# IGBT

IGBT with integrated diode in packages offering space saving advantage

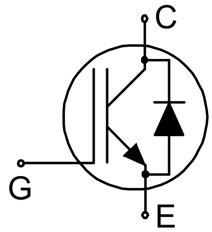
# IKD06N60RA

500V TRENCHSTOP$^{TM}$ RC-Series for hard switching applications
Qualified to automotive standard AECQ101

## Data Sheet

Industrial & Multimarket

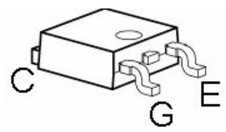
# IGBT with integrated diode in packages offering space saving advantage




**Features:**

TRENCHSTOP$^{TM}$ Reverse Conducting (RC) technology for 500V 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
- Fully qualified to automotive standard AECQ101
- Pb-free lead plating; RoHS compliant (for PG-TO252: solder temperature 260°C, MSL1)




PG-TO252-3 (D-Pak)

Complete product spectrum and PSpice Models:
http://www.infineon.com/igbt/

**Applications:**

- HID lighting
- Piezo injection

**Key Performance and Package Parameters**

| Type | $V_{CE}$ | $I_C$ | $V_{CEsat}$, $T_{vj}$=25°C | $T_{vjmax}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IKD06N60RA | 500V | 6A | 1.65V | 175°C | K06R60A | PG-TO252-3 |

## Table of Contents

**Maximum ratings**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage | $V_{CE}$ | 500 | 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 $V_{CE} \leq$ 500V, $T_{vj} \leq$ 175°C | - | 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...+175 | °C |
| Soldering temperature,<br>reflow soldering (according to JEDEC J-STA-020) | | 260 | °C |

**Thermal Resistance**

| Parameter | Symbol | Conditions | Max. Value | Unit |
|---|---|---|---|---|
| **Characteristic** | | | | |
| 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 | 500 | - | - | 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 | 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)] | $I_{CES}$ | $V_{CE}$ = 500V, $V_{GE}$ = 0V<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | -<br>- | 40.0<br>1000.0 | 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, at $T_{vj}$ = 25°C

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| 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>$r_G$ = 23.0Ω, $L_\sigma$ = 60nH,<br>$C_\sigma$ = 40pF<br>$L_\sigma$, $C_\sigma$ 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

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C,<br>$V_R$ = 400V,<br>$I_F$ = 6.0A,<br>$di_F/dt$ = 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, at $T_{vj}$ = 175°C**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 175°C,<br>$V_{CC}$ = 400V, $I_C$ = 6.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$r_G$ = 23.0Ω, $L_\sigma$ = 60nH,<br>$C_\sigma$ = 40pF<br>$L_\sigma$, $C_\sigma$ 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 |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 175°C,<br>$V_R$ = 400V,<br>$I_F$ = 6.0A,<br>$di_F/dt$ = 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 |

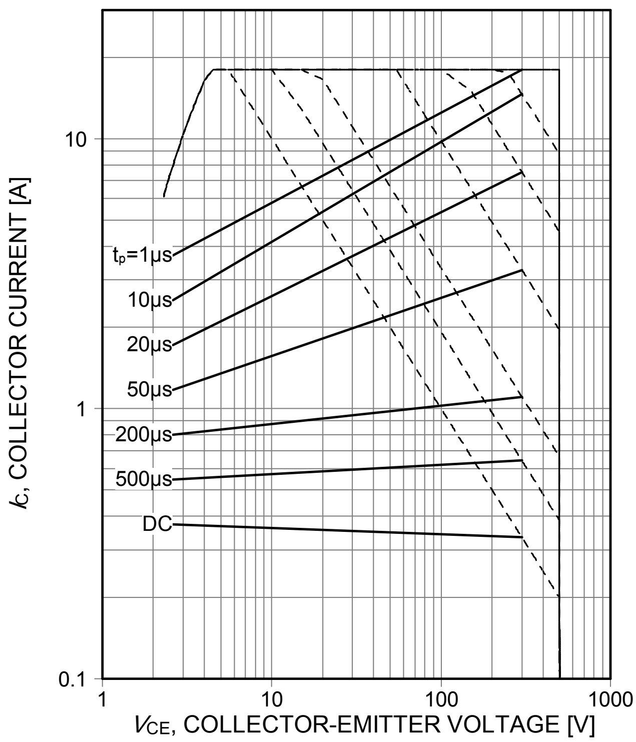



**Figure 1. Forward bias safe operating area**
($D$=0, $T_C$=25°C, $T_{vj}$≤175°C; $V_{GE}$=15V)

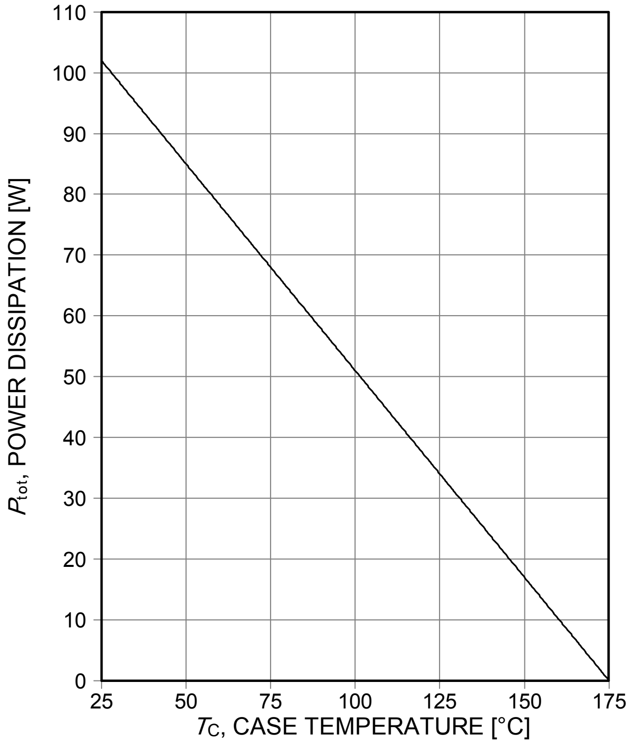



**Figure 2. Power dissipation as a function of case temperature**
($T_{vj}$≤175°C)

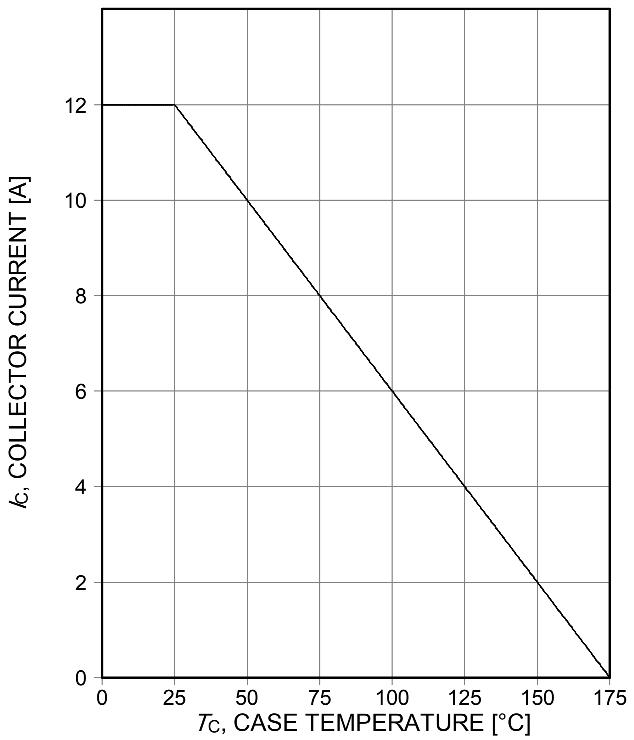



**Figure 3. Collector current as a function of case temperature**
($V_{GE}$≥15V, $T_{vj}$≤175°C)

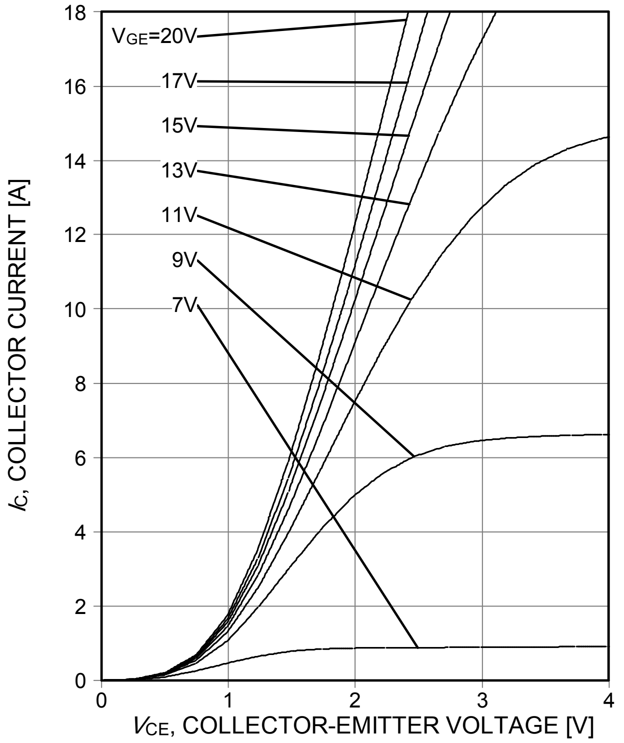



**Figure 4. Typical output characteristic**
($T_{vj}$=25°C)

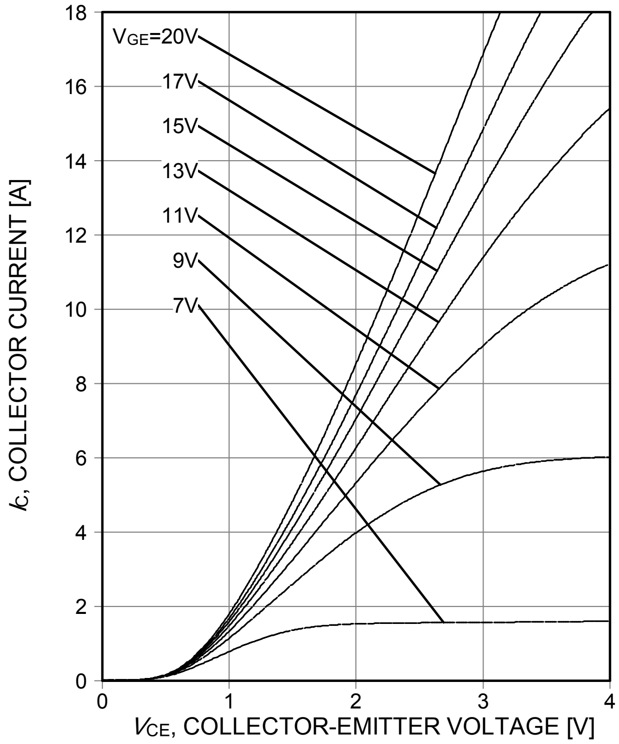



**Figure 5. Typical output characteristic**
($T_{vj}$=175°C)

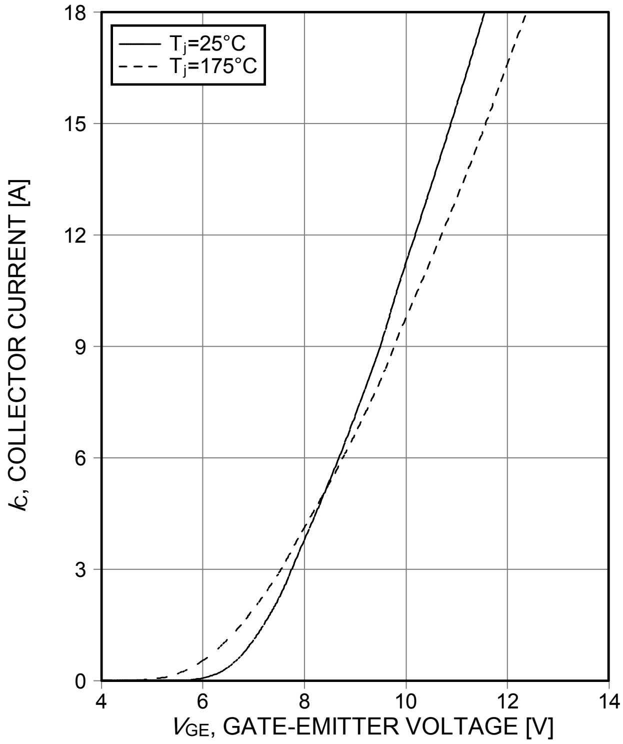



**Figure 6. Typical transfer characteristic**
($V_{CE}$=10V)

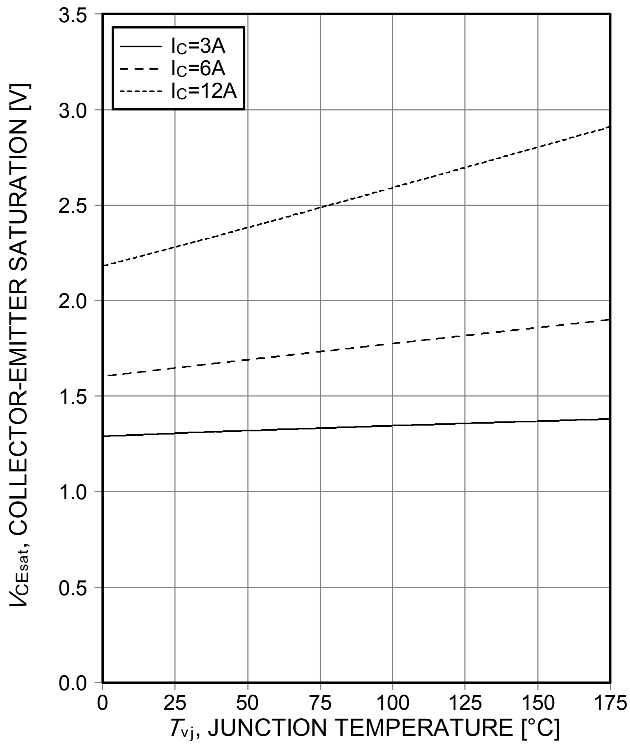



**Figure 7. Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$=15V)

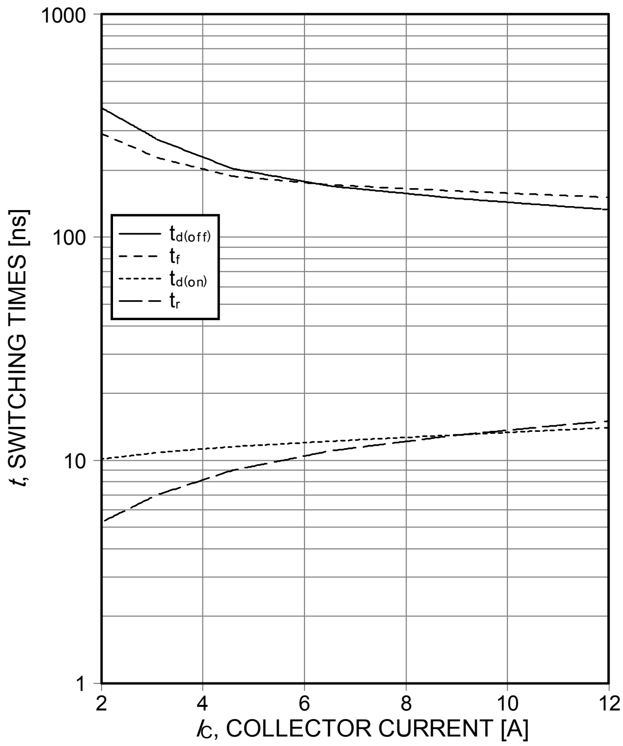



**Figure 8. Typical switching times as a function of collector current**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=23Ω, Dynamic test circuit in Figure E)

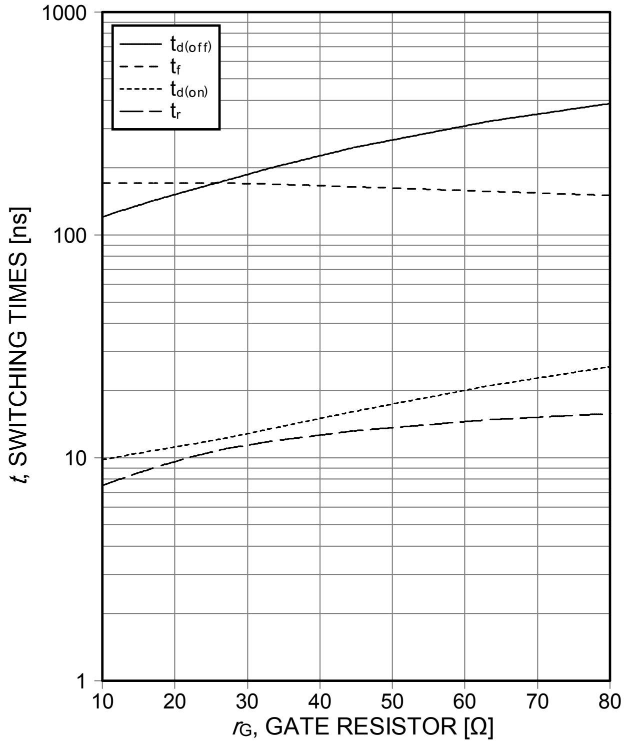



**Figure 9. Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, Dynamic test circuit in Figure E)

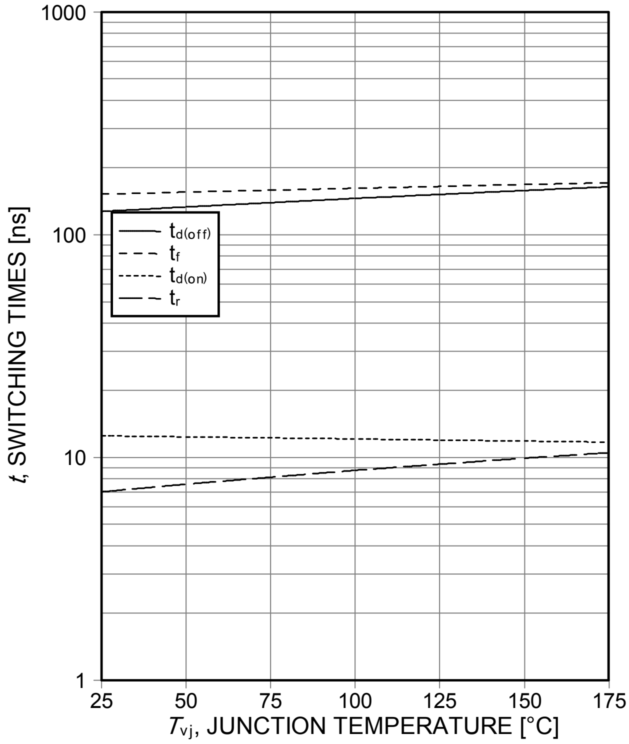



**Figure 10. Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

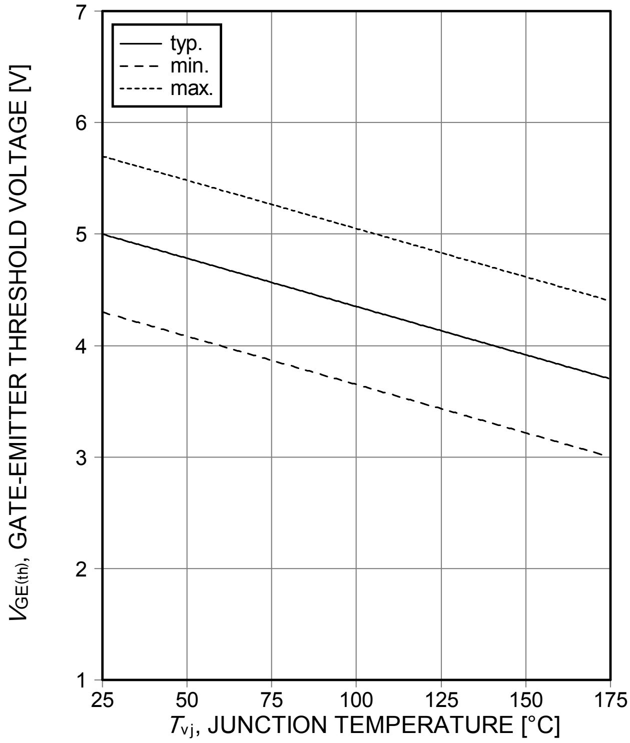



**Figure 11. Gate-emitter threshold voltage as a function of junction temperature**
($I_C$=0.11mA)

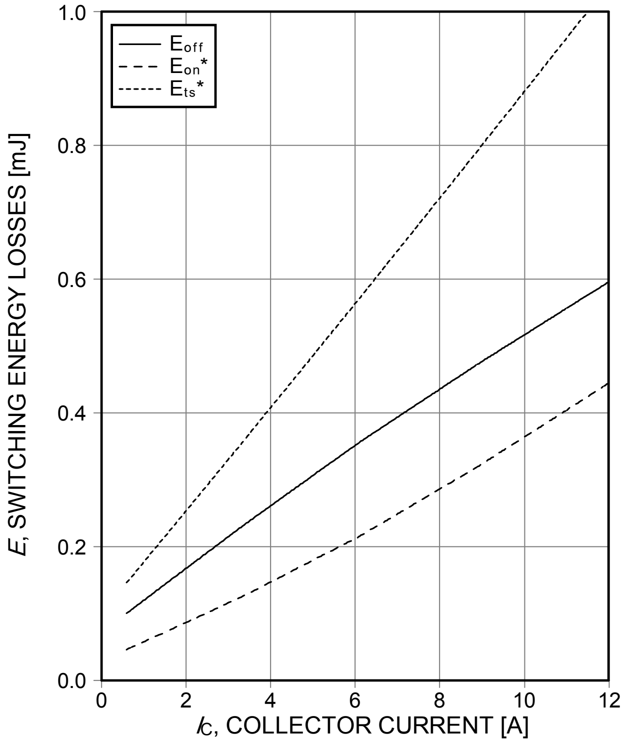



**Figure 12. Typical switching energy losses as a function of collector current**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=23Ω, Dynamic test circuit in Figure E)

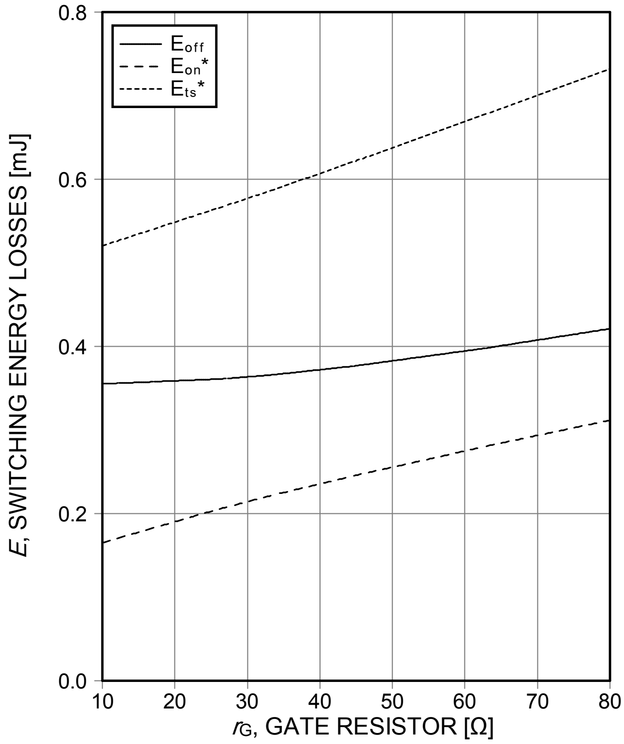



**Figure 13. Typical switching energy losses as a function of gate resistor**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, Dynamic test circuit in Figure E)

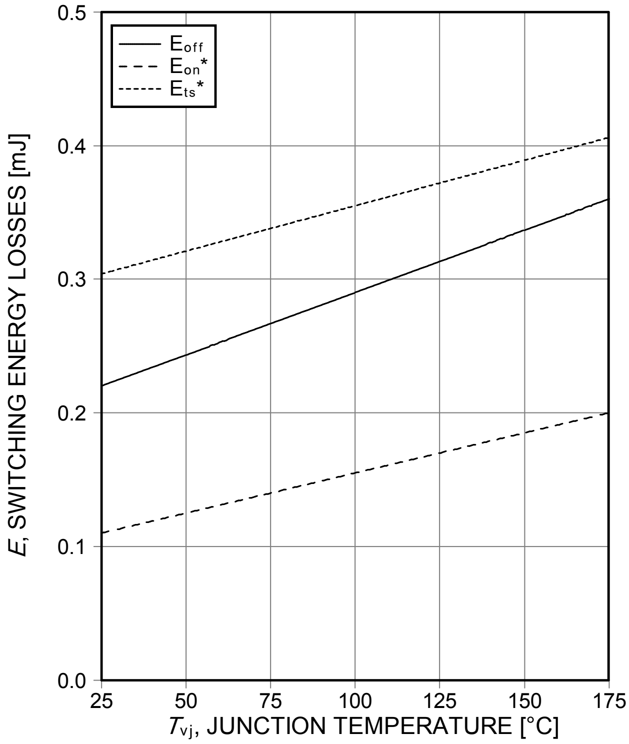



**Figure 14. Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

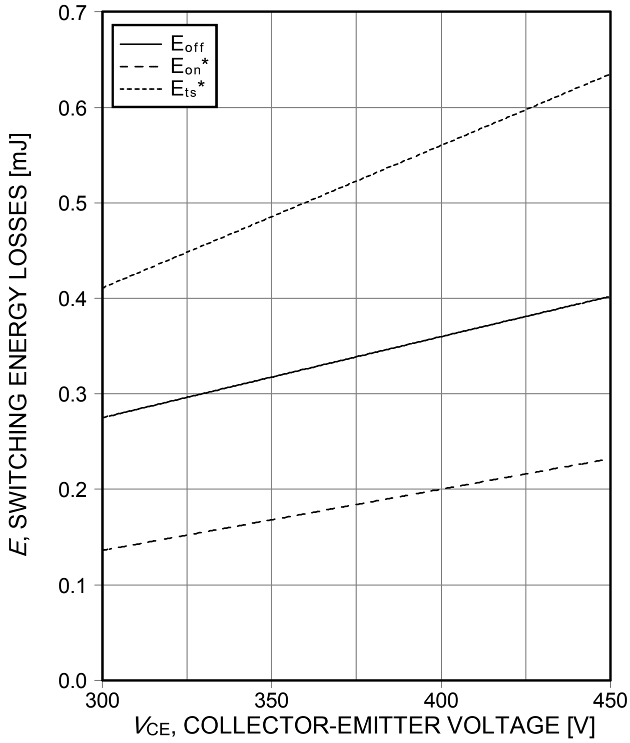



**Figure 15. Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_{vj}$=175°C, $V_{GE}$=15/0V, $I_C$=6A, $r_G$=23Ω, Dynamic test circuit in Figure E)

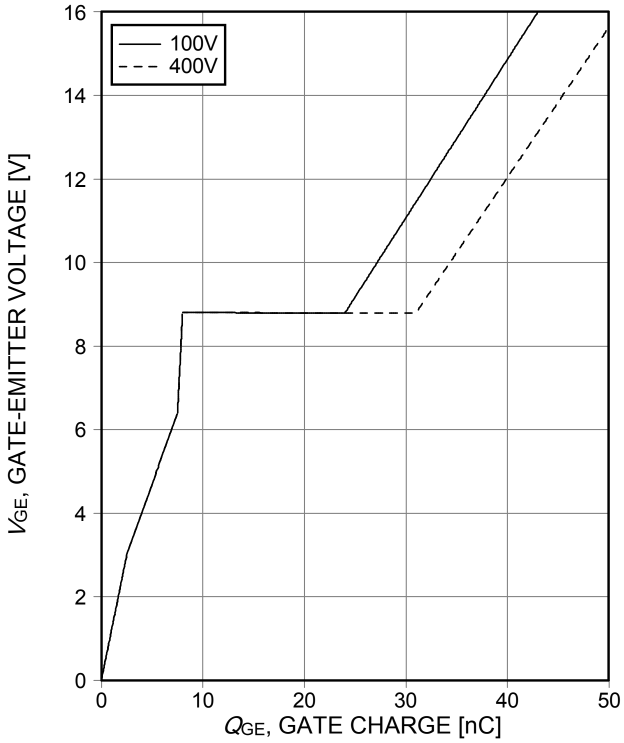



**Figure 16. Typical gate charge**
($I_C$=6A)

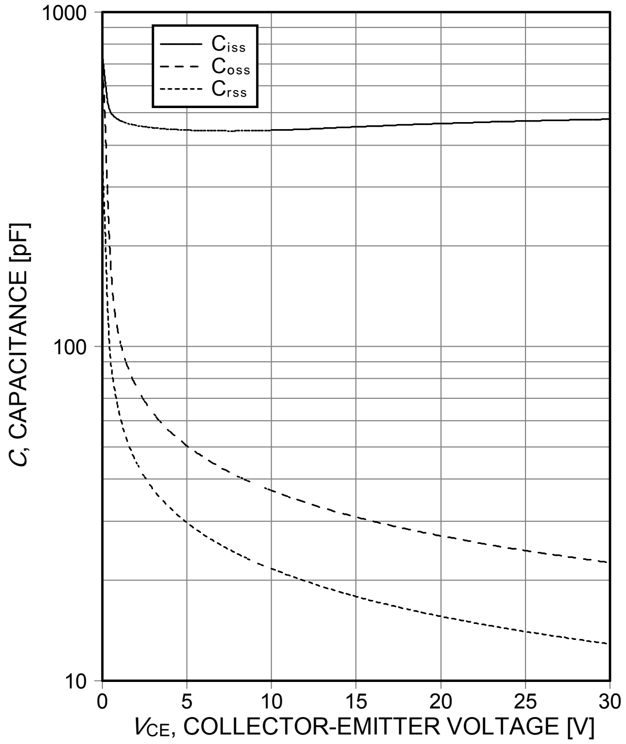



**Figure 17. Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$=0V, f=1MHz)

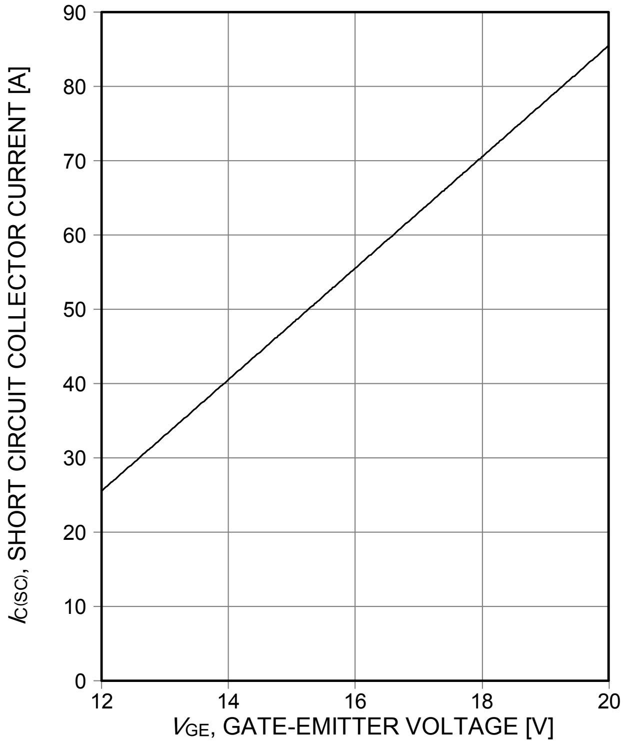



**Figure 18. Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE}$≤400V, start at $T_{vj}$=25°C)

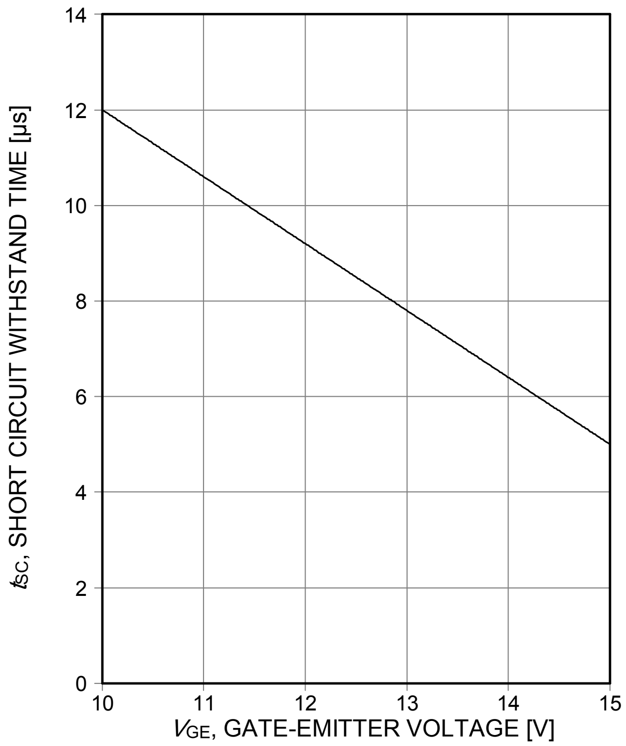



**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$≤400V, start at $T_{vj}$≤150°C)

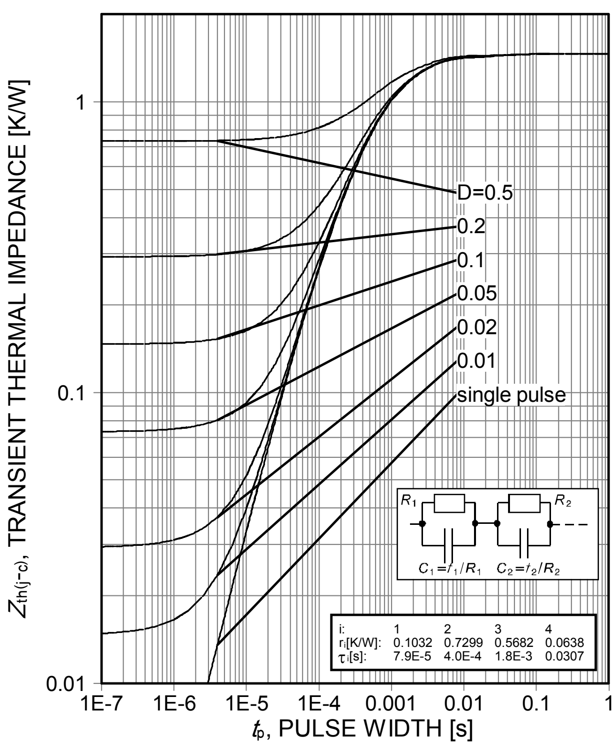



**Figure 20. IGBT transient thermal impedance as a function of pulse width [1] (see page 4)**
($D$=$t_p$/T)

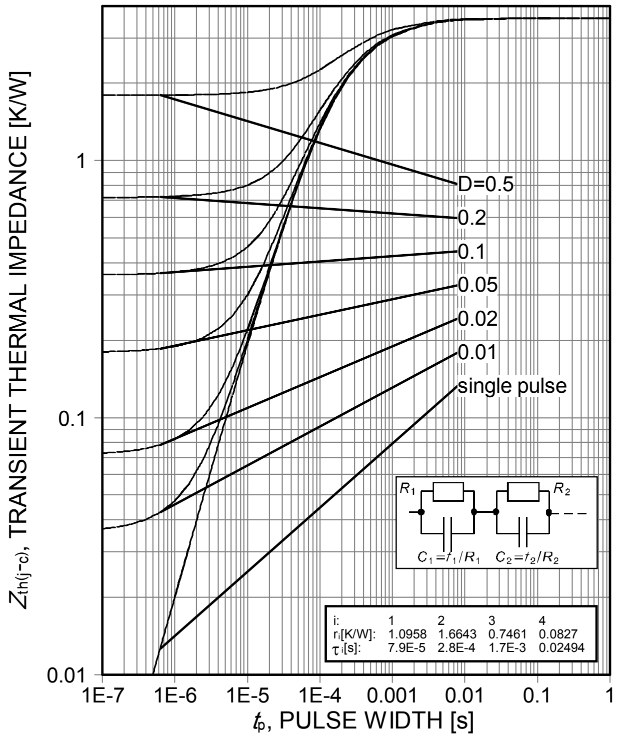



**Figure 21. Diode transient thermal impedance as a function of pulse width [2] (see page 4)**
($D=t_p/T$)

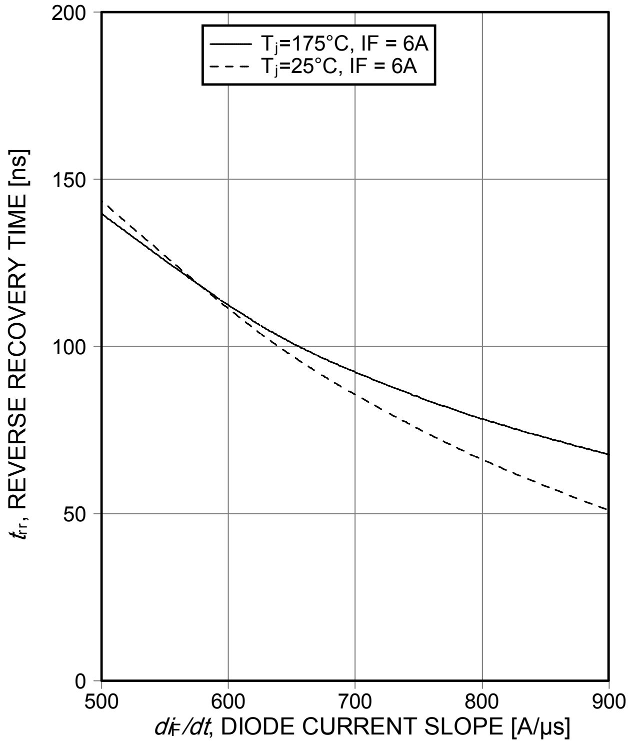



**Figure 22. Typical reverse recovery time as a function of diode current slope**
($V_R$=400V)

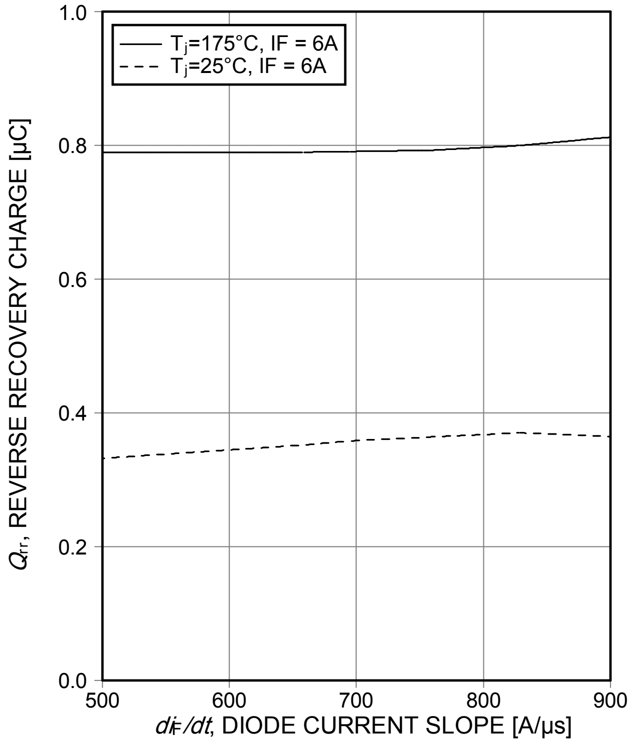



**Figure 23. Typical reverse recovery charge as a function of diode current slope**
($V_R$=400V)

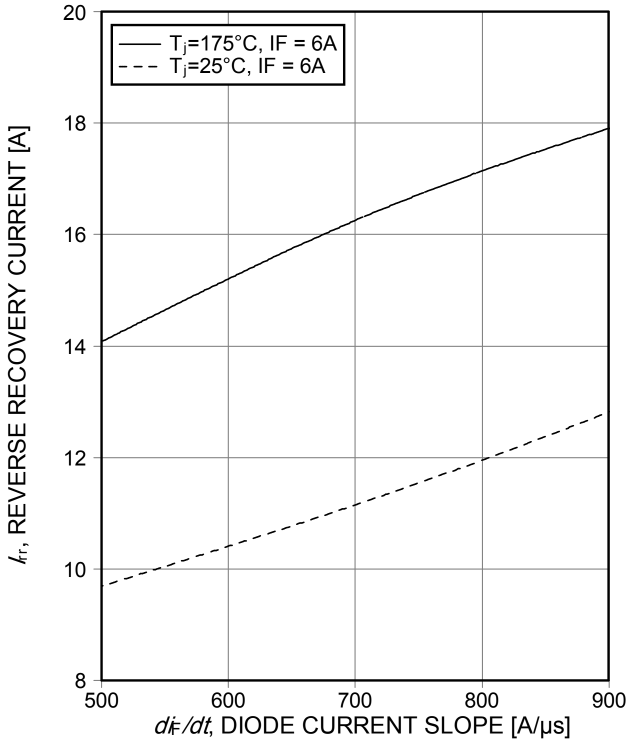



**Figure 24. Typical reverse recovery current as a function of diode current slope**
($V_R$=400V)

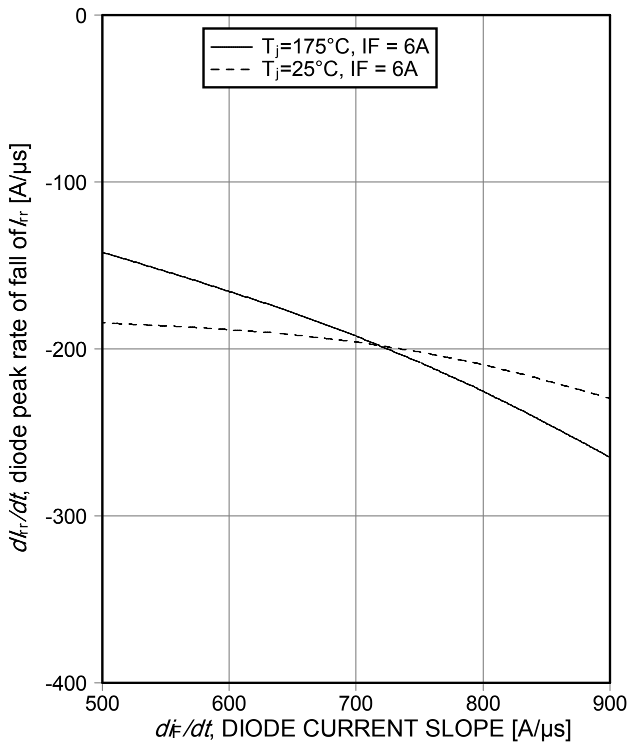



**Figure 25. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V)

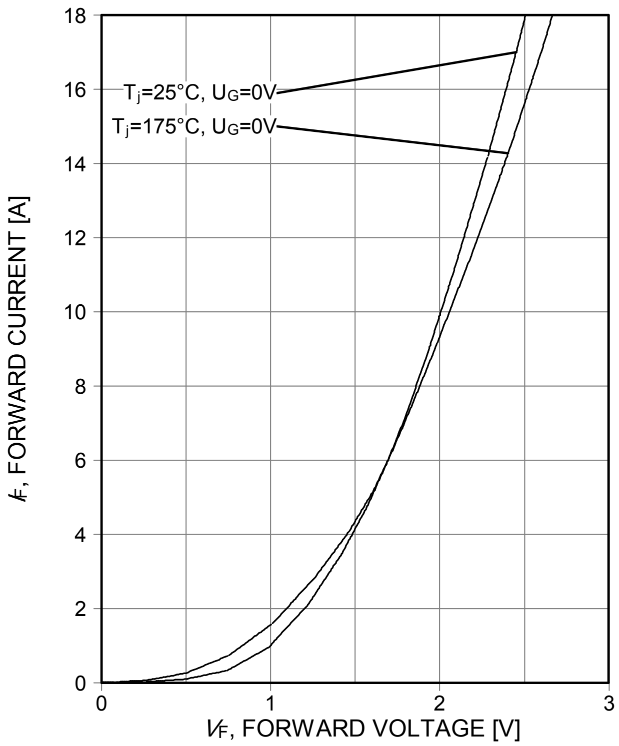



**Figure 26. Typical diode forward current as a function of forward voltage**

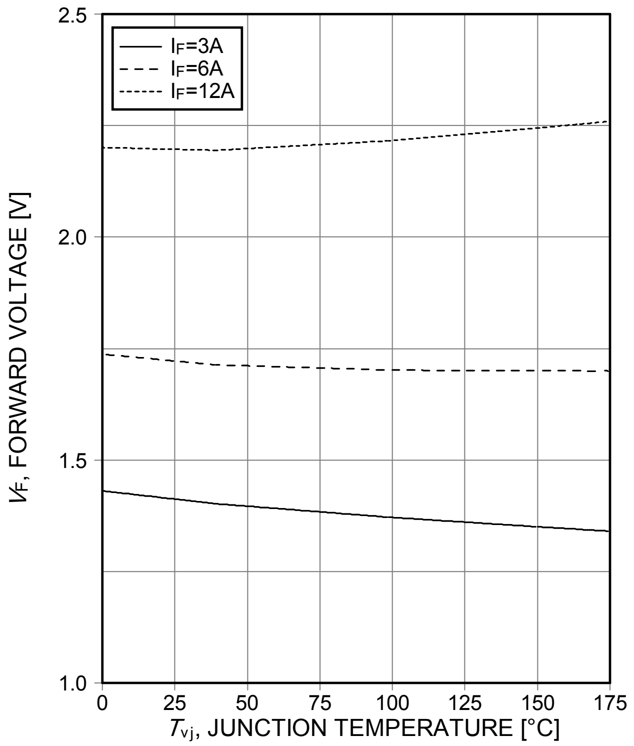
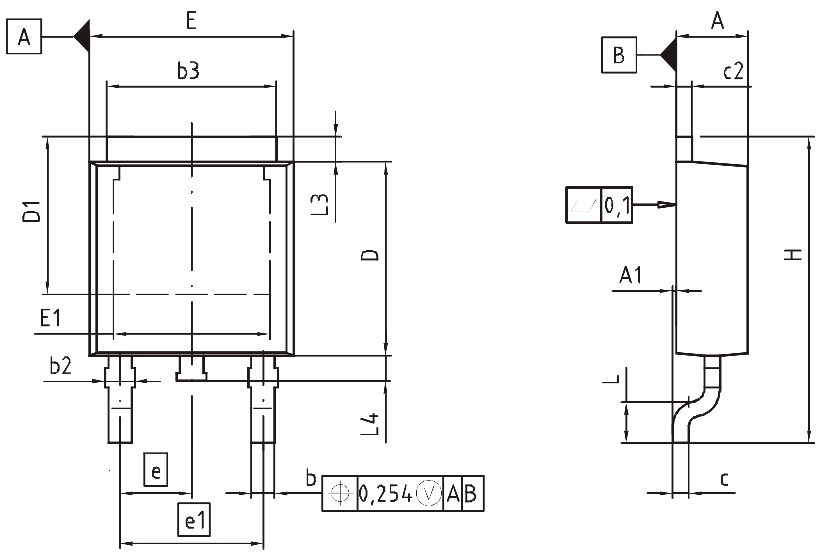
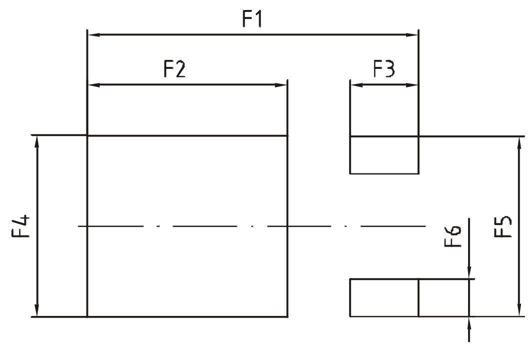



**Figure 27. Typical diode forward voltage as a function of junction temperature**

## TO252-3-1/-11/-21/-311/-341




| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 2.16 | 2.41 | 0.085 | 0.095 |
| A1 | 0.00 | 0.15 | 0.000 | 0.006 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b3 | 5.00 | 5.50 | 0.197 | 0.217 |
| c | 0.46 | 0.60 | 0.018 | 0.024 |
| c2 | 0.46 | 0.98 | 0.018 | 0.039 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.02 | 5.84 | 0.198 | 0.230 |
| E | 6.40 | 6.73 | 0.252 | 0.265 |
| E1 | 4.70 | 5.21 | 0.185 | 0.205 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| H | 9.40 | 10.48 | 0.370 | 0.413 |
| L | 1.18 | 1.70 | 0.046 | 0.067 |
| L3 | 0.90 | 1.25 | 0.035 | 0.049 |
| L4 | 0.51 | 1.00 | 0.020 | 0.039 |
| F1 | 10.50 | 10.70 | 0.413 | 0.421 |
| F2 | 6.30 | 6.50 | 0.248 | 0.256 |
| F3 | 2.10 | 2.30 | 0.083 | 0.091 |
| F4 | 5.70 | 5.90 | 0.224 | 0.232 |
| F5 | 5.66 | 5.86 | 0.223 | 0.231 |
| F6 | 1.10 | 1.30 | 0.043 | 0.051 |

DOCUMENT NO.
Z8B00003328

SCALE 0 2.0 4mm

EUROPEAN PROJECTION

ISSUE DATE
19-10-2007

REVISION
03

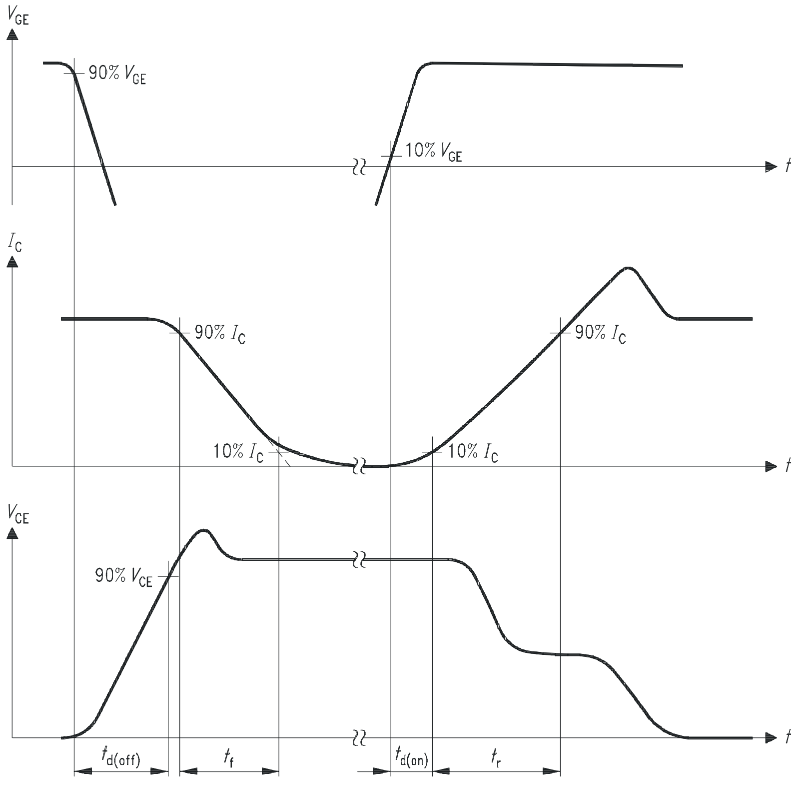



**Figure A. Definition of switching times**

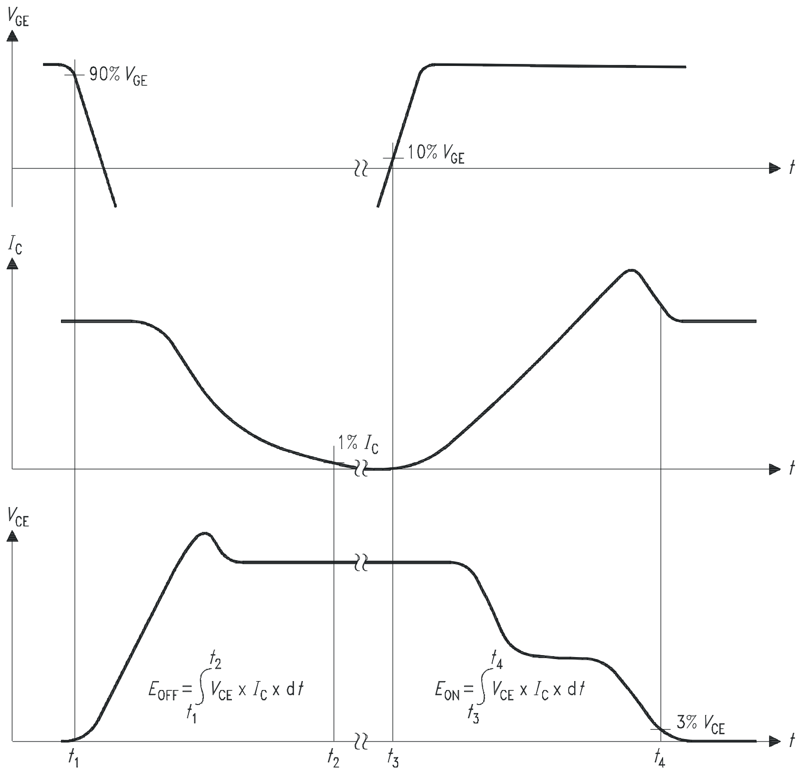



**Figure B. Definition of switching losses**

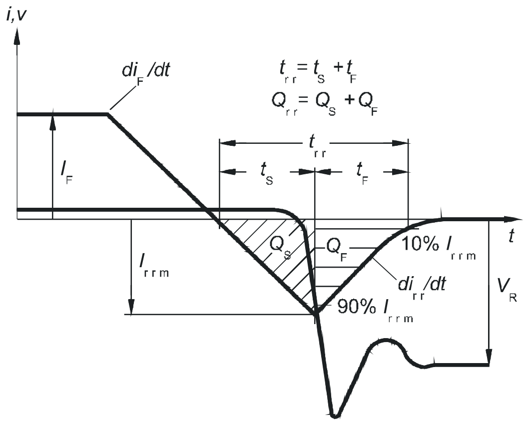



**Figure C. Definition of diodes switching characteristics**

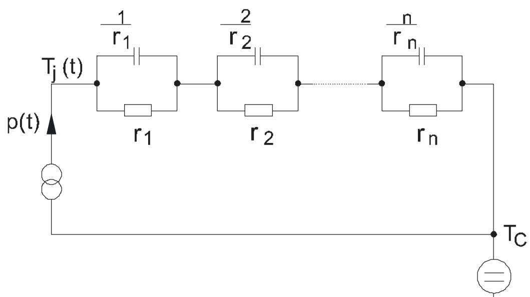



**Figure D. Thermal equivalent circuit**

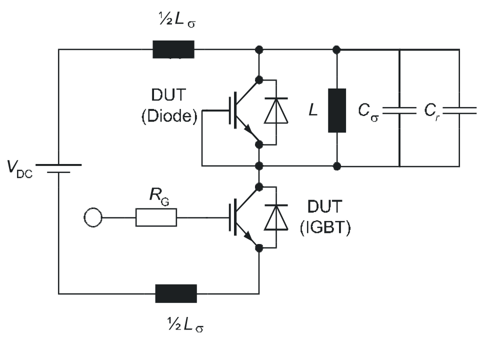



**Figure E. Dynamic test circuit**
Parasitic inductance $L_\sigma$,
Parasitic capacitor $C_\sigma$,
Relief capacitor $C_r$
(only for ZVT switching)

**Revision History**

IKD06N60RA

**Revision: 2010-07-20, Rev. 2.1**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 1.1 | 2010-06-10 | Preliminary datasheet |
| 2.1 | - | Release of final datasheet |

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