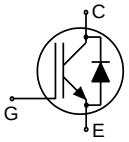
# IKP10N60T

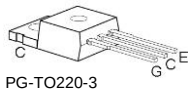
TRENCHSTOP™ Series

## Low Loss DuoPack : IGBT in TRENCHSTOP™ and Fieldstop technology with soft, fast recovery anti-parallel Emitter Controlled HE diode

**Features:**

- Very low $V_{CE(sat)}$ 1.5V (typ.)
- Maximum Junction Temperature 175°C
- Short circuit withstand time 5µs
- Designed for :
  - Variable Speed Drive for washing machines, air conditioners and induction cooking
  - Uninterrupted Power Supply
- TRENCHSTOP™ and Fieldstop technology for 600V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
- NPT technology offers easy parallel switching capability due to positive temperature coefficient in $V_{CE(sat)}$
- Low EMI
- Low Gate Charge
- Very soft, fast recovery anti-parallel Emitter Controlled HE diode
- Qualified according to JEDEC[1] for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/




PG-TO220-3

| Type | $V_{CE}$ | $I_C$ | $V_{CE(sat),Tj=25°C}$ | $T_{j,max}$ | Marking Code | Package |
|---|---|---|---|---|---|---|
| IKP10N60T | 600V | 10A | 1.5V | 175°C | K10T60 | PG-TO-220-3 |

### Maximum Ratings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage, $T_j \geq 25°C$ | $V_{CE}$ | 600 | V |
| DC collector current, limited by $T_{jmax}$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_C$ | <br>24<br>18 | A |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$ | $I_{Cpuls}$ | 30 | |
| Turn off safe operating area, $V_{CE} = 600V$, $T_j = 175°C$, $t_p = 1µs$ | - | 30 | |
| Diode forward current, limited by $T_{jmax}$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_F$ | <br>24<br>18 | |
| Diode pulsed current, $t_p$ limited by $T_{jmax}$ | $I_{Fpuls}$ | 30 | |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Short circuit withstand time[2)]<br>$V_{GE} = 15V$, $V_{CC} \leq 400V$, $T_j \leq 150°C$ | $t_{SC}$ | 5 | µs |
| Power dissipation $T_C = 25°C$ | $P_{tot}$ | 110 | W |
| Operating junction temperature | $T_j$ | -40...+175 | °C |
| Storage temperature | $T_{stg}$ | -55...+150 | |
| Soldering temperature,<br>wavesoldering, 1.6 mm (0.063 in.) from case for 10s | | 260 | |

[1] J-STD-020 and JESD-022

[2)] Allowed number of short circuits: <1000; time between short circuits: >1s.

**Thermal Resistance**

| Parameter | Symbol | Conditions | Max. Value | Unit |
|---|---|---|---|---|
| **Characteristic** | | | | |
| IGBT thermal resistance, junction – case | $R_{thJC}$ | | 1.35 | K/W |
| Diode thermal resistance, junction – case | $R_{thJCD}$ | | 1.9 | |
| Thermal resistance, junction – ambient | $R_{thJA}$ | | 62 | |

**Electrical Characteristic,** at $T_j$ = 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, $I_C$=0.2mA | 600 | - | - | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}$ = 15V, $I_C$=10A | | | | |
| | | $T_j$=25°C | - | 1.5 | 2.05 | |
| | | $T_j$=175°C | - | 1.8 | - | |
| Diode forward voltage | $V_F$ | $V_{GE}$=0V, $I_F$=10A | | | | |
| | | $T_j$=25°C | - | 1.6 | 2.0 | |
| | | $T_j$=175°C | - | 1.6 | - | |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$=0.3mA, $V_{CE}$=$V_{GE}$ | 4.1 | 4.6 | 5.7 | |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$=600V, $V_{GE}$=0V | | | | µA |
| | | $T_j$=25°C | - | - | 40 | |
| | | $T_j$=175°C | - | - | 1000 | |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$=0V, $V_{GE}$=20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$=20V, $I_C$=10A | - | 6 | - | S |
| Integrated gate resistor | $R_{Gint}$ | | none | | | Ω |
| **Dynamic Characteristic** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{CE}$=25V, | - | 551 | - | pF |
| Output capacitance | $C_{oss}$ | $V_{GE}$=0V, | - | 40 | - | |
| Reverse transfer capacitance | $C_{rss}$ | $f$=1MHz | - | 17 | - | |
| Gate charge | $Q_{Gate}$ | $V_{CC}$=480V, $I_C$=10A $V_{GE}$=15V | - | 62 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | | - | 7 | - | nH |
| Short circuit collector current[1)] | $I_{C(SC)}$ | $V_{GE}$=15V, $t_{SC}$≤5µs $V_{CC}$ = 400V, $T_j$ = 25°C | - | 100 | - | A |

[1)] Allowed number of short circuits: <1000; time between short circuits: >1s.

**Switching Characteristic, Inductive Load,** at $T_j$=25 °C

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_j$=25°C, $V_{CC}$=400V, $I_C$=10A, $V_{GE}$=0/15V, $r_G$=23Ω, $L_\sigma$=60nH, $C_\sigma$=40pF<br>$L_\sigma$, $C_\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 12 | - | ns |
| Rise time | $t_r$ | | - | 8 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 215 | - | |
| Fall time | $t_f$ | | - | 38 | - | |
| Turn-on energy | $E_{on}$ | | - | 0.16 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.27 | - | |
| Total switching energy | $E_{ts}$ | | - | 0.43 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=25°C, $V_R$=400V, $I_F$=10A, $di_F/dt$=880A/µs | - | 115 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.38 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 10 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 680 | - | A/µs |

**Switching Characteristic, Inductive Load,** at $T_j$=175 °C

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_j$=175°C, $V_{CC}$=400V, $I_C$=10A, $V_{GE}$=0/15V, $r_G$=23Ω, $L_\sigma$=60nH, $C_\sigma$=40pF<br>$L_\sigma$, $C_\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 10 | - | ns |
| Rise time | $t_r$ | | - | 11 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 233 | - | |
| Fall time | $t_f$ | | - | 63 | - | |
| Turn-on energy | $E_{on}$ | | - | 0.26 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.35 | - | |
| Total switching energy | $E_{ts}$ | | - | 0.61 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=175°C, $V_R$=400V, $I_F$=10A, $di_F/dt$=880A/µs | - | 200 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.92 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 13 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 390 | - | A/µs |

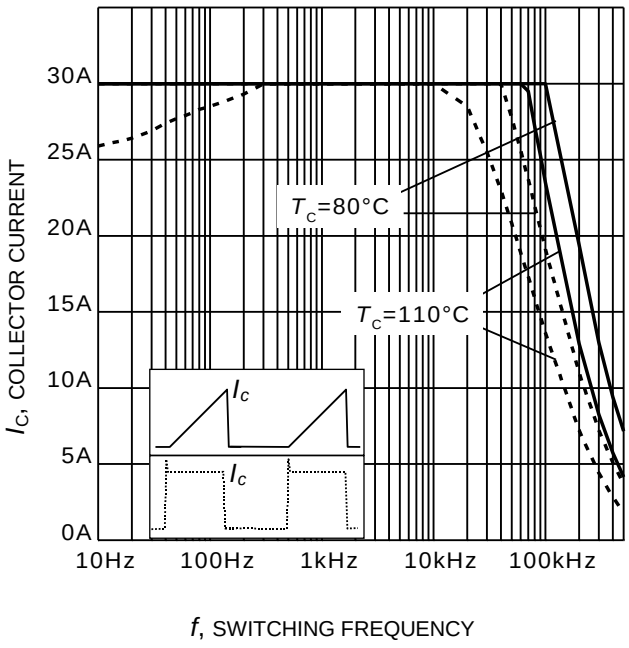



**Figure 1. Collector current as a function of switching frequency**
($T_j \leq 175°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/15V$, $r_G = 23\Omega$)

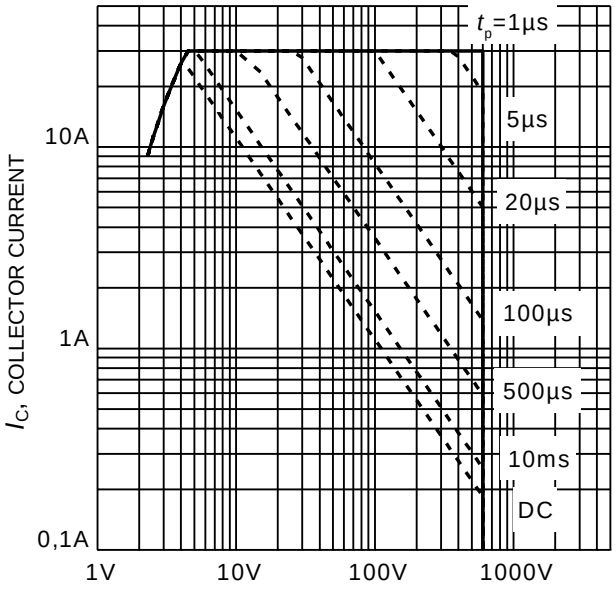



**Figure 2. Safe operating area**
($D = 0$, $T_C = 25°C$, $T_j \leq 175°C$; $V_{GE}$=0/15V)

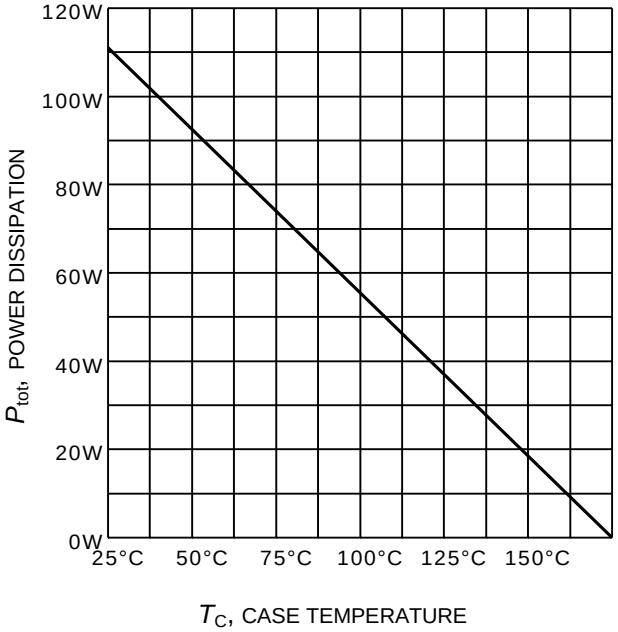



**Figure 3. Power dissipation as a function of case temperature**
($T_j \leq 175°C$)

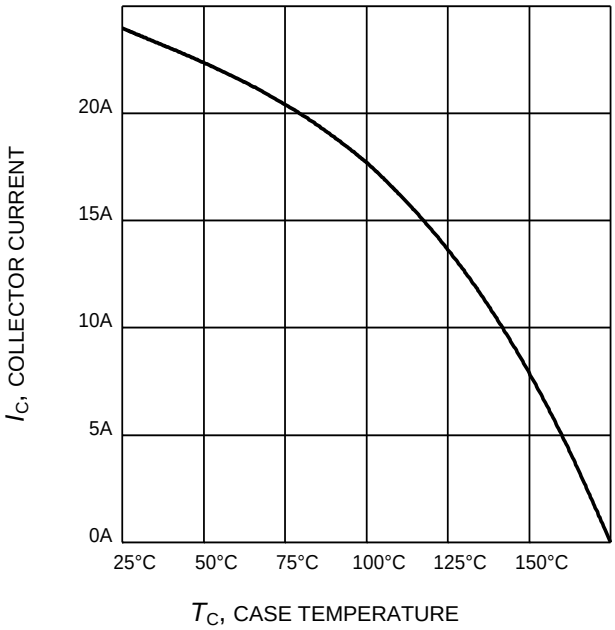



**Figure 4. Collector current as a function of case temperature**
($V_{GE} \geq 15V$, $T_j \leq 175°C$)

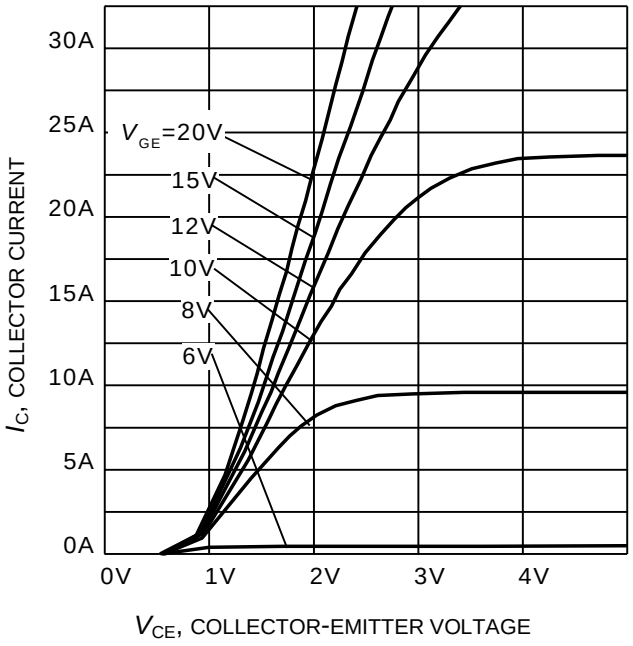



**Figure 5. Typical output characteristic**
($T_j$ = 25°C)

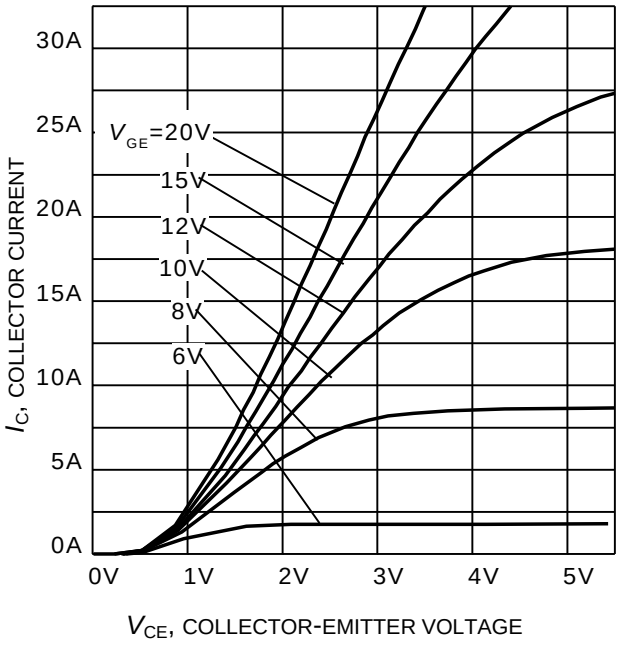



**Figure 6. Typical output characteristic**
($T_j$ = 175°C)

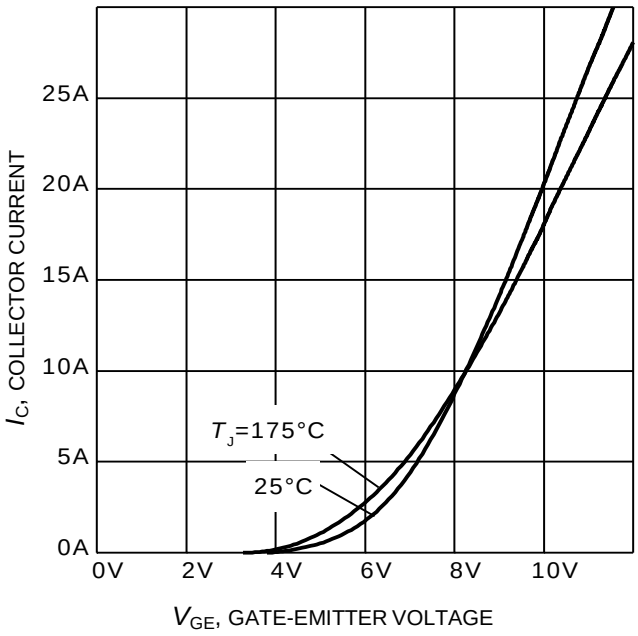



**Figure 7. Typical transfer characteristic**
($V_{CE}$=20V)

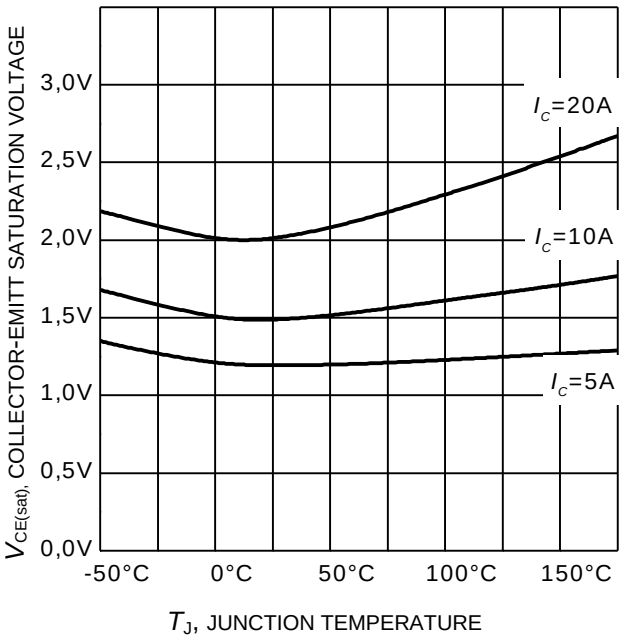



**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$ = 15V)

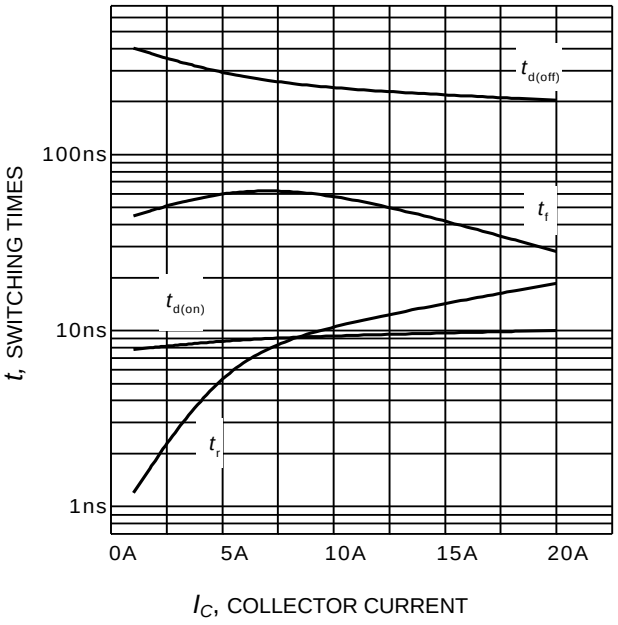



**Figure 9. Typical switching times as a function of collector current**
(inductive load, $T_J$=175°C,
$V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $r_G$ = 23Ω,
Dynamic test circuit in Figure E)

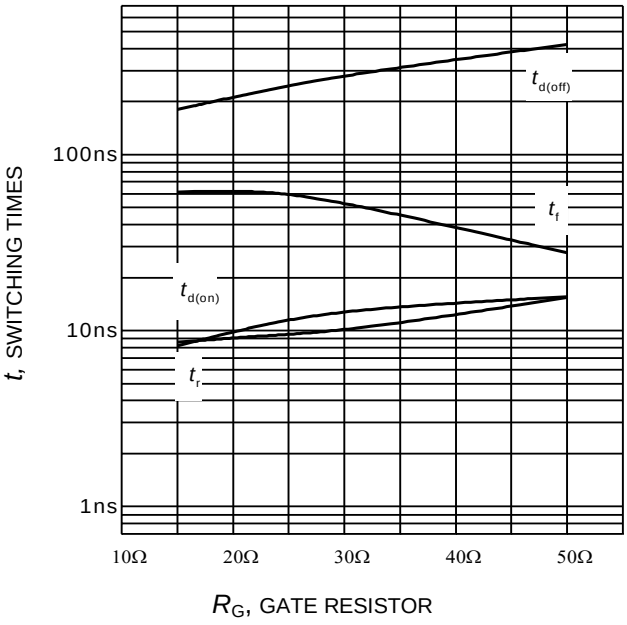



**Figure 10. Typical switching times as a function of gate resistor**
(inductive load, $T_J$ = 175°C,
$V_{CE}$= 400V, $V_{GE}$ = 0/15V, $I_C$ = 10A,
Dynamic test circuit in Figure E)

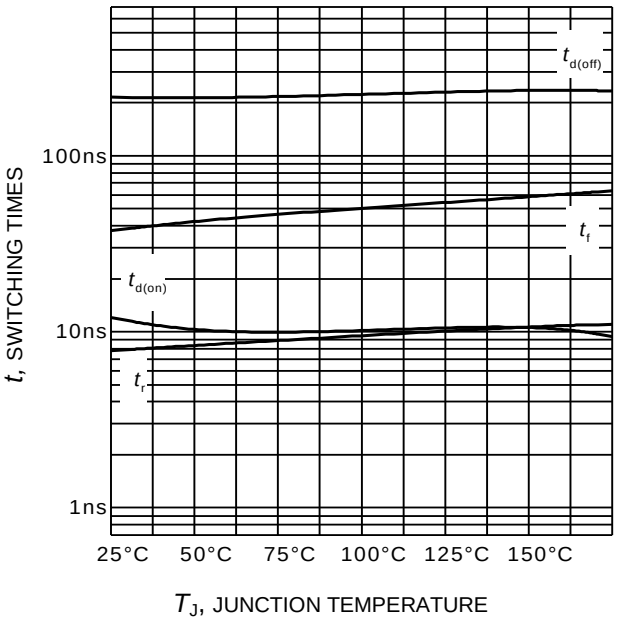



**Figure 11. Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V,
$V_{GE}$ = 0/15V, $I_C$ = 10A, $r_G$=23Ω,
Dynamic test circuit in Figure E)

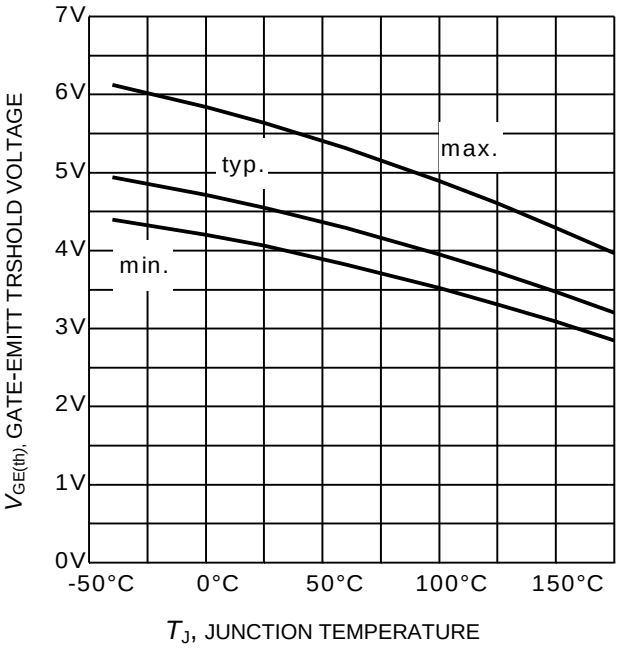



**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**
($I_C$ = 0.3mA)

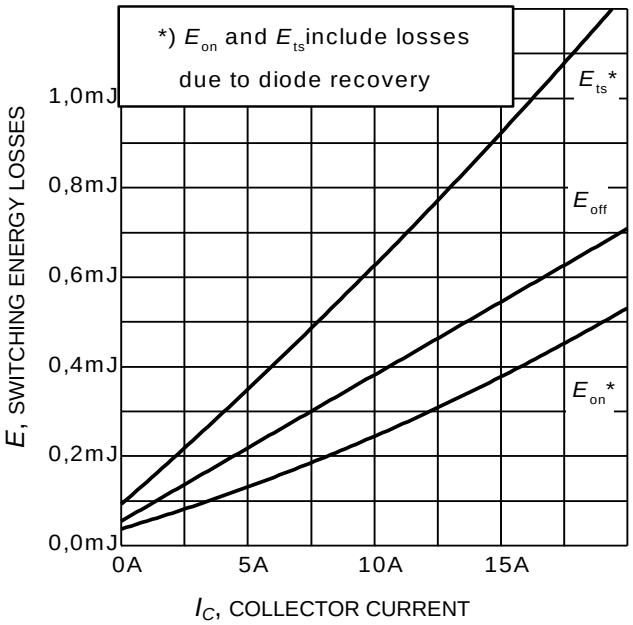



**Figure 13. Typical switching energy losses as a function of collector current**
(inductive load, $T_J$ = 175°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $r_G$ = 23Ω, Dynamic test circuit in Figure E)

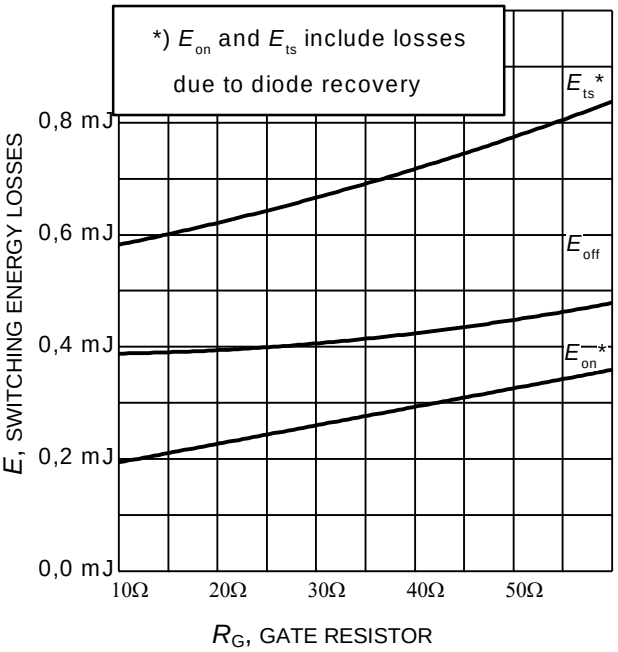



**Figure 14. Typical switching energy losses as a function of gate resistor**
(inductive load, $T_J$ = 175°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $I_C$ = 10A, Dynamic test circuit in Figure E)

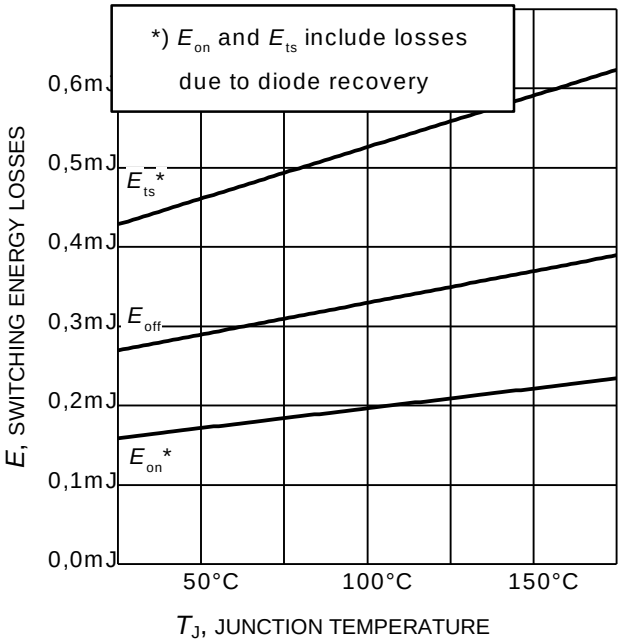



**Figure 15. Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $I_C$ = 10A, $r_G$ = 23Ω, Dynamic test circuit in Figure E)

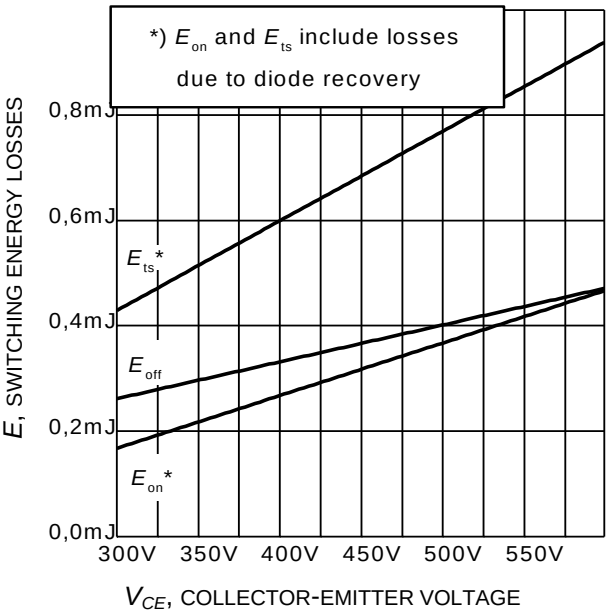



**Figure 16. Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_J$ = 175°C, $V_{GE}$ = 0/15V, $I_C$ = 10A, $r_G$ = 23Ω, Dynamic test circuit in Figure E)

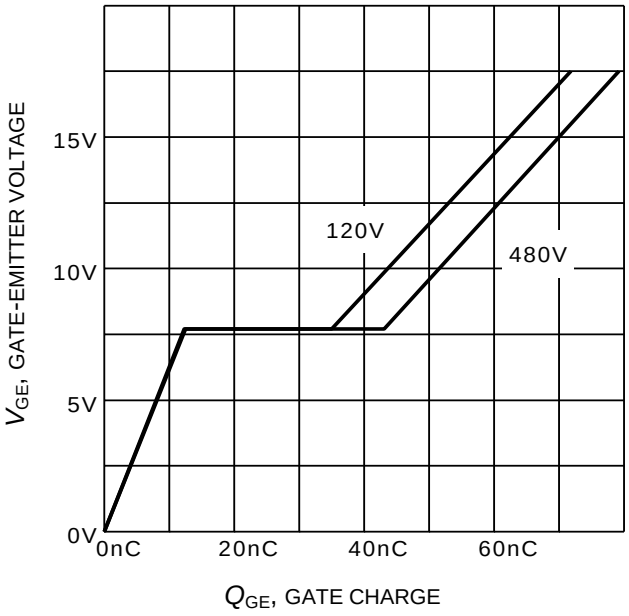



**Figure 17. Typical gate charge**
($I_C$=10 A)

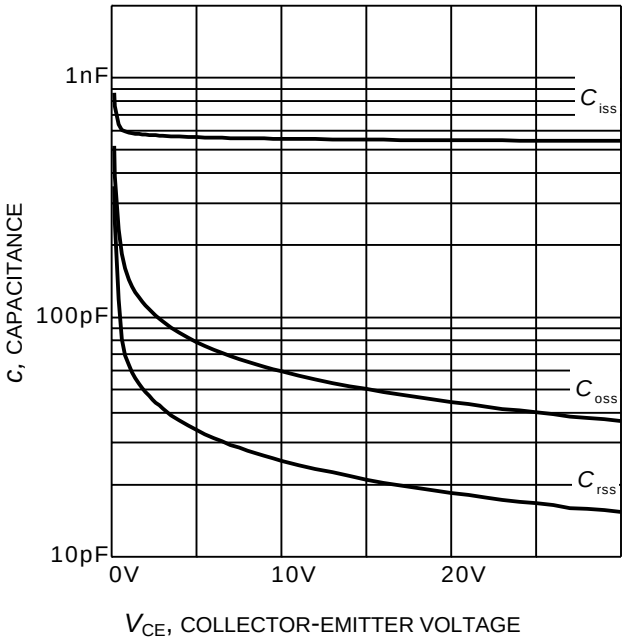



**Figure 18. Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$=0V, $f$ = 1 MHz)

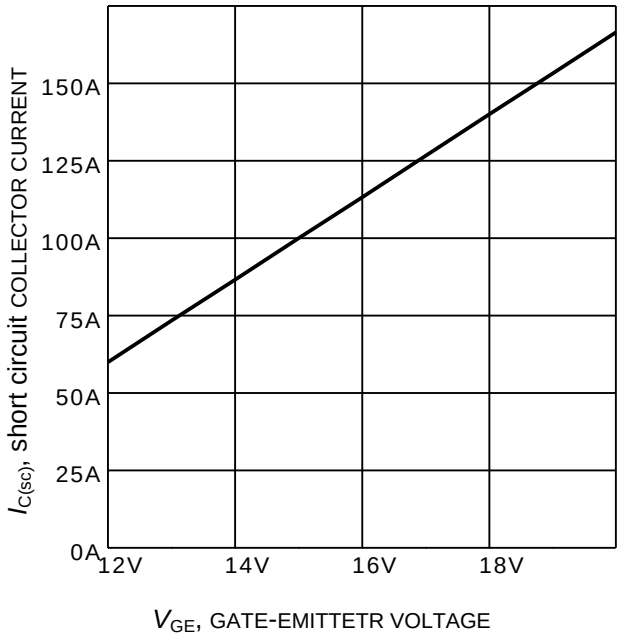



**Figure 19. Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE} \le$ 400V, $T_j \le$ 150°C)

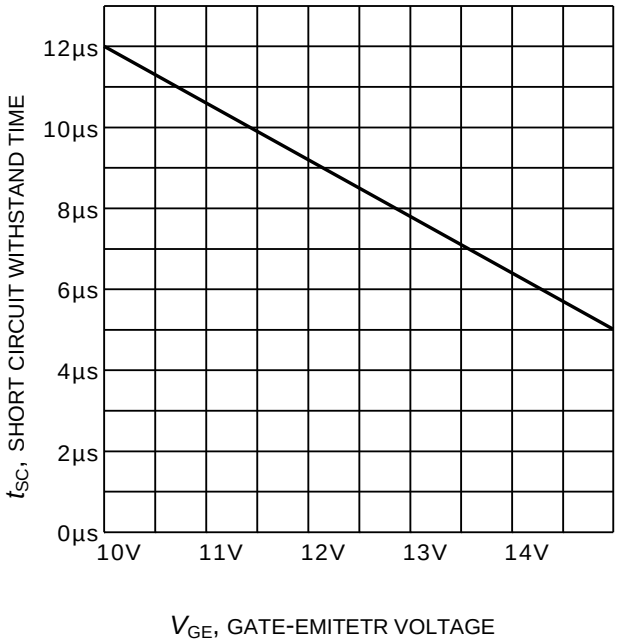



**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$=400V, start at $T_J$=25°C, $T_{Jmax}$<150°C)

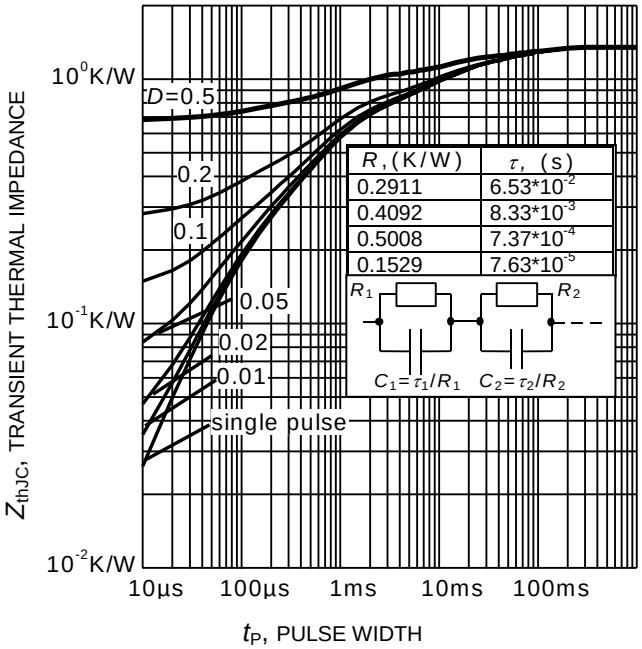



**Figure 21. IGBT transient thermal impedance**
($D = t_p / T$)

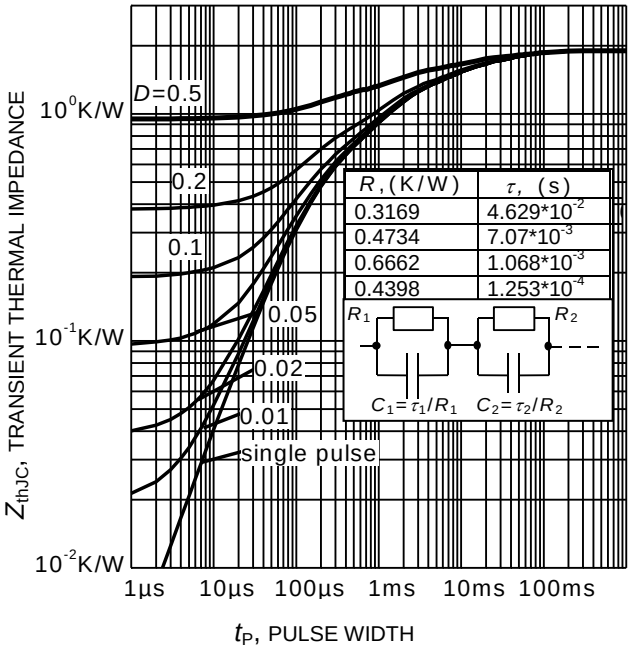



**Figure 22. Diode transient thermal impedance as a function of pulse width**
($D=t_P/T$)

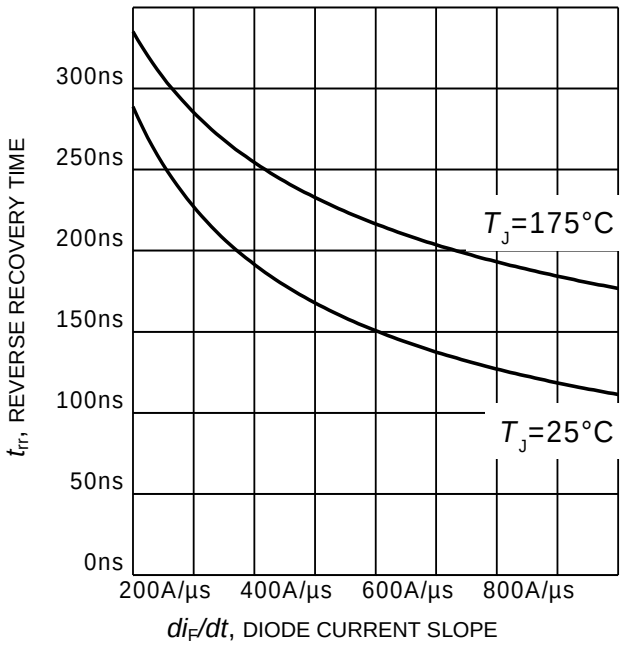



**Figure 23. Typical reverse recovery time as a function of diode current slope**
($V_R$=400V, $I_F$=10A,
Dynamic test circuit in Figure E)

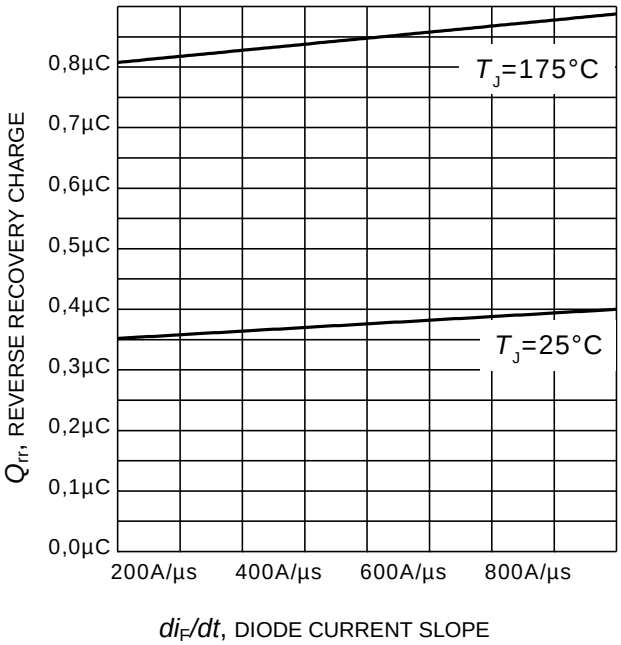



**Figure 24. Typical reverse recovery charge as a function of diode current slope**
($V_R$ = 400V, $I_F$ = 10A,
Dynamic test circuit in Figure E)

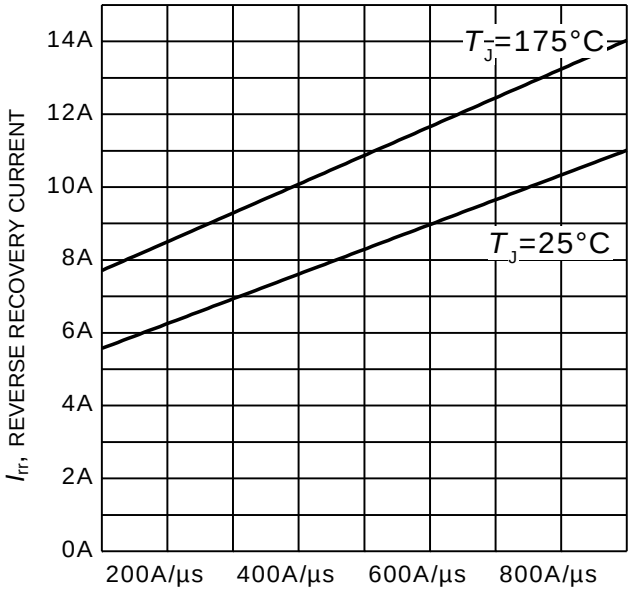



**Figure 25. Typical reverse recovery current as a function of diode current slope**
($V_R$ = 400V, $I_F$ = 10A,
Dynamic test circuit in Figure E)

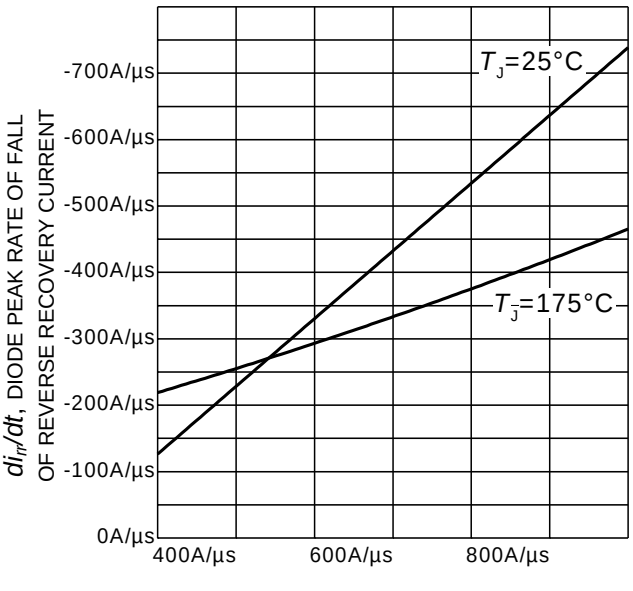



**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V, $I_F$=10A,
Dynamic test circuit in Figure E)

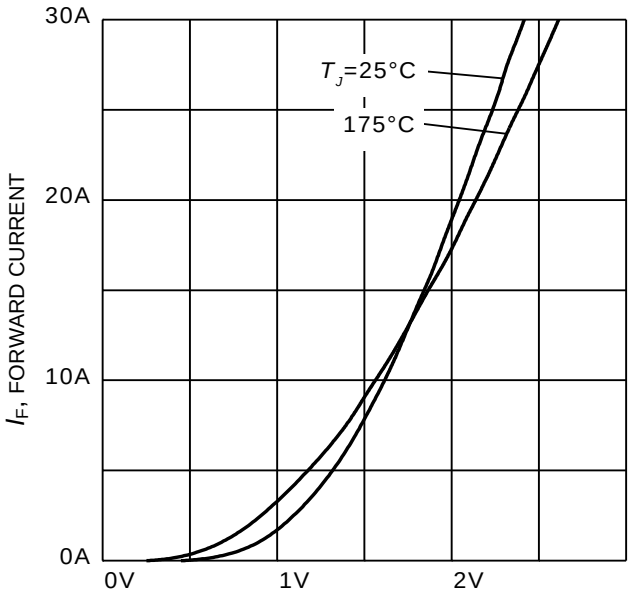



**Figure 27. Typical diode forward current as a function of forward voltage**

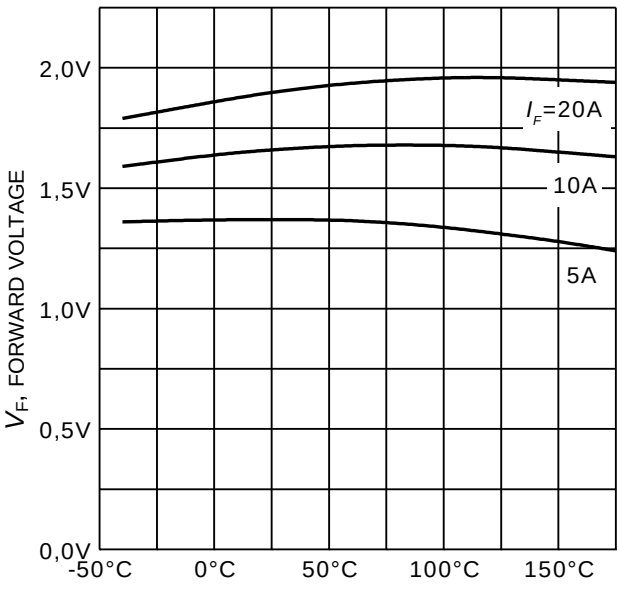
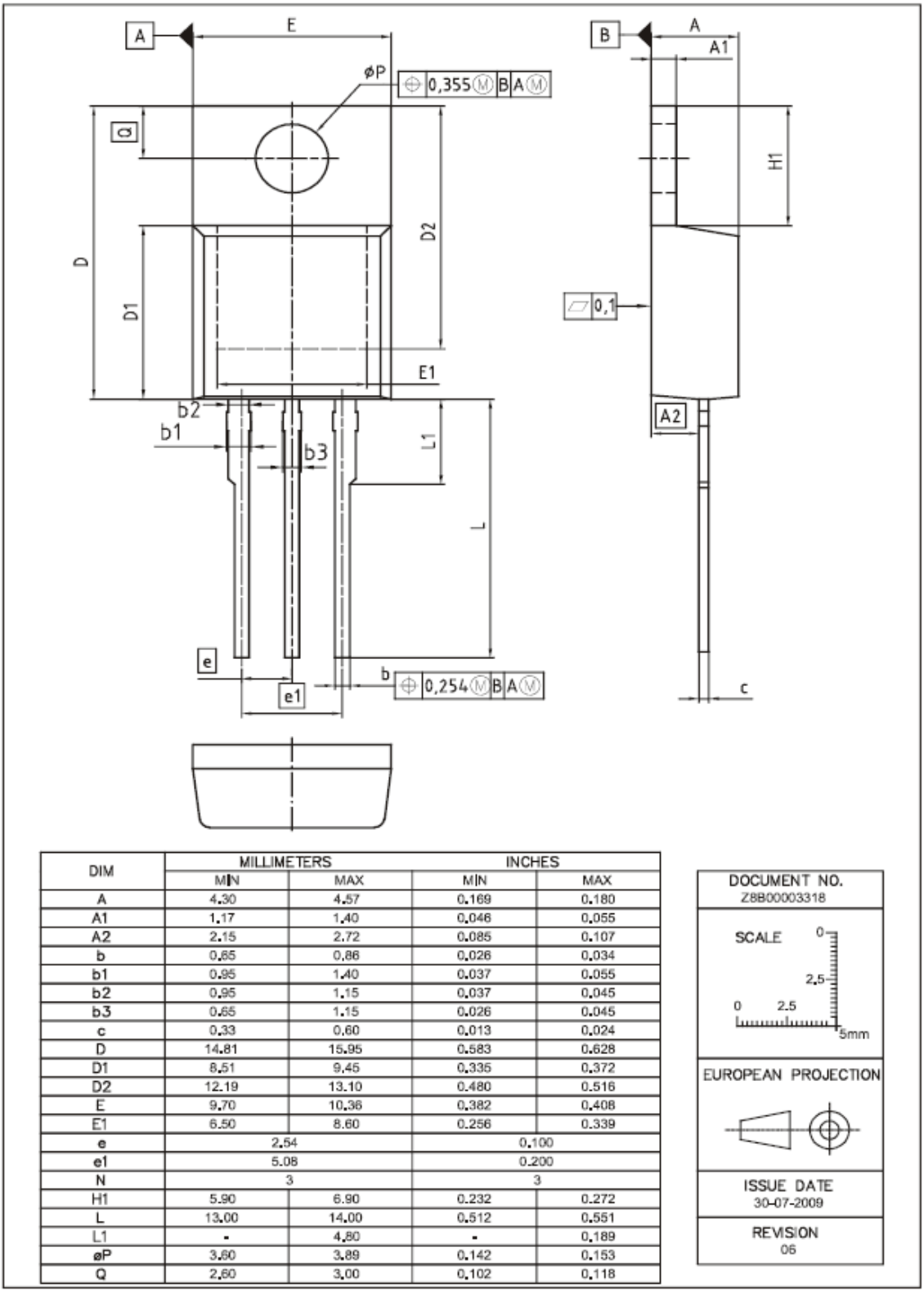



**Figure 28. Typical diode forward voltage as a function of junction temperature**

# 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 |

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SCALE 0 2,5 0 2.5 5mm

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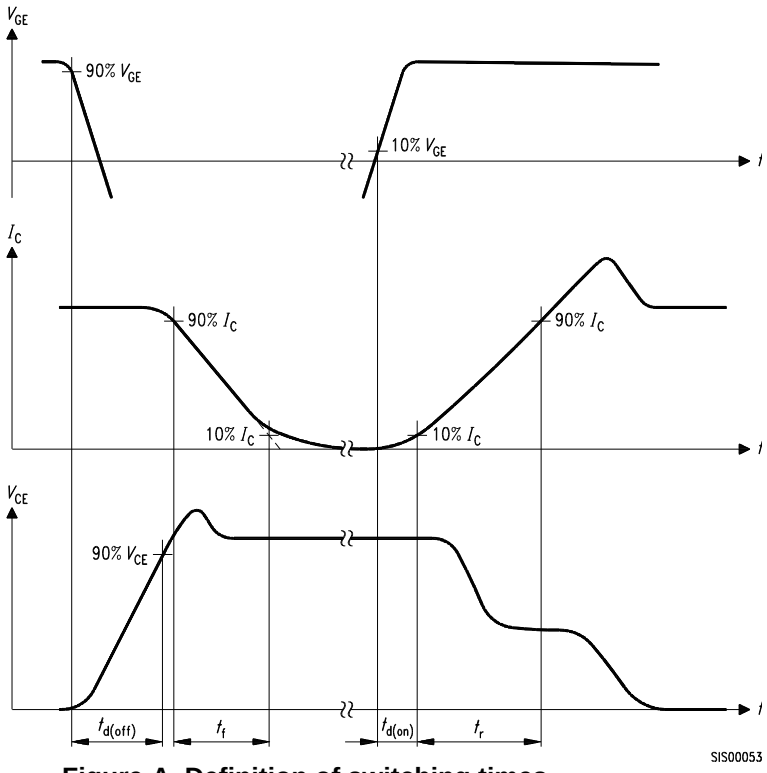


**Figure A. Definition of switching times**

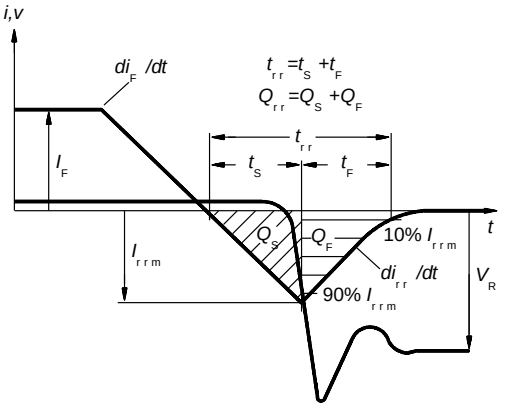


**Figure C. Definition of diodes switching characteristics**

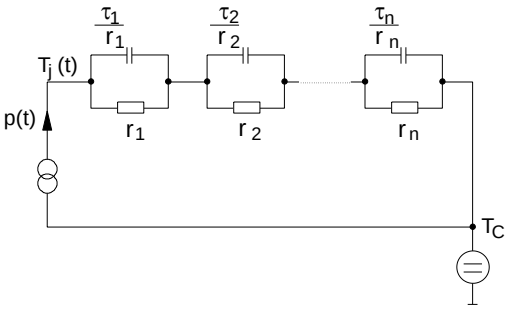


**Figure D. Thermal equivalent circuit**

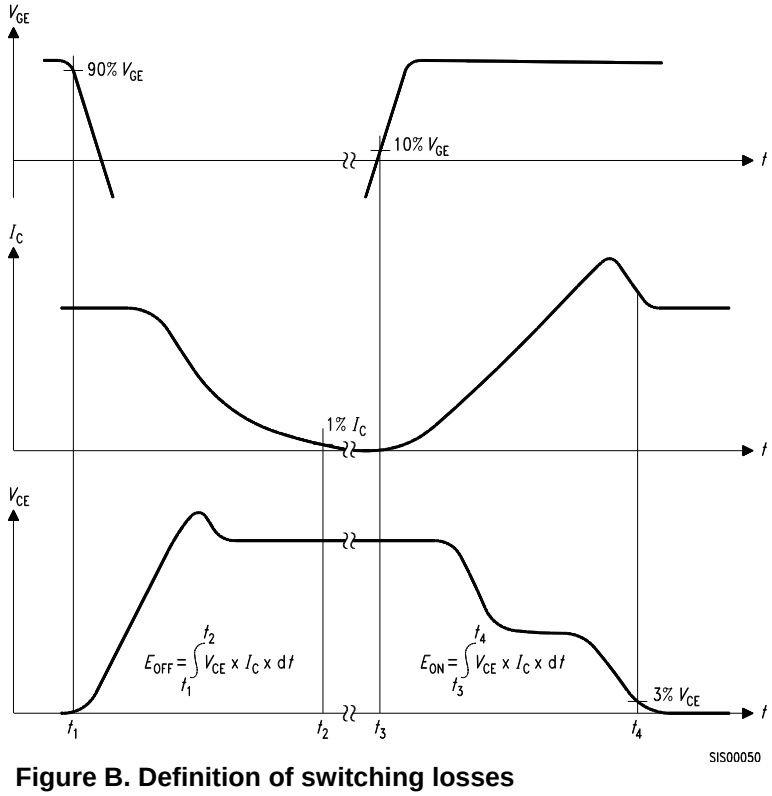


**Figure B. Definition of switching losses**

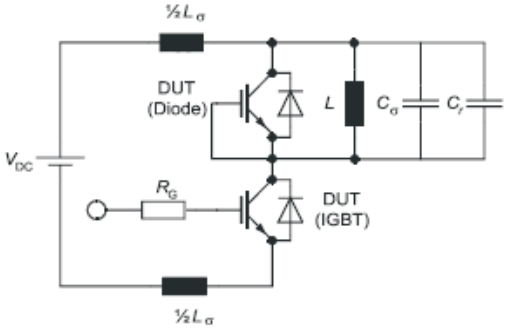


**Figure E. Dynamic test circuit**
Parasitic inductance $L_\sigma$,
Parasitic capacitor $C_\sigma$,
Relief capacitor $C_r$,
(only for ZVT switching)

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