# IGBT

IGBT with integrated diode in packages offering space saving advantage

# IKD06N60R

600V TRENCHSTOP™ RC-Series for hard switching applications

Data sheet

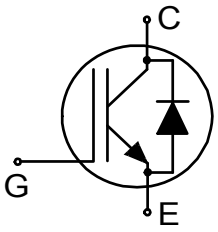
Industrial Power Control

TRENCHSTOP™ RC-Series for hard switching applications

# IGBT with integrated diode in packages offering space saving advantage

**Features:**

TRENCHSTOP™ Reverse Conducting (RC) technology for 600V applications offering
- Optimised $V_{CEsat}$ and $V_F$ for low conduction losses
- Smooth switching performance leading to low EMI levels
- Very tight parameter distribution
- Operating range of 1 to 20kHz
- Maximum junction temperature 175°C
- Short circuit capability of 5µs
- Best in class current versus package size performance
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant (for PG-TO252: solder temperature 260°C, MSL1)
- Complete product spectrum and PSpice Models: http://www.infineon.com/igbt/



**Applications:**

- Consumer motor drives

Green

Halogen-Free

RoHS

**Key Performance and Package Parameters**

| Type | $V_{CE}$ | $I_C$ | $V_{CEsat}$, $T_{vj}$=25°C | $T_{vjmax}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IKD06N60R | 600V | 6A | 1.65V | 175°C | K06R60 | PG-TO252-3 |

**Table of Contents**

Description . . . . . 2
Table of Contents . . . . . 3
Maximum Ratings . . . . . 4
Thermal Resistance . . . . . 4
Electrical Characteristics . . . . . 5
Electrical Characteristics Diagrams . . . . . 7
Package Drawing . . . . . 14
Testing Conditions . . . . . 15
Revision History . . . . . 16
Disclaimer . . . . . 17

## Maximum Ratings

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

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage, $T_{vj} \geq 25°C$ | $V_{CE}$ | 600 | V |
| DC collector current, limited by $T_{vjmax}$<br>$T_c = 25°C$<br>$T_c = 100°C$ | $I_C$ | 12.0<br>6.0 | A |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpuls}$ | 18.0 | A |
| Turn off safe operating area<br>$V_{CE} \leq 600V$, $T_{vj} \leq 175°C$, $t_p = 1\mu s$ | - | 18.0 | A |
| Diode forward current, limited by $T_{vjmax}$<br>$T_c = 25°C$<br>$T_c = 100°C$ | $I_F$ | 12.0<br>6.0 | A |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpuls}$ | 18.0 | A |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Short circuit withstand time<br>$V_{GE} = 15.0V$, $V_{CC} \leq 400V$<br>Allowed number of short circuits < 1000<br>Time between short circuits: ≥ 1.0s<br>$T_{vj} = 150°C$ | $t_{SC}$ | 5 | µs |
| Power dissipation $T_c = 25°C$ | $P_{tot}$ | 100.0 | W |
| Operating junction temperature | $T_{vj}$ | -40...+175 | °C |
| Storage temperature | $T_{stg}$ | -55...+150 | °C |
| Soldering temperature,<br>reflow soldering (MSL1 according to JEDEC J-STA-020) | | 260 | °C |

## Thermal Resistance

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **$R_{th}$ Characteristics** | | | | | | |
| IGBT thermal resistance,[1]<br>junction - case | $R_{th(j-c)}$ | | - | - | 1.50 | K/W |
| Diode thermal resistance,[2]<br>junction - case | $R_{th(j-c)}$ | | - | - | 3.60 | K/W |
| Thermal resistance, min. footprint<br>junction - ambient | $R_{th(j-a)}$ | | - | - | 75 | K/W |
| Thermal resistance, 6cm² Cu on PCB<br>junction - ambient | $R_{th(j-a)}$ | | - | - | 50 | K/W |

[1] Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the IGBT, is not possible using a thermocouple.
[2] Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the Diode, is not possible using a thermocouple.

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

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **Static Characteristic** | | | | | | |
| Collector-emitter breakdown voltage | $V_{(BR)CES}$ | $V_{GE}$ = 0V, $I_C$ = 0.20mA | 600 | - | - | V |
| Collector-emitter saturation voltage | $V_{CEsat}$ | $V_{GE}$ = 15.0V, $I_C$ = 6.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | 1.65<br>1.85 | 2.10<br>- | V |
| Diode forward voltage | $V_F$ | $V_{GE}$ = 0V, $I_F$ = 6.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | 1.70<br>1.70 | 2.10<br>- | V |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$ = 0.11mA, $V_{CE}$ = $V_{GE}$ | 4.3 | 5.0 | 5.7 | V |
| Zero gate voltage collector current[1)] | $I_{CES}$ | $V_{CE}$ = 600V, $V_{GE}$ = 0V<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | -<br>- | 40<br>1000 | µA |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$ = 0V, $V_{GE}$ = 20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$ = 20V, $I_C$ = 6.0A | - | 3.4 | - | S |
| Integrated gate resistor | $r_G$ | | | none | | Ω |

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

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **Dynamic Characteristic** | | | | | | |
| Input capacitance | $C_{ies}$ | $V_{CE}$ = 25V, $V_{GE}$ = 0V, f = 1MHz | - | 470 | - | pF |
| Output capacitance | $C_{oes}$ | | - | 24 | - | |
| Reverse transfer capacitance | $C_{res}$ | | - | 14 | - | |
| Gate charge | $Q_G$ | $V_{CC}$ = 480V, $I_C$ = 6.0A,<br>$V_{GE}$ = 15V | - | 48.0 | - | nC |
| Short circuit collector current<br>Max. 1000 short circuits<br>Time between short circuits: ≥ 1.0s | $I_{C(SC)}$ | $V_{GE}$ = 15.0V, $V_{CC}$ ≤ 400V,<br>$t_{SC}$ ≤ 5µs<br>$T_{vj}$ = 25°C | - | 46 | - | A |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic, at $T_{vj}$ = 25°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 25°C,<br>$V_{CC}$ = 400V, $I_C$ = 6.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 23.0Ω, $R_{G(off)}$ = 23.0Ω,<br>Lσ = 60nH, Cσ = 40pF<br>Lσ, Cσ from Fig. E | - | 12 | - | ns |
| Rise time | $t_r$ | | - | 7 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 127 | - | ns |
| Fall time | $t_f$ | | - | 152 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.11 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.22 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.33 | - | mJ |

[1)] Not subject to production test - verified by design/characterization

**Diode Characteristic, at $T_{vj}$ = 25°C**

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C, $V_R$ = 400V, $I_F$ = 6.0A, $di_F/dt$ = 800A/µs | - | 68 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.37 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 12.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -211 | - | A/µs |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic, at $T_{vj}$ = 175°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 175°C, $V_{CC}$ = 400V, $I_C$ = 6.0A, $V_{GE}$ = 0.0/15.0V, $R_{G(on)}$ = 23.0Ω, $R_{G(off)}$ = 23.0Ω, $L\sigma$ = 60nH, $C\sigma$ = 40pF $L\sigma$, $C\sigma$ from Fig. E | - | 12 | - | ns |
| Rise time | $t_r$ | | - | 10 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 164 | - | ns |
| Fall time | $t_f$ | | - | 171 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.20 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.36 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.56 | - | mJ |

**Diode Characteristic, at $T_{vj}$ = 175°C**

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 175°C, $V_R$ = 400V, $I_F$ = 6.0A, $di_F/dt$ = 800A/µs | - | 74 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.80 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 17.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -237 | - | A/µs |

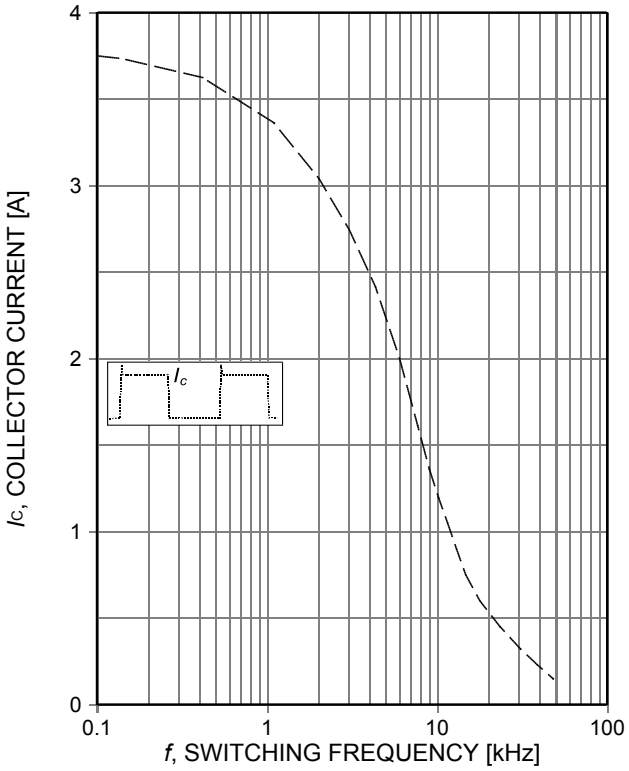



Figure 1. **Collector current as a function of switching frequency**
($T_{vj}$≤175°C, $T_a$=55°C, $D$=0.5, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=23Ω, PCB mounting, 6cm2 Cu, Ptot=2,4W)

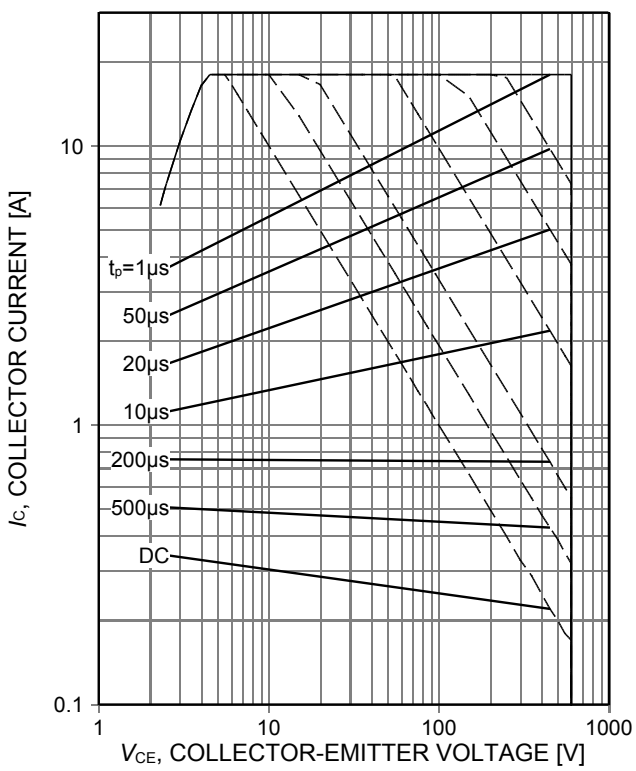



Figure 2. **Forward bias safe operating area**
($D$=0, $T_C$=25°C, $T_{vj}$≤175°C; $V_{GE}$=15V)

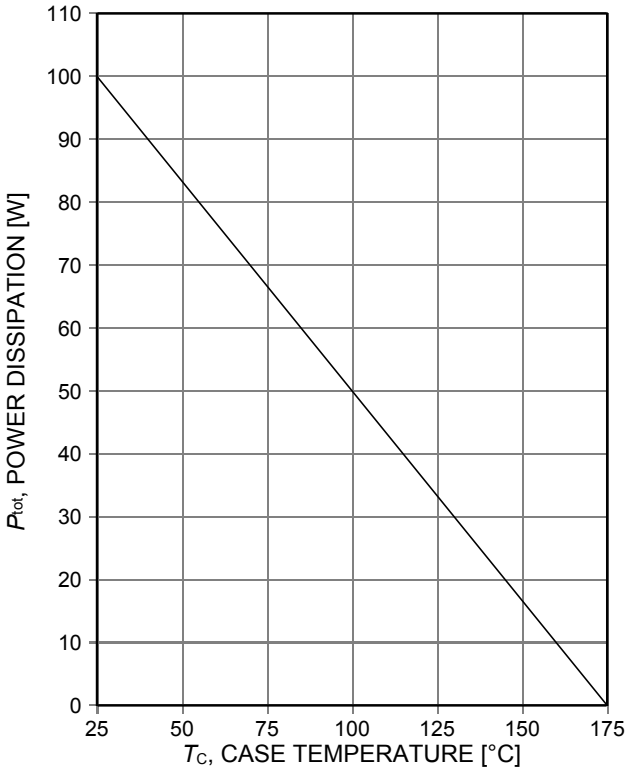



Figure 3. **Power dissipation as a function of case temperature**
($T_{vj}$≤175°C)

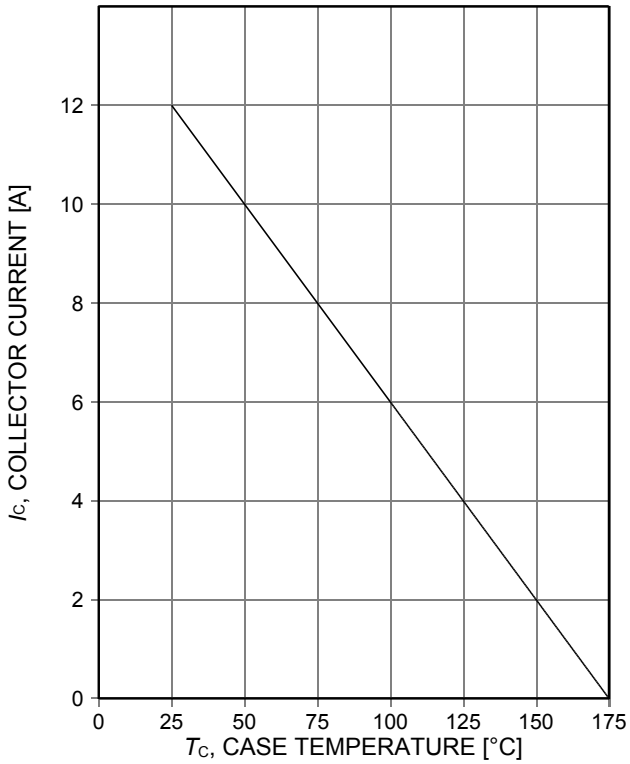



Figure 4. **Collector current as a function of case temperature**
($V_{GE}$≥15V, $T_{vj}$≤175°C)

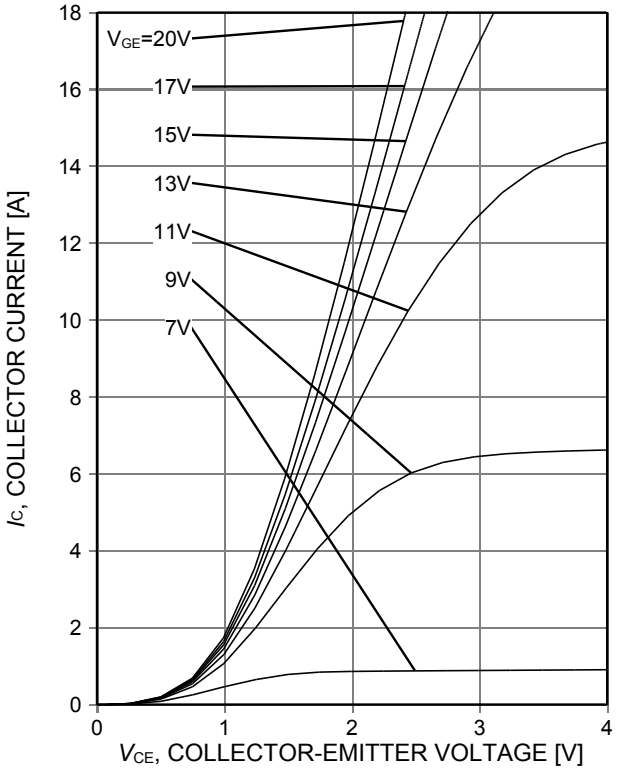



Figure 5. **Typical output characteristic** ($T_{vj}$=25°C)

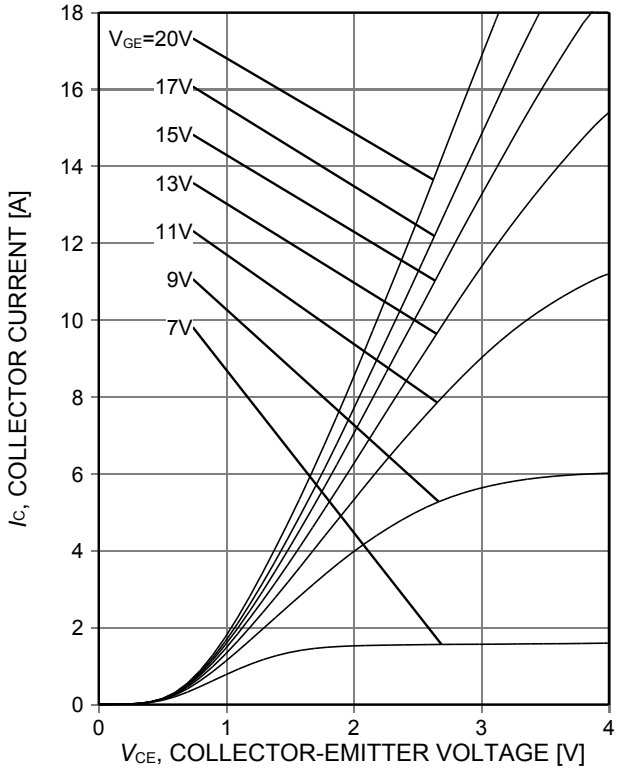



Figure 6. **Typical output characteristic** ($T_{vj}$=175°C)

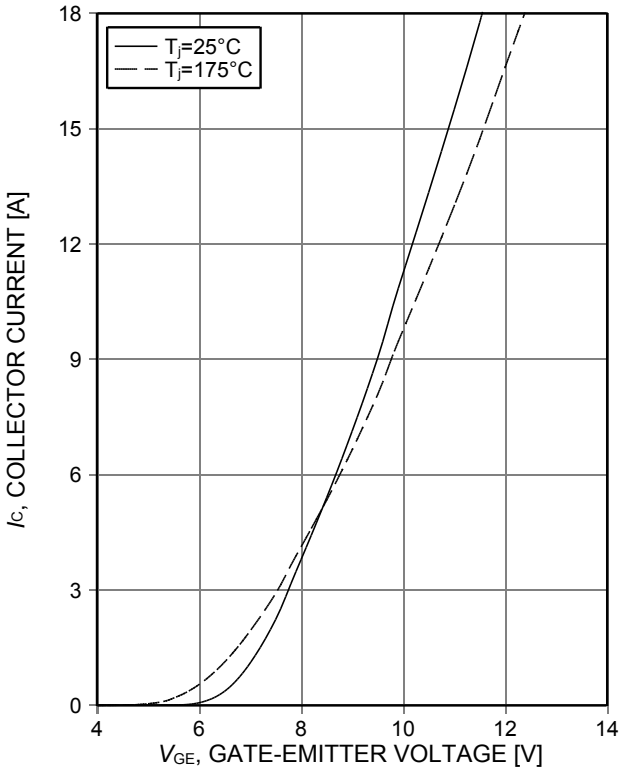



Figure 7. **Typical transfer characteristic** ($V_{CE}$=10V)

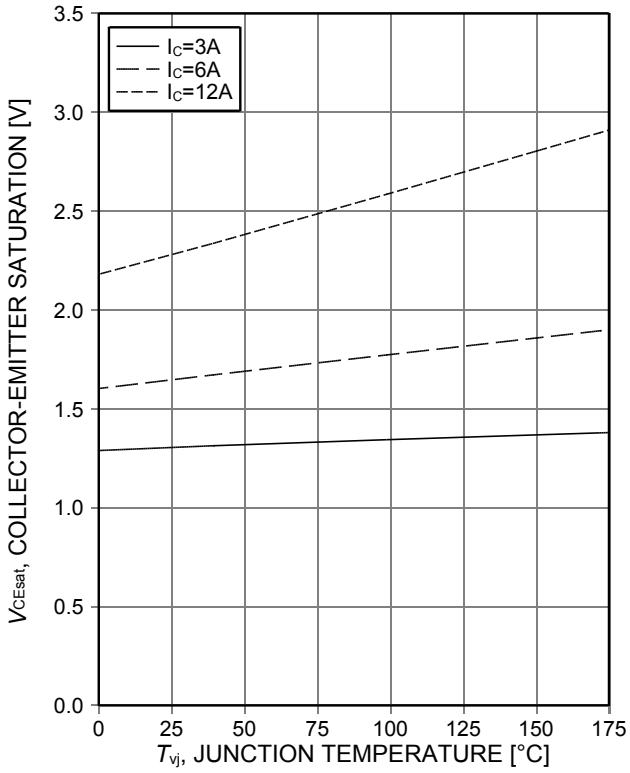



Figure 8. **Typical collector-emitter saturation voltage as a function of junction temperature** ($V_{GE}$=15V)

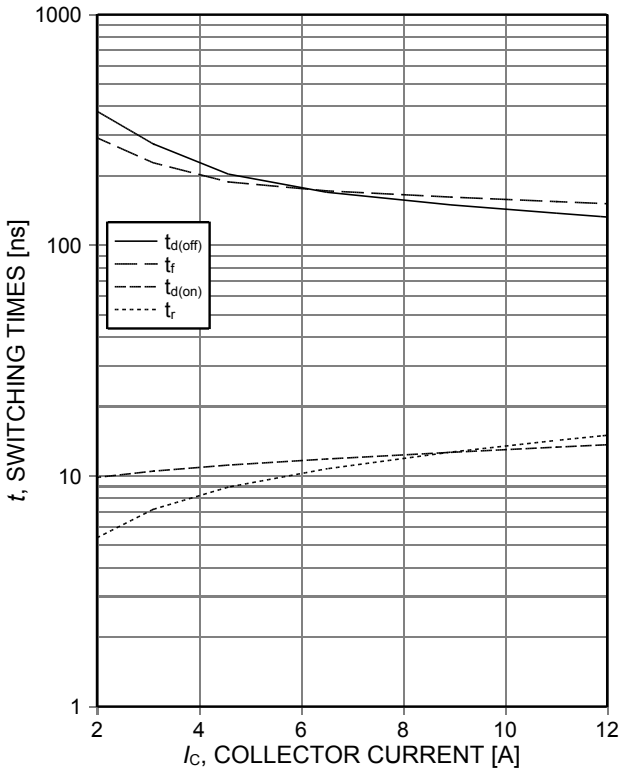



Figure 9. **Typical switching times as a function of collector current**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=23Ω, Dynamic test circuit in Figure E)

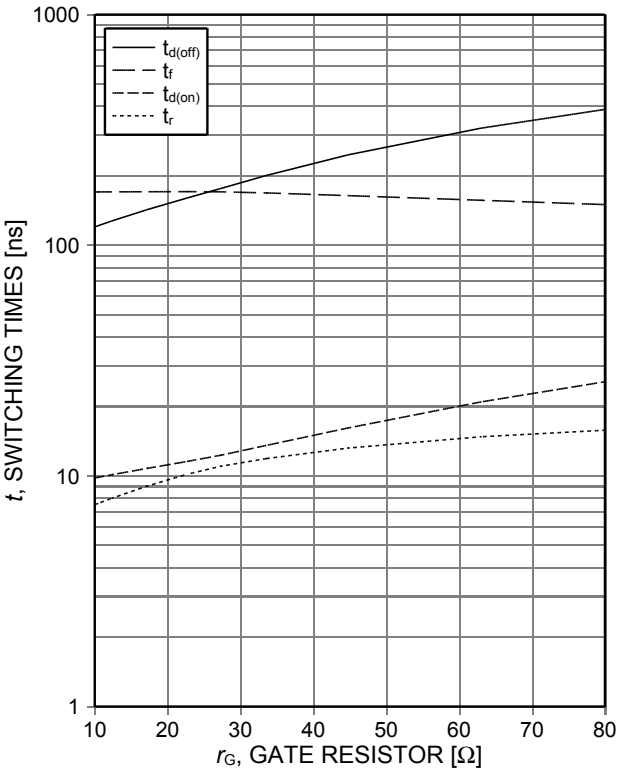



Figure 10. **Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, Dynamic test circuit in Figure E)

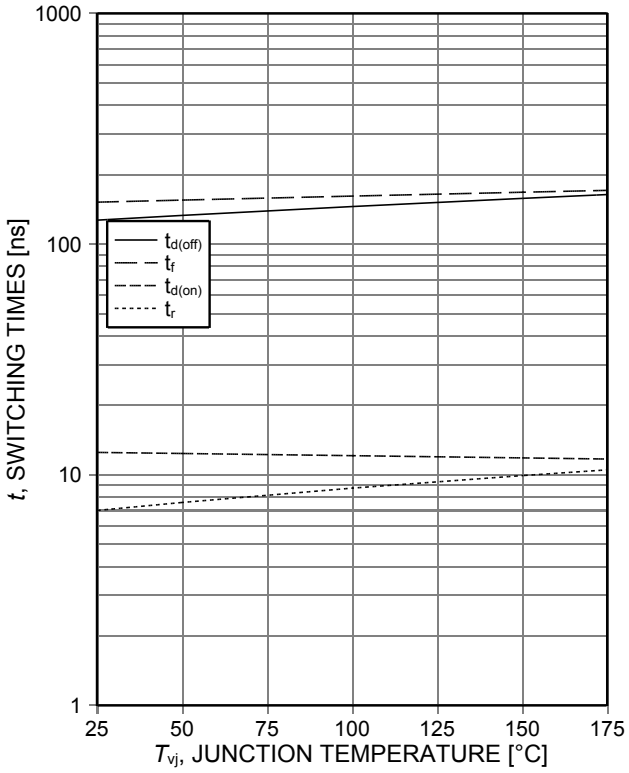



Figure 11. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

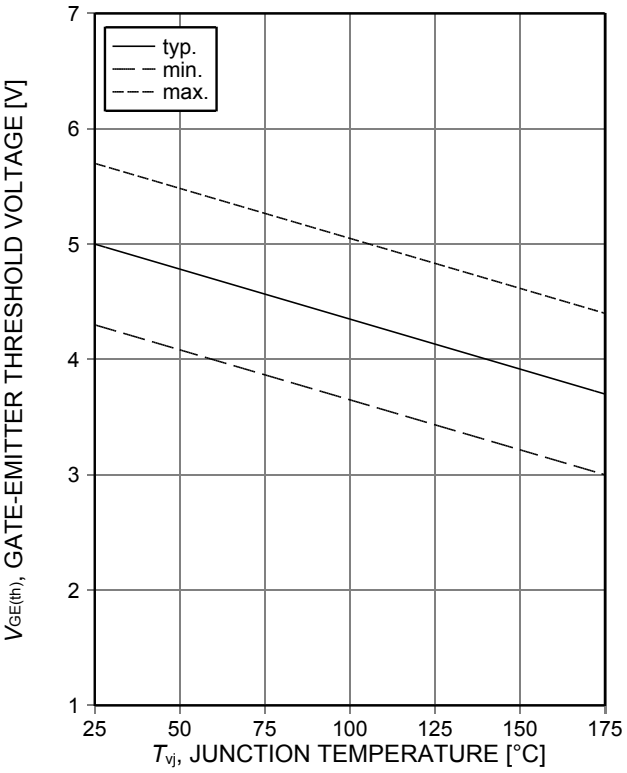



Figure 12. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C$=0.11mA)

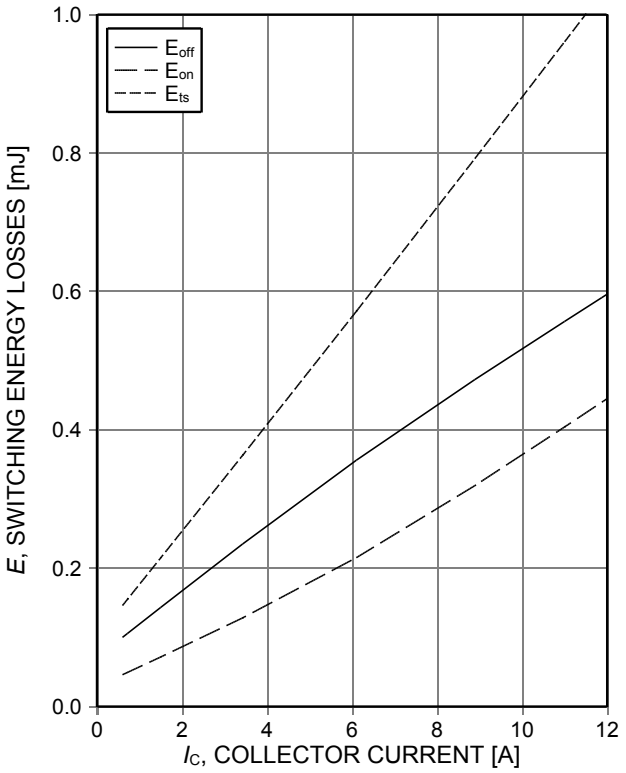



Figure 13. **Typical switching energy losses as a function of collector current** (inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=23Ω, Dynamic test circuit in Figure E)

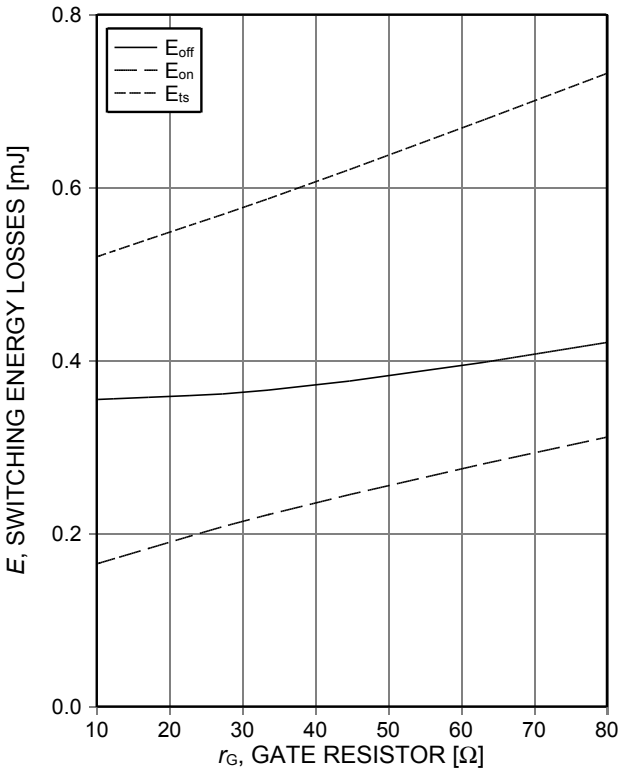



Figure 14. **Typical switching energy losses as a function of gate resistor** (inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, Dynamic test circuit in Figure E)

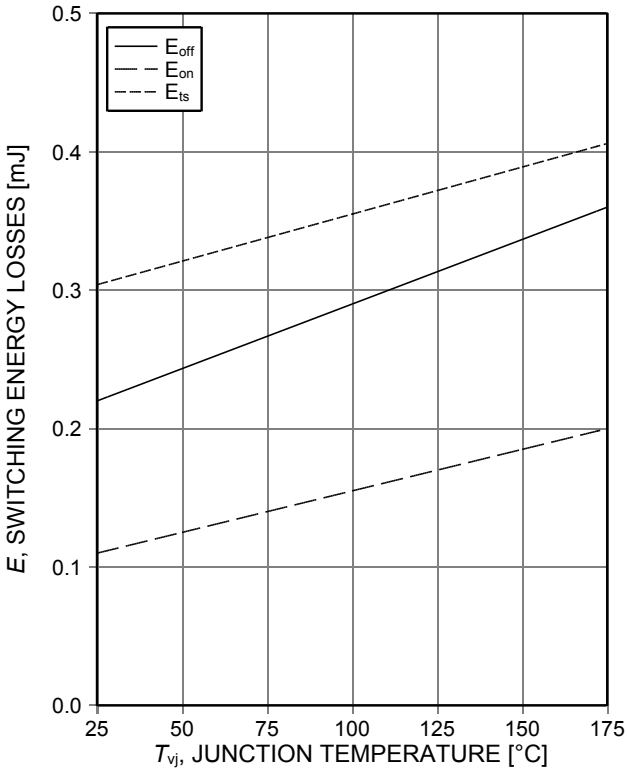



Figure 15. **Typical switching energy losses as a function of junction temperature** (inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

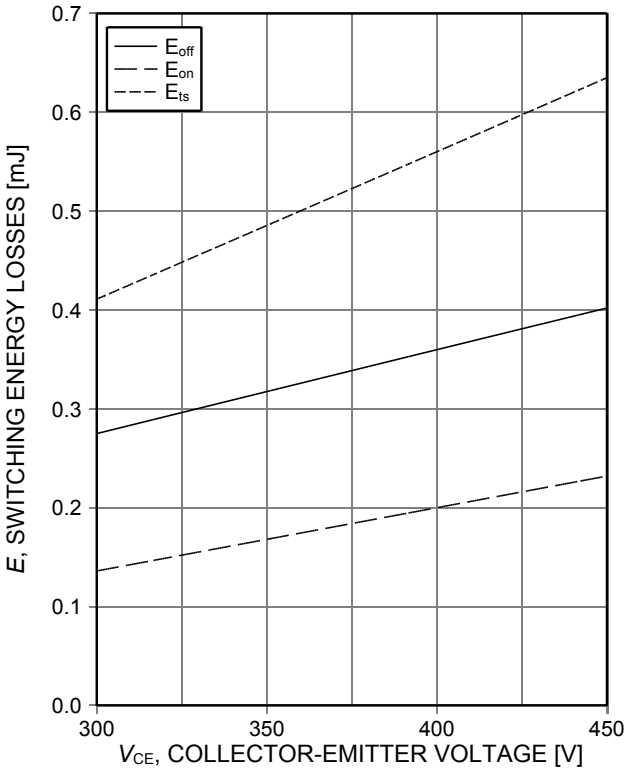



Figure 16. **Typical switching energy losses as a function of collector emitter voltage** (inductive load, $T_{vj}$=175°C, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

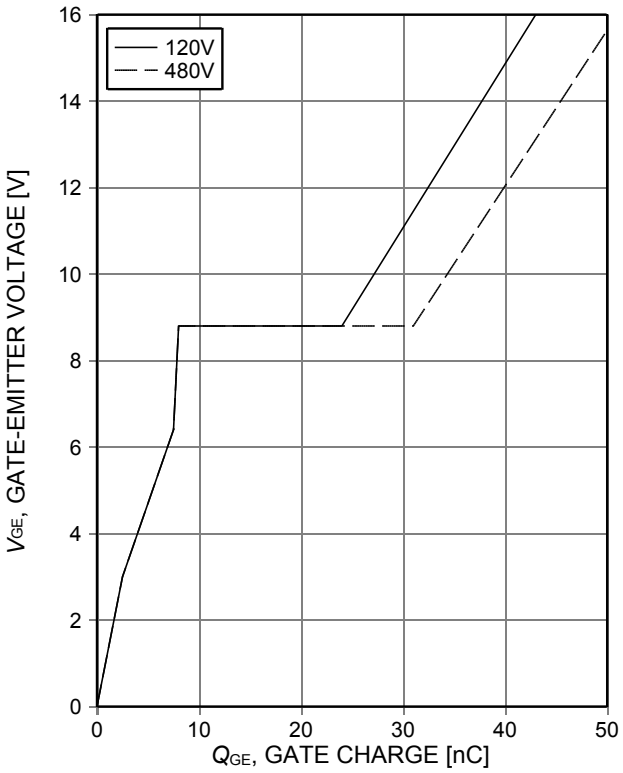



Figure 17. **Typical gate charge**
($I_C$=6A)

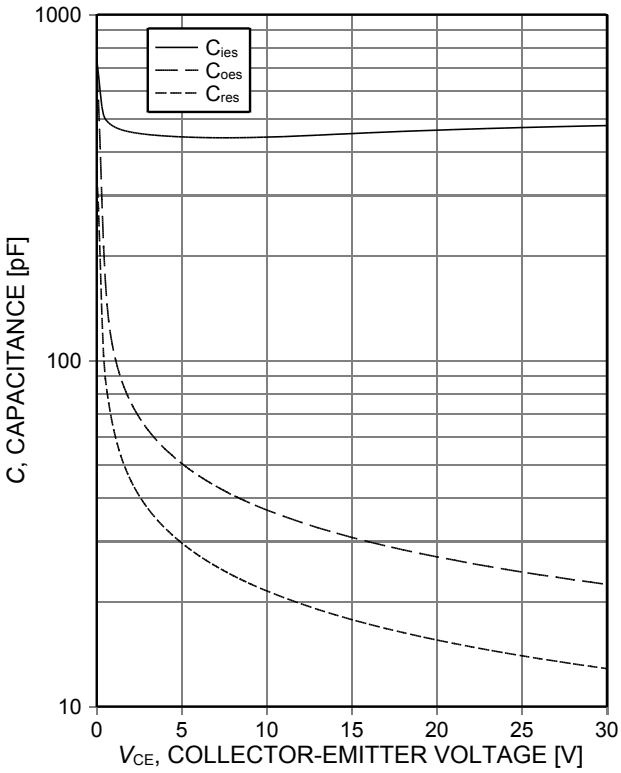



Figure 18. **Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$=0V, f=1MHz)

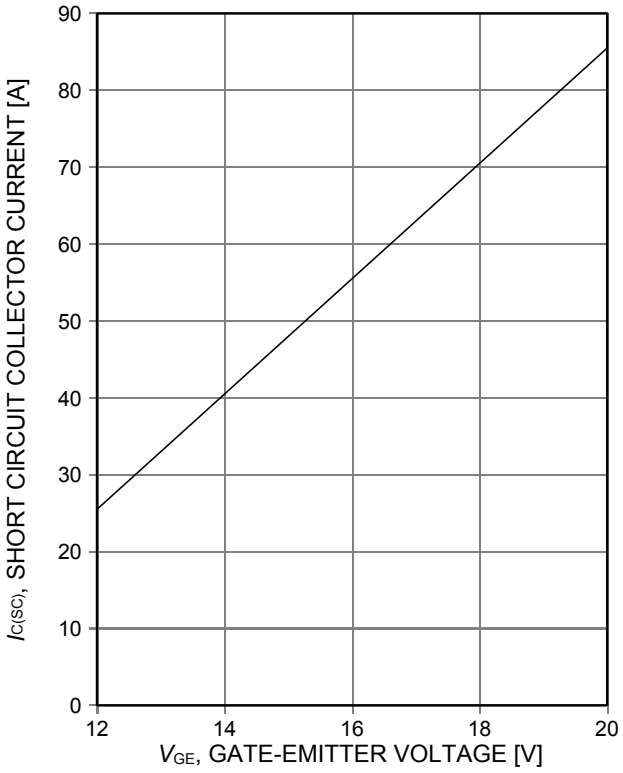



Figure 19. **Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE}$≤400V, start at $T_{vj}$=25°C)

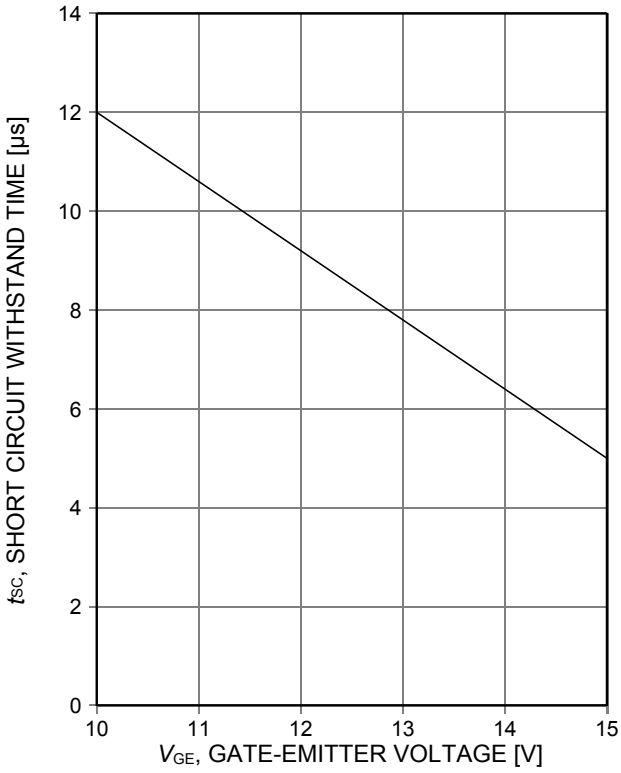



Figure 20. **Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$≤400V, start at $T_{vj}$≤150°C)

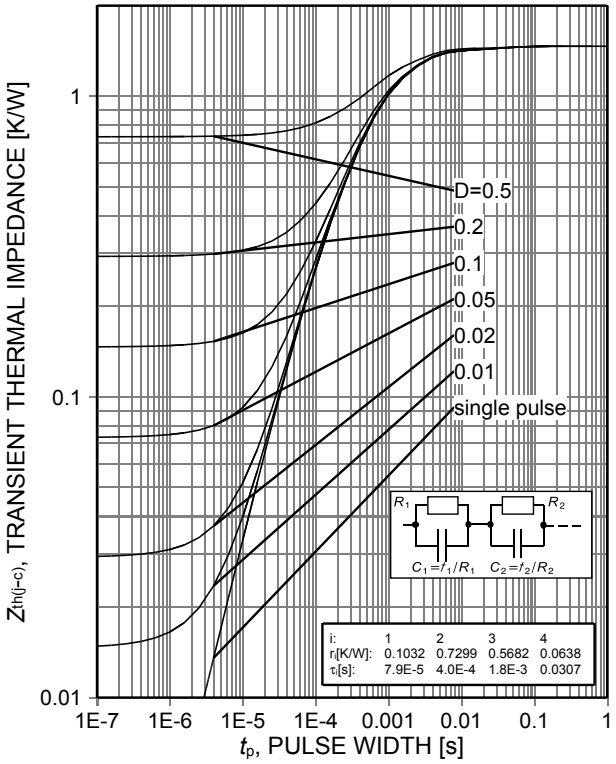



Figure 21. **IGBT transient thermal impedance as a function of pulse width [1] (see page 4)** ($D=t_p/T$)

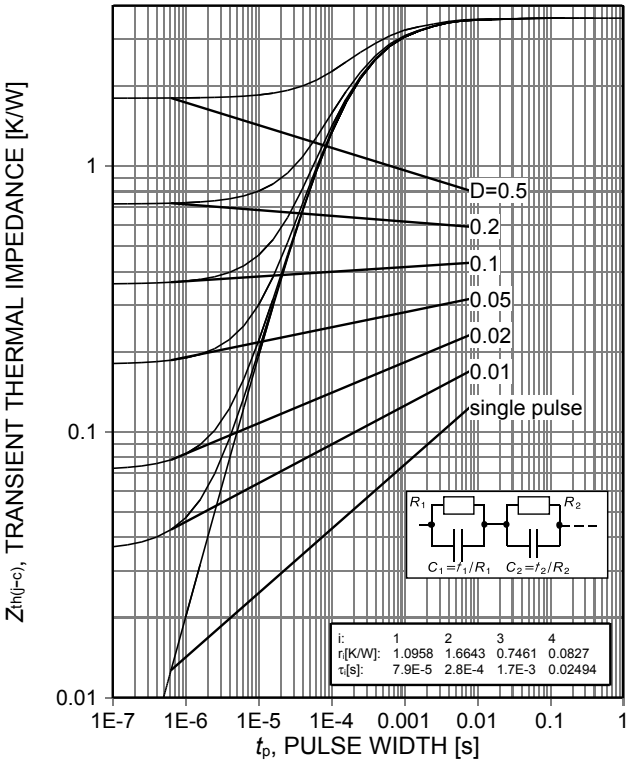



Figure 22. **Diode transient thermal impedance as a function of pulse width [2] (see page 4)** ($D=t_p/T$)

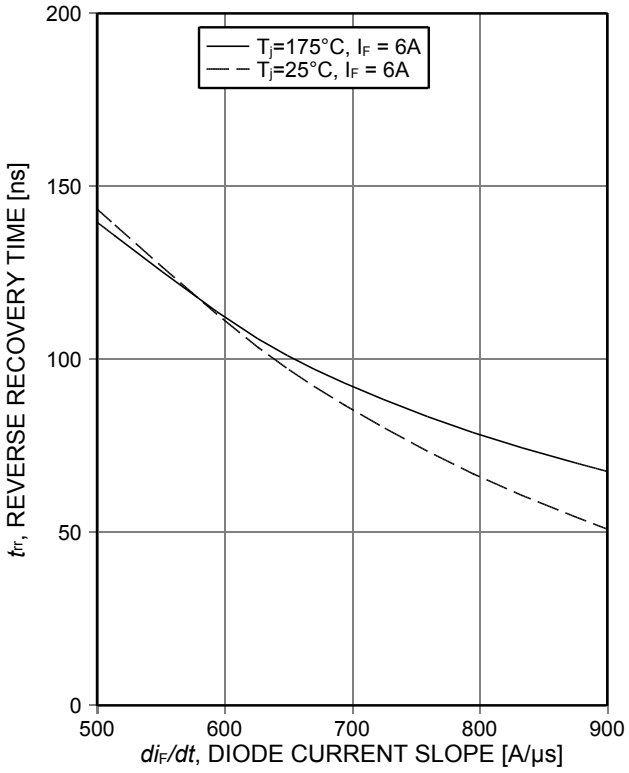



Figure 23. **Typical reverse recovery time as a function of diode current slope** ($V_R$=400V)

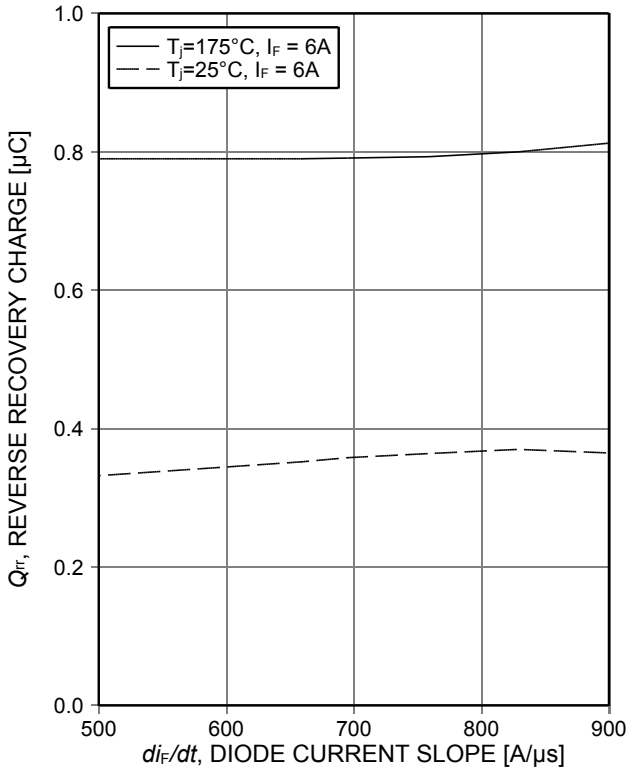



Figure 24. **Typical reverse recovery charge as a function of diode current slope** ($V_R$=400V)

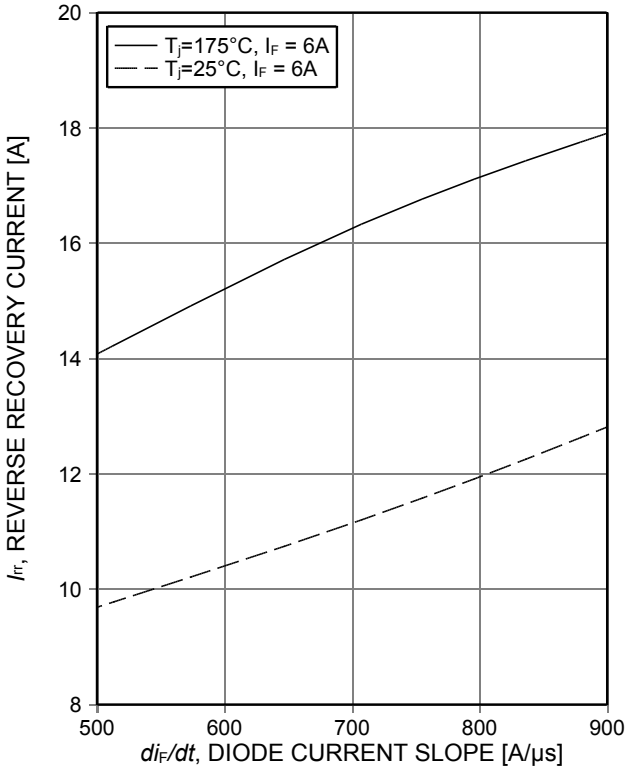



Figure 25. **Typical reverse recovery current as a function of diode current slope**
($V_R$=400V)

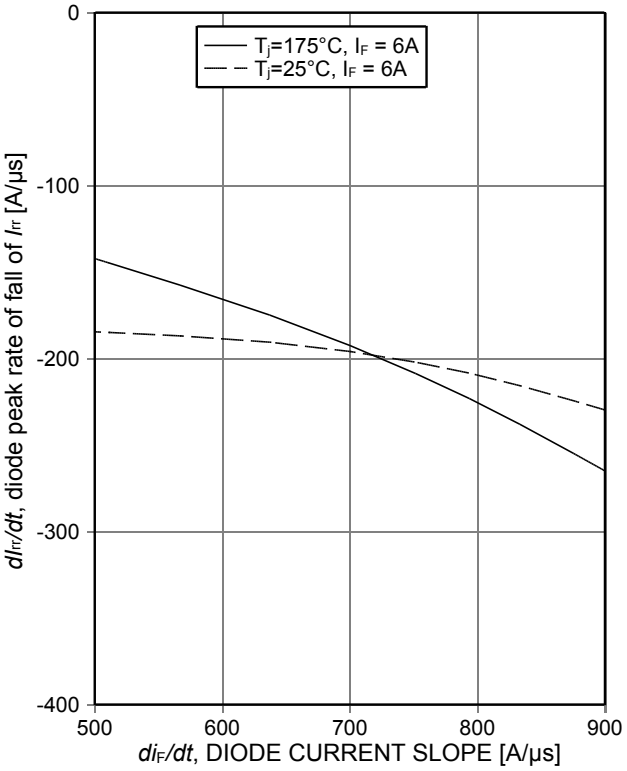



Figure 26. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V)

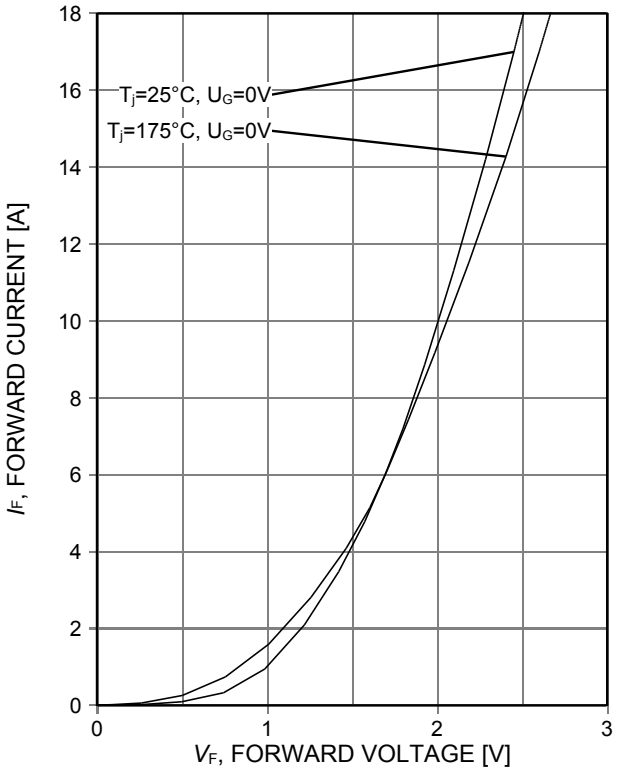



Figure 27. **Typical diode forward current as a function of forward voltage**

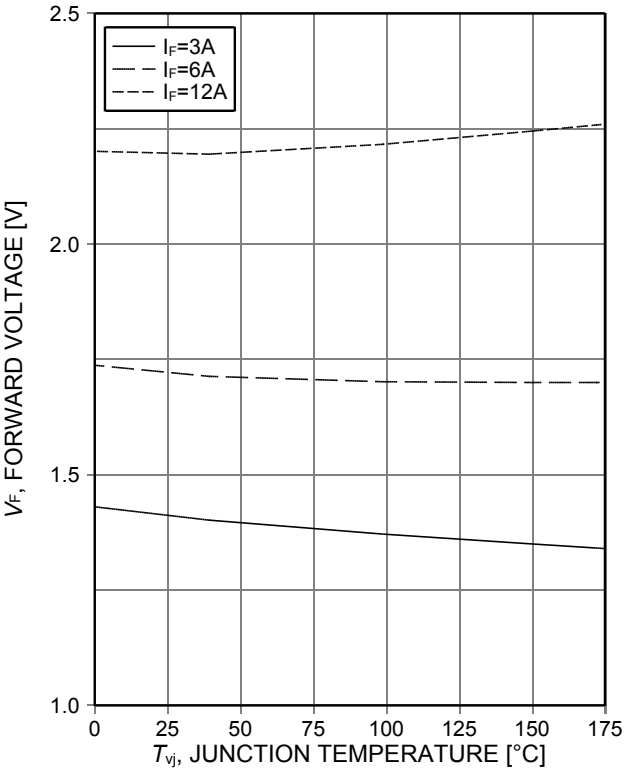
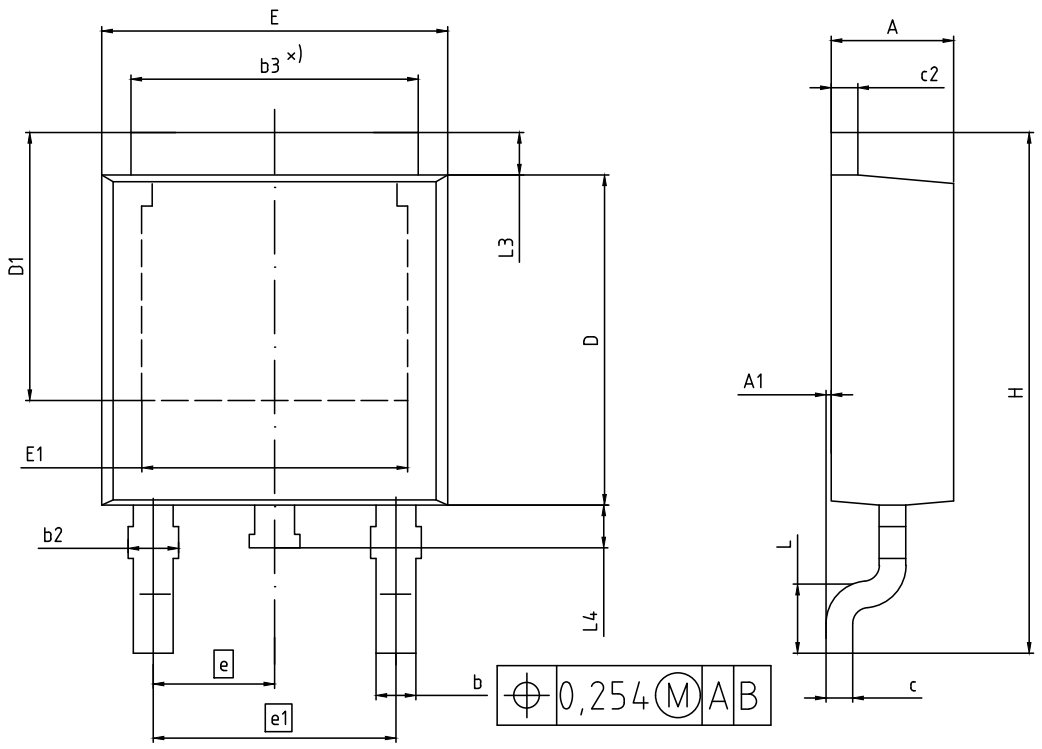
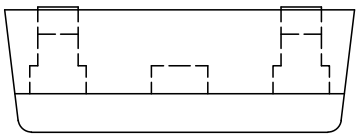



Figure 28. **Typical diode forward voltage as a function of junction temperature**

## Package Drawing PG-TO252-3



NOTES:

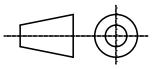
1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

| DIM | MILLIMETERS | |
|---|---|---|
| | MIN | MAX |
| **A** | 2.16 | 2.41 |
| **A1** | 0.00 | 0.15 |
| **b** | 0.64 | 0.89 |
| **b2** | 0.65 | 1.15 |
| **b3** | 4,95 | 5.50 |
| **c** | 0.46 | 0.61 |
| **c2** | 0.40 | 0.98 |
| **D** | 5.97 | 6.22 |
| **D1** | 5.02 | 5.84 |
| **E** | 6.35 | 6.73 |
| **E1** | 4.32 | 5.21 |
| **e** | 2.29 (BSC) | |
| **e1** | 4.57 (BSC) | |
| **N** | 3 | |
| **H** | 9.40 | 10.48 |
| **L** | 1.18 | 1.78 |
| **L3** | 0.89 | 1.27 |
| **L4** | 0.51 | 1.02 |

**DOCUMENT NO.**
Z8B00003328

**SCALE**
0 2.5 0 2.5 5mm

**EUROPEAN PROJECTION**



**ISSUE DATE**
05-02-2016

**REVISION**
06

### Testing Conditions

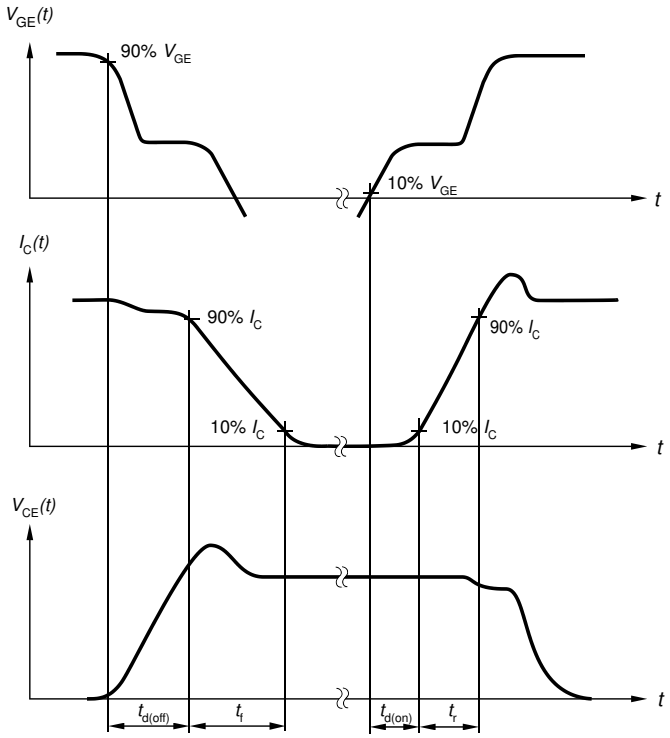



Figure A. **Definition of switching times**

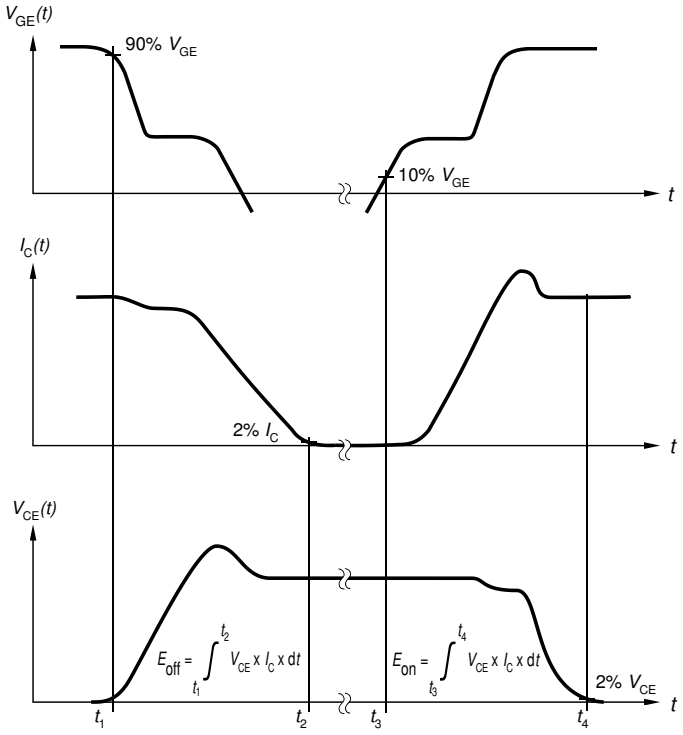



Figure B. **Definition of switching losses**

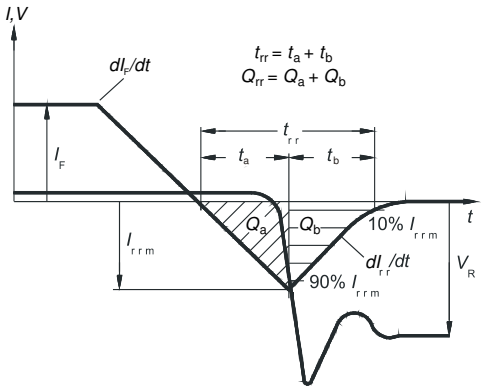



Figure C. **Definition of diode switching characteristics**

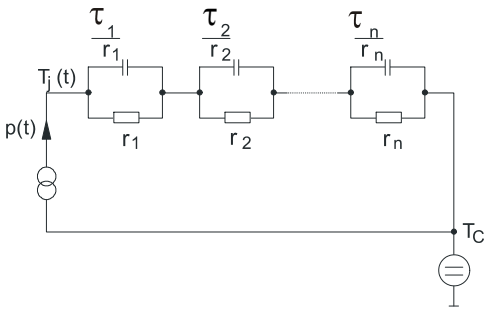



Figure D. **Thermal equivalent circuit**

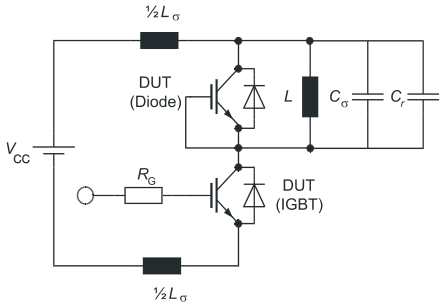



Figure E. **Dynamic test circuit**
Parasitic inductance $L_\sigma$,
parasitic capacitor $C_\sigma$,
relief capacitor $C_r$,
(only for ZVT switching)

## Revision History

IKD06N60R

**Revision: 2014-03-12, Rev. 2.5**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 1.2 | 2010-01-12 | - |
| 2.1 | 2011-01-17 | Release of final datasheet |
| 2.2 | 2013-02-19 | Change package |
| 2.3 | 2013-12-10 | Neu value ICES max limit at 175°C |
| 2.4 | 2014-02-26 | Without PB free logo |
| 2.5 | 2014-03-12 | Storage temp -55...+150°C |

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**Infineon Technologies AG**
**81726 München, Germany**
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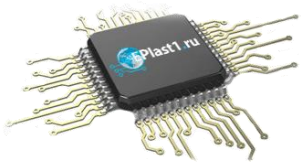
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.

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