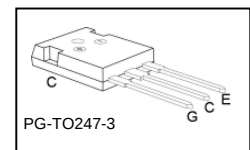
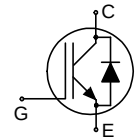


Low Loss DuoPack : IGBT in TRENCHSTOP™ technology with soft, fast recovery anti-parallel Emitter Controlled HE diode



### Features:

- Very low  $V_{CE(sat)}$  1.5V (typ.)
- Maximum junction temperature 175°C
- Short circuit withstand time 5μs
- TRENCHSTOP™ and fieldstop technology for 600V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - low  $V_{CE(sat)}$  and positive temperature coefficient
- 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/>



### Applications:

- Inductive Cooking
- Soft & Hard Switching Applications

| Type     | $V_{CE}$ | $I_C$ | $V_{CE(sat)}, T_j=25^\circ\text{C}$ | $T_{j,max}$ | Marking | Package    |
|----------|----------|-------|-------------------------------------|-------------|---------|------------|
| IHW40T60 | 600V     | 40A   | 1.55V                               | 175°C       | H40T60B | PG-TO247-3 |

### Maximum Ratings

| Parameter                                                                                               | Symbol      | Value      | Unit |
|---------------------------------------------------------------------------------------------------------|-------------|------------|------|
| Collector-emitter voltage, $T_j \geq 25^\circ\text{C}$                                                  | $V_{CE}$    | 600        | V    |
| DC collector current, limited by $T_{j,max}$                                                            | $I_C$       | 80         | A    |
| $T_C = 25^\circ\text{C}$                                                                                |             | 40         |      |
| $T_C = 100^\circ\text{C}$                                                                               |             |            |      |
| Pulsed collector current, $t_p$ limited by $T_{j,max}$                                                  | $I_{Cpuls}$ | 120        |      |
| Turn off safe operating area, $V_{CE} = 600\text{V}$ , $T_j = 175^\circ\text{C}$ , $t_p = 1\mu\text{s}$ | -           | 120        |      |
| Diode forward current, limited by $T_{j,max}$                                                           | $I_F$       | 60         | A    |
| $T_C = 25^\circ\text{C}$                                                                                |             | 30         |      |
| $T_C = 100^\circ\text{C}$                                                                               |             |            |      |
| Diode pulsed current, $t_p$ limited by $T_{j,max}$                                                      | $I_{Fpuls}$ | 90         |      |
| Gate-emitter voltage                                                                                    | $V_{GE}$    | $\pm 20$   | V    |
| Transient Gate-emitter voltage ( $t_p < 10\mu\text{s}$ , $D < 0.01$ )                                   |             | $\pm 25$   |      |
| 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 $T_C = 25^\circ\text{C}$                                                              | $P_{tot}$   | 303        | W    |
| Operating junction temperature                                                                          | $T_j$       | -40...+175 | °C   |
| Storage temperature                                                                                     | $T_{stg}$   | -55...+150 |      |
| Soldering temperature, 1.6mm (0.063 in.) from case for 10s                                              | -           | 260        |      |

<sup>1</sup> J-STD-020 and JESD-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  | $R_{thJC}$  |            | 0.49       | K/W  |
| Diode thermal resistance,<br>junction – case | $R_{thJCD}$ |            | 1.05       |      |
| Thermal resistance,<br>junction – ambient    | $R_{thJA}$  |            | 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  | $V_{(BR)CES}$ | $V_{GE}=0V, I_C=0.5mA$                                                   | 600    | -            | -          | V        |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE} = 15V, I_C=40A$<br>$T_j=25^{\circ}C$<br>$T_j=175^{\circ}C$       | -<br>- | 1.55<br>1.90 | 2.05<br>-  |          |
| Diode forward voltage                | $V_F$         | $V_{GE}=0V, I_F=30A$<br>$T_j=25^{\circ}C$<br>$T_j=175^{\circ}C$          | -<br>- | 1.65<br>1.60 | 2.05<br>-  |          |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C=0.58mA,$<br>$V_{CE}=V_{GE}$                                         | 4.1    | 4.9          | 5.7        |          |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE}=600V,$<br>$V_{GE}=0V$<br>$T_j=25^{\circ}C$<br>$T_j=175^{\circ}C$ | -<br>- | -<br>-       | 40<br>3000 |          |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE}=0V, V_{GE}=20V$                                                  | -      | -            | 100        | nA       |
| Transconductance                     | $g_{fs}$      | $V_{CE}=20V, I_C=40A$                                                    | -      | 22           | -          | S        |
| Integrated gate resistor             | $R_{Gint}$    |                                                                          | -      |              |            | $\Omega$ |

### Dynamic Characteristic

|                                                                   |            |                                           |   |      |   |    |
|-------------------------------------------------------------------|------------|-------------------------------------------|---|------|---|----|
| Input capacitance                                                 | $C_{iss}$  | $V_{CE}=25V,$<br>$V_{GE}=0V,$<br>$f=1MHz$ | - | 2423 | - | pF |
| Output capacitance                                                | $C_{oss}$  |                                           | - | 113  | - |    |
| Reverse transfer capacitance                                      | $C_{rss}$  |                                           | - | 72   | - |    |
| Gate charge                                                       | $Q_{Gate}$ | $V_{CC}=480V, I_C=40A$<br>$V_{GE}=15V$    | - | 215  | - | nC |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from case | $L_E$      |                                           | - | 13   | - | nH |

### 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>$V_{CC}=400\text{V}$ , $I_C=40\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ , $r_G=5.6\Omega$<br>$L_{\sigma}=40\text{nH}$ , $C_{\sigma}=30\text{pF}$<br>$L_{\sigma}$ , $C_{\sigma}$ from Fig. E<br>Energy losses include<br>“tail” and diode reverse<br>recovery. | -     | -    | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                        | -     | -    | -    |      |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                        | -     | 186  | -    |      |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                        | -     | 66.3 | -    |      |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                        | -     | -    | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                        | -     | 0.92 | -    |      |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                        | -     | 0.92 | -    |      |

### Anti-Parallel Diode Characteristic

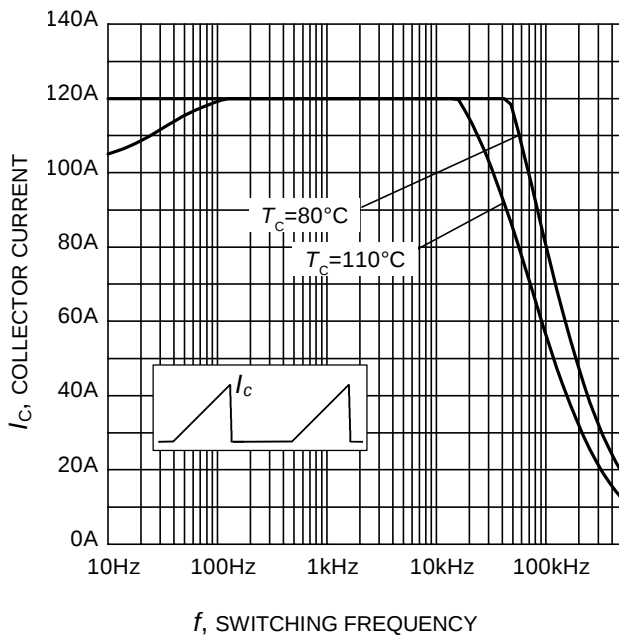
|                                                                  |              |                                                                                                         |   |      |   |                        |
|------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=25^\circ\text{C}$ ,<br>$V_R=400\text{V}$ , $I_F=30\text{A}$ ,<br>$di_F/dt=910\text{A}/\mu\text{s}$ | - | 143  | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                         | - | 0.92 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                         | - | 16.3 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                         | - | 603  | - | $\text{A}/\mu\text{s}$ |

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

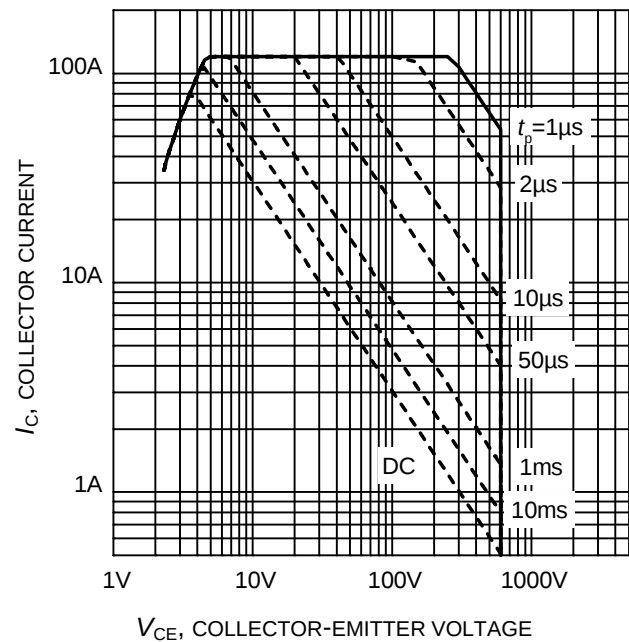
| Parameter              | Symbol       | Conditions                                                                                                                                                                                                                                                                              | Value |      |      | Unit |
|------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                                                                                                                         | min.  | Typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                                                                                                                         |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_j=175^{\circ}\text{C}$ ,<br>$V_{CC}=400\text{V}$ , $I_C=40\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ , $r_G=5.6\Omega$<br>$L_{\sigma}=40\text{nH}$ , $C_{\sigma}=30\text{pF}$<br>$L_{\sigma}$ , $C_{\sigma}$ from Fig. E<br>Energy losses include<br>“tail” and diode reverse<br>recovery. | -     | -    | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                         | -     | -    | -    |      |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                         | -     | 196  | -    |      |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                         | -     | 76.5 | -    |      |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                         | -     | -    | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                         | -     | 1.4  | -    |      |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                         | -     | 1.4  | -    |      |

### Anti-Parallel Diode Characteristic

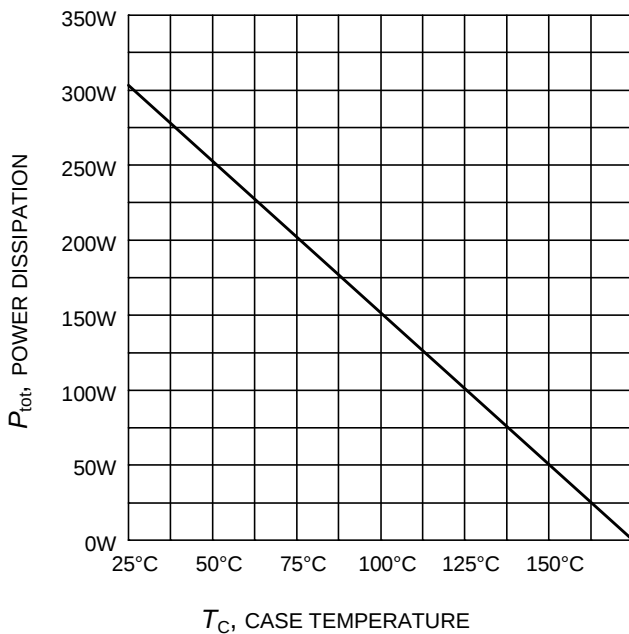
|                                                                  |              |                                                                                                        |   |      |   |                        |
|------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=175^\circ\text{C}$<br>$V_R=400\text{V}$ , $I_F=30\text{A}$ ,<br>$di_F/dt=910\text{A}/\mu\text{s}$ | - | 225  | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                        | - | 2.39 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                        | - | 22.3 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                        | - | 310  | - | $\text{A}/\mu\text{s}$ |



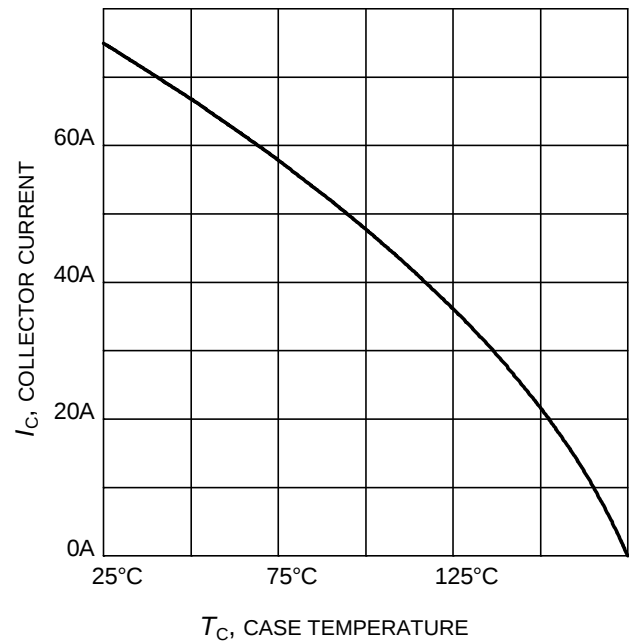
**Figure 1. Collector current as a function of switching frequency for triangular current ( $E_{on} = 0$ , hard turn-off)**  
( $T_j \leq 175^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $r_G = 5.6\Omega$ )



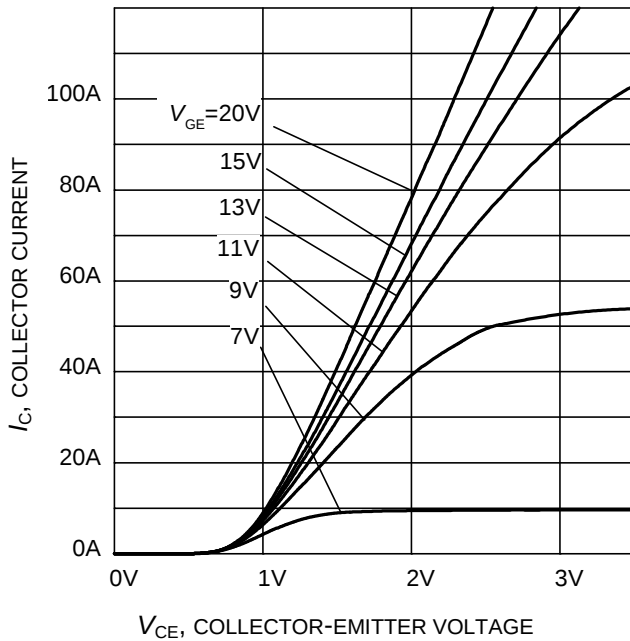
**Figure 2. Safe operating area**  
( $D = 0$ ,  $T_C = 25^\circ\text{C}$ ,  $T_j \leq 175^\circ\text{C}$ ;  
 $V_{GE} = 0/15\text{V}$ )



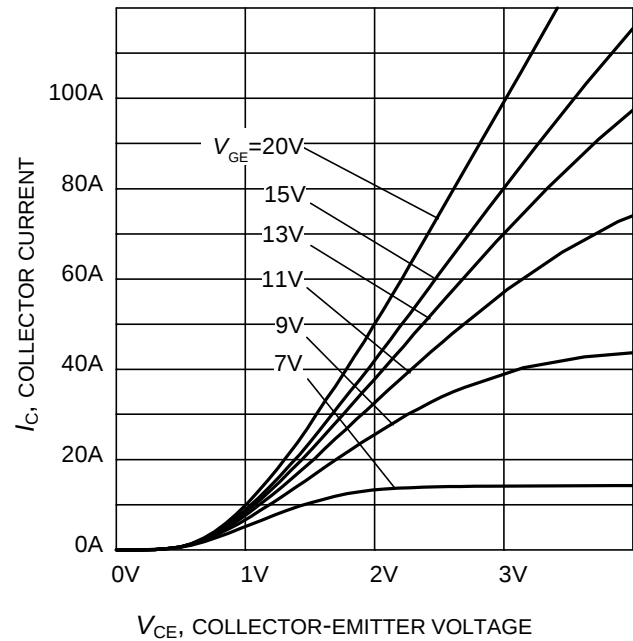
**Figure 3. Power dissipation as a function of case temperature**  
( $T_j \leq 175^\circ\text{C}$ )



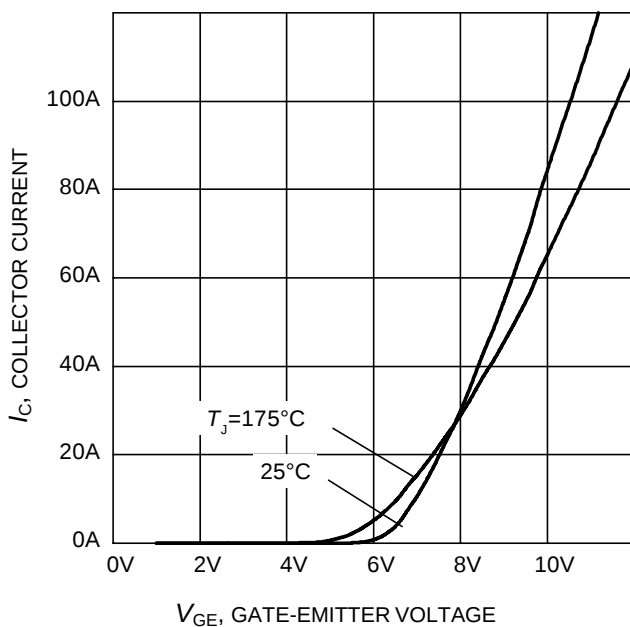
**Figure 4. Collector current as a function of case temperature**  
( $V_{GE} \geq 15\text{V}$ ,  $T_j \leq 175^\circ\text{C}$ )



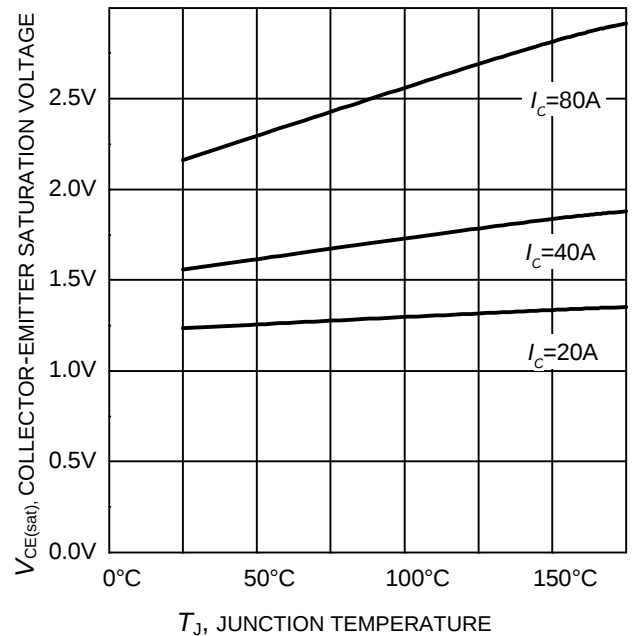
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



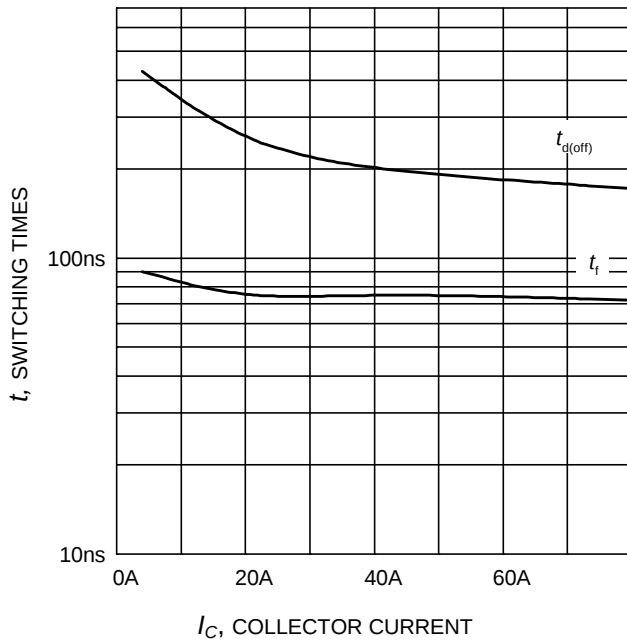
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



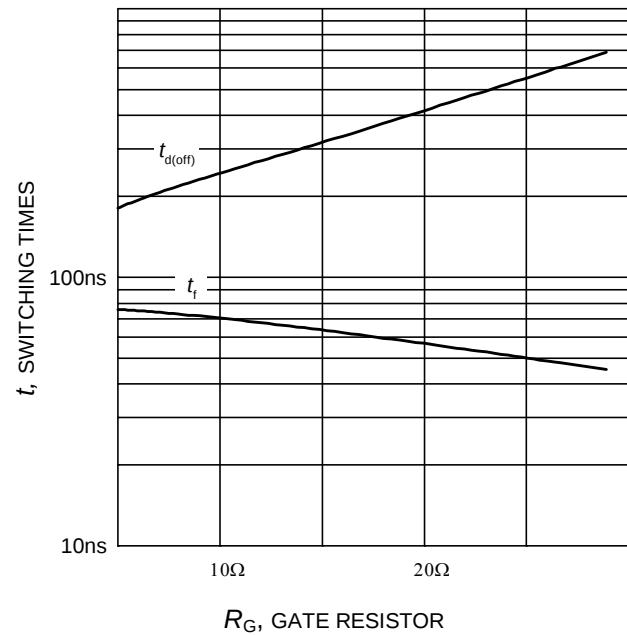
**Figure 7. Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )



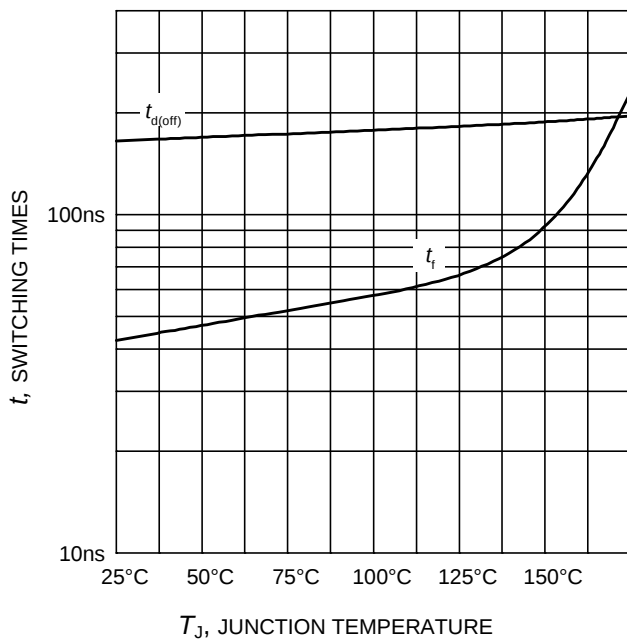
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



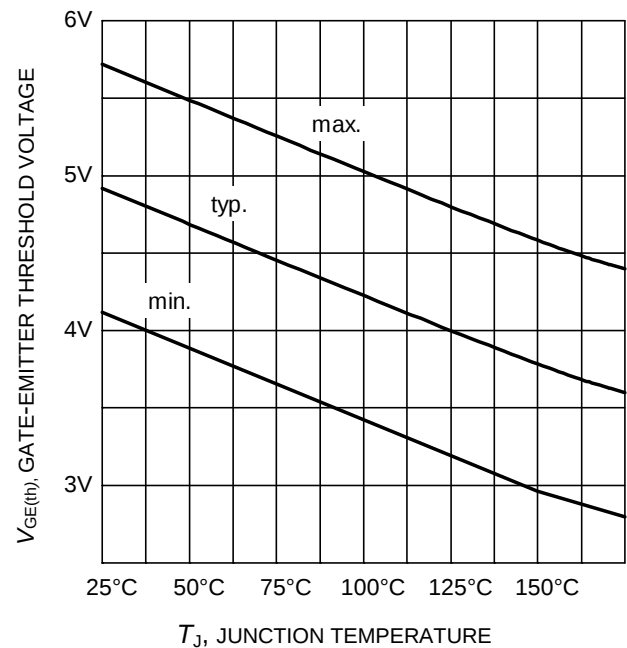
**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $r_G = 5.6\Omega$ , Dynamic test circuit in Figure E)



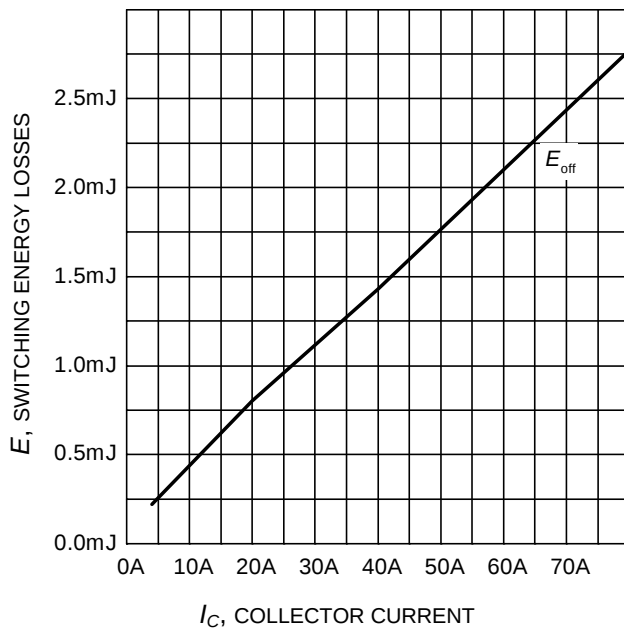
**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 40\text{A}$ , Dynamic test circuit in Figure E)



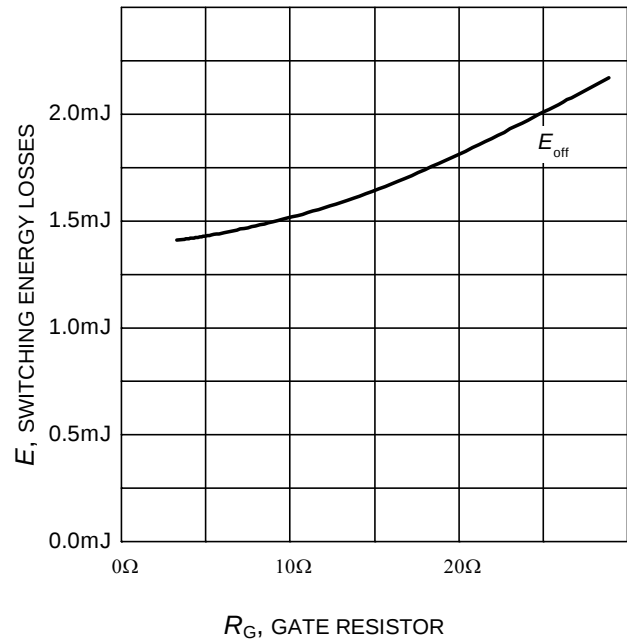
**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 40\text{A}$ ,  $r_G = 5.6\Omega$ , Dynamic test circuit in Figure E)



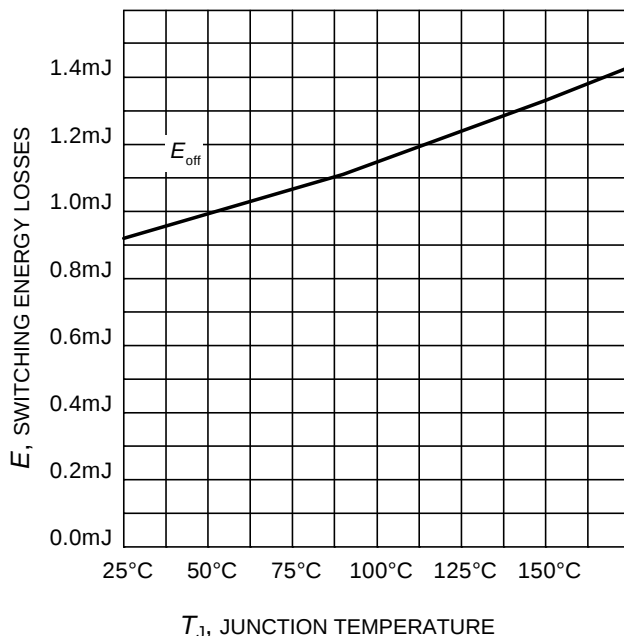
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.8\text{mA}$ )



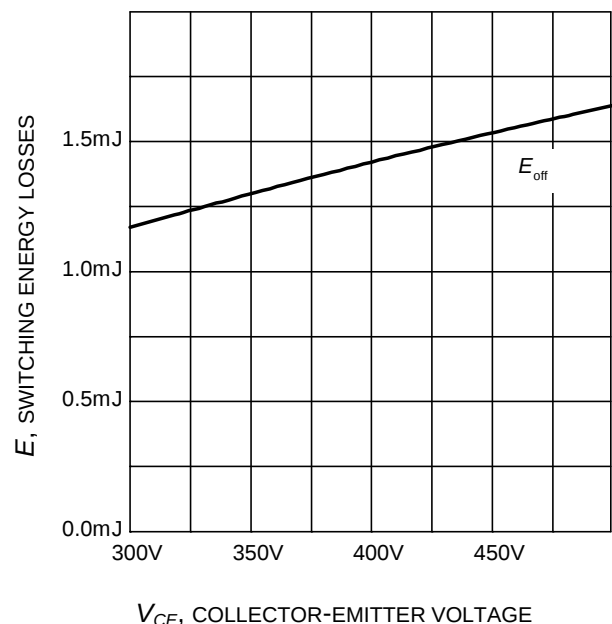
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $r_G = 5.6\Omega$ , Dynamic test circuit in Figure E)



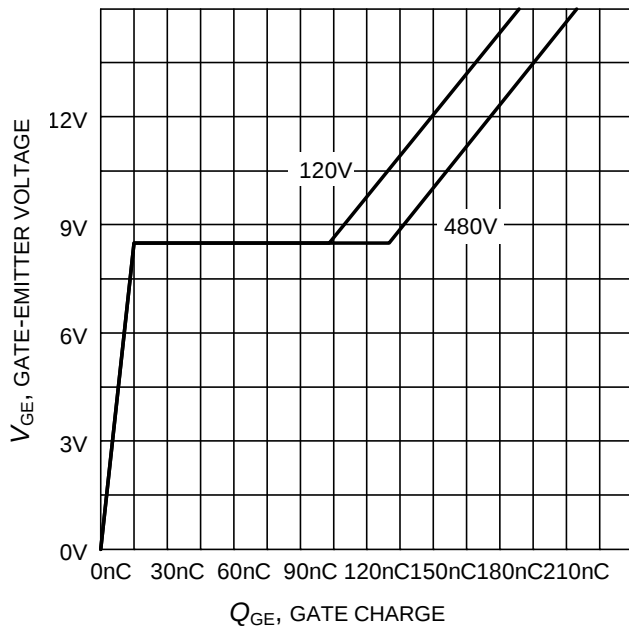
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 40\text{A}$ , Dynamic test circuit in Figure E)



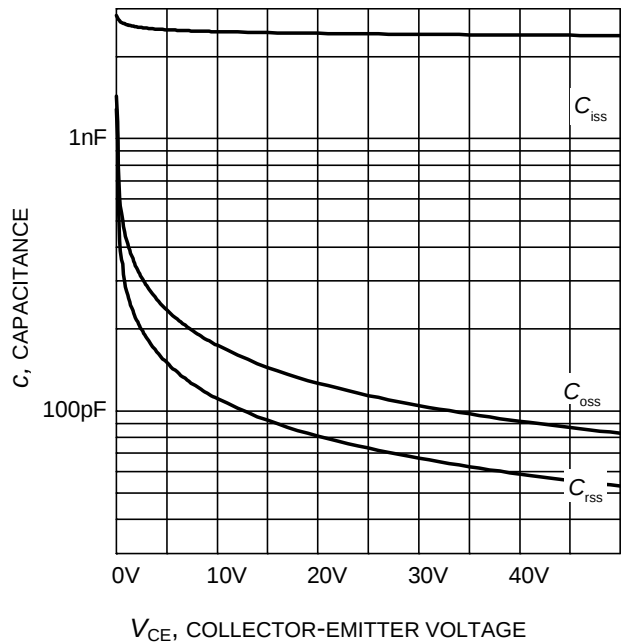
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 40\text{A}$ ,  $r_G = 5.6\Omega$ , Dynamic test circuit in Figure E)



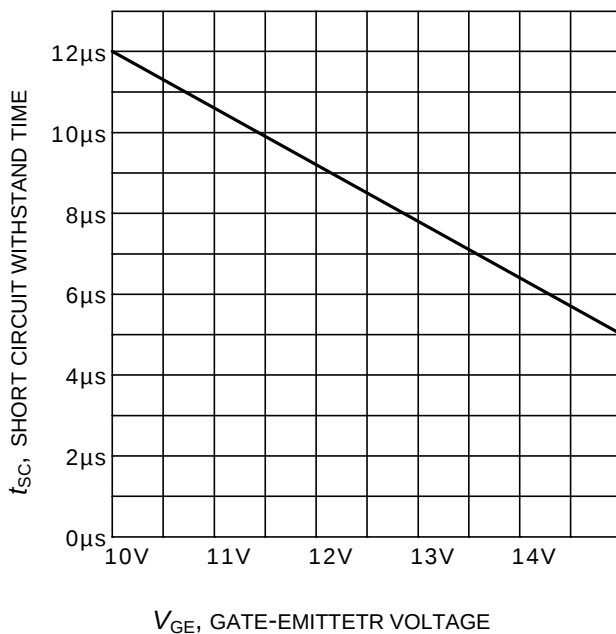
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 40\text{A}$ ,  $r_G = 5.6\Omega$ , Dynamic test circuit in Figure E)



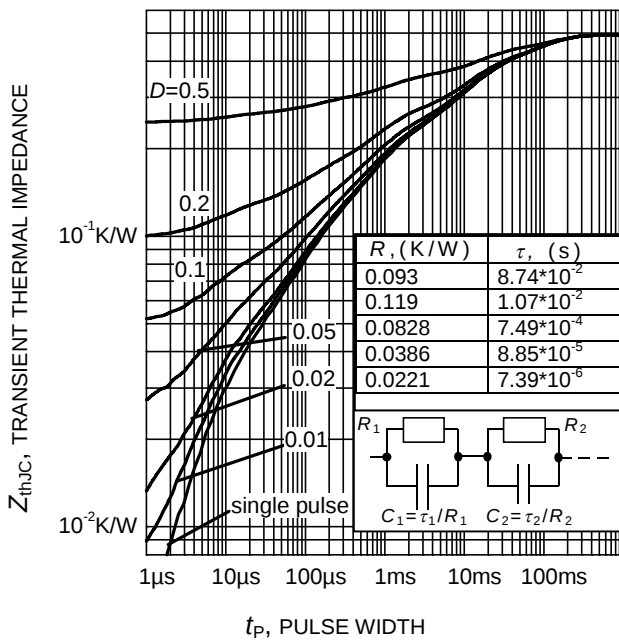
**Figure 17. Typical gate charge**  
( $I_C = 40$  A)



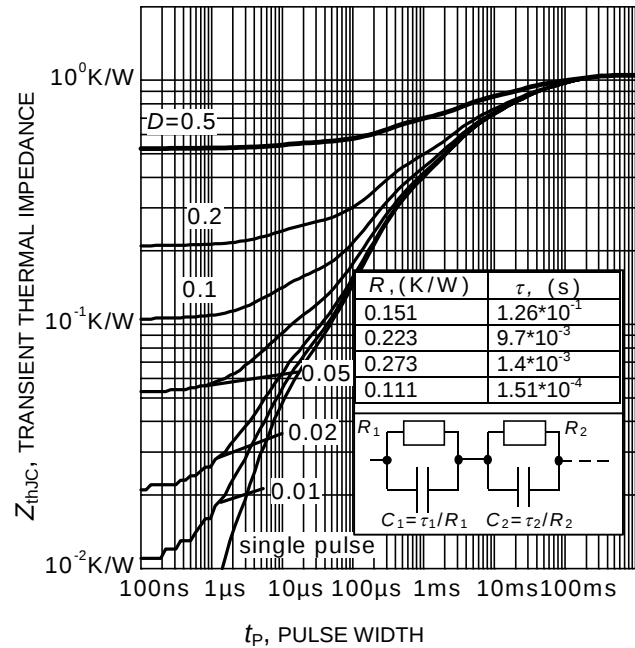
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE} = 0$  V,  $f = 1$  MHz)



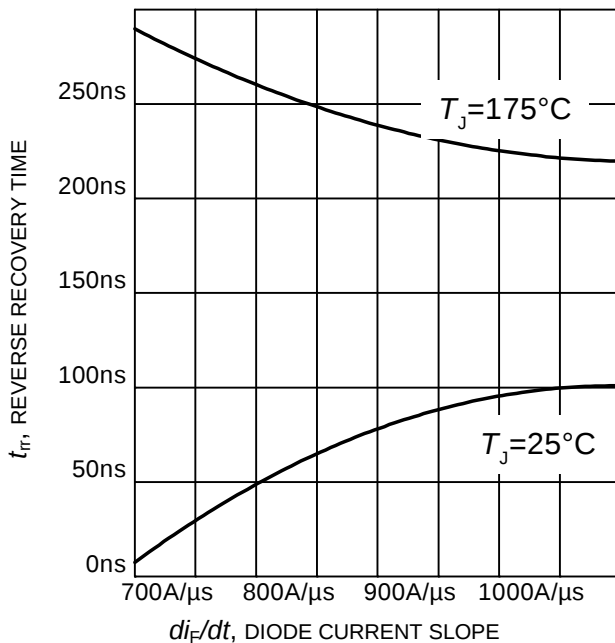
**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE} = 400$  V, start at  $T_J = 25^\circ\text{C}$ ,  $T_{Jmax} < 150^\circ\text{C}$ )



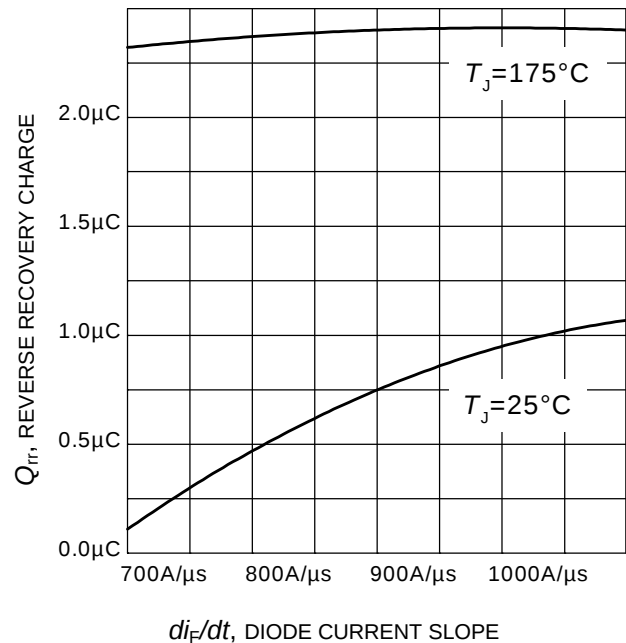
**Figure 20. IGBT transient thermal impedance**  
( $D = t_p / T$ )



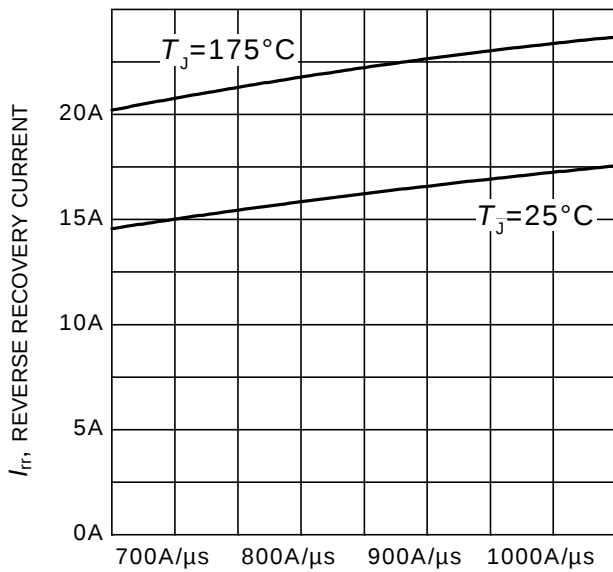
**Figure 21. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



**Figure 22. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 30A$ ,  
Dynamic test circuit in Figure E)



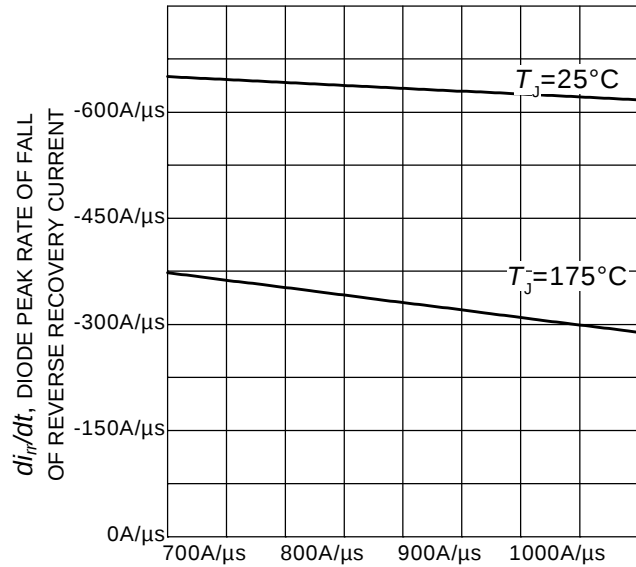
**Figure 23. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 30A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

**Figure 24. Typical reverse recovery current as a function of diode current slope**

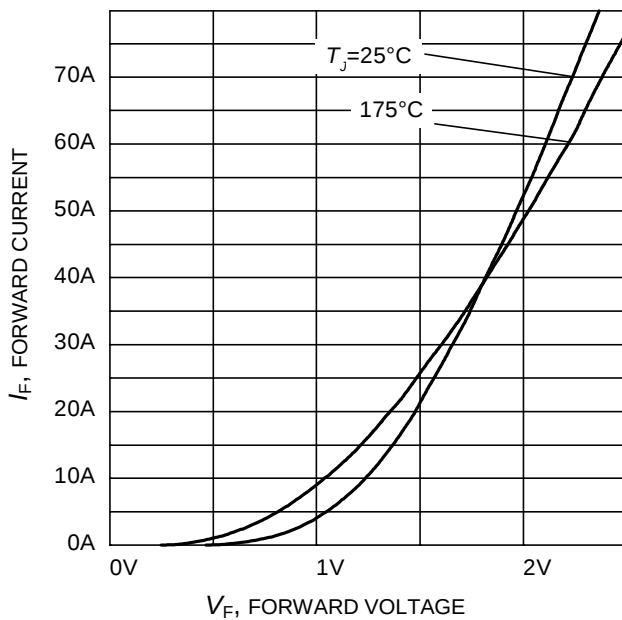
( $V_R = 400V$ ,  $I_F = 30A$ ,  
Dynamic test circuit in Figure E)



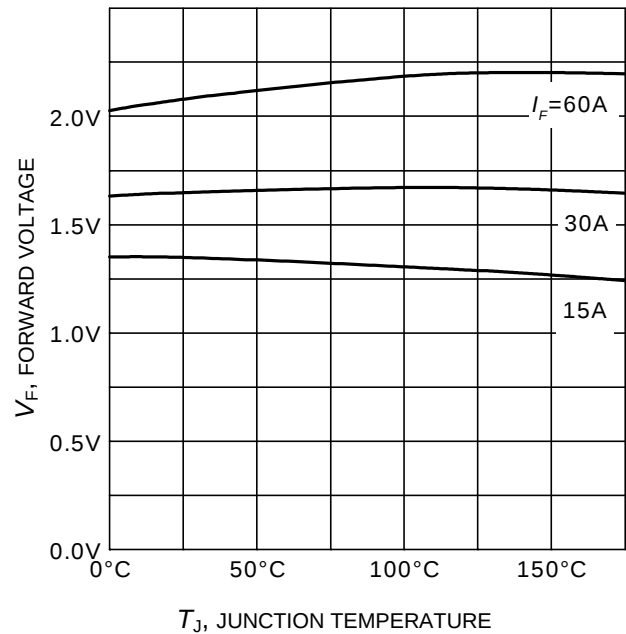
$di_F/dt$ , DIODE CURRENT SLOPE

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

( $V_R = 400V$ ,  $I_F = 30A$ ,  
Dynamic test circuit in Figure E)

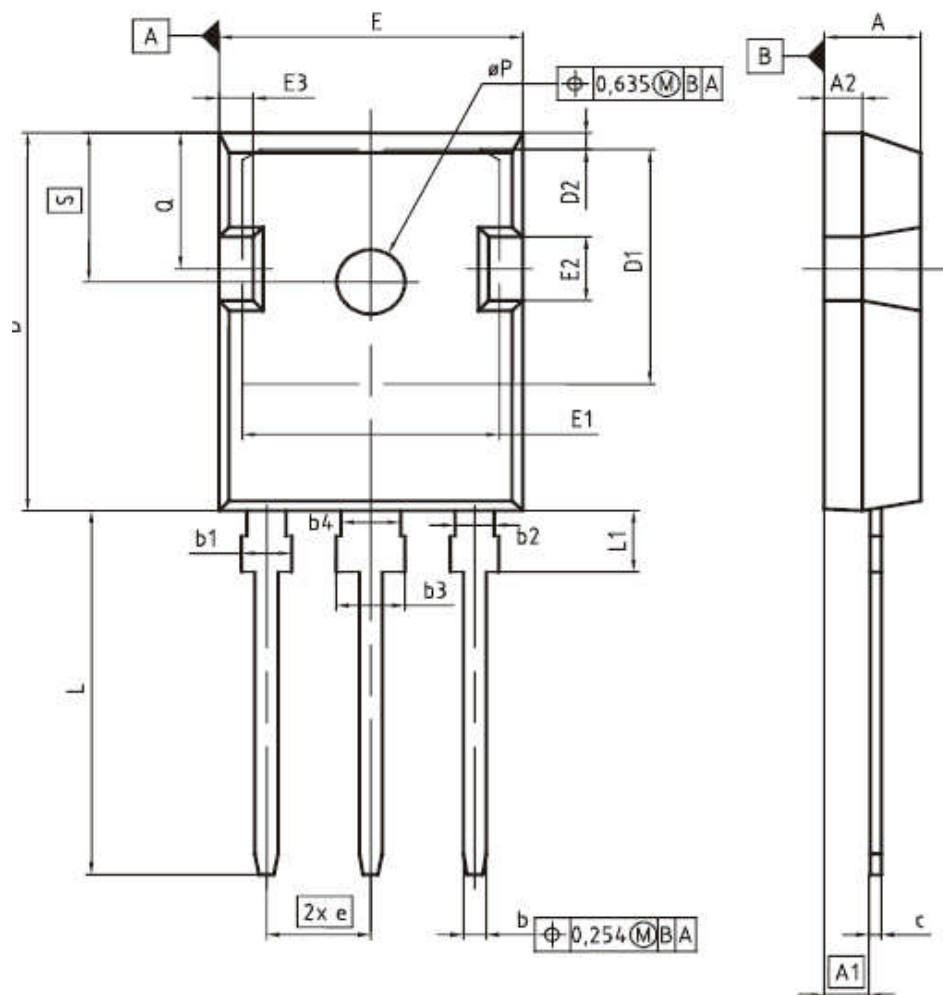


**Figure 26. Typical diode forward current as a function of forward voltage**

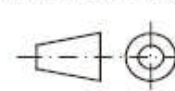


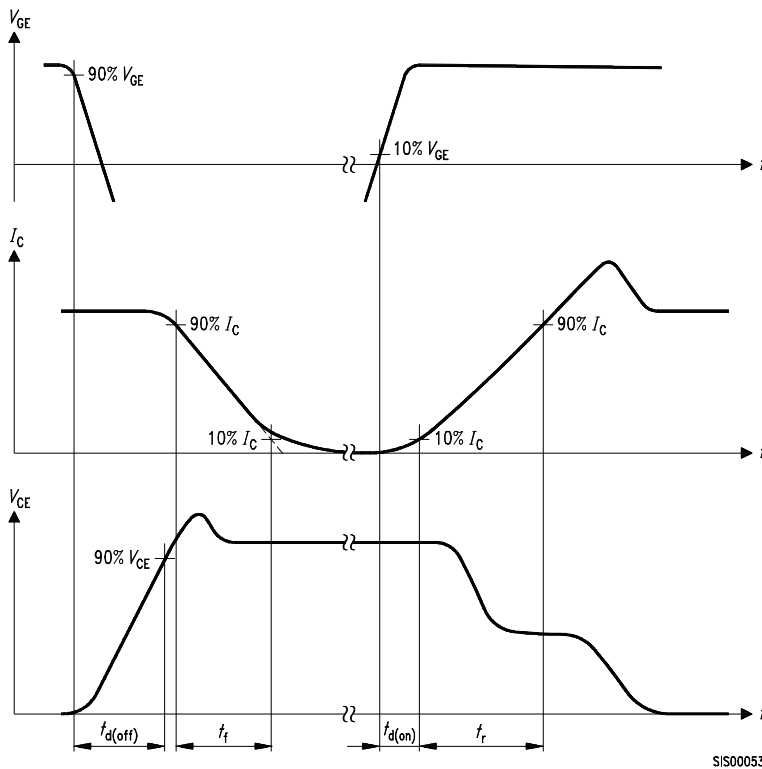
**Figure 27. Typical diode forward voltage as a function of junction temperature**

### PG-TO247-3

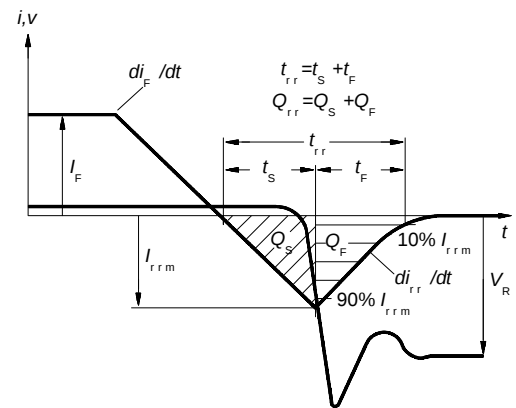


| DIM | MILLIMETERS |       | INCHES      |       |
|-----|-------------|-------|-------------|-------|
|     | MIN         | MAX   | MIN         | MAX   |
| A   | 4,83        | 5,21  | 0,190       | 0,205 |
| A1  | 2,27        | 2,54  | 0,089       | 0,100 |
| A2  | 1,85        | 2,16  | 0,073       | 0,085 |
| b   | 1,07        | 1,33  | 0,042       | 0,052 |
| b1  | 1,90        | 2,41  | 0,075       | 0,095 |
| b2  | 1,90        | 2,16  | 0,075       | 0,085 |
| b3  | 2,87        | 3,38  | 0,113       | 0,133 |
| b4  | 2,87        | 3,13  | 0,113       | 0,123 |
| c   | 0,55        | 0,68  | 0,022       | 0,027 |
| D   | 20,80       | 21,10 | 0,819       | 0,831 |
| D1  | 16,25       | 17,65 | 0,640       | 0,695 |
| D2  | 0,95        | 1,35  | 0,037       | 0,053 |
| E   | 15,70       | 16,13 | 0,618       | 0,635 |
| E1  | 13,10       | 14,15 | 0,516       | 0,557 |
| E2  | 3,68        | 5,10  | 0,145       | 0,201 |
| E3  | 1,00        | 2,60  | 0,039       | 0,102 |
| e   | 5,44 (BSC)  |       | 0,214 (BSC) |       |
| N   | 3           |       | 3           |       |
| L   | 19,80       | 20,32 | 0,780       | 0,800 |
| L1  | 4,10        | 4,47  | 0,161       | 0,176 |
| øP  | 3,50        | 3,70  | 0,138       | 0,146 |
| Q   | 5,49        | 6,00  | 0,216       | 0,236 |
| S   | 6,04        | 6,30  | 0,238       | 0,248 |

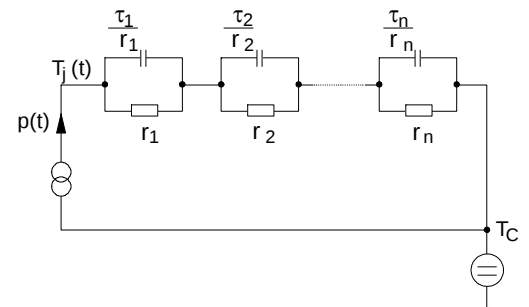
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| DOCUMENT NO.<br>Z8B00003327                                                                                  |
| SCALE<br>0 5 7,5mm                                                                                           |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>09-07-2010                                                                                     |
| REVISION<br>05                                                                                               |



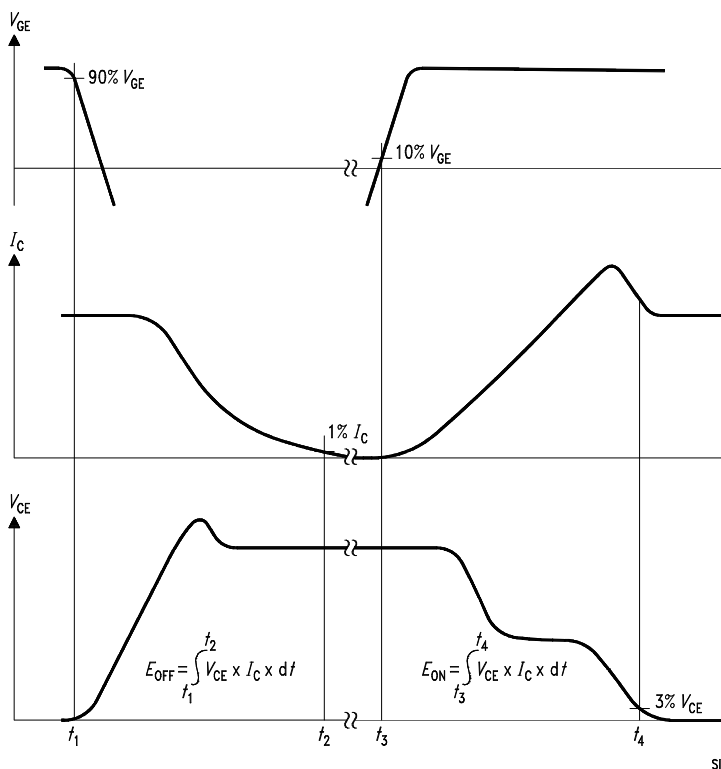
**Figure A. Definition of switching times**



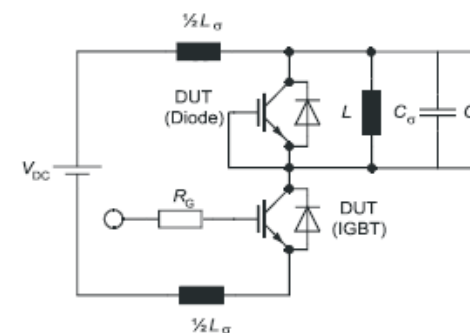
**Figure C. Definition of diodes switching characteristics**



**Figure D. Thermal equivalent circuit**



**Figure B. Definition of switching losses**



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

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