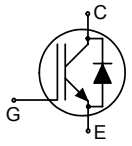
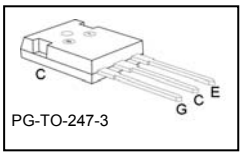
## Low Loss DuoPack : IGBT in TrenchStop®-technology with soft, fast recovery anti-parallel EmCon HE diode



PG-TO-247-3

**Features:**

- Very low $V_{CE(sat)}$ 1.5 V (typ.)
- Maximum junction temperature 175 °C
- Short circuit withstand time – 5µs
- Trench and fieldstop technology for 600 V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - low $V_{CE(sat)}$ and positive temperature coefficient
- Low EMI
- Low gate charge
- 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/

**Applications:**

- Inductive Cooking
- Soft & Hard Switching Applications

| Type | $V_{CE}$ | $I_C$ | $V_{CE(sat),Tj=25°C}$ | $T_{j,max}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IHW40T60 | 600V | 40A | 1.55V | 175°C | H40T60B | PG-TO-247-3 |

**Maximum Ratings**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage | $V_{CE}$ | 600 | V |
| DC collector current, limited by $T_{jmax}$ | $I_C$ | | A |
| $T_C$ = 25°C | | 80 | |
| $T_C$ = 100°C | | 40 | |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$ | $I_{Cpuls}$ | 120 | |
| Turn off safe operating area ($V_{CE} \le 600V$, $T_j \le 175°C$) | - | 120 | |
| Diode forward current, limited by $T_{jmax}$ | $I_F$ | | |
| $T_C$ = 25°C | | 60 | |
| $T_C$ = 100°C | | 30 | |
| Diode pulsed current, $t_p$ limited by $T_{jmax}$ | $I_{Fpuls}$ | 90 | |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Transient Gate-emitter voltage ($t_p$ < 10 µs, D<0.01) | | ±25 | |
| Short circuit withstand time[2)] | $t_{SC}$ | 5 | µs |
| $V_{GE}$ = 15V, $V_{CC} \le 400V$, $T_j \le 150°C$ | | | |
| Power dissipation $T_C$ = 25°C | $P_{tot}$ | 303 | W |
| Operating junction temperature | $T_j$ | -40...+175 | °C |
| Storage temperature | $T_{stg}$ | -55...+175 | |
| Soldering temperature, 1.6mm (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 | $R_{thJC}$ | | 0.49 | K/W |
| Diode thermal resistance, junction – case | $R_{thJCD}$ | | 1.05 | |
| Thermal resistance, junction – ambient | $R_{thJA}$ | | 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, $I_C$=0.5mA | 600 | - | - | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}$ = 15V, $I_C$=40A | | | | |
| | | $T_j$=25°C | - | 1.55 | 2.05 | |
| | | $T_j$=175°C | - | 1.90 | - | |
| Diode forward voltage | $V_F$ | $V_{GE}$=0V, $I_F$=30A | | | | |
| | | $T_j$=25°C | - | 1.65 | 2.05 | |
| | | $T_j$=175°C | - | 1.60 | - | |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$=0.58mA, $V_{CE}$=$V_{GE}$ | 4.1 | 4.9 | 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, $I_C$=40A | - | 22 | - | S |
| Integrated gate resistor | $R_{Gint}$ | | | - | | Ω |
| **Dynamic Characteristic** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{CE}$=25V, | - | 2423 | - | pF |
| Output capacitance | $C_{oss}$ | $V_{GE}$=0V, | - | 113 | - | |
| Reverse transfer capacitance | $C_{rss}$ | $f$=1MHz | - | 72 | - | |
| Gate charge | $Q_{Gate}$ | $V_{CC}$=480V, $I_C$=40A $V_{GE}$=15V | - | 215 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | | - | 13 | - | nH |

**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, $I_C$=40A, $V_{GE}$=0/15V, $R_G$=5.6 Ω, $L_\sigma$[1)]=40nH, $C_\sigma$[1)]=30pF Energy losses include "tail" and diode reverse recovery. | - | - | - | ns |
| Rise time | $t_r$ | | - | - | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 186 | - | |
| Fall time | $t_f$ | | - | 66.3 | - | |
| Turn-on energy | $E_{on}$ | | - | - | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.92 | - | |
| Total switching energy | $E_{ts}$ | | - | 0.92 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=25°C, $V_R$=400V, $I_F$=30A, $di_F/dt$=910A/µs | - | 143 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.92 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 16.3 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 603 | - | 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, $I_C$=40A, $V_{GE}$=0/15V, $R_G$= 5.6 Ω $L_\sigma$[1)]=40nH, $C_\sigma$[1)]=30pF Energy losses include "tail" and diode reverse recovery. | - | - | - | ns |
| Rise time | $t_r$ | | - | - | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 196 | - | |
| Fall time | $t_f$ | | - | 76.5 | - | |
| Turn-on energy | $E_{on}$ | | - | - | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 1.4 | - | |
| Total switching energy | $E_{ts}$ | | - | 1.4 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=175°C $V_R$=400V, $I_F$=30A, $di_F/dt$=910A/µs | - | 225 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 2.39 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 22.3 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 310 | - | A/µs |

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

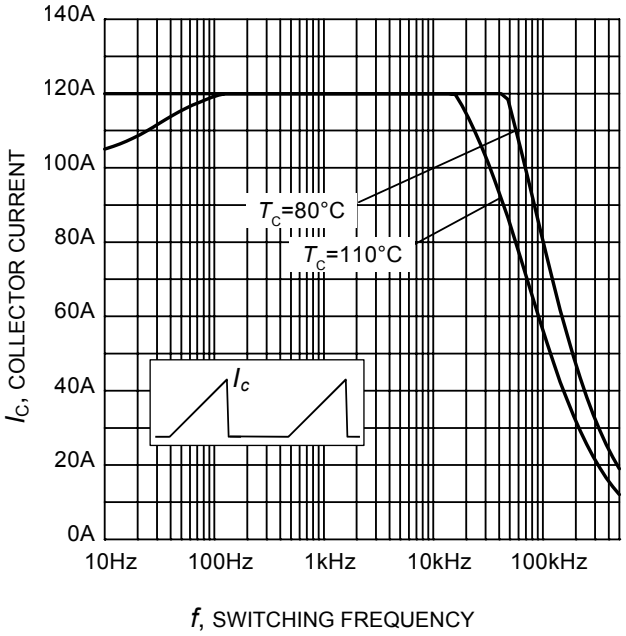



**Figure 1. Collector current as a function of switching frequency for triangular current ($E_{on}$ = 0, hard turn-off)**
($T_j \le 175°C$, $D = 0.5$, $V_{CE} = 400V$, $V_{GE} = 0/+15V$, $R_G = 5.6\Omega$)

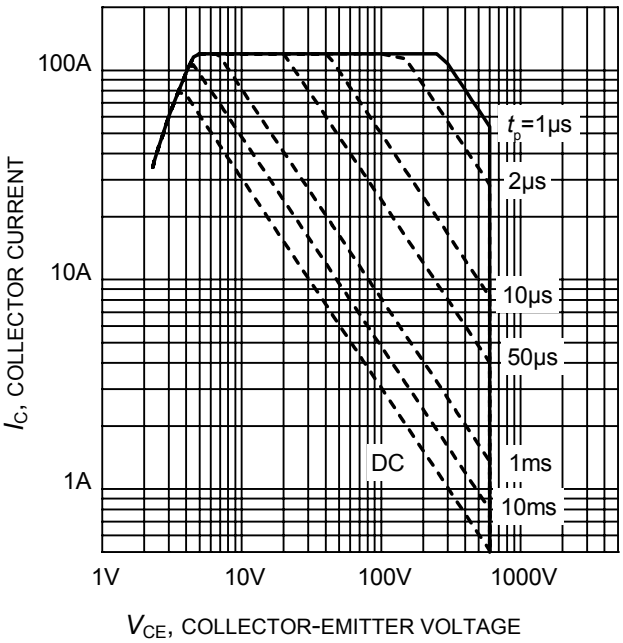



**Figure 2. Safe operating area**
($D = 0$, $T_C = 25°C$, $T_j \le 175°C$; $V_{GE}$=15V)

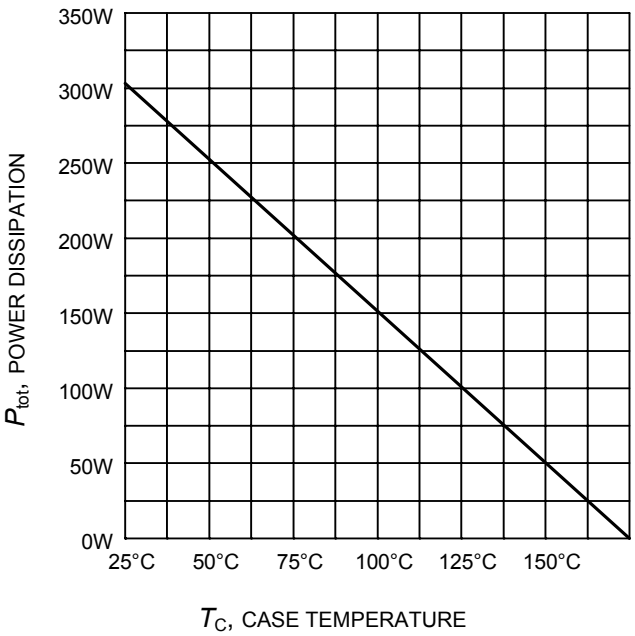



**Figure 3. Power dissipation as a function of case temperature**
($T_j \le 175°C$)

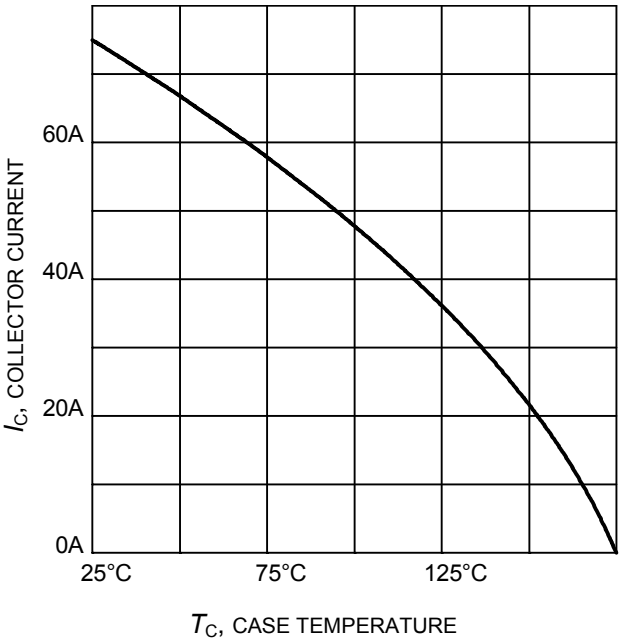



**Figure 4. Collector current as a function of case temperature**
($V_{GE} \ge 15V$, $T_j \le 175°C$)

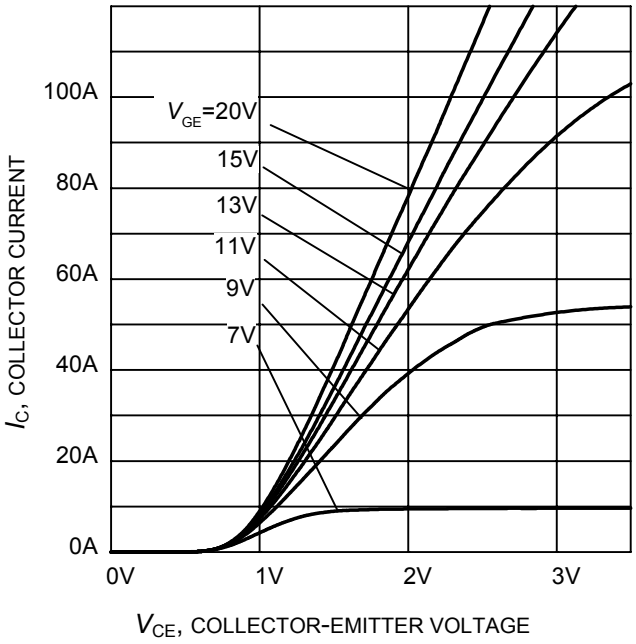



**Figure 5. Typical output characteristic**
($T_j$ = 25°C)

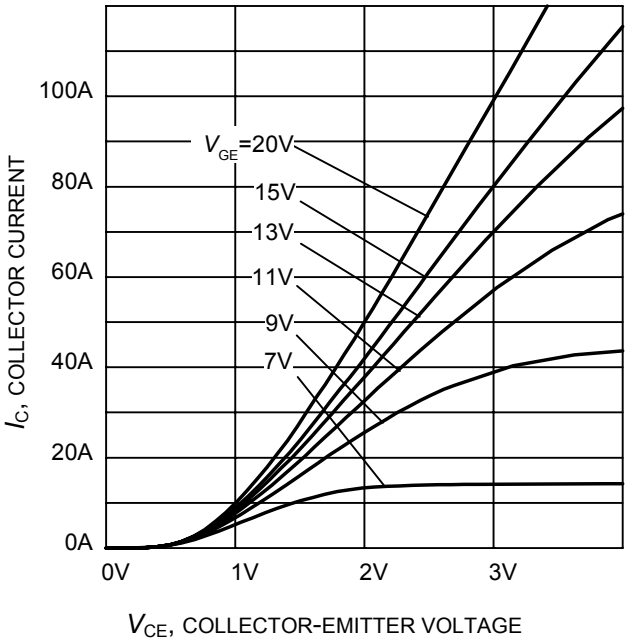



**Figure 6. Typical output characteristic**
($T_j$ = 175°C)

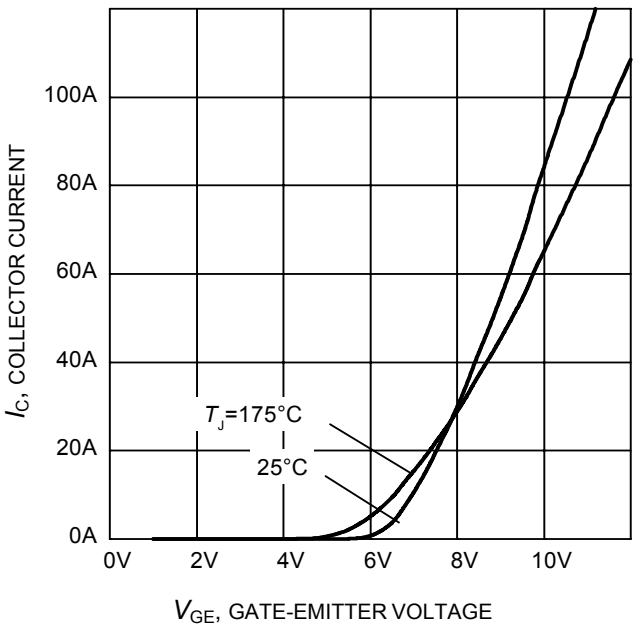



**Figure 7. Typical transfer characteristic**
($V_{CE}$=20V)

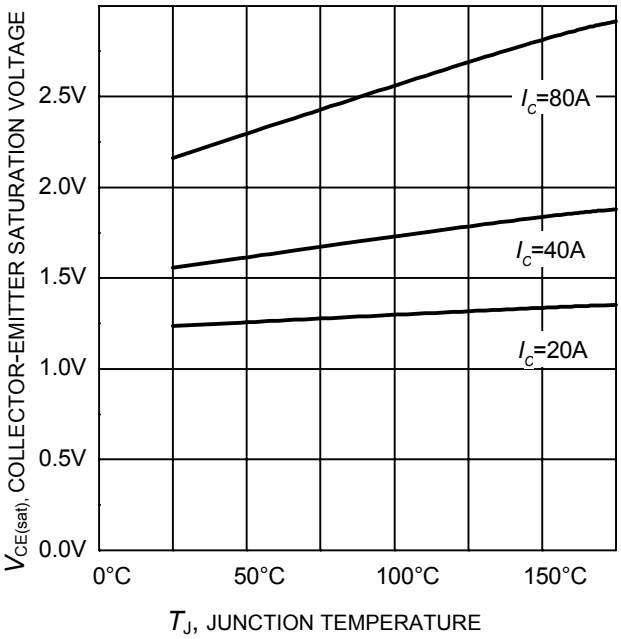



**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$ = 15V)

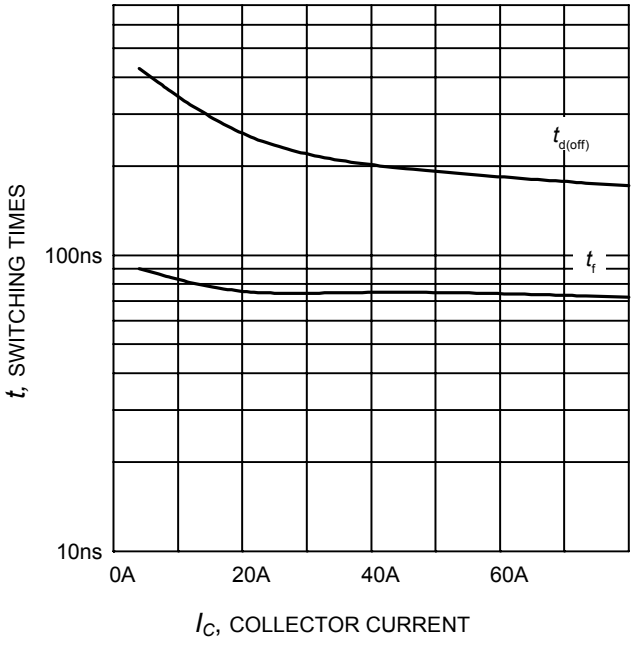



**Figure 9. Typical switching times as a function of collector current**
(inductive load, $T_J$=175°C,
$V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $R_G$ = 5.6Ω,
Dynamic test circuit in Figure E)

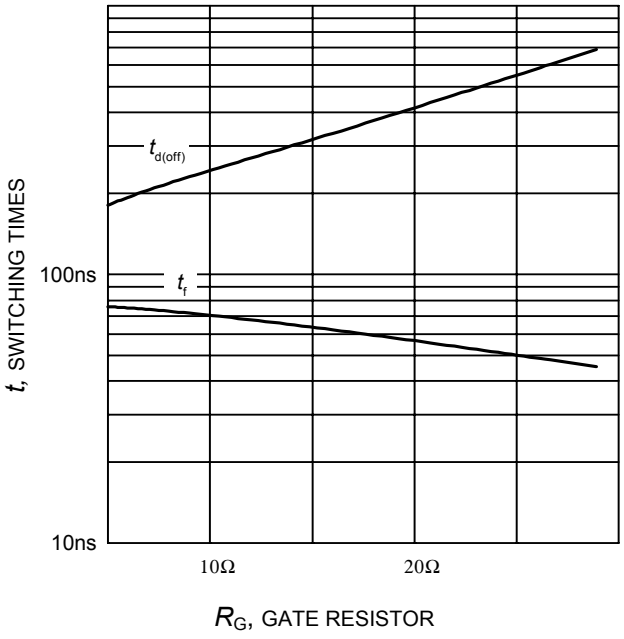



**Figure 10. Typical switching times as a function of gate resistor**
(inductive load, $T_J$ = 175°C,
$V_{CE}$= 400V, $V_{GE}$ = 0/15V, $I_C$ = 40A,
Dynamic test circuit in Figure E)

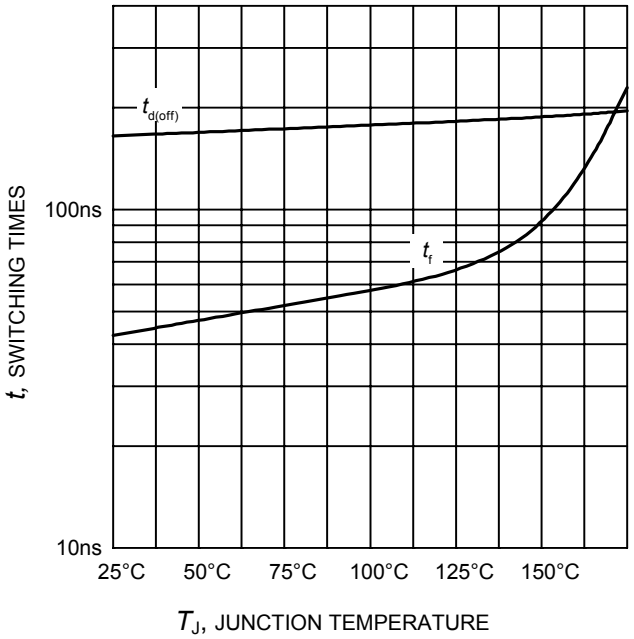



**Figure 11. Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V,
$V_{GE}$ = 0/15V, $I_C$ = 40A, $R_G$=5.6Ω,
Dynamic test circuit in Figure E)

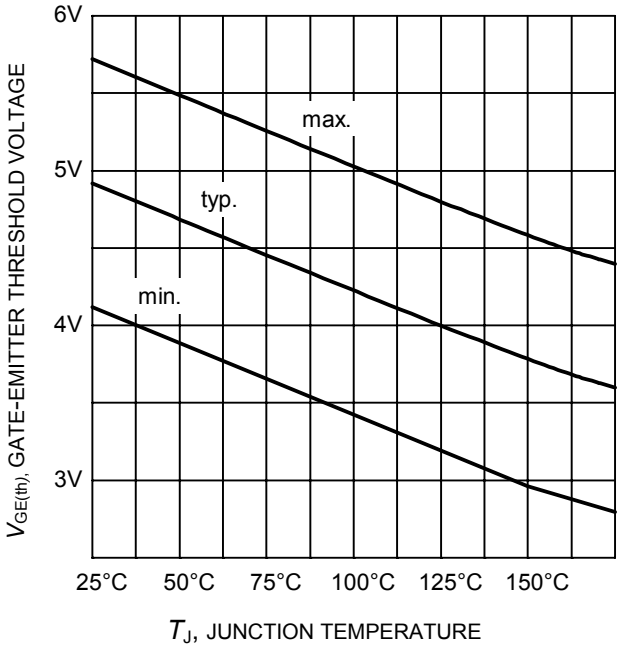



**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**
($I_C$ = 0.8mA)

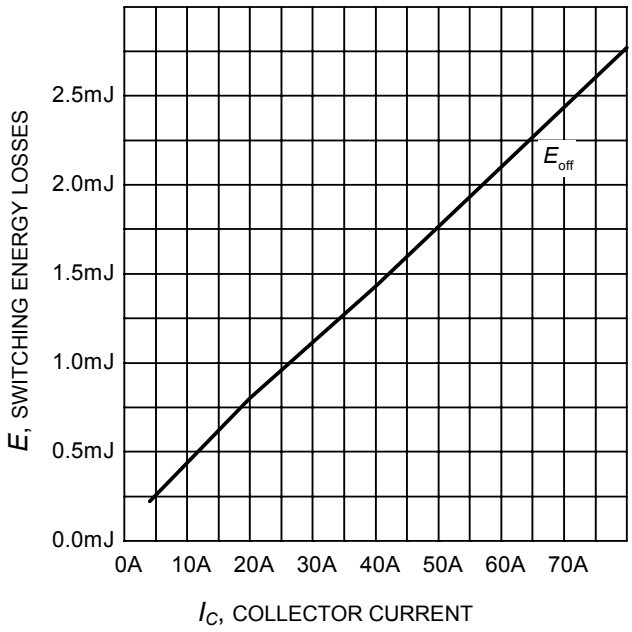



**Figure 13. Typical switching energy losses as a function of collector current**
(inductive load, $T_J$ = 175°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $R_G$ = 5.6Ω, Dynamic test circuit in Figure E)

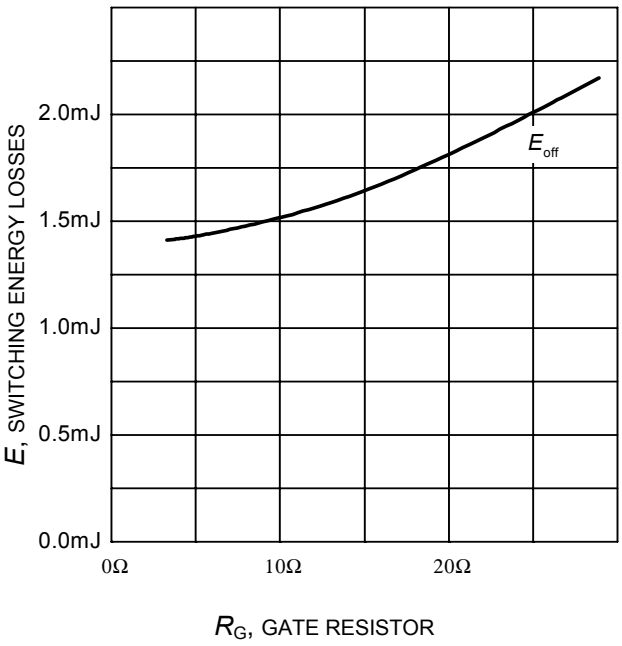



**Figure 14. Typical switching energy losses as a function of gate resistor**
(inductive load, $T_J$ = 175°C, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $I_C$ = 40A, Dynamic test circuit in Figure E)

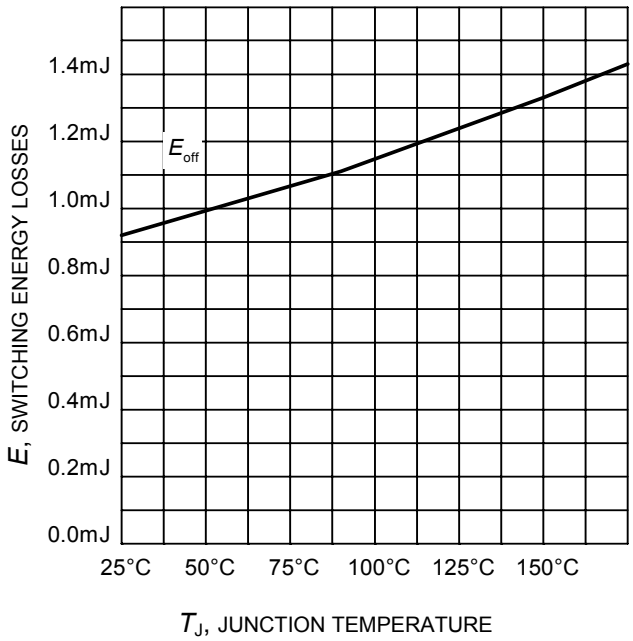



**Figure 15. Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$ = 400V, $V_{GE}$ = 0/15V, $I_C$ = 40A, $R_G$ = 5.6Ω, Dynamic test circuit in Figure E)

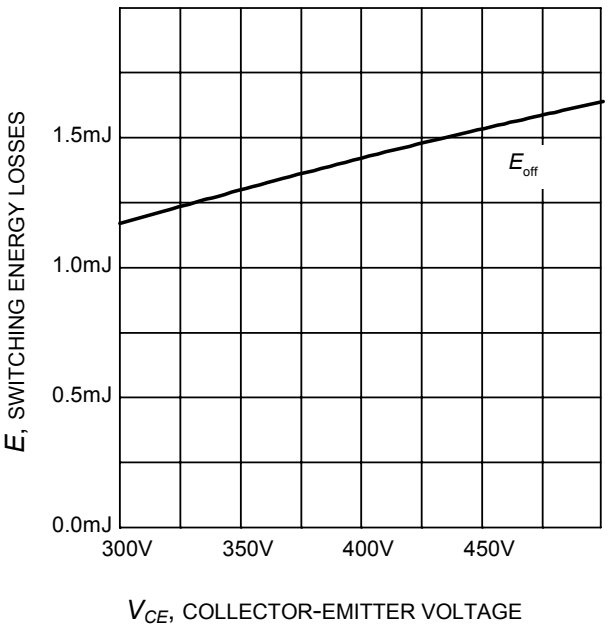



**Figure 16. Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_J$ = 175°C, $V_{GE}$ = 0/15V, $I_C$ = 40A, $R_G$ = 5.6Ω, Dynamic test circuit in Figure E)

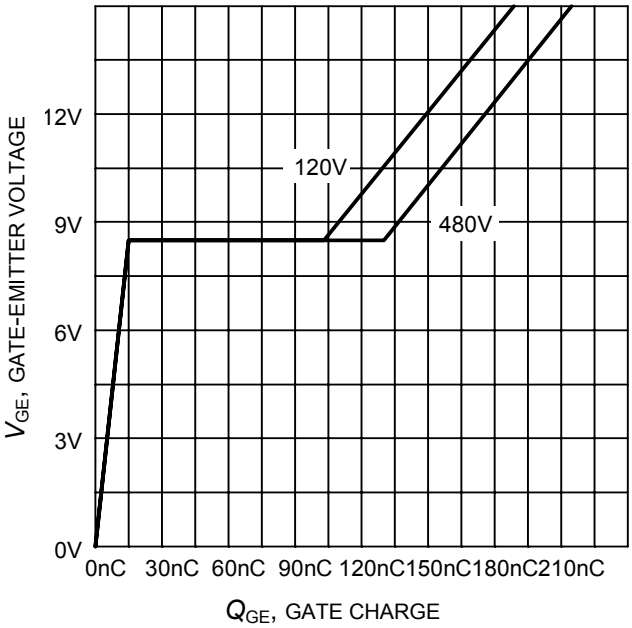



**Figure 17. Typical gate charge**
($I_C$=40 A)

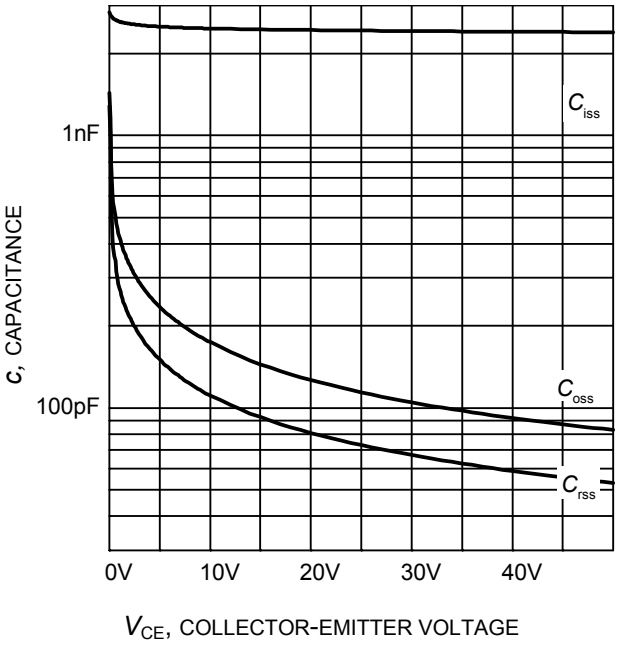



**Figure 18. Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$=0V, $f$ = 1 MHz)

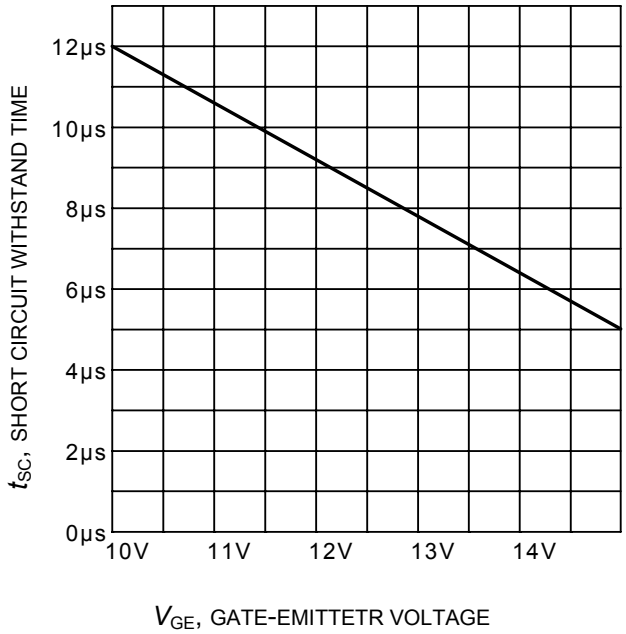



**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$=600V, start at $T_J$=25°C,
$T_{Jmax}$<150°C)

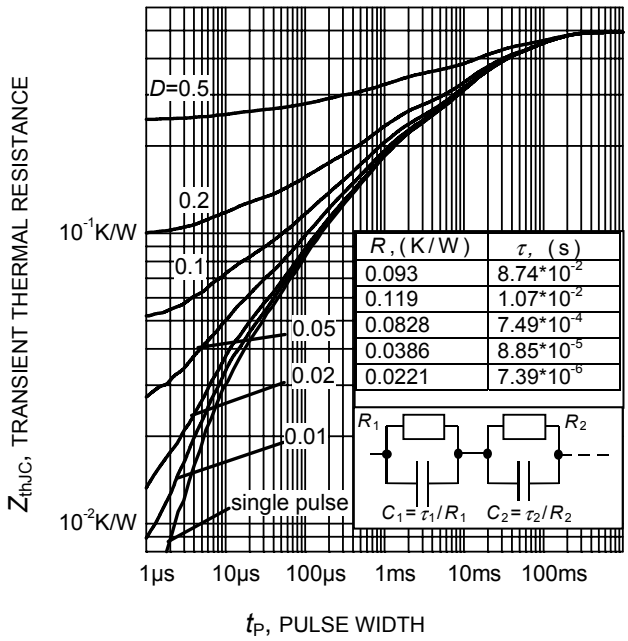



**Figure 20. IGBT transient thermal resistance**
($D = t_p / T$)

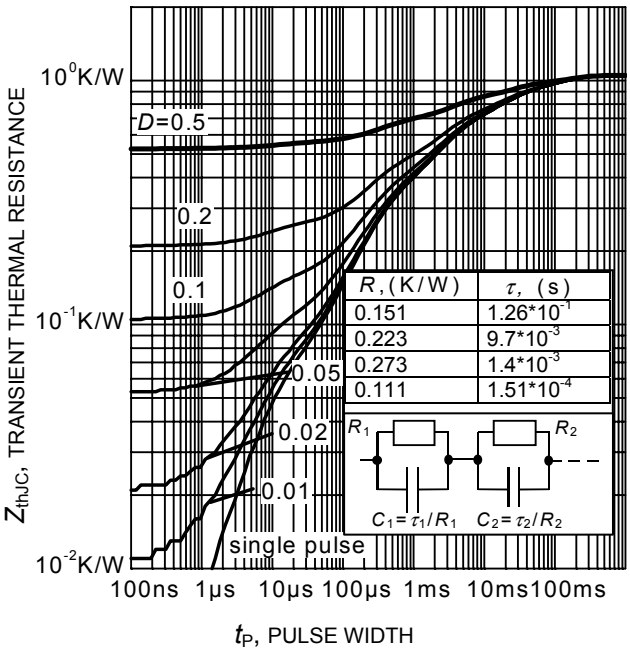



**Figure 21. Diode transient thermal impedance as a function of pulse width**
($D=t_P/T$)

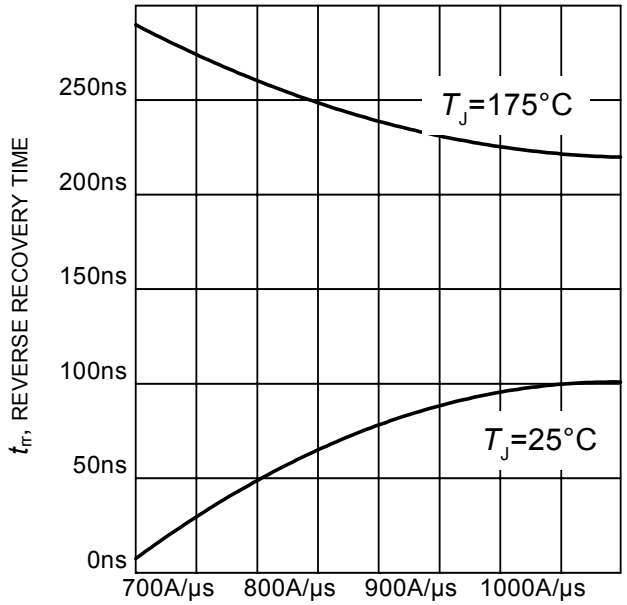



**Figure 22. Typical reverse recovery time as a function of diode current slope**
($V_R$=400V, $I_F$=30A,
Dynamic test circuit in Figure E)

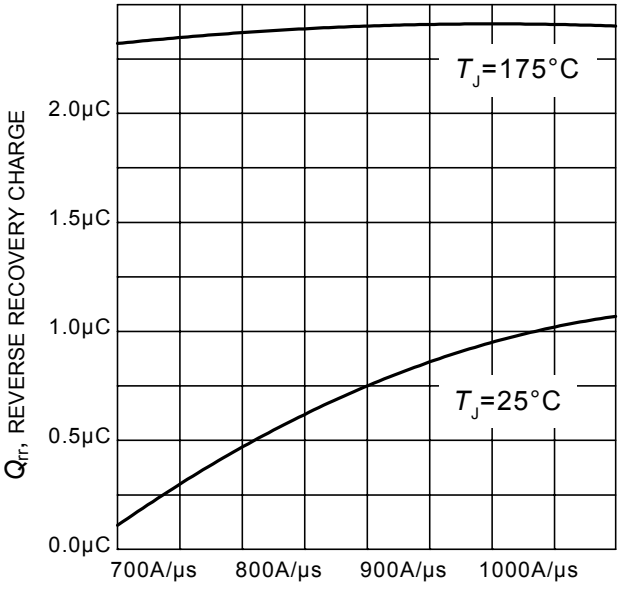



**Figure 23. Typical reverse recovery charge as a function of diode current slope**
($V_R$ = 400V, $I_F$ = 30A,
Dynamic test circuit in Figure E)

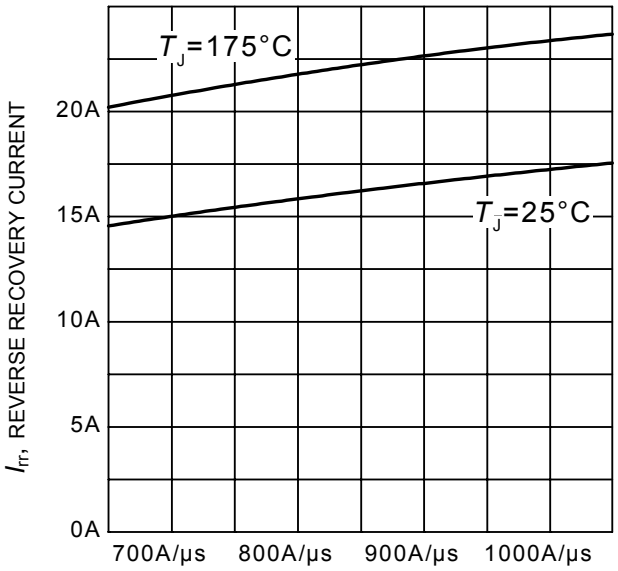



**Figure 24. Typical reverse recovery current as a function of diode current slope**
($V_R$ = 400V, $I_F$ = 30A,
Dynamic test circuit in Figure E)

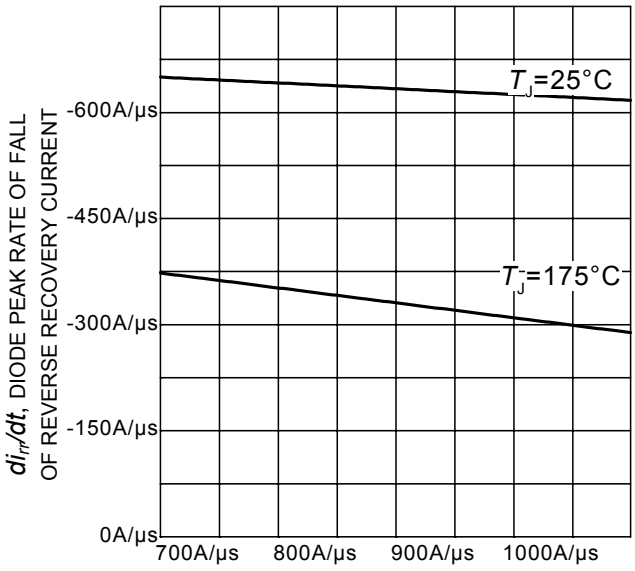



**Figure 25. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V, $I_F$=30A,
Dynamic test circuit in Figure E)

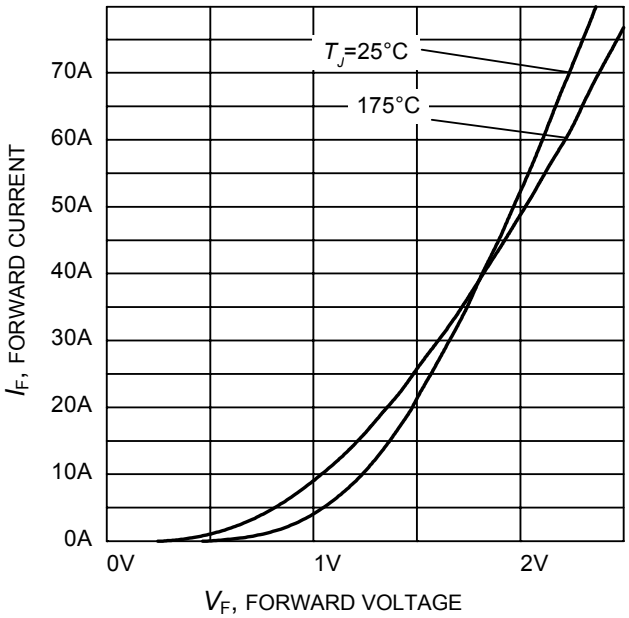



**Figure 26. Typical diode forward current as a function of forward voltage**

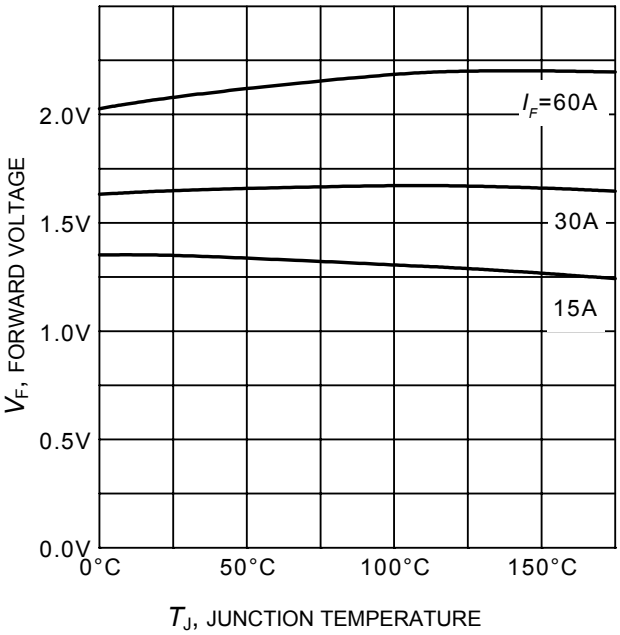



**Figure 27. Typical diode forward voltage as a function of junction temperature**

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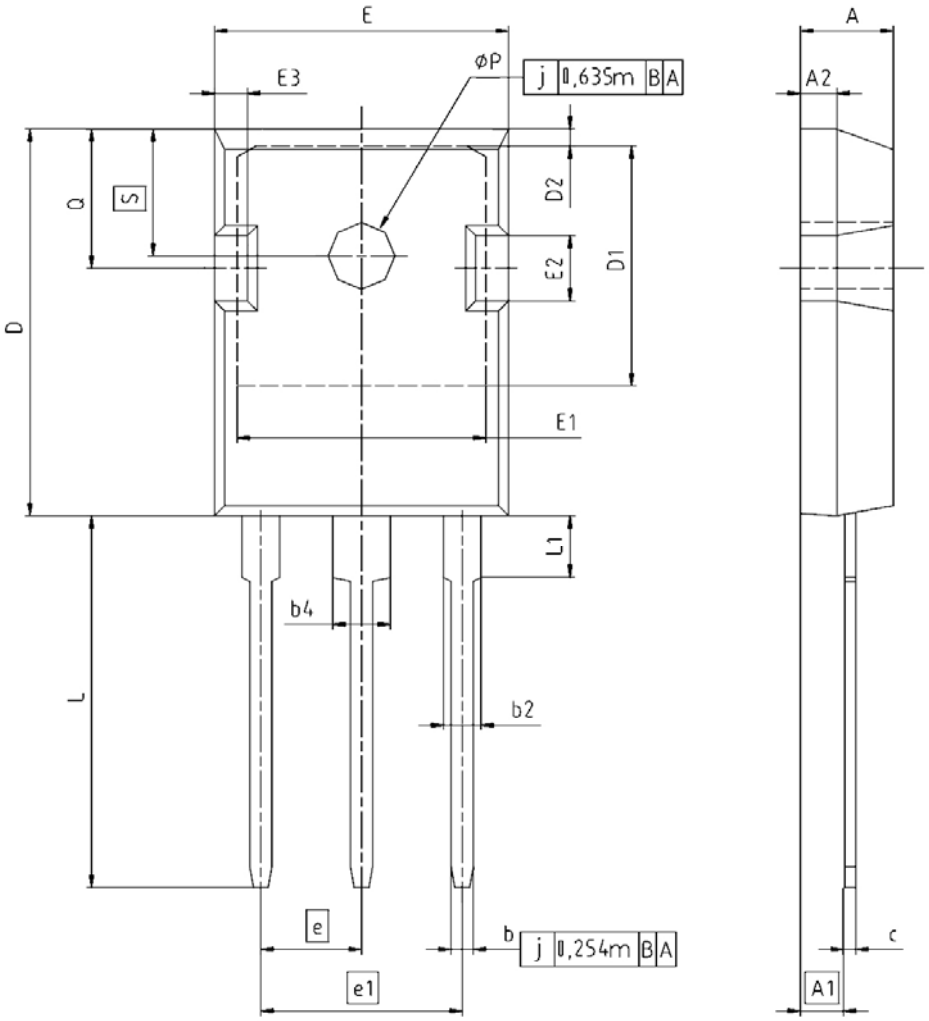


| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.90 | 5.16 | 0.193 | 0.203 |
| A1 | 2.27 | 2.53 | 0.089 | 0.099 |
| A2 | 1.85 | 2.11 | 0.073 | 0.083 |
| b | 1.07 | 1.33 | 0.042 | 0.052 |
| b2 | 1.90 | 2.39 | 0.075 | 0.094 |
| b4 | 2.87 | 3.45 | 0.113 | 0.136 |
| c | 0.55 | 0.75 | 0.022 | 0.030 |
| D | 20.82 | 21.10 | 0.820 | 0.831 |
| D1 | 16.25 | 17.83 | 0.640 | 0.702 |
| D2 | 1.05 | 1.35 | 0.041 | 0.053 |
| E | 15.70 | 16.03 | 0.618 | 0.631 |
| E1 | 13.10 | 14.15 | 0.516 | 0.557 |
| E2 | 3.68 | 5.10 | 0.145 | 0.201 |
| E3 | 1.68 | 2.60 | 0.066 | 0.102 |
| e | 5.44 | | 0.214 | |
| e1 | 10.90 | | 0.429 | |
| N | 3 | | 3 | |
| L | 19.80 | 20.31 | 0.780 | 0.799 |
| L1 | 4.17 | 4.47 | 0.164 | 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 |

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SCALE 0 5 5 7.5mm

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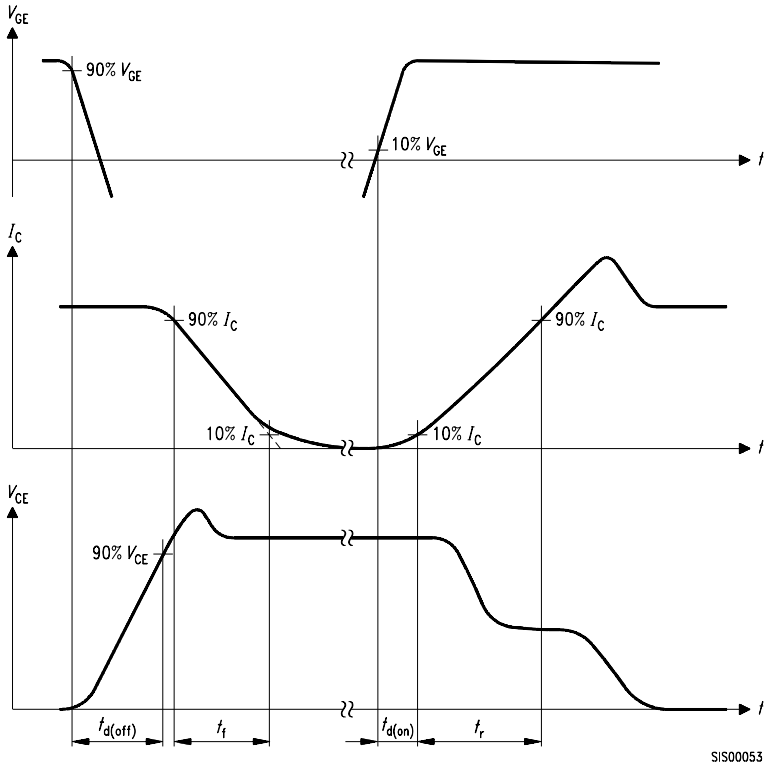


**Figure A. Definition of switching times**

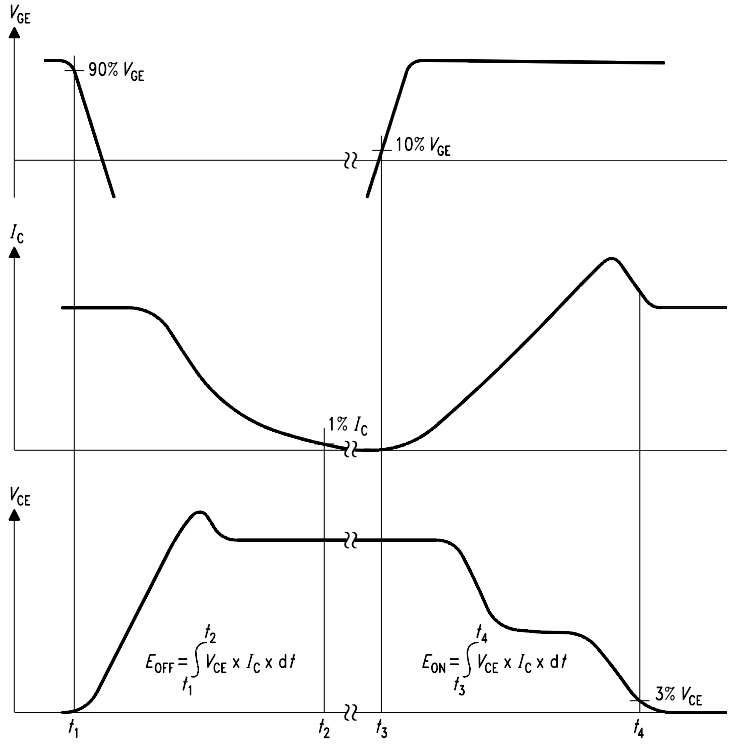


**Figure B. Definition of switching losses**

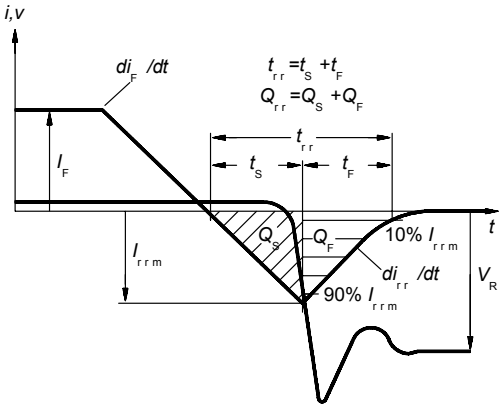


**Figure C. Definition of diodes switching characteristics**

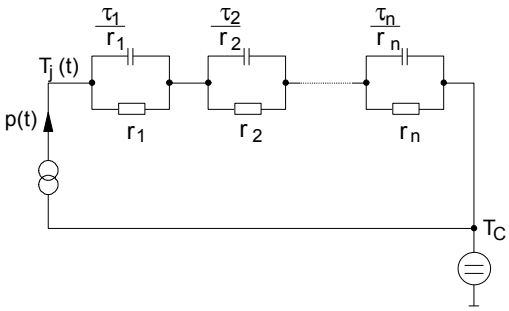


**Figure D. Thermal equivalent circuit**

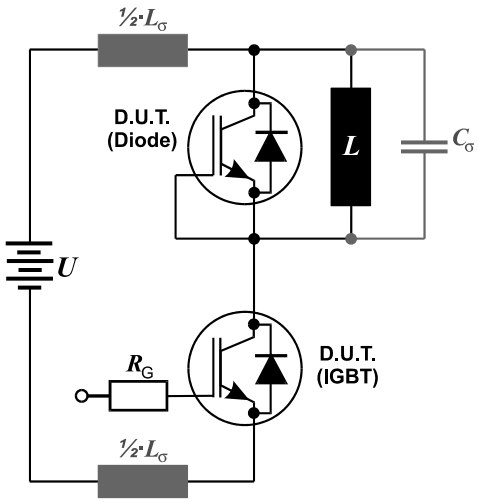


**Figure E. Dynamic test circuit**

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