# IGBT

High speed 5 FAST IGBT in TRENCHSTOP$^{TM}$ 5 technology copacked with RAPID 1 fast and soft antiparallel diode

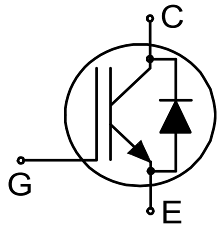
# IKP15N65F5

650V DuoPack IGBT and Diode
High speed switching series fifth generation

## Data sheet

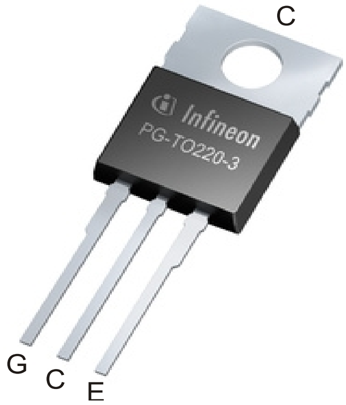
Industrial Power Control

# High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology copacked with RAPID 1 fast and soft antiparallel diode




**Features and Benefits:**

High speed F5 technology offering
• Best-in-Class efficiency in hard switching and resonant topologies
• 650V breakdown voltage
• Low gate charge $Q_G$
• IGBT copacked with RAPID 1 fast and soft antiparallel diode
• Maximum junction temperature 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/




**Applications:**

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

**Key Performance and Package Parameters**

| Type | $V_{CE}$ | $I_C$ | $V_{CEsat}$, $T_{vj}$=25°C | $T_{vjmax}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IKP15N65F5 | 650V | 15A | 1.6V | 175°C | K15EF5 | PG-TO220-3 |

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## 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 | $V_{CE}$ | 650 | V |
| DC collector current, limited by $T_{vjmax}$<br>$T_C$ = 25°C<br>$T_C$ = 100°C | $I_C$ | 30.0<br>18.0 | A |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpuls}$ | 45.0 | A |
| Turn off safe operating area $V_{CE} \leq$ 650V, $T_{vj} \leq$ 175°C | - | 45.0 | A |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C$ = 25°C<br>$T_C$ = 100°C | $I_F$ | 20.0<br>12.0 | A |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpuls}$ | 45.0 | A |
| Gate-emitter voltage<br>Transient Gate-emitter voltage ($t_p \leq$ 10µs, D < 0.010) | $V_{GE}$ | ±20<br>±30 | V |
| Power dissipation $T_C$ = 25°C<br>Power dissipation $T_C$ = 100°C | $P_{tot}$ | 105.0<br>52.5 | W |
| Operating junction temperature | $T_{vj}$ | -40...+175 | °C |
| Storage temperature | $T_{stg}$ | -55...+150 | °C |
| Soldering temperature,<br>wave soldering 1.6mm (0.063in.) from case for 10s | | 260 | °C |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3 | $M$ | 0.6 | Nm |

## Thermal Resistance

| Parameter | Symbol | Conditions | Max. Value | Unit |
|---|---|---|---|---|
| **Characteristic** | | | | |
| IGBT thermal resistance,<br>junction - case | $R_{th(j-c)}$ | | 1.40 | K/W |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ | | 2.90 | K/W |
| Thermal resistance<br>junction - ambient | $R_{th(j-a)}$ | | 62 | K/W |

**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 | 650 | - | - | V |
| Collector-emitter saturation voltage | $V_{CEsat}$ | $V_{GE}$ = 15.0V, $I_C$ = 15.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 125°C<br>$T_{vj}$ = 175°C | -<br>-<br>- | 1.60<br>1.80<br>1.90 | 2.10<br>-<br>- | V |
| Diode forward voltage | $V_F$ | $V_{GE}$ = 0V, $I_F$ = 9.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 125°C<br>$T_{vj}$ = 175°C | -<br>-<br>- | 1.45<br>1.40<br>1.40 | 1.80<br>-<br>- | V |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$ = 0.15mA, $V_{CE}$ = $V_{GE}$ | 3.2 | 4.0 | 4.8 | V |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$ = 650V, $V_{GE}$ = 0V<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | -<br>- | 40.0<br>4000.0 | µA |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$ = 0V, $V_{GE}$ = 20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$ = 20V, $I_C$ = 15.0A | - | 22.0 | - | S |

**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 | - | 930 | - | pF |
| Output capacitance | $C_{oes}$ | | - | 24 | - | |
| Reverse transfer capacitance | $C_{res}$ | | - | 4 | - | |
| Gate charge | $Q_G$ | $V_{CC}$ = 520V, $I_C$ = 15.0A,<br>$V_{GE}$ = 15V | - | 38.0 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | | - | 7.0 | - | nH |

**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, $I_C$ = 7.5A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 39.0Ω, $R_{G(off)}$ = 39.0Ω,<br>$L\sigma$ = 30nH, $C\sigma$ = 30pF<br>$L\sigma$, $C\sigma$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | - | 17 | - | ns |
| Rise time | $t_r$ | | - | 7 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 150 | - | ns |
| Fall time | $t_f$ | | - | 16 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.13 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.04 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.17 | - | mJ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 25°C,<br>$V_{CC}$ = 400V, $I_C$ = 2.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 39.0Ω, $R_{G(off)}$ = 39.0Ω,<br>$L\sigma$ = 30nH, $C\sigma$ = 30pF<br>$L\sigma$, $C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 17 | - | ns |
| Rise time | $t_r$ | | - | 4 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 190 | - | ns |
| Fall time | $t_f$ | | - | 10 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.04 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.02 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.06 | - | mJ |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C,<br>$V_R$ = 400V,<br>$I_F$ = 7.5A,<br>$di_F/dt$ = 1000A/µs | - | 50 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.19 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 8.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -190 | - | A/µs |
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C,<br>$V_R$ = 400V,<br>$I_F$ = 2.0A,<br>$di_F/dt$ = 1000A/µs | - | 22 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.10 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 8.6 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -620 | - | A/µs |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic, at $T_{vj}$ = 150°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 150°C,<br>$V_{CC}$ = 400V, $I_C$ = 7.5A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 39.0Ω, $R_{G(off)}$ = 39.0Ω,<br>$L\sigma$ = 30nH, $C\sigma$ = 30pF<br>$L\sigma$, $C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 16 | - | ns |
| Rise time | $t_r$ | | - | 10 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 190 | - | ns |
| Fall time | $t_f$ | | - | 5 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.18 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.06 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.24 | - | mJ |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 150°C,<br>$V_{CC}$ = 400V, $I_C$ = 2.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 39.0Ω, $R_{G(off)}$ = 39.0Ω,<br>$L\sigma$ = 30nH, $C\sigma$ = 30pF<br>$L\sigma$, $C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 15 | - | ns |
| Rise time | $t_r$ | | - | 4 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 230 | - | ns |
| Fall time | $t_f$ | | - | 30 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.06 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.02 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.08 | - | mJ |

**Diode Characteristic, at $T_{vj}$ = 150°C**

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 150°C,<br>$V_R$ = 400V,<br>$I_F$ = 7.5A,<br>$di_F/dt$ = 1000A/µs | - | 67 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.39 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 9.6 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -140 | - | A/µs |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 150°C,<br>$V_R$ = 400V,<br>$I_F$ = 2.0A,<br>$di_F/dt$ = 1000A/µs | - | 35 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.20 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 10.2 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -360 | - | A/µs |

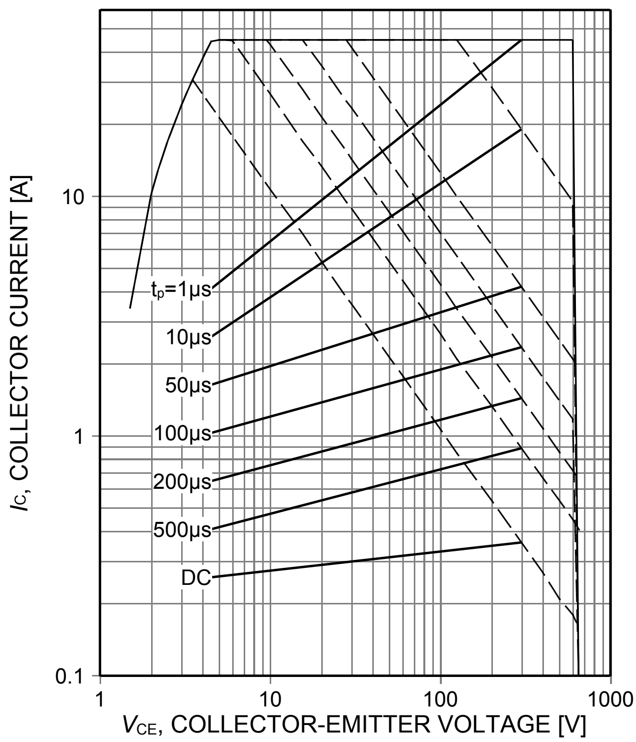



Figure 1. **Forward bias safe operating area**
($D$=0, $T_C$=25°C, $T_{vj}$≤175°C; $V_{GE}$=15V. Recommended use at $V_{GE}$≥7.5V)

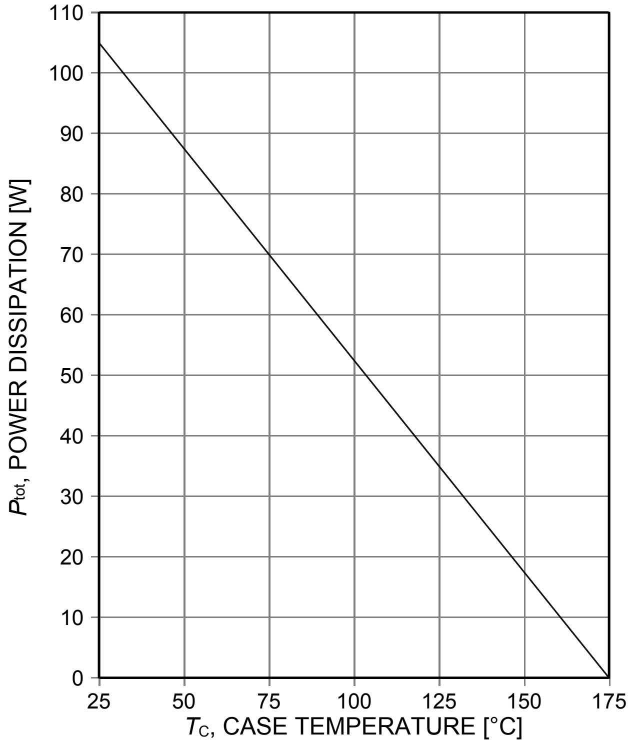



Figure 2. **Power dissipation as a function of case temperature**
($T_{vj}$≤175°C)

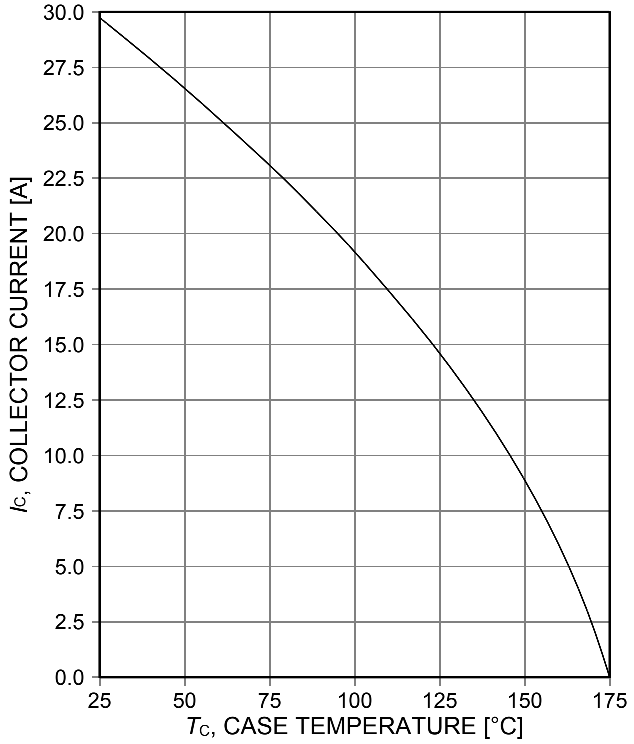



Figure 3. **Collector current as a function of case temperature**
($V_{GE}$≥15V, $T_{vj}$≤175°C)

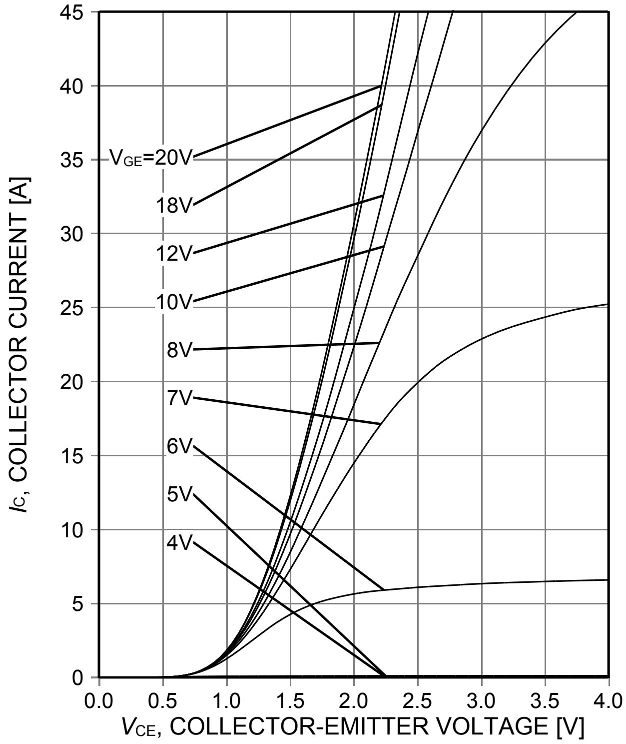



Figure 4. **Typical output characteristic**
($T_{vj}$=25°C)

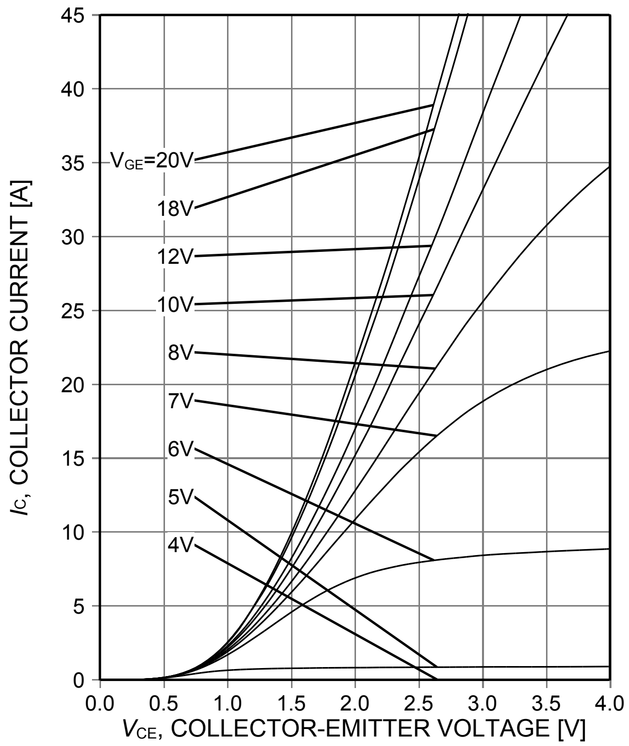



Figure 5. **Typical output characteristic**
($T_{vj}$=150°C)

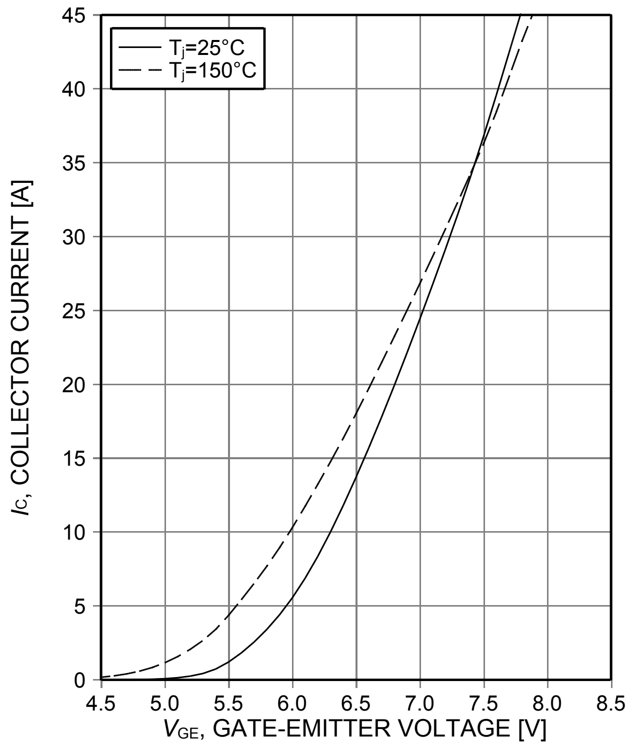



Figure 6. **Typical transfer characteristic**
($V_{CE}$=20V)

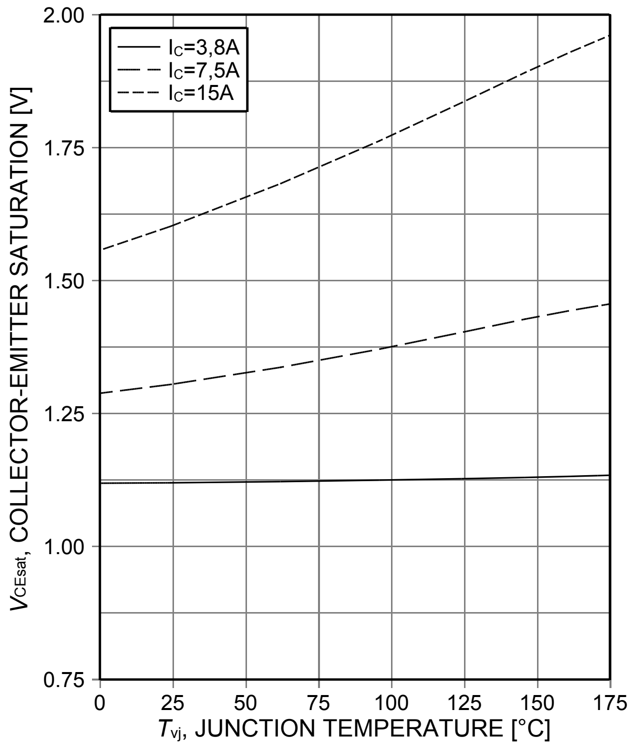



Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$=15V)

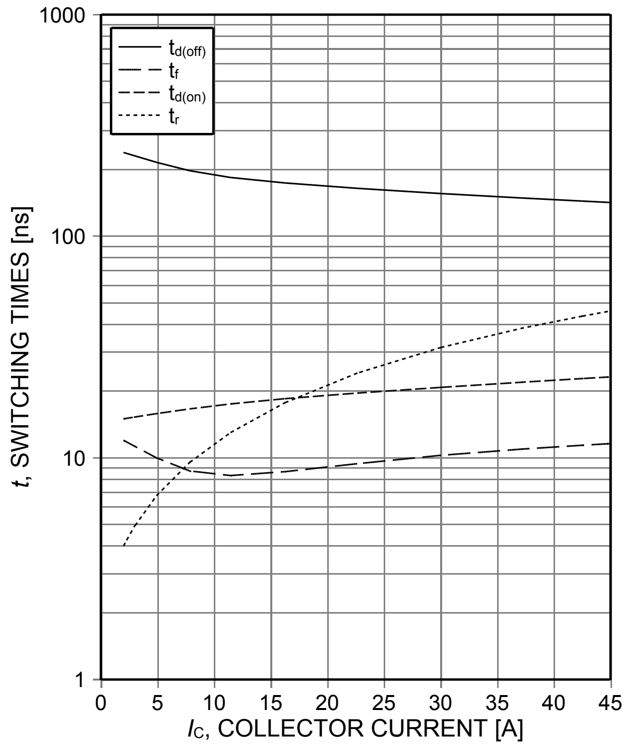



Figure 8. **Typical switching times as a function of collector current**
(inductive load, $T_{vj}$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=39Ω, Dynamic test circuit in Figure E)

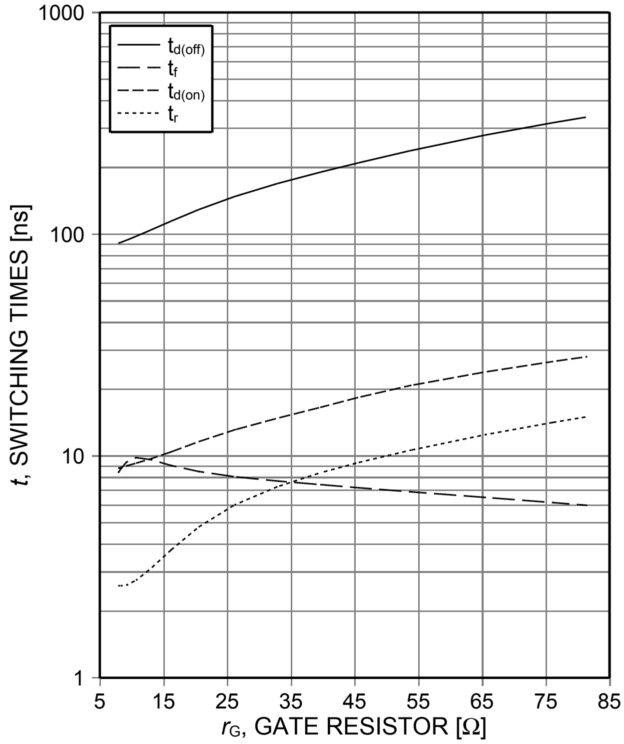



Figure 9. **Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=7,5A,Dynamic test circuit in Figure E)

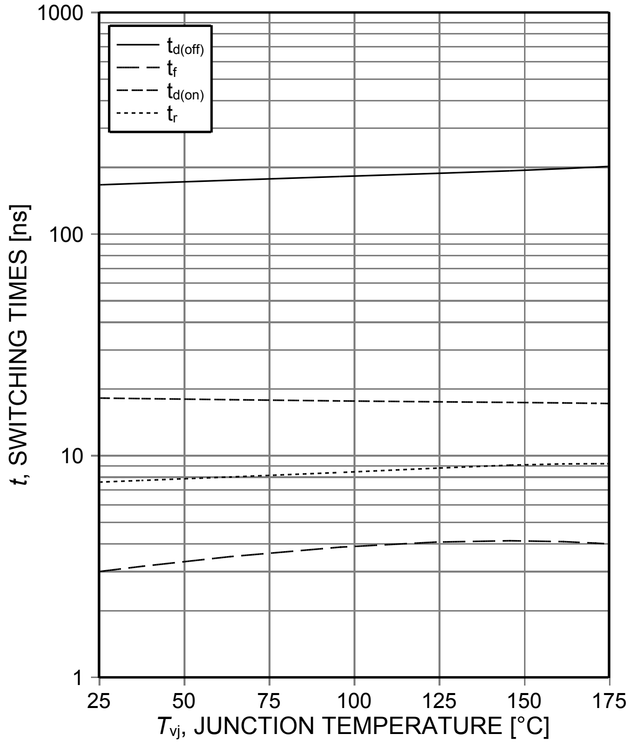



Figure 10. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=7,5A, $r_G$=39Ω,Dynamic test circuit in Figure E)

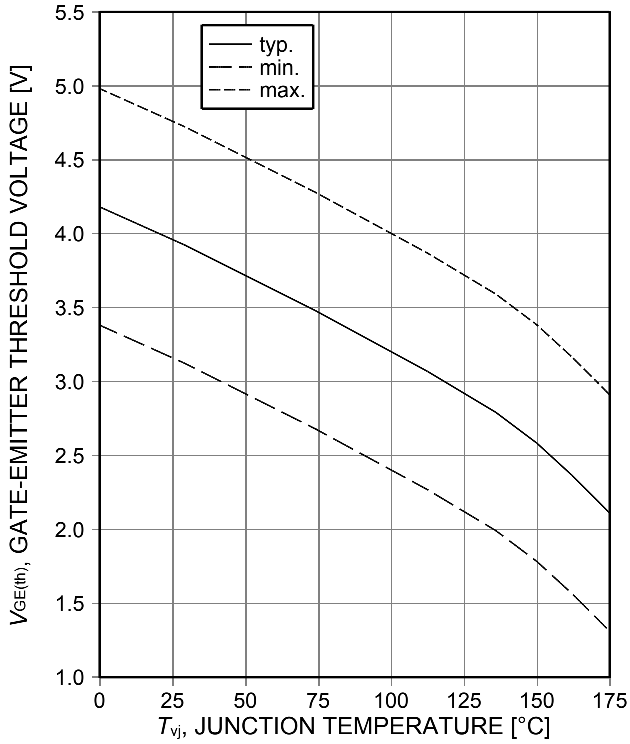



Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C$=0.15mA)

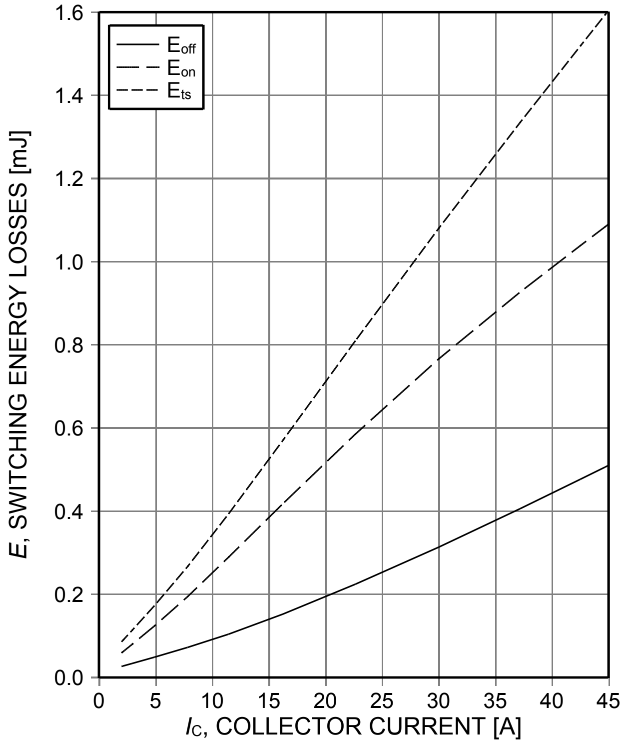



Figure 12. **Typical switching energy losses as a function of collector current**
(inductive load, $T_{vj}$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $r_G$=39Ω,Dynamic test circuit in Figure E)

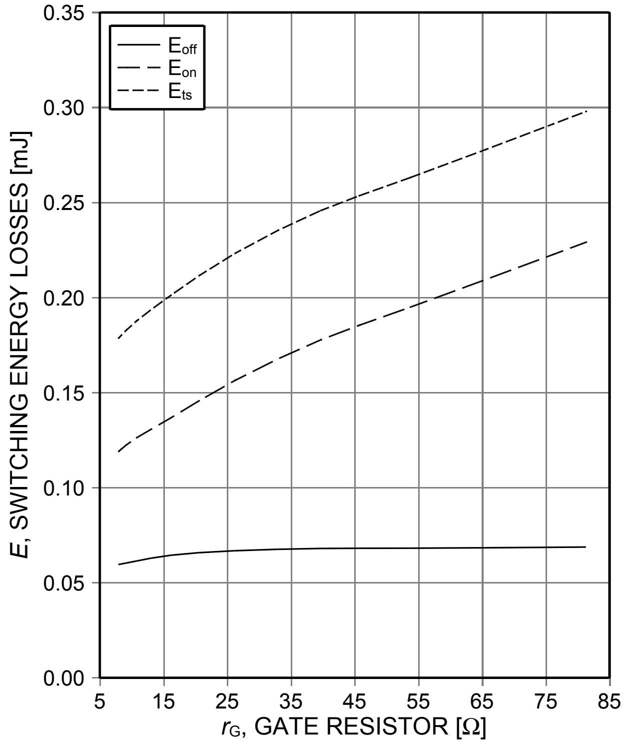



Figure 13. **Typical switching energy losses as a function of gate resistor**
(inductive load, $T_{vj}$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=7,5A, Dynamic test circuit in Figure E)

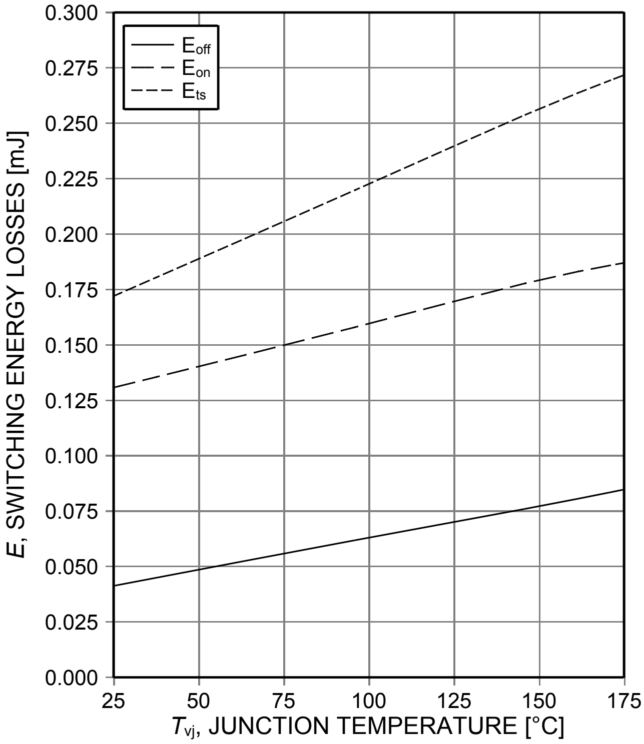



Figure 14. **Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=7,5A, $r_G$=39Ω,Dynamic test circuit in Figure E)

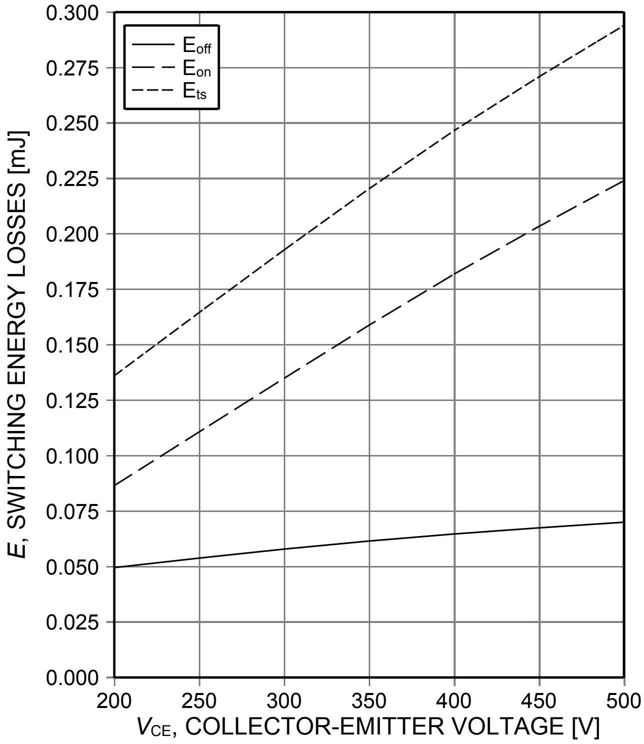



Figure 15. **Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_{vj}$=150°C, $V_{GE}$=15/0V, $I_C$=7,5A, $r_G$=39Ω,Dynamic test circuit in Figure E)

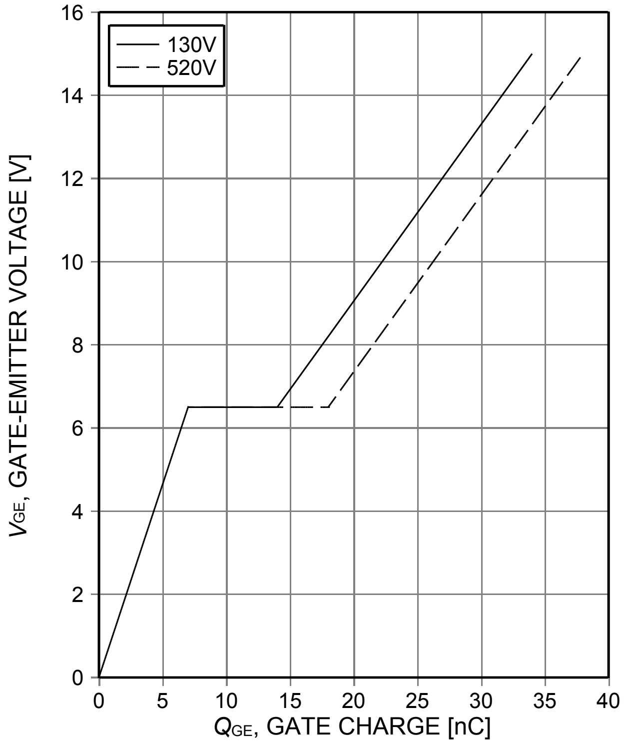



Figure 16. **Typical gate charge**
($I_C$=15A)

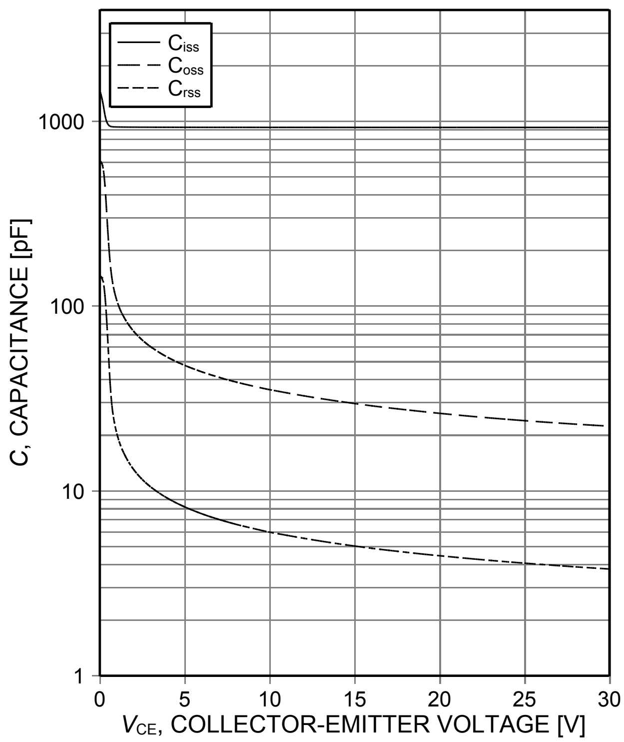



Figure 17. **Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$=0V, f=1MHz)

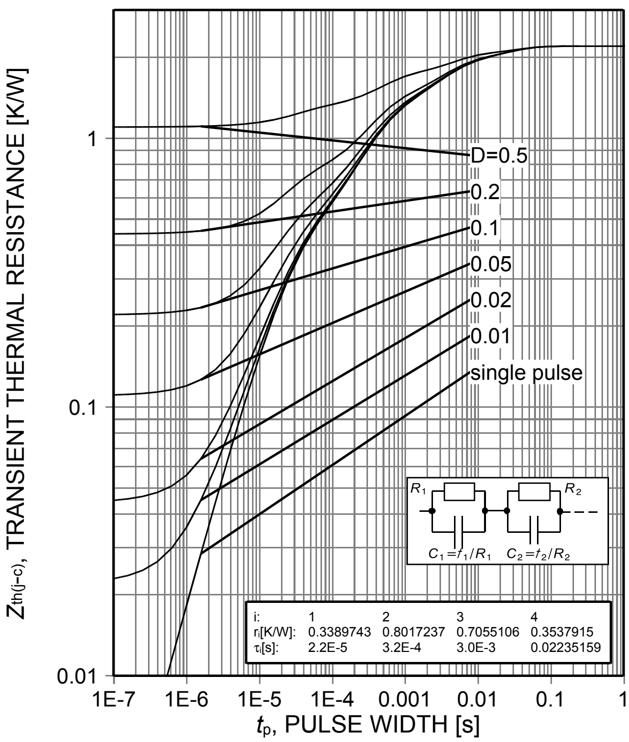



Figure 18. **IGBT transient thermal resistance**
($D$=$t_p$/T)

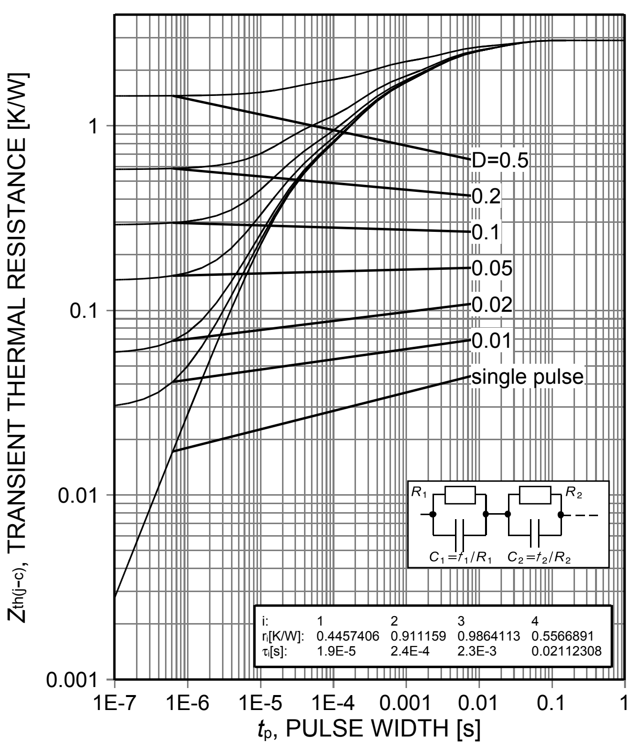



Figure 19. **Diode transient thermal impedance as a function of pulse width**
($D$=$t_p$/T)

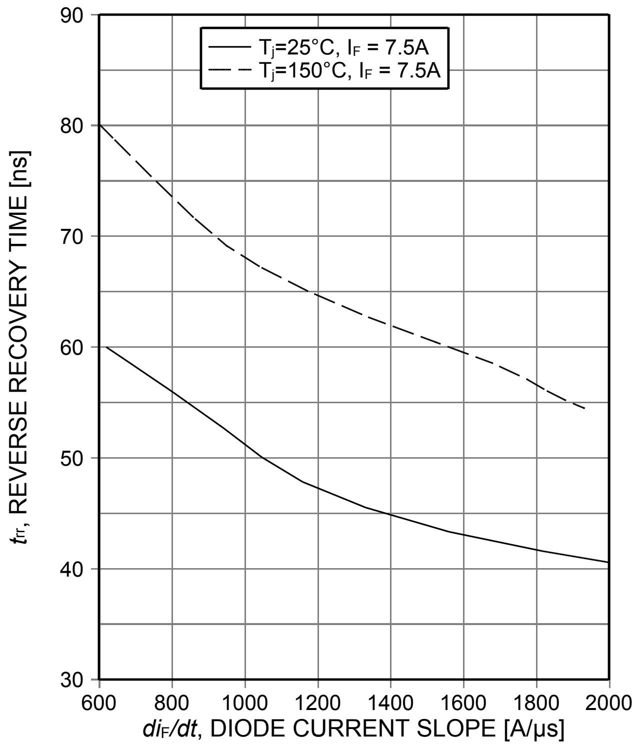



Figure 20. **Typical reverse recovery time as a function of diode current slope**
($V_R$=400V)

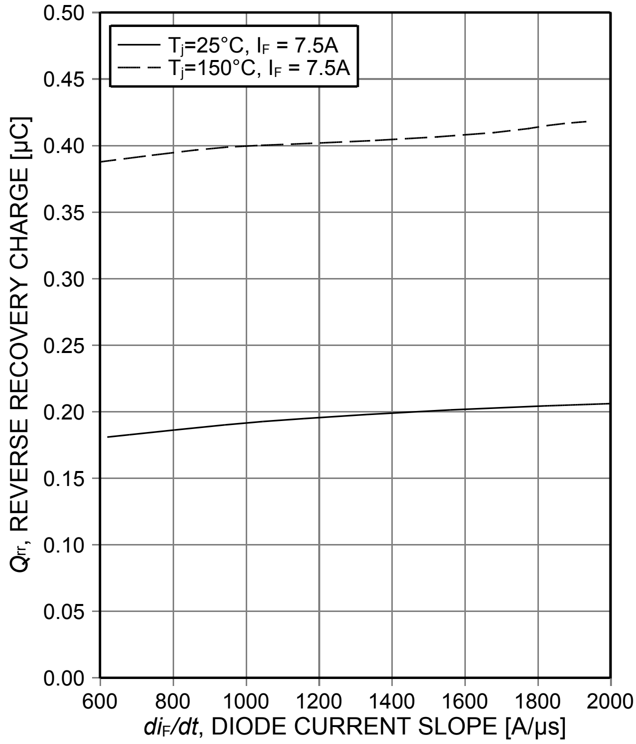



Figure 21. **Typical reverse recovery charge as a function of diode current slope**
($V_R$=400V)

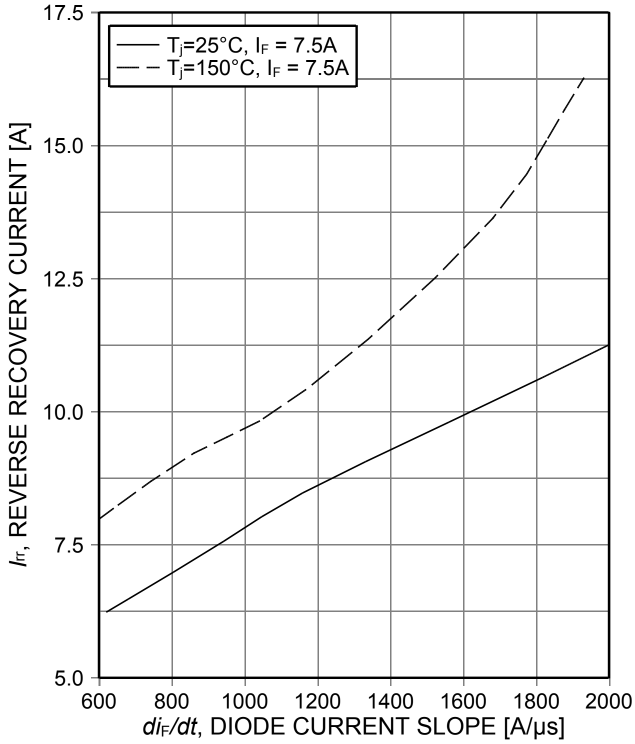



Figure 22. **Typical reverse recovery current as a function of diode current slope**
($V_R$=400V)

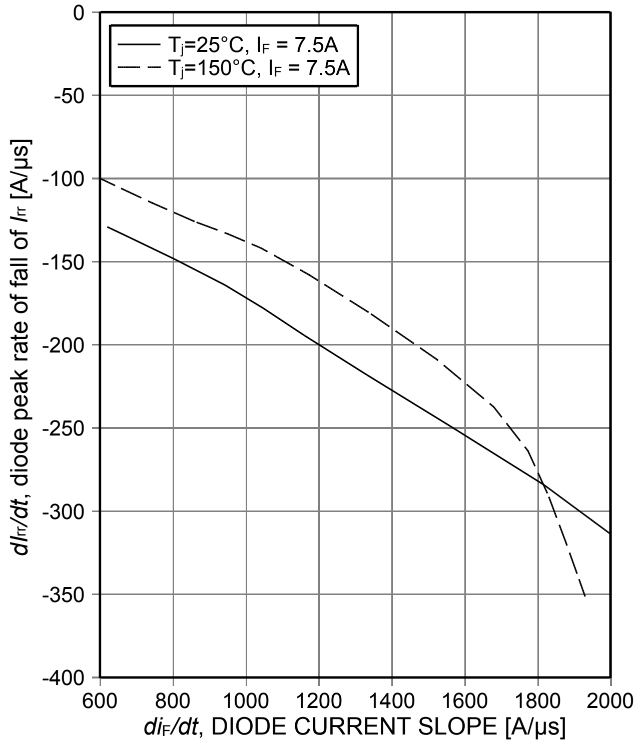



Figure 23. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V)

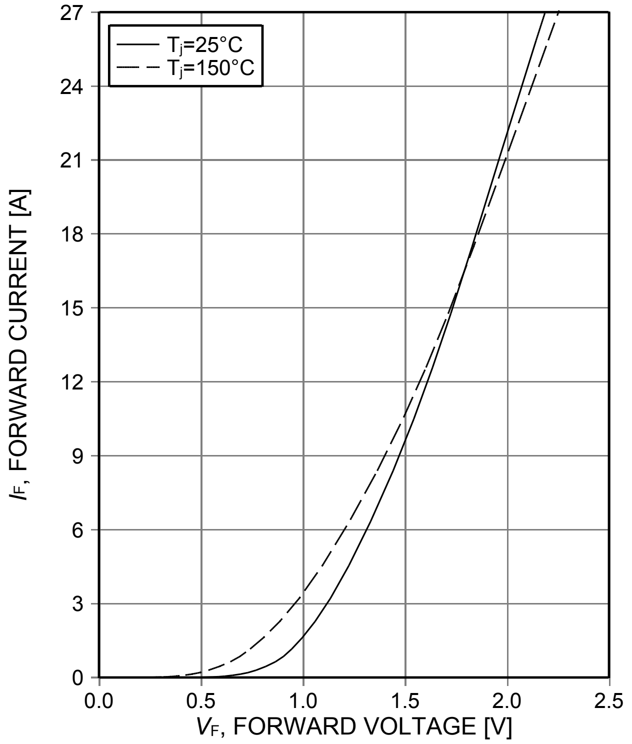



Figure 24. **Typical diode forward current as a function of forward voltage**

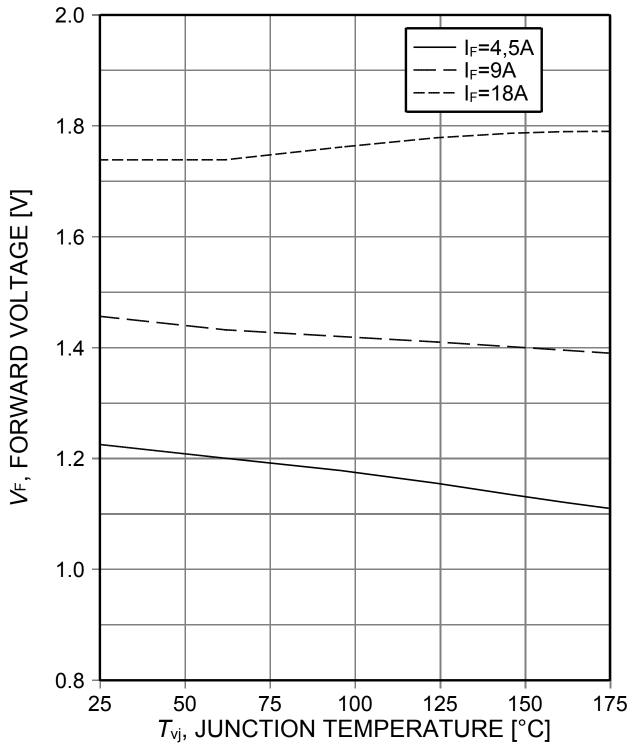
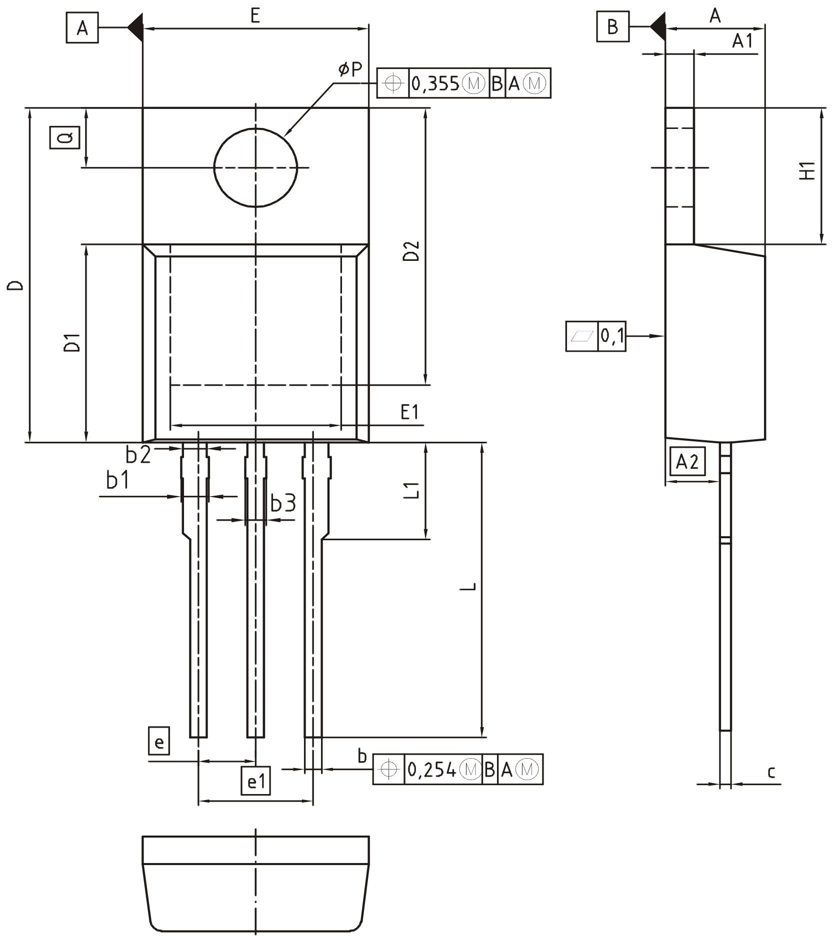



Figure 25. **Typical diode forward voltage as a function of junction temperature**

## Package Drawing PG-TO220-3

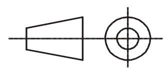



| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.30 | 4.57 | 0.169 | 0.180 |
| A1 | 1.17 | 1.40 | 0.046 | 0.055 |
| A2 | 2.15 | 2.72 | 0.085 | 0.107 |
| b | 0.65 | 0.86 | 0.026 | 0.034 |
| b1 | 0.95 | 1.40 | 0.037 | 0.055 |
| b2 | 0.95 | 1.15 | 0.037 | 0.045 |
| b3 | 0.65 | 1.15 | 0.026 | 0.045 |
| c | 0.33 | 0.60 | 0.013 | 0.024 |
| D | 14.81 | 15.95 | 0.583 | 0.628 |
| D1 | 8.51 | 9.45 | 0.335 | 0.372 |
| D2 | 12.19 | 13.10 | 0.480 | 0.516 |
| E | 9.70 | 10.36 | 0.382 | 0.408 |
| E1 | 6.50 | 8.60 | 0.256 | 0.339 |
| e | 2.54 | | 0.100 | |
| e1 | 5.08 | | 0.200 | |
| N | 3 | | 3 | |
| H1 | 5.90 | 6.90 | 0.232 | 0.272 |
| L | 13.00 | 14.00 | 0.512 | 0.551 |
| L1 | - | 4.80 | - | 0.189 |
| øP | 3.60 | 3.89 | 0.142 | 0.153 |
| Q | 2.60 | 3.00 | 0.102 | 0.118 |

DOCUMENT NO.
Z8B00003318

SCALE 0 2.5 5mm

EUROPEAN PROJECTION



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30-07-2009

REVISION
06

**Testing Conditions**

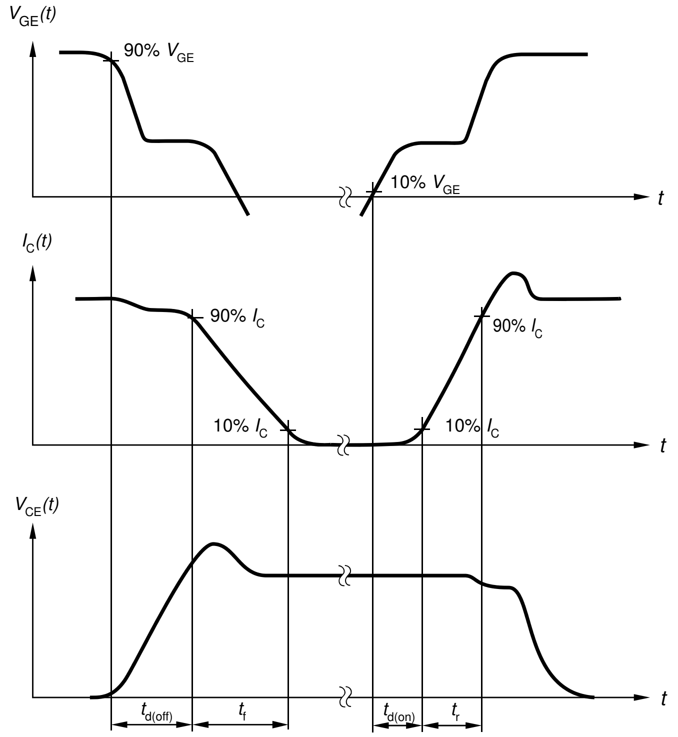


Figure A. **Definition of switching times**

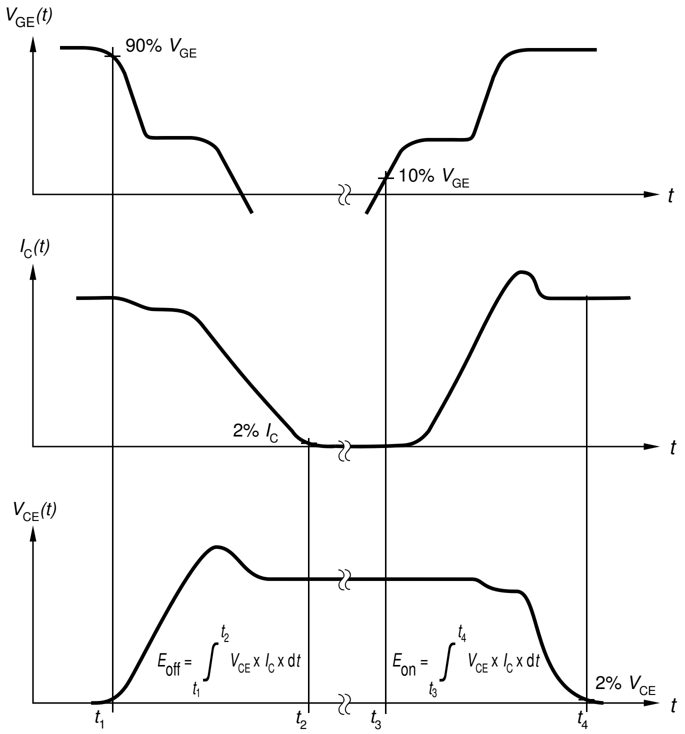


Figure B. **Definition of switching losses**

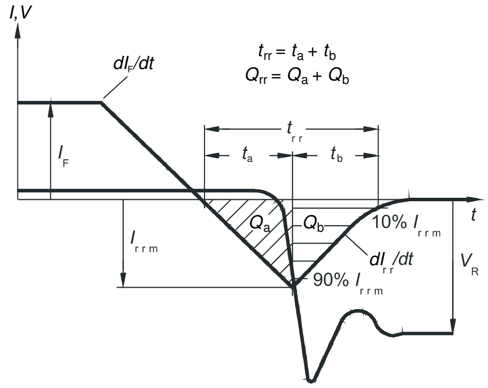


Figure C. **Definition of diode switching characteristics**

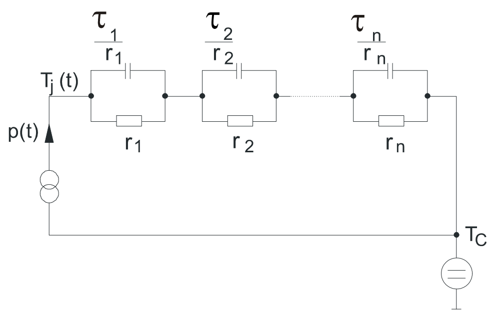


Figure D. **Thermal equivalent circuit**

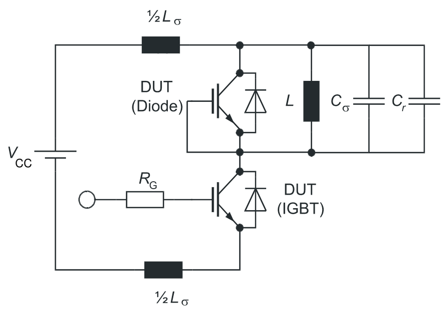


Figure E. **Dynamic test circuit**
Parasitic inductance $L_{\sigma}$,
parasitic capacitor $C_{\sigma}$,
relief capacitor $C_r$,
(only for ZVT switching)

## Revision History

IKP15N65F5

**Revision: 2015-05-05, Rev. 2.1**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 1.1 | 2012-11-09 | Preliminary data sheet |
| 1.2 | 2013-12-18 | New Marking Pattern |
| 2.1 | 2015-05-05 | Final data sheet |

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