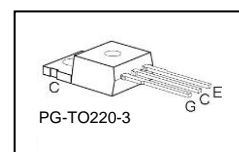
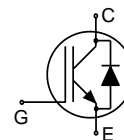


Low Loss DuoPack : IGBT in TRENCHSTOP™ and Fieldstop technology with soft, fast recovery anti-parallel Emitter Controlled HE diode


**Features:**

- Very low  $V_{CE(sat)}$  1.5V (typ.)
- Maximum Junction Temperature 175°C
- Short circuit withstand time 5 $\mu$ s
- Designed for :
  - Frequency Converters
  - Uninterrupted Power Supply
- TRENCHSTOP™ and Fieldstop technology for 600V applications offers :
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - very high switching speed
  - low  $V_{CE(sat)}$
- Positive temperature coefficient in  $V_{CE(sat)}$
- Low EMI
- Low Gate Charge
- Very soft, fast recovery anti-parallel Emitter Controlled HE diode
- 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      | $V_{CE}$ | $I_C$ | $V_{CE(sat), T_j=25^\circ C}$ | $T_{j,max}$ | Marking | Package    |
|-----------|----------|-------|-------------------------------|-------------|---------|------------|
| IKP20N60T | 600V     | 20A   | 1.5V                          | 175°C       | K20T60  | PG-TO220-3 |

**Maximum Ratings**

| Parameter  | Symbol       | Value      | Unit    |
|--|--------------|------------|---------|
| Collector-emitter voltage, $T_j \geq 25^\circ C$   | $V_{CE}$     | 600        | V       |
| DC collector current, limited by $T_{j,max}$ $T_C = 25^\circ C$  | $I_C$        | 41         | A       |
| $T_C = 100^\circ C$  |              | 28         |         |
| Pulsed collector current, $t_p$ limited by $T_{j,max}$   | $I_{C,puls}$ | 60         |         |
| Turn off safe operating area, $V_{CE} = 600V$ , $T_j = 175^\circ C$ , $t_p = 1\mu s$                       | -            | 60         |         |
| Diode forward current, limited by $T_{j,max}$ $T_C = 25^\circ C$   | $I_F$        | 41         |         |
| $T_C = 100^\circ C$  |              | 28         |         |
| Diode pulsed current, $t_p$ limited by $T_{j,max}$   | $I_{F,puls}$ | 60         |         |
| Gate-emitter voltage   | $V_{GE}$     | $\pm 20$   | V       |
| Short circuit withstand time <sup>2)</sup><br>$V_{GE} = 15V$ , $V_{CC} \leq 400V$ , $T_j \leq 150^\circ C$ | $t_{SC}$     | 5          | $\mu s$ |
| Power dissipation $T_C = 25^\circ C$   | $P_{tot}$    | 166        | 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, junction – case  | $R_{thJC}$  |            | 0.9        | K/W  |
| Diode thermal resistance, junction – case | $R_{thJCD}$ |            | 1.5        |      |
| Thermal resistance, junction – ambient    | $R_{thJA}$  |            | 62         |      |

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

| Parameter                            | Symbol        | Conditions  | Value |             |            | Unit     |
|--------------------------------------|---------------|---|-------|-------------|------------|----------|
|                                      |               |   | min.  | Typ.        | max.       |          |
| <b>Static Characteristic</b>         |               |   |       |             |            |          |
| Collector-emitter breakdown voltage  | $V_{(BR)CES}$ | $V_{GE}=0V, I_C=0.2mA$  | 600   | -           | -          | V        |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE} = 15V, I_C=20A$<br>$T_j=25^\circ\text{C}$<br>$T_j=175^\circ\text{C}$  | -     | 1.5<br>1.9  | 2.05<br>-  |          |
| Diode forward voltage                | $V_F$         | $V_{GE}=0V, I_F=20A$<br>$T_j=25^\circ\text{C}$<br>$T_j=175^\circ\text{C}$     | -     | 1.65<br>1.6 | 2.05<br>-  |          |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C=290\mu A, V_{CE}=V_{GE}$   | 4.1   | 4.9         | 5.7        |          |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE}=600V, V_{GE}=0V$<br>$T_j=25^\circ\text{C}$<br>$T_j=175^\circ\text{C}$ | -     | -           | 40<br>1500 | $\mu A$  |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE}=0V, V_{GE}=20V$   | -     | -           | 100        | nA       |
| Transconductance                     | $g_{fs}$      | $V_{CE}=20V, I_C=20A$   | -     | 11          | -          | S        |
| Integrated gate resistor             | $R_{Gint}$    |   |       | -           |            | $\Omega$ |

### Dynamic Characteristic

|  |             |   |   |       |   |    |
|--|-------------|---|---|-------|---|----|
| Input capacitance  | $C_{iss}$   | $V_{CE}=25V,$<br>$V_{GE}=0V,$<br>$f=1MHz$   | - | 1100  | - | pF |
| Output capacitance   | $C_{oss}$   |   | - | 71    | - |    |
| Reverse transfer capacitance                                   | $C_{riss}$  |   | - | 32    | - |    |
| Gate charge  | $Q_{Gate}$  | $V_{CC}=480V, I_C=20A$<br>$V_{GE}=15V$  | - | 120   | - | nC |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$       | PG-TO220-3  | - | 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>$T_j \leq 150^\circ\text{C}$ | - | 183.3 | - | A  |

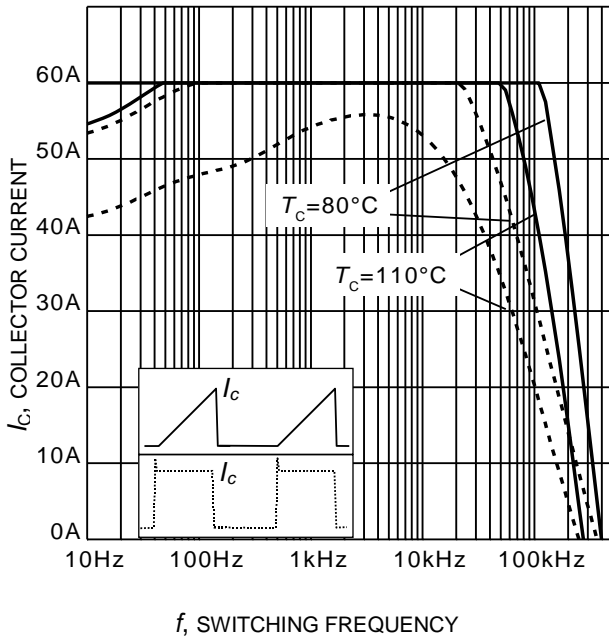
<sup>1)</sup> Allowed number of short circuits: <1000; time between short circuits: >1s.

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

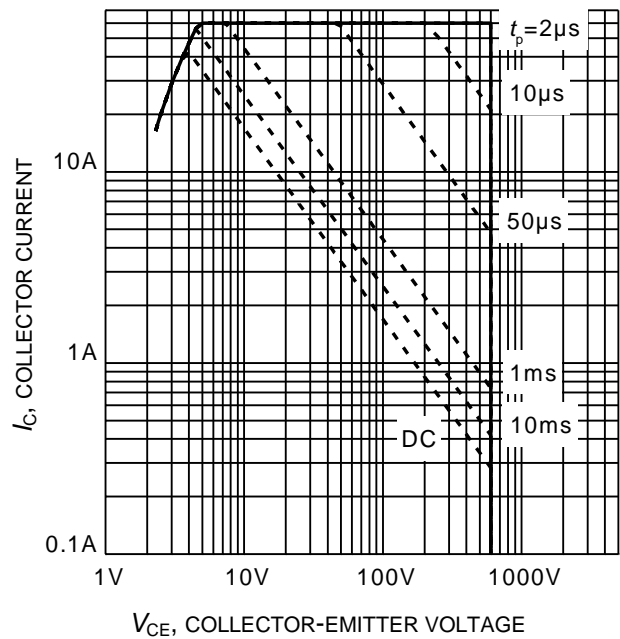
| Parameter  | Symbol       | Conditions  | Value |      |      | Unit                   |
|--|--------------|---|-------|------|------|------------------------|
|  |              |   | min.  | Typ. | max. |                        |
| <b>IGBT Characteristic</b>                                       |              |   |       |      |      |                        |
| Turn-on delay time   | $t_{d(on)}$  | $T_j=25^\circ\text{C}$ ,<br>$V_{CC}=400\text{V}$ , $I_C=20\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ , $r_G=12\Omega$ ,<br>$L_\sigma=131\text{nH}$ , $C_\sigma=31\text{pF}$ | -     | 18   | -    | ns                     |
| Rise time  | $t_r$        |   | -     | 14   | -    |                        |
| Turn-off delay time  | $t_{d(off)}$ |   | -     | 199  | -    |                        |
| Fall time  | $t_f$        |   | -     | 42   | -    |                        |
| Turn-on energy   | $E_{on}$     | $L_\sigma$ , $C_\sigma$ from Fig. E<br>Energy losses include<br>"tail" and diode reverse<br>recovery.   | -     | 0.31 | -    | mJ                     |
| Turn-off energy  | $E_{off}$    |   | -     | 0.46 | -    |                        |
| Total switching energy   | $E_{ts}$     |   | -     | 0.77 | -    |                        |
| <b>Anti-Parallel Diode Characteristic</b>                        |              |   |       |      |      |                        |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=25^\circ\text{C}$ ,  | -     | 41   | -    | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     | $V_R=400\text{V}$ , $I_F=20\text{A}$ ,  | -     | 0.31 | -    | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    | $di_F/dt=880\text{A}/\mu\text{s}$   | -     | 13.3 | -    | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |   | -     | 711  | -    | $\text{A}/\mu\text{s}$ |

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

| Parameter  | Symbol       | Conditions   | Value |      |      | Unit                   |
|--|--------------|--|-------|------|------|------------------------|
|  |              |  | min.  | Typ. | max. |                        |
| <b>IGBT Characteristic</b>                                       |              |  |       |      |      |                        |
| Turn-on delay time   | $t_{d(on)}$  | $T_j=175^\circ\text{C}$ ,<br>$V_{CC}=400\text{V}$ , $I_C=20\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ , $r_G=12\Omega$ ,<br>$L_\sigma=131\text{nH}$ , $C_\sigma=31\text{pF}$ | -     | 18   | -    | ns                     |
| Rise time  | $t_r$        |  | -     | 18   | -    |                        |
| Turn-off delay time  | $t_{d(off)}$ |  | -     | 223  | -    |                        |
| Fall time  | $t_f$        |  | -     | 76   | -    |                        |
| Turn-on energy   | $E_{on}$     | $L_\sigma$ , $C_\sigma$ from Fig. E<br>Energy losses include<br>"tail" and diode reverse<br>recovery.  | -     | 0.51 | -    | mJ                     |
| Turn-off energy  | $E_{off}$    |  | -     | 0.64 | -    |                        |
| Total switching energy   | $E_{ts}$     |  | -     | 1.15 | -    |                        |
| <b>Anti-Parallel Diode Characteristic</b>                        |              |  |       |      |      |                        |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=175^\circ\text{C}$  | -     | 176  | -    | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     | $V_R=400\text{V}$ , $I_F=20\text{A}$ ,   | -     | 1.46 | -    | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    | $di_F/dt=880\text{A}/\mu\text{s}$  | -     | 18.9 | -    | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |  | -     | 467  | -    | $\text{A}/\mu\text{s}$ |



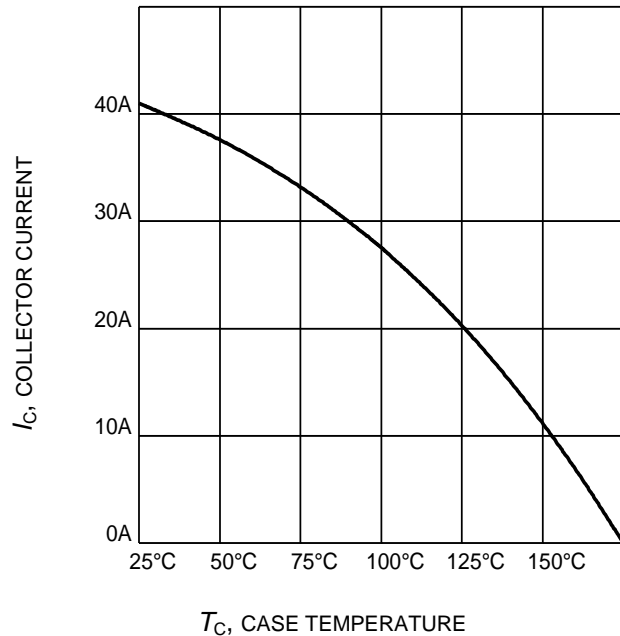
**Figure 1. Collector current as a function of switching frequency**  
 ( $T_j \leq 175^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  
 $V_{GE} = 0/15\text{V}$ ,  $r_G = 12\Omega$ )



**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**  
( $T_j = 25^\circ\text{C}$ )



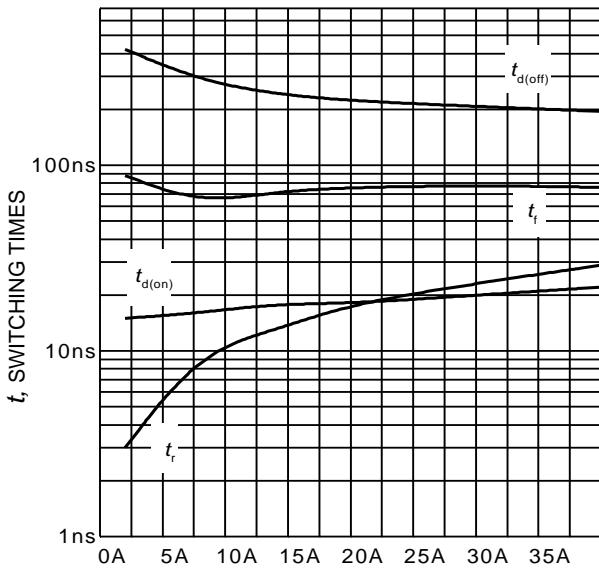
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



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

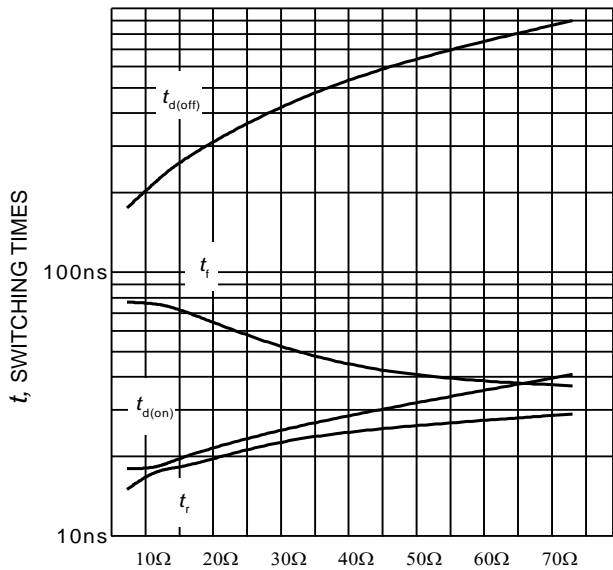


**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



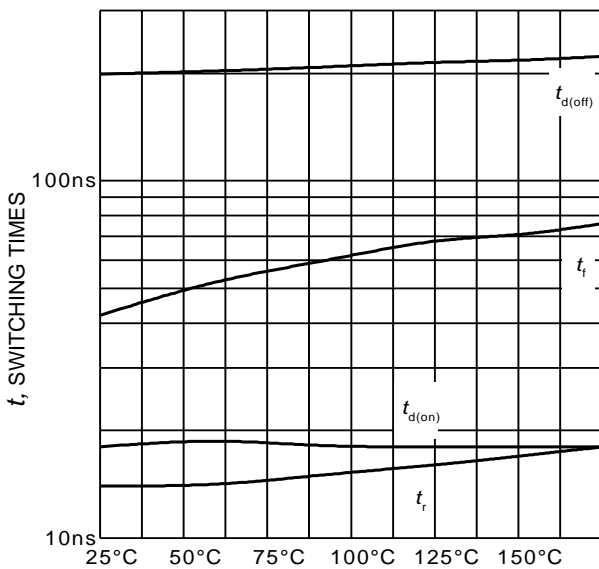
$I_C$ , COLLECTOR CURRENT

**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_J=175^\circ\text{C}$ ,  
 $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $r_G = 12\Omega$ ,  
Dynamic test circuit in Figure E)



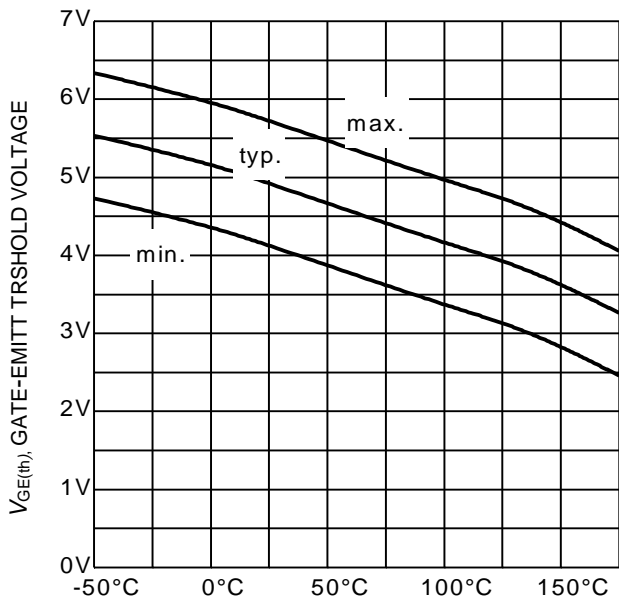
$R_G$ , GATE RESISTOR

**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  
 $V_{CE}= 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 20\text{A}$ ,  
Dynamic test circuit in Figure E)



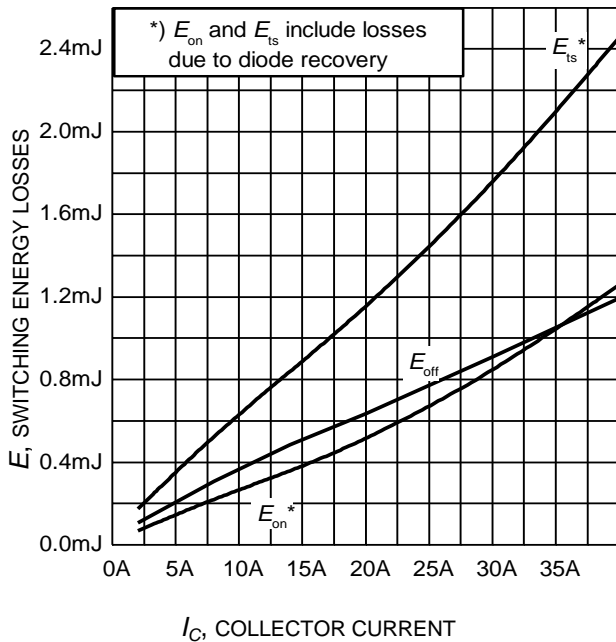
$T_J$ , JUNCTION TEMPERATURE

**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  
 $V_{GE} = 0/15\text{V}$ ,  $I_C = 20\text{A}$ ,  $r_G=12\Omega$ ,  
Dynamic test circuit in Figure E)

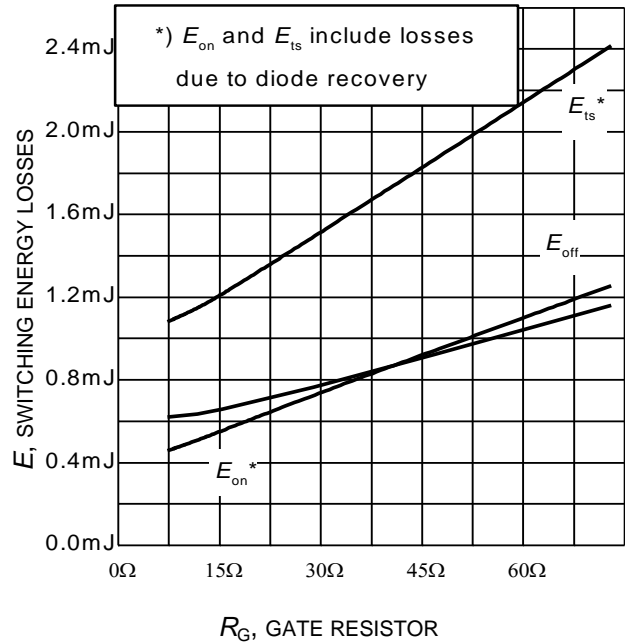


$T_J$ , JUNCTION TEMPERATURE

**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.29\text{mA}$ )



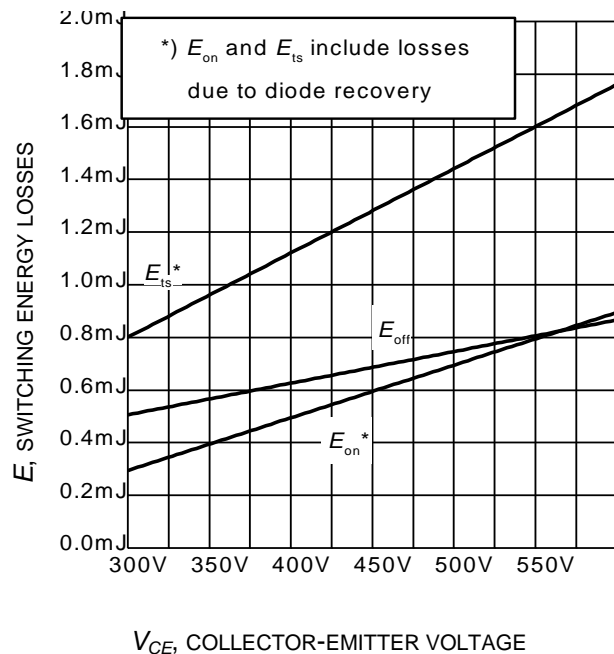
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $r_G = 12\Omega$ , Dynamic test circuit in Figure E)



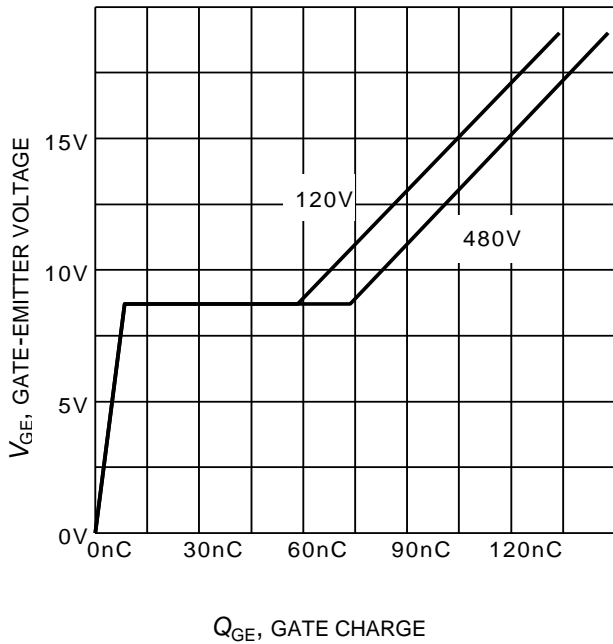
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 20\text{A}$ , Dynamic test circuit in Figure E)



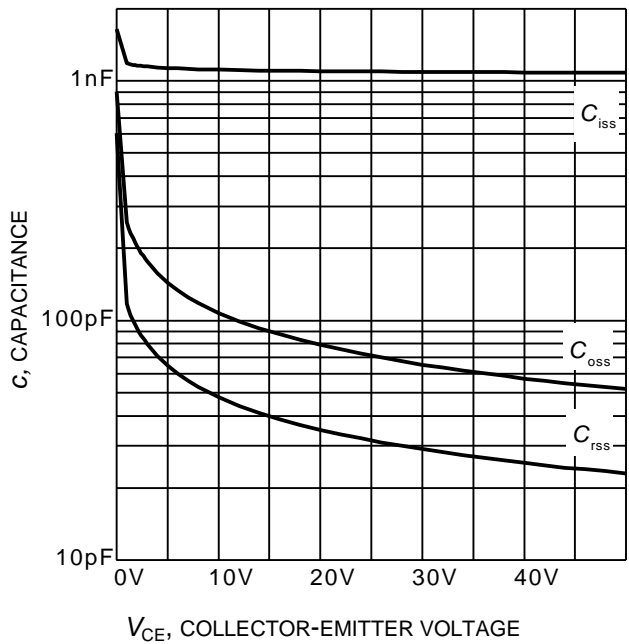
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 20\text{A}$ ,  $r_G = 12\Omega$ , Dynamic test circuit in Figure E)



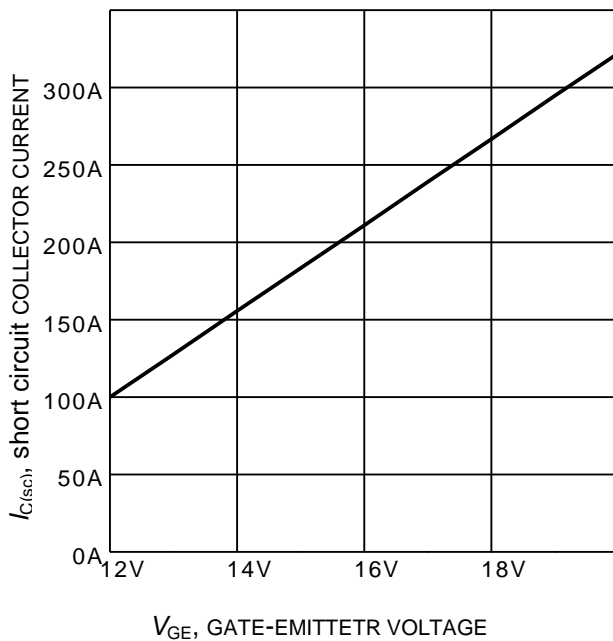
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_J = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{V}$ ,  $I_C = 20\text{A}$ ,  $r_G = 12\Omega$ , Dynamic test circuit in Figure E)



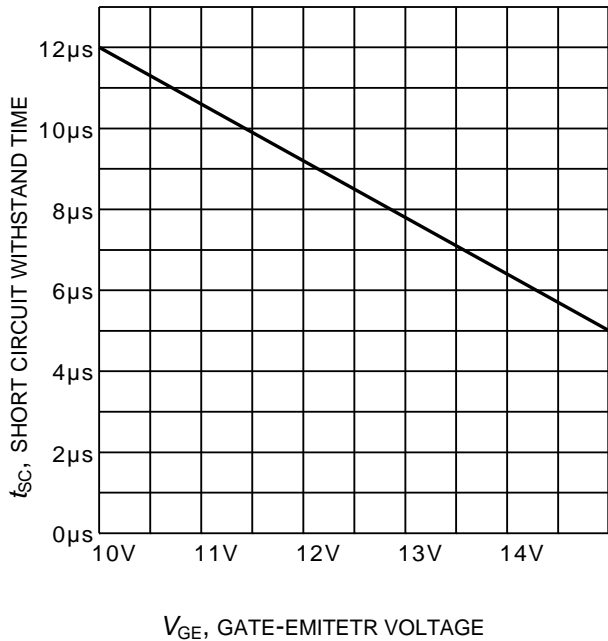
**Figure 17. Typical gate charge**  
( $I_C=20\text{ A}$ )



**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**  
( $V_{CE} \leq 400\text{V}$ ,  $T_j \leq 150^\circ\text{C}$ )

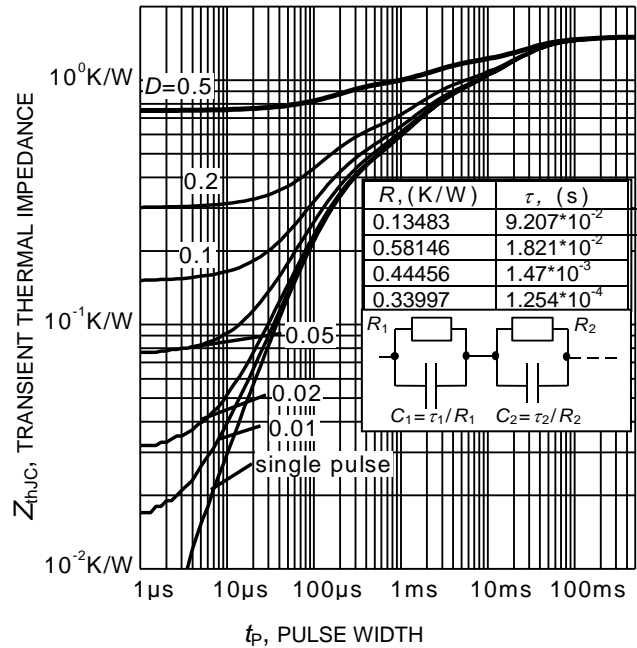


**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE}=400\text{V}$ , start at  $T_j=25^\circ\text{C}$ ,  $T_{jmax}<150^\circ\text{C}$ )





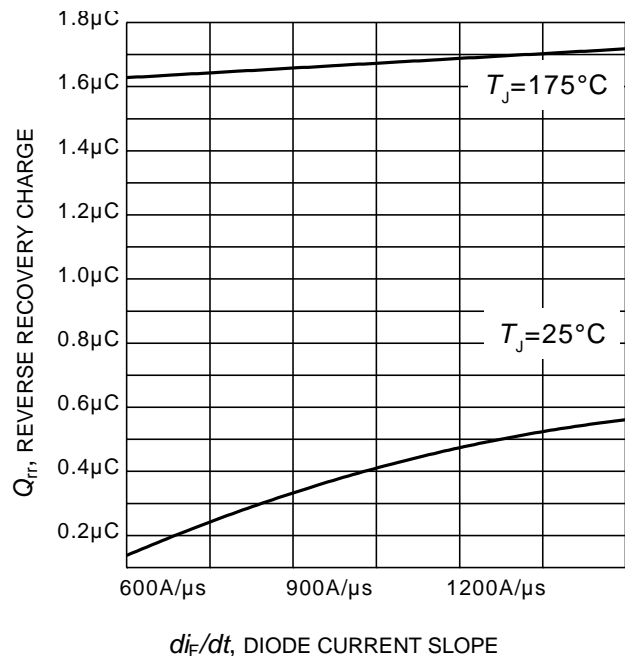
**Figure 21. IGBT transient thermal impedance**  
( $D = t_p / T$ )



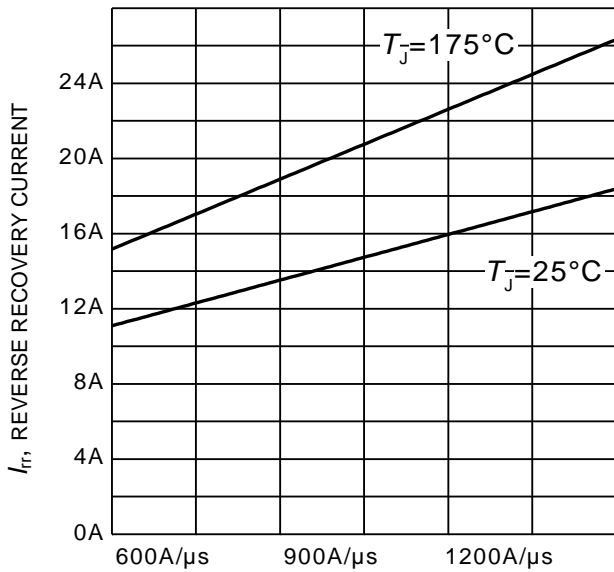
**Figure 22. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



**Figure 23. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 20A$ ,  
Dynamic test circuit in Figure E)



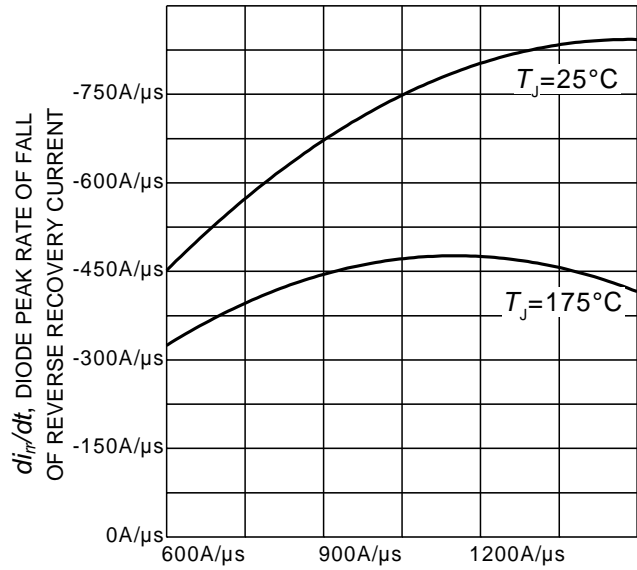
**Figure 24. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 400V$ ,  $I_F = 20A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

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

( $V_R = 400V$ ,  $I_F = 20A$ ,  
Dynamic test circuit in Figure E)



$di_F/dt$ , DIODE CURRENT SLOPE

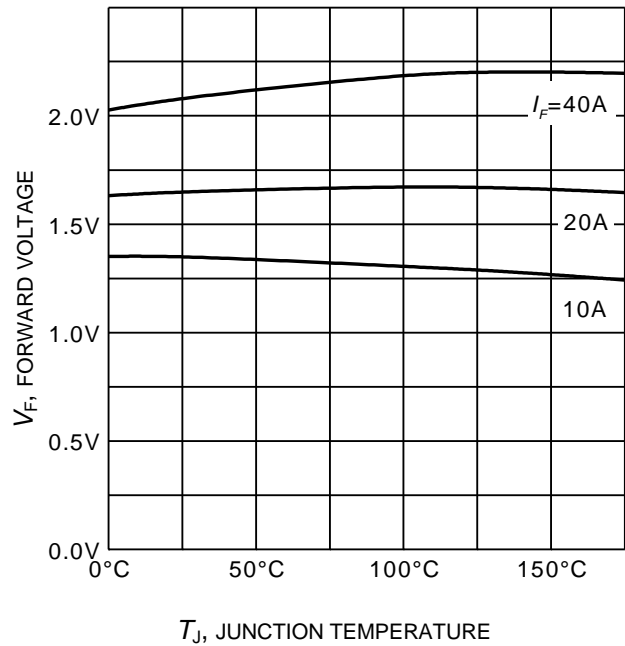
**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**

( $V_R = 400V$ ,  $I_F = 20A$ ,  
Dynamic test circuit in Figure E)



$V_F$ , FORWARD VOLTAGE

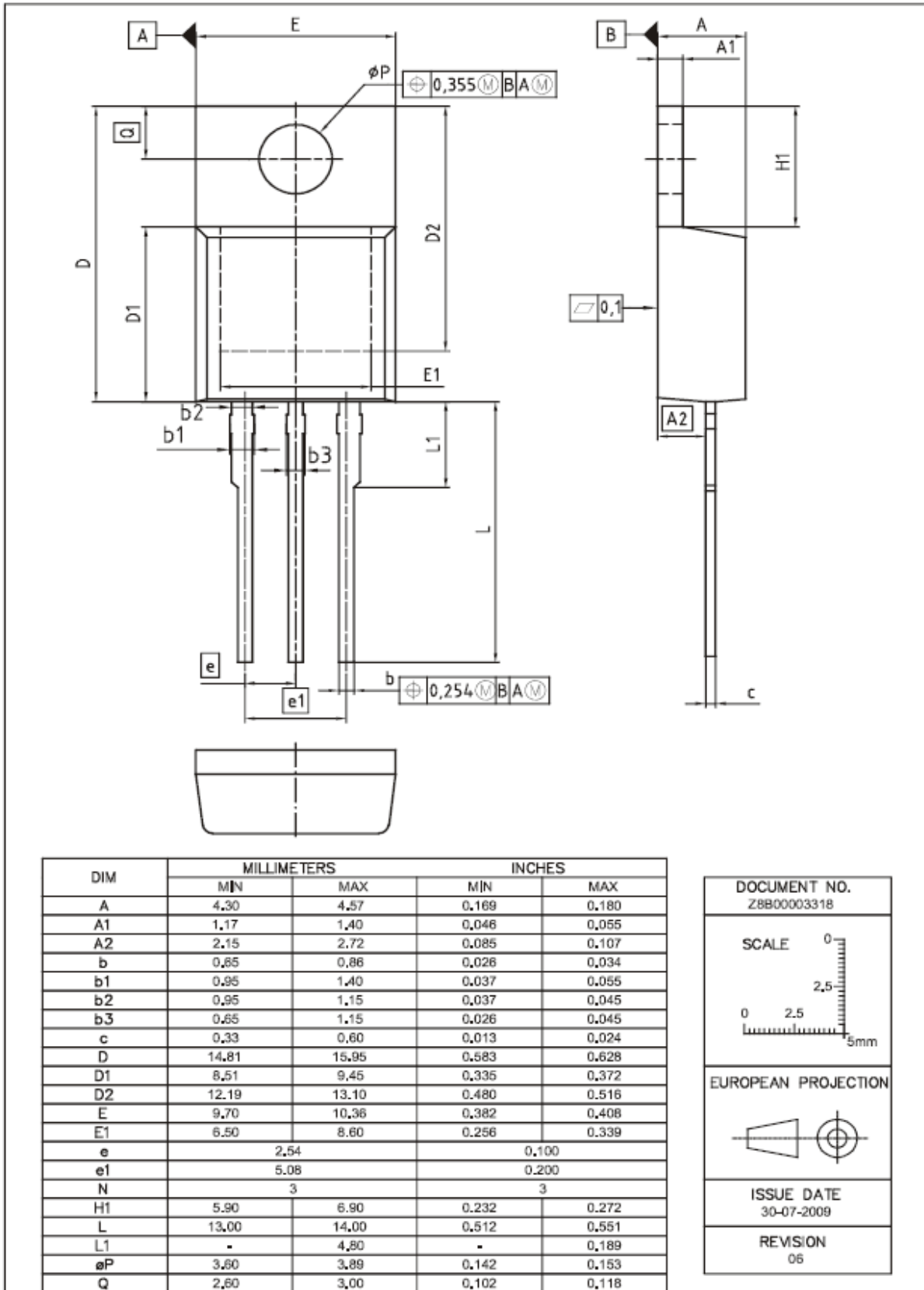
**Figure 27. Typical diode forward current as a function of forward voltage**

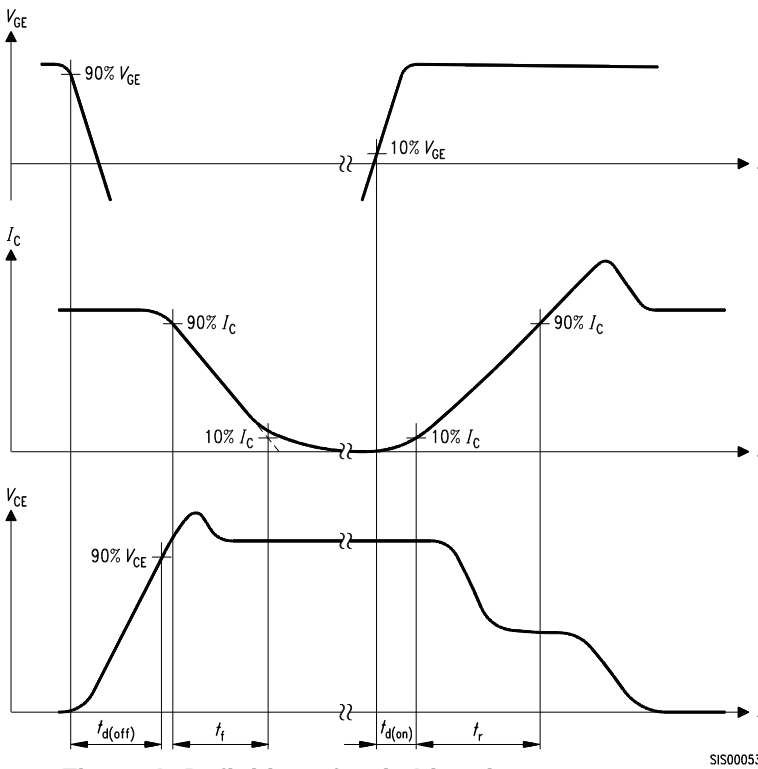


$T_J$ , JUNCTION TEMPERATURE

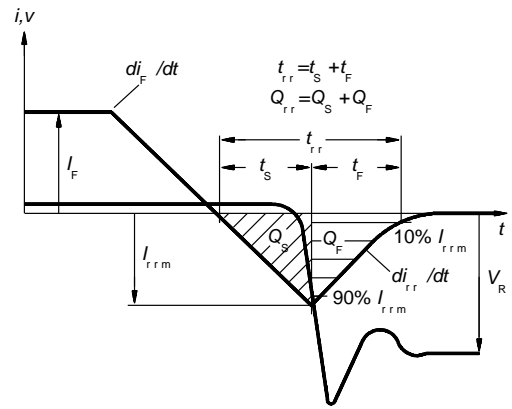
**Figure 28. Typical diode forward voltage as a function of junction temperature**

### PG-TO220-3

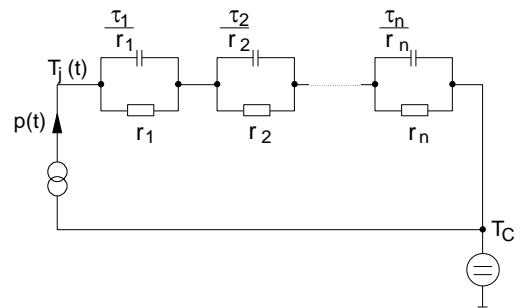




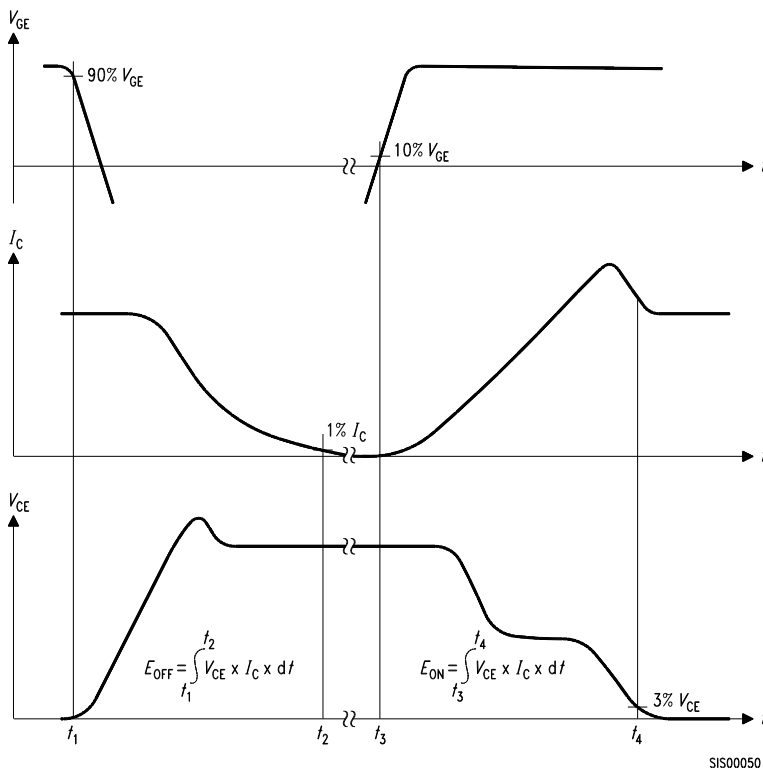
**Figure A. Definition of switching times**



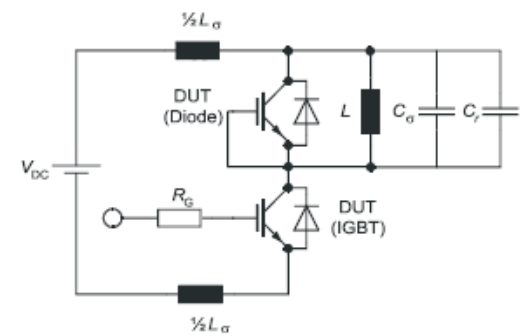
**Figure C. Definition of diodes switching characteristics**



**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)