HighSpeed 2-Technology with soft, fast recovery anti-parallel Emitter Controlled HE diode

- **Designed for:**
  - SMPS
  - Lamp Ballast
  - ZVS-Converter

- **2nd generation HighSpeed-Technology for 1200V applications offers:**
  - loss reduction in resonant circuits
  - temperature stable behavior
  - parallel switching capability
  - tight parameter distribution
  - $E_{off}$ optimized for $I_C$ =3A

- Qualified according to JEDEC[2] for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/

PG-TO-247-3
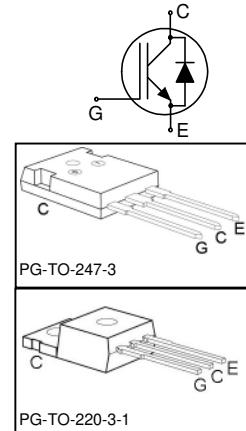
PG-TO-220-3-1

| Type | $V_{CE}$ | $I_C$ | $E_{off}$ | $T_j$ | Marking | Package |
|---|---|---|---|---|---|---|
| IKW03N120H2 | 1200V | 3A | 0.15mJ | 150°C | K03H1202 | PG-TO-247-3 |
| IKP03N120H2 | 1200V | 3A | 0.15mJ | 150°C | K03H1202 | PG-TO-220-3-1 |

**Maximum Ratings**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage | $V_{CE}$ | 1200 | V |
| Triangular collector current | $I_C$ | | A |
| $T_C = 25°C$, $f = 140kHz$ | | 9.6 | |
| $T_C = 100°C$, $f = 140kHz$ | | 3.9 | |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$ | $I_{Cpuls}$ | 9.9 | |
| Turn off safe operating area | - | 9.9 | |
| $V_{CE} \leq 1200V$, $T_j \leq 150°C$ | | | |
| Diode forward current | $I_F$ | | |
| $T_C = 25°C$ | | 9.6 | |
| $T_C = 100°C$ | | 3.9 | |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Power dissipation | $P_{tot}$ | 62.5 | W |
| $T_C = 25°C$ | | | |
| Operating junction and storage temperature | $T_j$ , $T_{stg}$ | -40...+150 | °C |
| Soldering temperature, 1.6mm (0.063 in.) from case for 10s | - | 260 | |

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

## Thermal Resistance

| Parameter | Symbol | Conditions | Max. Value | Unit |
|---|---|---|---|---|
| **Characteristic** | | | | |
| IGBT thermal resistance, junction – case | $R_{thJC}$ | | 2.0 | K/W |
| Diode thermal resistance, junction - case | $R_{thJCD}$ | | 3.2 | |
| Thermal resistance, junction – ambient | $R_{thJA}$ | P-TO-220-3-1 P-TO-247-3-21 | 62 | |

**Electrical Characteristic,** at $T_j$ = 25 °C, unless otherwise specified

| Parameter | Symbol | Conditions | Value min. | Value Typ. | Value max. | Unit |
|---|---|---|---|---|---|---|
| **Static Characteristic** | | | | | | |
| Collector-emitter breakdown voltage | $V_{(BR)CES}$ | $V_{GE}$=0V, $I_C$=300µA | 1200 | - | - | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}$ = 15V, $I_C$=3A | | | | |
| | | $T_j$=25°C | - | 2.2 | 2.8 | |
| | | $T_j$=150°C | - | 2.5 | - | |
| | | $V_{GE}$ = 10V, $I_C$=3A, $T_j$=25°C | - | 2.4 | - | |
| Diode forward voltage | $V_F$ | $V_{GE}$ = 0, $I_F$=2A | | | | |
| | | $T_j$=25°C | - | 2.0 | 2.5 | |
| | | $T_j$=150°C | - | 1.75 | - | |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$=90µA, $V_{CE}$=$V_{GE}$ | 2.1 | 3 | 3.9 | |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$=1200V, $V_{GE}$=0V | | | | µA |
| | | $T_j$=25°C | - | - | 20 | |
| | | $T_j$=150°C | - | - | 80 | |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$=0V, $V_{GE}$=20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$=20V, $I_C$=3A | - | 2 | - | S |
| **Dynamic Characteristic** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{CE}$=25V, | - | 205 | - | pF |
| Output capacitance | $C_{oss}$ | $V_{GE}$=0V, | - | 24 | - | |
| Reverse transfer capacitance | $C_{rss}$ | $f$=1MHz | - | 7 | - | |
| Gate charge | $Q_{Gate}$ | $V_{CC}$=960V, $I_C$=3A $V_{GE}$=15V | - | 22 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | PG-TO-220-3-1 PG-TO-247-3-21 | - - | 7 13 | - - | nH |

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

| Parameter | Symbol | Conditions | Value min. | Value typ. | Value max. | Unit |
|---|---|---|---|---|---|---|
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_j$=25°C, $V_{CC}$=800V, $I_C$=3A, $V_{GE}$=15V/0V, $R_G$=82Ω, $L_\sigma$ [2)]=180nH, $C_\sigma$ [2)]=40pF Energy losses include "tail" and diode [3)] reverse recovery. | - | 9.2 | - | ns |
| Rise time | $t_r$ | | - | 5.2 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 281 | - | |
| Fall time | $t_f$ | | - | 29 | - | |
| Turn-on energy | $E_{on}$ | | - | 0.14 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.15 | - | |
| Total switching energy | $E_{ts}$ | | - | 0.29 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=25°C, $V_R$=800V, $I_F$=3A, $R_G$=82Ω | - | 42 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.23 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 10.3 | - | A |
| Diode current slope | $di_F/dt$ | | - | 993 | - | A/µs |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 1180 | - | |

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

| Parameter | Symbol | Conditions | Value min. | Value typ. | Value max. | Unit |
|---|---|---|---|---|---|---|
| **IGBT Characteristic** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_j$=150°C $V_{CC}$=800V, $I_C$=3A, $V_{GE}$=15V/0V, $R_G$=82Ω, $L_\sigma$ [2)]=180nH, $C_\sigma$ [2)]=40pF Energy losses include "tail" and diode [3)] reverse recovery. | - | 9.4 | - | ns |
| Rise time | $t_r$ | | - | 6.7 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 340 | - | |
| Fall time | $t_f$ | | - | 63 | - | |
| Turn-on energy | $E_{on}$ | | - | 0.22 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.26 | - | |
| Total switching energy | $E_{ts}$ | | - | 0.48 | - | |
| **Anti-Parallel Diode Characteristic** | | | | | | |
| Diode reverse recovery time | $t_{rr}$ | $T_j$=150°C $V_R$=800V, $I_F$=3A, $R_G$=82Ω | - | 125 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.51 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 12 | - | A |
| Diode current slope | $di_F/dt$ | | - | 829 | - | A/µs |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 540 | - | |

[2)] Leakage inductance $L_\sigma$ and stray capacity $C_\sigma$ due to dynamic test circuit in figure E
[3)] Commutation diode from device IKP03N120H2

**Switching Energy ZVT, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic** | | | | | | |
| Turn-off energy | $E_{off}$ | $V_{CC}=800V$, $I_C=3A$, $V_{GE}=15V/0V$, $R_G=82\Omega$, $C_r{}^{2)}=4nF$ | | | | mJ |
| | | $T_j=25°C$ | - | 0.05 | - | |
| | | $T_j=150°C$ | - | 0.09 | - | |
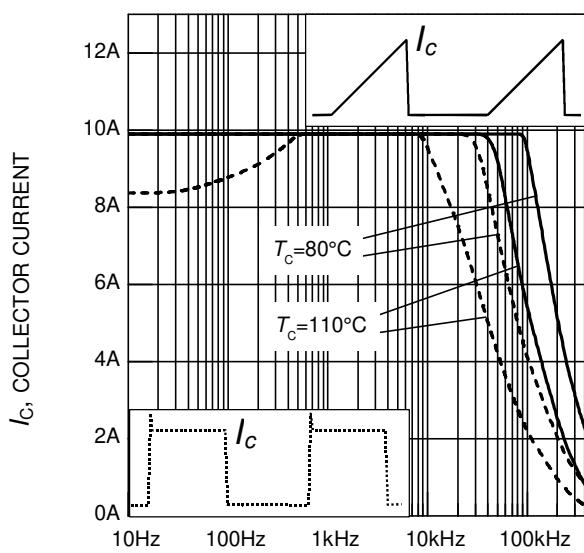
*f*, SWITCHING FREQUENCY

**Figure 1. Collector current as a function of switching frequency**
($T_j \leq 150°C$, $D = 0.5$, $V_{CE} = 800V$, $V_{GE} = +15V/0V$, $R_G = 82\Omega$)
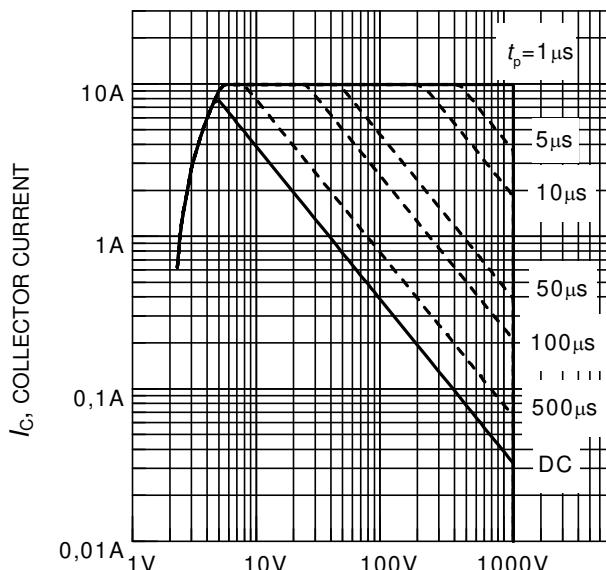


$V_{CE}$, COLLECTOR-EMITTER VOLTAGE

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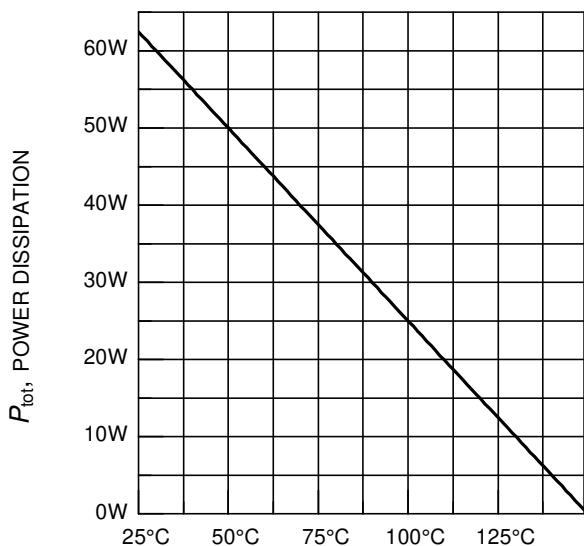


$T_C$, CASE TEMPERATURE

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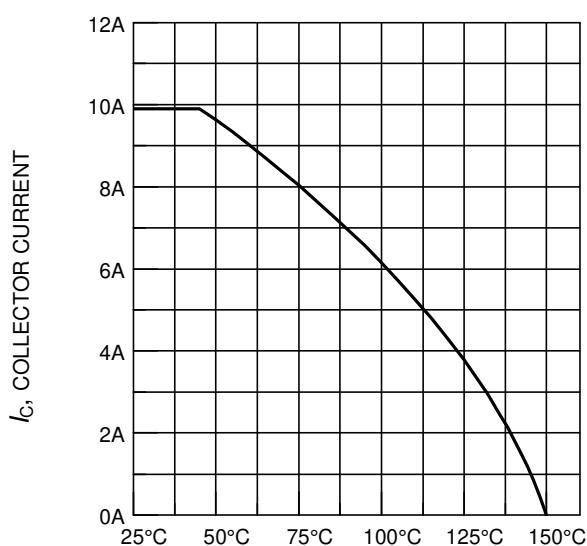


$T_C$, CASE TEMPERATURE

**Figure 4. Collector current as a function of case temperature**
($V_{GE} \leq 15V$, $T_j \leq 150°C$)
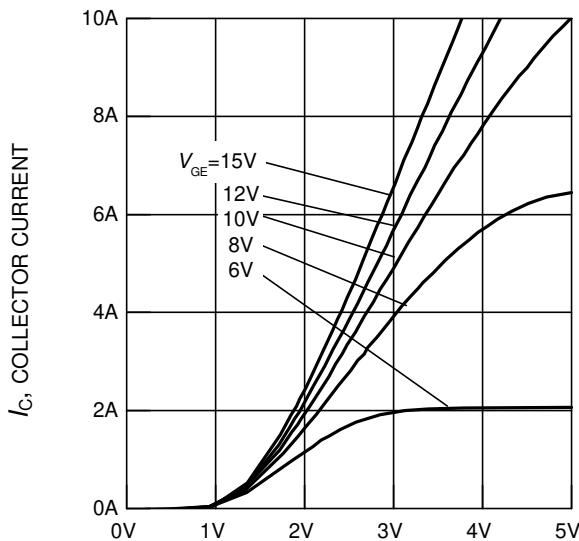
$V_{CE}$, COLLECTOR-EMITTER VOLTAGE
**Figure 5. Typical output characteristics**
($T_i$ = 25°C)
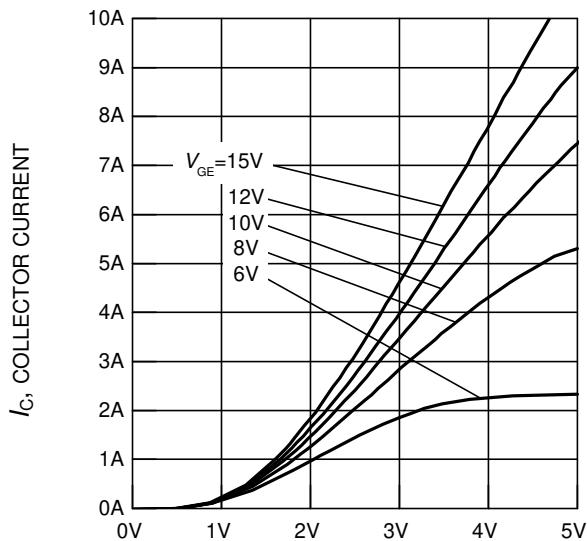


$V_{CE}$, COLLECTOR-EMITTER VOLTAGE
**Figure 6. Typical output characteristics**
($T_i$ = 150°C)
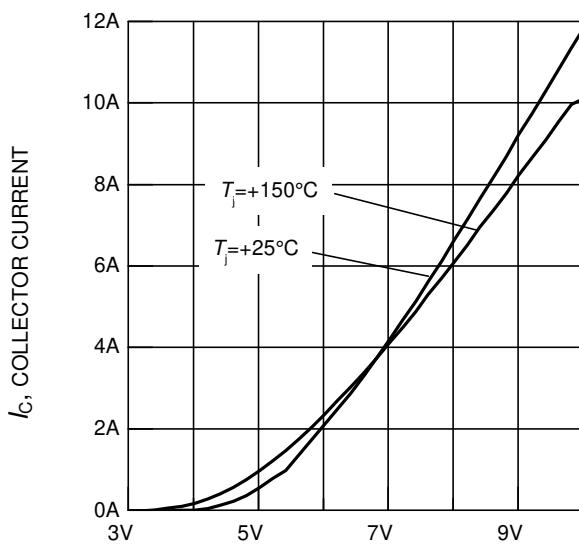


$V_{GE}$, GATE-EMITTER VOLTAGE
**Figure 7. Typical transfer characteristics**
($V_{CE}$ = 20V)
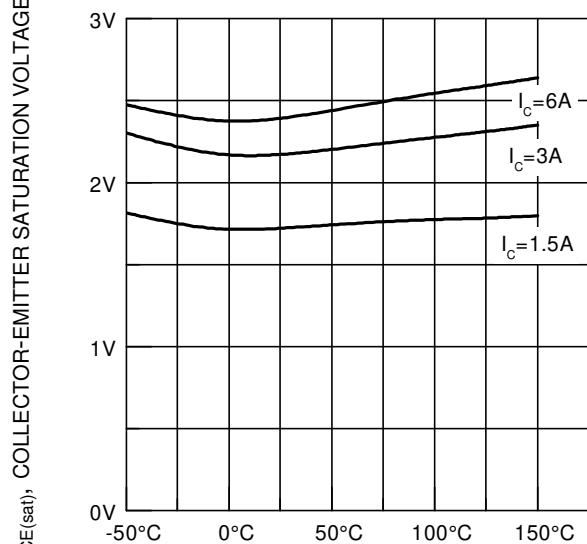


$T_j$, JUNCTION TEMPERATURE
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$ = 15V)
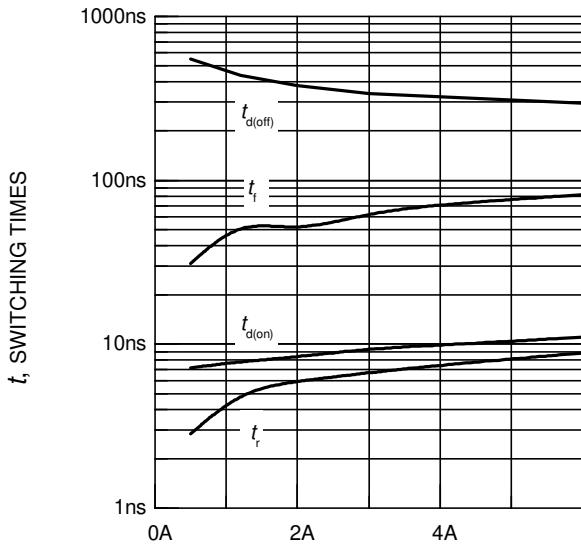
**Figure 9. Typical switching times as a function of collector current**
(inductive load, $T_j = 150°C$,
$V_{CE} = 800V$, $V_{GE} = +15V/0V$, $R_G = 82\Omega$,
dynamic test circuit in Fig.E)
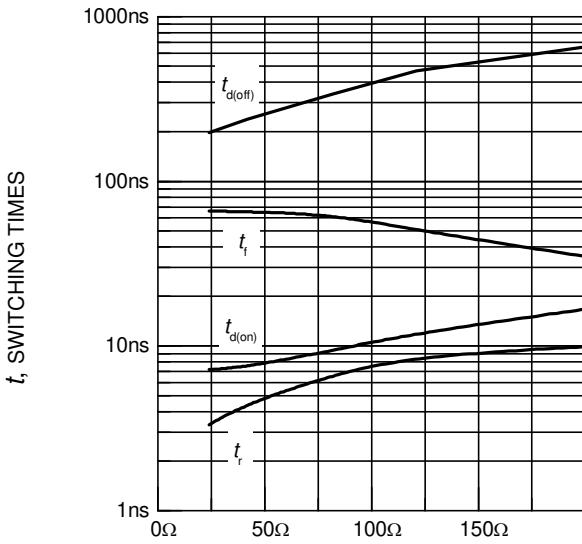


**Figure 10. Typical switching times as a function of gate resistor**
(inductive load, $T_j = 150°C$,
$V_{CE} = 800V$, $V_{GE} = +15V/0V$, $I_C = 3A$,
dynamic test circuit in Fig.E)
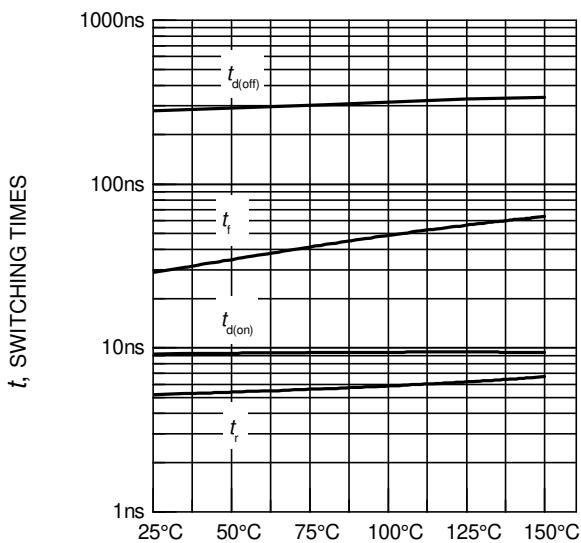


**Figure 11. Typical switching times as a function of junction temperature**
(inductive load, $V_{CE} = 800V$,
$V_{GE} = +15V/0V$, $I_C = 3A$, $R_G = 82\Omega$,
dynamic test circuit in Fig.E)
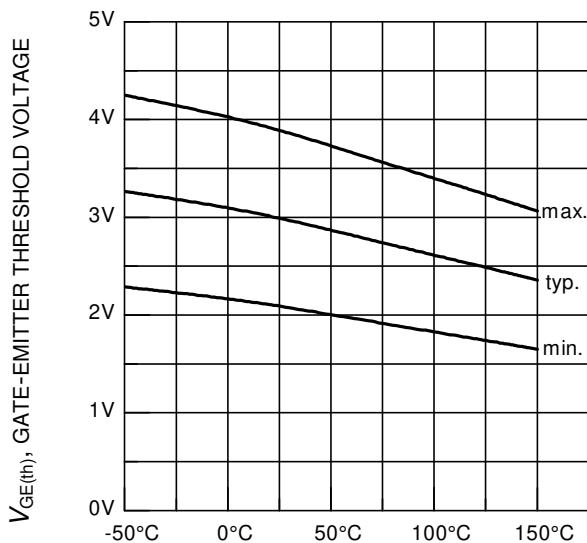


**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**
($I_C = 0.09mA$)
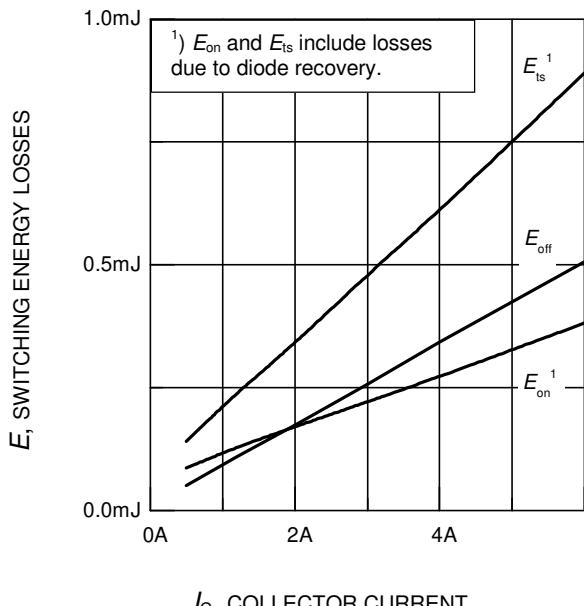
**Figure 13. Typical switching energy losses as a function of collector current**
(inductive load, $T_j$ = 150°C,
$V_{CE}$ = 800V, $V_{GE}$ = +15V/0V, $R_G$ = 82$\Omega$,
dynamic test circuit in Fig.E )
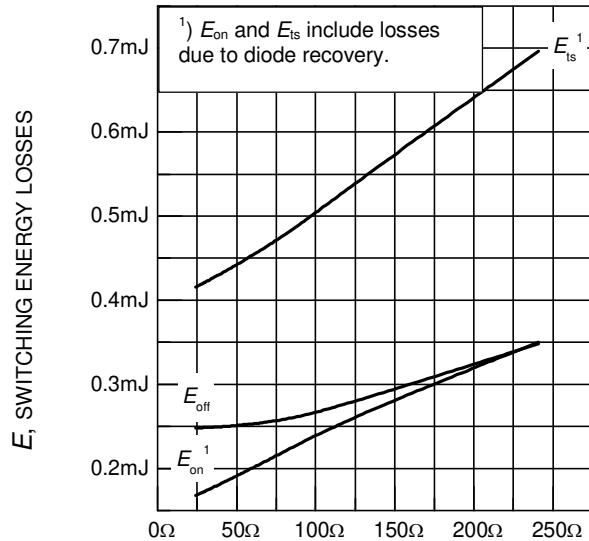


**Figure 14. Typical switching energy losses as a function of gate resistor**
(inductive load, $T_j$ = 150°C,
$V_{CE}$ = 800V, $V_{GE}$ = +15V/0V, $I_C$ = 3A,
dynamic test circuit in Fig.E )
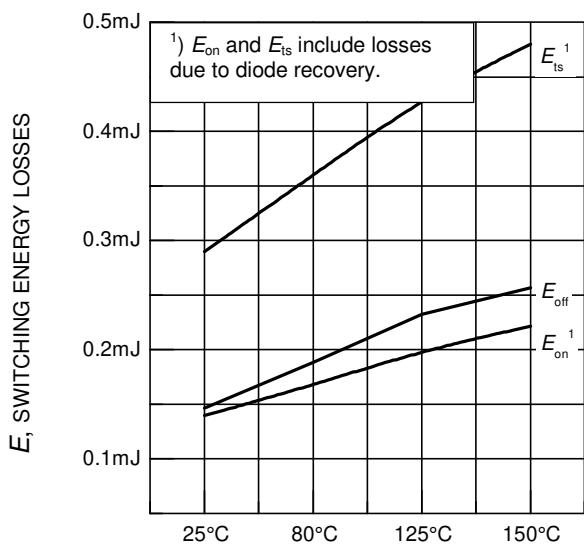


**Figure 15. Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$ = 800V,
$V_{GE}$ = +15V/0V, $I_C$ = 3A, $R_G$ = 82$\Omega$,
dynamic test circuit in Fig.E )
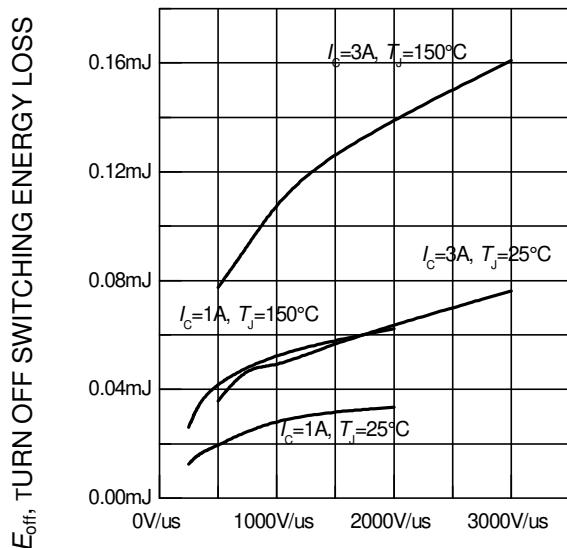


**Figure 16. Typical turn off switching energy loss for soft switching**
(*dynamic test circuit in Fig. E*)

$Q_{GE}$, GATE CHARGE
**Figure 17. Typical gate charge**
($I_C$ = 3A)

| $R$, (K/W) | $\tau$, (s) |
|---|---|
| 1.082517 | 0.000795 |
| 0.328671 | 0.000179 |
| 0.588811 | 0.004631 |

$C_1 = \tau_1 / R_1$   $C_2 = \tau_2 / R_2$
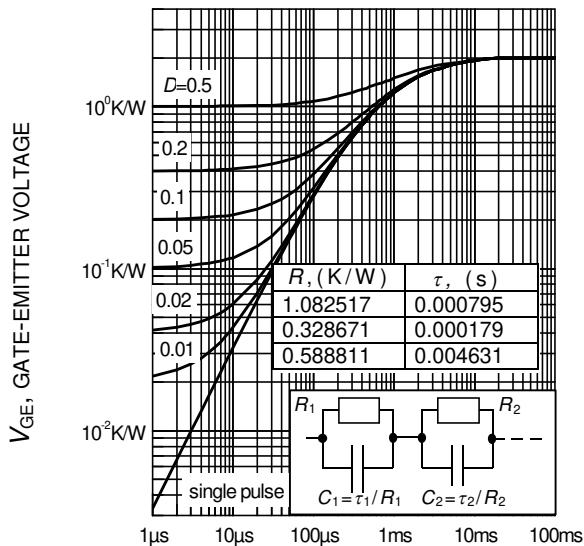


$Q_{GE}$, GATE CHARGE
**Figure 17. Typical gate charge**
($I_C$ = 3A)
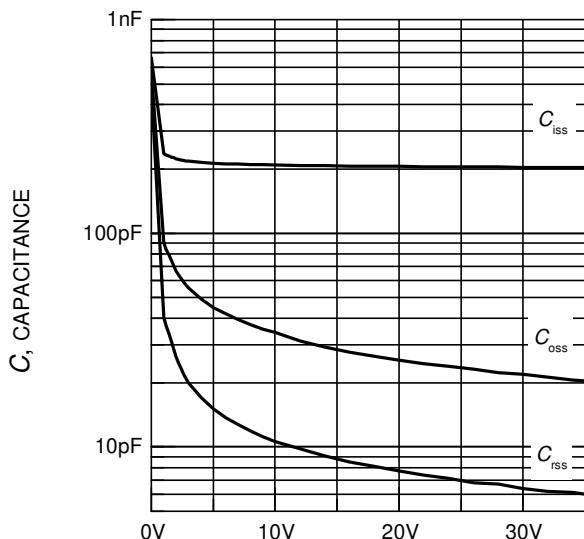


$V_{CE}$, COLLECTOR-EMITTER VOLTAGE
**Figure 18. Typical capacitance as a function of collector-emitter voltage**
($V_{GE}$ = 0V, $f$ = 1MHz)
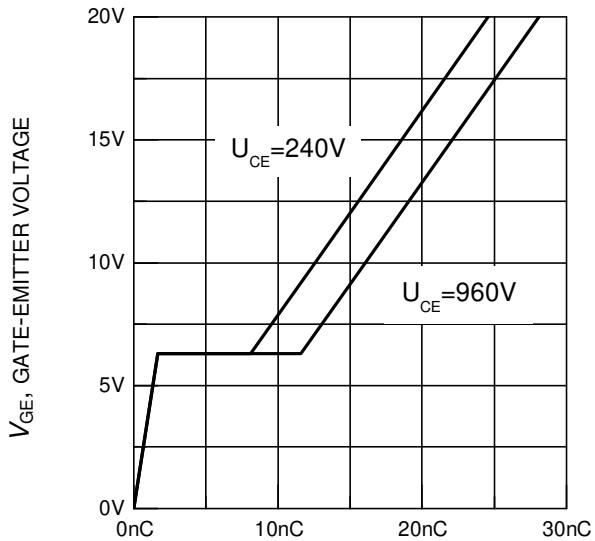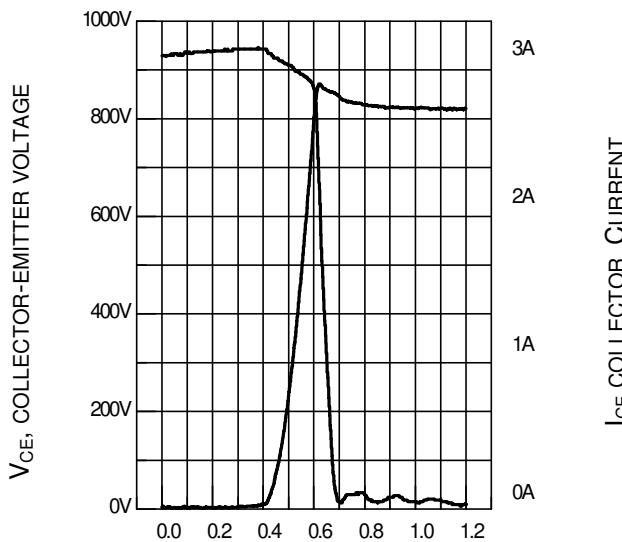


$t_p$, PULSE WIDTH
**Figure 20. Typical turn off behavior, hard switching**
($V_{GE}$=15/0V, $R_G$=82Ω, $T_j$ = 150°C, Dynamic test circuit in Figure E)
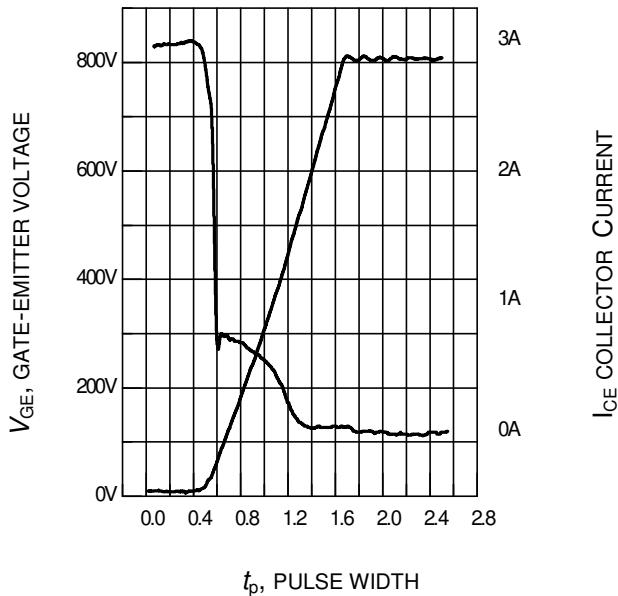
**Figure 21. Typical turn off behavior, soft switching**
($V_{GE}$=15/0V, $R_G$=82Ω, $T_j$ = 150°C, Dynamic test circuit in Figure E)
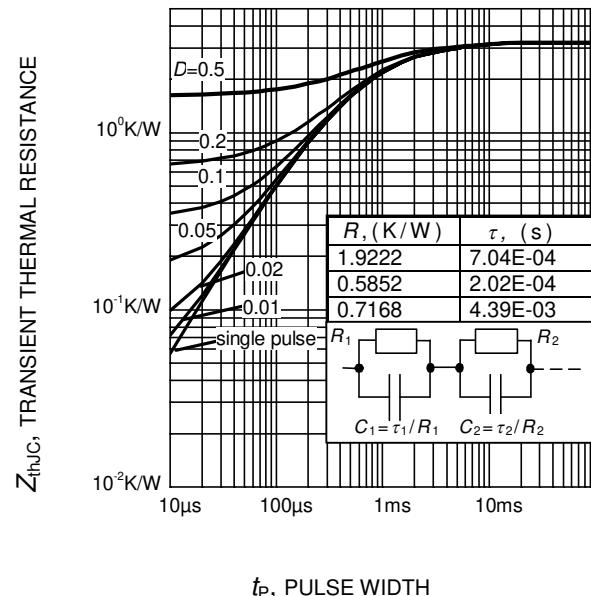


**Figure 22. Diode transient thermal impedance as a function of pulse width**
($D$=$t_P/T$)
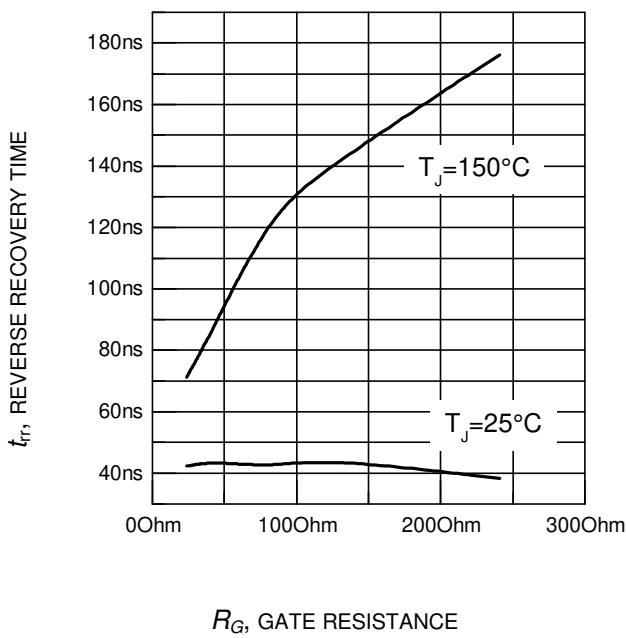


**Figure 23. Typical reverse recovery time as a function of diode current slope**
$V_R$=800V, $I_F$=3A, Dynamic test circuit in Figure E)
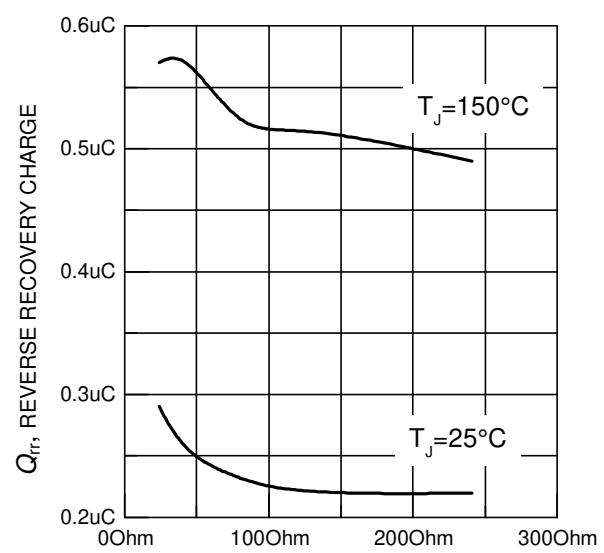


**Figure 24. Typical reverse recovery charge as a function of diode current slope**
($V_R$=800V, $I_F$=3A, Dynamic test circuit in Figure E)
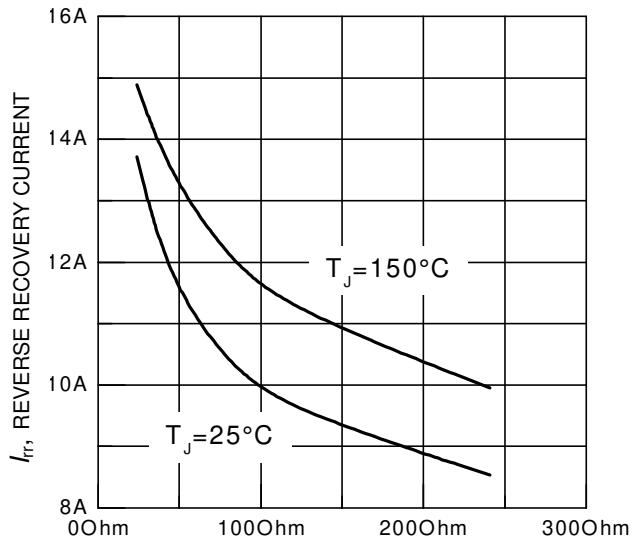
$R_G$, GATE RESISTANCE

**Figure 25. Typical reverse recovery current as a function of diode current slope**
($V_R$=800V, $I_F$=3A,
Dynamic test circuit in Figure E)
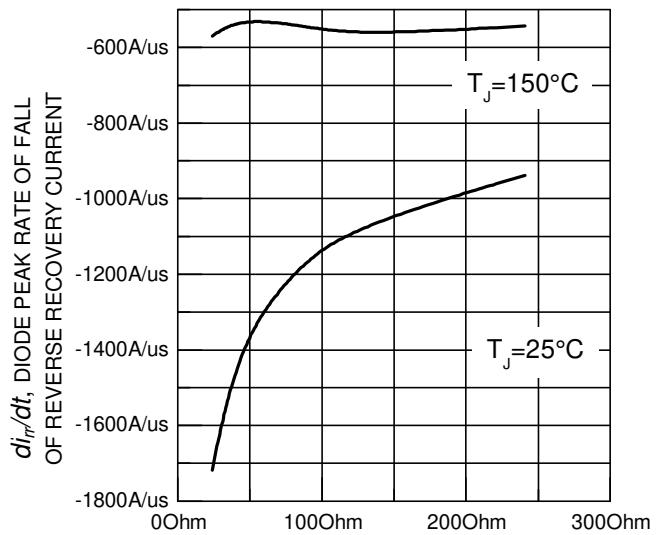


$R_G$, GATE RESISTANCE

**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=800V, $I_F$=3A,
Dynamic test circuit in Figure E)
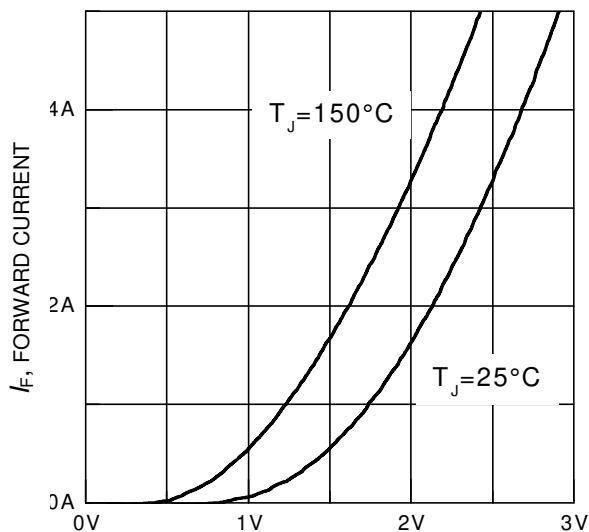


$V_F$, FORWARD VOLTAGE

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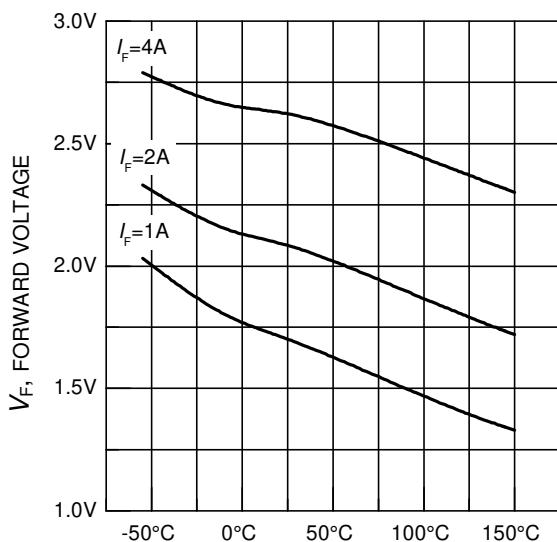


$T_J$, JUNCTION TEMPERATURE

**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 | 0.563 | 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

EUROPEAN PROJECTION

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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 |

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7.5mm

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**Figure A. Definition of switching times**

SIS00053



**Figure B. Definition of switching losses**

$$E_{OFF} = \int_{t_1}^{t_2} V_{CE} \times I_C \times dt$$

$$E_{ON} = \int_{t_3}^{t_4} V_{CE} \times I_C \times dt$$

SIS00050



$$t_{rr} = t_S + t_F$$
$$Q_{rr} = Q_S + Q_F$$
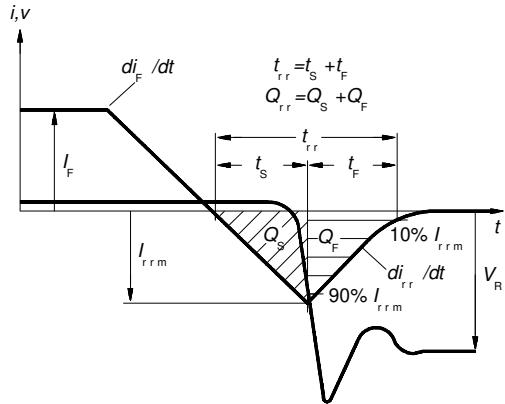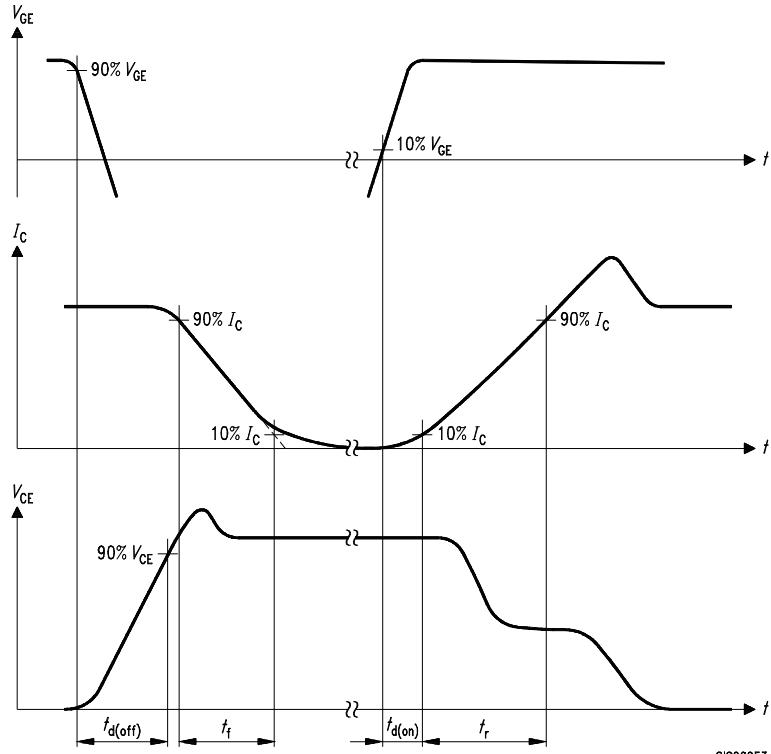
**Figure C. Definition of diodes switching characteristics**
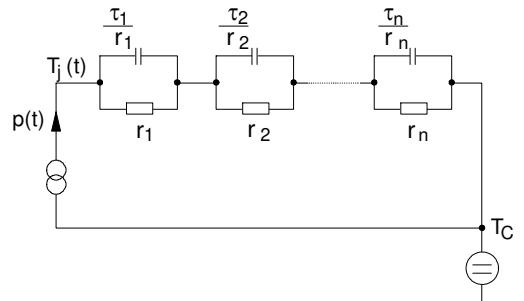


**Figure D. Thermal equivalent circuit**
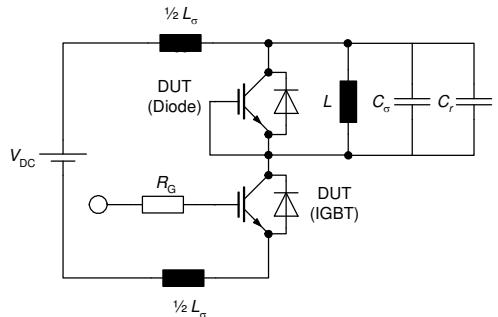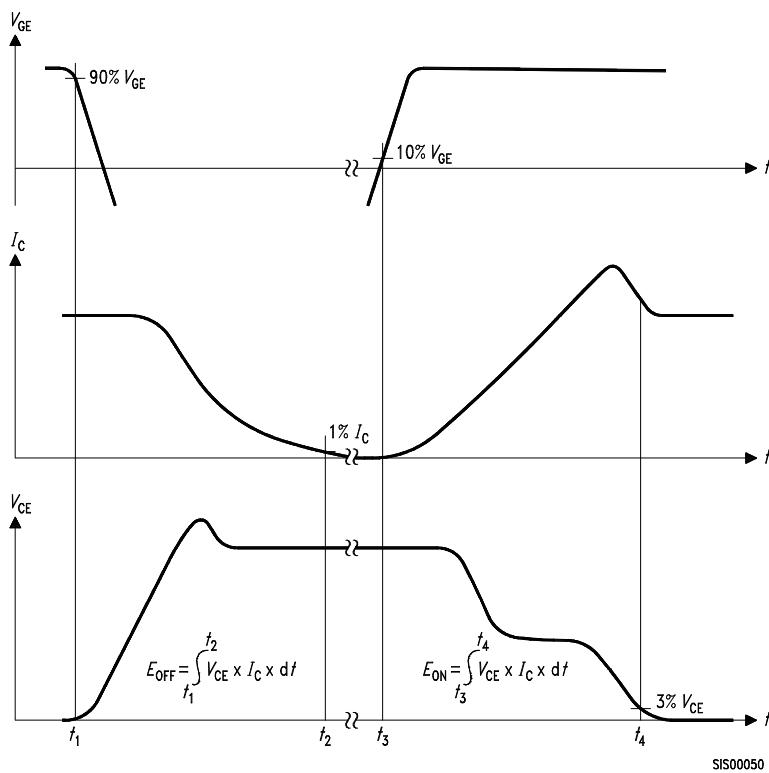


**Figure E. Dynamic test circuit**
Leakage inductance $L_\sigma = 180nH$,
Stray capacitor $C_\sigma = 40pF$,
Relief capacitor $C_r = 4nF$ (only for ZVT switching)

**Legal Disclaimer**

**Information**

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**Warnings**