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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



IGBT

IGBT with integrated diode in packages offering space saving advantage

IKD10N60R, IKU10N60R

600V TRENCHSTOP™ RC-Series for hard switching applications

Datasheet

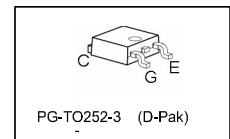
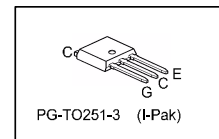
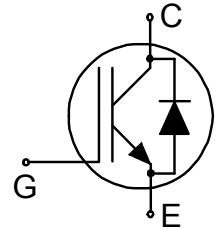
Industrial & Multimarket

IGBT with integrated diode in packages offering space saving advantage

Features:

TRENCHSTOP™ Reverse Conducting (RC) technology for 600V applications offering

- Optimised V_{CEsat} and V_F for low conduction losses
- Smooth switching performance leading to low EMI levels
- Very tight parameter distribution
- Operating range of 1 to 20kHz
- Maximum junction temperature 175°C
- Short circuit capability of 5μs
- Best in class current versus package size performance
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant (for PG-TO252: solder temperature 260°C, MSL1)
- Complete product spectrum and PSpice Models:
<http://www.infineon.com/igbt/>



Applications:

- Consumer motor drives



Key Performance and Package Parameters

| Type | V_{CE} | I_C | $V_{CEsat}, T_{vj}=25^\circ\text{C}$ | T_{vjmax} | Marking | Package |
|-----------|----------|-------|--------------------------------------|-------------|---------|------------|
| IKD10N60R | 600V | 10A | 1.65V | 175°C | K10R60 | PG-TO252-3 |
| IKU10N60R | 600V | 10A | 1.65V | 175°C | K10R60 | PG-TO251-3 |



Table of Contents

Description 2

Table of Contents 3

Maximum ratings 4

Thermal Resistance 4

Electrical Characteristics 5

Electrical Characteristics diagrams 8

Package Drawing PG-TO252-315

Package Drawing PG-TO251-316

Testing Conditions17

Revision History18

Disclaimer18

Maximum ratings

| Parameter | Symbol | Value | Unit |
|---|-------------|--------------|------------------|
| Collector-emitter voltage | V_{CE} | 600 | V |
| DC collector current, limited by T_{vjmax} $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$ | I_C | 20.0 10.0 | A |
| Pulsed collector current, t_p limited by T_{vjmax} | I_{Cpuls} | 30.0 | A |
| Turn off safe operating area $V_{CE} \leq 600\text{V}$, $T_{vj} \leq 175^\circ\text{C}$ | - | 30.0 | A |
| Diode forward current, limited by T_{vjmax} $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$ | I_F | 20.0 10.0 | A |
| Diode pulsed current, t_p limited by T_{vjmax} | I_{Fpuls} | 30.0 | A |
| Gate-emitter voltage | V_{GE} | ± 20 | V |
| Short circuit withstand time $V_{GE} = 15.0\text{V}$, $V_{CC} \leq 400\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^\circ\text{C}$ | t_{SC} | 5 | μs |
| Power dissipation $T_C = 25^\circ\text{C}$ | P_{tot} | 150.0 | W |
| Operating junction temperature | T_{vj} | -40...+175 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | -55...+175 | $^\circ\text{C}$ |
| Soldering temperature, wave soldering 1.6 mm (0.063 in.) from case for 10s | PG-TO251-3 | 260 | $^\circ\text{C}$ |
| reflow soldering (MSL1 according to JEDEC J-STA-020) | PG-TO252-3 | 260 | |

Thermal Resistance

| Parameter | Symbol | Conditions | Max. Value | Unit |
|---|---------------|------------|------------|------|
| Characteristic | | | | |
| IGBT thermal resistance, ¹⁾ junction - case | $R_{th(j-c)}$ | | 1.00 | K/W |
| Diode thermal resistance, ²⁾ junction - case | $R_{th(j-c)}$ | | 2.60 | K/W |
| Thermal resistance, min. footprint junction - ambient | $R_{th(j-a)}$ | PG-TO252-3 | 75 | K/W |
| Thermal resistance, 6cm ² Cu on PCB junction - ambient | $R_{th(j-a)}$ | PG-TO252-3 | 50 | K/W |
| Thermal resistance junction - ambient | $R_{th(j-a)}$ | PG-TO251-3 | 75 | K/W |

¹⁾ Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the IGBT, is not possible using a thermocouple.

²⁾ Rth/Zth based on single cooling pulse. Please be aware that a correct Rth measurement of the Diode, is not possible using a thermocouple.

Electrical Characteristic, at $T_{vj} = 25^{\circ}\text{C}$, unless otherwise specified

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---------------|--|--------|--------------|----------------|---------------|
| | | | min. | typ. | max. | |
| Static Characteristic | | | | | | |
| Collector-emitter breakdown voltage | $V_{(BR)CES}$ | $V_{GE} = 0\text{V}, I_C = 0.20\text{mA}$ | 600 | - | - | V |
| Collector-emitter saturation voltage | V_{CEsat} | $V_{GE} = 15.0\text{V}, I_C = 10.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$ | - - | 1.65 1.85 | 2.10 - | V |
| Diode forward voltage | V_F | $V_{GE} = 0\text{V}, I_F = 10.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$ | - - | 1.70 1.70 | 2.10 | V |
| Gate-emitter threshold voltage | $V_{GE(th)}$ | $I_C = 0.17\text{mA}, V_{CE} = V_{GE}$ | 4.3 | 5.0 | 5.7 | V |
| Zero gate voltage collector current ¹⁾ | I_{CES} | $V_{CE} = 600\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$ | - - | - - | 40.0 1000.0 | μA |
| Gate-emitter leakage current | I_{GES} | $V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$ | - | - | 100 | nA |
| Transconductance | g_{fs} | $V_{CE} = 20\text{V}, I_C = 10.0\text{A}$ | - | 6.1 | - | S |
| Integrated gate resistor | r_G | | | none | | Ω |

Electrical Characteristic, at $T_{vj} = 25^{\circ}\text{C}$, unless otherwise specified

| Parameter | Symbol | Conditions | Value | | | Unit |
|--|-------------|--|-------|----------|------|------|
| | | | min. | typ. | max. | |
| Dynamic Characteristic | | | | | | |
| Input capacitance | C_{ies} | $V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$ | - | 655 | - | pF |
| Output capacitance | C_{oes} | | - | 37 | - | |
| Reverse transfer capacitance | C_{res} | | - | 22 | - | |
| Gate charge | Q_G | $V_{CC} = 480\text{V}, I_C = 10.0\text{A},$ $V_{GE} = 15\text{V}$ | - | 64.0 | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | L_E | PG-TO252-3 PG-TO251-3 | - | - 7.0 | - | nH |
| Short circuit collector current Max. 1000 short circuits Time between short circuits: $\geq 1.0\text{s}$ | $I_{C(SC)}$ | $V_{GE} = 15.0\text{V}, V_{CC} \leq 400\text{V},$ $t_{SC} \leq 5\mu\text{s}$ $T_{vj} = 25^{\circ}\text{C}$ | - | 74 | - | A |

¹⁾ Not subject to production test - verified by design/characterization

Switching Characteristic, Inductive Load, at $T_{vj} = 25^{\circ}\text{C}$

| Parameter | Symbol | Conditions | Value | | | Unit |
|----------------------------|--------------|---|-------|------|------|------|
| | | | min. | typ. | max. | |
| IGBT Characteristic | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj} = 25^{\circ}\text{C}$, $V_{CC} = 400\text{V}$, $I_C = 10.0\text{A}$, $V_{GE} = 0.0/15.0\text{V}$, $r_G = 23.0\Omega$, $L_{\sigma} = 60\text{nH}$, $C_{\sigma} = 40\text{pF}$ L_{σ} , C_{σ} from Fig. E | - | 14 | - | ns |
| Rise time | t_r | | - | 10 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 192 | - | ns |
| Fall time | t_f | | - | 139 | - | ns |
| Turn-on energy | E_{on} | | - | 0.21 | - | mJ |
| Turn-off energy | E_{off} | | - | 0.38 | - | mJ |
| Total switching energy | E_{ts} | | - | 0.59 | - | mJ |

Diode Characteristic, at $T_{vj} = 25^{\circ}\text{C}$

| | | | | | | |
|--|--------------|--|---|------|---|------------------------|
| Diode reverse recovery time | t_{rr} | $T_{vj} = 25^{\circ}\text{C}$, $V_R = 400\text{V}$, $I_F = 10.0\text{A}$, $di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 62 | - | ns |
| Diode reverse recovery charge | Q_{rr} | | - | 0.56 | - | μC |
| Diode peak reverse recovery current | I_{rrm} | | - | 20.3 | - | A |
| Diode peak rate of fall of reverse recovery current during t_b | di_{rr}/dt | | - | -260 | - | $\text{A}/\mu\text{s}$ |

Switching Characteristic, Inductive Load, at $T_{vj} = 175^{\circ}\text{C}$

| Parameter | Symbol | Conditions | Value | | | Unit |
|----------------------------|--------------|--|-------|------|------|------|
| | | | min. | typ. | max. | |
| IGBT Characteristic | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $T_{vj} = 175^{\circ}\text{C}$, $V_{CC} = 400\text{V}$, $I_C = 10.0\text{A}$, $V_{GE} = 0.0/15.0\text{V}$, $r_G = 23.0\Omega$, $L_{\sigma} = 60\text{nH}$, $C_{\sigma} = 40\text{pF}$ L_{σ} , C_{σ} from Fig. E | - | 13 | - | ns |
| Rise time | t_r | | - | 11 | - | ns |
| Turn-off delay time | $t_{d(off)}$ | | - | 217 | - | ns |
| Fall time | t_f | | - | 211 | - | ns |
| Turn-on energy | E_{on} | | - | 0.35 | - | mJ |
| Turn-off energy | E_{off} | | - | 0.58 | - | mJ |
| Total switching energy | E_{ts} | | - | 0.93 | - | mJ |

Diode Characteristic, at $T_{vj} = 175^{\circ}\text{C}$

| | | | | | | |
|--|--------------|---|---|------|---|------------------------|
| Diode reverse recovery time | t_{rr} | $T_{vj} = 175^{\circ}\text{C}$, $V_R = 400\text{V}$, $I_F = 10.0\text{A}$, $di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 98 | - | ns |
| Diode reverse recovery charge | Q_{rr} | | - | 1.22 | - | μC |
| Diode peak reverse recovery current | I_{rrm} | | - | 20.5 | - | A |
| Diode peak rate of fall of reverse recovery current during t_b | di_{rr}/dt | | - | -259 | - | $\text{A}/\mu\text{s}$ |

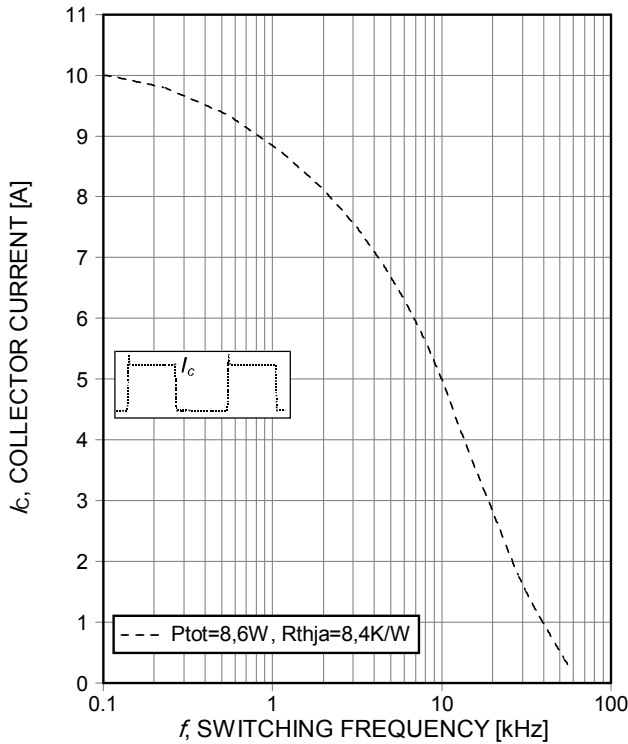


Figure 1. Collector current as a function of switching frequency
 ($T_{vj} \leq 175^\circ\text{C}$, $T_a = 55^\circ\text{C}$, $D = 0.5$, $V_{CE} = 400\text{V}$, $V_{GE} = 15/0\text{V}$, $r_G = 23\Omega$, PCB mounting with thermal vias and heatsink, see Appnote: www.infineon.com/igbt)

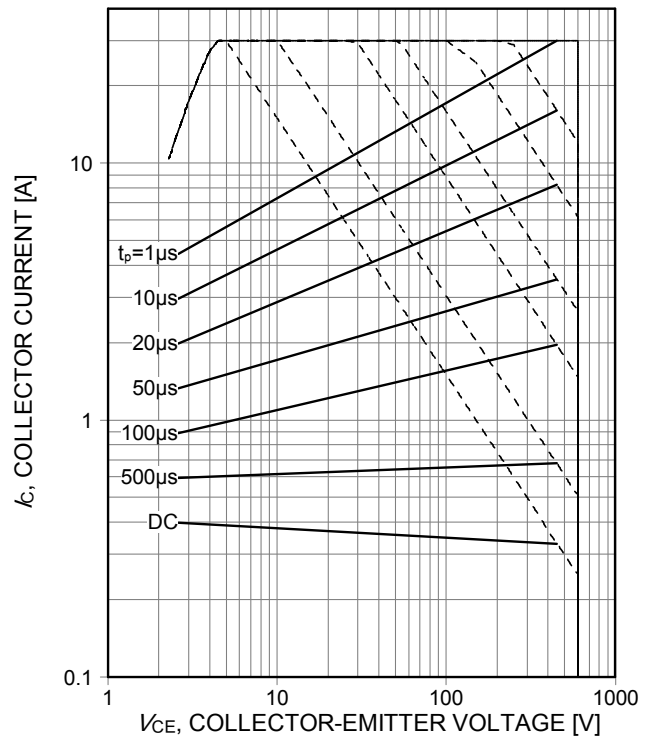


Figure 2. Forward bias safe operating area
 ($D = 0$, $T_C = 25^\circ\text{C}$, $T_{vj} \leq 175^\circ\text{C}$; $V_{GE} = 15\text{V}$)

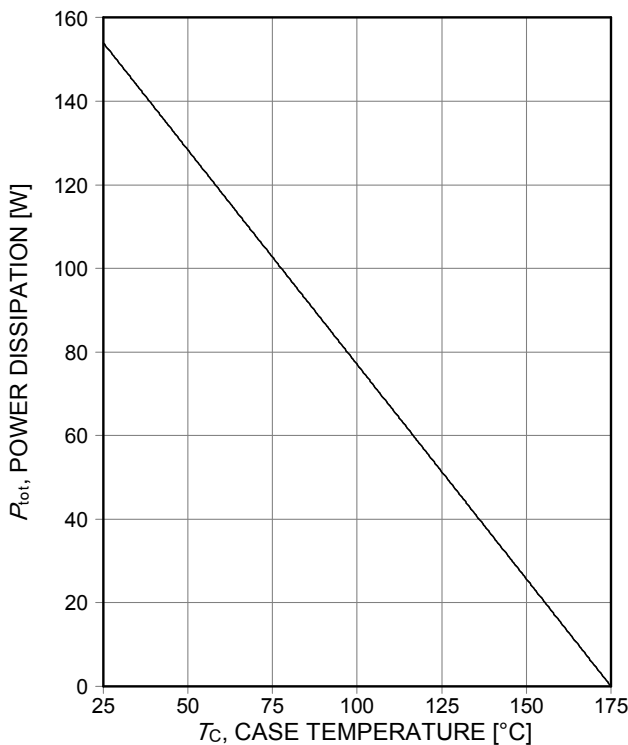


Figure 3. Power dissipation as a function of case temperature
 ($T_{vj} \leq 175^\circ\text{C}$)

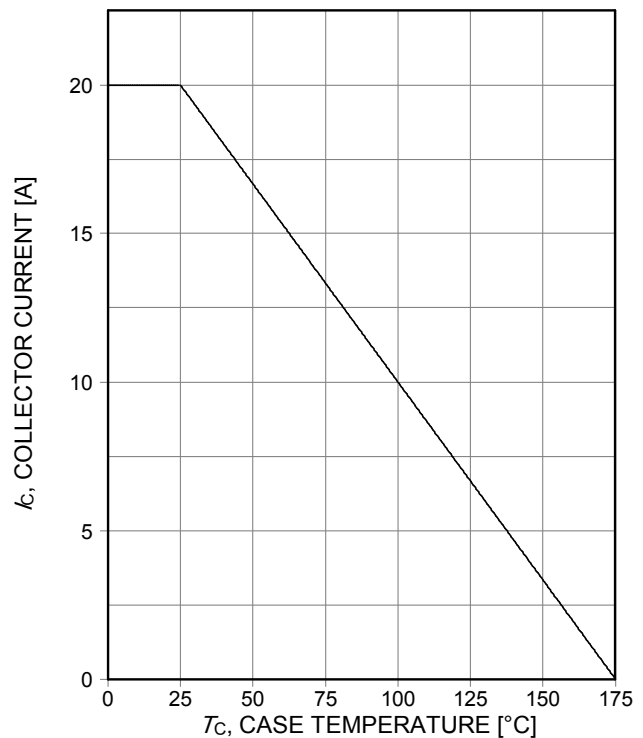


Figure 4. Collector current as a function of case temperature
 ($V_{GE} \geq 15\text{V}$, $T_{vj} \leq 175^\circ\text{C}$)

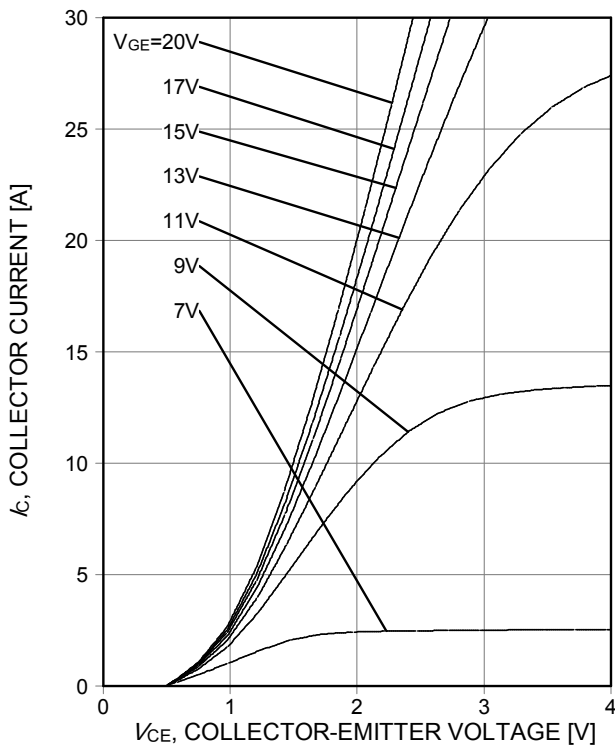


Figure 5. Typical output characteristic
($T_{vj}=25^{\circ}\text{C}$)

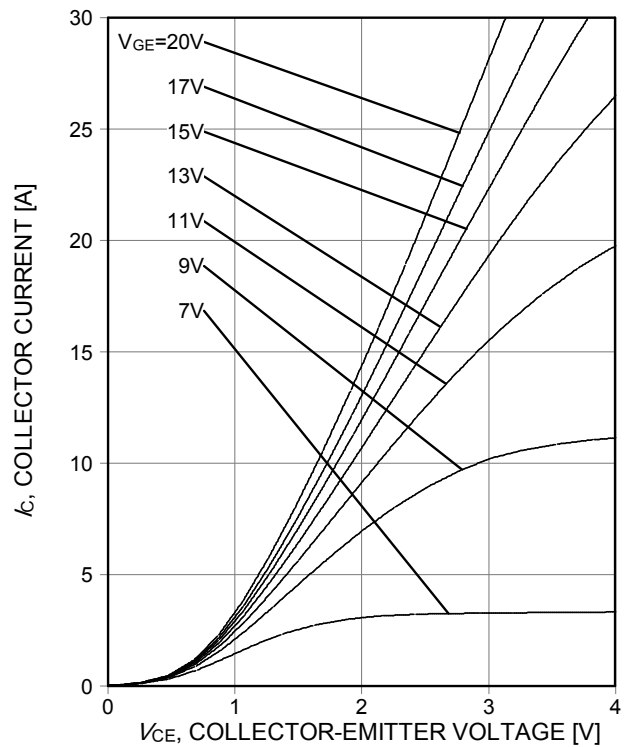


Figure 6. Typical output characteristic
($T_{vj}=175^{\circ}\text{C}$)

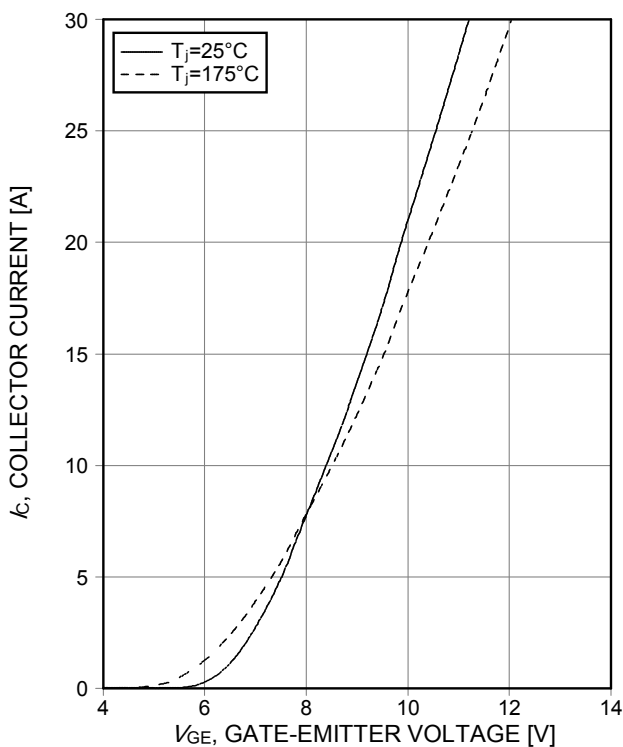


Figure 7. Typical transfer characteristic
($V_{ce}=10\text{V}$)

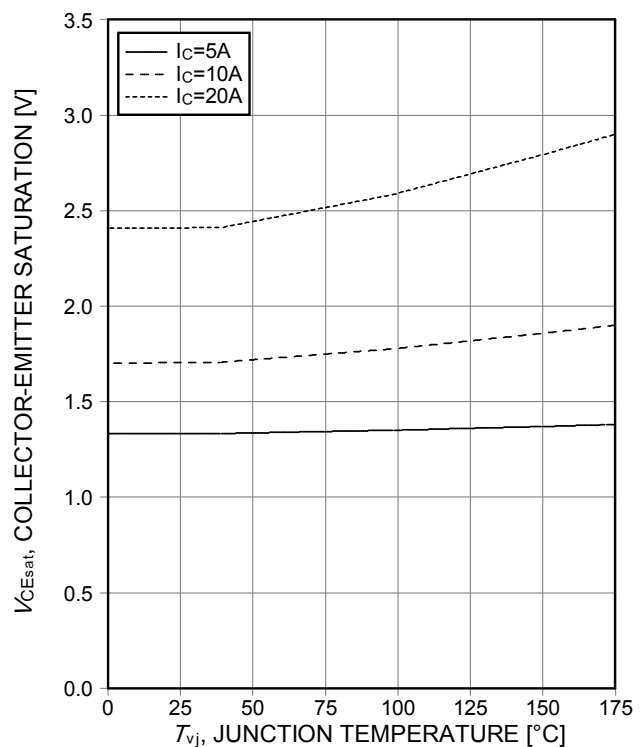


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
($V_{ge}=15\text{V}$)

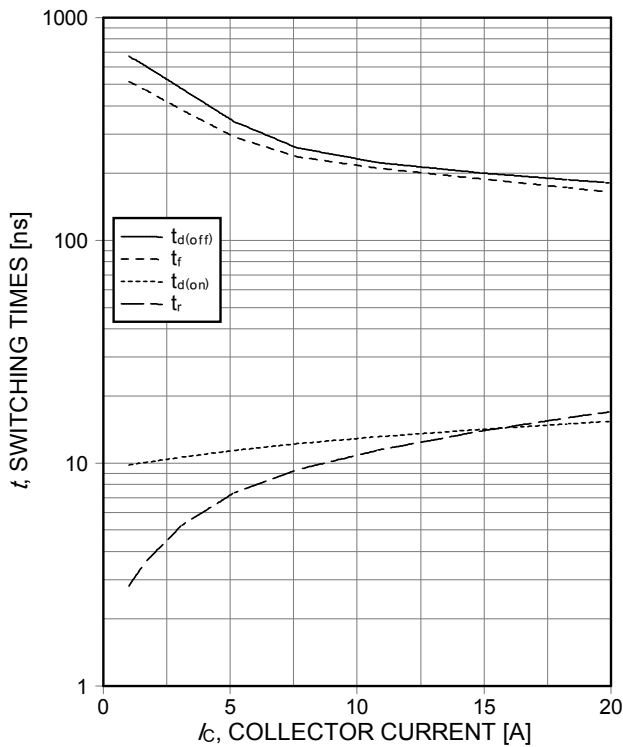


Figure 9. Typical switching times as a function of collector current
 (inductive load, $T_{vj}=175^{\circ}\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

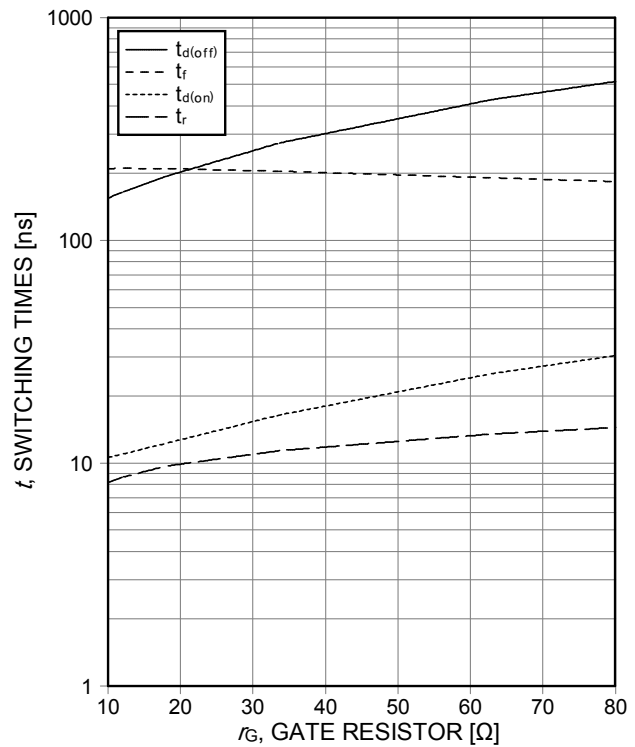


Figure 10. Typical switching times as a function of gate resistor
 (inductive load, $T_{vj}=175^{\circ}\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $I_C=10\text{A}$, Dynamic test circuit in Figure E)

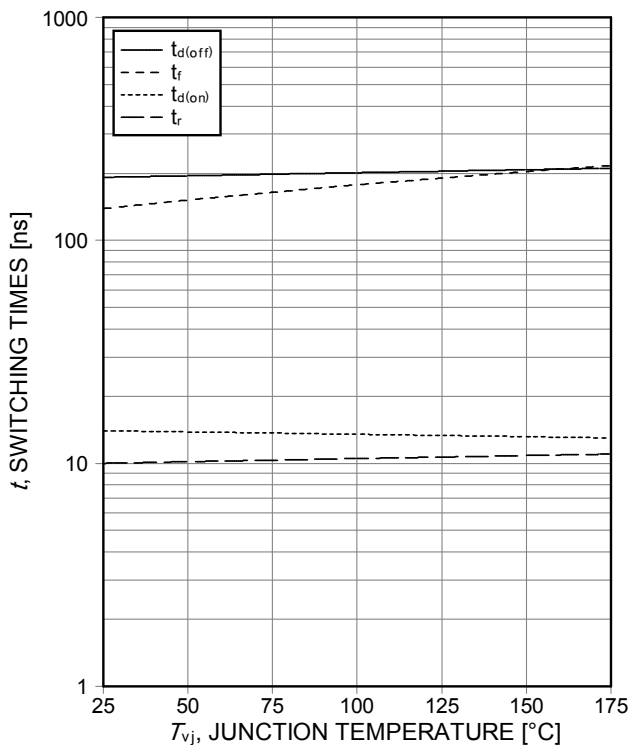


Figure 11. Typical switching times as a function of junction temperature
 (inductive load, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $I_C=10\text{A}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

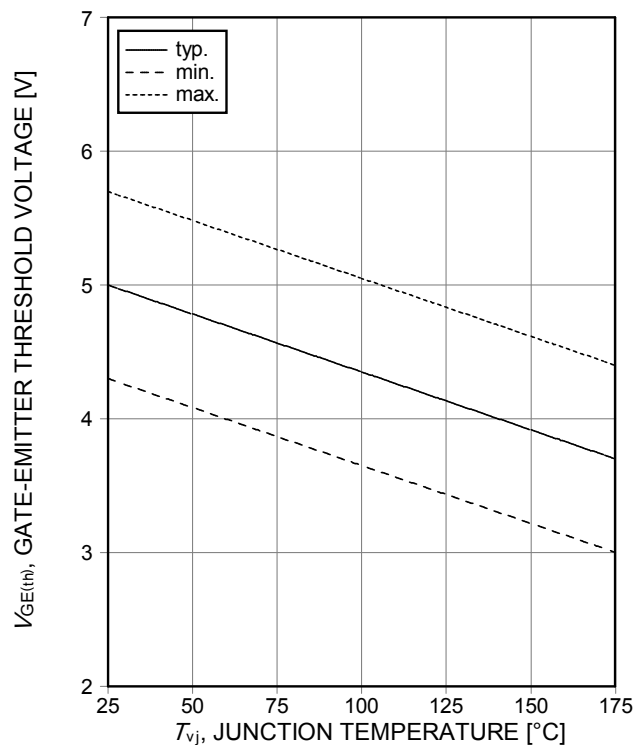


Figure 12. Gate-emitter threshold voltage as a function of junction temperature
 ($I_C=0.17\text{mA}$)

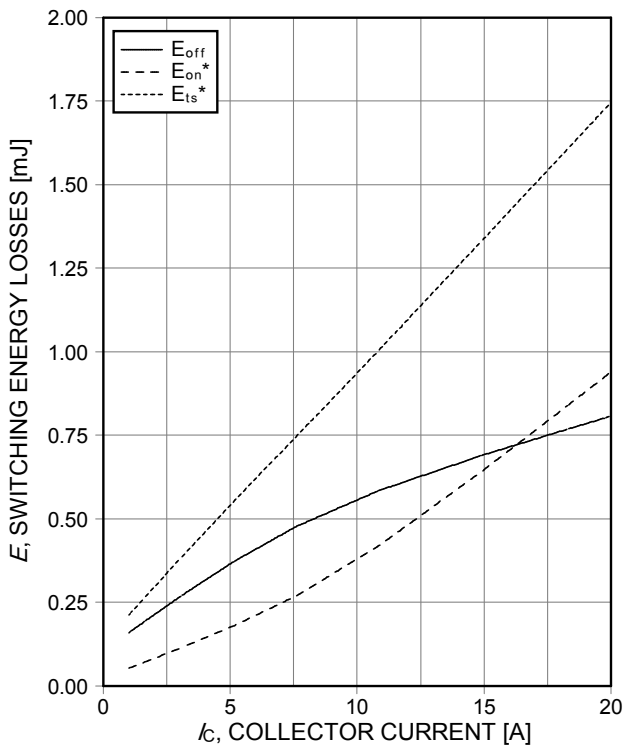


Figure 13. Typical switching energy losses as a function of collector current
 (inductive load, $T_{vj}=175^{\circ}\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

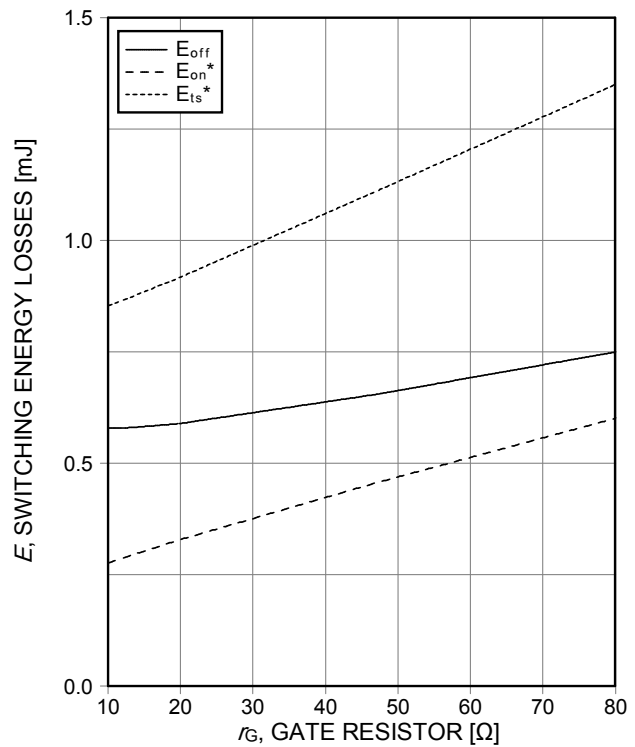


Figure 14. Typical switching energy losses as a function of gate resistor
 (inductive load, $T_{vj}=175^{\circ}\text{C}$, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $I_C=10\text{A}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

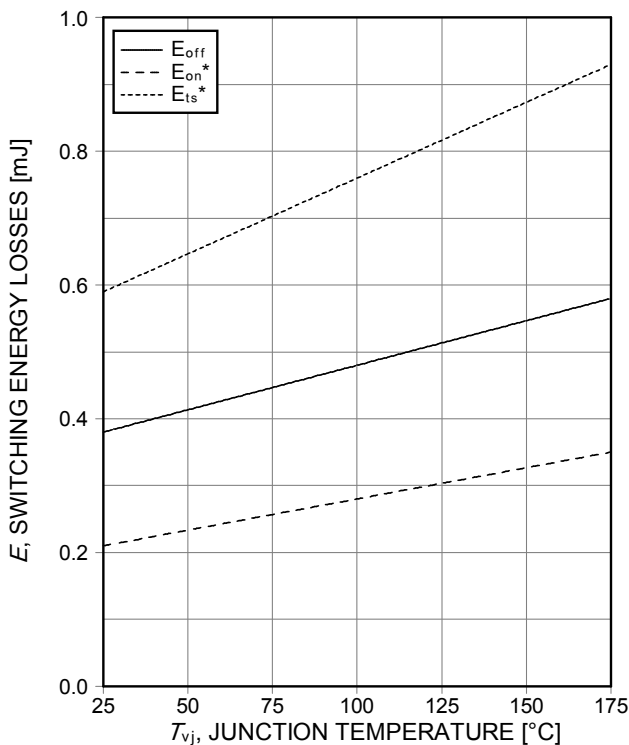


Figure 15. Typical switching energy losses as a function of junction temperature
 (inductive load, $V_{CE}=400\text{V}$, $V_{GE}=15/0\text{V}$, $I_C=10\text{A}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

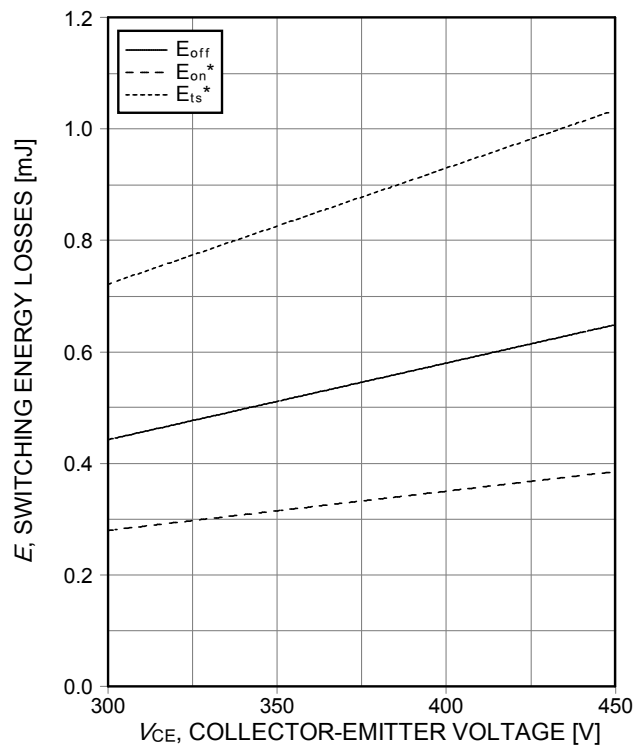


Figure 16. Typical switching energy losses as a function of collector emitter voltage
 (inductive load, $T_{vj}=175^{\circ}\text{C}$, $V_{GE}=15/0\text{V}$, $I_C=10\text{A}$, $r_G=23\Omega$, Dynamic test circuit in Figure E)

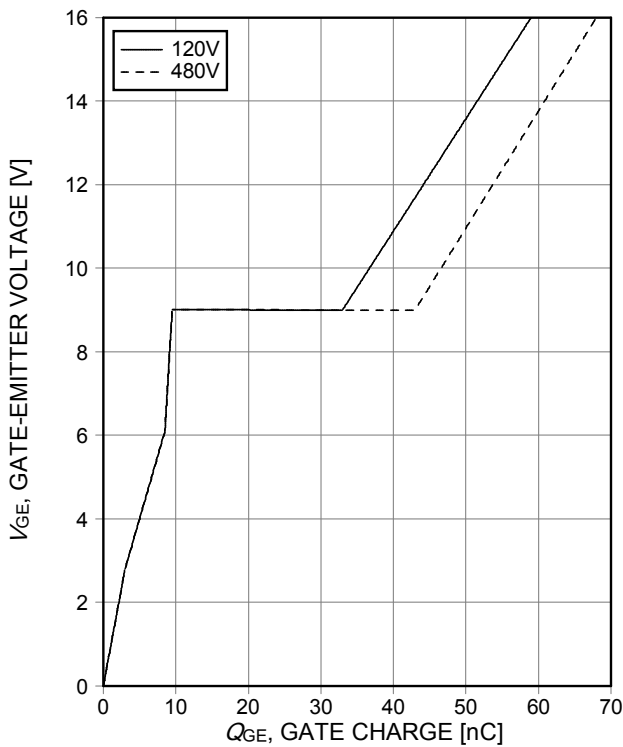


Figure 17. Typical gate charge
($I_C=10A$)

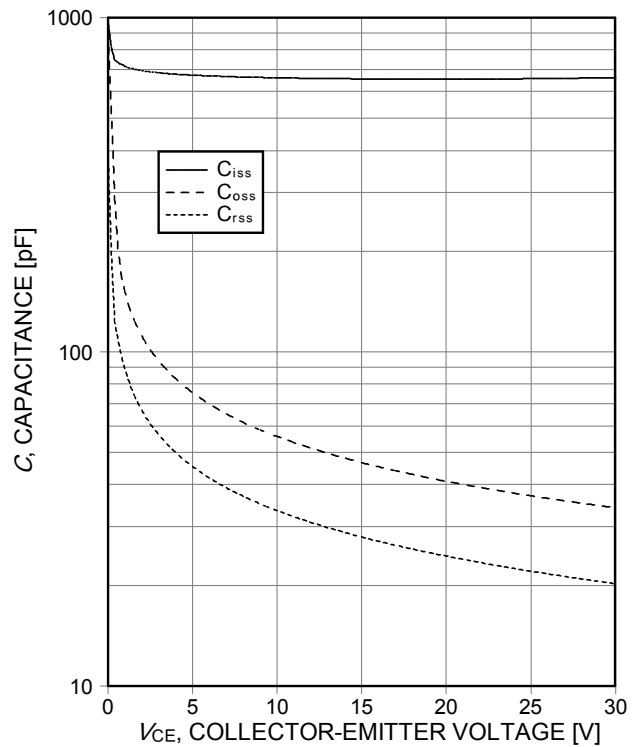


Figure 18. Typical capacitance as a function of collector-emitter voltage
($V_{GE}=0V$, $f=1MHz$)

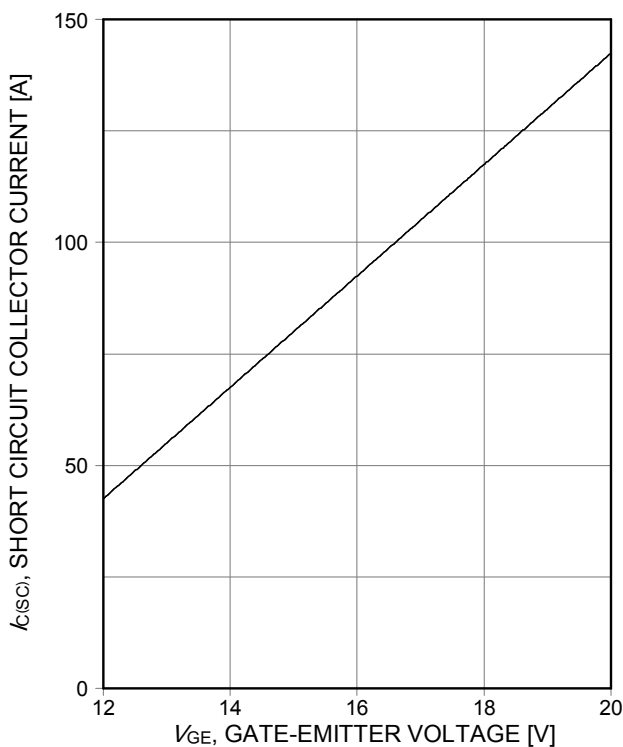


Figure 19. Typical short circuit collector current as a function of gate-emitter voltage
($V_{CE} \leq 400V$, start at $T_{vj}=25^\circ C$)

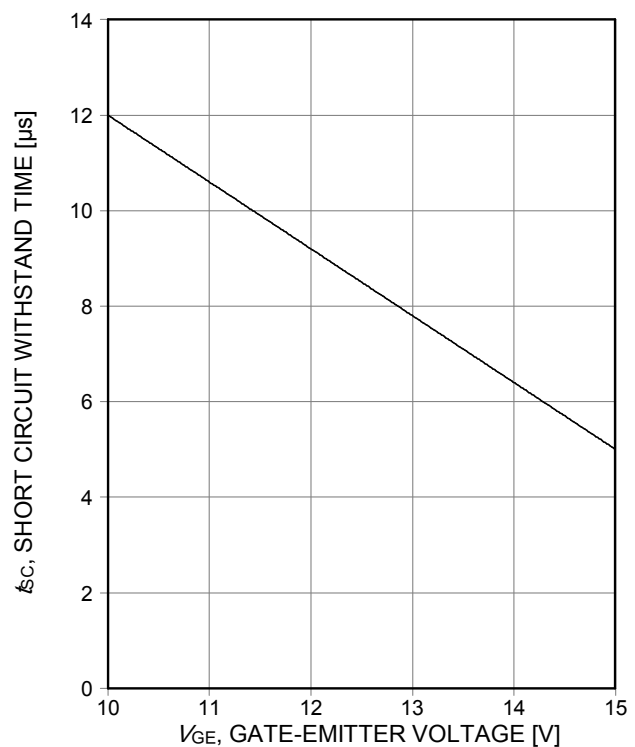


Figure 20. Short circuit withstand time as a function of gate-emitter voltage
($V_{CE} \leq 400V$, start at $T_{vj} \leq 150^\circ C$)

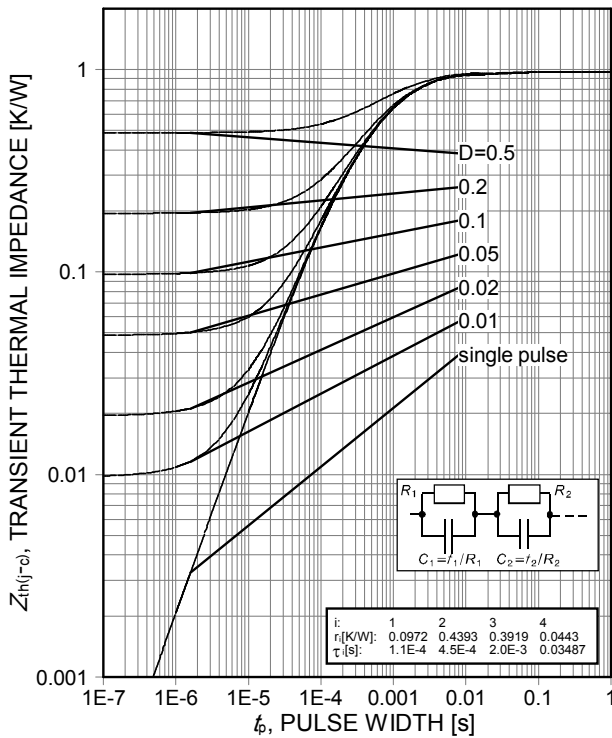


Figure 21. IGBT transient thermal impedance as a function of pulse width ¹⁾ (see page 4) ($D=t_p/T$)

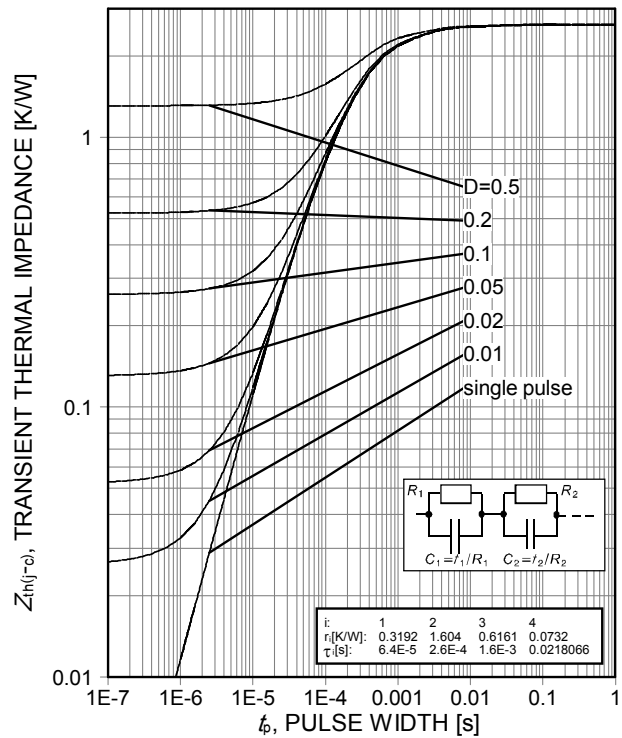


Figure 22. Diode transient thermal impedance as a function of pulse width ²⁾ (see page 4) ($D=t_p/T$)

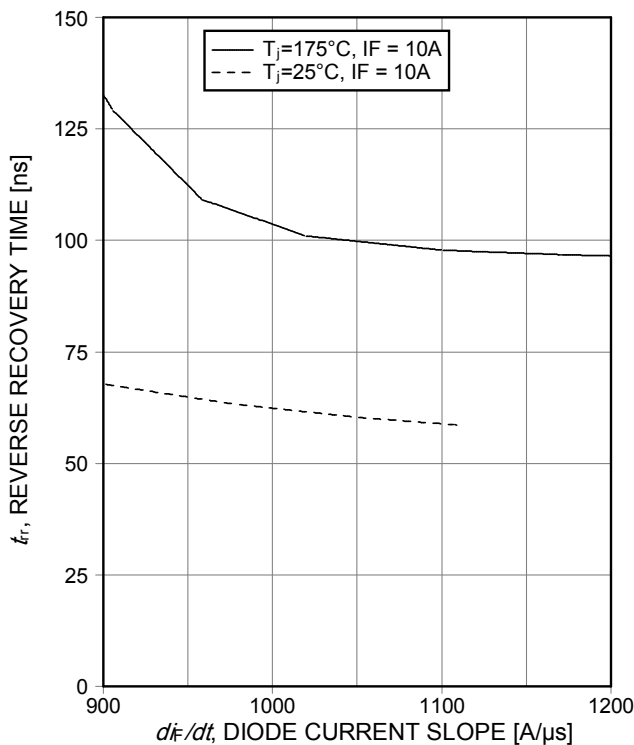


Figure 23. Typical reverse recovery time as a function of diode current slope ($V_R=400V$)

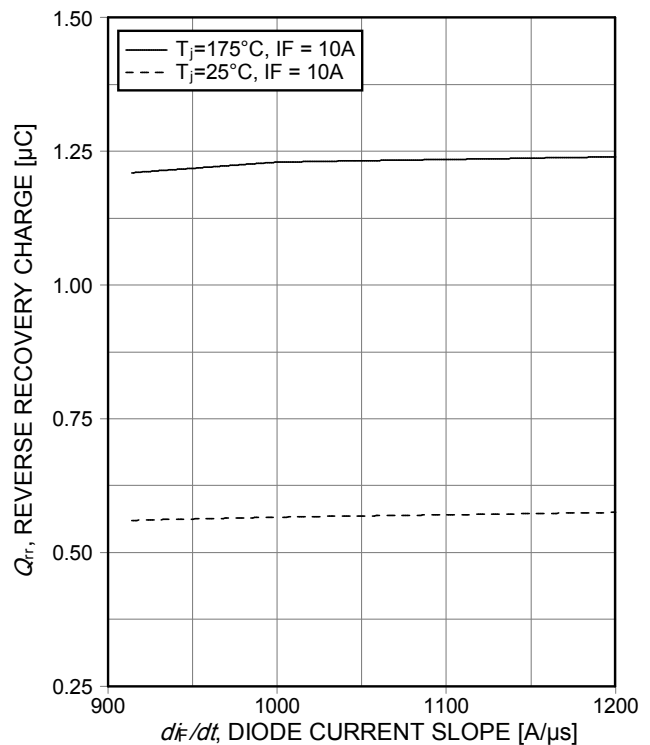


Figure 24. Typical reverse recovery charge as a function of diode current slope ($V_R=400V$)

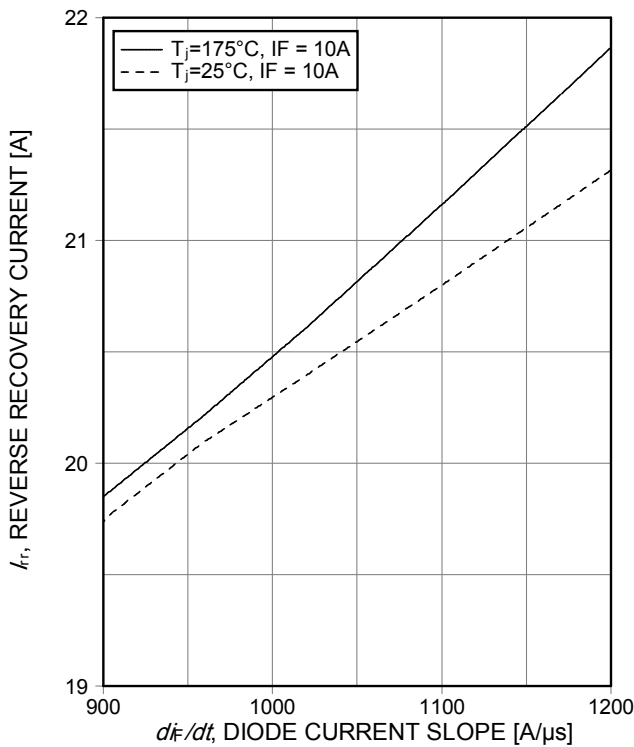


Figure 25. Typical reverse recovery current as a function of diode current slope
($V_R=400V$)

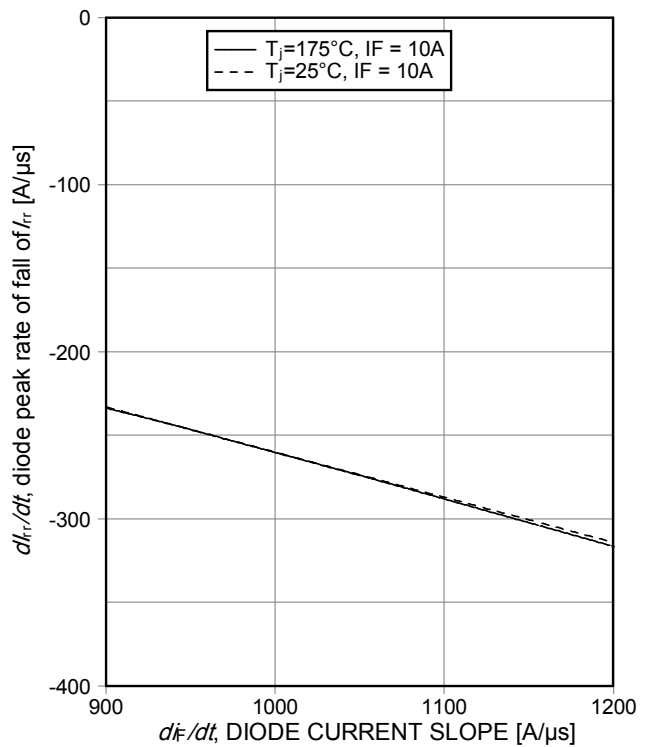


Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
($V_R=400V$)

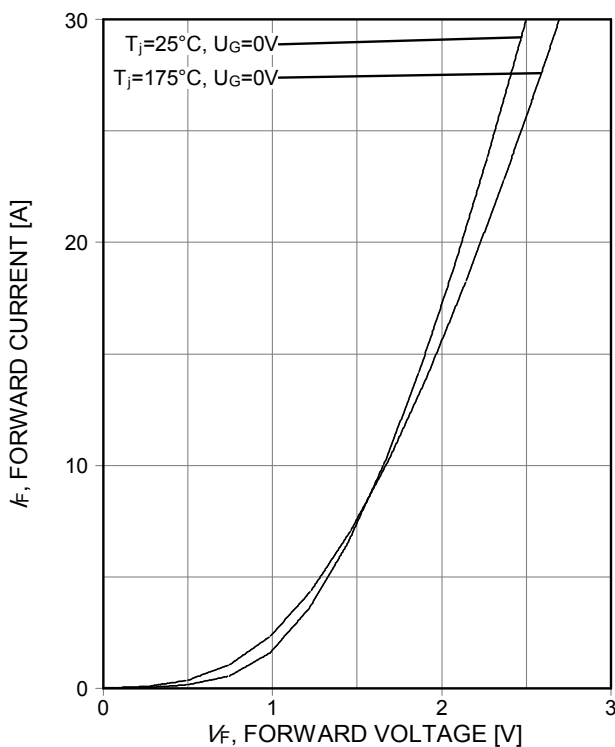


Figure 27. Typical diode forward current as a function of forward voltage

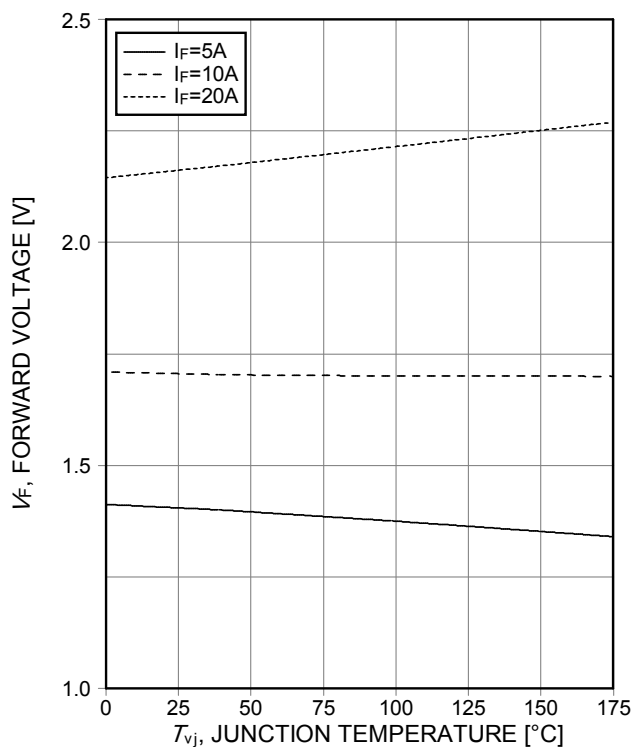
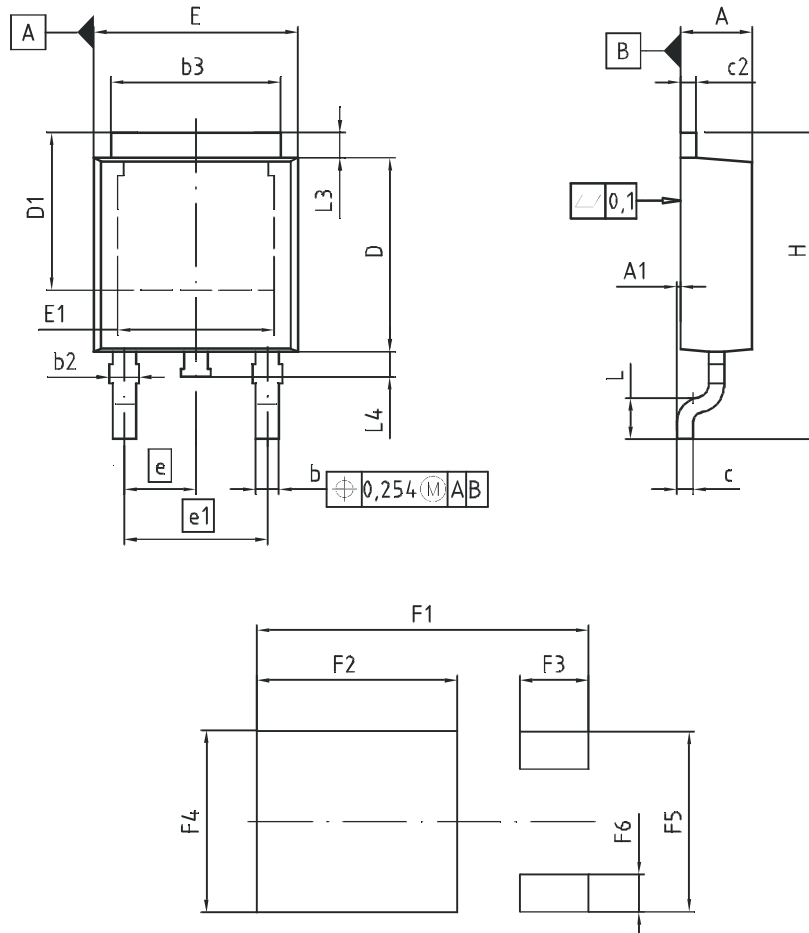


Figure 28. Typical diode forward voltage as a function of junction temperature

PG- TO252-3



| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|-------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.16 | 2.41 | 0.085 | 0.095 |
| A1 | 0.00 | 0.15 | 0.000 | 0.006 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b3 | 5.00 | 5.50 | 0.197 | 0.217 |
| c | 0.46 | 0.60 | 0.018 | 0.024 |
| c2 | 0.46 | 0.98 | 0.018 | 0.039 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.02 | 5.84 | 0.198 | 0.230 |
| E | 6.40 | 6.73 | 0.252 | 0.265 |
| E1 | 4.70 | 5.21 | 0.185 | 0.205 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| H | 9.40 | 10.48 | 0.370 | 0.413 |
| L | 1.18 | 1.70 | 0.046 | 0.067 |
| L3 | 0.90 | 1.25 | 0.035 | 0.049 |
| L4 | 0.51 | 1.00 | 0.020 | 0.039 |
| F1 | 10.50 | 10.70 | 0.413 | 0.421 |
| F2 | 6.30 | 6.50 | 0.248 | 0.256 |
| F3 | 2.10 | 2.30 | 0.083 | 0.091 |
| F4 | 5.70 | 5.90 | 0.224 | 0.232 |
| F5 | 5.66 | 5.86 | 0.223 | 0.231 |
| F6 | 1.10 | 1.30 | 0.043 | 0.051 |

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Z8B00003328

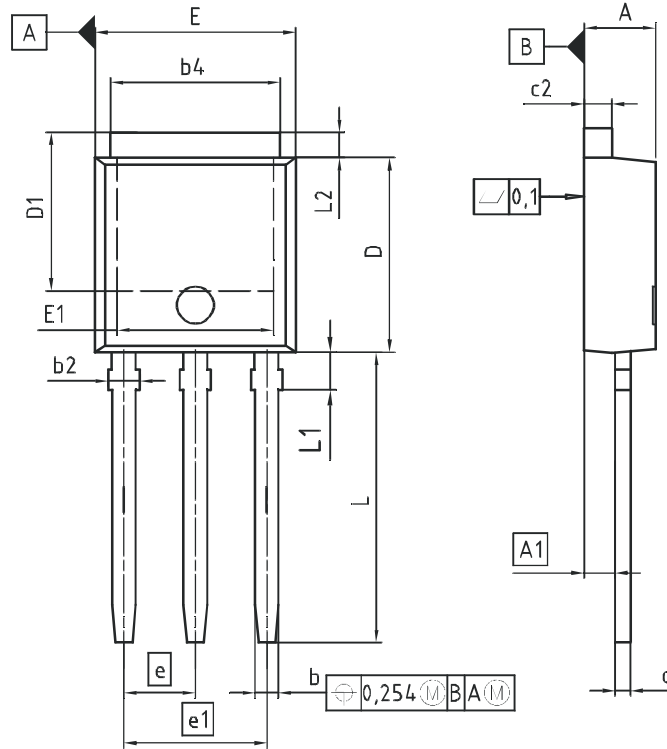
SCALE 0 2.0 4mm

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PG-TO251-3



| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.16 | 2.41 | 0.085 | 0.095 |
| A1 | 0.90 | 1.14 | 0.035 | 0.045 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b4 | 4.95 | 5.50 | 0.195 | 0.217 |
| c | 0.46 | 0.60 | 0.018 | 0.024 |
| c2 | 0.46 | 0.89 | 0.018 | 0.035 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.04 | 5.77 | 0.198 | 0.227 |
| E | 6.35 | 6.73 | 0.250 | 0.265 |
| E1 | 4.70 | 5.21 | 0.185 | 0.205 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| L | 8.89 | 9.65 | 0.350 | 0.380 |
| L1 | 1.90 | 2.29 | 0.075 | 0.090 |
| L2 | 0.89 | 1.37 | 0.035 | 0.054 |

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Z8B00003330

SCALE

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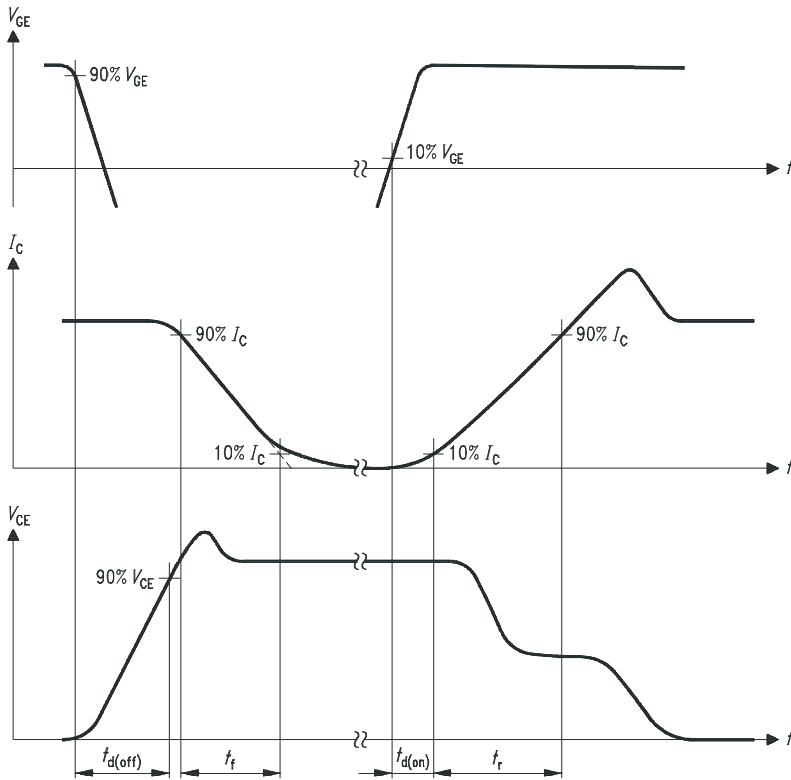


Figure A. Definition of switching times

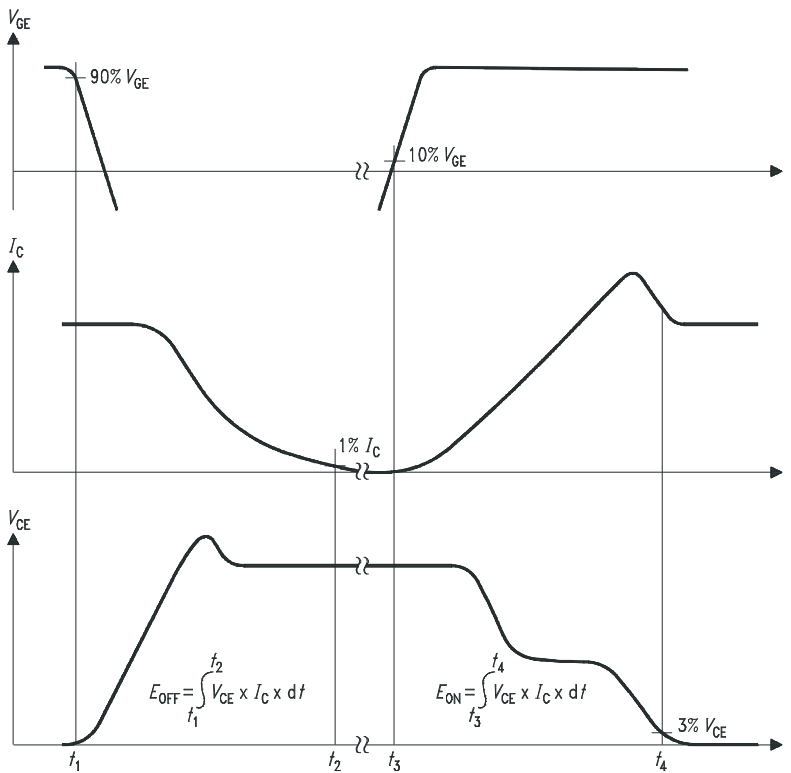


Figure B. Definition of switching losses

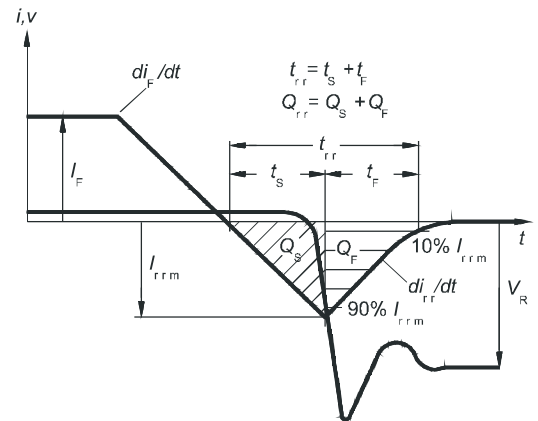


Figure C. Definition of diodes switching characteristics

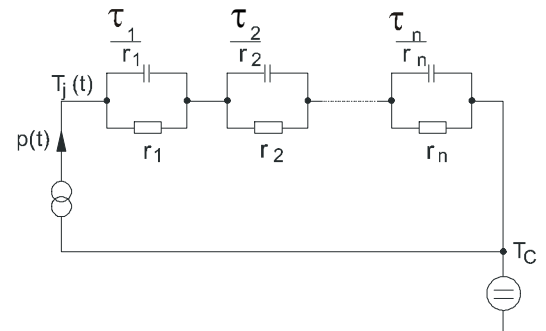


Figure D. Thermal equivalent circuit

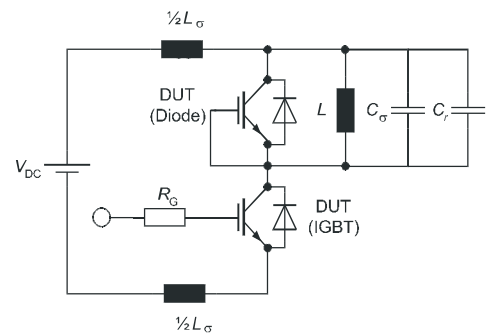


Figure E. Dynamic test circuit
 Parasitic inductance L_σ ,
 Parasitic capacitor C_σ ,
 Relief capacitor C_r
 (only for ZVT switching)



Revision History

IKD10N60R, IKU10N60R

Revision: 2011-01-17, Rev. 2.1

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 1.1 | 2010-01-12 | - |
| 2.1 | - | Release of final datasheet |

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