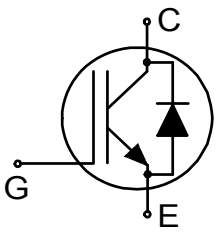
TRENCHSTOP™ Series

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

**Features:**

- Automotive AEC Q101 qualified
- Designed for DC/AC converters for Automotive Application
- Very low $V_{CE(sat)}$ 1.5V (typ.)
- Maximum Junction Temperature 150°C
- Dynamically stress tested
- Short circuit withstand time 5µs
- Positive temperature coefficient in $V_{CE(sat)}$
- Low EMI
- Low Gate Charge
- Green Package
- TRENCHSTOP™ and Fieldstop technology for 600V applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - very high switching speed





**Applications:**

- Main inverter
- Climate compressor
- PTC heater
- Motor drives

AEC Qualified

PB

Green

RoHS

**Key Performance and Package Parameters**

| Type | $V_{CE}$ | $I_C$ | $V_{CEsat}$, $T_{vj}$=25°C | $T_{vjmax}$ | Marking | Package |
|---|---|---|---|---|---|---|
| AIKP20N60CT | 600V | 20A | 1.5V | 150°C | AK20DCT | PG-TO220-3 |

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### Maximum Ratings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-emitter voltage, $T_{vj} \geq 25°C$ | $V_{CE}$ | 600 | V |
| DC collector current, limited by $T_{vjmax}$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_C$ | <br>40.0<br>20.0 | A |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpuls}$ | 60.0 | A |
| Turn off safe operating area $V_{CE} \leq 600V$, $T_{vj} \leq 150°C$[1)] | - | 60.0 | A |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_F$ | <br>40.0<br>20.0 | A |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpuls}$ | 60.0 | A |
| Gate-emitter voltage | $V_{GE}$ | ±20 | V |
| Short circuit withstand time<br>$V_{GE} = 15.0V$, $V_{CC} \leq 400V$<br>Allowed number of short circuits < 1000<br>Time between short circuits: ≥ 1.0s<br>$T_{vj} = 150°C$ | $t_{SC}$ | <br><br><br>5 | µs |
| Power dissipation $T_C = 25°C$ | $P_{tot}$ | 156.0 | W |
| Operating junction temperature | $T_{vj}$ | -40...+150 | °C |
| Storage temperature | $T_{stg}$ | -40...+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 | $R_{th(j-c)}$ | | - | - | 0.90 | K/W |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ | | - | - | 1.50 | K/W |
| Thermal resistance<br>junction - ambient | $R_{th(j-a)}$ | | - | - | 62 | K/W |

[1)] $t_p \leq 1µs$

**Electrical Characteristic, at $T_{vj}$ = 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, $I_C$ = 0.20mA | 600 | - | - | V |
| Collector-emitter saturation voltage | $V_{CEsat}$ | $V_{GE}$ = 15.0V, $I_C$ = 20.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 150°C | -<br>- | 1.50<br>1.85 | 2.05<br>- | V |
| Diode forward voltage | $V_F$ | $V_{GE}$ = 0V, $I_F$ = 20.0A<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 150°C | -<br>- | 1.65<br>1.65 | 2.05<br>- | V |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C$ = 0.29mA, $V_{CE}$ = $V_{GE}$ | 4.1 | 4.9 | 5.7 | V |
| Zero gate voltage collector current | $I_{CES}$ | $V_{CE}$ = 600V, $V_{GE}$ = 0V<br>$T_{vj}$ = 25°C<br>$T_{vj}$ = 150°C | -<br>- | -<br>550 | 40<br>- | µA |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$ = 0V, $V_{GE}$ = 20V | - | - | 100 | nA |
| Transconductance | $g_{fs}$ | $V_{CE}$ = 20V, $I_C$ = 20.0A | - | 11.0 | - | S |
| Integrated gate resistor | $r_G$ | | | none | | Ω |

**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 | - | 1100 | - | pF |
| Output capacitance | $C_{oes}$ | | - | 71 | - | |
| Reverse transfer capacitance | $C_{res}$ | | - | 32 | - | |
| Gate charge | $Q_G$ | $V_{CC}$ = 480V, $I_C$ = 20.0A,<br>$V_{GE}$ = 15V | - | 120.0 | - | nC |
| Short circuit collector current<br>Max. 1000 short circuits<br>Time between short circuits: ≥ 1.0s | $I_{C(SC)}$ | $V_{GE}$ = 15.0V, $V_{CC}$ ≤ 400V,<br>$t_{SC}$ ≤ 5µs<br>$T_{vj}$ = 150°C | - | 183 | - | A |

**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>$V_{CC}$ = 400V, $I_C$ = 20.0A,<br>$V_{GE}$ = 0.0/15.0V,<br>$R_{G(on)}$ = 12.0Ω, $R_{G(off)}$ = 12.0Ω,<br>Lσ = 131nH, Cσ = 31pF<br>Lσ, Cσ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | - | 18 | - | ns |
| Rise time | $t_r$ | | - | 14 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 199 | - | ns |
| Fall time | $t_f$ | | - | 42 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.31 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.46 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 0.77 | - | mJ |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 25°C, $V_R$ = 400V, $I_F$ = 20.0A, $di_F/dt$ = 880A/µs | - | 41 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 0.31 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 13.3 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 711 | - | A/µs |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **IGBT Characteristic, at $T_{vj}$ = 150°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj}$ = 150°C, $V_{CC}$ = 400V, $I_C$ = 20.0A, $V_{GE}$ = 0.0/15.0V, $R_{G(on)}$ = 12.0Ω, $R_{G(off)}$ = 12.0Ω, Lσ = 131nH, Cσ = 31pF Lσ, Cσ from Fig. E Energy losses include “tail” and diode reverse recovery. | - | 18 | - | ns |
| Rise time | $t_r$ | | - | 17 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 217 | - | ns |
| Fall time | $t_f$ | | - | 70 | - | ns |
| Turn-on energy | $E_{on}$ | | - | 0.47 | - | mJ |
| Turn-off energy | $E_{off}$ | | - | 0.60 | - | mJ |
| Total switching energy | $E_{ts}$ | | - | 1.07 | - | mJ |

**Diode Characteristic, at $T_{vj}$ = 150°C**

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode reverse recovery time | $t_{rr}$ | $T_{vj}$ = 150°C, $V_R$ = 400V, $I_F$ = 20.0A, $di_F/dt$ = 800A/µs | - | 201 | - | ns |
| Diode reverse recovery charge | $Q_{rr}$ | | - | 1.28 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 16.6 | - | A |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | | - | 481 | - | A/µs |

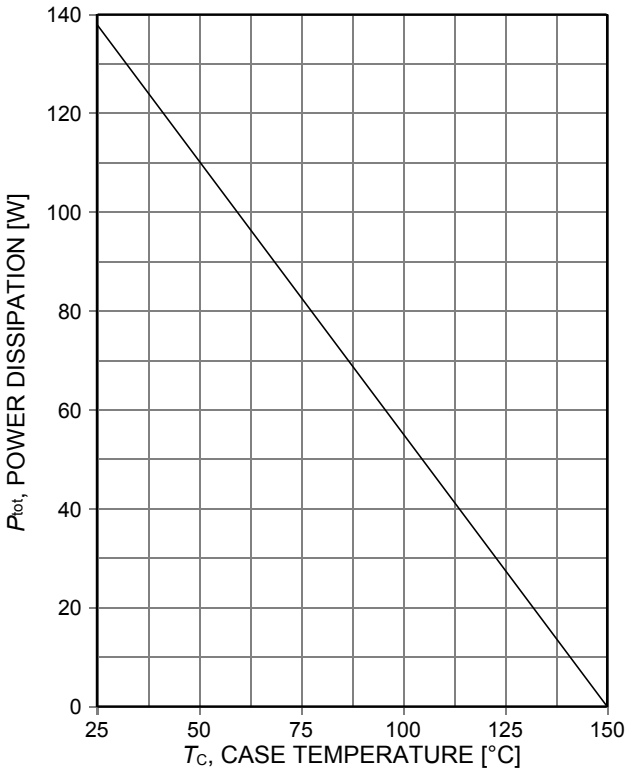



Figure 1. **Power dissipation as a function of case temperature**
($T_j \leq 150°C$)

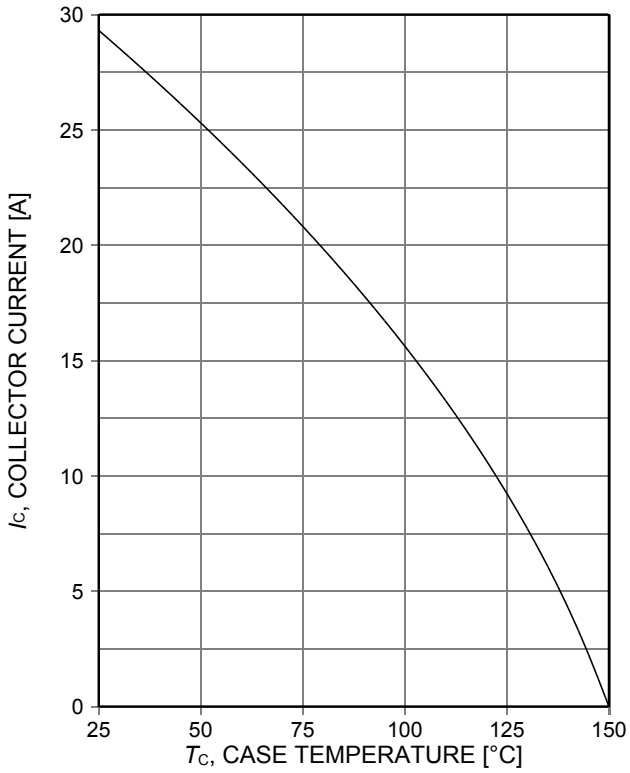



Figure 2. **Collector current as a function of case temperature**
($V_{GE} \geq 15V$, $T_j \leq 150°C$)

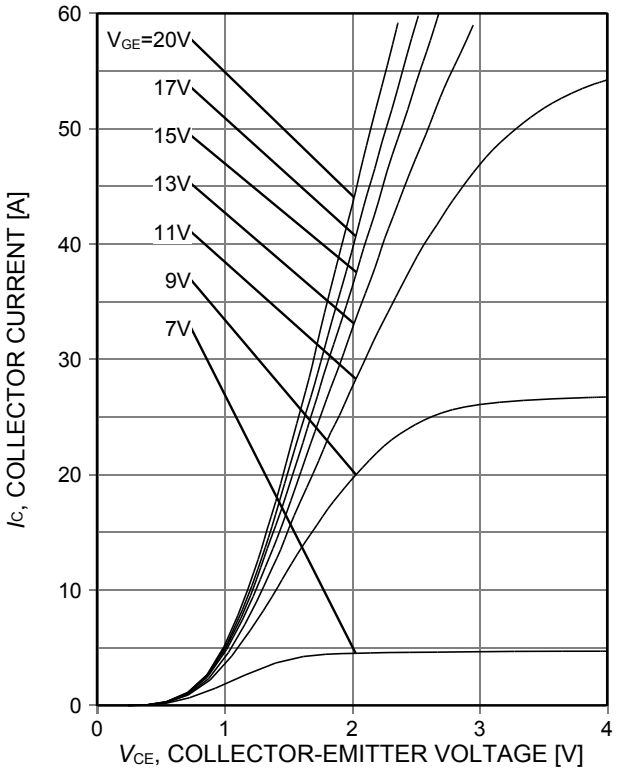



Figure 3. **Typical output characteristic**
($T_j$=25°C)

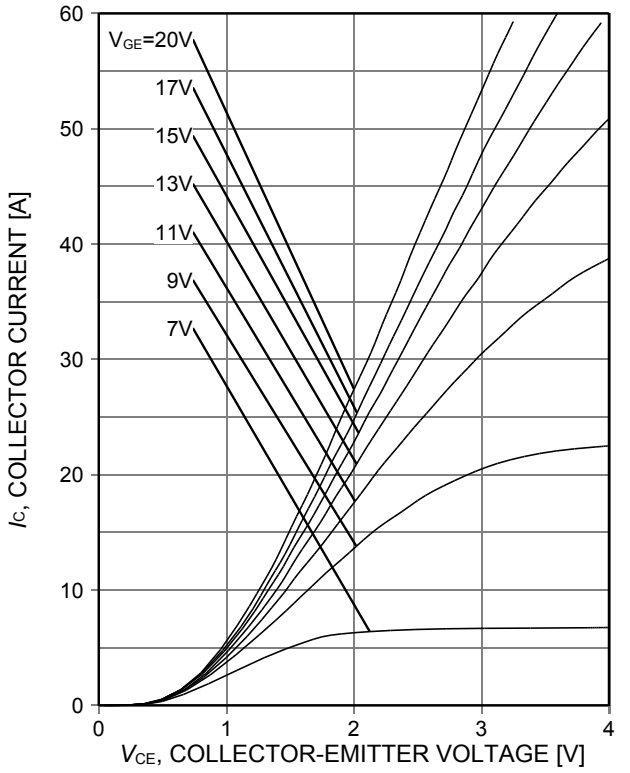



Figure 4. **Typical output characteristic**
($T_j$=150°C)

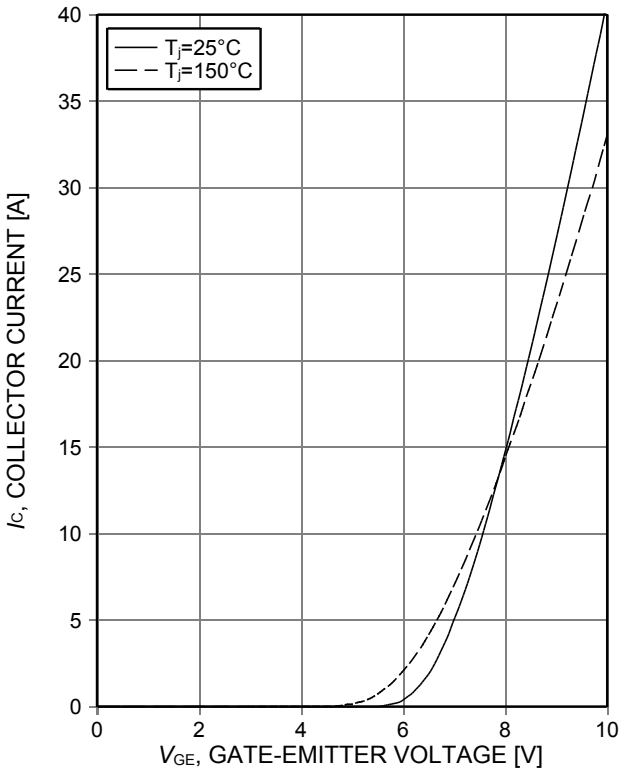



Figure 5. **Typical transfer characteristic**
($V_{CE}$=10V)

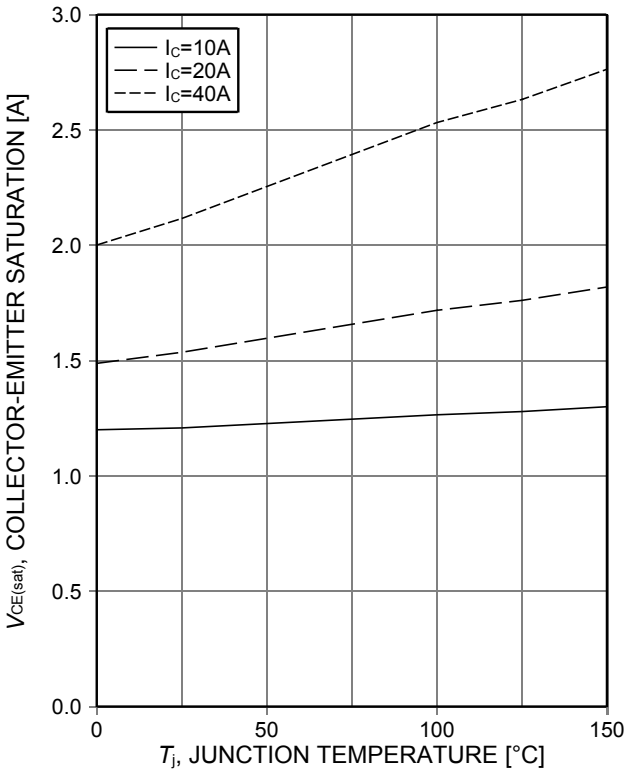



Figure 6. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}$=15V)

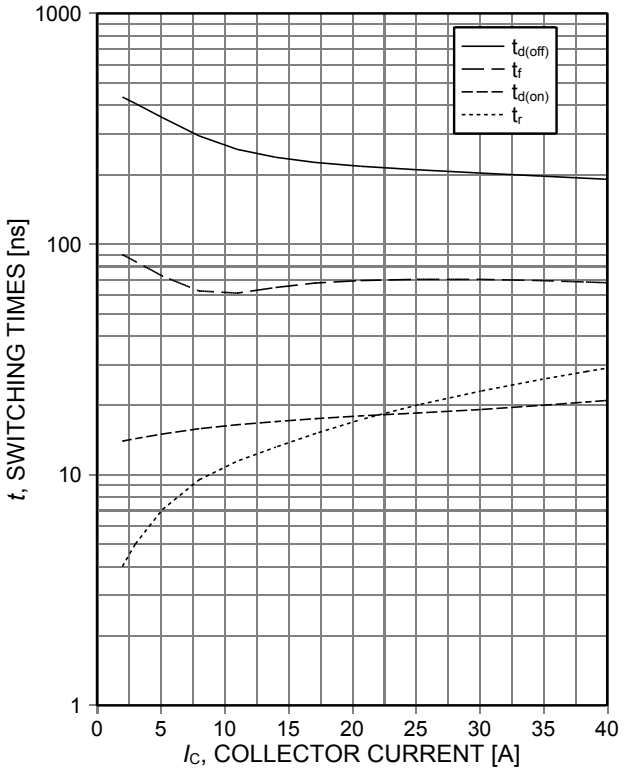



Figure 7. **Typical switching times as a function of collector current**
(inductive load, $T_j$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $R_G$=12Ω,Dynamic test circuit in Figure E)

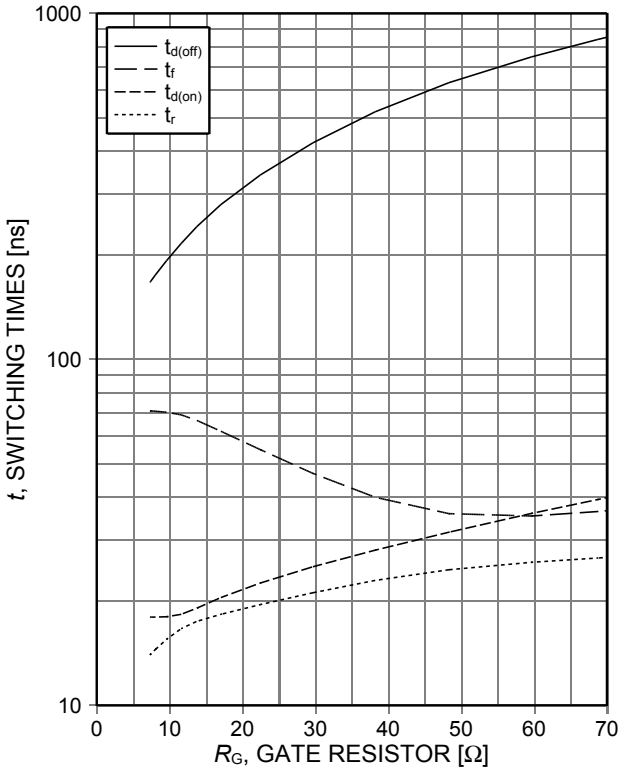



Figure 8. **Typical switching times as a function of gate resistor**
(inductive load, $T_j$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=20A,Dynamic test circuit in Figure E)

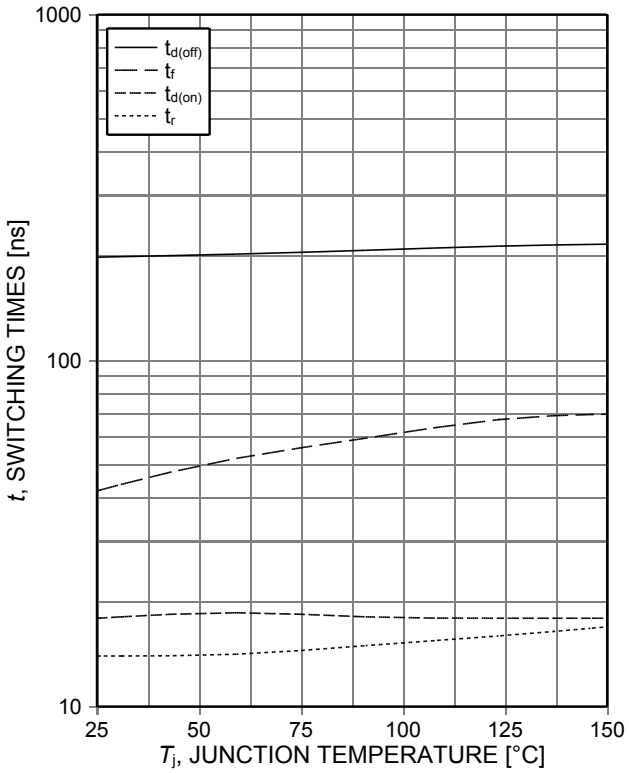



Figure 9. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=20A, $R_G$=12Ω,Dynamic test circuit in Figure E)

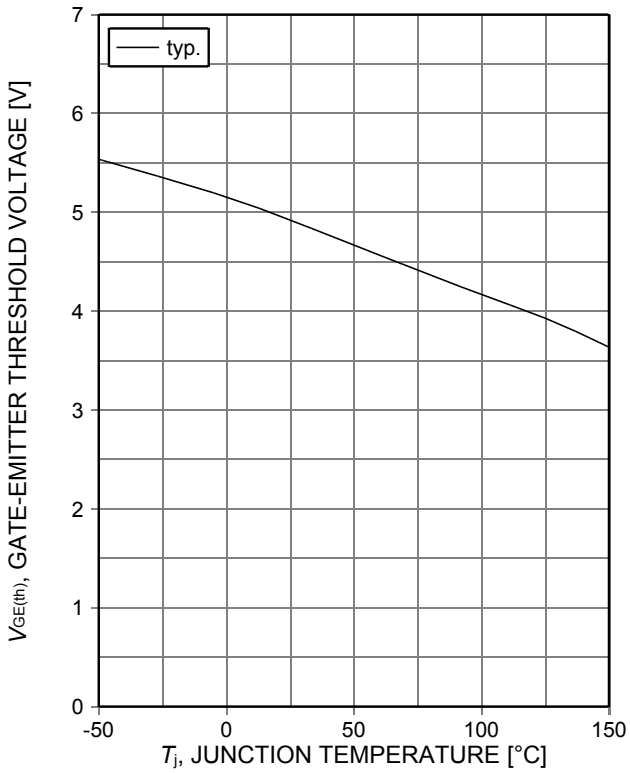



Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C$=0.29mA)

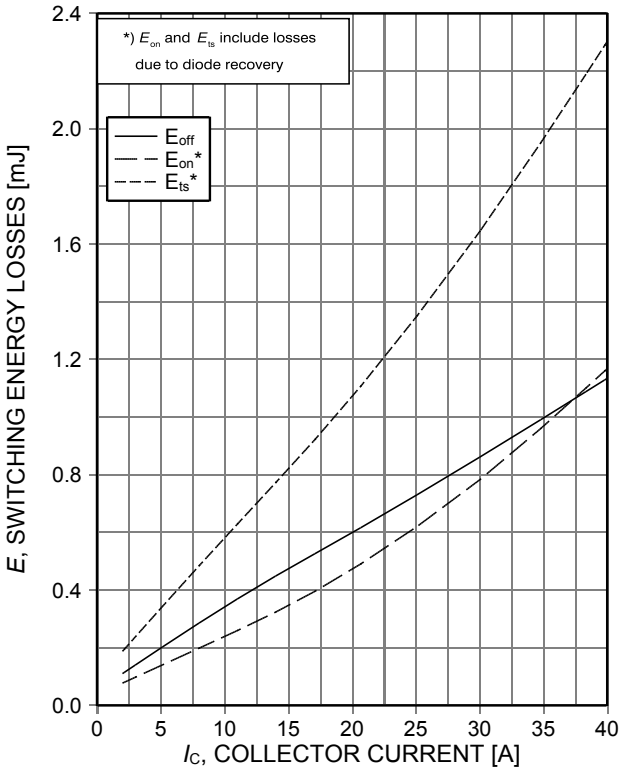



Figure 11. **Typical switching energy losses as a function of collector current**
(inductive load, $T_j$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $R_G$=12Ω,Dynamic test circuit in Figure E)

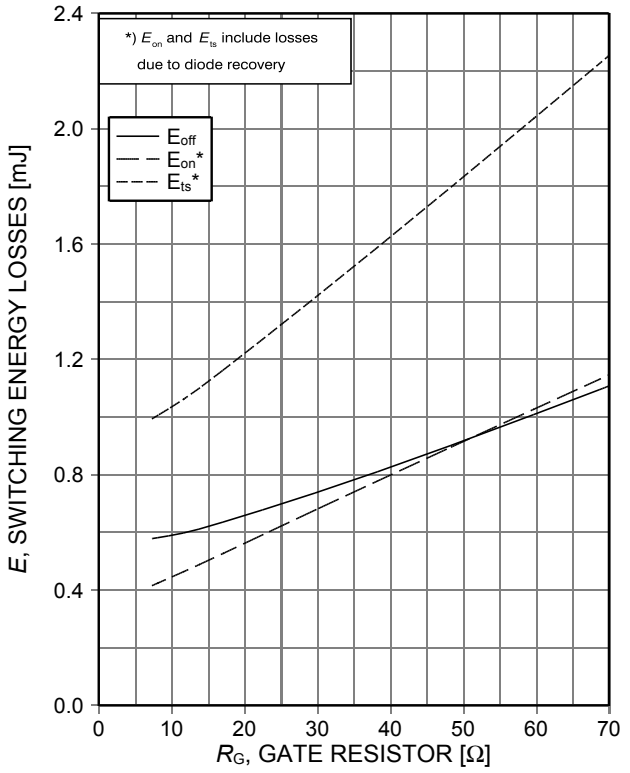



Figure 12. **Typical switching energy losses as a function of gate resistor**
(inductive load, $T_j$=150°C, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=20A,Dynamic test circuit in Figure E)

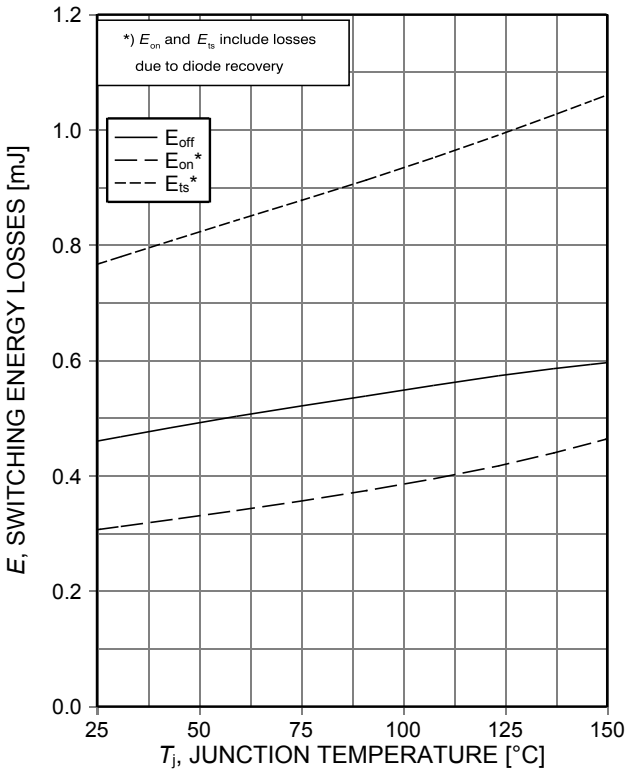



Figure 13. **Typical switching energy losses as a function of junction temperature** (inductive load, $V_{CE}$=400V, $V_{GE}$=15/0V, $I_C$=20A, $R_G$=12Ω,Dynamic test circuit in Figure E)

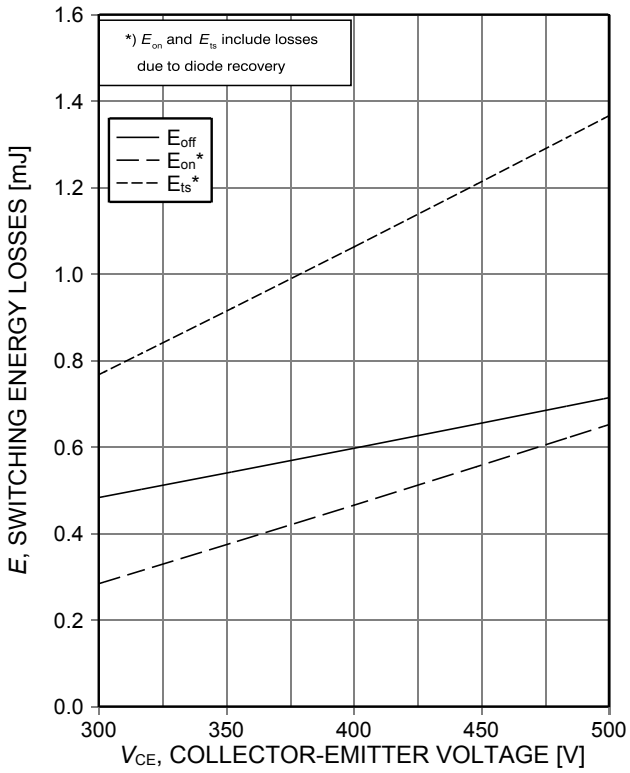



Figure 14. **Typical switching energy losses as a function of collector emitter voltage** (inductive load, $T_j$=150°C, $V_{GE}$=15/0V, $I_C$=20A, $R_G$=12Ω, Dynamic test circuit in Figure E)

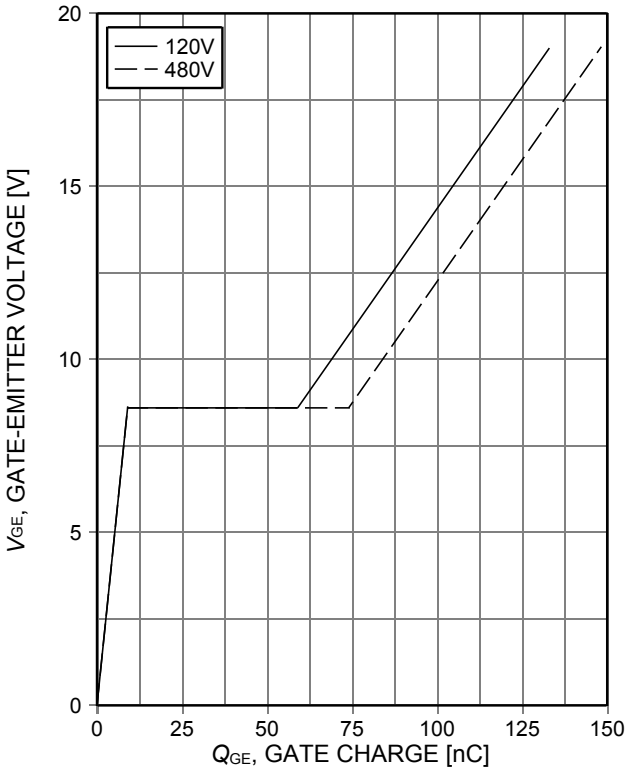



Figure 15. **Typical gate charge** ($I_C$=20A)

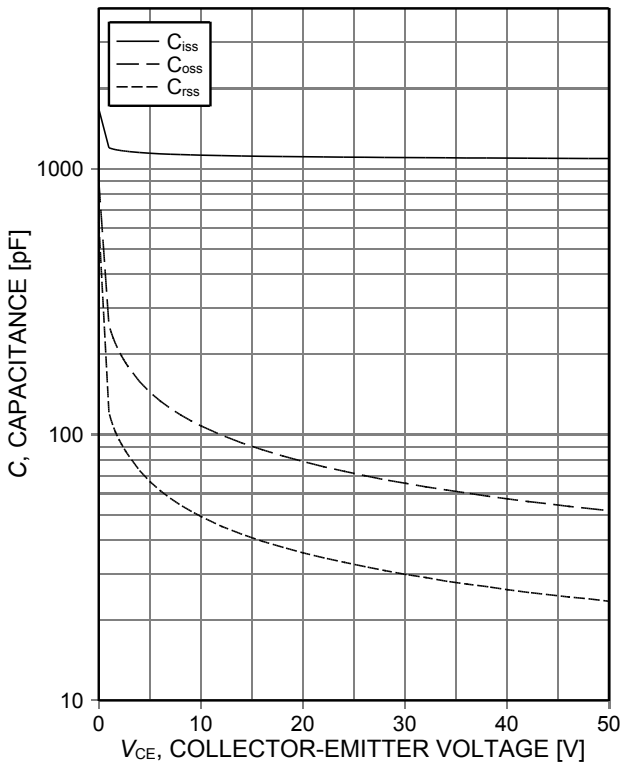



Figure 16. **Typical capacitance as a function of collector-emitter voltage** ($V_{GE}$=0V, f=1MHz)

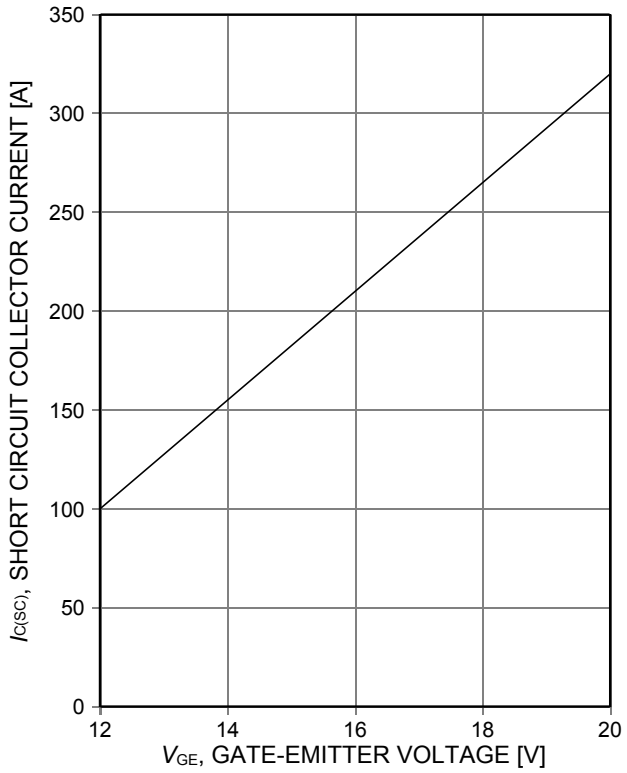



Figure 17. **Typical short circuit collector current as a function of gate-emitter voltage**
($V_{CE}$≤400V, $T_j$≤150°C)

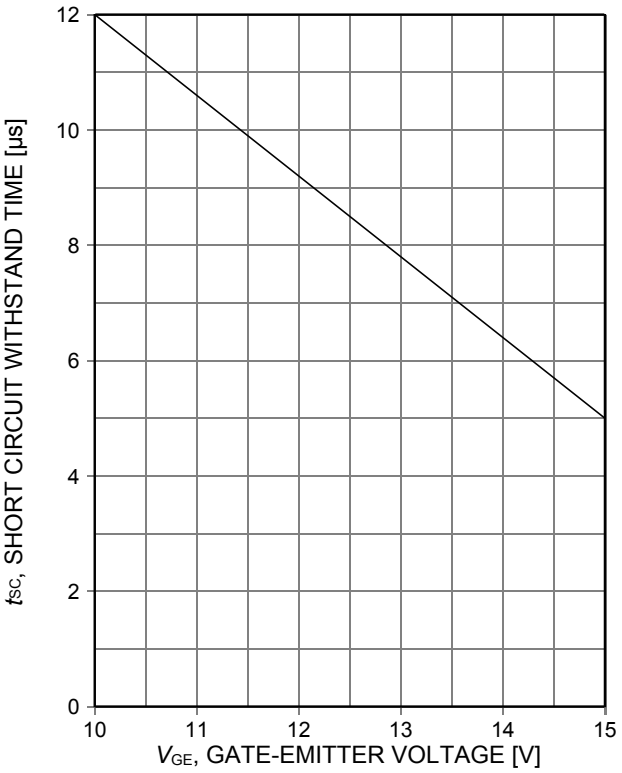



Figure 18. **Short circuit withstand time as a function of gate-emitter voltage**
($V_{CE}$=400V, start at $T_j$=25°C, $T_j$max≤150°C)

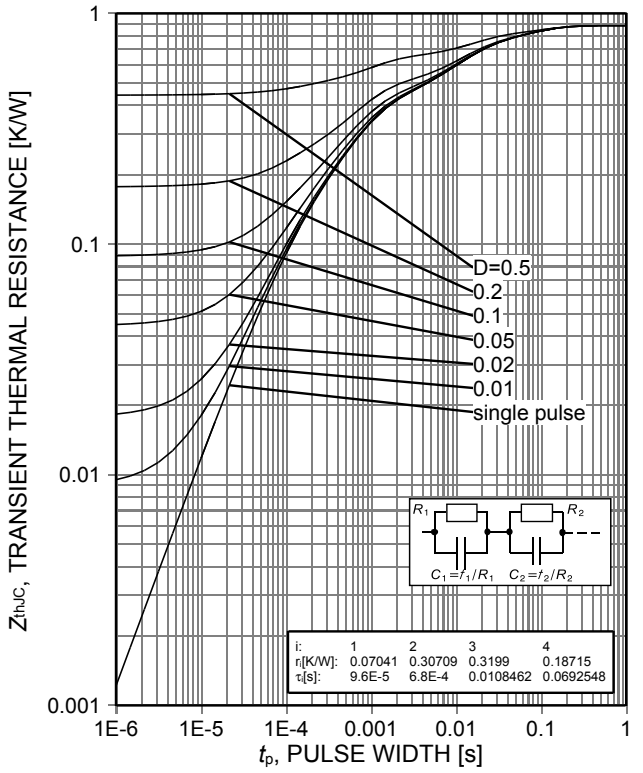



Figure 19. **IGBT transient thermal resistance as a function of pulse width for different duty cycles *D***
(*D*=$t_p$/T)

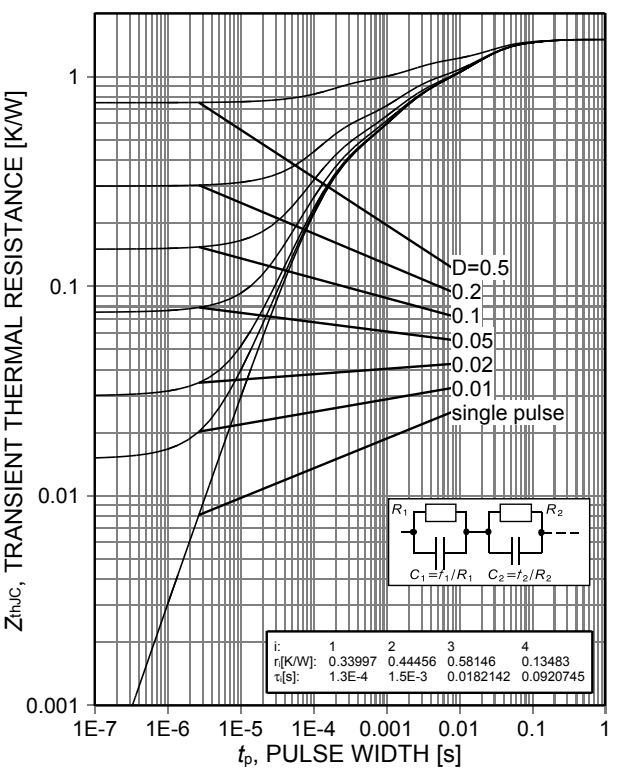



Figure 20. **Diode transient thermal impedance as a function of pulse width for different duty cycles *D***
(*D*=$t_p$/T)

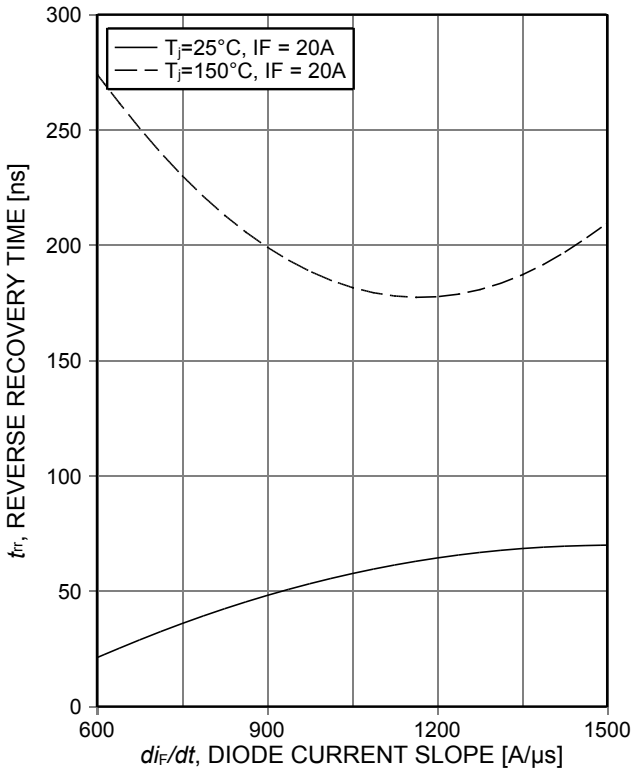



Figure 21. **Typical reverse recovery time as a function of diode current slope**
($V_R$=400V, Dynamic test circuit in Figure E)

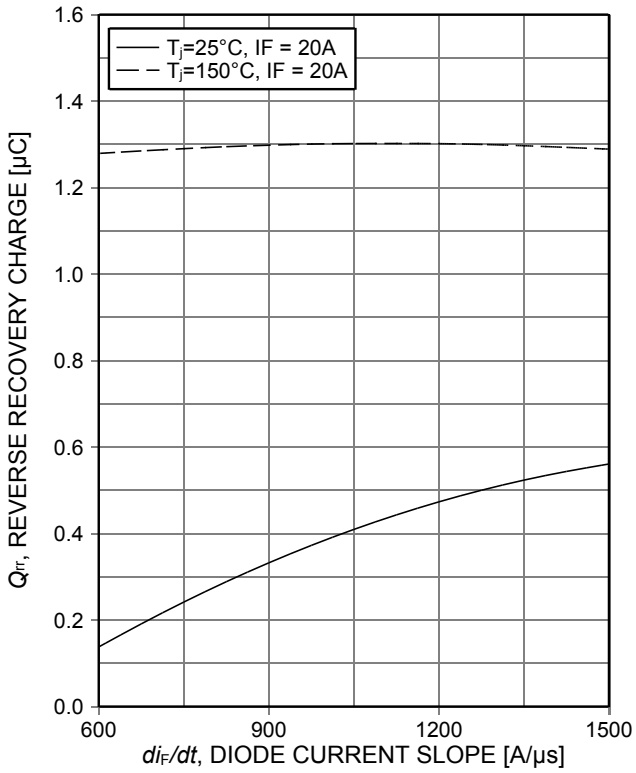



Figure 22. **Typical reverse recovery charge as a function of diode current slope**
($V_R$=400V, Dynamic test circuit in Figure E)

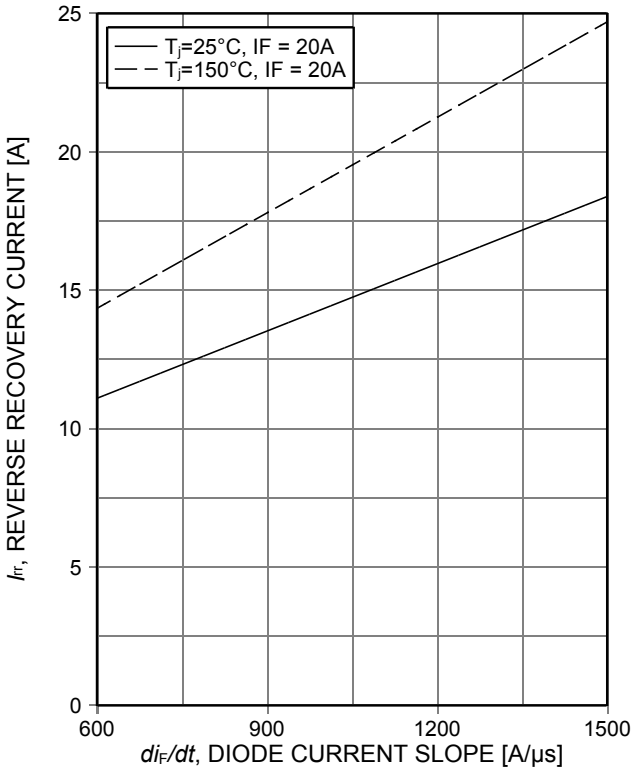



Figure 23. **Typical reverse recovery current as a function of diode current slope**
($V_R$=400V, Dynamic test circuit in Figure E)

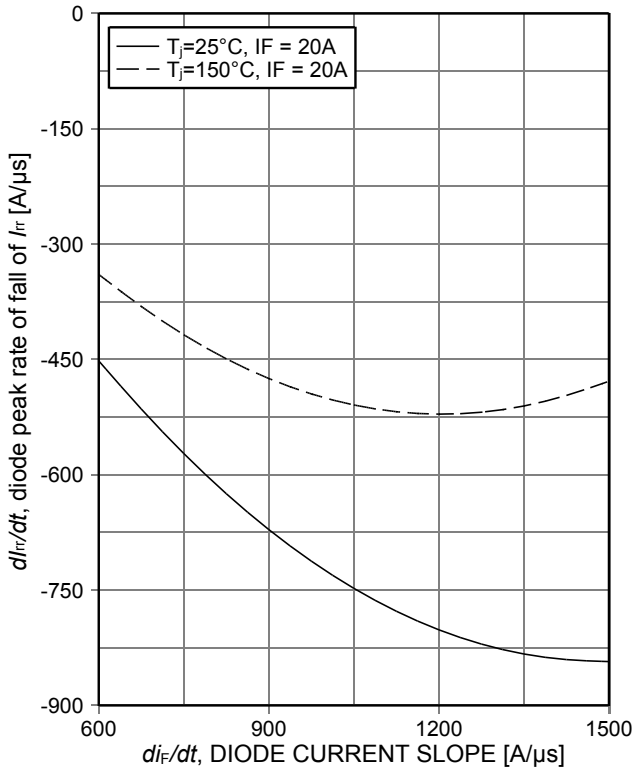



Figure 24. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**
($V_R$=400V, Dynamic test circuit in Figure E)

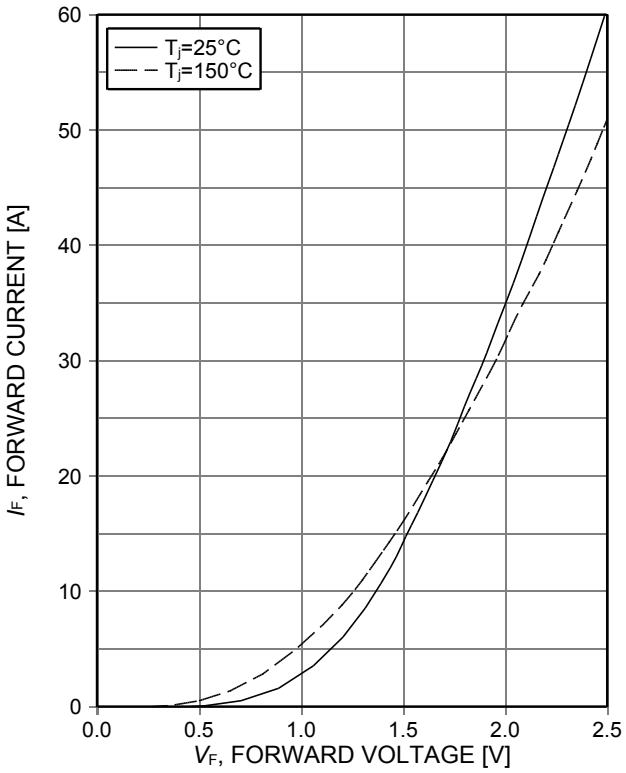



Figure 25. **Typical diode forward current as a function of forward voltage**

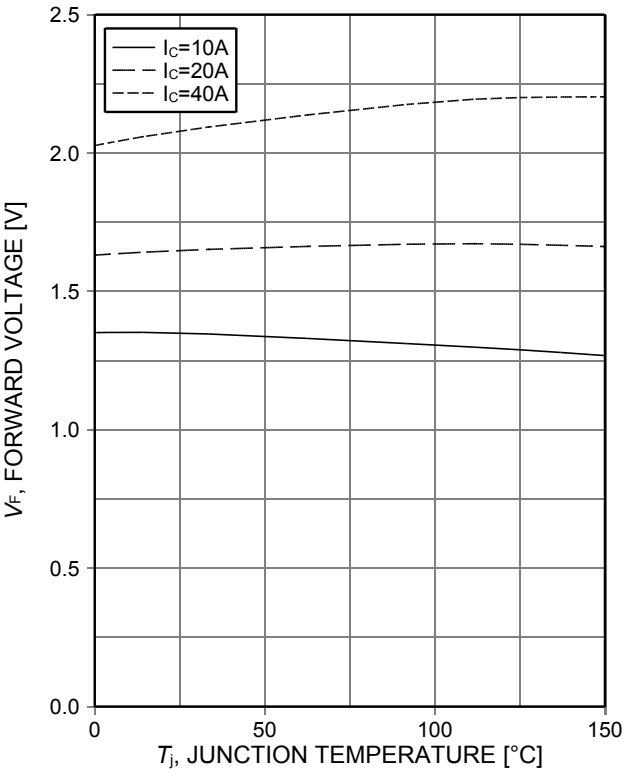
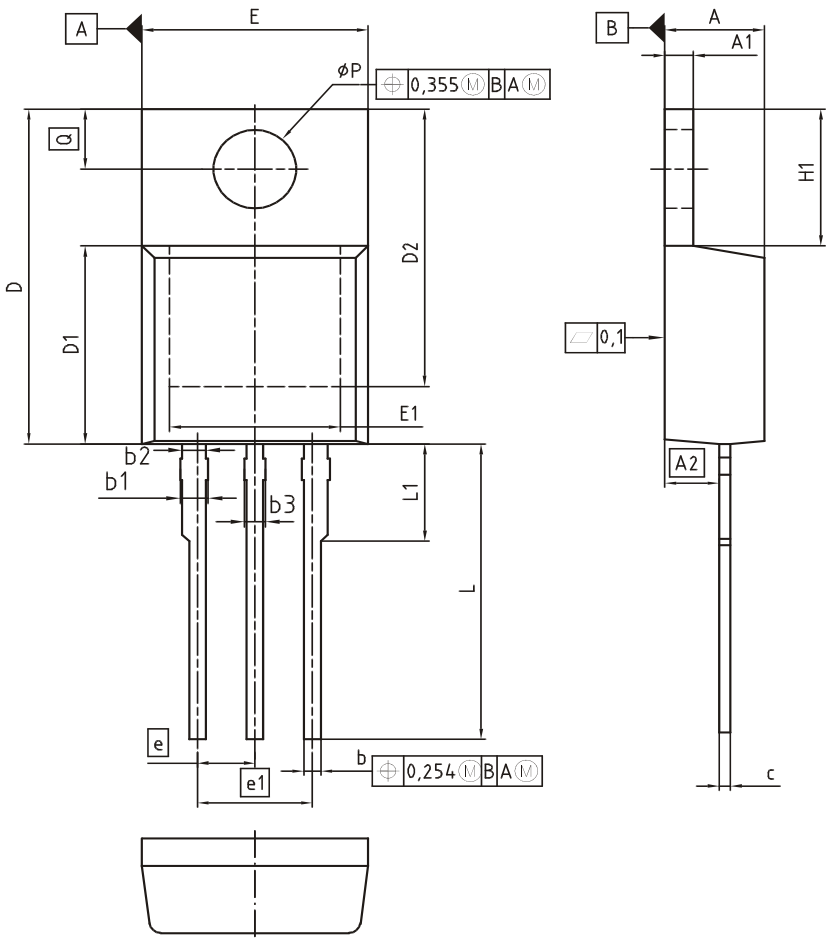



Figure 26. **Typical diode forward voltage as a function of junction temperature**

## Package Drawing 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 0 2.5 5mm

EUROPEAN PROJECTION

ISSUE DATE
30-07-2009

REVISION
06

### Testing Conditions

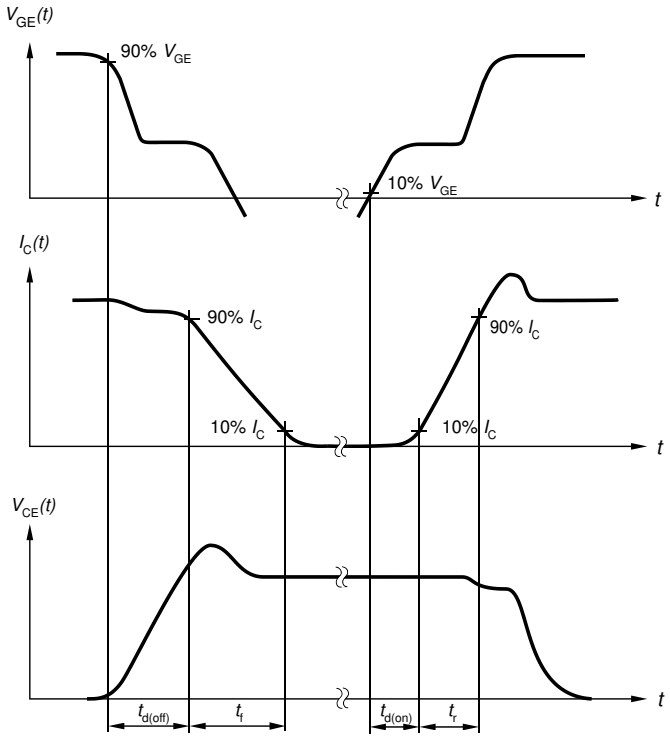



Figure A. **Definition of switching times**

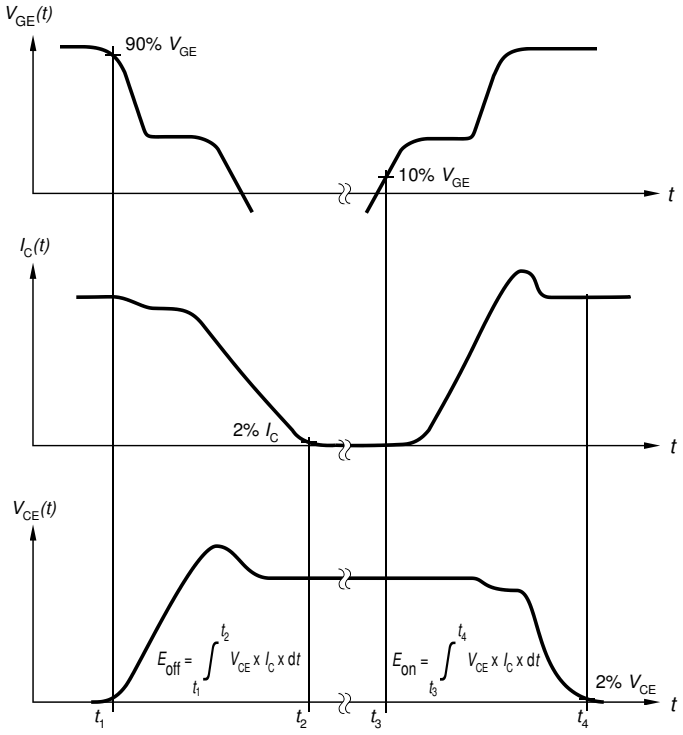



Figure B. **Definition of switching losses**

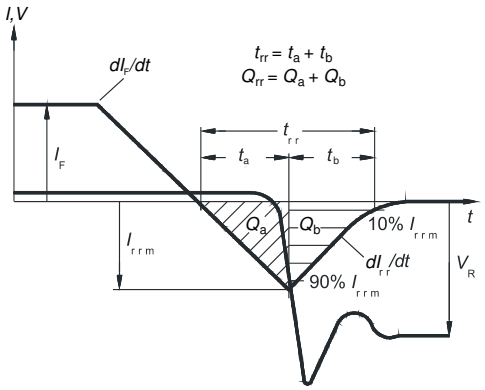



Figure C. **Definition of diode switching characteristics**

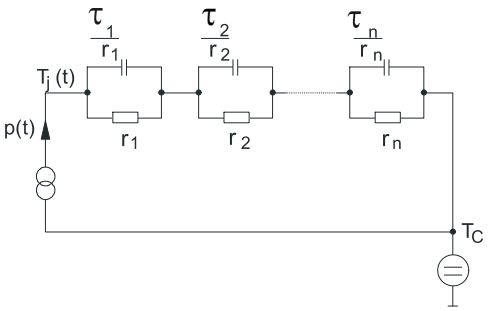



Figure D. **Thermal equivalent circuit**

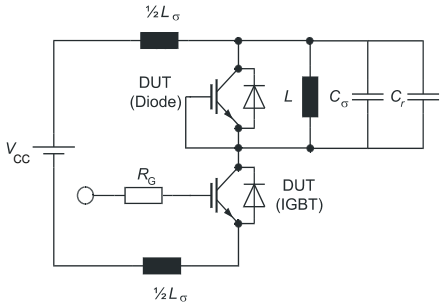



Figure E. **Dynamic test circuit**
Parasitic inductance $L_\sigma$,
parasitic capacitor $C_\sigma$,
relief capacitor $C_r$,
(only for ZVT switching)

## Revision History

AIKP20N60CT

**Revision: 2017-02-09, Rev. 2.1**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|---|---|---|
| 2.1 | 2017-02-09 | Data sheet created |

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