

## IGBT

High speed 5 IGBT in TRENCHSTOP™ 5 technology copacked with RAPID 2 fast and soft antiparallel diode

### IKZ50N65NH5

650V DuoPack IGBT and diode  
High speed series fifth generation

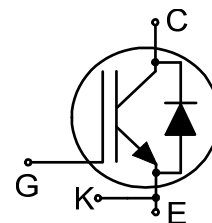
Data sheet

### High speed 5 IGBT in TRENCHSTOP™ 5 technology copacked with RAPID 2 fast and soft antiparallel diode

#### Features and Benefits:

High speed H5 technology offering

- Ultra low loss switching thanks to Kelvin emitter pin in combination with TRENCHSTOP™ 5
- Best-in-class efficiency in hard switching and resonant topologies
- Plug and play replacement of previous generation IGBTs
- 650V breakdown voltage
- Low gate charge  $Q_G$
- IGBT copacked with RAPID 2 fast and soft antiparallel diode
- Maximum junction temperature 175°C
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>



#### Applications

- Uninterruptible power supplies
- Welding converters
- Mid to high range switching frequency converters
- Solar string inverters

#### Package pin definition:

- Pin C & backside - collector
- Pin E - emitter
- Pin K - Kelvin emitter
- Pin G - gate

Please note: The emitter and Kelvin emitter pins are not exchangeable. Their exchange might lead to malfunction.



#### Key Performance and Package Parameters

| Type        | $V_{CE}$ | $I_C$ | $V_{CEsat}, T_{vj}=25^\circ C$ | $T_{vjmax}$ | Marking | Package    |
|-------------|----------|-------|--------------------------------|-------------|---------|------------|
| IKZ50N65NH5 | 650V     | 50A   | 1.65V                          | 175°C       | K50ENH5 | PG-TO247-4 |

**Table of Contents**

|                                           |    |
|-------------------------------------------|----|
| Description .....                         | 2  |
| Table of Contents .....                   | 3  |
| Maximum Ratings .....                     | 4  |
| Thermal Resistance .....                  | 4  |
| Electrical Characteristics .....          | 5  |
| Electrical Characteristics Diagrams ..... | 7  |
| Package Drawing .....                     | 14 |
| Testing Conditions .....                  | 15 |
| Revision History .....                    | 16 |
| Disclaimer .....                          | 16 |

## 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, $T_{vj} \geq 25^{\circ}\text{C}$                                                               | $V_{CE}$    | 650                  | V                  |
| DC collector current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$                 | $I_C$       | 85.0<br>54.0         | A                  |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}^{1)}$                                                               | $I_{Cpuls}$ | 200.0                | A                  |
| Turn off safe operating area<br>$V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}^{1)}$ | -           | 200.0                | A                  |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$                | $I_F$       | 79.0<br>54.0         | A                  |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}^{1)}$                                                                   | $I_{Fpuls}$ | 200.0                | A                  |
| Gate-emitter voltage<br>Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )                         | $V_{GE}$    | $\pm 20$<br>$\pm 30$ | V                  |
| Power dissipation $T_C = 25^{\circ}\text{C}$<br>Power dissipation $T_C = 100^{\circ}\text{C}$                             | $P_{tot}$   | 273.0<br>136.0       | W                  |
| Operating junction temperature                                                                                            | $T_{vj}$    | $-40 \dots +175$     | $^{\circ}\text{C}$ |
| Storage temperature                                                                                                       | $T_{stg}$   | $-55 \dots +150$     | $^{\circ}\text{C}$ |
| Soldering temperature,<br>wave soldering 1.6mm (0.063in.) from case for 10s                                               |             | 260                  | $^{\circ}\text{C}$ |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3                                                             | $M$         | 0.6                  | Nm                 |

## Thermal Resistance

| Parameter                                    | Symbol        | Conditions | Max. Value | Unit |
|----------------------------------------------|---------------|------------|------------|------|
| <b>Characteristic</b>                        |               |            |            |      |
| IGBT thermal resistance,<br>junction - case  | $R_{th(j-c)}$ |            | 0.55       | K/W  |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ |            | 0.63       | K/W  |
| Thermal resistance<br>junction - ambient     | $R_{th(j-a)}$ |            | 40         | K/W  |

<sup>1)</sup> Defined by design. Not subject to production test.

**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  | $V_{(BR)CES}$ | $V_{GE} = 0V, I_C = 0.20mA$                                                                                   | 650         | -                    | -              | V       |
| Collector-emitter saturation voltage | $V_{CEsat}$   | $V_{GE} = 15.0V, I_C = 50.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 100^{\circ}C$<br>$T_{vj} = 150^{\circ}C$ | -<br>-<br>- | 1.65<br>1.82<br>1.90 | 2.10<br>-<br>- | V       |
| Diode forward voltage                | $V_F$         | $V_{GE} = 0V, I_F = 50.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 100^{\circ}C$<br>$T_{vj} = 150^{\circ}C$    | -<br>-<br>- | 1.60<br>1.65<br>1.65 | 2.20<br>-<br>- | V       |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.50mA, V_{CE} = V_{GE}$                                                                               | 3.2         | 4.0                  | 4.8            | V       |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE} = 650V, V_{GE} = 0V$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 175^{\circ}C$                             | -<br>-      | -<br>2500.0          | 50.0<br>-      | $\mu A$ |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE} = 0V, V_{GE} = 20V$                                                                                   | -           | -                    | 100            | nA      |
| Transconductance                     | $g_{fs}$      | $V_{CE} = 20V, I_C = 50.0A$                                                                                   | -           | 65.0                 | -              | S       |

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

| Parameter                                                                       | Symbol    | Conditions                                 | Value |       |      | Unit |
|---------------------------------------------------------------------------------|-----------|--------------------------------------------|-------|-------|------|------|
|                                                                                 |           |                                            | min.  | typ.  | max. |      |
| Dynamic Characteristic                                                          |           |                                            |       |       |      |      |
| Input capacitance                                                               | $C_{ies}$ | $V_{CE} = 25V, V_{GE} = 0V, f = 1MHz$      | -     | 3100  | -    | pF   |
| Output capacitance                                                              | $C_{oes}$ |                                            | -     | 90    | -    |      |
| Reverse transfer capacitance                                                    | $C_{res}$ |                                            | -     | 11    | -    |      |
| Gate charge                                                                     | $Q_G$     | $V_{CC} = 520V, I_C = 50.0A, V_{GE} = 15V$ | -     | 109.0 | -    | nC   |
| Internal emitter inductance <sup>1)</sup><br>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 $T_{vj} = 25^{\circ}\text{C}$ |                     |                                                                                                                                                                                                                                                                                                                                                               |       |      |      |      |
| Turn-on delay time                                    | $t_{d(\text{on})}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 25.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$R_{G(\text{on})} = 15.0\Omega$ , $R_{G(\text{off})} = 20.0\Omega$ ,<br>$L_{\sigma} = 30\text{nH}$ , $C_{\sigma} = 25\text{pF}$<br>$L_{\sigma}$ , $C_{\sigma}$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | -     | 22   | -    | ns   |
| Rise time                                             | $t_r$               |                                                                                                                                                                                                                                                                                                                                                               | -     | 8    | -    | ns   |
| Turn-off delay time                                   | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                                                                               | -     | 252  | -    | ns   |
| Fall time                                             | $t_f$               |                                                                                                                                                                                                                                                                                                                                                               | -     | 23   | -    | ns   |
| Turn-on energy                                        | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                                                                               | -     | 0.35 | -    | mJ   |
| Turn-off energy                                       | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                                                                               | -     | 0.20 | -    | mJ   |
| Total switching energy                                | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                                                                               | -     | 0.55 | -    | mJ   |

<sup>1)</sup> The internal emitter inductance does not affect the gate control circuitry if bypassed by using the emitter sense pin.

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

|                                                                  |              |                                                                                                                         |   |       |   |                  |
|------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------|---|-------|---|------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 25^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 25.0\text{A},$<br>$di_F/dt = 1500\text{A}/\mu\text{s}$ | - | 46    | - | ns               |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                         | - | 0.49  | - | $\mu\text{C}$    |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                         | - | 22.0  | - | A                |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                         | - | -4330 | - | A/ $\mu\text{s}$ |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value |      |      | Unit |
|-----------|--------|------------|-------|------|------|------|
|           |        |            | min.  | typ. | max. |      |

**IGBT Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$** 

|                        |              |                                                                                                                                                                                                                                                                                                                      |   |      |   |    |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C},$<br>$V_{CC} = 400\text{V}, I_C = 25.0\text{A},$<br>$V_{GE} = 0.0/15.0\text{V},$<br>$R_{G(on)} = 15.0\Omega, R_{G(off)} = 20.0\Omega,$<br>$L\sigma = 30\text{nH}, C\sigma = 25\text{pF}$<br>$L\sigma, C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 21   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                      | - | 9    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                      | - | 294  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                      | - | 19   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                      | - | 0.52 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                      | - | 0.28 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                      | - | 0.80 | - | mJ |

**Diode Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$** 

|                                                                  |              |                                                                                                                          |   |       |   |                  |
|------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------|---|-------|---|------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 150^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 25.0\text{A},$<br>$di_F/dt = 1500\text{A}/\mu\text{s}$ | - | 62    | - | ns               |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                          | - | 1.00  | - | $\mu\text{C}$    |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                          | - | 31.0  | - | A                |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                          | - | -4810 | - | A/ $\mu\text{s}$ |

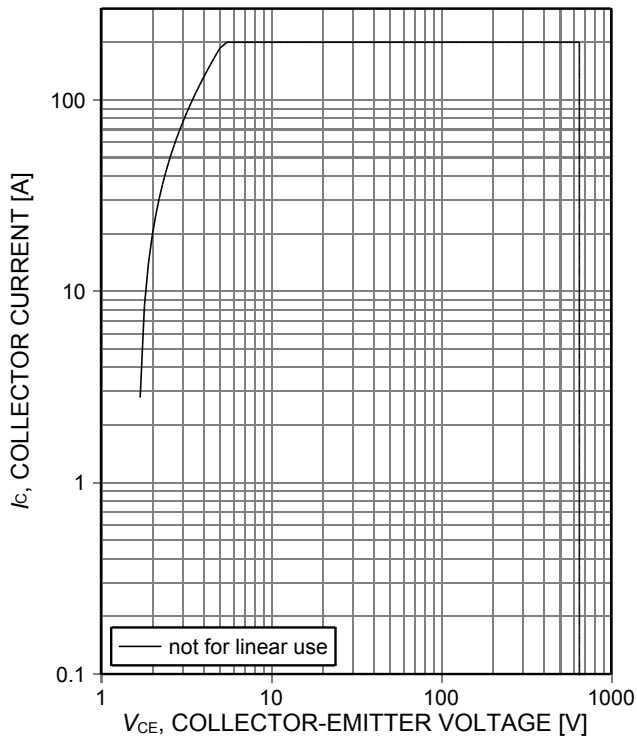


Figure 1. **Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $t_p=1\mu\text{s}$ ,  
 $I_{Cmax}$  defined by design - not subject to  
production test)

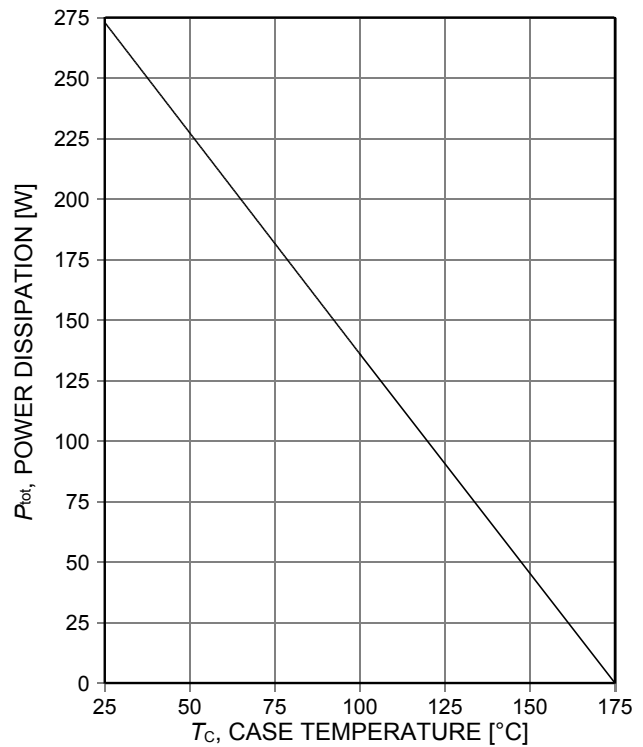


Figure 2. **Power dissipation as a function of case temperature**  
( $T_{vj}\leq 175^\circ\text{C}$ )

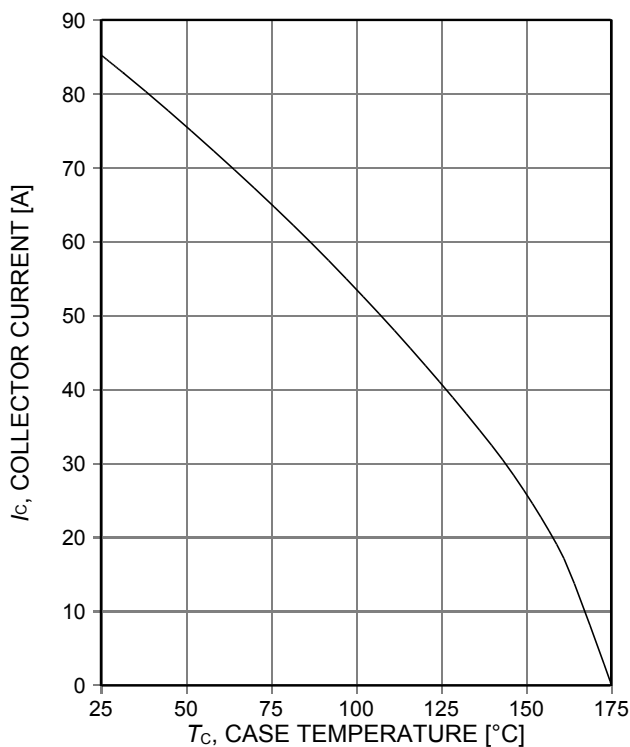


Figure 3. **Collector current as a function of case temperature**  
( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

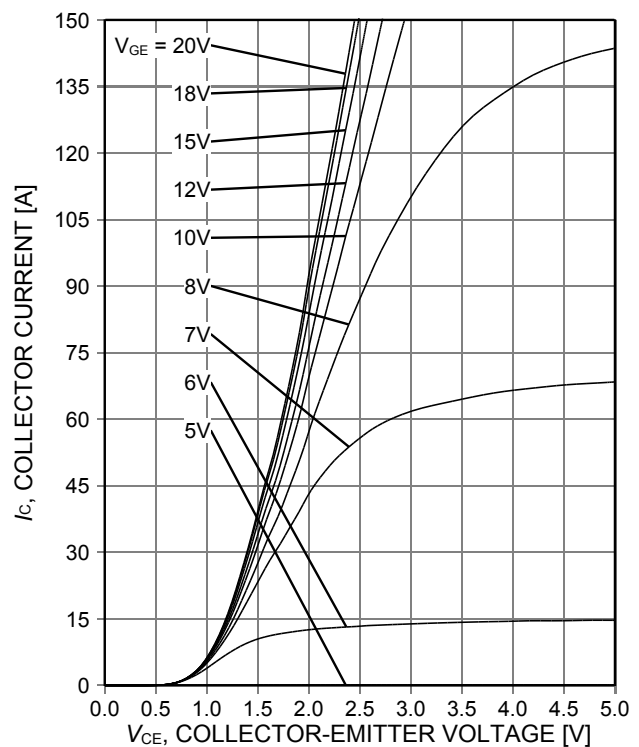


Figure 4. **Typical output characteristic**  
( $T_{vj}=25^\circ\text{C}$ )

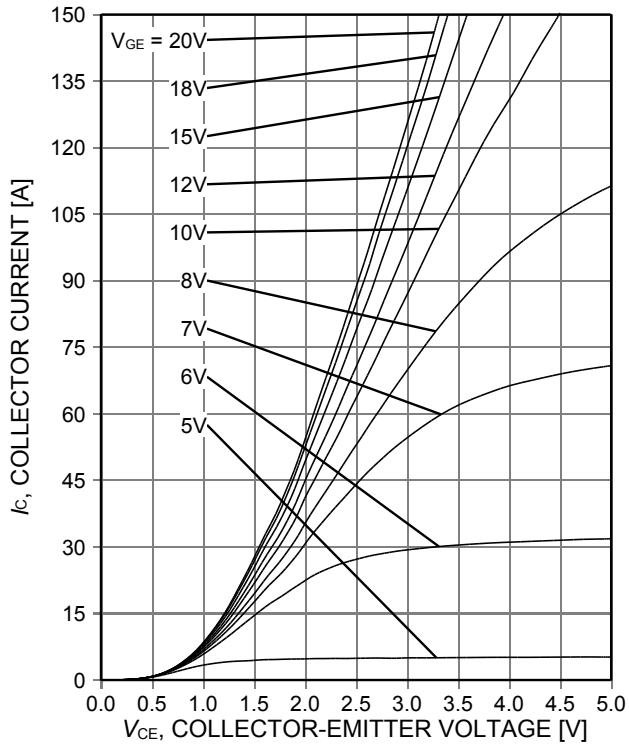


Figure 5. **Typical output characteristic**  
( $T_{vj}=175^{\circ}\text{C}$ )

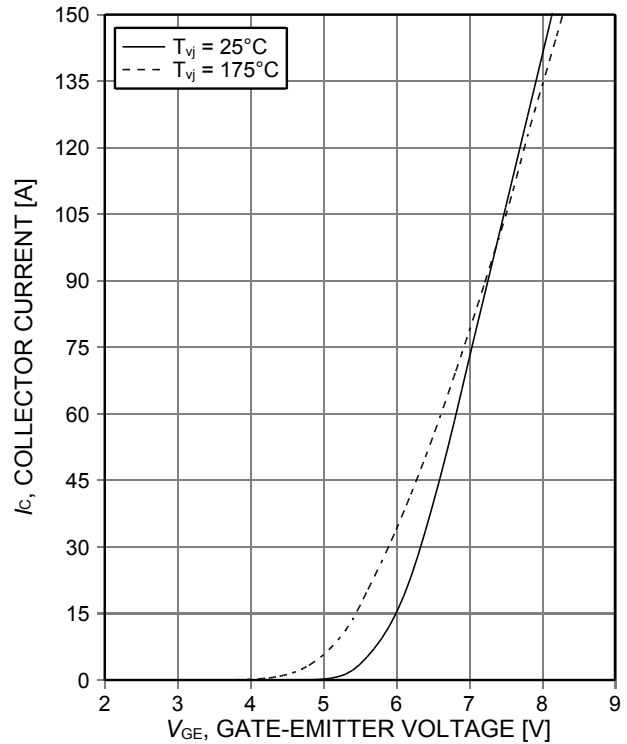


Figure 6. **Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )

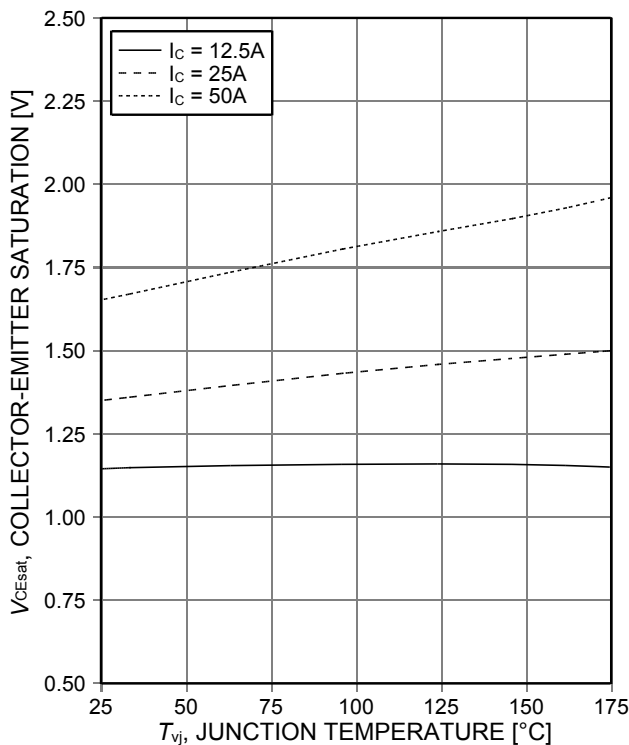


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15\text{V}$ )

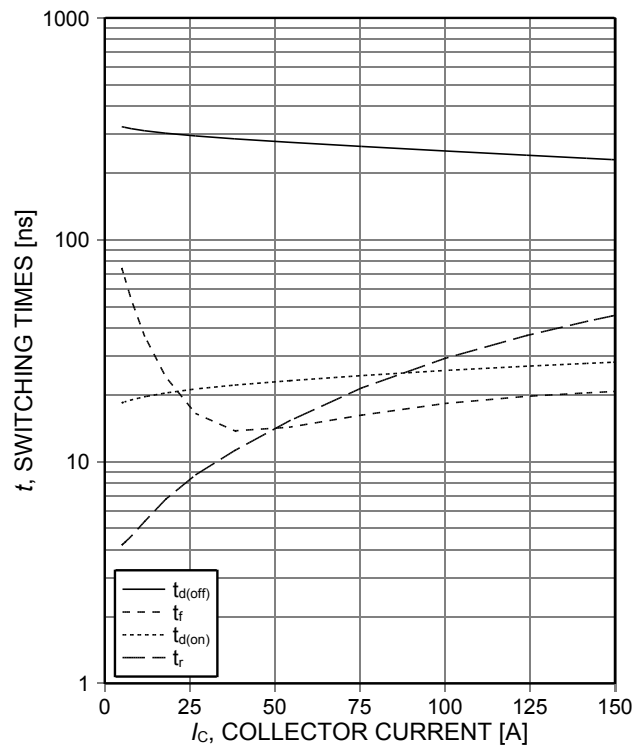


Figure 8. **Typical switching times as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=15\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)



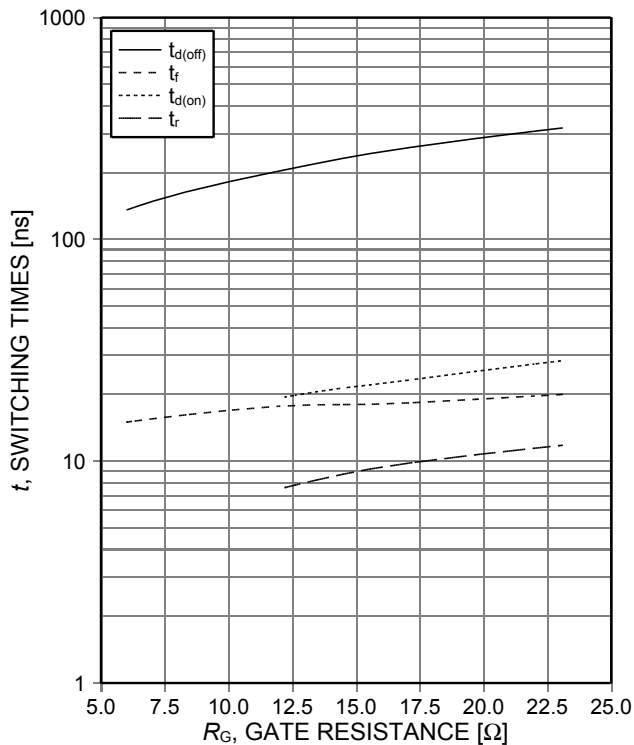


Figure 9. **Typical switching times as a function of gate resistance**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=25\text{A}$ ,  $V_{Dmax}\leq 650\text{V}$ , dynamic test circuit in Figure E)

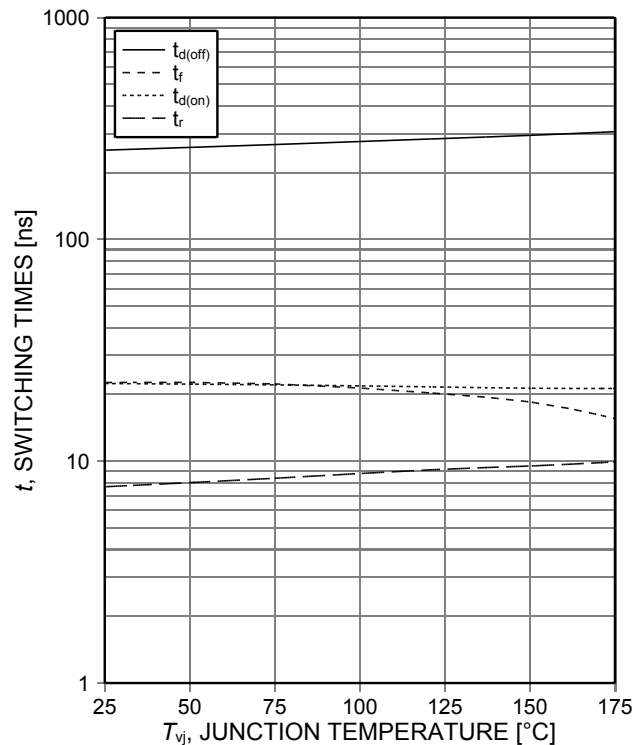


Figure 10. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=25\text{A}$ ,  $R_{G(on)}=15\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

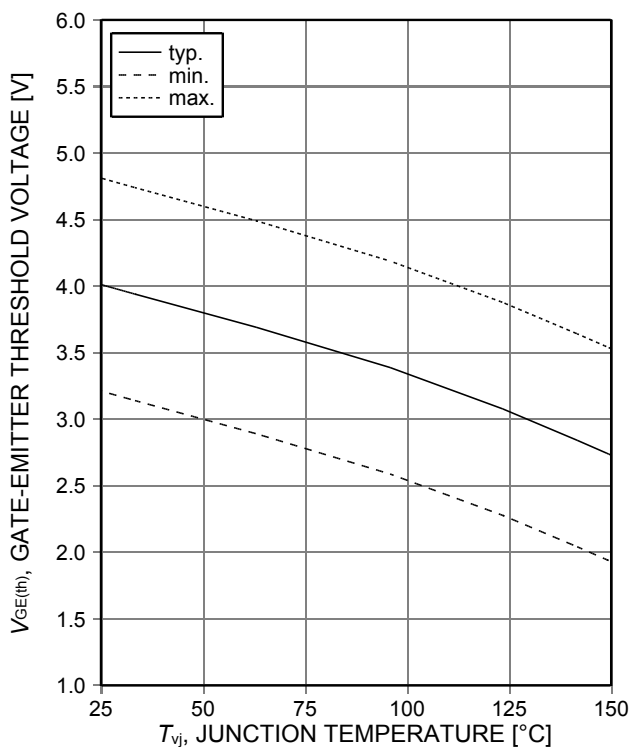


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0.5\text{mA}$ )

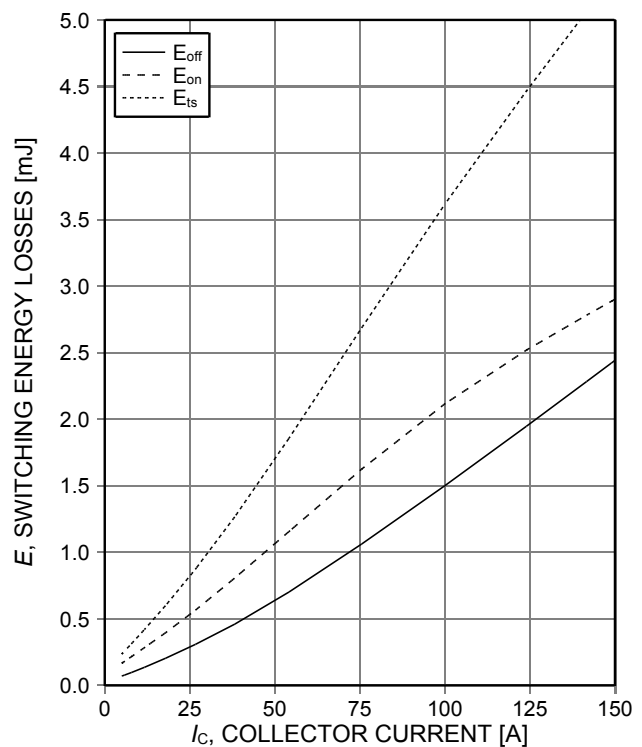


Figure 12. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=15\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

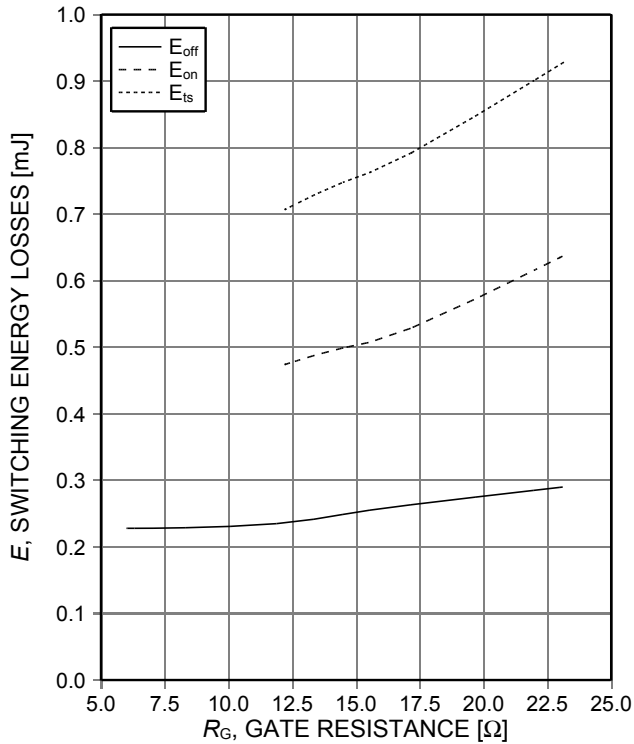


Figure 13. **Typical switching energy losses as a function of gate resistance**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=25\text{A}$ ,  $V_{Dmax}\leq 650\text{V}$ , dynamic test circuit in Figure E)

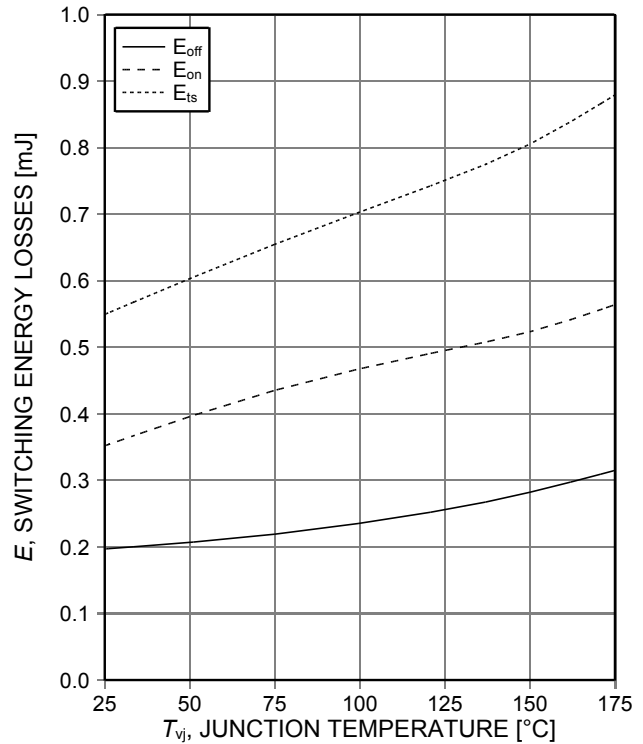


Figure 14. **Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=25\text{A}$ ,  $R_{G(on)}=15\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

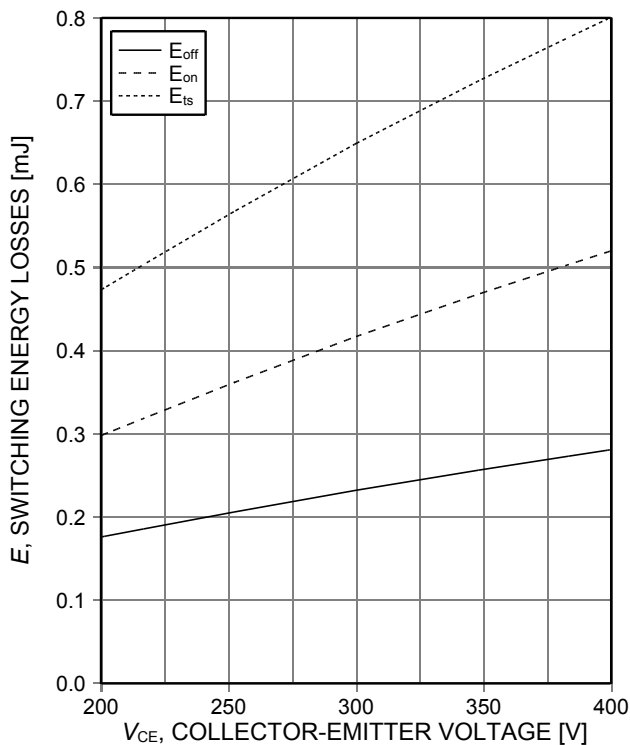


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=25\text{A}$ ,  $R_{G(on)}=15\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

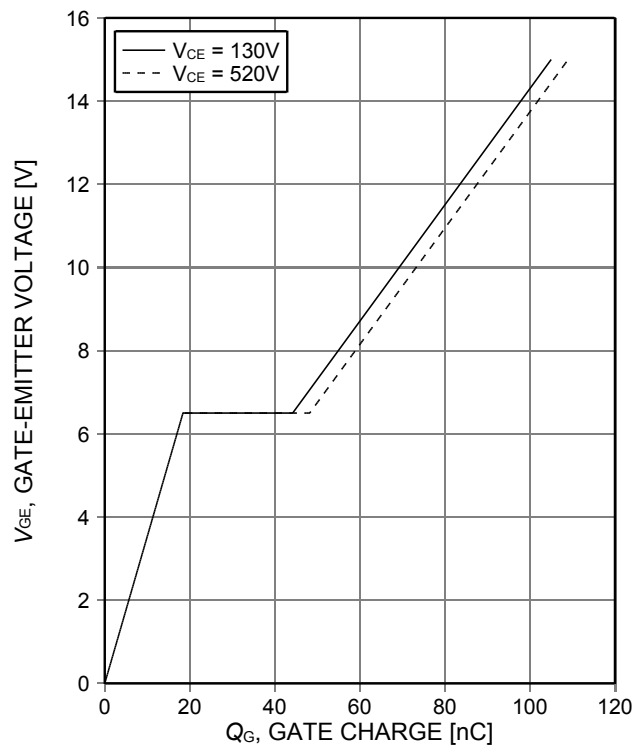


Figure 16. **Typical gate charge**  
( $I_C=50\text{A}$ )

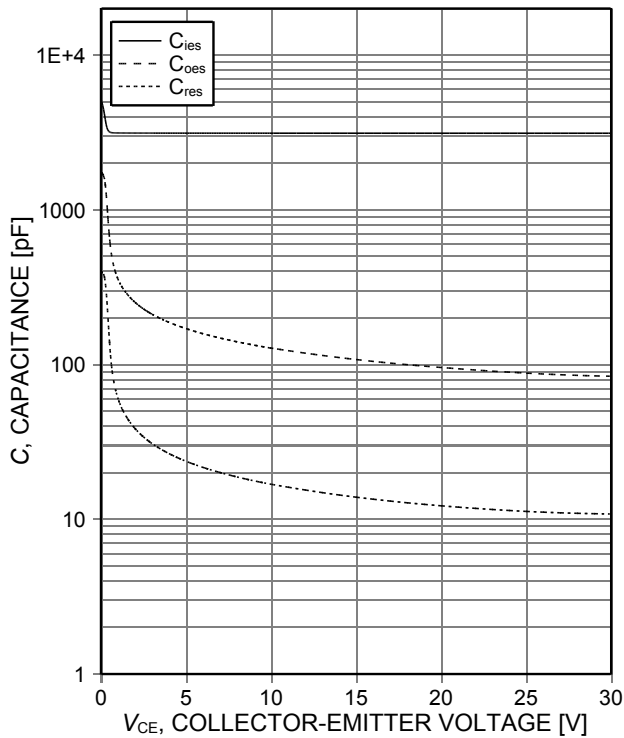


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=1MHz$ )

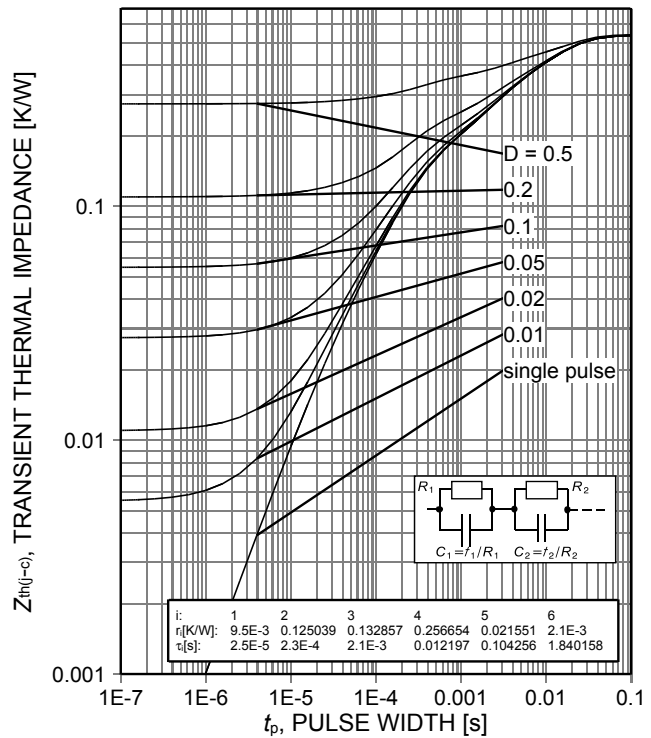


Figure 18. IGBT transient thermal impedance ( $D=t_p/T$ )

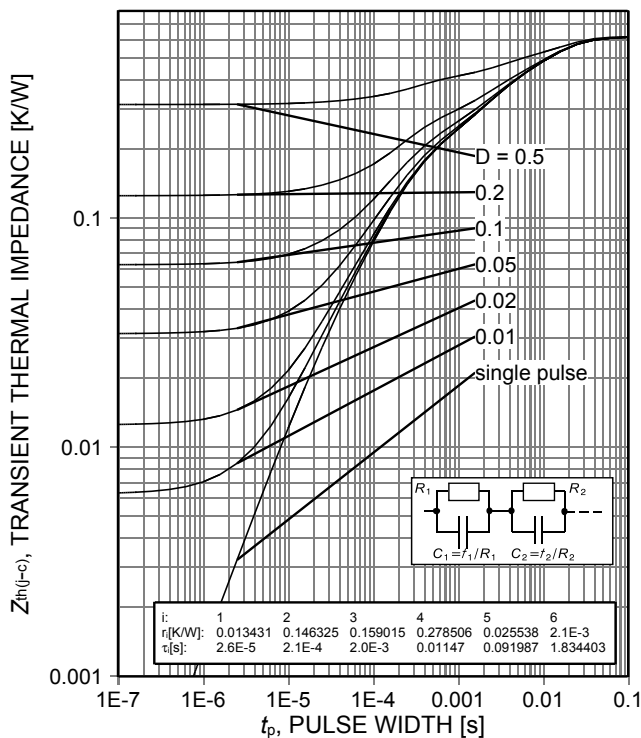


Figure 19. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

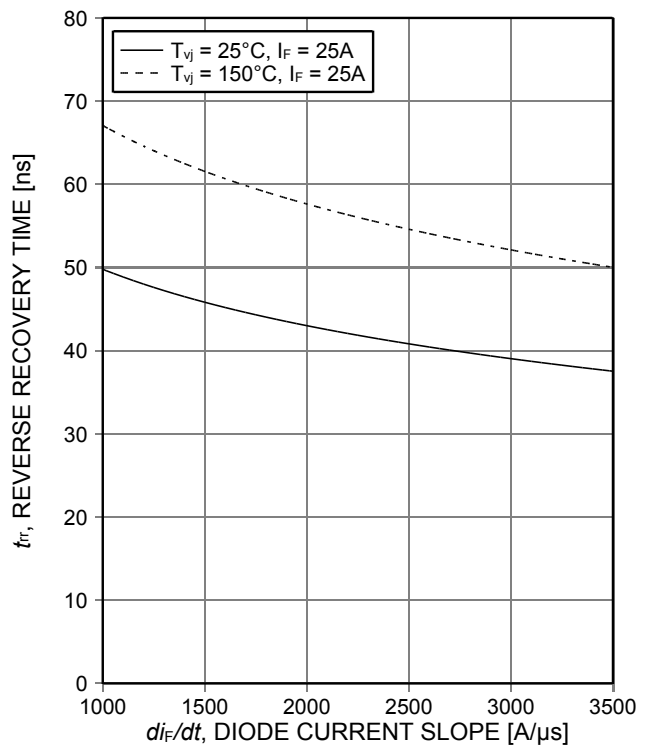


Figure 20. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

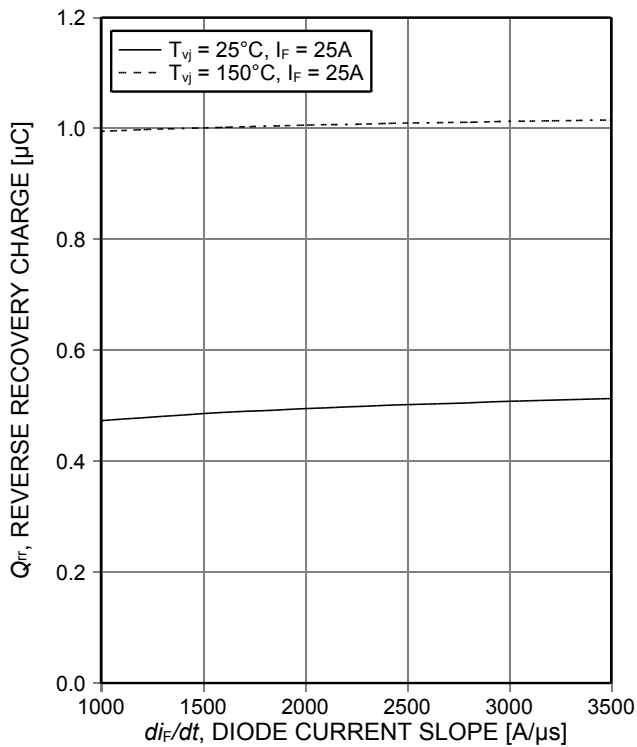


Figure 21. **Typical reverse recovery charge as a function of diode current slope**  
( $V_R=400V$ )

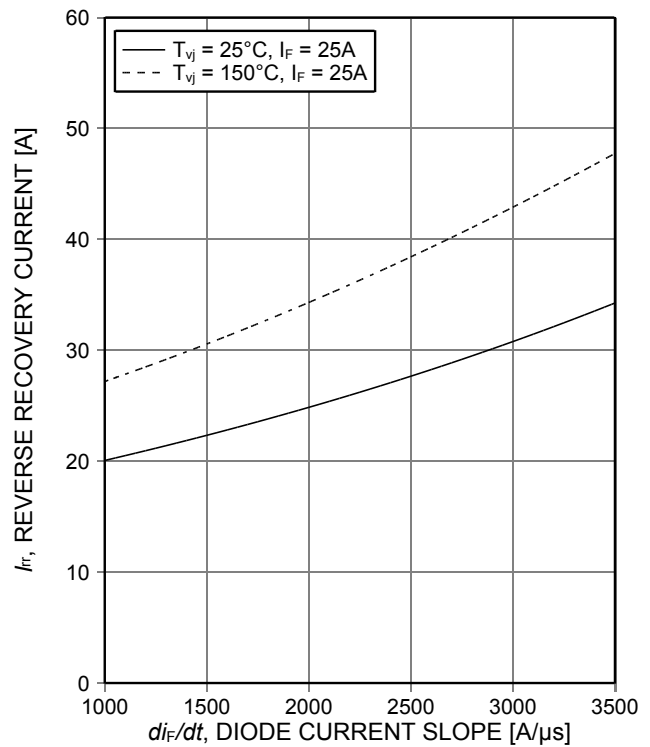


Figure 22. **Typical reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

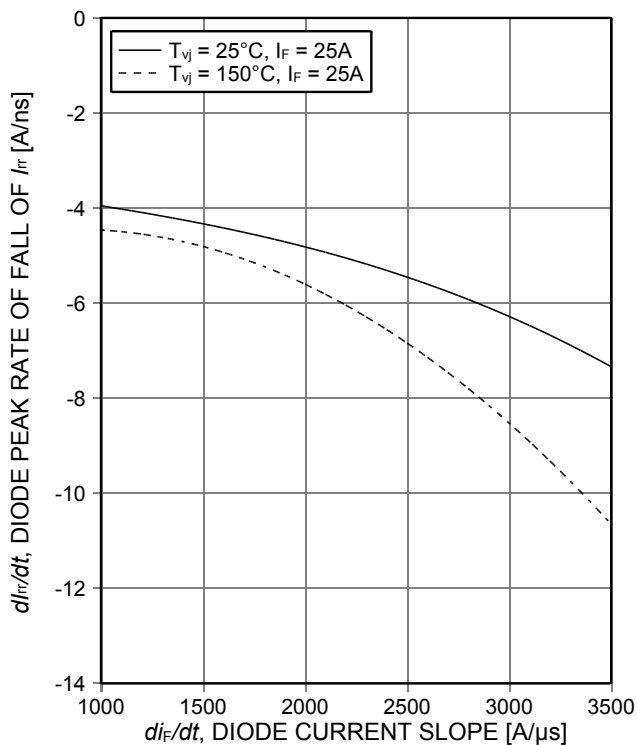


Figure 23. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

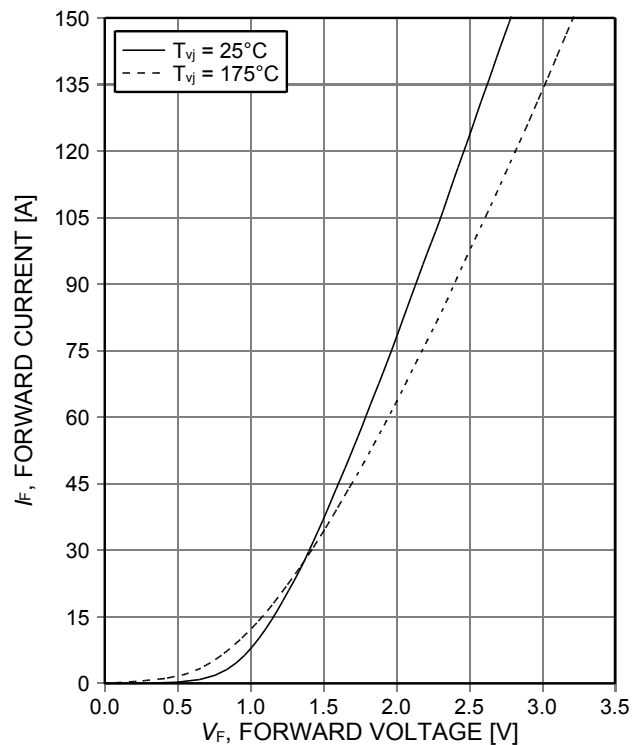


Figure 24. **Typical diode forward current as a function of forward voltage**

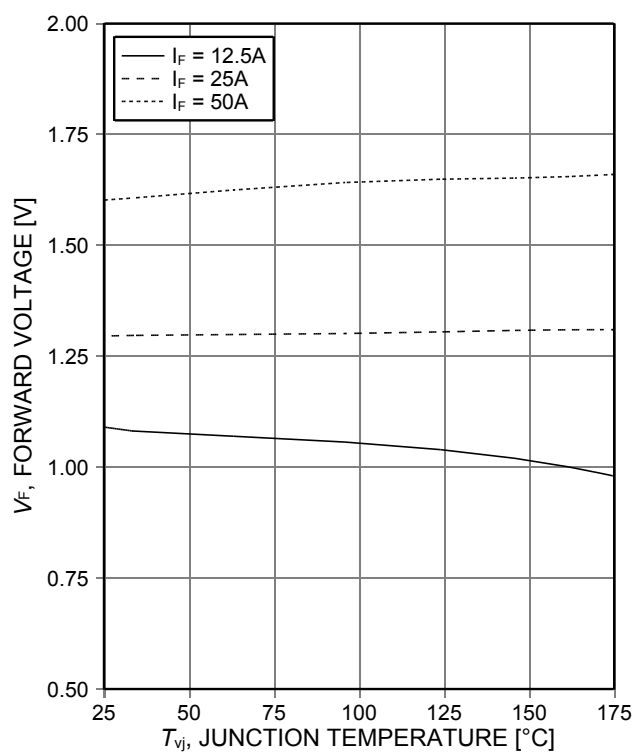
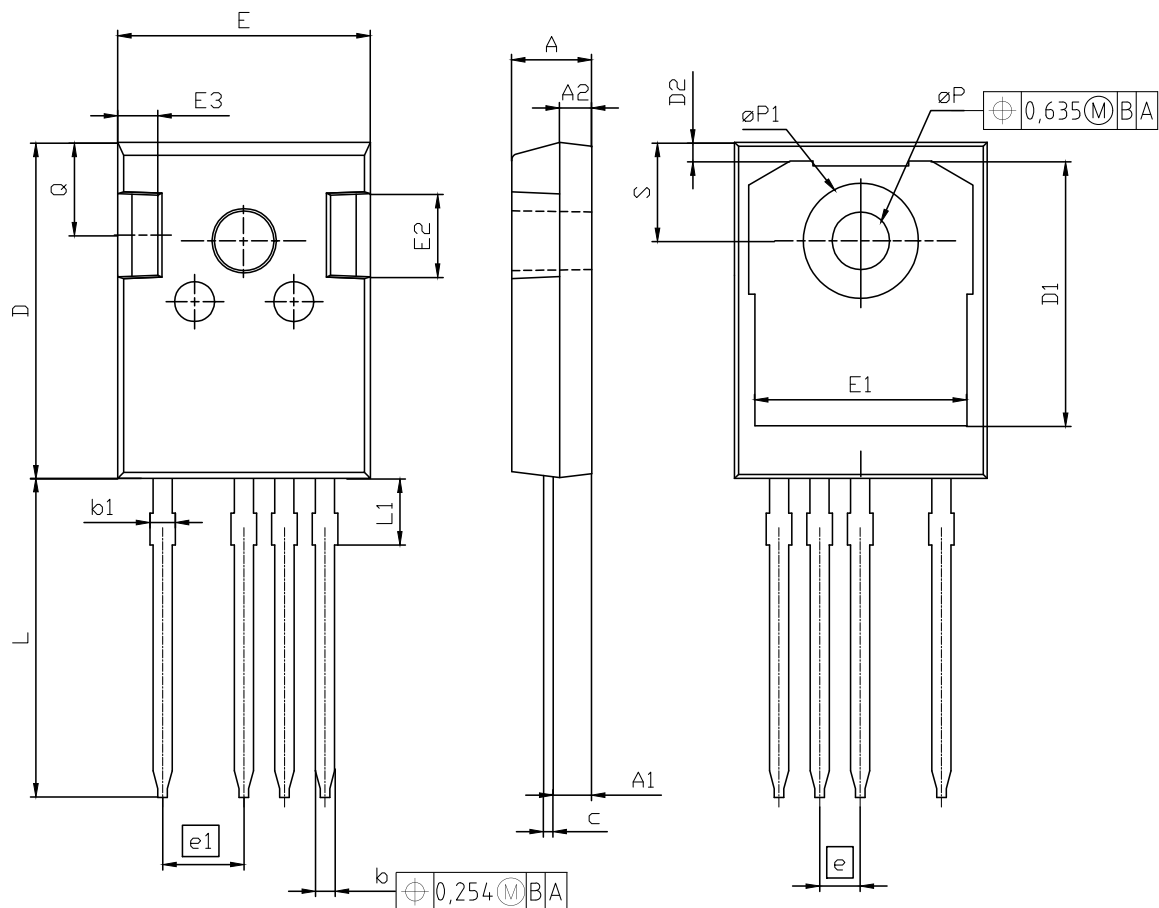


Figure 25. Typical diode forward voltage as a function of junction temperature

## PG-TO247-4



| DIM       | MILLIMETERS |       | INCHES      |       |
|-----------|-------------|-------|-------------|-------|
|           | MIN         | MAX   | MIN         | MAX   |
| A         | 4.83        | 5.21  | 0.190       | 0.205 |
| A1        | 2.29        | 2.54  | 0.090       | 0.100 |
| A2        | 1.90        | 2.16  | 0.075       | 0.085 |
| b         | 1.07        | 1.33  | 0.042       | 0.052 |
| b1        | 1.10        | 1.70  | 0.043       | 0.067 |
| c         | 0.50        | 0.70  | 0.020       | 0.028 |
| 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         | 2.54 (BSC)  |       | 0.100 (BSC) |       |
| e1        | 5.08        |       | 0.200       |       |
| N         | 4           |       | 4           |       |
| L         | 19.72       | 20.32 | 0.776       | 0.800 |
| L1        | 4.02        | 4.40  | 0.158       | 0.173 |
| $\phi P$  | 3.50        | 3.70  | 0.138       | 0.146 |
| $\phi P1$ | 7.00        | 7.40  | 0.276       | 0.291 |
| Q         | 5.49        | 6.00  | 0.216       | 0.236 |
| S         | 6.04        | 6.30  | 0.238       | 0.248 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NO.</b><br>Z8B00168124                                                                                  |
| <b>SCALE</b><br>0 5 5 7.5mm                                                                                         |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>29-01-2013                                                                                     |
| <b>REVISION</b><br>1                                                                                                |

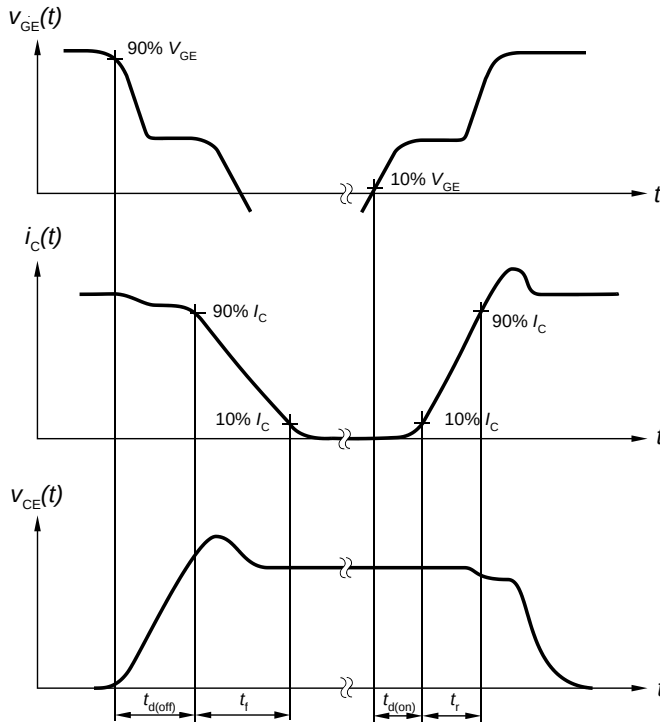


Figure A. Definition of switching times

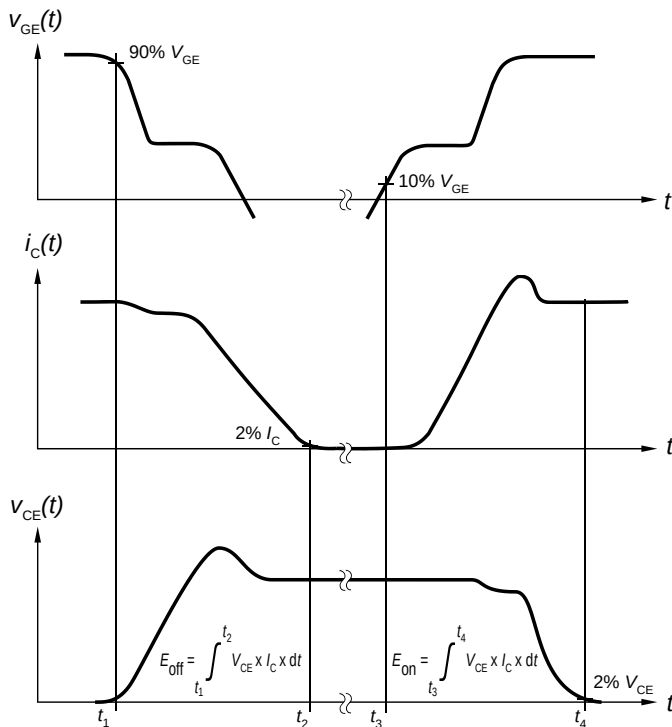


Figure B. Definition of switching losses

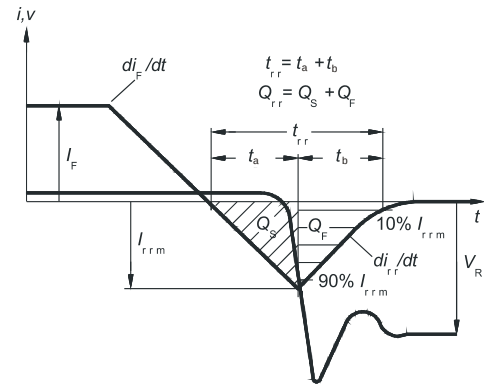


Figure C. Definition of diodes switching characteristics

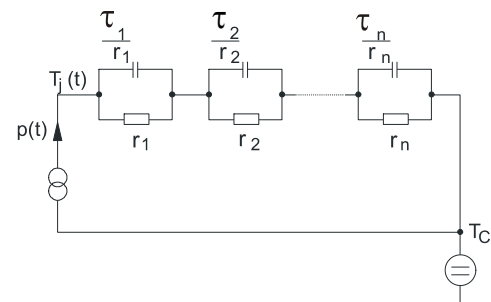


Figure D. Thermal equivalent circuit

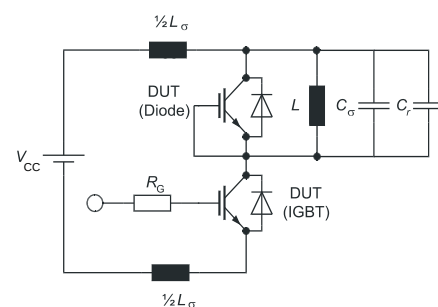


Figure E. Dynamic test circuit

Parasitic inductance  $L_\sigma$ ,  
parasitic capacitor  $C_\sigma$ ,  
relief capacitor  $C_r$   
(only for ZVT switching)

## Revision History

IKZ50N65NH5

Revision: 2014-10-31, Rev. 2.1

## Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 1.1      | 2014-10-17 | Preliminary data sheet                       |
| 2.1      | 2014-10-31 | Final data sheet                             |

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