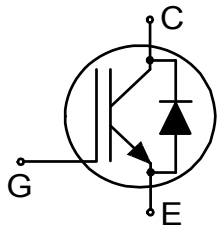
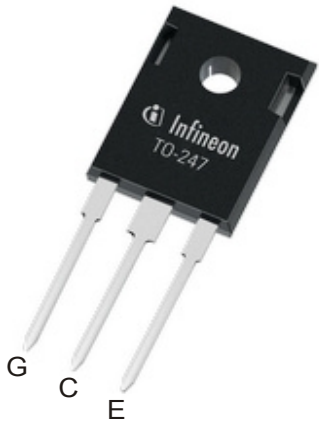
Sixth generation, high speed soft switching series

# High speed soft switching TRENCHSTOP™ IGBT 6 in Trench and Fieldstop technology copacked with soft and fast recovery anti-parallel diode




**Features:**

1200V TRENCHSTOP™ IGBT6 technology offering:
- High efficiency in hard switching and resonant topologies
- Easy paralleling capability due to positive temperature coefficient in $V_{CEsat}$
- Low EMI
- Low Gate Charge $Q_g$
- Very soft, fast recovery full current anti-parallel diode
- Maximum junction temperature 175°C
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models: http://www.infineon.com/igbt/




**Applications:**

- Industrial UPS
- Charger
- Energy storage
- Three-level Solar String Inverter
- Welding

**Product Validation:**

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22

**Key Performance and Package Parameters**

| Type | $V_{CE}$ | $I_C$ | $V_{CEsat}$, $T_{vj}$=25°C | $T_{vjmax}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IKW40N120CS6 | 1200V | 40A | 1.85V | 175°C | K40MCS6 | PG-TO247-3 |

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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, $T_{vj} \geq 25°C$ | $V_{CE}$ | 1200 | V |
| DC collector current, limited by $T_{vjmax}$<br>$T_c = 25°C$<br>$T_c = 100°C$ | $I_C$ | 80.0<br>40.0 | A |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpuls}$ | 160.0 | A |
| Turn off safe operating area $V_{CE} \leq 1200V$, $T_{vj} \leq 175°C$ | - | 160.0 | A |
| Diode forward current, limited by $T_{vjmax}$<br>$T_c = 25°C$<br>$T_c = 100°C$ | $I_F$ | 80.0<br>40.0 | A |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpuls}$ | 160.0 | A |
| Gate-emitter voltage<br>Transient Gate-emitter voltage ($t_p \leq 0.5\mu s$, $D < 0.001$) | $V_{GE}$ | ±20<br>25 | V |
| Short circuit withstand time<br>$V_{GE} = 15.0V$, $V_{CC} \leq 500V$<br>Allowed number of short circuits < 1000<br>Time between short circuits: ≥ 1.0s<br>$T_{vj} = 150°C$ | $t_{SC}$ | 3 | µs |
| Power dissipation $T_c = 25°C$<br>Power dissipation $T_c = 100°C$ | $P_{tot}$ | 500.0<br>250.0 | 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 | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **$R_{th}$ Characteristics** | | | | | | |
| IGBT thermal resistance,<br>junction - case | $R_{th(j-c)}$ | | - | - | 0.30 | K/W |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ | | - | - | 0.78 | K/W |
| Thermal resistance<br>junction - ambient | $R_{th(j-a)}$ | | - | - | 40 | K/W |

**Electrical Characteristic, at $T_{vj}$ = 25°C, unless otherwise specified**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **Static Characteristic** | | | | | | |
| Collector-emitter saturation voltage | $V_{CEsat}$ | $V_{GE}$ = 15.0V, $I_C$ = 40.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 125°C<br>$T_{vj}$ = 175°C | -<br>-<br>- | 1.85<br>2.15<br>2.25 | 2.15<br>-<br>- | V |
| Diode forward voltage | $V_F$ | $V_{GE}$ = 0V, $I_F$ = 40.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | 2.20<br>2.25 | 2.55<br>- | V |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$ = 1.90mA, $V_{CE}$ = $V_{GE}$ | 5.1 | 5.7 | 6.3 | V |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$ = 1200V, $V_{GE}$ = 0V<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 175°C | -<br>- | -<br>1600 | 850<br>- | µA |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$ = 0V, $V_{GE}$ = 20V | - | - | 600 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$ = 20V, $I_C$ = 40.0A | - | 32.0 | - | 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 | - | 2700 | - | pF |
| Output capacitance | $C_{oes}$ | | - | 185 | - | |
| Reverse transfer capacitance | $C_{res}$ | | - | 120 | - | |
| Gate charge | $Q_G$ | $V_{CC}$ = 960V, $I_C$ = 40.0A,<br>$V_{GE}$ = 15V | - | 285.0 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$ | | - | 13.0 | - | 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>$V_{CC}$ = 600V, $I_C$ = 40.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 9.0Ω, $R_{G(off)}$ = 9.0Ω,<br>$L\sigma$ = 70nH, $C\sigma$ = 67pF<br>$L\sigma$, $C\sigma$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | - | 27 | - | ns |
| Rise time | $t_r$ | | - | 39 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 315 | - | ns |
| Fall time | $t_f$ | | - | 27 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 2.55 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 1.55 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 4.10 | - | mJ |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C, $V_R$ = 600V, $I_F$ = 40.0A, $di_F/dt$ = 700A/µs, $L\sigma$ = 70nH, $C\sigma$ = 67pF | - | 400 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 2.65 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 18.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -65 | - | A/µs |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic, at $T_{vj}$ = 175°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 175°C, $V_{CC}$ = 600V, $I_C$ = 40.0A, $V_{GE}$ = 0.0/15.0V, $R_{G(on)}$ = 9.0Ω, $R_{G(off)}$ = 9.0Ω, $L\sigma$ = 70nH, $C\sigma$ = 67pF $L\sigma$, $C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery. | - | 27 | - | ns |
| Rise time | $t_r$ | | - | 38 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 390 | - | ns |
| Fall time | $t_f$ | | - | 55 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 3.50 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 2.95 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 6.45 | - | mJ |

**Diode Characteristic, at $T_{vj}$ = 175°C**

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 175°C, $V_R$ = 600V, $I_F$ = 40.0A, $di_F/dt$ = 800A/µs, $L\sigma$ = 70nH, $C\sigma$ = 67pF | - | 720 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 6.40 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 27.0 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | -70 | - | A/µs |

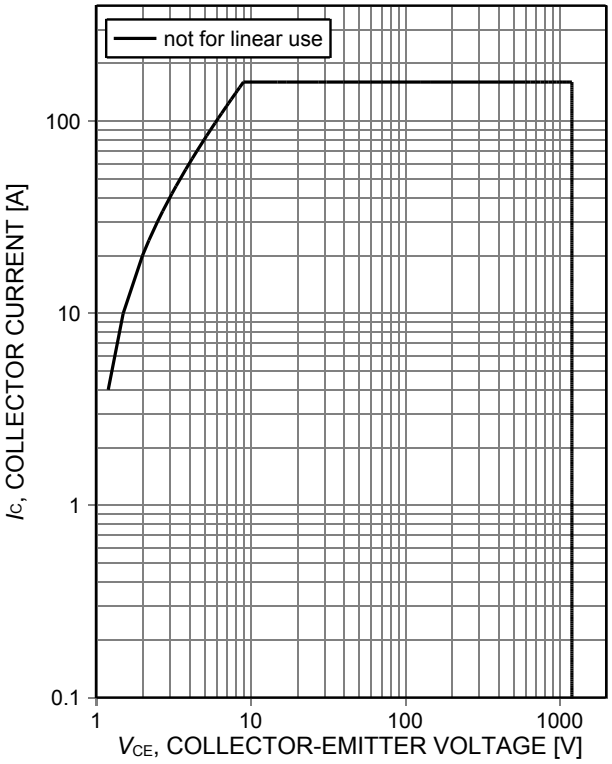



Figure 1. **Forward bias safe operating area** ($D$=0, $T_{vj}$≤175°C; $V_{GE}$=15V, pulse width limited by $T_{vjmax}$)

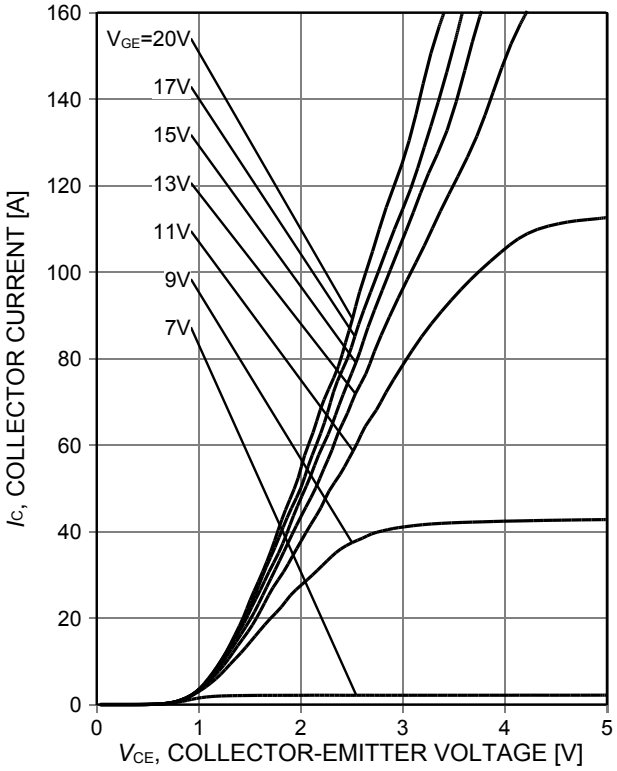



Figure 2. **Typical output characteristic** ($T_{vj}$=25°C)

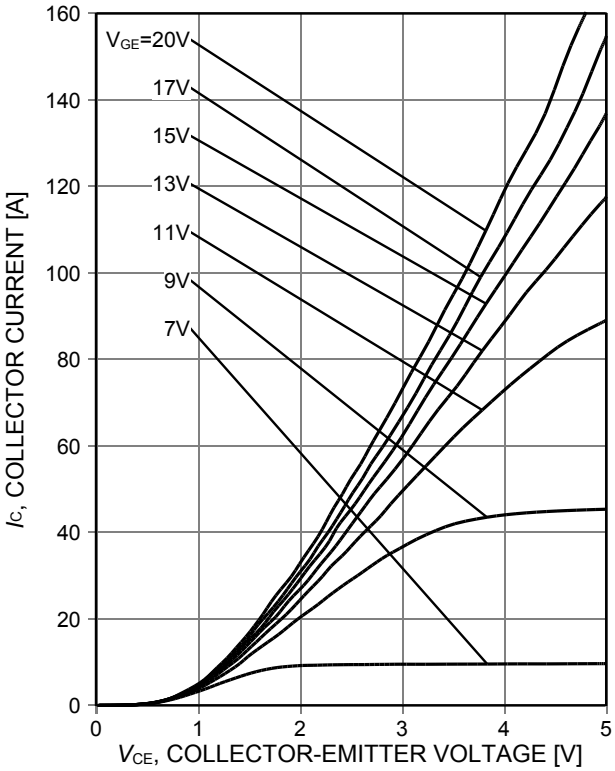



Figure 3. **Typical output characteristic** ($T_{vj}$=175°C)

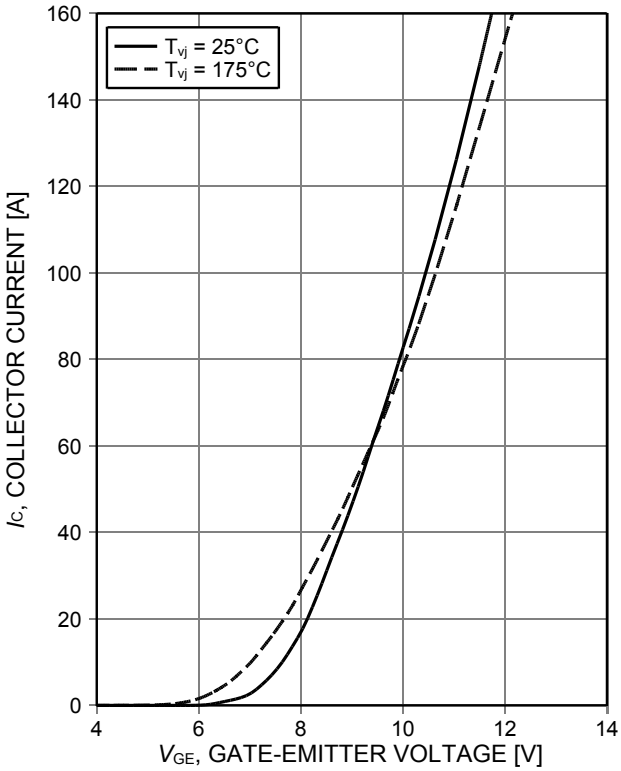



Figure 4. **Typical transfer characteristic** ($V_{CE}$=20V)

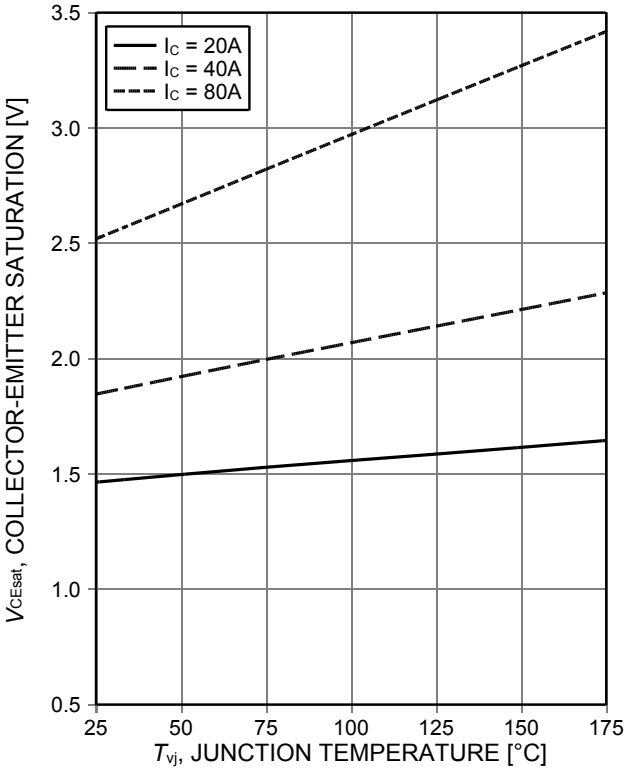



Figure 5. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$=15V)

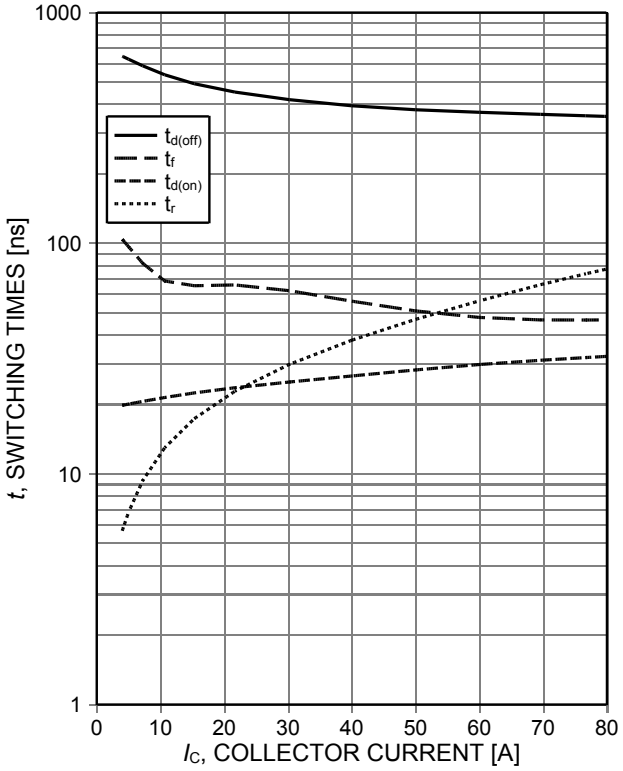



Figure 6. **Typical switching times as a function of collector current**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=600V, $V_{GE}$=0/15V, $R_G$=9Ω, Dynamic test circuit in Figure E)

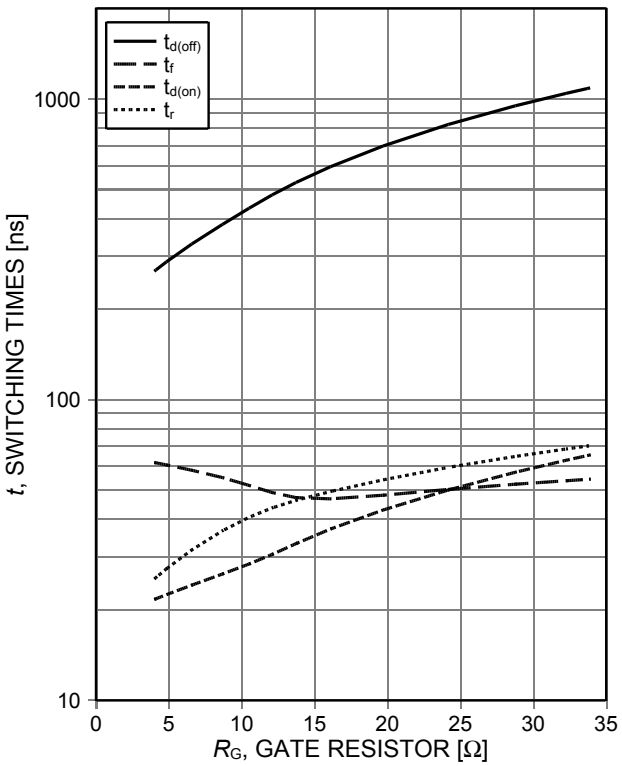



Figure 7. **Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=600V, $V_{GE}$=0/15V, $I_C$=40A, Dynamic test circuit in Figure E)

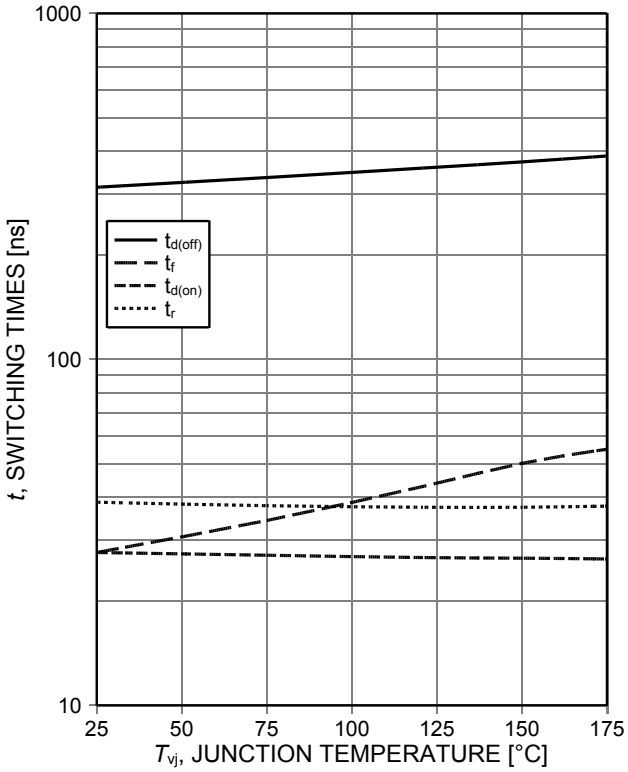



Figure 8. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$=600V, $V_{GE}$=0/15V, $I_C$=40A, $R_G$=9Ω, Dynamic test circuit in Figure E)

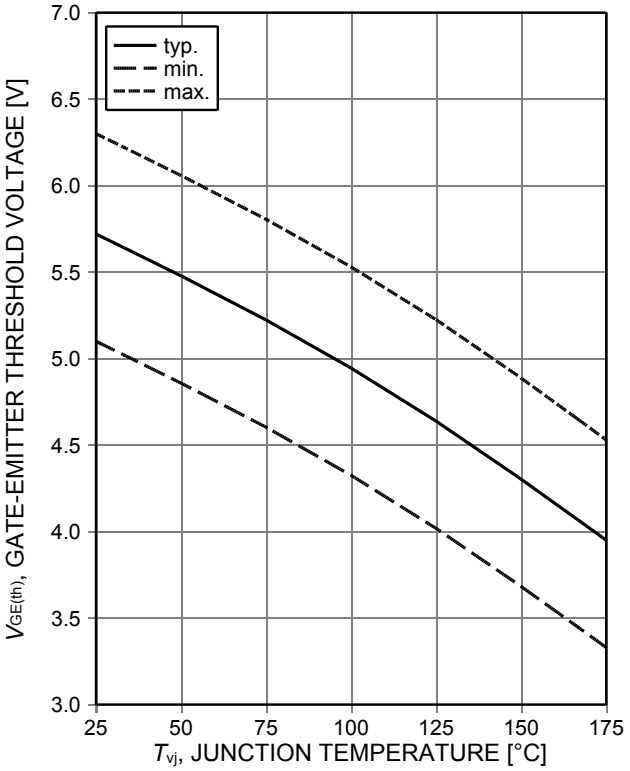



Figure 9. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C$=1.9mA)

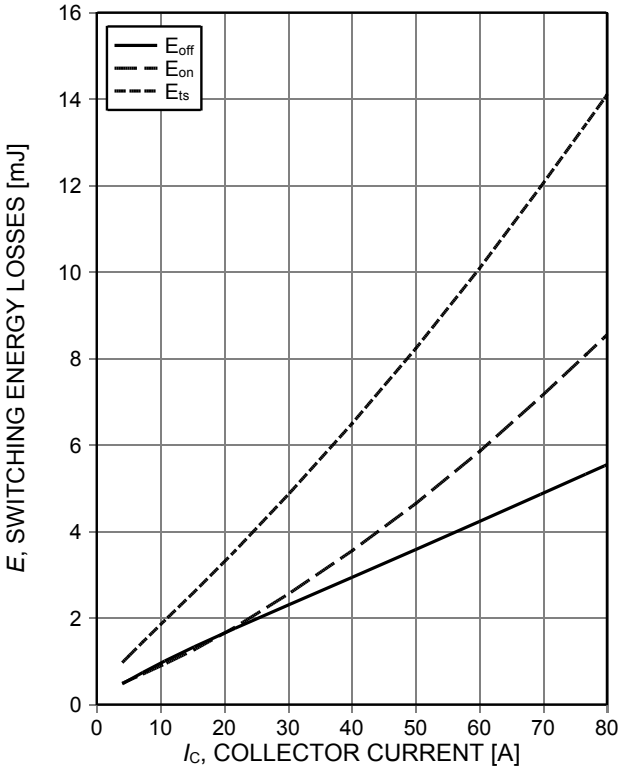



Figure 10. **Typical switching energy losses as a function of collector current**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=600V, $V_{GE}$=0/15V, $R_G$=9Ω, Dynamic test circuit in Figure E)

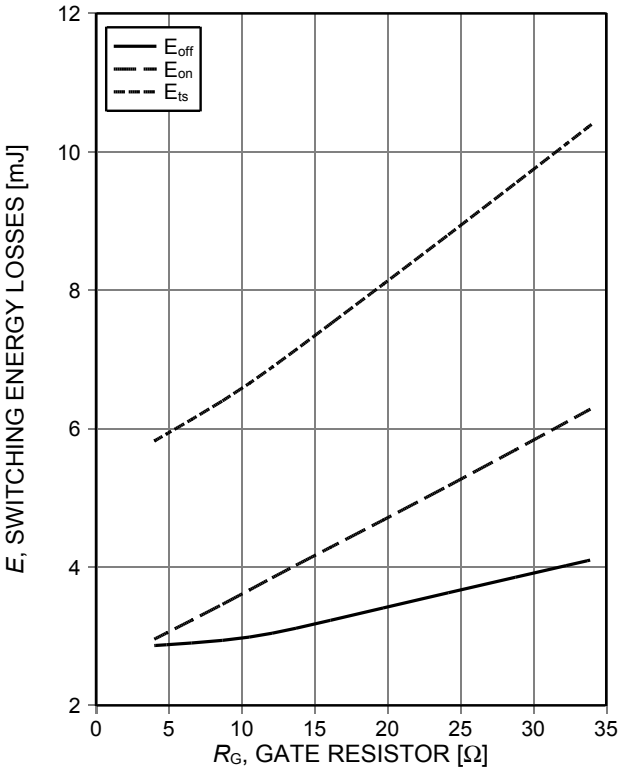



Figure 11. **Typical switching energy losses as a function of gate resistor**
(inductive load, $T_{vj}$=175°C, $V_{CE}$=600V, $V_{GE}$=0/15V, $I_C$=40A, Dynamic test circuit in Figure E)

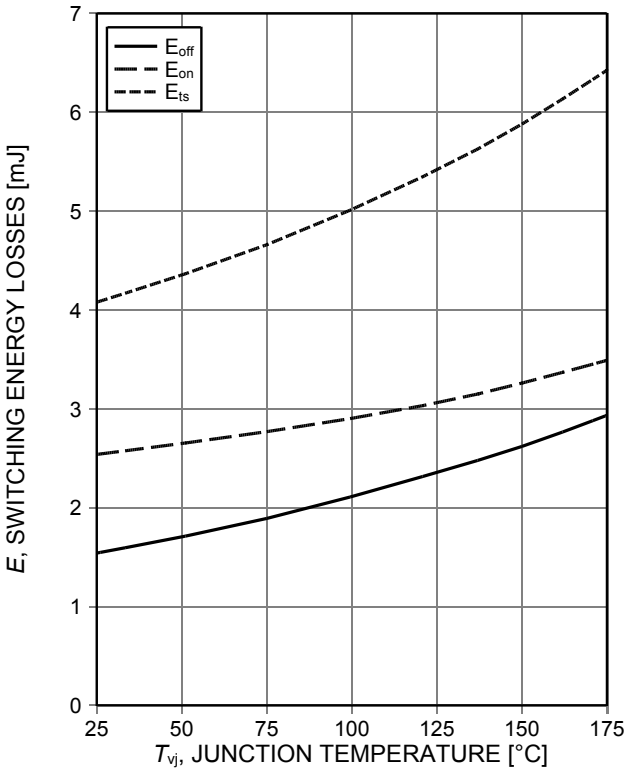



Figure 12. **Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}$=600V, $V_{GE}$=0/15V, $I_C$=40A, $R_G$=9Ω, Dynamic test circuit in Figure E)

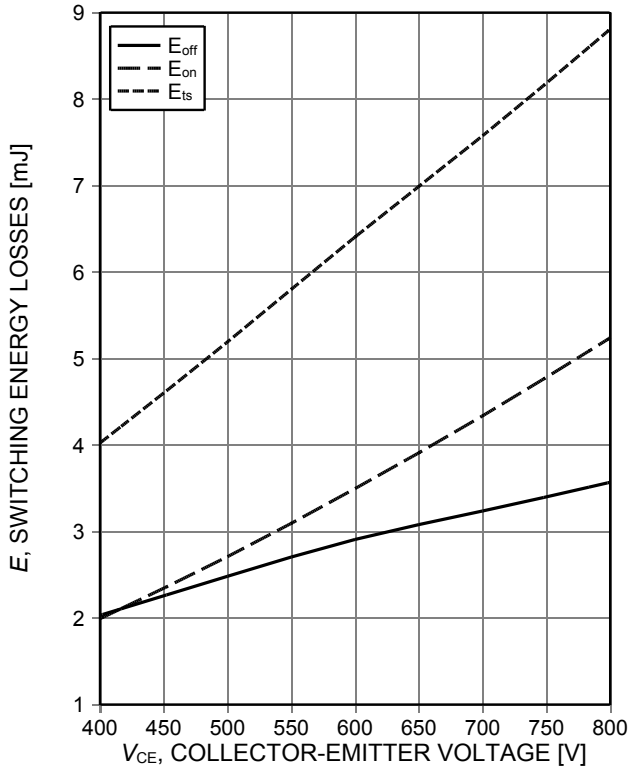



Figure 13. **Typical switching energy losses as a function of collector emitter voltage** (inductive load, $T_{vj}$=175°C, $V_{GE}$=0/15V, $I_C$=40A, $R_G$=9Ω, Dynamic test circuit in Figure E)

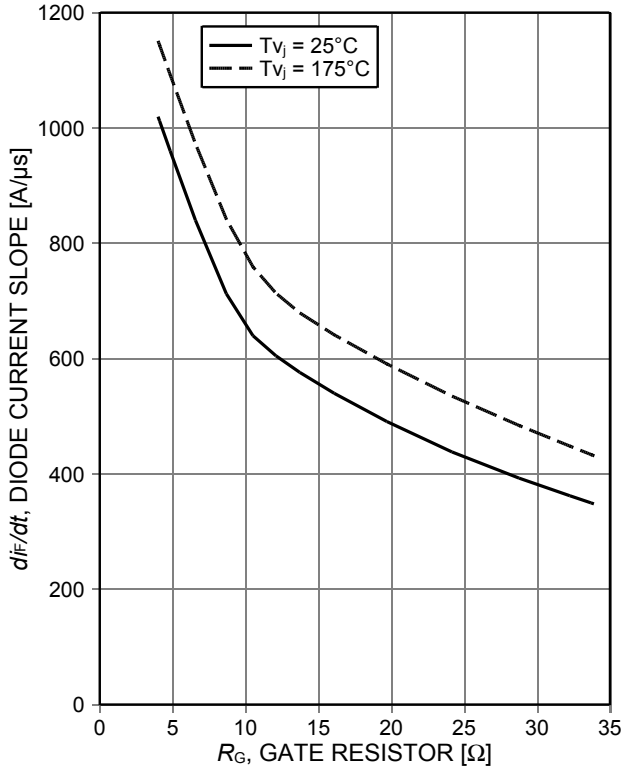



Figure 14. **Typical diode current slope as a function of gate resistor** (inductive load, $V_{CE}$=600V, $V_{GE}$=0/15V, $I_C$=40A, Dynamic test circuit in Figure E)

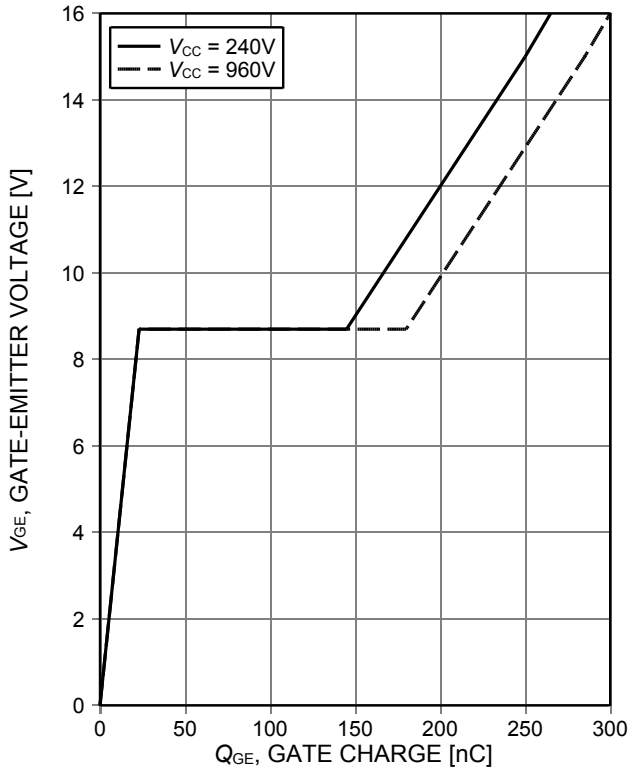



Figure 15. **Typical gate charge** ($I_C$=40A)

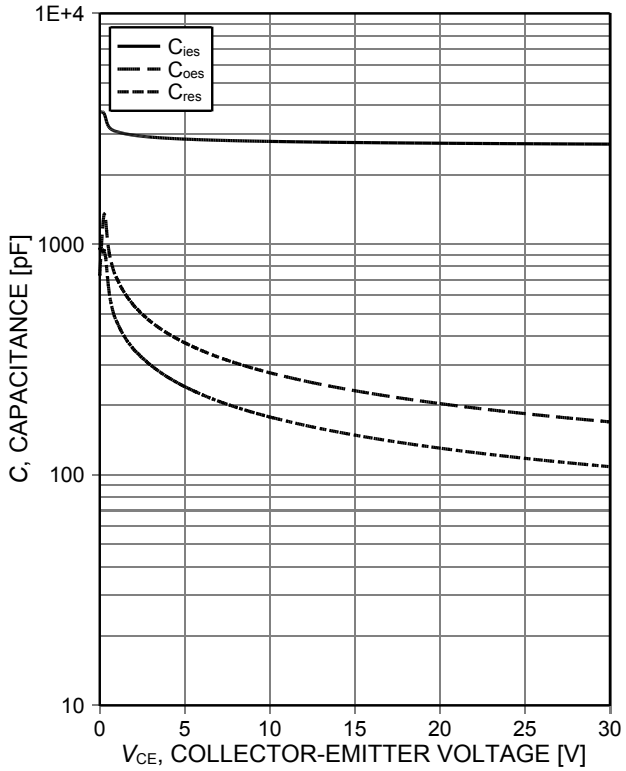



Figure 16. **Typical capacitance as a function of collector-emitter voltage** ($V_{GE}$=0V, f=1MHz)

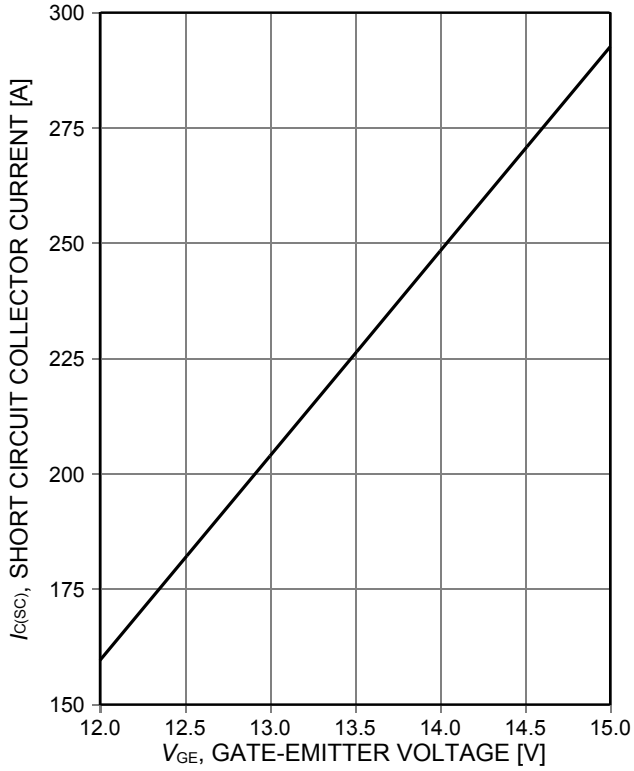



Figure 17. **Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE}$≤500V, $T_{vj}$≤175°C)

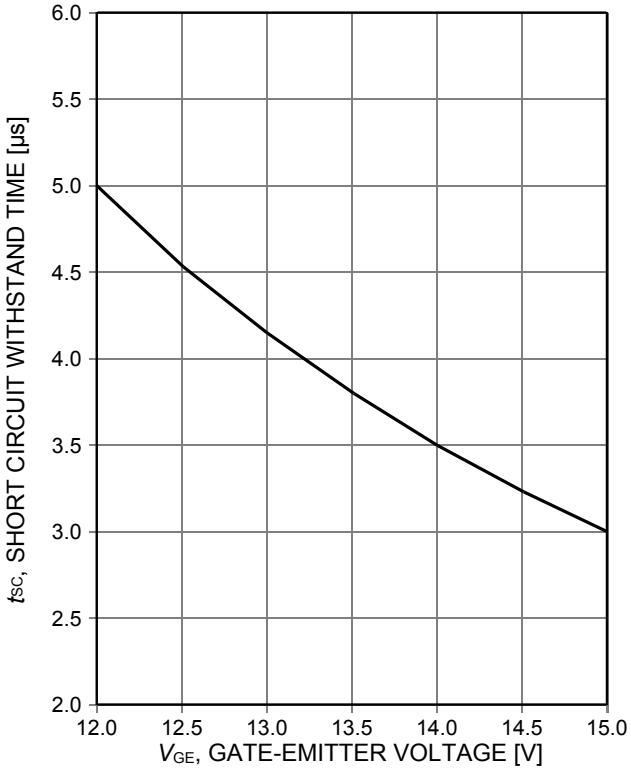



Figure 18. **Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$≤500V, start at $T_{vj}$≤175°C)

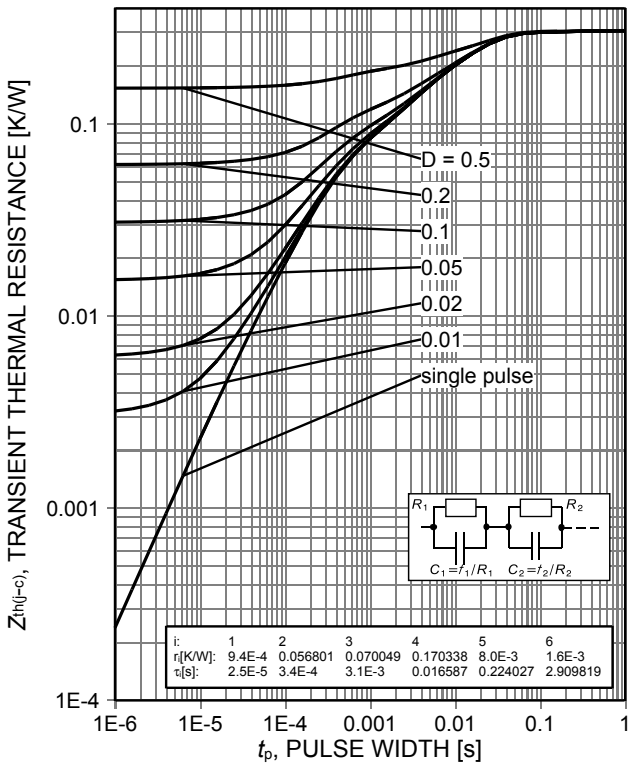



Figure 19. **IGBT transient thermal resistance**
($D$=$t_p$/T)

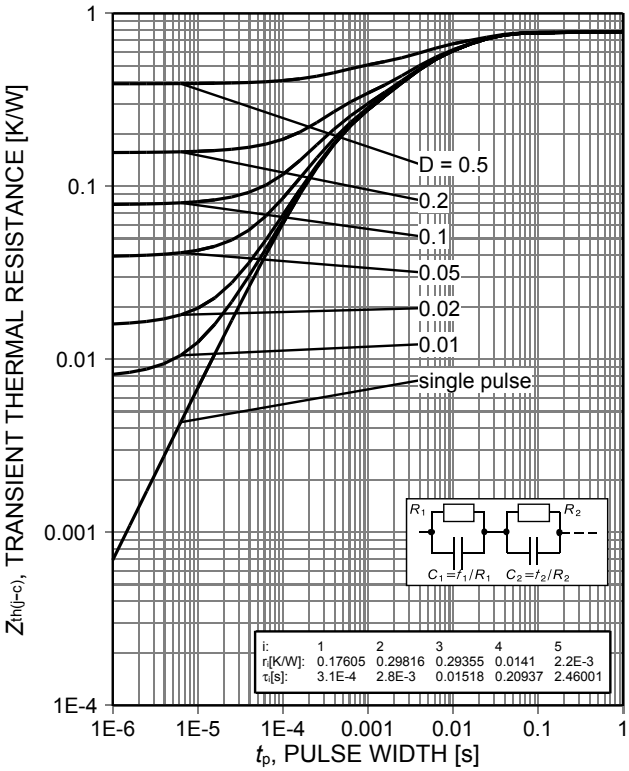



Figure 20. **Diode transient thermal impedance as a function of pulse width**
($D$=$t_p$/T)

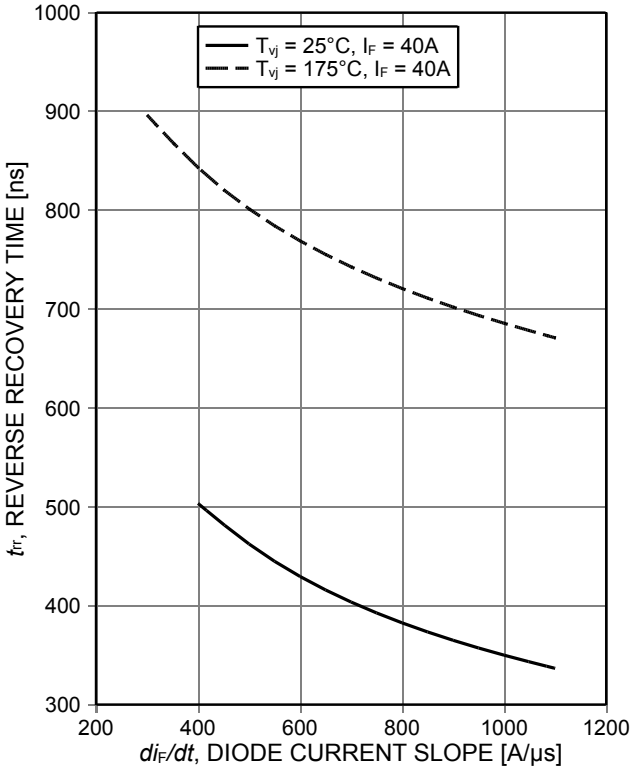



Figure 21. **Typical reverse recovery time as a function of diode current slope** ($V_R$=600V)

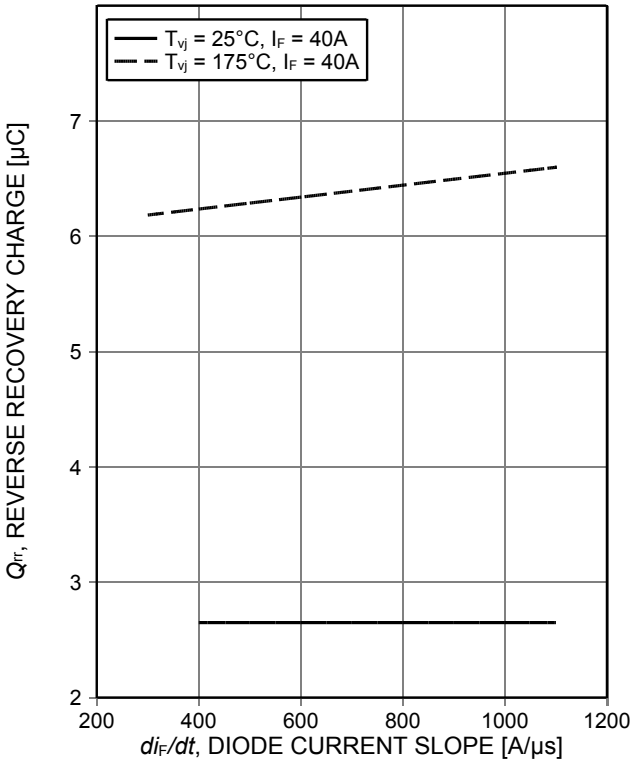



Figure 22. **Typical reverse recovery charge as a function of diode current slope** ($V_R$=600V)

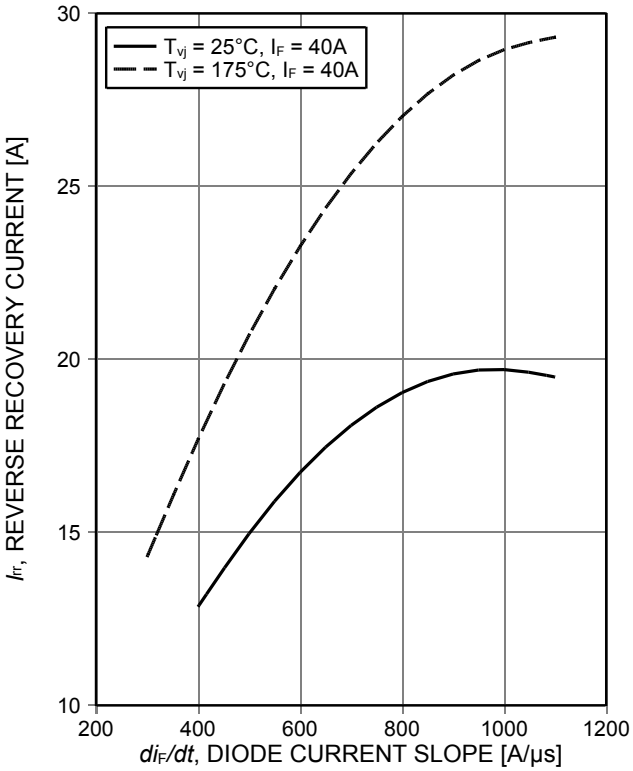



Figure 23. **Typical reverse recovery current as a function of diode current slope** ($V_R$=600V)

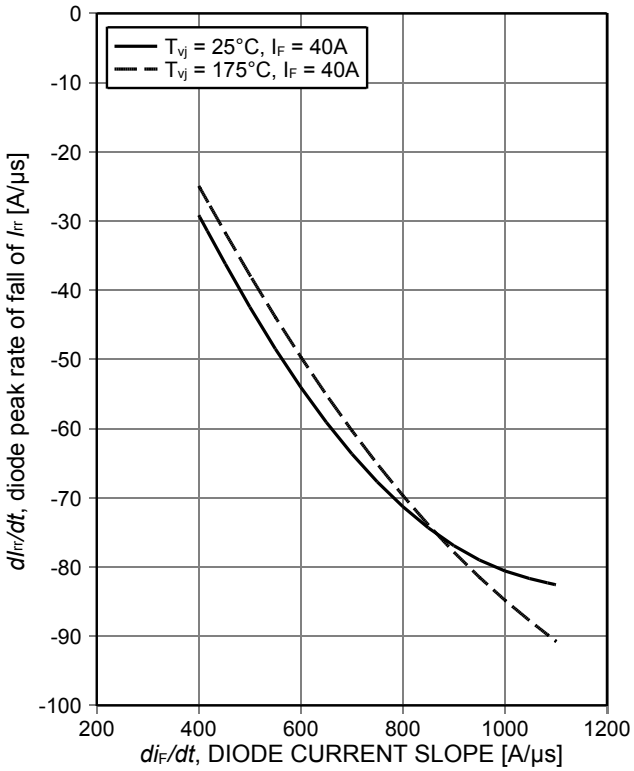



Figure 24. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope** ($V_R$=600V)

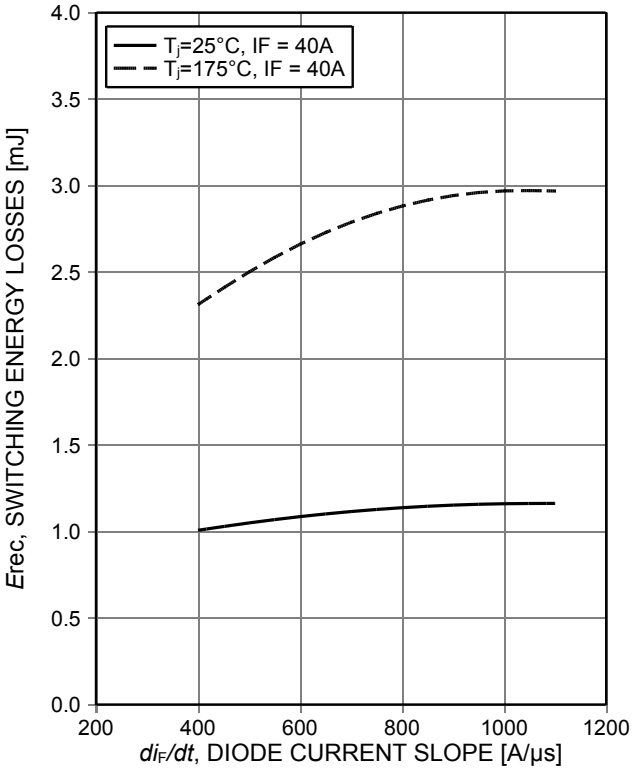



Figure 25. **Typical reverse energy losses as a function of diode current slope** ($V_R$=600V)

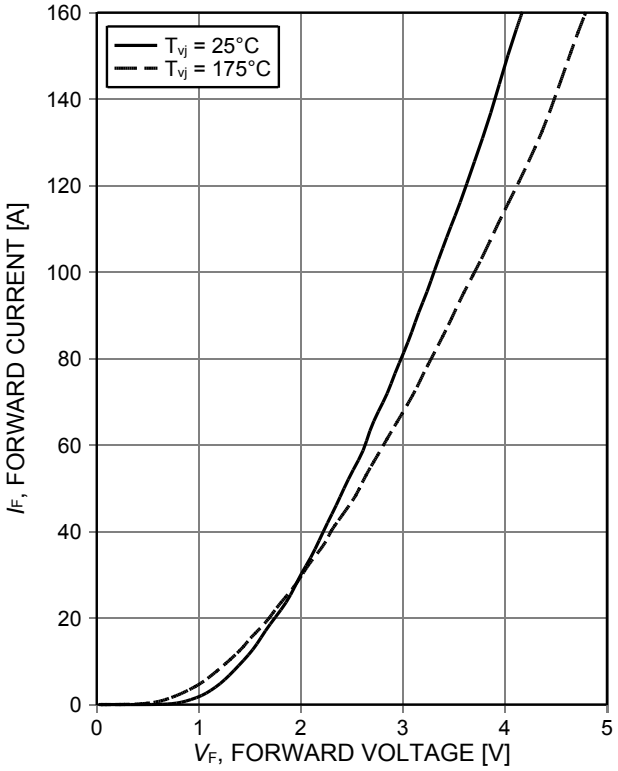



Figure 26. **Typical diode forward current as a function of forward voltage**

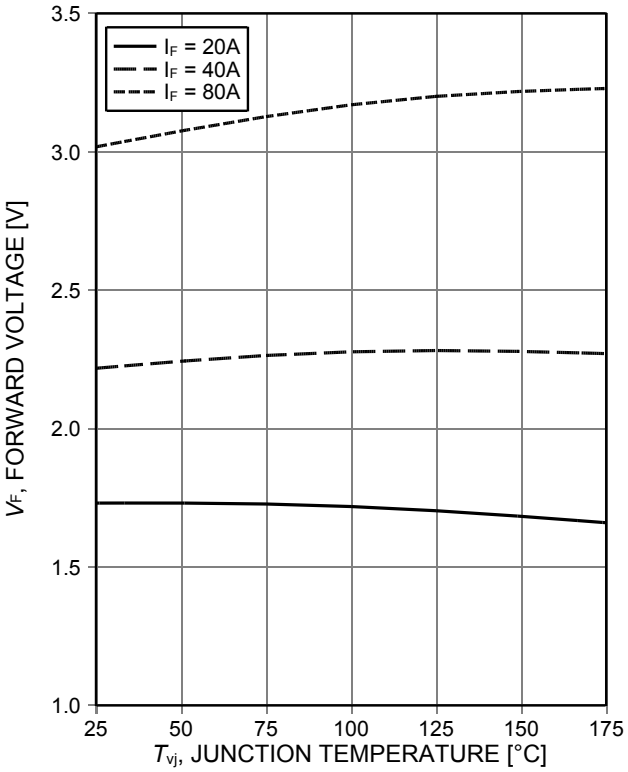
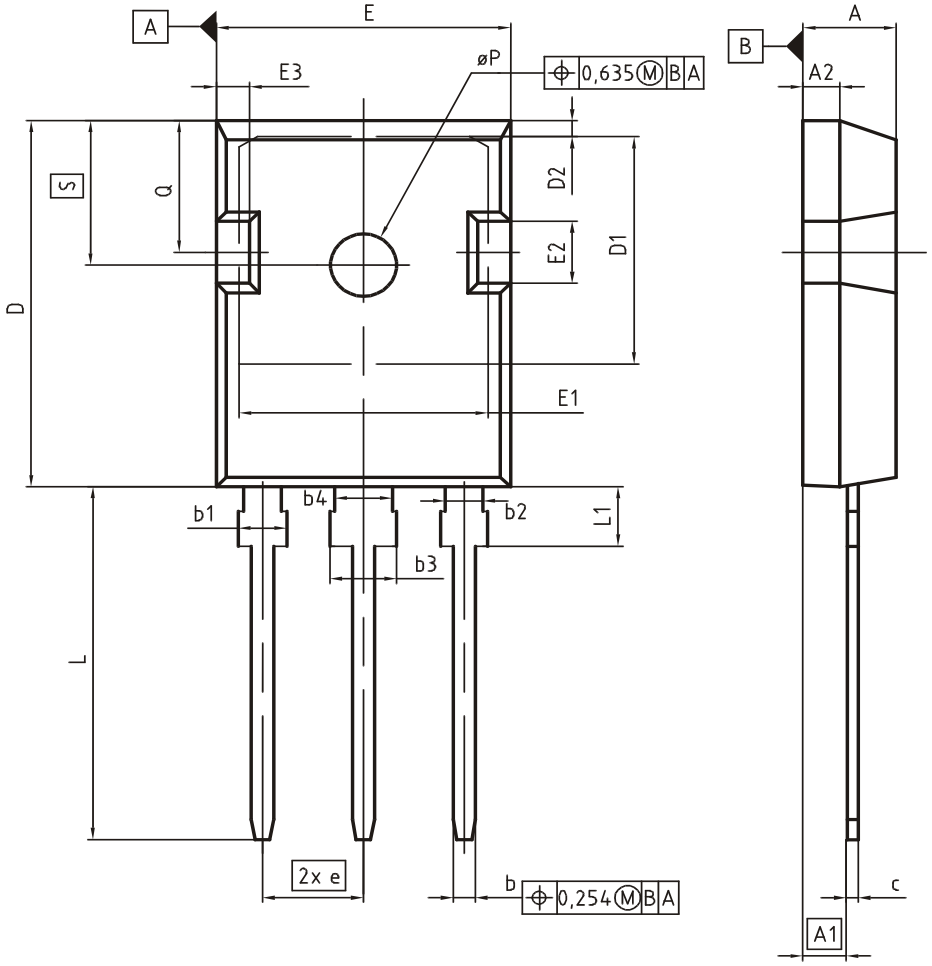



Figure 27. **Typical diode forward voltage as a function of junction temperature**

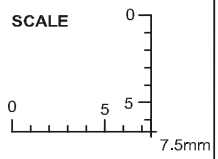
## Package Drawing PG-TO247-3



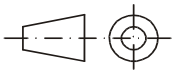

| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| **A** | 4.83 | 5.21 | 0.190 | 0.205 |
| **A1** | 2.27 | 2.54 | 0.089 | 0.100 |
| **A2** | 1.85 | 2.16 | 0.073 | 0.085 |
| **b** | 1.07 | 1.33 | 0.042 | 0.052 |
| **b1** | 1.90 | 2.41 | 0.075 | 0.095 |
| **b2** | 1.90 | 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**




**EUROPEAN PROJECTION**



**ISSUE DATE**
09-07-2010

**REVISION**
05

**Testing Conditions**

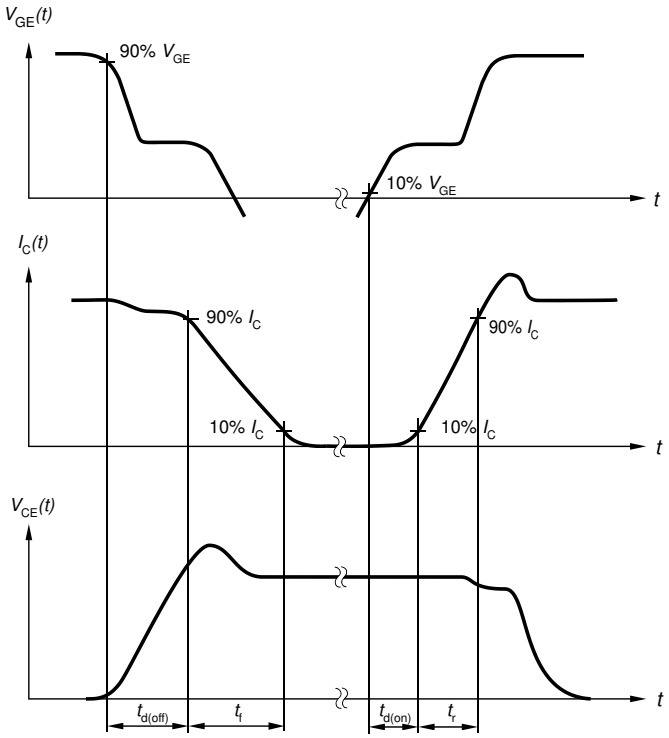



Figure A. **Definition of switching times**

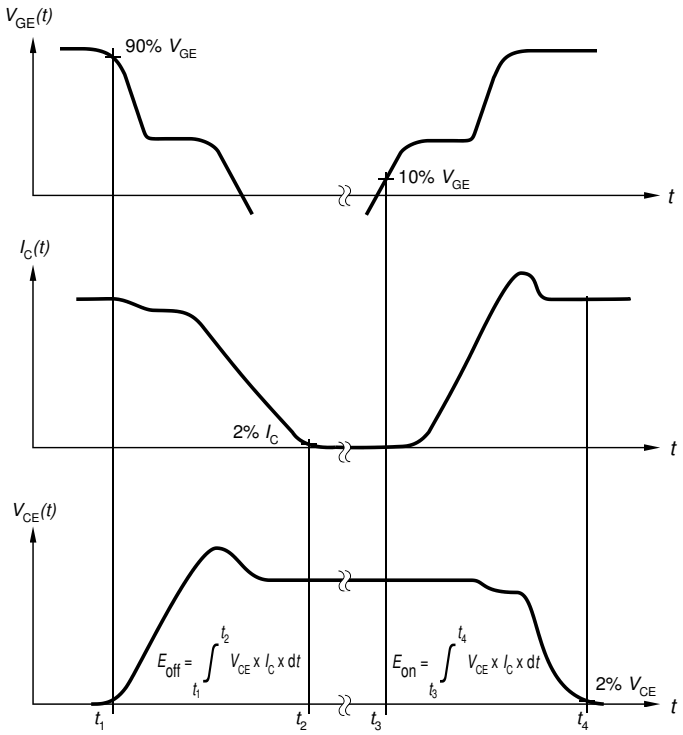



Figure B. **Definition of switching losses**

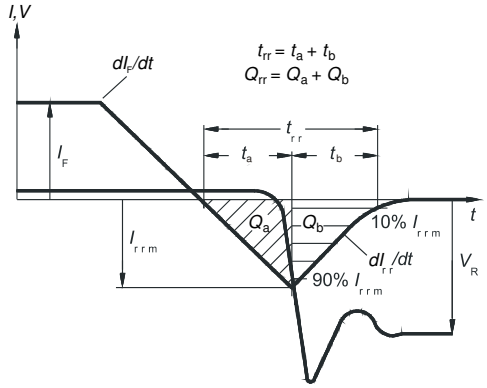



Figure C. **Definition of diode switching characteristics**

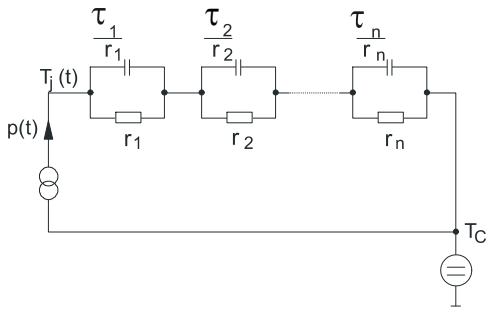



Figure D. **Thermal equivalent circuit**

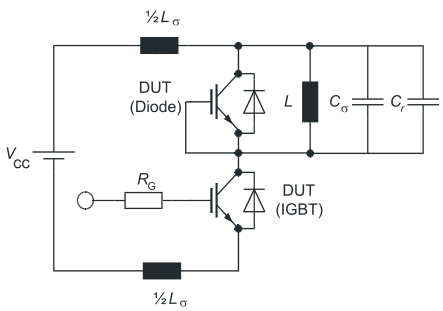



Figure E. **Dynamic test circuit**
Parasitic inductance $L_\sigma$,
parasitic capacitor $C_\sigma$,
relief capacitor $C_r$,
(only for ZVT switching)

**Revision History**

IKW40N120CS6

**Revision: 2018-05-07, Rev. 2.1**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 2.1 | 2018-05-07 | Final data sheet |

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