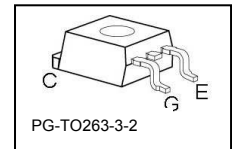
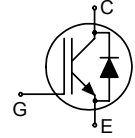


Low Loss DuoPack : IGBT in TrenchStop® and Fieldstop technology  
with soft, fast recovery anti-parallel EmCon 3 diode

- Very low  $V_{CE(sat)}$  1.5 V (typ.)
- Maximum Junction Temperature 175 °C
- Short circuit withstand time – 5µs
- Designed for frequency inverters for washing machines, fans, pumps and vacuum cleaners
- TrenchStop® technology for 600 V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - very high switching speed
- Positive temperature coefficient in  $V_{CE(sat)}$
- Low EMI
- Low Gate Charge
- Qualified according to JEDEC<sup>1</sup> for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>



| Type      | $V_{CE}$ | $I_C$ | $V_{CE(sat)}, T_j=25^\circ\text{C}$ | $T_{j,max}$ | Marking Code | Package      |
|-----------|----------|-------|-------------------------------------|-------------|--------------|--------------|
| IKB15N60T | 600V     | 15A   | 1.5V                                | 175°C       | K15T60       | PG-TO263-3-2 |

### Maximum Ratings

| Parameter                                                                                 | Symbol      | Value      | Unit |
|-------------------------------------------------------------------------------------------|-------------|------------|------|
| Collector-emitter voltage                                                                 | $V_{CE}$    | 600        | V    |
| DC collector current, limited by $T_{jmax}$                                               | $I_C$       |            | A    |
| $T_C = 25^\circ\text{C}$                                                                  |             | 30         |      |
| $T_C = 100^\circ\text{C}$                                                                 |             | 15         |      |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$                                     | $I_{Cpuls}$ | 45         |      |
| Turn off safe operating area ( $V_{CE} \leq 600\text{V}$ , $T_j \leq 175^\circ\text{C}$ ) | -           | 45         |      |
| Diode forward current, limited by $T_{jmax}$                                              | $I_F$       |            |      |
| $T_C = 25^\circ\text{C}$                                                                  |             | 30         |      |
| $T_C = 100^\circ\text{C}$                                                                 |             | 15         |      |
| Diode pulsed current, $t_p$ limited by $T_{jmax}$                                         | $I_{Fpuls}$ | 45         |      |
| Gate-emitter voltage                                                                      | $V_{GE}$    | $\pm 20$   | V    |
| Short circuit withstand time <sup>2)</sup>                                                | $t_{SC}$    | 5          | µs   |
| $V_{GE} = 15\text{V}$ , $V_{CC} \leq 400\text{V}$ , $T_j \leq 150^\circ\text{C}$          |             |            |      |
| Power dissipation $T_C = 25^\circ\text{C}$                                                | $P_{tot}$   | 130        | W    |
| Operating junction temperature                                                            | $T_j$       | -40...+175 | °C   |
| Storage temperature                                                                       | $T_{stg}$   | -55...+175 |      |
| Soldering temperature (reflow soldering, MSL1)                                            | -           | 245        |      |

<sup>1</sup> J-STD-020 and JEDEC-022

<sup>2)</sup> Allowed number of short circuits: <1000; time between short circuits: >1s.

### Thermal Resistance

| Parameter                                    | Symbol      | Conditions          | Max. Value | Unit |
|----------------------------------------------|-------------|---------------------|------------|------|
| <b>Characteristic</b>                        |             |                     |            |      |
| IGBT thermal resistance,<br>junction – case  | $R_{thJC}$  |                     | 1.15       | K/W  |
| Diode thermal resistance,<br>junction – case | $R_{thJCD}$ |                     | 1.9        |      |
| Thermal resistance,<br>junction – ambient    | $R_{thJA}$  | 6cm <sup>2</sup> Cu | 40         |      |

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

| Parameter                            | Symbol        | Conditions                    | Value |      |      | Unit     |
|--------------------------------------|---------------|-------------------------------|-------|------|------|----------|
|                                      |               |                               | min.  | Typ. | max. |          |
| Static Characteristic                |               |                               |       |      |      |          |
| Collector-emitter breakdown voltage  | $V_{(BR)CES}$ | $V_{GE}=0V, I_C=0.2mA$        | 600   | -    | -    | V        |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE} = 15V, I_C=15A$       |       |      |      |          |
|                                      |               | $T_j=25^{\circ}C$             | -     | 1.5  | 2.05 |          |
|                                      |               | $T_j=175^{\circ}C$            | -     | 1.9  | -    |          |
| Diode forward voltage                | $V_F$         | $V_{GE}=0V, I_F=15A$          |       |      |      |          |
|                                      |               | $T_j=25^{\circ}C$             | -     | 1.65 | 2.05 |          |
|                                      |               | $T_j=175^{\circ}C$            | -     | 1.6  | -    |          |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C=210\mu A, V_{CE}=V_{GE}$ | 4.1   | 4.9  | 5.7  |          |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE}=600V,$<br>$V_{GE}=0V$ |       |      |      | $\mu A$  |
|                                      |               | $T_j=25^{\circ}C$             | -     | -    | 40   |          |
|                                      |               | $T_j=175^{\circ}C$            | -     | -    | 1000 |          |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE}=0V, V_{GE}=20V$       | -     | -    | 100  | nA       |
| Transconductance                     | $g_{fs}$      | $V_{CE}=20V, I_C=15A$         | -     | 8.7  | -    | S        |
| Integrated gate resistor             | $R_{Gint}$    |                               | -     |      |      | $\Omega$ |

### Dynamic Characteristic

|                                                                   |             |                                                                                     |   |       |   |    |
|-------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------|---|-------|---|----|
| Input capacitance                                                 | $C_{iss}$   | $V_{CE}=25V,$<br>$V_{GE}=0V,$<br>$f=1MHz$                                           | - | 860   | - | pF |
| Output capacitance                                                | $C_{oss}$   |                                                                                     | - | 55    | - |    |
| Reverse transfer capacitance                                      | $C_{rss}$   |                                                                                     | - | 24    | - |    |
| Gate charge                                                       | $Q_{Gate}$  | $V_{CC}=480V, I_C=15A$<br>$V_{GE}=15V$                                              | - | 87    | - | nC |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from case | $L_E$       |                                                                                     | - | 7     | - | nH |
| Short circuit collector current <sup>1)</sup>                     | $I_{C(SC)}$ | $V_{GE}=15V, t_{SC}\leq 5\mu s$<br>$V_{CC} = 400V,$<br>$T_j \leq 150^\circ\text{C}$ | - | 137.5 | - | A  |

<sup>1)</sup> Allowed number of short circuits: <1000; time between short circuits: >1s.

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

| Parameter              | Symbol       | Conditions                                                                                                                                                                                  | Value |      |      | Unit |
|------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                             | min.  | Typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                             |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_j=25^{\circ}\text{C}$ ,<br>$V_{CC}=400\text{V}$ , $I_C=15\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ ,<br>$R_G=15\Omega$ ,<br>$L_{\sigma}^{1)}=154\text{nH}$ ,<br>$C_{\sigma}^{1)}=39\text{pF}$ | -     | 17   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                             | -     | 11   | -    |      |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                             | -     | 188  | -    |      |
| Fall time              | $t_f$        |                                                                                                                                                                                             | -     | 50   | -    |      |
| Turn-on energy         | $E_{on}$     | $C_{\sigma}^{1)}=39\text{pF}$                                                                                                                                                               | -     | 0.22 | -    | mJ   |
| Turn-off energy        | $E_{off}$    | Energy losses include “tail” and diode                                                                                                                                                      | -     | 0.35 | -    |      |
| Total switching energy | $E_{ts}$     | reverse recovery.                                                                                                                                                                           | -     | 0.57 | -    |      |

### Anti-Parallel Diode Characteristic

|                                                                  |              |                                                                                                         |   |      |   |                        |
|------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=25^\circ\text{C}$ ,<br>$V_R=400\text{V}$ , $I_F=15\text{A}$ ,<br>$di_F/dt=825\text{A}/\mu\text{s}$ | - | 34   | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                         | - | 0.24 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                         | - | 10.4 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                         | - | 718  | - | $\text{A}/\mu\text{s}$ |

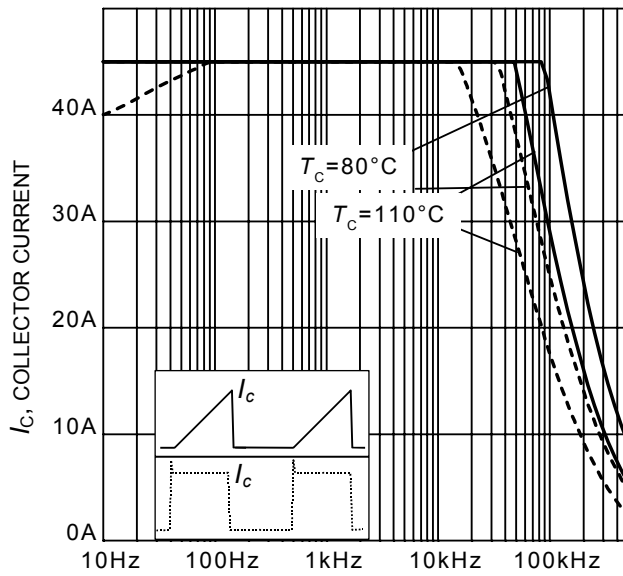
### Switching Characteristic, Inductive Load, at $T_j=175^\circ\text{C}$

| Parameter              | Symbol       | Conditions                                                                                                                                                                                   | Value |      |      | Unit |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                              | min.  | Typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                              |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_j=175^{\circ}\text{C}$ ,<br>$V_{CC}=400\text{V}$ , $I_C=15\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ ,<br>$R_G=15\ \Omega$<br>$L_{\sigma}^{1)}=154\text{nH}$ ,<br>$C_{\sigma}^{1)}=39\text{pF}$ | -     | 17   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                              | -     | 15   | -    |      |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                              | -     | 212  | -    |      |
| Fall time              | $t_f$        |                                                                                                                                                                                              | -     | 79   | -    |      |
| Turn-on energy         | $E_{on}$     | Energy losses include<br>“tail” and diode<br>reverse recovery.                                                                                                                               | -     | 0.34 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                              | -     | 0.47 | -    |      |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                              | -     | 0.81 | -    |      |

### Anti-Parallel Diode Characteristic

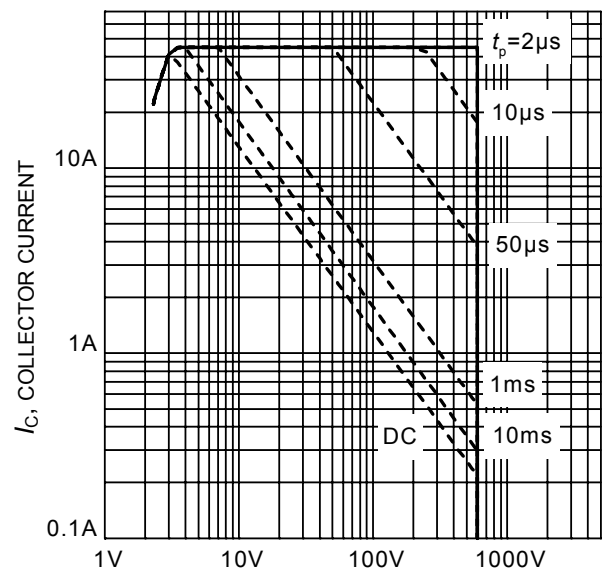
|                                                                  |              |                                                                                                          |   |      |   |                        |
|------------------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=175^\circ\text{C}$ ,<br>$V_R=400\text{V}$ , $I_F=15\text{A}$ ,<br>$di_F/dt=825\text{A}/\mu\text{s}$ | - | 140  | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                          | - | 1.0  | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                          | - | 14.7 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                          | - | 495  | - | $\text{A}/\mu\text{s}$ |

<sup>1)</sup> Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to dynamic test circuit in Figure E.



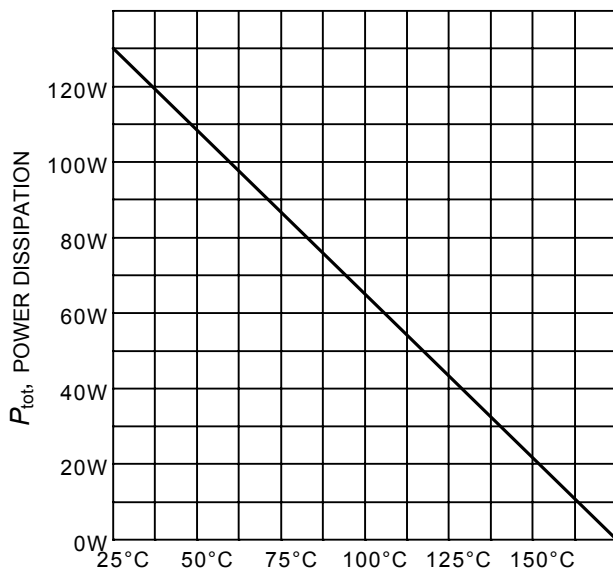
$f$ , SWITCHING FREQUENCY

**Figure 1. Collector current as a function of switching frequency**  
( $T_j \leq 175^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 15\Omega$ )



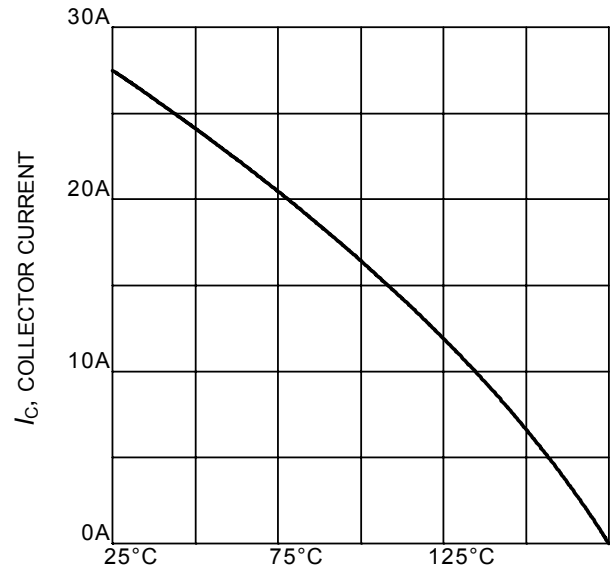
$V_{CE}$ , COLLECTOR-EMITTER VOLTAGE

**Figure 2. Safe operating area**  
( $D = 0$ ,  $T_C = 25^\circ\text{C}$ ,  $T_j \leq 175^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$ )



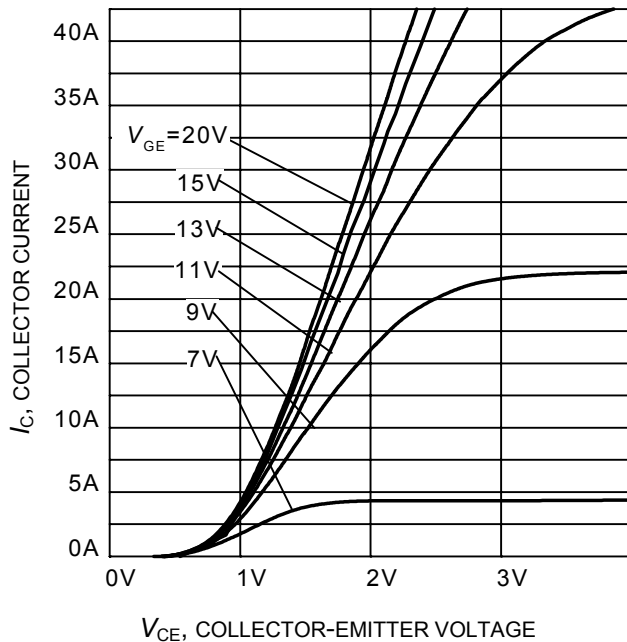
$T_C$ , CASE TEMPERATURE

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

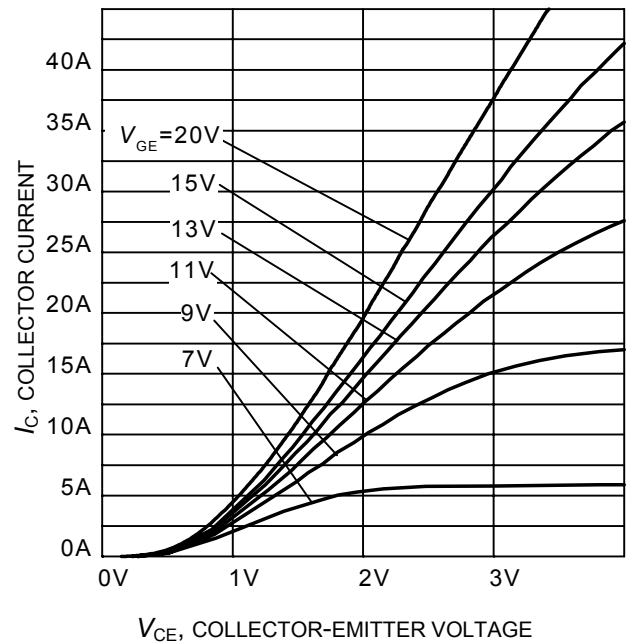


$T_C$ , CASE TEMPERATURE

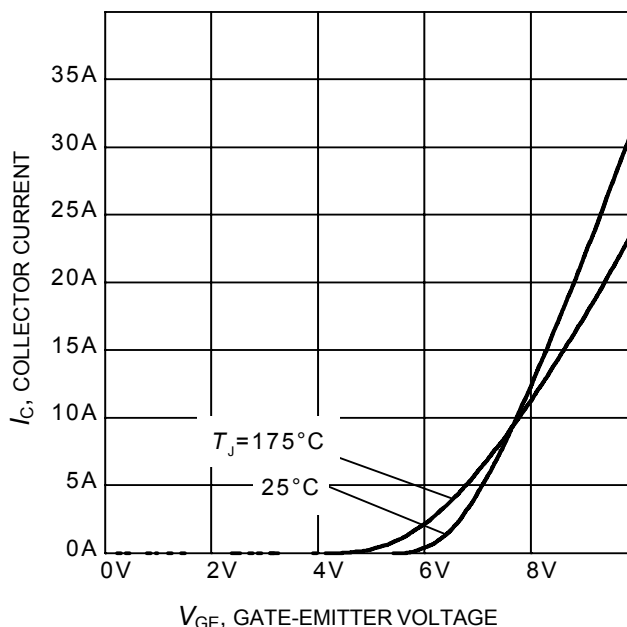
**Figure 4. Collector current as a function of case temperature**  
( $V_{GE} \geq 15\text{V}$ ,  $T_j \leq 175^\circ\text{C}$ )



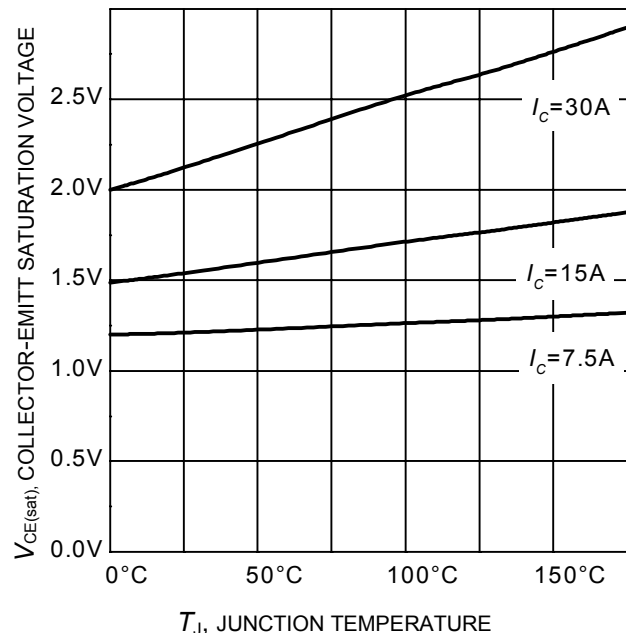
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



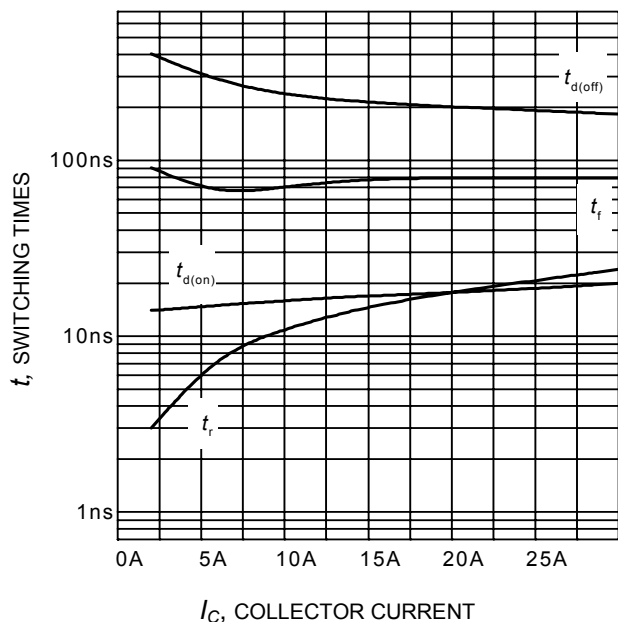
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



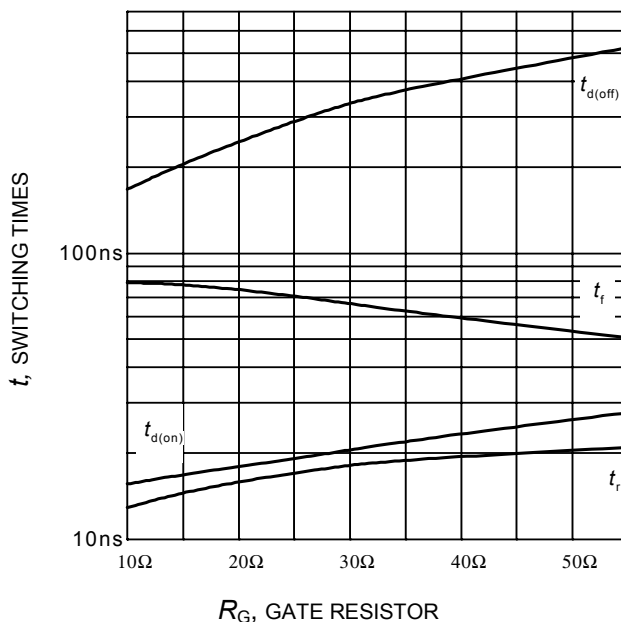
**Figure 7. Typical transfer characteristic**  
( $V_{ce} = 20\text{V}$ )



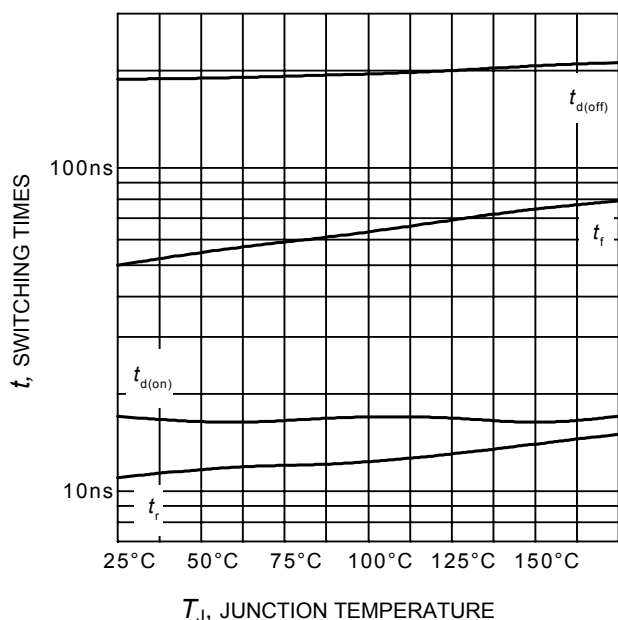
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{ge} = 15\text{V}$ )



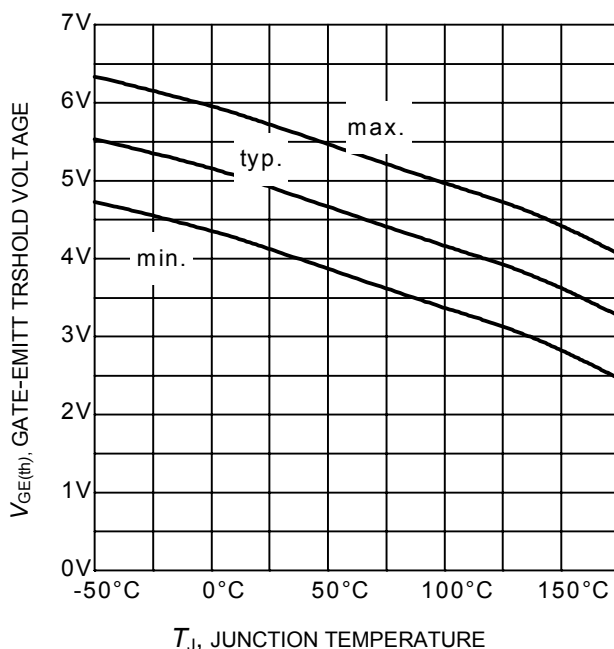
**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $R_G = 15\Omega$ , Dynamic test circuit in Figure E)



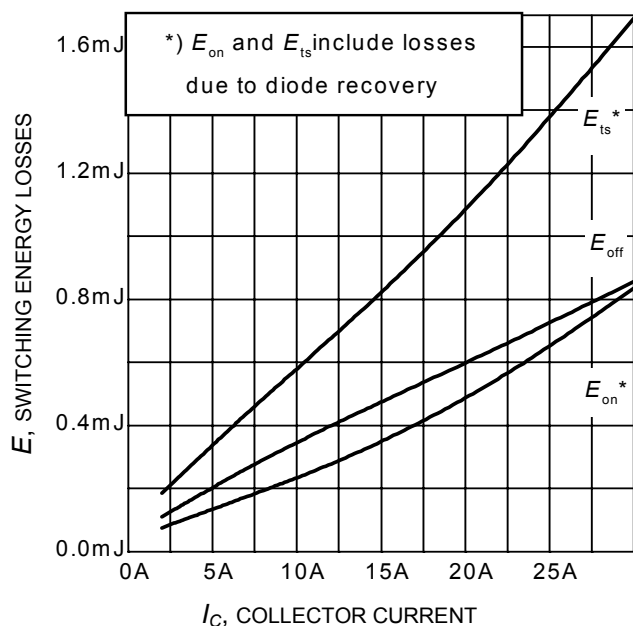
**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 15\text{A}$ , Dynamic test circuit in Figure E)



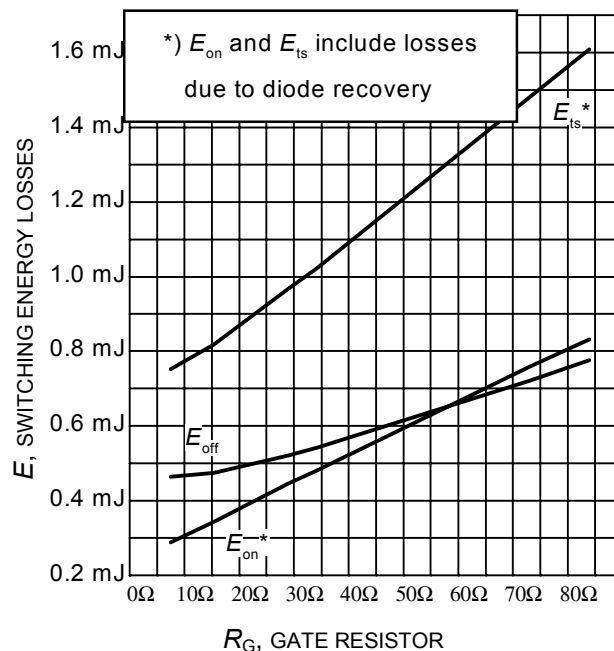
**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 15\Omega$ , Dynamic test circuit in Figure E)



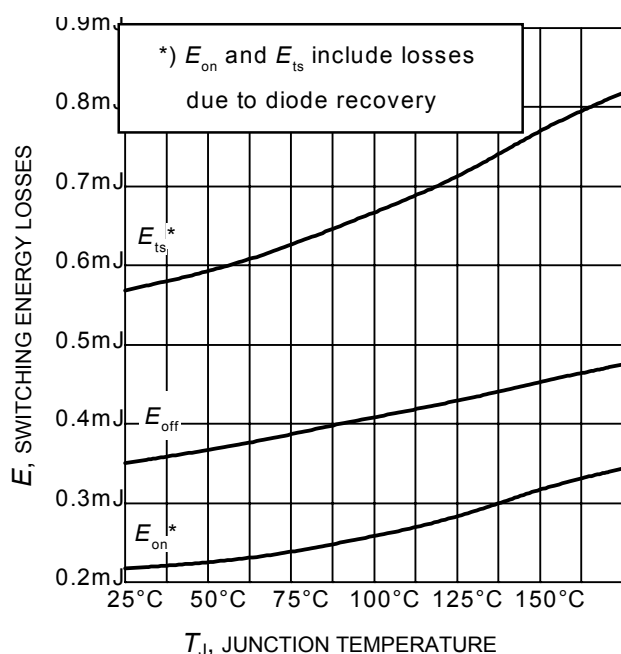
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.21\text{mA}$ )



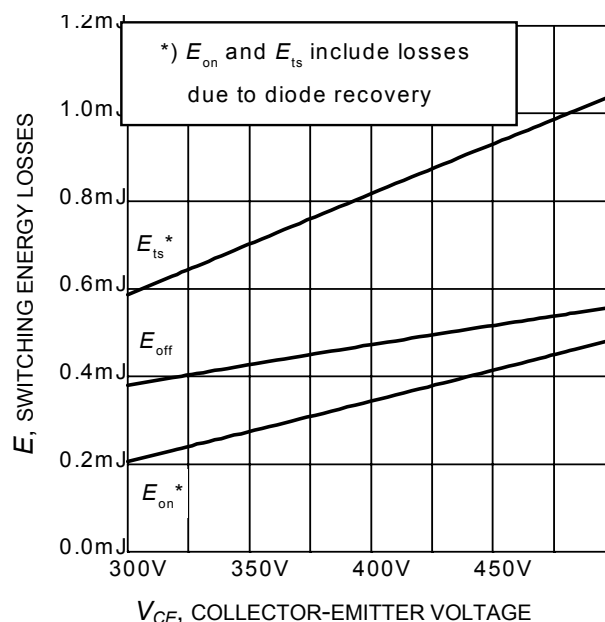
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $R_G = 15\Omega$ , Dynamic test circuit in Figure E)



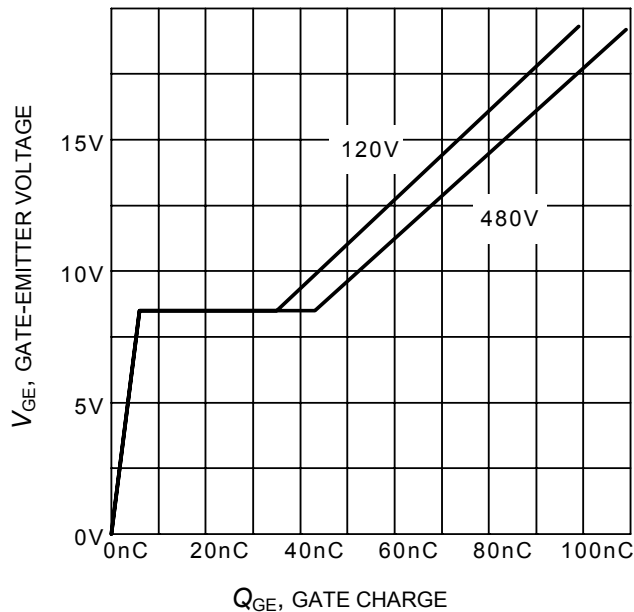
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 15\text{A}$ , Dynamic test circuit in Figure E)



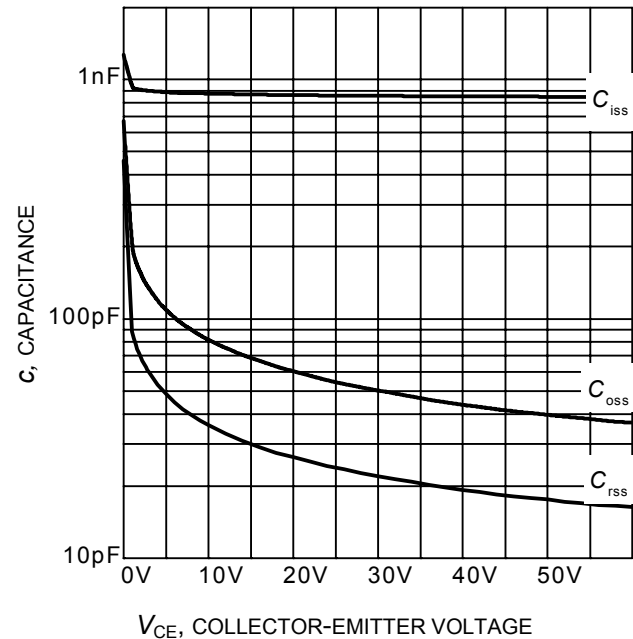
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 15\Omega$ , Dynamic test circuit in Figure E)



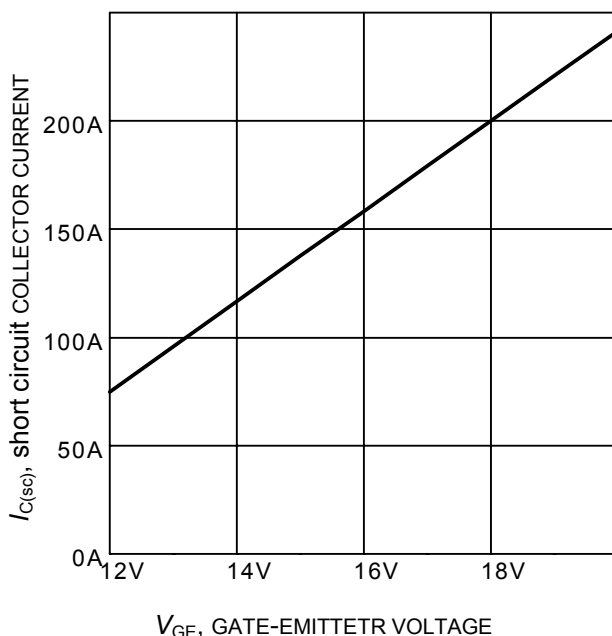
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 15\Omega$ , Dynamic test circuit in Figure E)



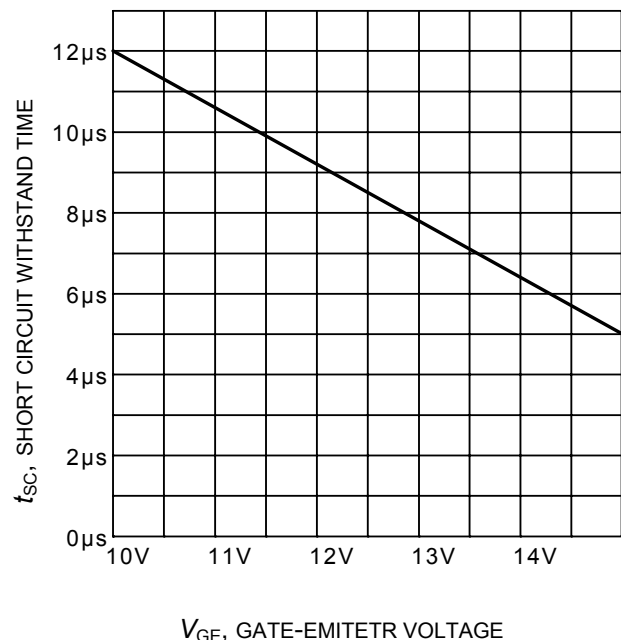
**Figure 17. Typical gate charge**  
( $I_C=15\text{ A}$ )



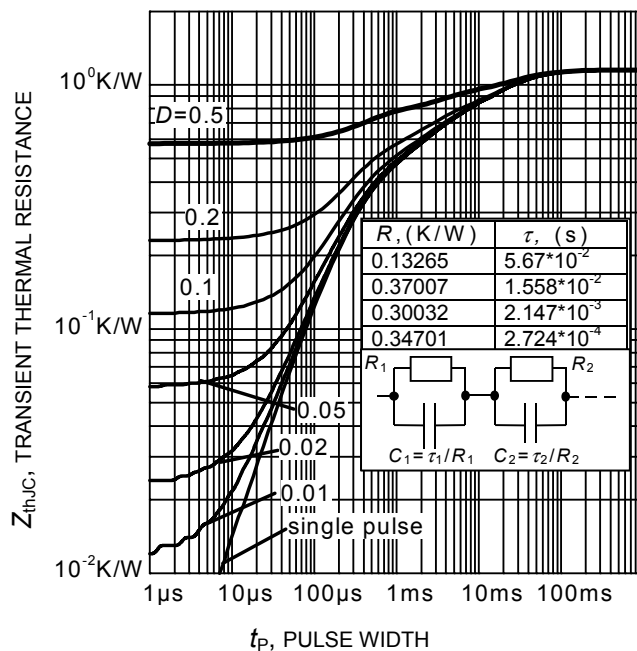
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE}=0\text{V}$ ,  $f = 1\text{ MHz}$ )



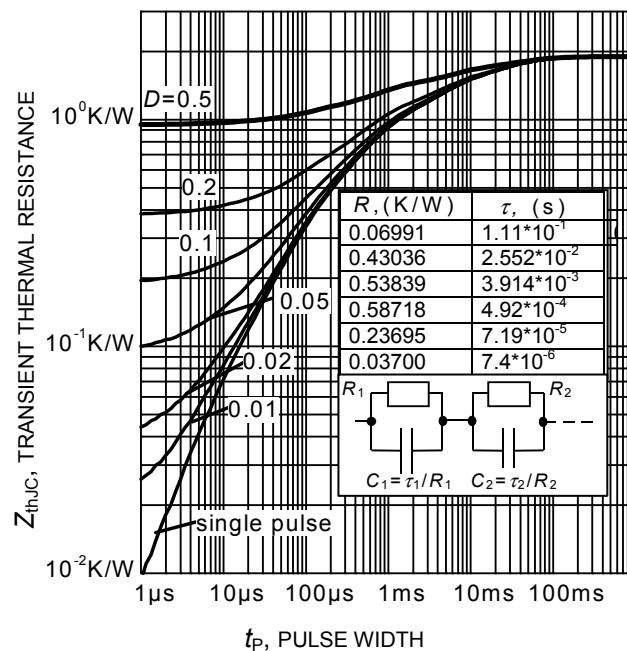
**Figure 19. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 400\text{V}$ ,  $T_J \leq 150^\circ\text{C}$ )



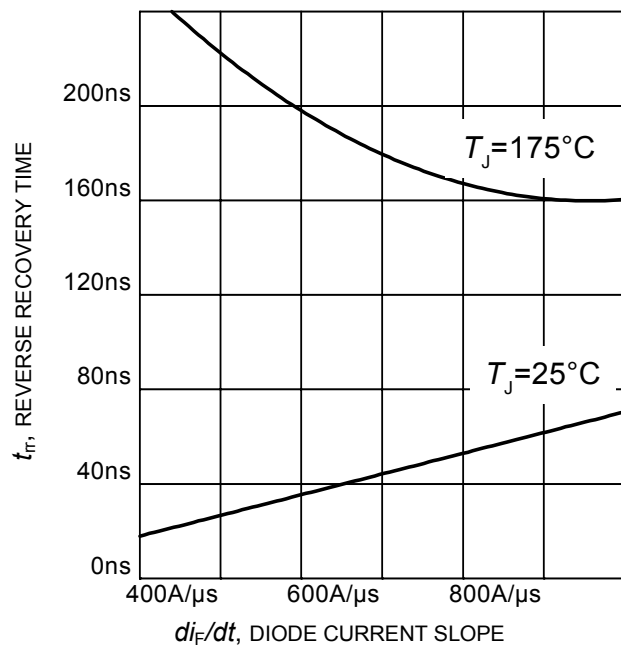
**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE}=600\text{V}$ , start at  $T_J=25^\circ\text{C}$ ,  $T_{Jmax}<150^\circ\text{C}$ )



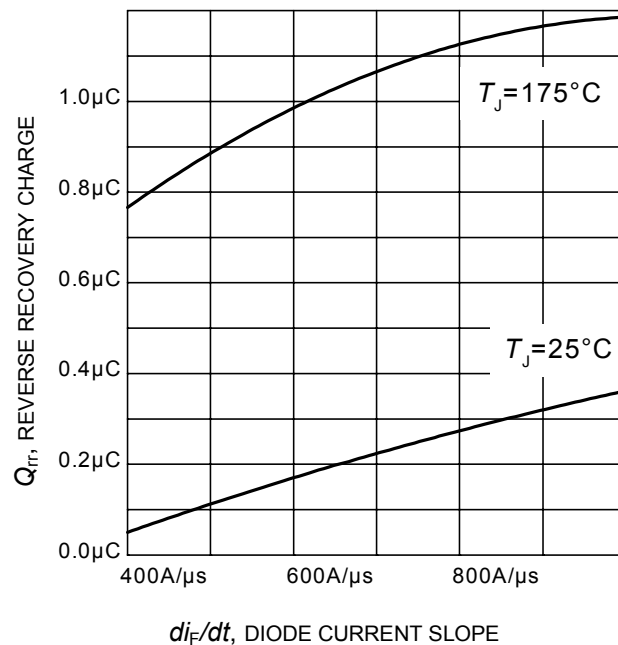
**Figure 21. IGBT transient thermal resistance**  
( $D = t_p / T$ )



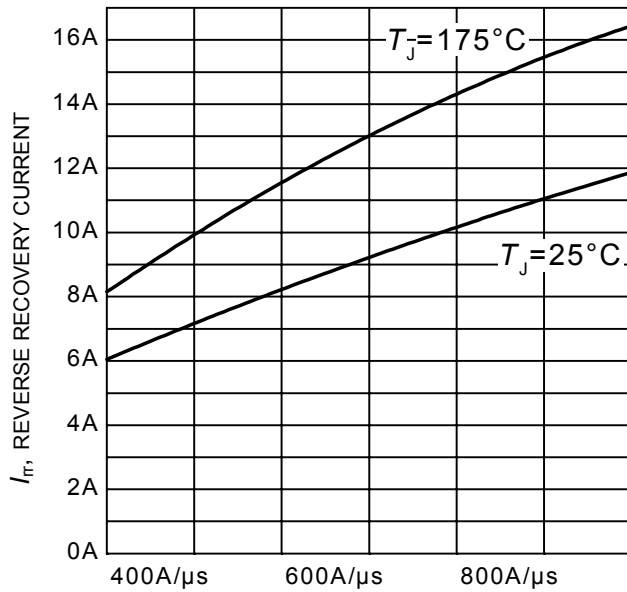
**Figure 22. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



**Figure 23. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 15A$ ,  
Dynamic test circuit in Figure E)



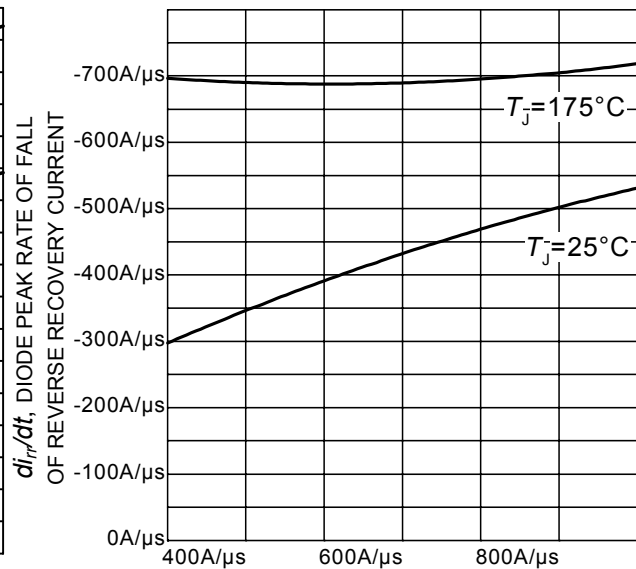
**Figure 24. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 15A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

**Figure 25. Typical reverse recovery current as a function of diode current slope**

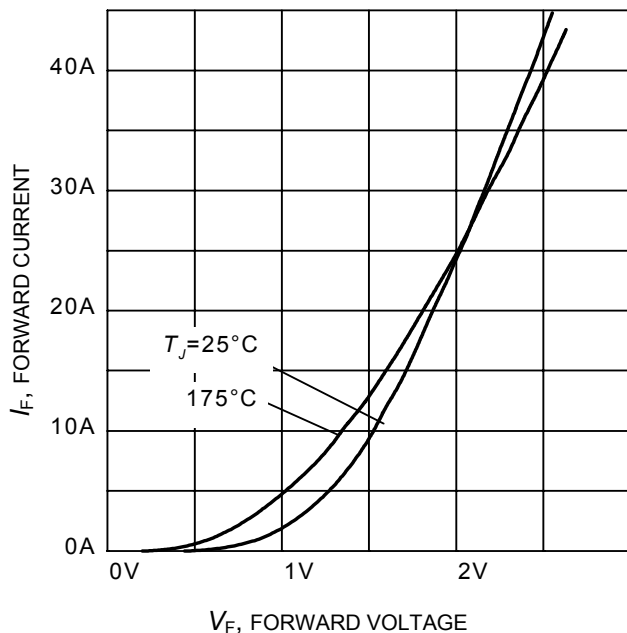
( $V_R = 400V$ ,  $I_F = 15A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

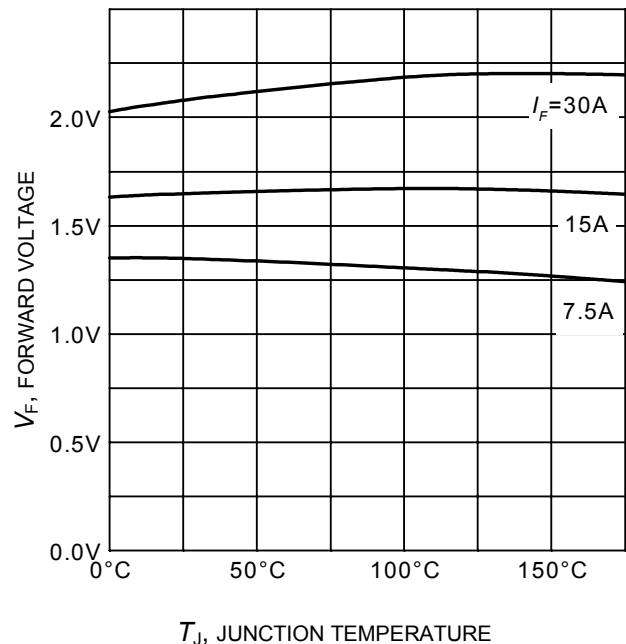
**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**

( $V_R = 400V$ ,  $I_F = 15A$ ,  
Dynamic test circuit in Figure E)



$V_F$ , FORWARD VOLTAGE

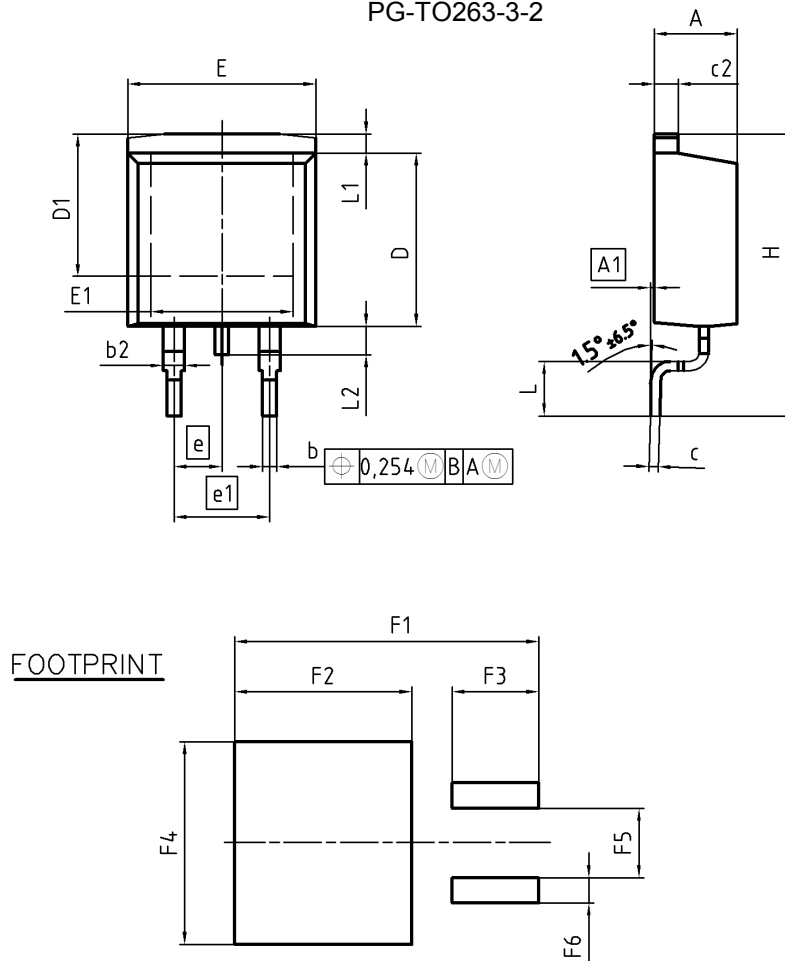
**Figure 27. Typical diode forward current as a function of forward voltage**



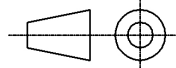
$T_J$ , JUNCTION TEMPERATURE

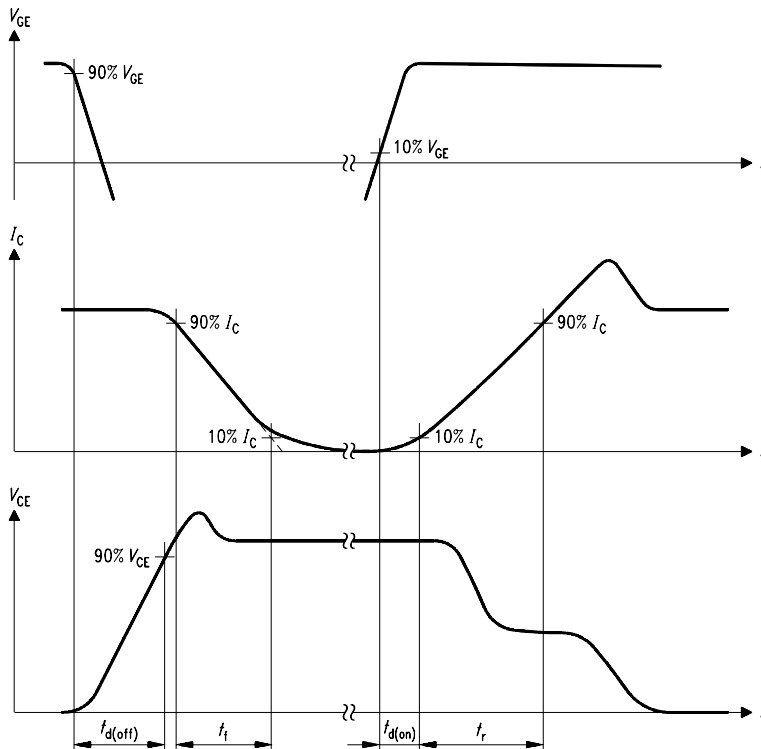
**Figure 28. Typical diode forward voltage as a function of junction temperature**

PG-TO263-3-2

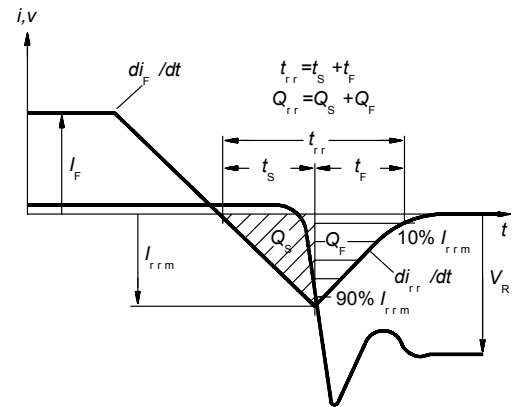


| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.30        | 4.57  | 0.169  | 0.180 |
| A1  | 0.00        | 0.25  | 0.000  | 0.010 |
| b   | 0.65        | 0.85  | 0.026  | 0.033 |
| b2  | 0.95        | 1.15  | 0.037  | 0.045 |
| c   | 0.33        | 0.65  | 0.013  | 0.026 |
| c2  | 1.17        | 1.40  | 0.046  | 0.055 |
| D   | 8.51        | 9.45  | 0.335  | 0.372 |
| D1  | 7.10        | 7.90  | 0.280  | 0.311 |
| E   | 9.80        | 10.31 | 0.386  | 0.406 |
| E1  | 6.50        | 8.60  | 0.256  | 0.339 |
| e   | 2.54        |       | 0.100  |       |
| e1  | 5.08        |       | 0.200  |       |
| N   | 2           |       | 2      |       |
| H   | 14.61       | 15.88 | 0.575  | 0.625 |
| L   | 2.29        | 3.00  | 0.090  | 0.118 |
| L1  | 0.70        | 1.60  | 0.028  | 0.063 |
| L2  | 1.00        | 1.78  | 0.039  | 0.070 |
| F1  | 16.05       | 16.25 | 0.632  | 0.640 |
| F2  | 9.30        | 9.50  | 0.366  | 0.374 |
| F3  | 4.50        | 4.70  | 0.177  | 0.185 |
| F4  | 10.70       | 10.90 | 0.421  | 0.429 |
| F5  | 3.65        | 3.85  | 0.144  | 0.152 |
| F6  | 1.25        | 1.45  | 0.049  | 0.057 |

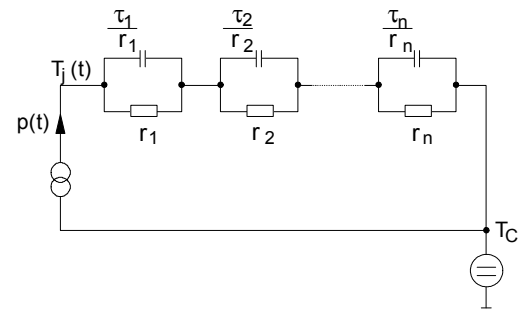
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| DOCUMENT NO.<br>Z8B00003324                                                                                  |
| SCALE<br>0 5 5 7.5mm                                                                                         |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>30-08-2007                                                                                     |
| REVISION<br>01                                                                                               |



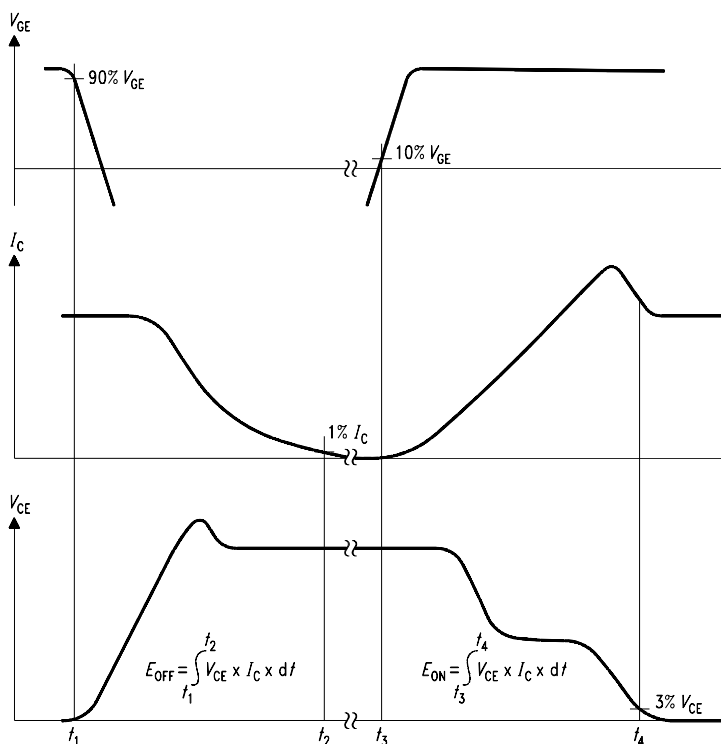
**Figure A. Definition of switching times**



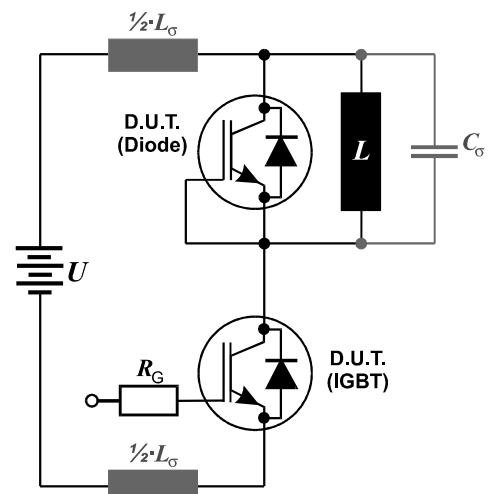
**Figure C. Definition of diodes switching characteristics**



**Figure D. Thermal equivalent circuit**



**Figure B. Definition of switching losses**



**Figure E. Dynamic test circuit**  
Leakage inductance  $L_\sigma = 60\text{nH}$   
and Stray capacity  $C_\sigma = 40\text{pF}$ .

**Edition 2006-01**

**Published by**  
**Infineon Technologies AG**  
**81726 München, Germany**

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