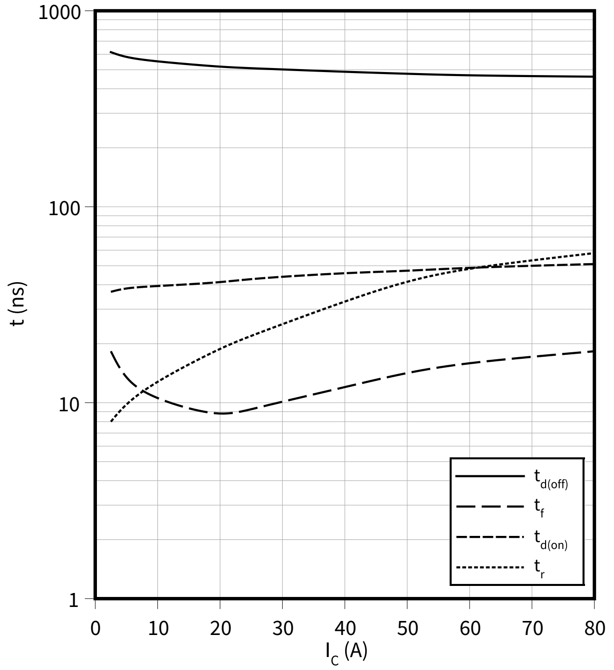
$I_C = 0.4\ mA$



Typical switching times as a function of collector current

$t = f(I_C)$

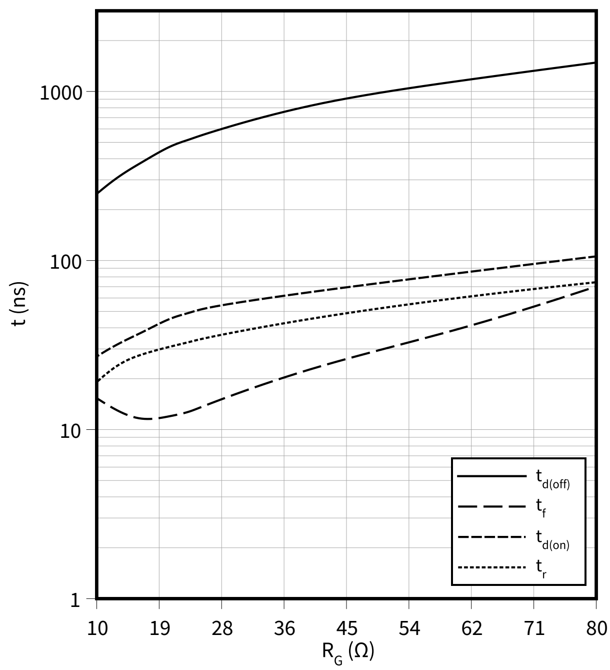
$V_{CC} = 400$ V, $T_{vj} = 175$ °C, $V_{GE} = 0/15$ V, $R_G = 20$ Ω



Typical switching times as a function of gate resistor

$t = f(R_G)$

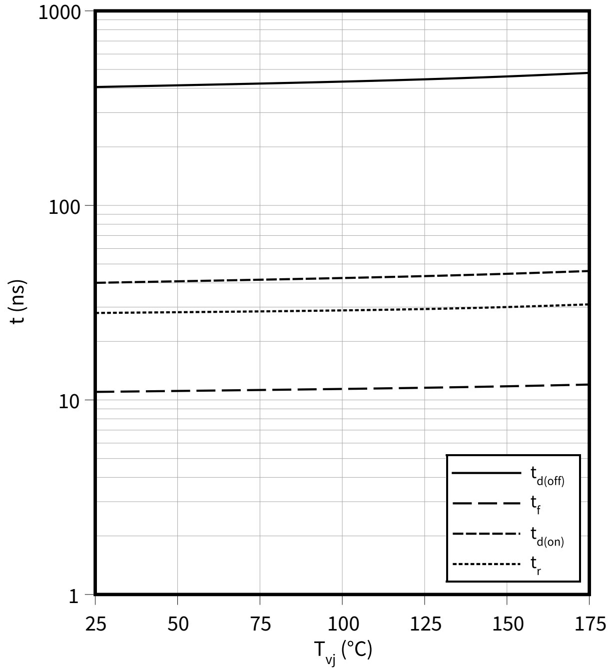
$I_C = 40$ A, $V_{CC} = 400$ V, $T_{vj} = 175$ °C, $V_{GE} = 0/15$ V



Typical switching times as a function of junction temperature

$t = f(T_{vj})$

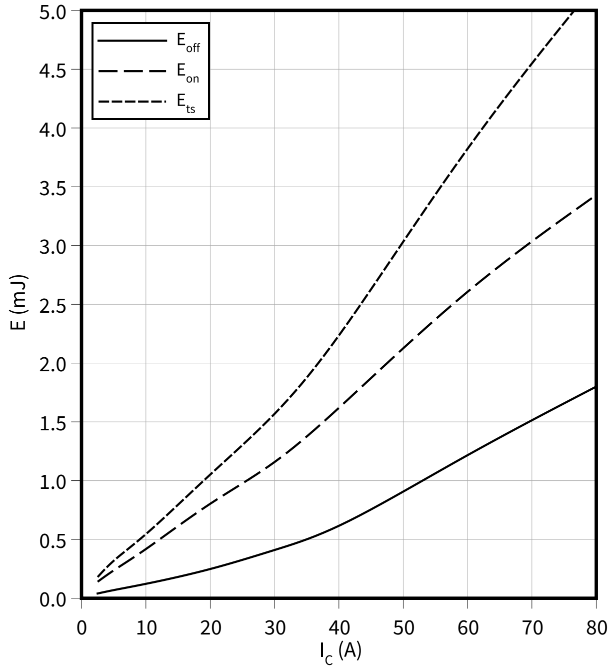
$I_C = 40$ A, $V_{CC} = 400$ V, $V_{GE} = 0/15$ V, $R_G = 20$ Ω

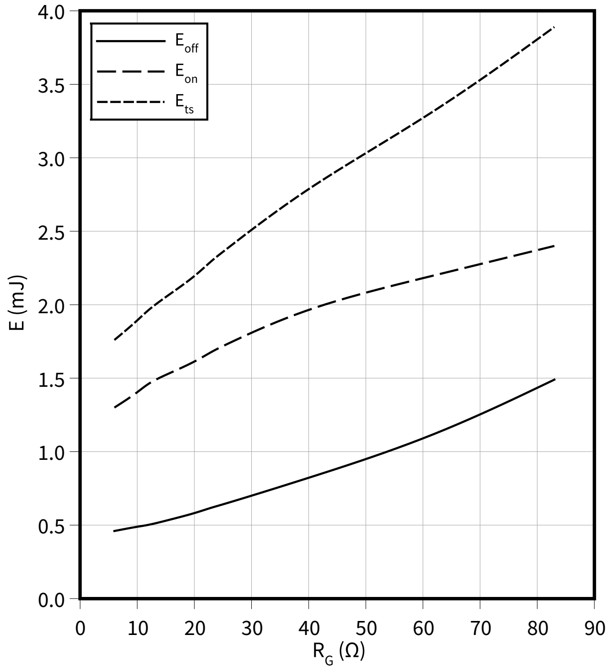
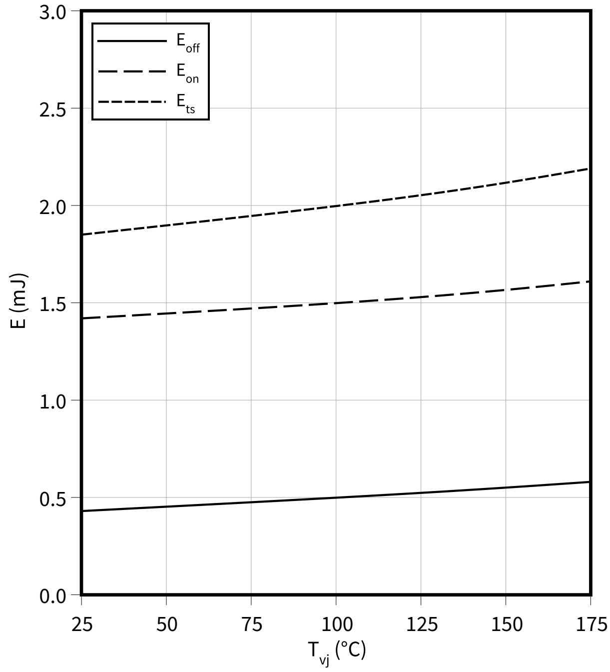
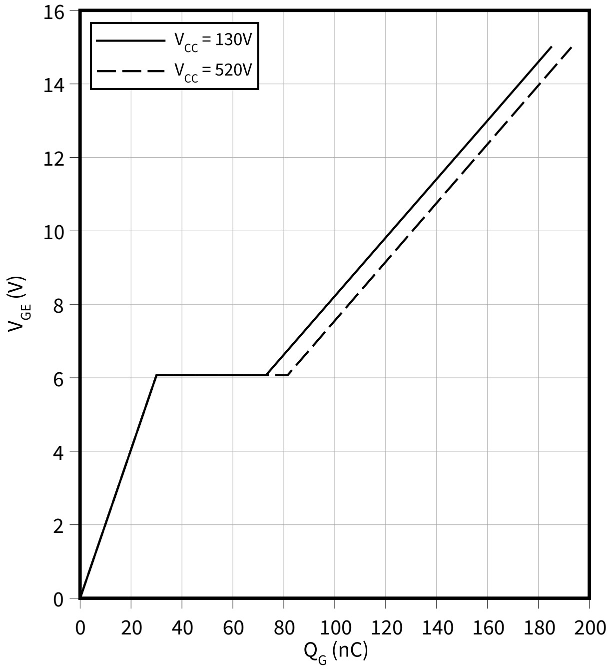
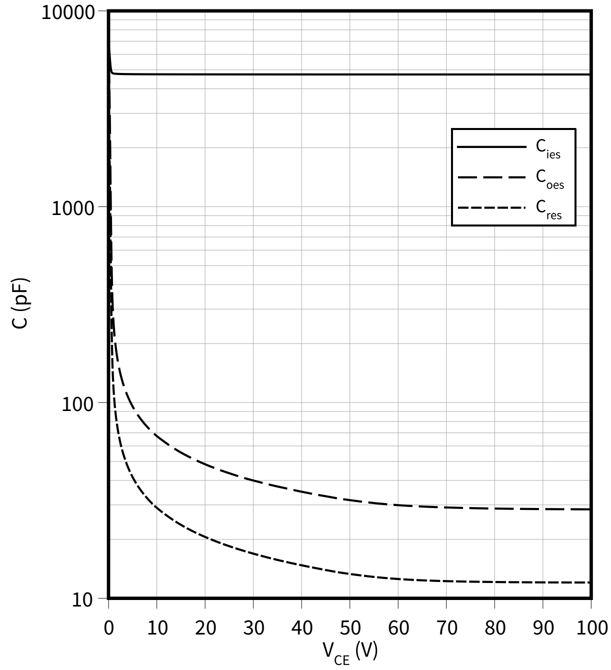


Typical switching energy losses as a function of collector current

$E = f(I_C)$

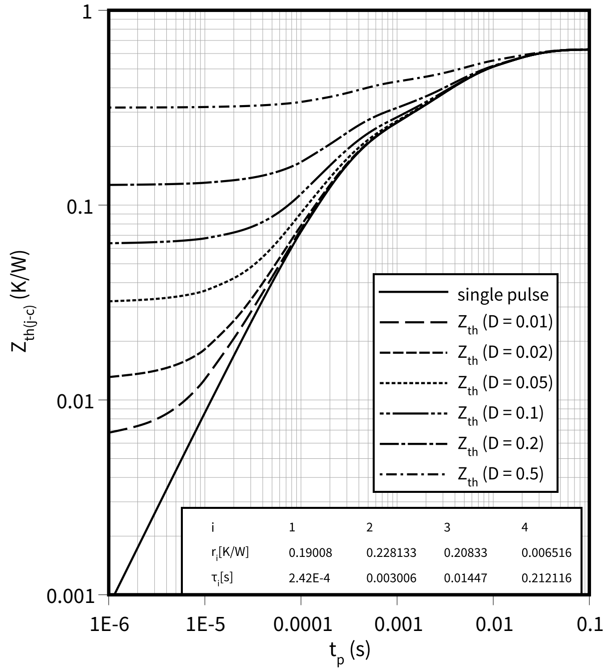
$V_{CC} = 400$ V, $T_{vj} = 175$ °C, $V_{GE} = 0/15$ V, $R_G = 20$ Ω



Typical switching energy losses as a function of gate resistor $E = f(R_G)$ I_C = 40 A, V_{CC} = 400 V, T_{vj} = 175 °C, V_{GE} = 0/15 V	**Typical switching energy losses as a function of junction temperature** $E = f(T_{vj})$ V_{CC} = 400 V, I_C = 40 A, V_{GE} = 0/15 V, R_G = 20 Ω
	
Typical gate charge $V_{GE} = f(Q_G)$ I_C = 40 A	**Typical capacitance as a function of collector-emitter voltage** $C = f(V_{CE})$ f = 1000 kHz, V_{GE} = 0 V
	

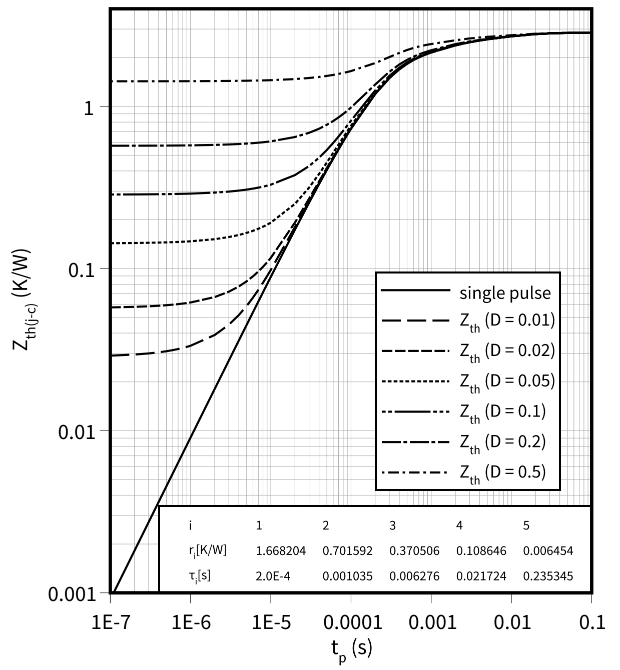
IGBT transient thermal impedance as a function of pulse width

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



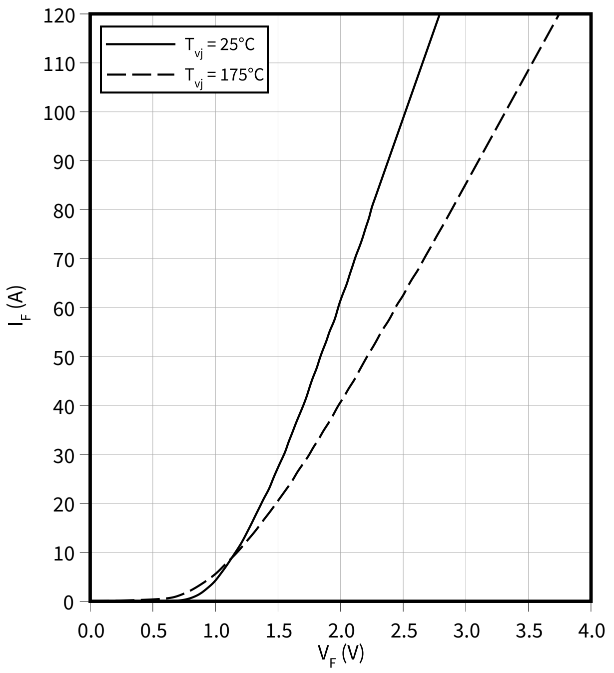
Diode transient thermal impedance as a function of pulse width

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



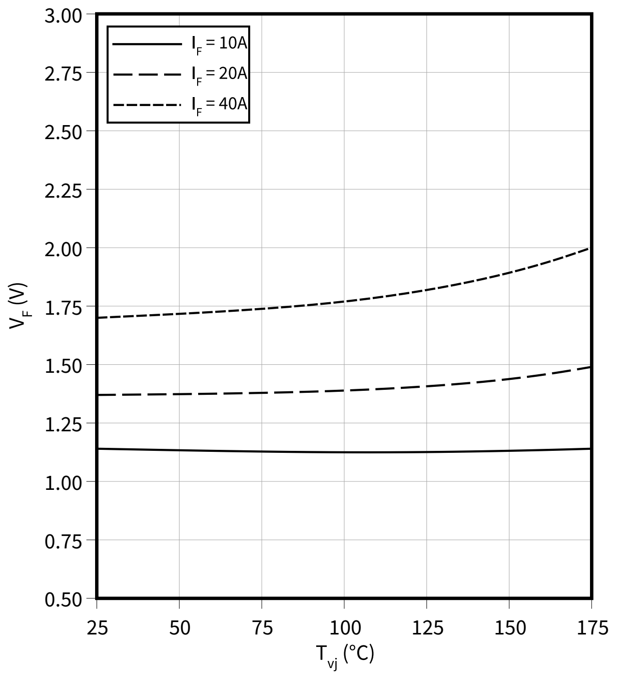
Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



Typical diode forward voltage as a function of junction temperature

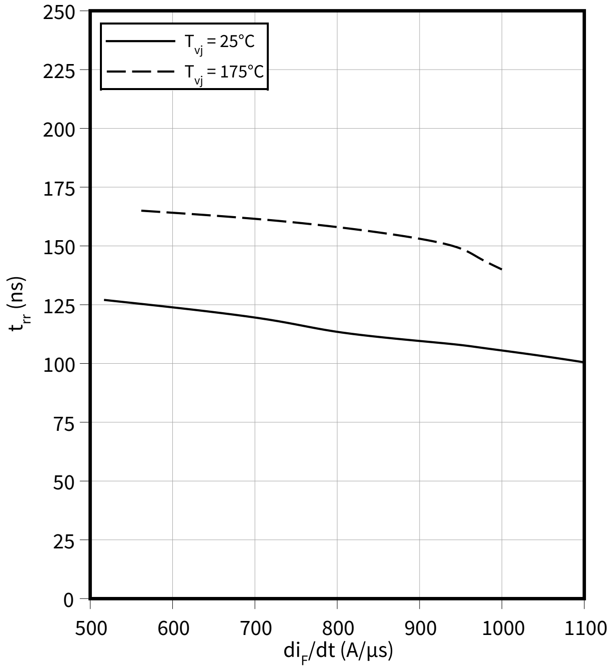
$V_F = f(T_{vj})$



Typical reverse recovery time as a function of diode current slope

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

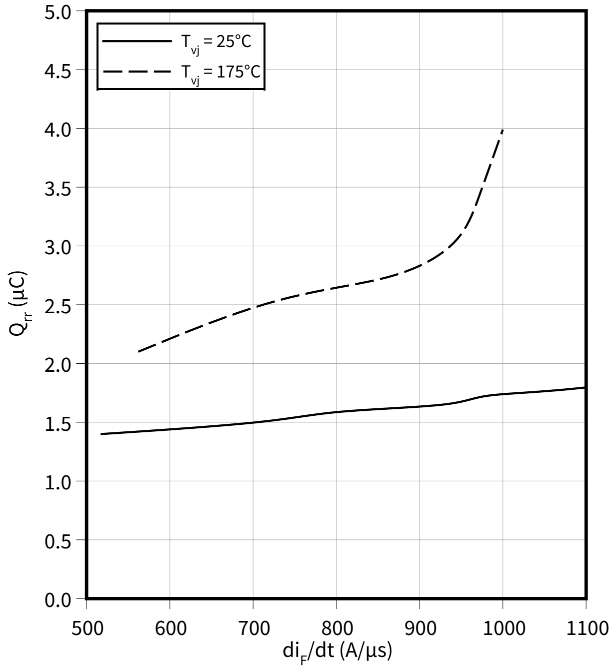
$V_R = 400$ V, $I_F = 20$ A



Typical reverse recovery charge as a function of diode current slope

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

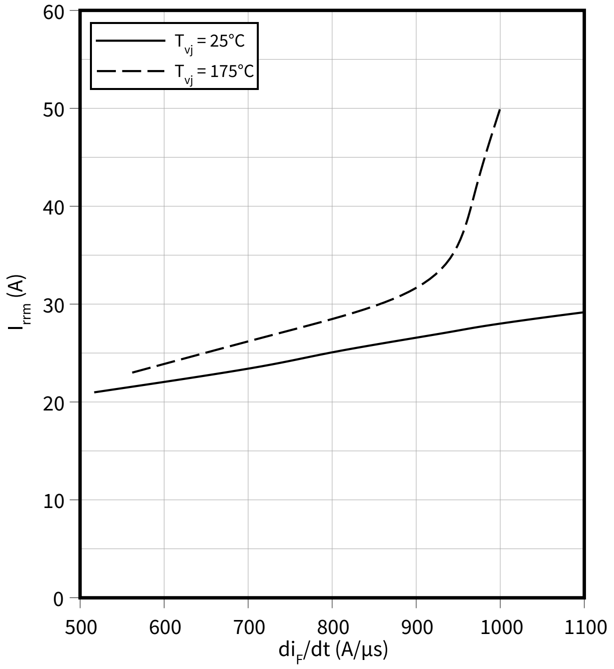
$V_R = 400$ V, $I_F = 20$ A



Typical reverse recovery current as a function of diode current slope

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

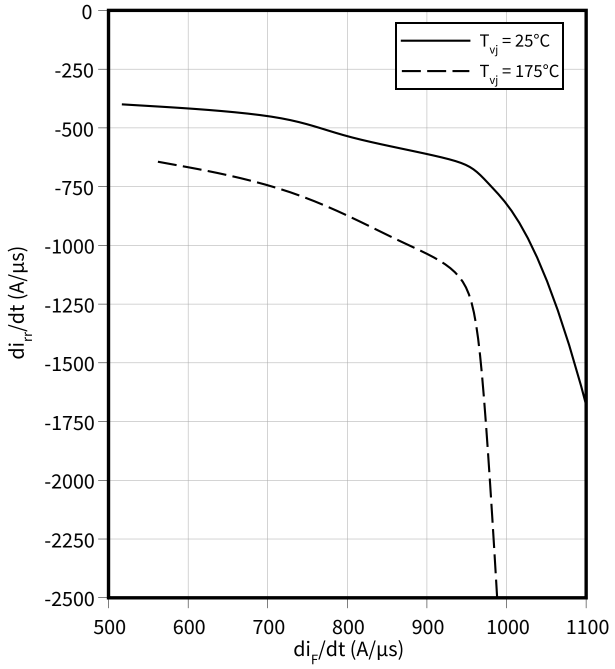
$V_R = 400$ V, $I_F = 20$ A



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

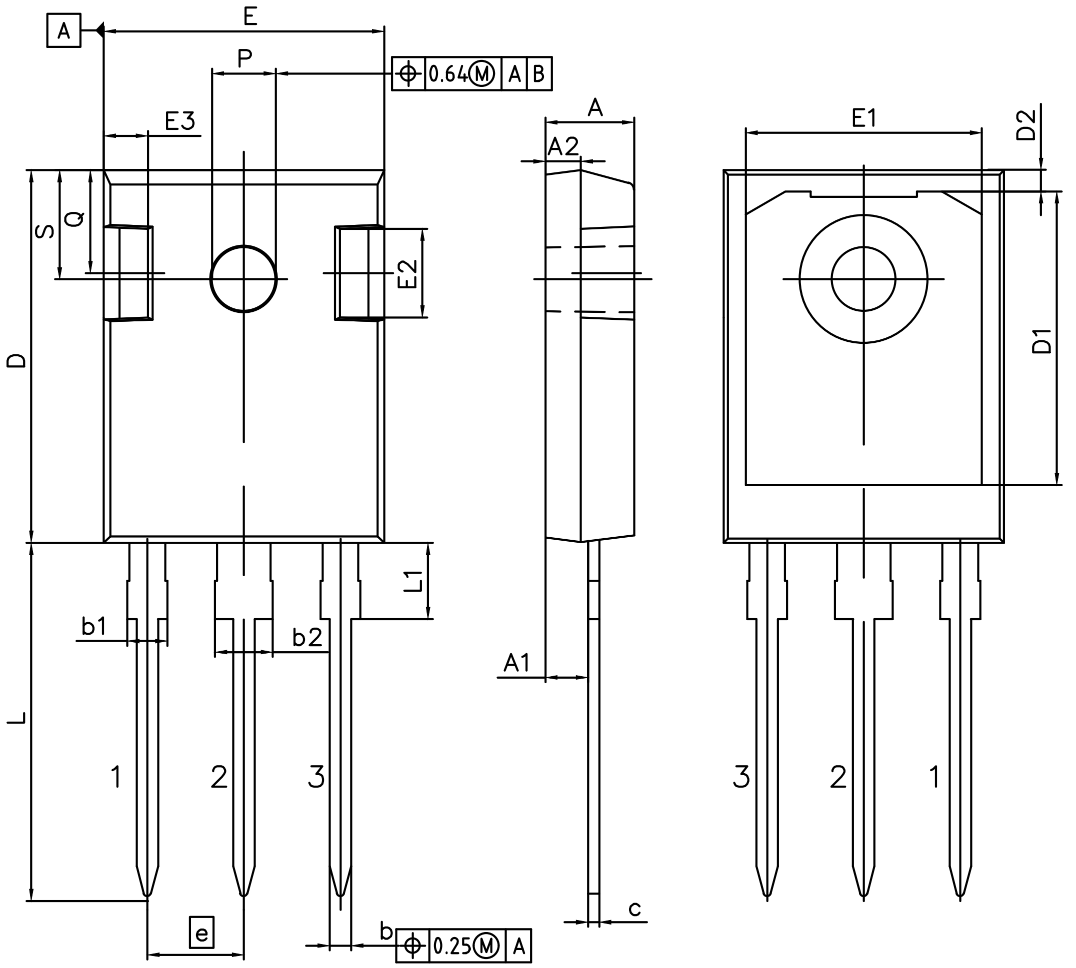
$di_{rr}/dt = f(di_F/dt)$

$V_R = 400$ V, $I_F = 20$ 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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EUROPEAN PROJECTION

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25.07.2018

Figure 1

6 Testing conditions

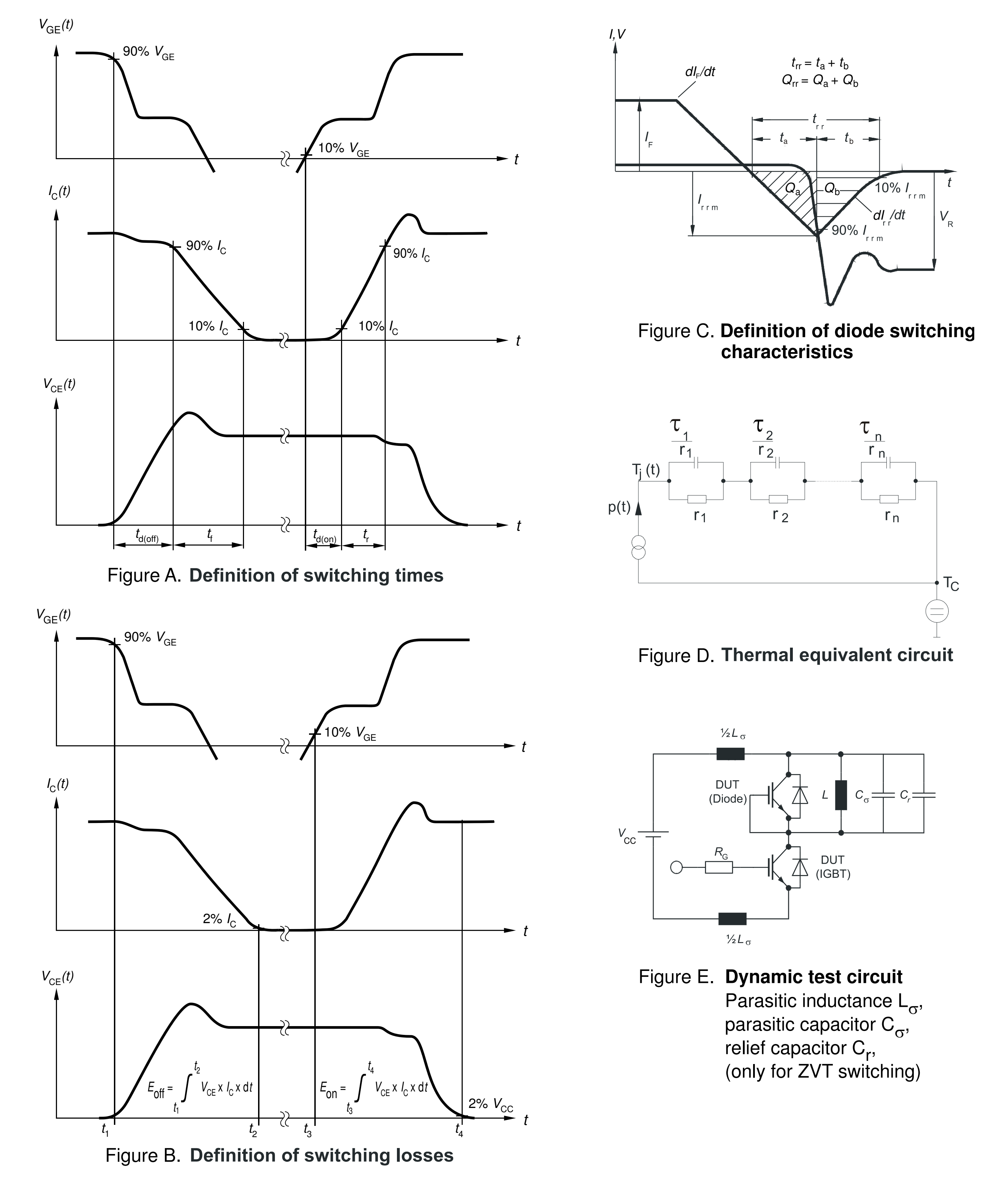

Figure A. **Definition of switching times**

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
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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