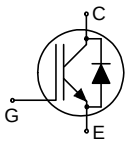
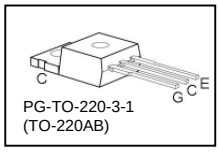
# SKP15N60
# SKW15N60

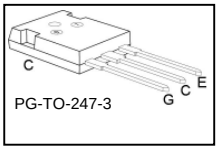
Fast IGBT in NPT-technology with soft, fast recovery anti-parallel Emitter Controlled Diode




- 75% lower $E_{off}$ compared to previous generation
  combined with low conduction losses
- Short circuit withstand time – 10 µs
- Designed for:
  - Motor controls
  - Inverter
- NPT-Technology for 600V applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behaviour
  - parallel switching capability
- Very soft, fast recovery anti-parallel Emitter Controlled Diode
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC[1] for target applications
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/



PG-TO-220-3-1
(TO-220AB)



PG-TO-247-3

| Type | $V_{CE}$ | $I_C$ | $V_{CE(sat)}$ | $T_j$ | Marking | Package |
|---|---|---|---|---|---|---|
| SKP15N60 | 600V | 15A | 2.3V | 150°C | K15N60 | PG-TO-220-3-1 |
| SKW15N60 | 600V | 15A | 2.3V | 150°C | K15N60 | PG-TO-247-3 |

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

**Maximum Ratings**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage | $V_{CE}$ | 600 | V |
| DC collector current<br>$T_C$ = 25°C<br>$T_C$ = 100°C | $I_C$ | <br>31<br>15 | A |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$ | $I_{Cpuls}$ | 62 | |
| Turn off safe operating area<br>$V_{CE} \le 600V$, $T_j \le 150°C$ | - | 62 | |
| Diode forward current<br>$T_C$ = 25°C<br>$T_C$ = 100°C | $I_F$ | <br>31<br>15 | |
| Diode pulsed current, $t_p$ limited by $T_{jmax}$ | $I_{Fpuls}$ | 62 | |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Short circuit withstand time[2]<br>$V_{GE}$ = 15V, $V_{CC} \le 600V$, $T_j \le 150°C$ | $t_{SC}$ | 10 | µs |
| Power dissipation<br>$T_C$ = 25°C | $P_{tot}$ | 139 | W |
| Operating junction and storage temperature | $T_j$ , $T_{stg}$ | -55...+150 | °C |
| Soldering temperature<br>wavesoldering, 1.6 mm (0.063 in.) from case for 10s | $T_s$ | 260 | °C |

[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 | $R_{thJC}$ | | 0.9 | K/W |
| Diode thermal resistance, junction – case | $R_{thJCD}$ | | 1.7 | |
| Thermal resistance, junction – ambient | $R_{thJA}$ | PG-TO-220-3-1<br>PG-TO-247-3-1 | 62<br>40 | |

**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, $I_C$=500µA | 600 | - | - | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}$ = 15V, $I_C$=15A | | | | |
| | | $T_j$=25°C | 1.7 | 2 | 2.4 | |
| | | $T_j$=150°C | - | 2.3 | 2.8 | |
| Diode forward voltage | $V_F$ | $V_{GE}$=0V, $I_F$=15A | | | | |
| | | $T_j$=25°C | 1.2 | 1.4 | 1.8 | |
| | | $T_j$=150°C | - | 1.25 | 1.65 | |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$=400µA,$V_{CE}$=$V_{GE}$ | 3 | 4 | 5 | |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$=600V,$V_{GE}$=0V | | | | µA |
| | | $T_j$=25°C | - | - | 40 | |
| | | $T_j$=150°C | - | - | 2000 | |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$=0V,$V_{GE}$=20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$=20V, $I_C$=15A | 3 | 10.9 | - | S |
| **Dynamic Characteristic** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{CE}$=25V, | - | 800 | 960 | pF |
| Output capacitance | $C_{oss}$ | $V_{GE}$=0V, | - | 84 | 101 | |
| Reverse transfer capacitance | $C_{rss}$ | $f$=1MHz | - | 52 | 62 | |
| Gate charge | $Q_{Gate}$ | $V_{CC}$=480V, $I_C$=15A<br>$V_{GE}$=15V | - | 76 | 99 | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | PG-TO-220-3-1 | - | 7 | - | nH |
| | | PG-TO-247-3-21 | - | 13 | - | |
| Short circuit collector current[2)] | $I_{C(SC)}$ | $V_{GE}$=15V,$t_{SC}$≤10µs<br>$V_{CC}$ ≤ 600V,<br>$T_j$ ≤ 150°C | - | 150 | - | A |

[2)] 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, $I_C$=15A, $V_{GE}$=0/15V, $R_G$=21Ω, $L_\sigma$ [1)] =180nH, $C_\sigma$ [1)] =250pF Energy losses include "tail" and diode reverse recovery. | - | 32 | 38 | ns |
| Rise time | $t_r$ | | - | 23 | 28 | |
| Turn-off delay time | $t_{d(off)}$ | | - | 234 | 281 | |
| Fall time | $t_f$ | | - | 46 | 55 | |
| Turn-on energy | $E_{on}$ | | - | 0.30 | 0.36 | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.27 | 0.35 | |
| Total switching energy | $E_{ts}$ | | - | 0.57 | 0.71 | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=25°C, $V_R$=200V, $I_F$=15A, $di_F/dt$=200A/µs | - | 279 | - | ns |
| | $t_S$ | | - | 28 | - | |
| | $t_F$ | | - | 254 | - | |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 390 | - | nC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 5.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 180 | - | A/µs |

**Switching Characteristic, Inductive Load,** at $T_j$=150 °C

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_j$=150°C $V_{CC}$=400V, $I_C$=15A, $V_{GE}$=0/15V, $R_G$=21Ω, $L_\sigma$ [1)] =180nH, $C_\sigma$ [1)] =250pF Energy losses include "tail" and diode reverse recovery. | - | 31 | 38 | ns |
| Rise time | $t_r$ | | - | 23 | 28 | |
| Turn-off delay time | $t_{d(off)}$ | | - | 261 | 313 | |
| Fall time | $t_f$ | | - | 54 | 65 | |
| Turn-on energy | $E_{on}$ | | - | 0.45 | 0.54 | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.41 | 0.53 | |
| Total switching energy | $E_{ts}$ | | - | 0.86 | 1.07 | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=150°C $V_R$=200V, $I_F$=15A, $di_F/dt$=200A/µs | - | 360 | - | ns |
| | $t_S$ | | - | 40 | - | |
| | $t_F$ | | - | 320 | - | |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 1020 | - | nC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 7.5 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 200 | - | A/µs |

[1)] Leakage inductance $L_\sigma$ and Stray capacity $C_\sigma$ due to dynamic test circuit in Figure E.

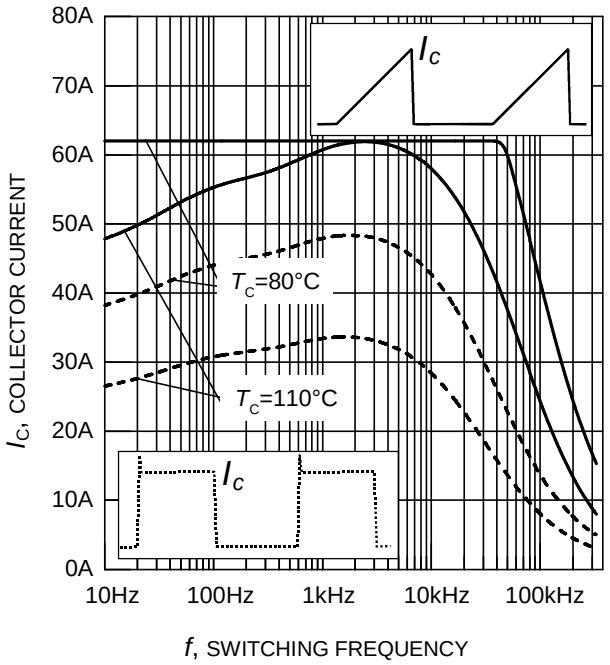



**Figure 1. Collector current as a function of switching frequency**
($T_j \le 150°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/+15V$, $R_G = 21\Omega$)

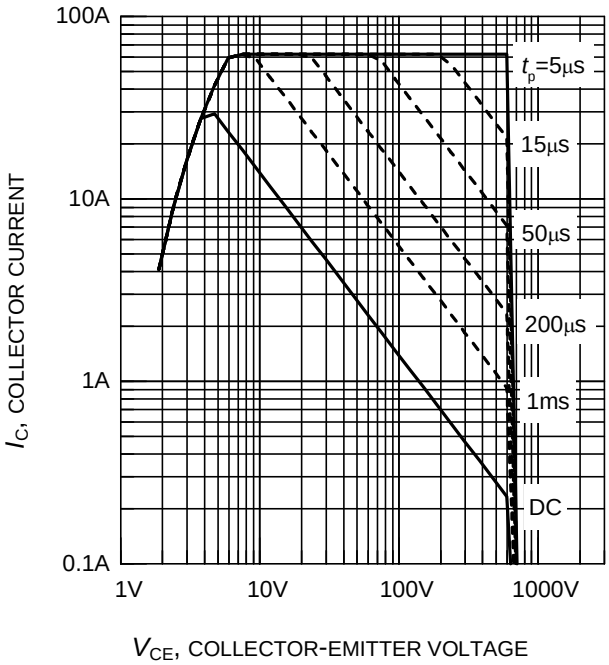



**Figure 2. Safe operating area**
($D = 0$, $T_C = 25°C$, $T_j \le 150°C$)

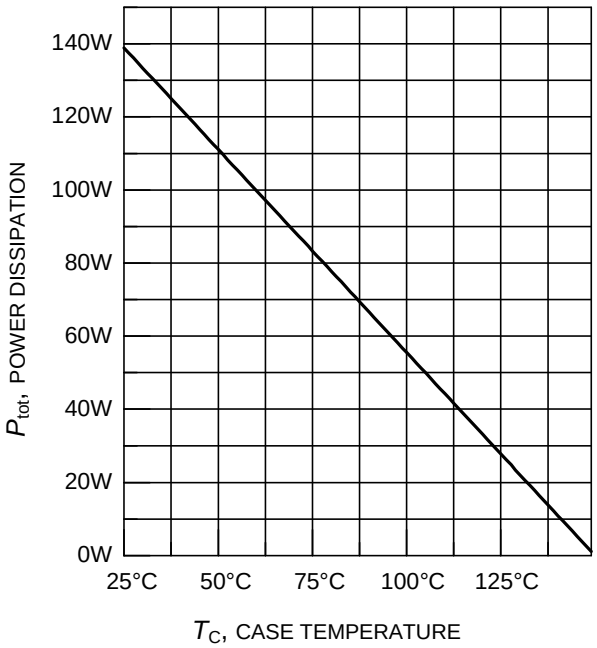



**Figure 3. Power dissipation as a function of case temperature**
($T_j \le 150°C$)

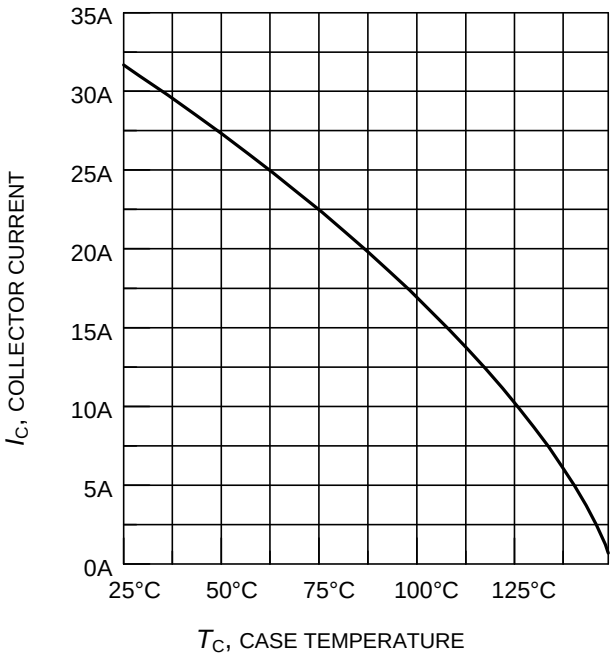



**Figure 4. Collector current as a function of case temperature**
($V_{GE} \le 15V$, $T_j \le 150°C$)

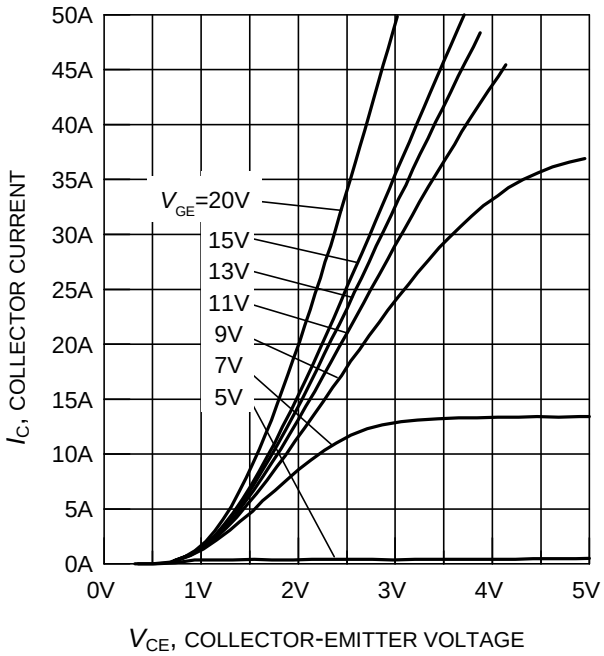



**Figure 5. Typical output characteristics**
($T_j$ = 25°C)

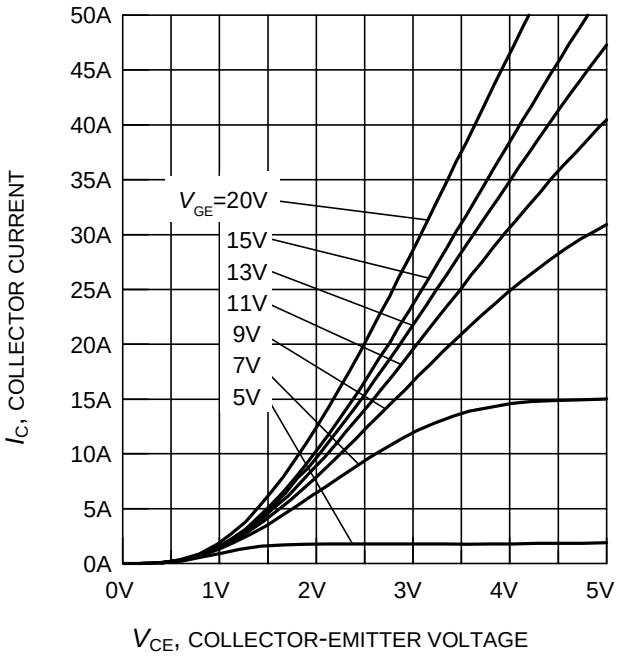



**Figure 6. Typical output characteristics**
($T_j$ = 150°C)

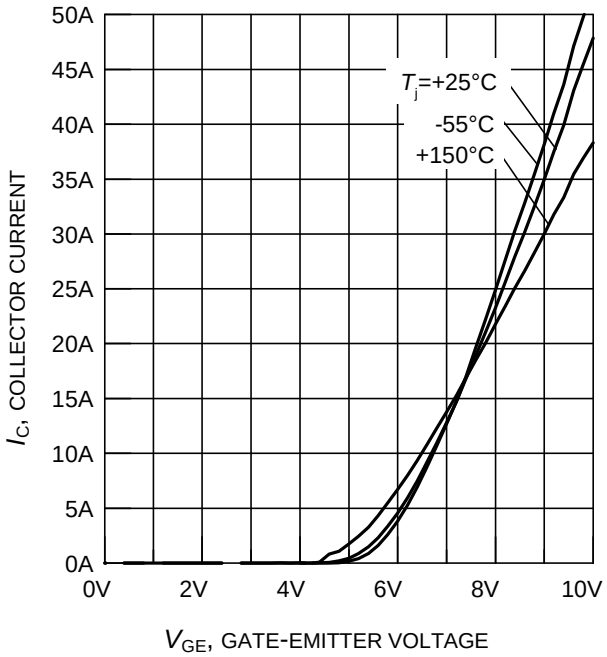



**Figure 7. Typical transfer characteristics**
($V_{CE}$ = 10V)

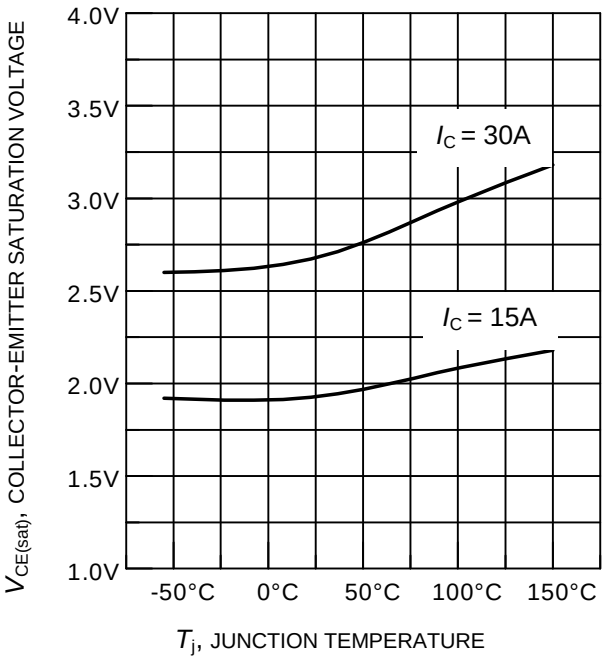



**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$ = 15V)

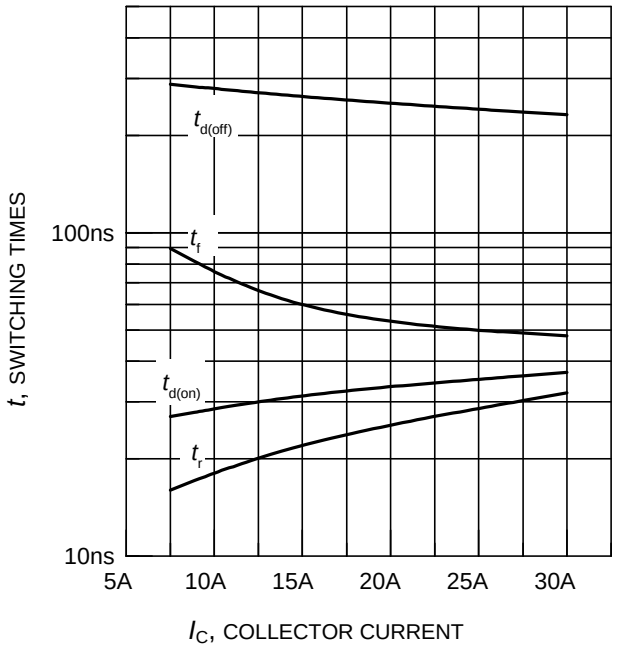



**Figure 9. Typical switching times as a function of collector current**
(inductive load, $T_j$ = 150°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/+15V, $R_G$ = 21Ω, Dynamic test circuit in Figure E)

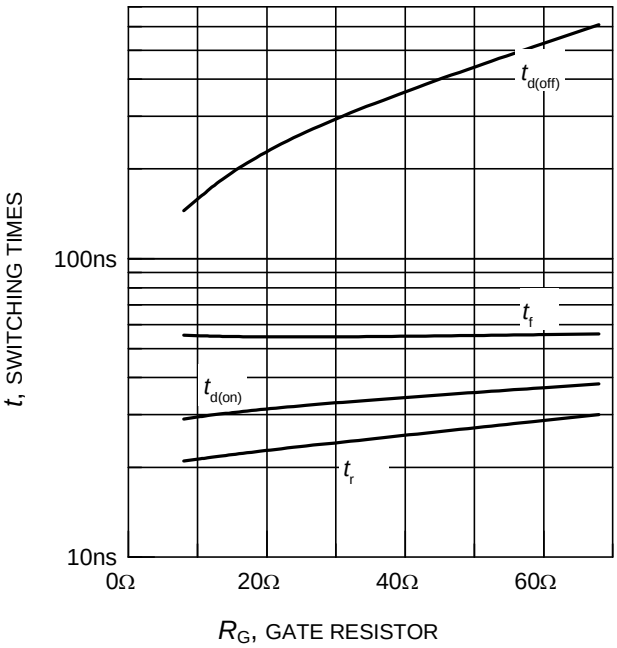



**Figure 10. Typical switching times as a function of gate resistor**
(inductive load, $T_j$ = 150°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/+15V, $I_C$ = 15A, Dynamic test circuit in Figure E)

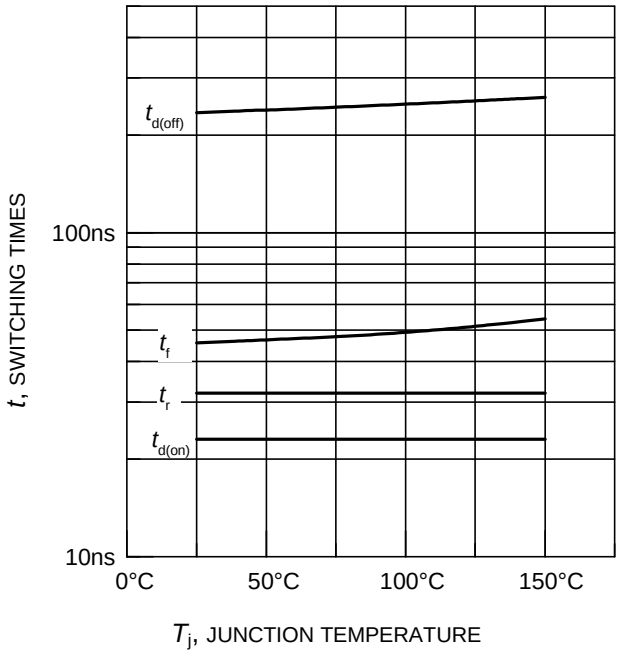



**Figure 11. Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V, $V_{GE}$ = 0/+15V, $I_C$ = 15A, $R_G$ = 21Ω, Dynamic test circuit in Figure E)

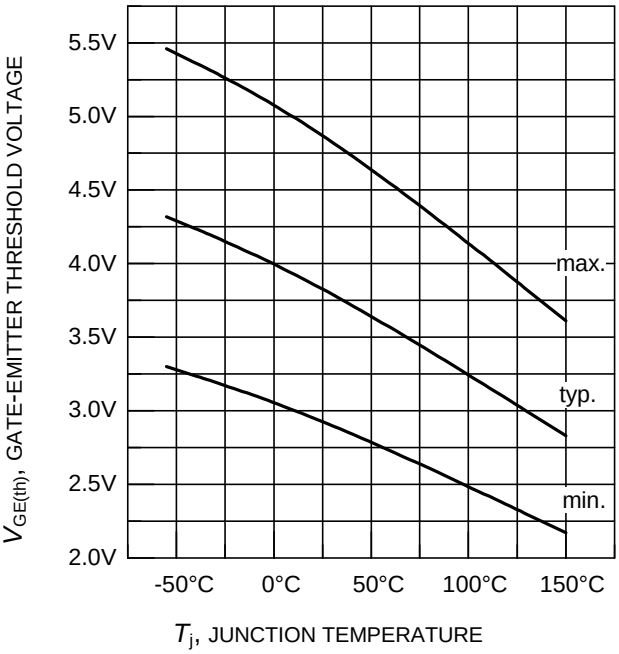



**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**
($I_C$ = 0.4mA)

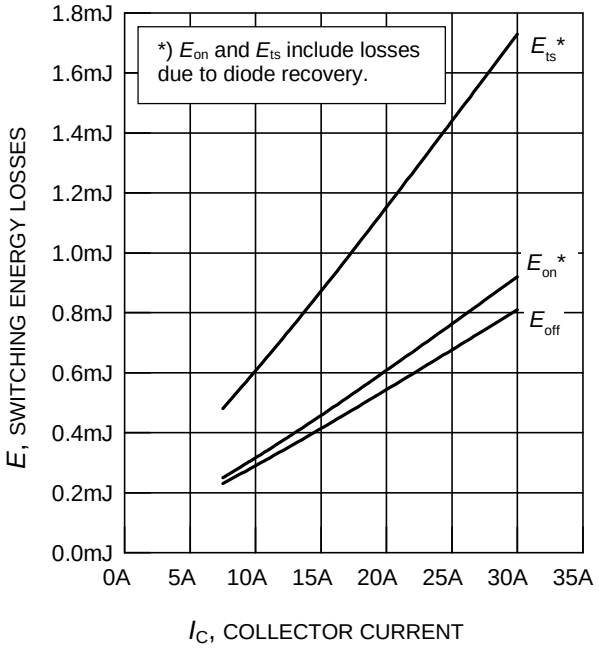



**Figure 13. Typical switching energy losses as a function of collector current**
(inductive load, $T_j$ = 150°C, $V_{CE}$ = 400V,
$V_{GE}$ = 0/+15V, $R_G$ = 21Ω,
Dynamic test circuit in Figure E)

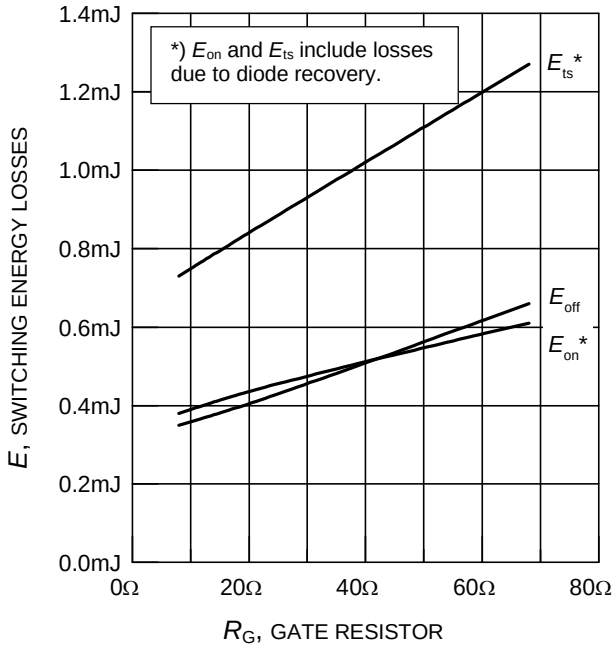



**Figure 14. Typical switching energy losses as a function of gate resistor**
(inductive load, $T_j$ = 150°C, $V_{CE}$ = 400V,
$V_{GE}$ = 0/+15V, $I_C$ = 15A,
Dynamic test circuit in Figure E)

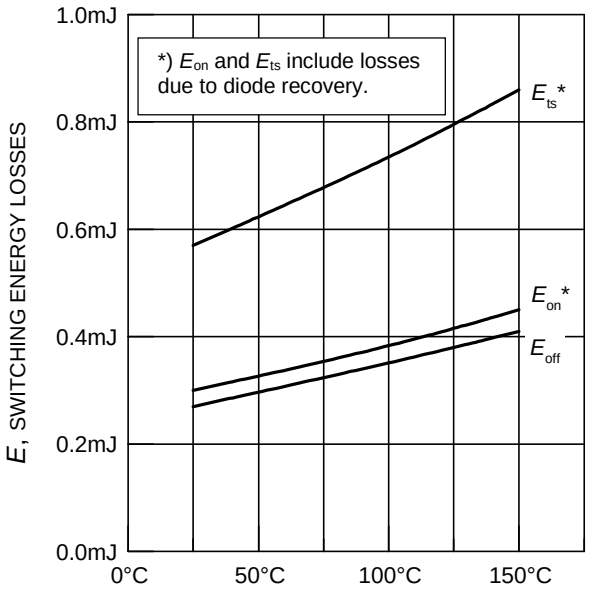



**Figure 15. Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V, $V_{GE}$ = 0/+15V,
$I_C$ = 15A, $R_G$ = 21Ω,
Dynamic test circuit in Figure E)

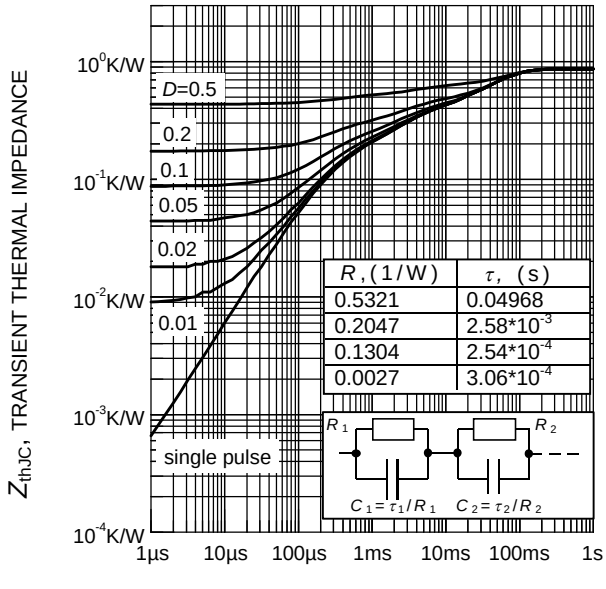



**Figure 16. IGBT transient thermal impedance as a function of pulse width**
($D = t_p / T$)

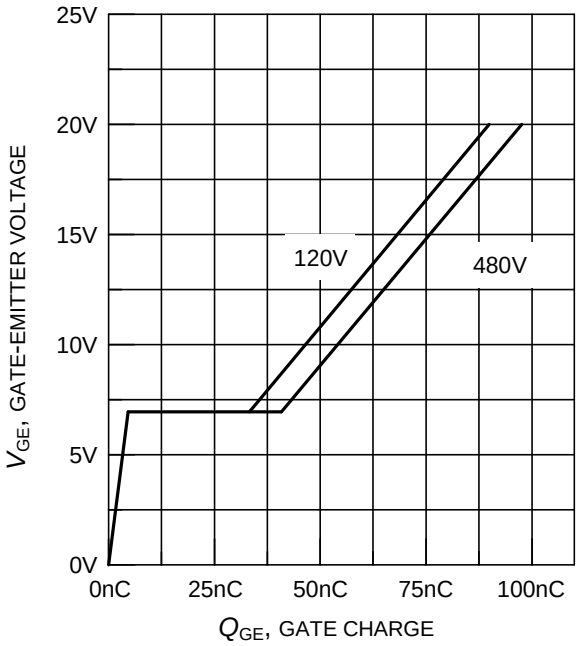



**Figure 17. Typical gate charge**
($I_C$ = 15A)

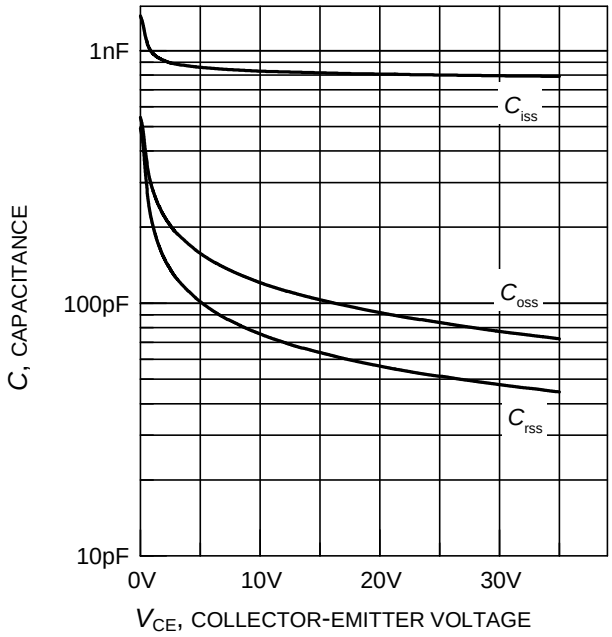



**Figure 18. Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$ = 0V, $f$ = 1MHz)

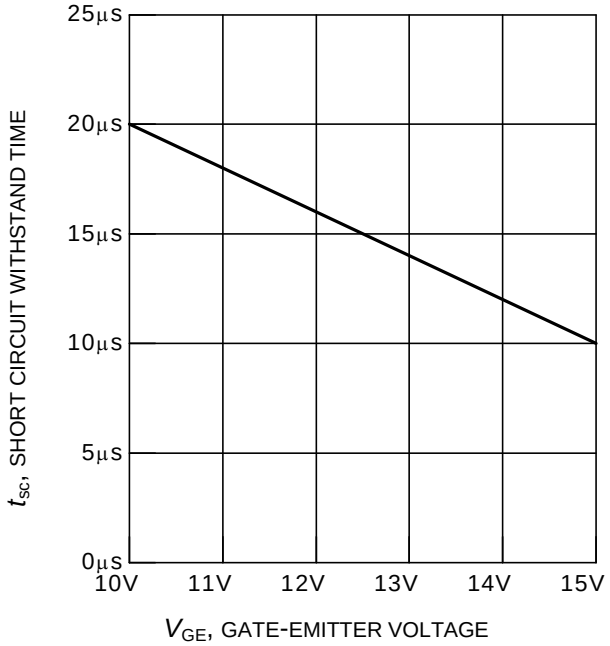



**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$ = 600V, start at $T_j$ = 25°C)

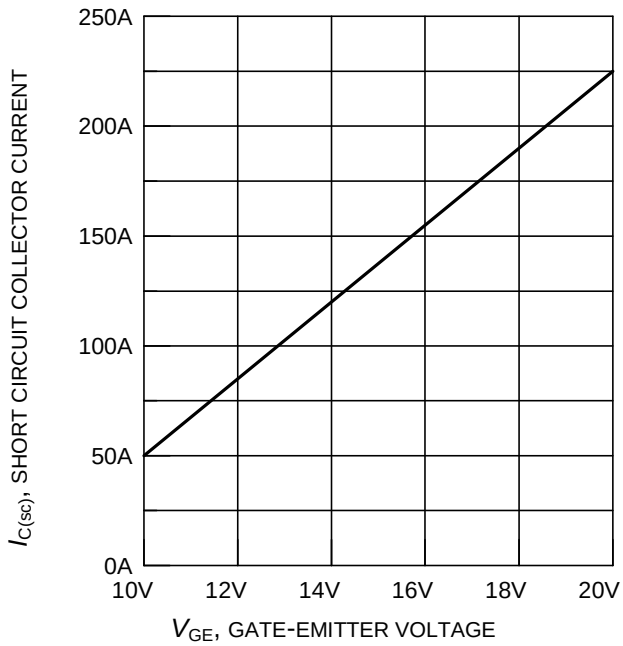



**Figure 20. Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE} \le$ 600V, $T_j$ = 150°C)

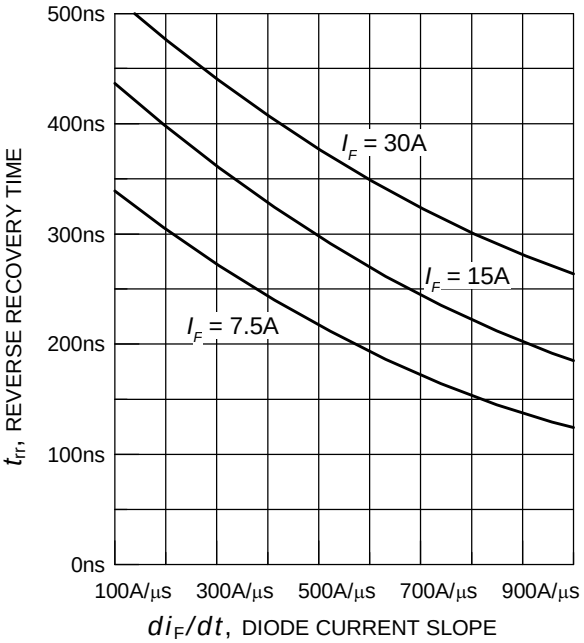



**Figure 21. Typical reverse recovery time as a function of diode current slope**
($V_R$ = 200V, $T_j$ = 125°C,
Dynamic test circuit in Figure E)

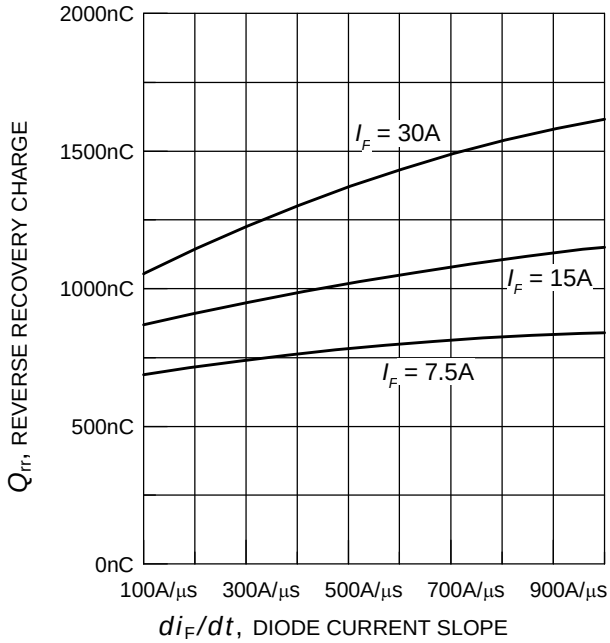



**Figure 22. Typical reverse recovery charge as a function of diode current slope**
($V_R$ = 200V, $T_j$ = 125°C,
Dynamic test circuit in Figure E)

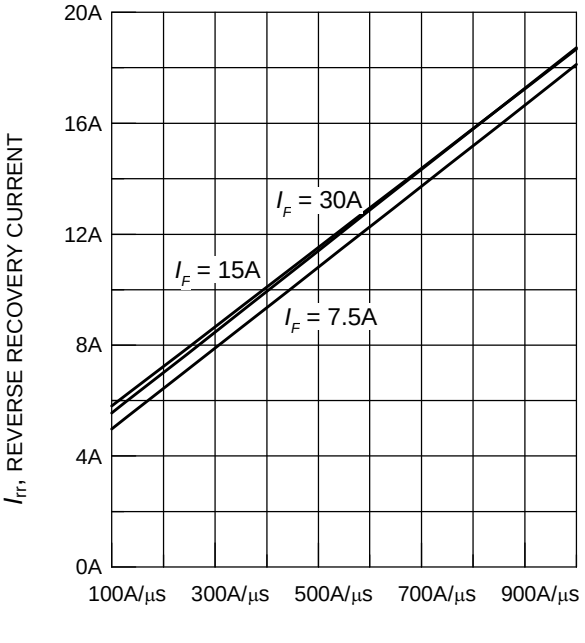



**Figure 23. Typical reverse recovery current as a function of diode current slope**
($V_R$ = 200V, $T_j$ = 125°C,
Dynamic test circuit in Figure E)

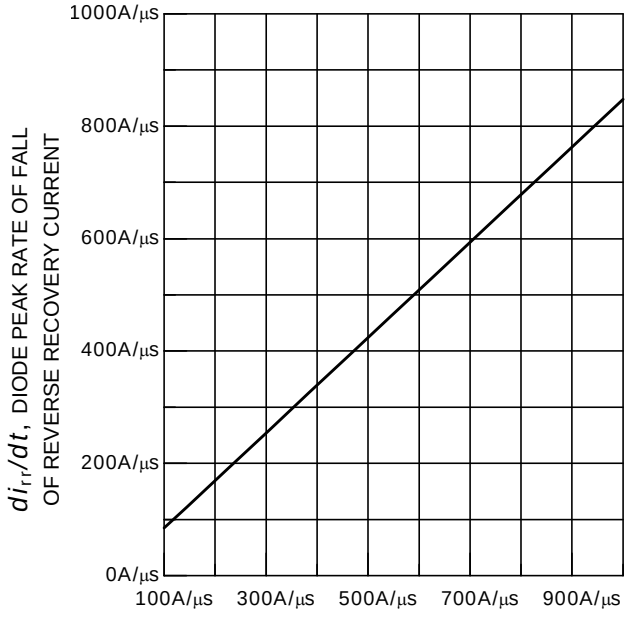



**Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$ = 200V, $T_j$ = 125°C,
Dynamic test circuit in Figure E)

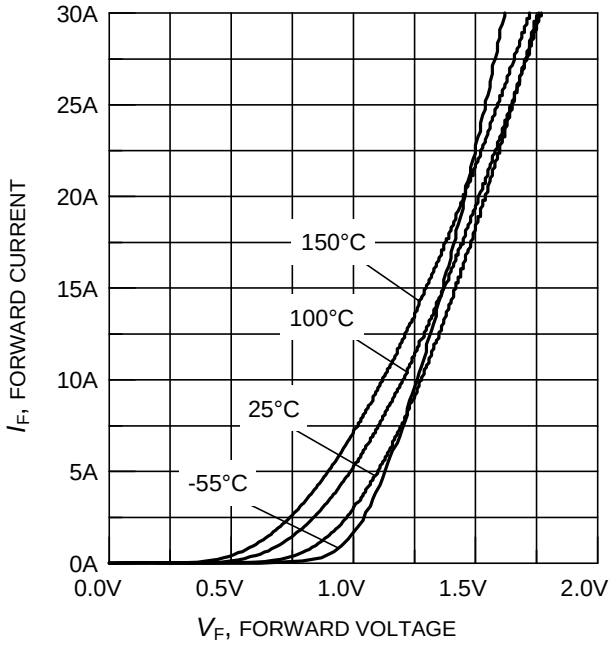



**Figure 25. Typical diode forward current as a function of forward voltage**

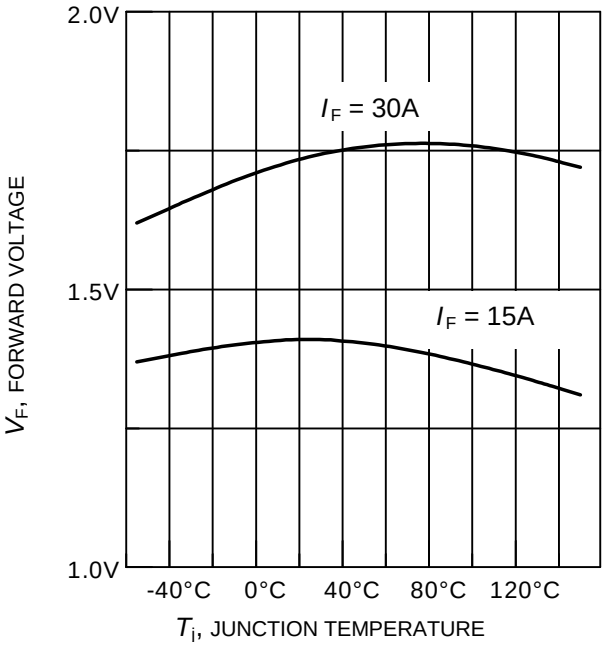
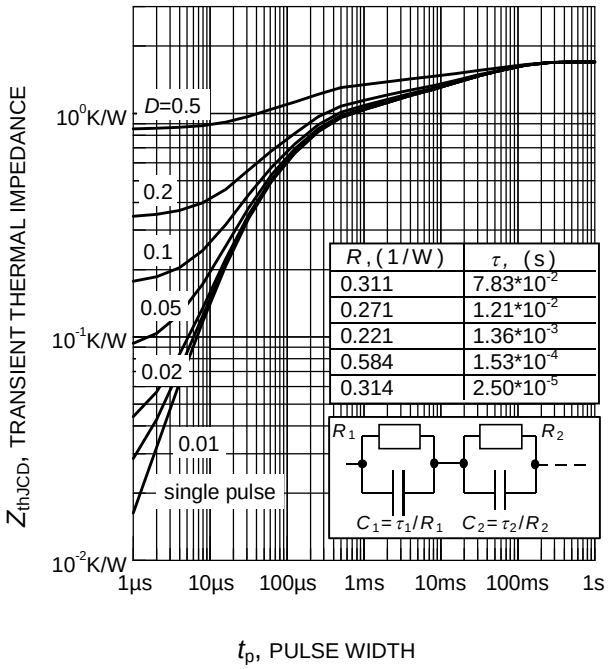


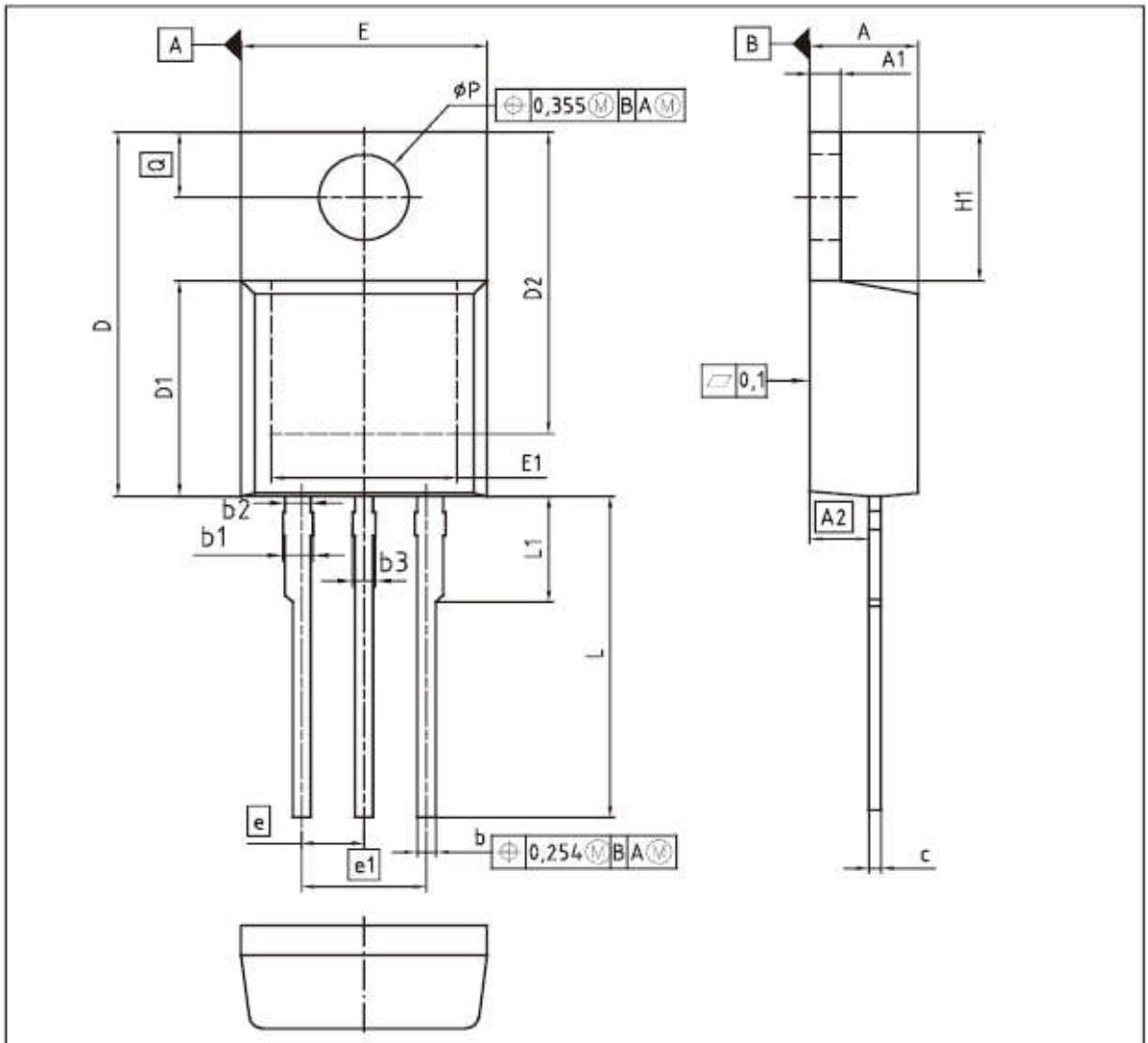

**Figure 26. Typical diode forward voltage as a function of junction temperature**




| $R_i$ (1/W) | $\tau_i$ (s) |
|---|---|
| 0.311 | $7.83*10^{-2}$ |
| 0.271 | $1.21*10^{-2}$ |
| 0.221 | $1.36*10^{-3}$ |
| 0.584 | $1.53*10^{-4}$ |
| 0.314 | $2.50*10^{-5}$ |

**Figure 27. Diode transient thermal impedance as a function of pulse width**
($D = t_p / T$)

# 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

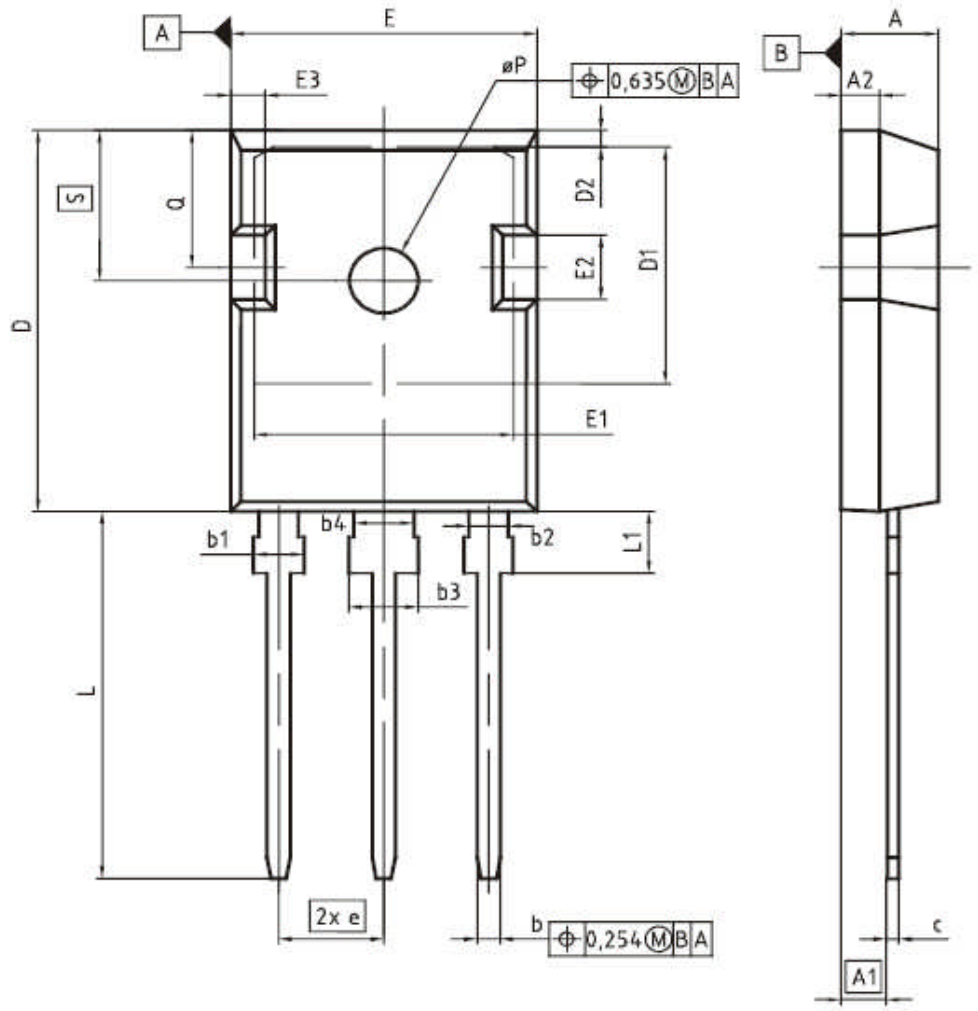
SCALE 0 2.5 5mm

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06

# PG-TO247-3




| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4,83 | 5,21 | 0,190 | 0,205 |
| A1 | 2,27 | 2,54 | 0,089 | 0,100 |
| A2 | 1,85 | 2,16 | 0,073 | 0,085 |
| b | 1,07 | 1,33 | 0,042 | 0,052 |
| b1 | 1,90 | 2,41 | 0,075 | 0,095 |
| b2 | 1,90 | 2,16 | 0,075 | 0,085 |
| b3 | 2,87 | 3,38 | 0,113 | 0,133 |
| b4 | 2,87 | 3,13 | 0,113 | 0,123 |
| c | 0,55 | 0,68 | 0,022 | 0,027 |
| D | 20,80 | 21,10 | 0,819 | 0,831 |
| D1 | 16,25 | 17,65 | 0,640 | 0,695 |
| D2 | 0,95 | 1,35 | 0,037 | 0,053 |
| E | 15,70 | 16,13 | 0,618 | 0,635 |
| E1 | 13,10 | 14,15 | 0,516 | 0,557 |
| E2 | 3,68 | 5,10 | 0,145 | 0,201 |
| E3 | 1,00 | 2,60 | 0,039 | 0,102 |
| e | 5,44 (BSC) | | 0,214 (BSC) | |
| N | 3 | | 3 | |
| L | 19,80 | 20,32 | 0,780 | 0,800 |
| L1 | 4,10 | 4,47 | 0,161 | 0,176 |
| øP | 3,50 | 3,70 | 0,138 | 0,146 |
| Q | 5,49 | 6,00 | 0,216 | 0,236 |
| S | 6,04 | 6,30 | 0,238 | 0,248 |

DOCUMENT NO.
Z8B00003327

SCALE 0 5 5 7,5mm

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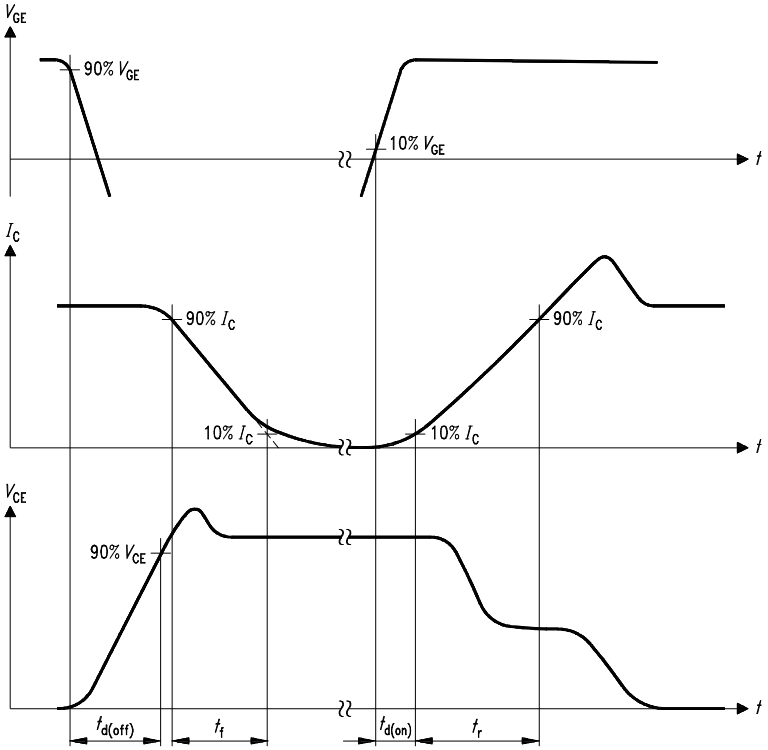



**Figure A. Definition of switching times**

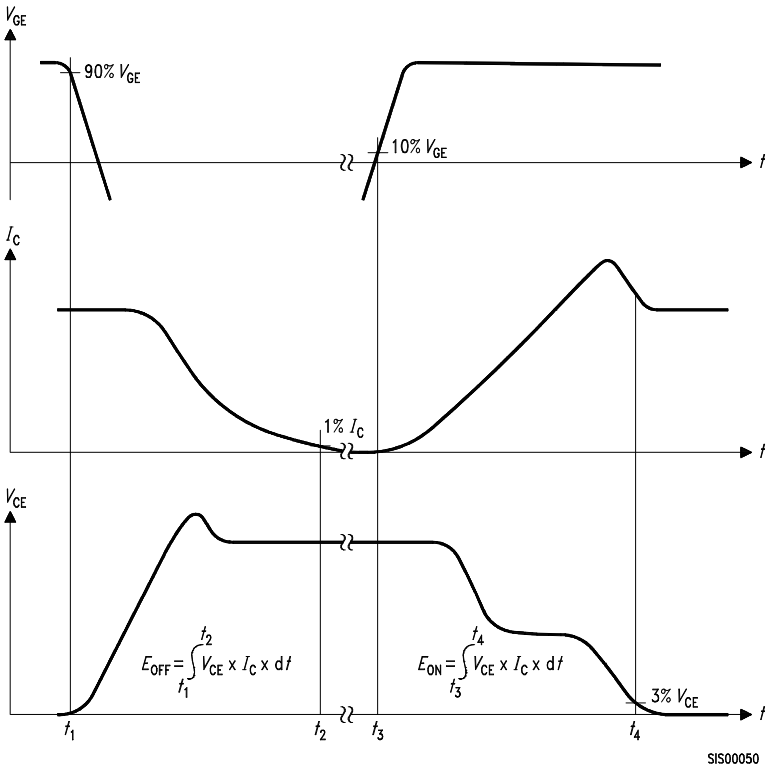



**Figure B. Definition of switching losses**

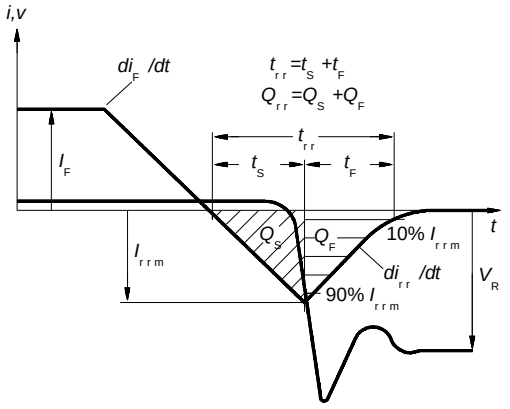



**Figure C. Definition of diodes switching characteristics**

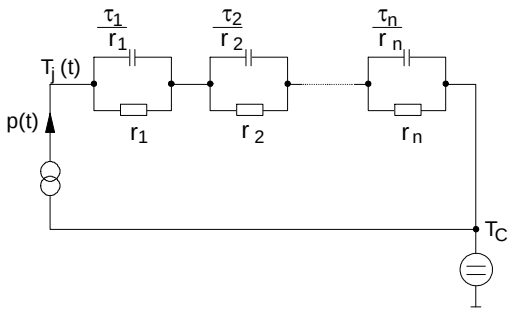



**Figure D. Thermal equivalent circuit**

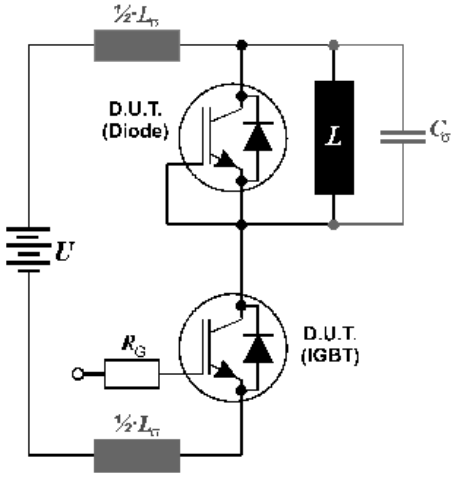



**Figure E. Dynamic test circuit**
Leakage inductance $L_\sigma$ =180nH
and Stray capacity $C_\sigma$ =250pF.

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