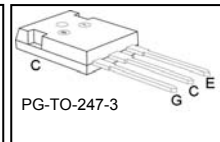
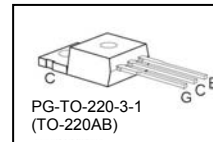
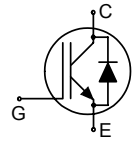


## Fast IGBT in NPT-technology with soft, fast recovery anti-parallel EmCon diode

- 75% lower  $E_{off}$  compared to previous generation combined with low conduction losses
- Short circuit withstand time – 10  $\mu$ s
- Designed for:
  - Motor controls
  - Inverter
- NPT-Technology for 600V applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behaviour
  - parallel switching capability
- Very soft, fast recovery anti-parallel EmCon diode
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>1</sup> for target applications
- Complete product spectrum and PSpice Models : <http://www.infineon.com/igbt/>



| Type     | $V_{CE}$ | $I_C$ | $V_{CE(sat)}$ | $T_j$ | Marking | Package       |
|----------|----------|-------|---------------|-------|---------|---------------|
| SKP15N60 | 600V     | 15A   | 2.3V          | 150°C | K15N60  | PG-TO-220-3-1 |
| SKW15N60 | 600V     | 15A   | 2.3V          | 150°C | K15N60  | PG-TO-247-3   |

### Maximum Ratings

| Parameter                                                                        | Symbol            | Value      | Unit    |
|----------------------------------------------------------------------------------|-------------------|------------|---------|
| Collector-emitter voltage                                                        | $V_{CE}$          | 600        | V       |
| DC collector current                                                             | $I_C$             | 31         | A       |
| $T_C = 25^\circ\text{C}$                                                         |                   | 15         |         |
| $T_C = 100^\circ\text{C}$                                                        |                   | 62         |         |
| Pulsed collector current, $t_p$ limited by $T_{jmax}$                            | $I_{Cpuls}$       | 62         |         |
| Turn off safe operating area                                                     | -                 | 62         |         |
| $V_{CE} \leq 600\text{V}$ , $T_j \leq 150^\circ\text{C}$                         |                   |            |         |
| Diode forward current                                                            | $I_F$             | 31         |         |
| $T_C = 25^\circ\text{C}$                                                         |                   | 15         |         |
| $T_C = 100^\circ\text{C}$                                                        |                   | 62         |         |
| Diode pulsed current, $t_p$ limited by $T_{jmax}$                                | $I_{Fpuls}$       | 62         |         |
| Gate-emitter voltage                                                             | $V_{GE}$          | $\pm 20$   | V       |
| Short circuit withstand time <sup>2</sup>                                        | $t_{SC}$          | 10         | $\mu$ s |
| $V_{GE} = 15\text{V}$ , $V_{CC} \leq 600\text{V}$ , $T_j \leq 150^\circ\text{C}$ |                   |            |         |
| Power dissipation                                                                | $P_{tot}$         | 139        | W       |
| $T_C = 25^\circ\text{C}$                                                         |                   |            |         |
| Operating junction and storage temperature                                       | $T_j$ , $T_{stg}$ | -55...+150 | °C      |
| Soldering temperature                                                            | $T_s$             | 260        | °C      |
| wavesoldering, 1.6 mm (0.063 in.) from case for 10s                              |                   |            |         |

<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  | $R_{thJC}$  |                                | 0.9        | K/W  |
| Diode thermal resistance,<br>junction – case | $R_{thJCD}$ |                                | 1.7        |      |
| Thermal resistance,<br>junction – ambient    | $R_{thJA}$  | PG-TO-220-3-1<br>PG-TO-247-3-1 | 62<br>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                               | $V_{(BR)CES}$ | $V_{GE}=0V, I_C=500\mu A$                                                        | 600      | -           | -           | V       |
| Collector-emitter saturation voltage                              | $V_{CE(sat)}$ | $V_{GE} = 15V, I_C=15A$<br>$T_j=25^{\circ}C$<br>$T_j=150^{\circ}C$               | 1.7<br>- | 2<br>2.3    | 2.4<br>2.8  |         |
| Diode forward voltage                                             | $V_F$         | $V_{GE}=0V, I_F=15A$<br>$T_j=25^{\circ}C$<br>$T_j=150^{\circ}C$                  | 1.2<br>- | 1.4<br>1.25 | 1.8<br>1.65 |         |
| Gate-emitter threshold voltage                                    | $V_{GE(th)}$  | $I_C=400\mu A, V_{CE}=V_{GE}$                                                    | 3        | 4           | 5           |         |
| Zero gate voltage collector current                               | $I_{CES}$     | $V_{CE}=600V, V_{GE}=0V$<br>$T_j=25^{\circ}C$<br>$T_j=150^{\circ}C$              | -<br>-   | -<br>-      | 40<br>2000  | $\mu A$ |
| Gate-emitter leakage current                                      | $I_{GES}$     | $V_{CE}=0V, V_{GE}=20V$                                                          | -        | -           | 100         |         |
| Transconductance                                                  | $g_{fs}$      | $V_{CE}=20V, I_C=15A$                                                            | 3        | 10.9        | -           | S       |
| Dynamic Characteristic                                            |               |                                                                                  |          |             |             |         |
| Input capacitance                                                 | $C_{iss}$     | $V_{CE}=25V,$<br>$V_{GE}=0V,$<br>$f=1MHz$                                        | -        | 800         | 960         | pF      |
| Output capacitance                                                | $C_{oss}$     |                                                                                  | -        | 84          | 101         |         |
| Reverse transfer capacitance                                      | $C_{rss}$     |                                                                                  | -        | 52          | 62          |         |
| Gate charge                                                       | $Q_{Gate}$    | $V_{CC}=480V, I_C=15A$<br>$V_{GE}=15V$                                           | -        | 76          | 99          | nC      |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from case | $L_E$         | PG-TO-220-3-1                                                                    | -        | 7           | -           | nH      |
|                                                                   |               | PG-TO-247-3-21                                                                   | -        | 13          | -           |         |
| Short circuit collector current <sup>2)</sup>                     | $I_{C(SC)}$   | $V_{GE}=15V, t_{SC}\leq 10\mu s$<br>$V_{CC}\leq 600V,$<br>$T_j\leq 150^{\circ}C$ | -        | 150         | -           | A       |

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

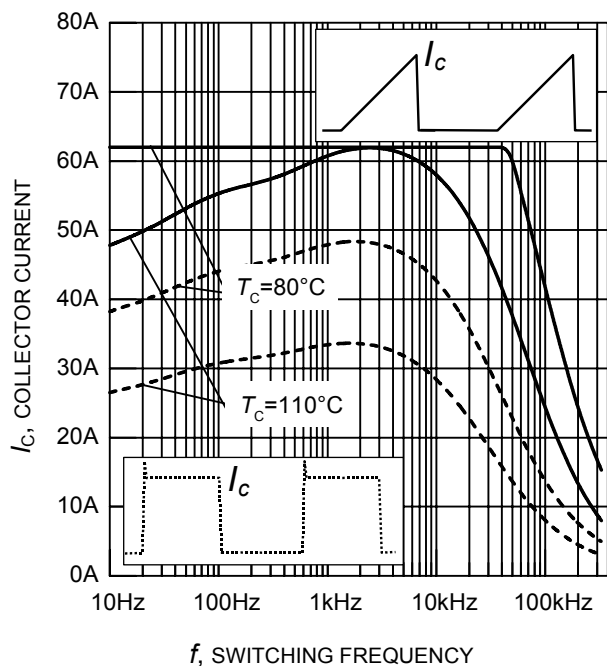
## Switching Characteristic, Inductive Load, at $T_j=25^\circ\text{C}$

| 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>$R_G=21\Omega$ ,<br>$L_{\sigma}^{1)}=180\text{nH}$ ,<br>$C_{\sigma}^{1)}=250\text{pF}$ | -     | 32   | 38               | ns   |
| Rise time                                                        | $t_r$        |                                                                                                                                                                                              | -     | 23   | 28               |      |
| Turn-off delay time                                              | $t_{d(off)}$ |                                                                                                                                                                                              | -     | 234  | 281              |      |
| Fall time                                                        | $t_f$        |                                                                                                                                                                                              | -     | 46   | 55               |      |
| Turn-on energy                                                   | $E_{on}$     | Energy losses include<br>“tail” and diode<br>reverse recovery.                                                                                                                               | -     | 0.30 | 0.36             | mJ   |
| Turn-off energy                                                  | $E_{off}$    |                                                                                                                                                                                              | -     | 0.27 | 0.35             |      |
| Total switching energy                                           | $E_{ts}$     |                                                                                                                                                                                              | -     | 0.57 | 0.71             |      |
| Anti-Parallel Diode Characteristic                               |              |                                                                                                                                                                                              |       |      |                  |      |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=25^{\circ}\text{C}$ ,<br>$V_R=200\text{V}$ , $I_F=15\text{A}$ ,<br>$di_F/dt=200\text{A}/\mu\text{s}$                                                                                    | -     | 279  | -                | ns   |
|                                                                  | $t_S$        |                                                                                                                                                                                              | -     | 28   | -                |      |
|                                                                  | $t_F$        |                                                                                                                                                                                              | -     | 254  | -                |      |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                                                                                              | -     | 390  | -                | nC   |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                                                                                              | -     | 5.0  | -                | A    |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | -                                                                                                                                                                                            | 180   | -    | A/ $\mu\text{s}$ |      |

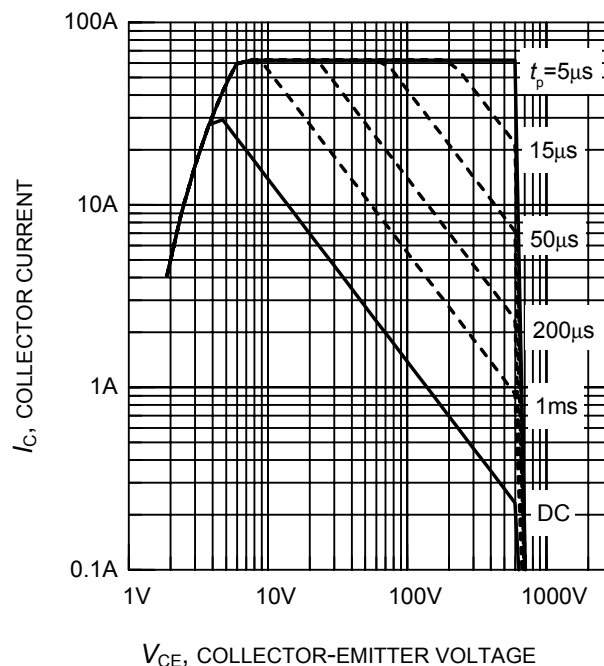
## Switching Characteristic, Inductive Load, at $T_j=150^\circ\text{C}$

| Parameter                                                        | Symbol       | Conditions                                                                                                                                                                           | Value |      |                  | Unit |
|------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------------------|------|
|                                                                  |              |                                                                                                                                                                                      | min.  | typ. | max.             |      |
| IGBT Characteristic                                              |              |                                                                                                                                                                                      |       |      |                  |      |
| Turn-on delay time                                               | $t_{d(on)}$  | $T_j=150^{\circ}\text{C}$<br>$V_{CC}=400\text{V}, I_C=15\text{A},$<br>$V_{GE}=0/15\text{V},$<br>$R_G=21\Omega,$<br>$L_{\sigma}^{1)}=180\text{nH},$<br>$C_{\sigma}^{1)}=250\text{pF}$ | -     | 31   | 38               | ns   |
| Rise time                                                        | $t_r$        |                                                                                                                                                                                      | -     | 23   | 28               |      |
| Turn-off delay time                                              | $t_{d(off)}$ |                                                                                                                                                                                      | -     | 261  | 313              |      |
| Fall time                                                        | $t_f$        |                                                                                                                                                                                      | -     | 54   | 65               |      |
| Turn-on energy                                                   | $E_{on}$     | Energy losses include<br>“tail” and diode<br>reverse recovery.                                                                                                                       | -     | 0.45 | 0.54             | mJ   |
| Turn-off energy                                                  | $E_{off}$    |                                                                                                                                                                                      | -     | 0.41 | 0.53             |      |
| Total switching energy                                           | $E_{ts}$     |                                                                                                                                                                                      | -     | 0.86 | 1.07             |      |
| Anti-Parallel Diode Characteristic                               |              |                                                                                                                                                                                      |       |      |                  |      |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_j=150^{\circ}\text{C}$<br>$V_R=200\text{V}, I_F=15\text{A},$<br>$di_F/dt=200\text{A}/\mu\text{s}$                                                                                 | -     | 360  | -                | ns   |
|                                                                  | $t_S$        |                                                                                                                                                                                      | -     | 40   | -                |      |
|                                                                  | $t_F$        |                                                                                                                                                                                      | -     | 320  | -                |      |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                                                                                      | -     | 1020 | -                | nC   |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                                                                                      | -     | 7.5  | -                | A    |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ | -                                                                                                                                                                                    | 200   | -    | A/ $\mu\text{s}$ |      |

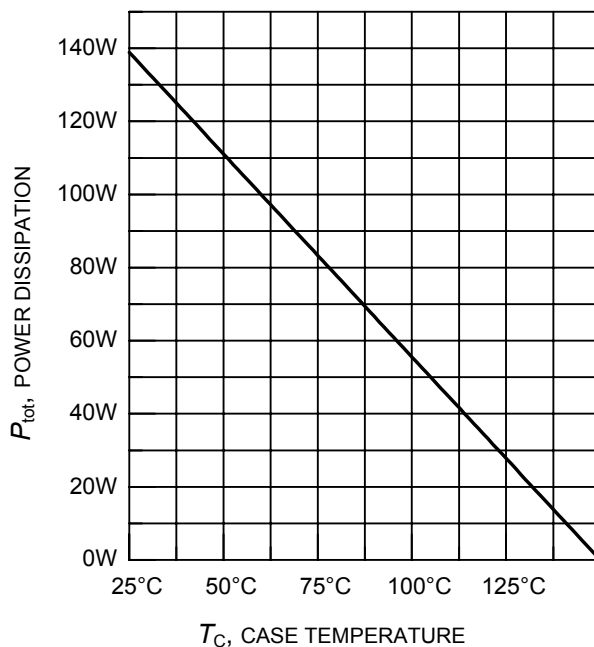
<sup>1)</sup> Leakage inductance  $L_{\sigma}$  and Stray capacity  $C_{\sigma}$  due to dynamic test circuit in Figure E.



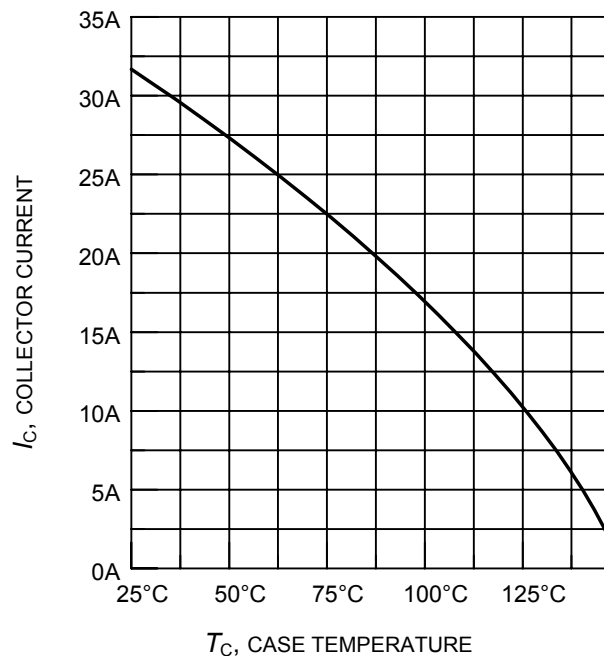
**Figure 1. Collector current as a function of switching frequency**  
 $(T_j \leq 150^\circ\text{C}, D = 0.5, V_{CE} = 400\text{V}, V_{GE} = 0/+15\text{V}, R_G = 21\Omega)$



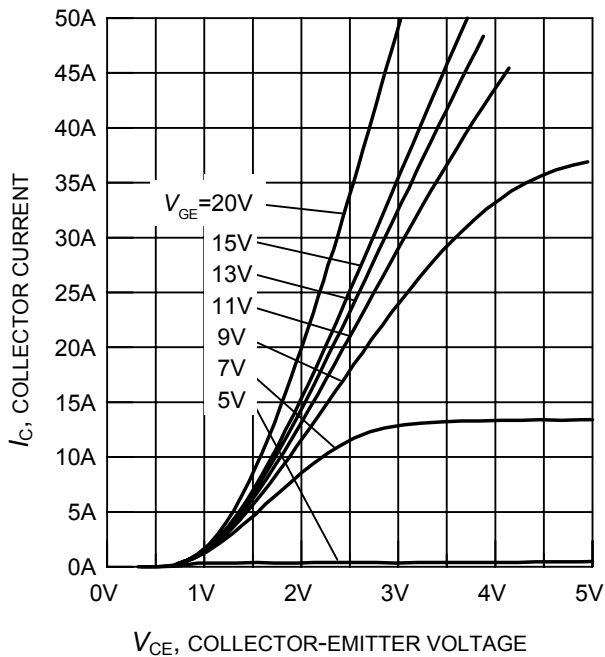
**Figure 2. Safe operating area**  
 $(D = 0, T_C = 25^\circ\text{C}, T_j \leq 150^\circ\text{C})$



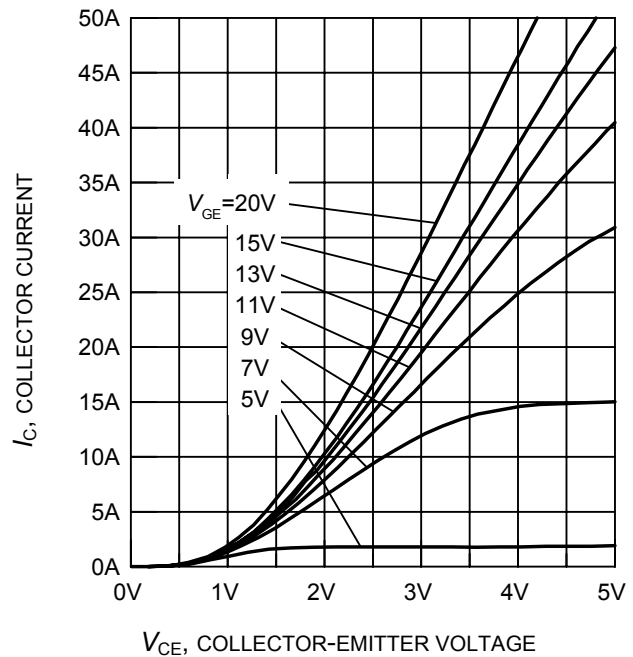
**Figure 3. Power dissipation as a function of case temperature**  
 $(T_j \leq 150^\circ\text{C})$



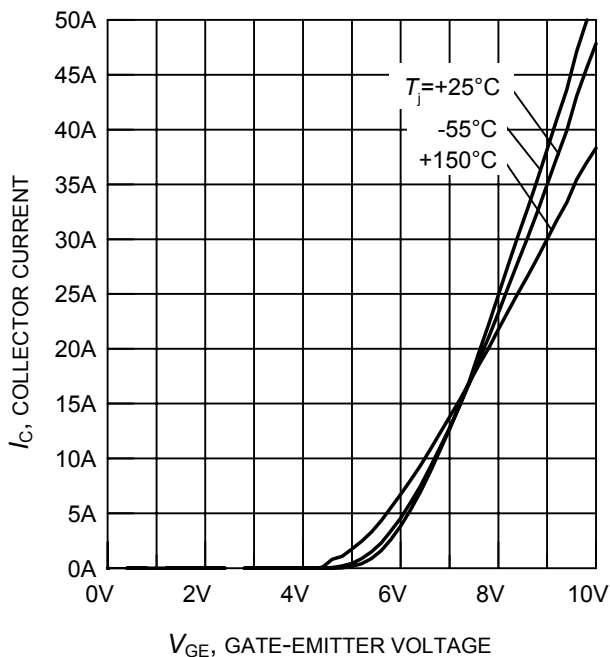
**Figure 4. Collector current as a function of case temperature**  
 $(V_{GE} \leq 15\text{V}, T_j \leq 150^\circ\text{C})$



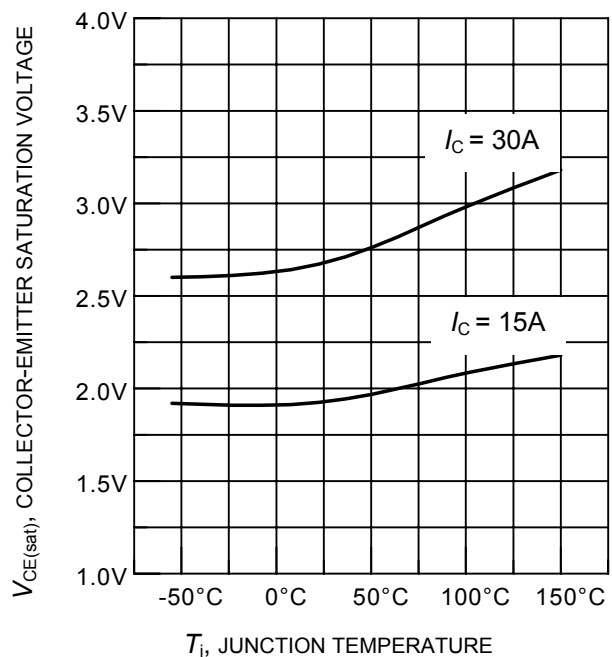
**Figure 5. Typical output characteristics**  
( $T_j = 25^\circ\text{C}$ )



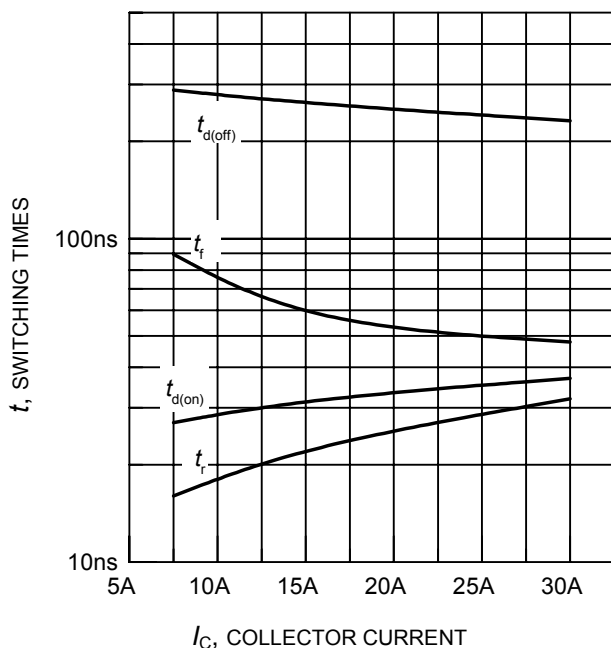
**Figure 6. Typical output characteristics**  
( $T_j = 150^\circ\text{C}$ )



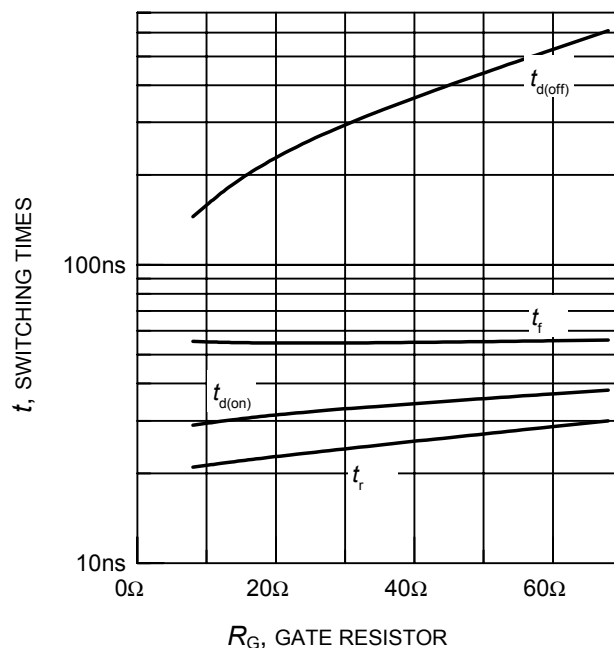
**Figure 7. Typical transfer characteristics**  
( $V_{CE} = 10\text{V}$ )



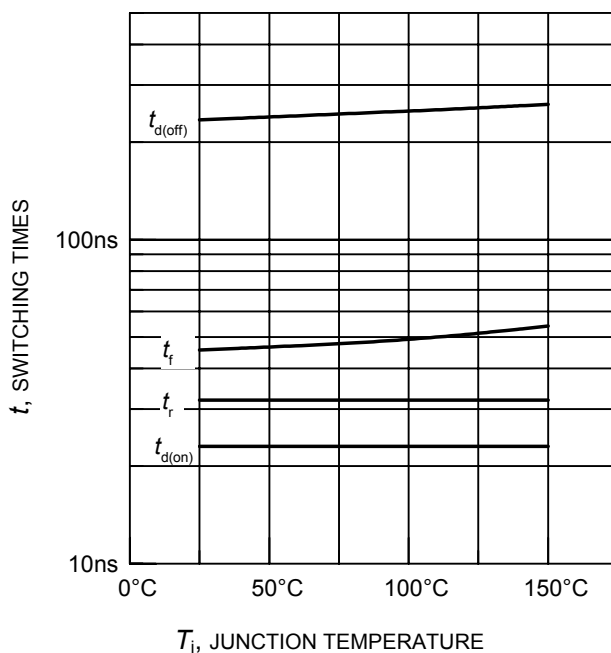
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



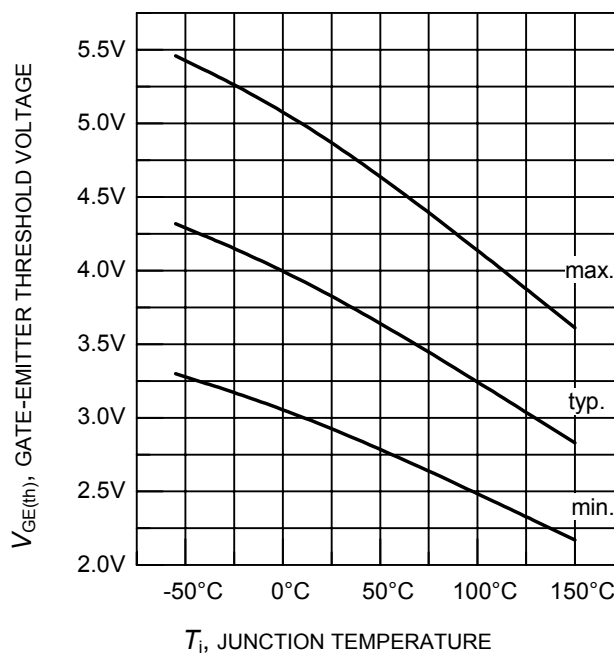
**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 21\Omega$ , Dynamic test circuit in Figure E)



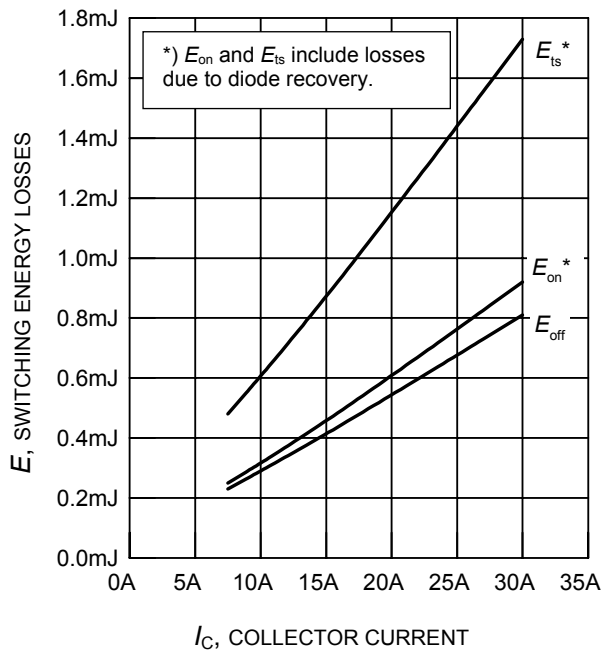
**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ , Dynamic test circuit in Figure E)



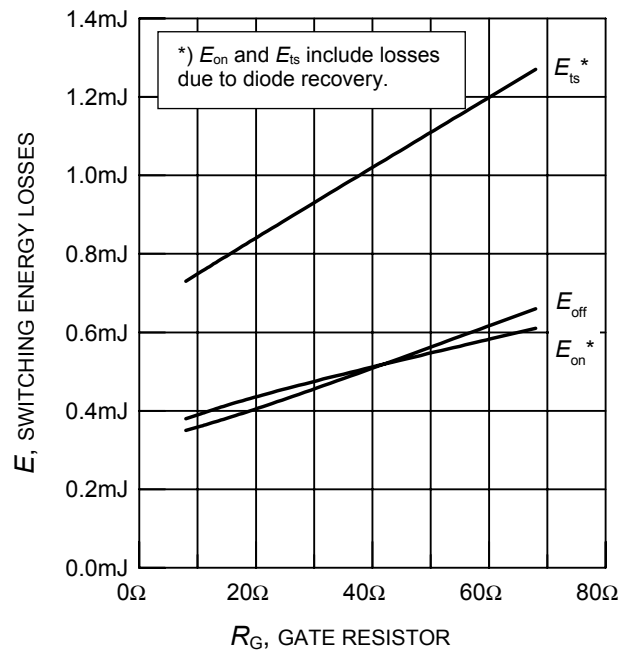
**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 21\Omega$ , Dynamic test circuit in Figure E)



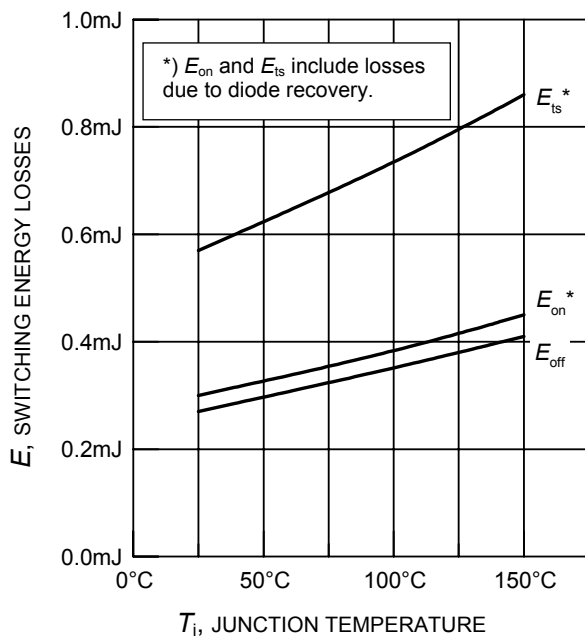
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.4\text{mA}$ )



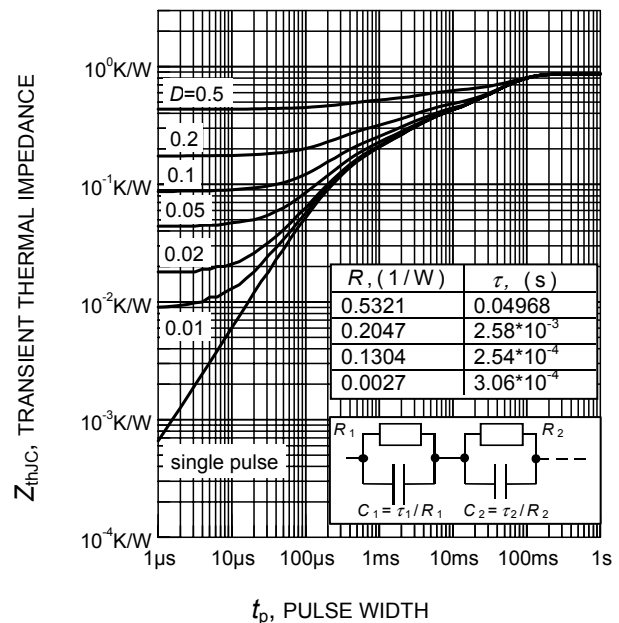
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 21\Omega$ , Dynamic test circuit in Figure E)



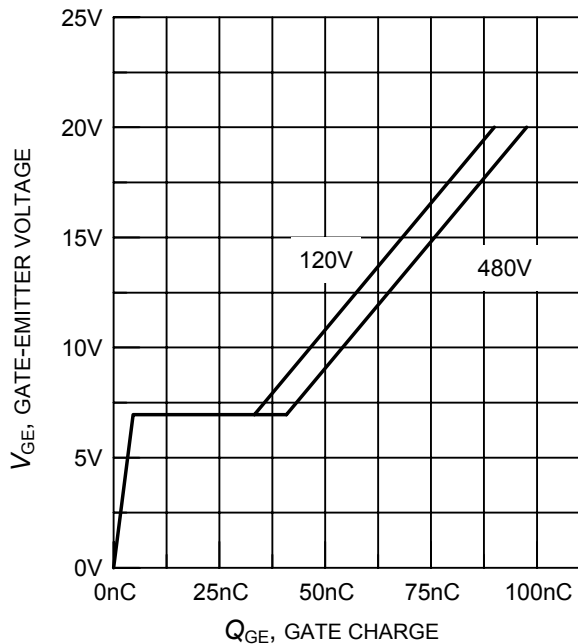
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ , Dynamic test circuit in Figure E)



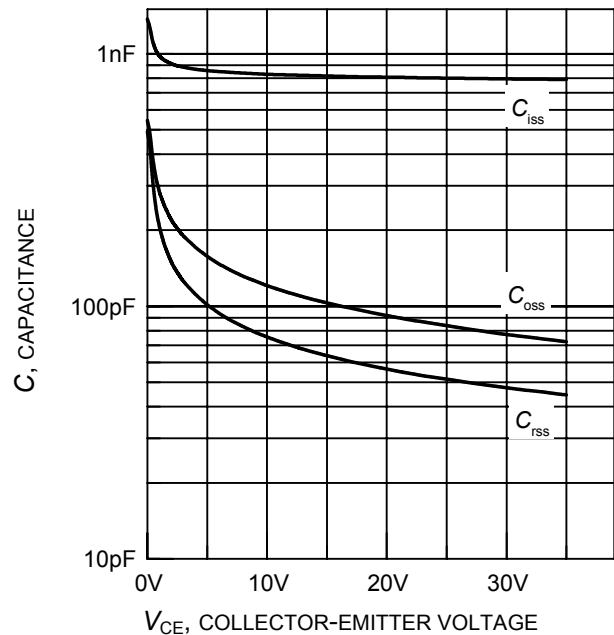
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 21\Omega$ , Dynamic test circuit in Figure E)



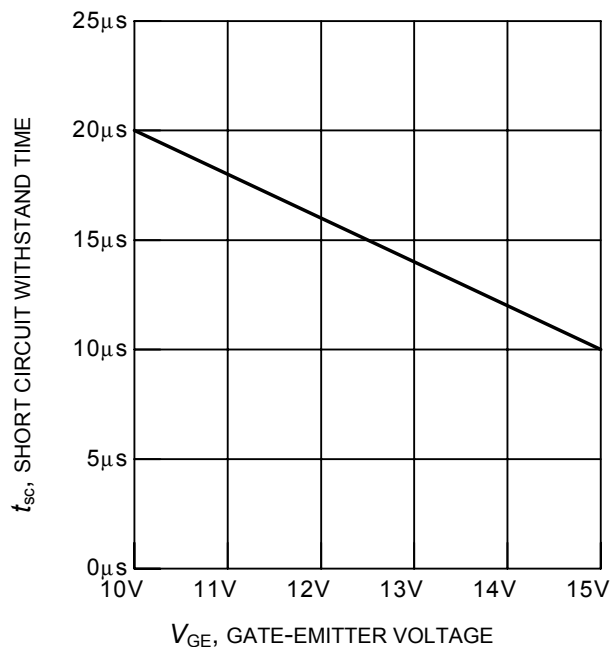
**Figure 16. IGBT transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



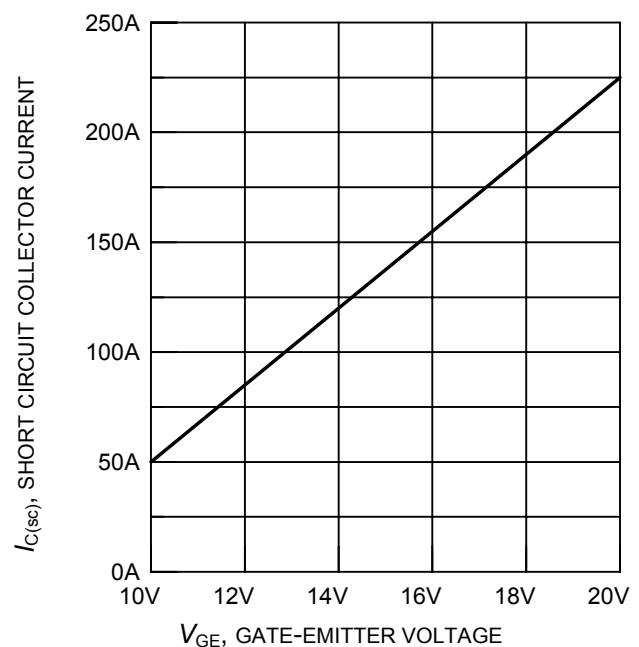
**Figure 17. Typical gate charge**  
( $I_C = 15A$ )



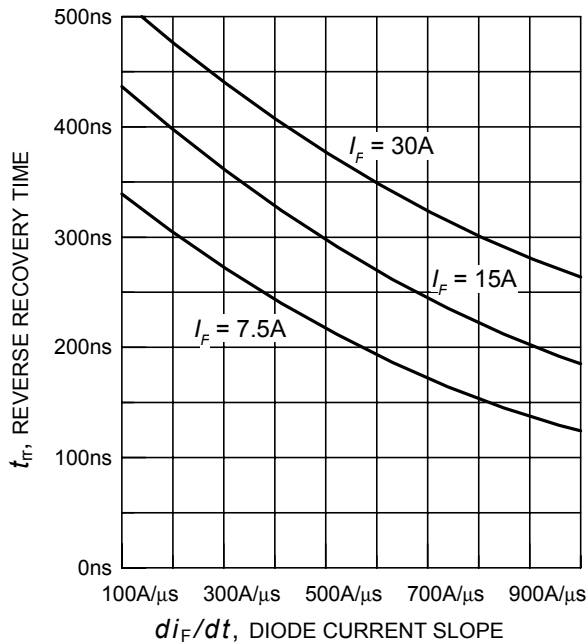
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE} = 0V$ ,  $f = 1MHz$ )



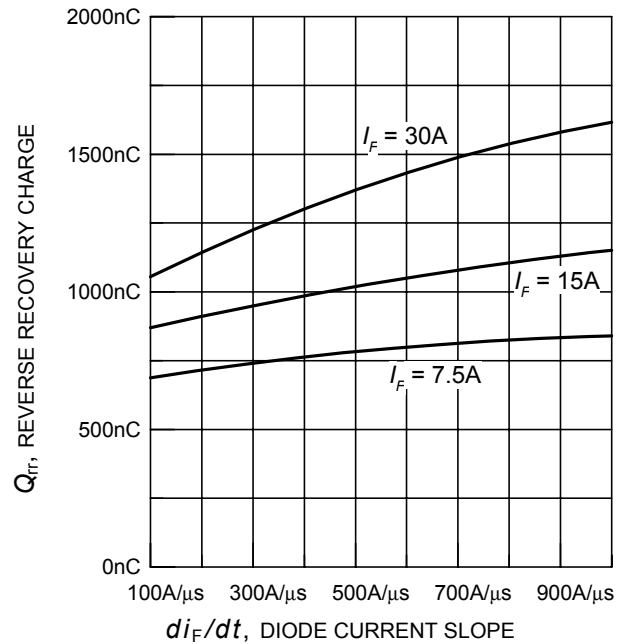
**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE} = 600V$ , start at  $T_j = 25^\circ C$ )



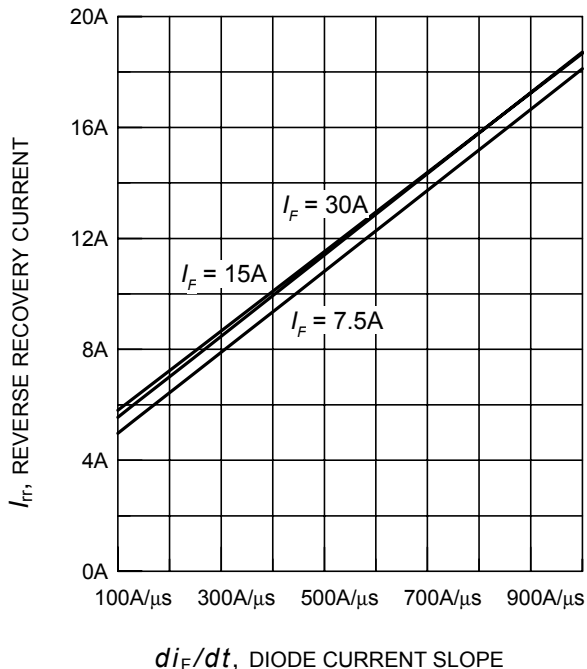
**Figure 20. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 600V$ ,  $T_j = 150^\circ C$ )



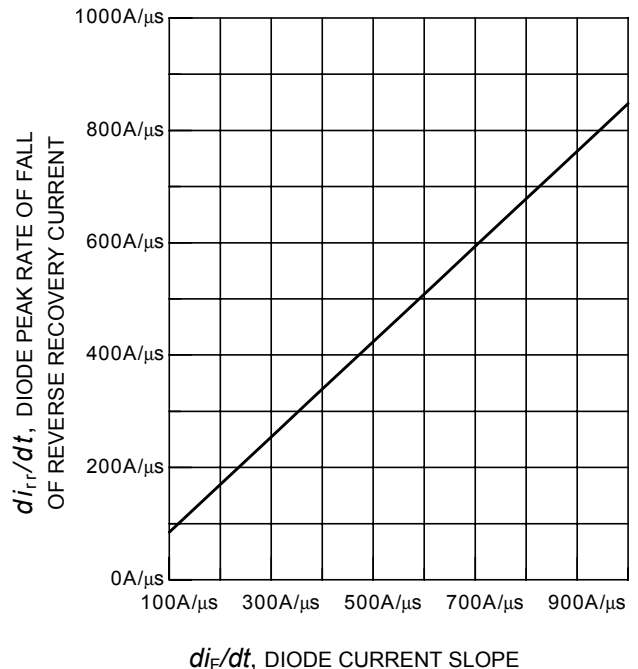
**Figure 21. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 200V$ ,  $T_J = 125^\circ C$ ,  
Dynamic test circuit in Figure E)



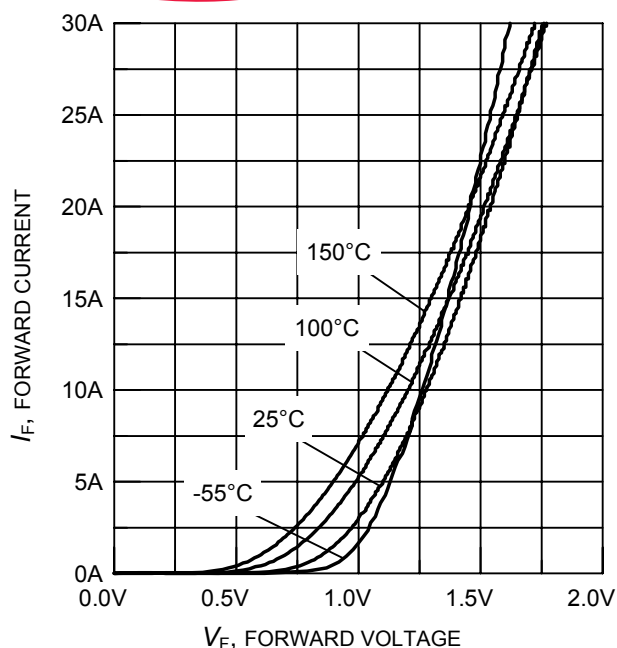
**Figure 22. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 200V$ ,  $T_J = 125^\circ C$ ,  
Dynamic test circuit in Figure E)



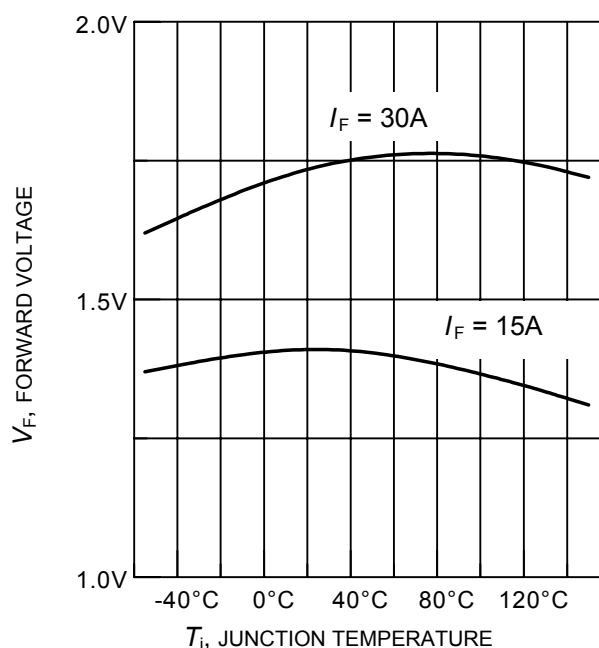
**Figure 23. Typical reverse recovery current as a function of diode current slope**  
( $V_R = 200V$ ,  $T_J = 125^\circ C$ ,  
Dynamic test circuit in Figure E)



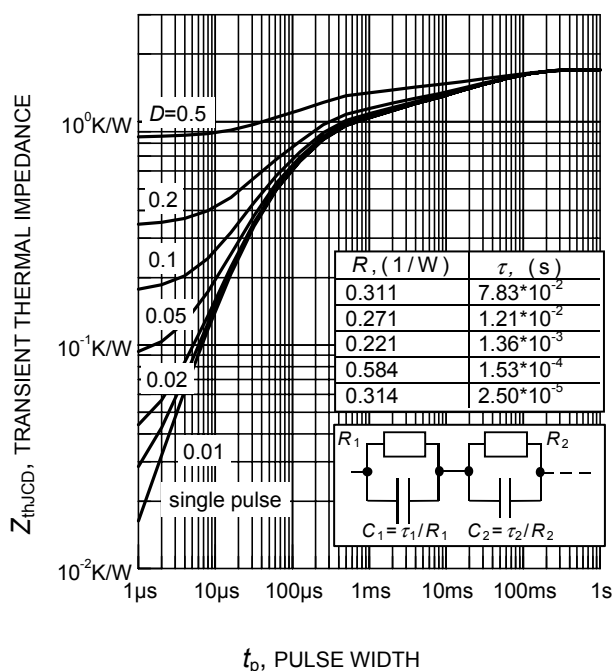
**Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R = 200V$ ,  $T_J = 125^\circ C$ ,  
Dynamic test circuit in Figure E)



**Figure 25. Typical diode forward current as a function of forward voltage**

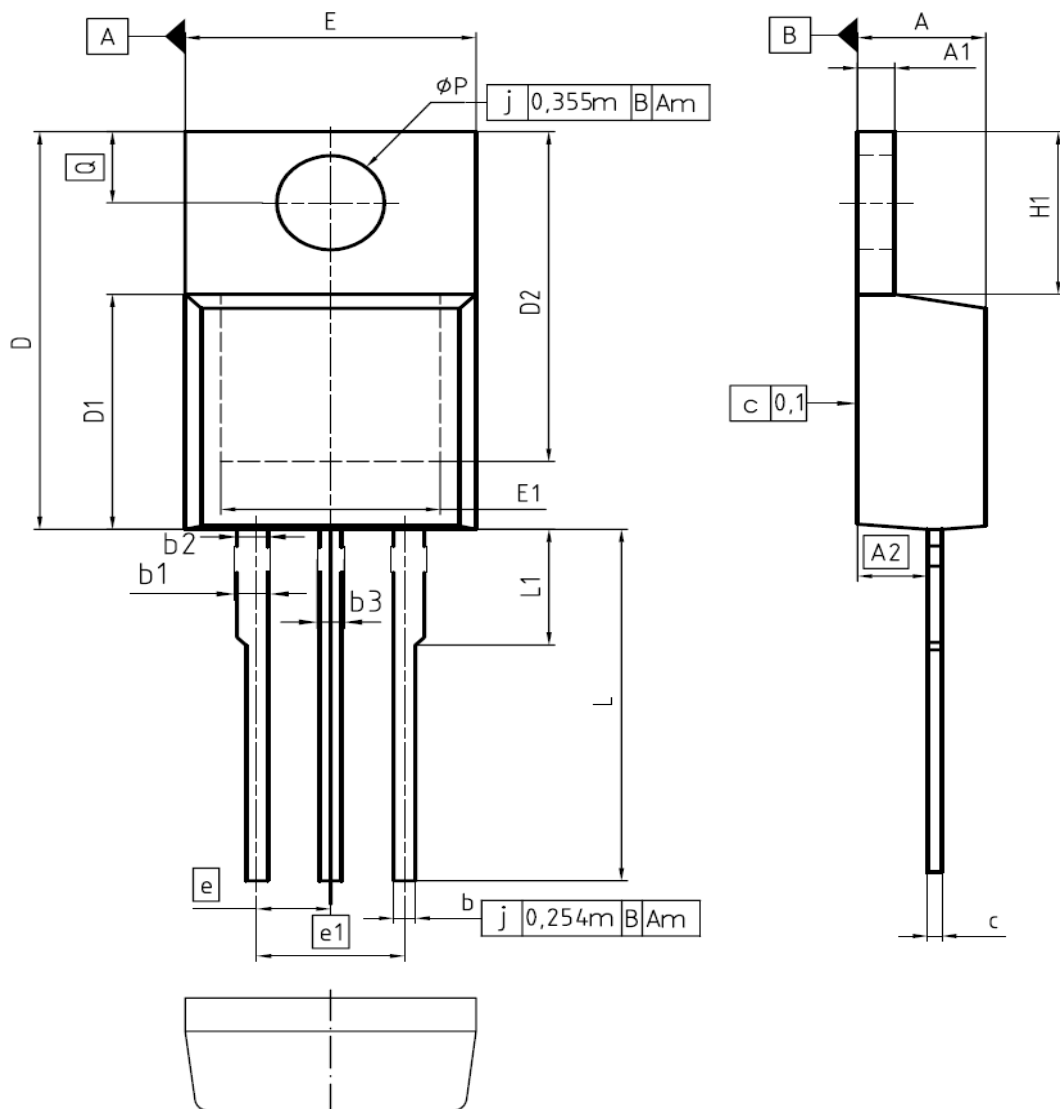


**Figure 26. Typical diode forward voltage as a function of junction temperature**

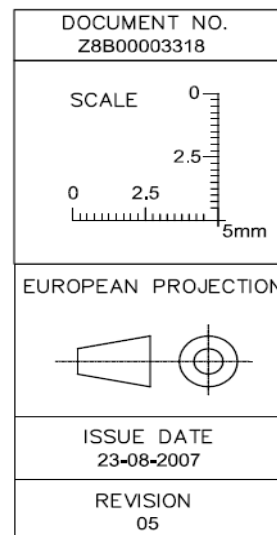


**Figure 27. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )

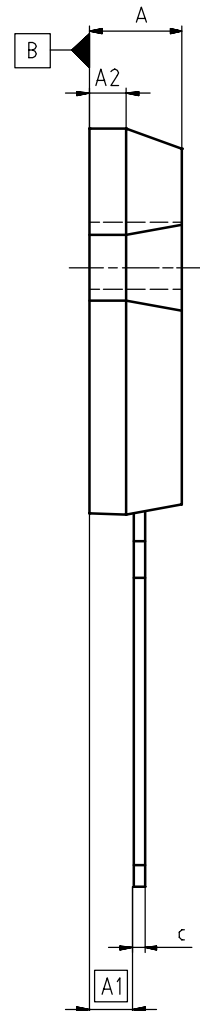
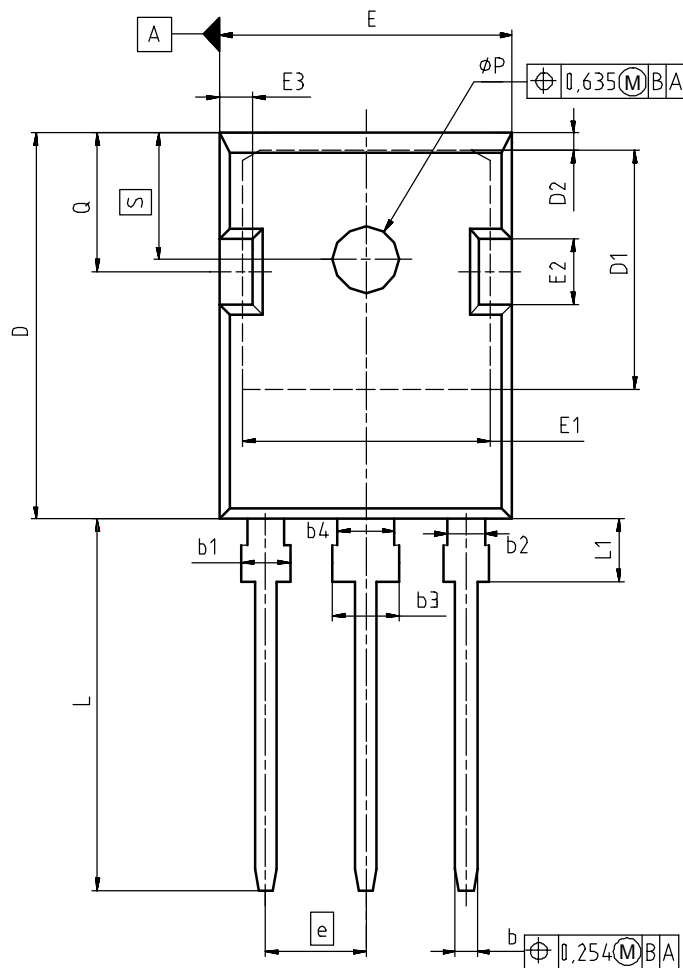
PG-TO220-3-1



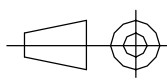
| DIM      | MILLIMETERS |       | INCHES |       |
|----------|-------------|-------|--------|-------|
|          | MIN         | MAX   | MIN    | MAX   |
| A        | 4.30        | 4.57  | 0.169  | 0.180 |
| A1       | 1.17        | 1.40  | 0.046  | 0.055 |
| A2       | 2.15        | 2.72  | 0.085  | 0.107 |
| b        | 0.65        | 0.86  | 0.026  | 0.034 |
| b1       | 0.95        | 1.40  | 0.037  | 0.055 |
| b2       | 0.95        | 1.15  | 0.037  | 0.045 |
| b3       | 0.65        | 1.15  | 0.026  | 0.045 |
| c        | 0.33        | 0.60  | 0.013  | 0.024 |
| D        | 14.81       | 15.95 | 0.583  | 0.628 |
| D1       | 8.51        | 9.45  | 0.335  | 0.372 |
| D2       | 12.19       | 13.10 | 0.480  | 0.516 |
| E        | 9.70        | 10.36 | 0.382  | 0.408 |
| E1       | 6.50        | 8.60  | 0.256  | 0.339 |
| e        | 2.54        |       | 0.100  |       |
| e1       | 5.08        |       | 0.200  |       |
| N        | 3           |       | 3      |       |
| H1       | 5.90        | 6.90  | 0.232  | 0.272 |
| L        | 13.00       | 14.00 | 0.512  | 0.551 |
| L1       | -           | 4.80  | -      | 0.189 |
| $\phi P$ | 3.60        | 3.89  | 0.142  | 0.153 |
| Q        | 2.60        | 3.00  | 0.102  | 0.118 |

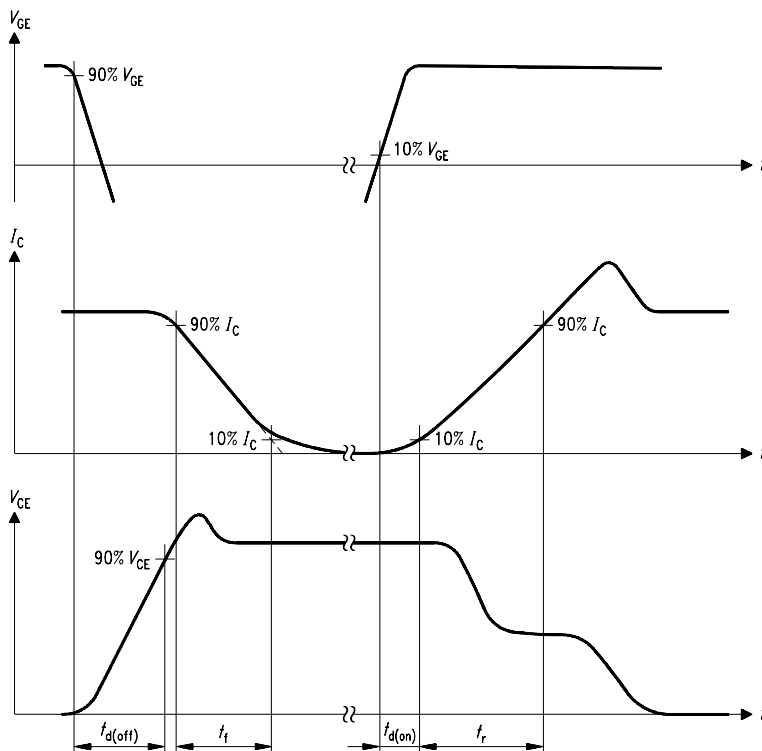


# PG-TO247-3



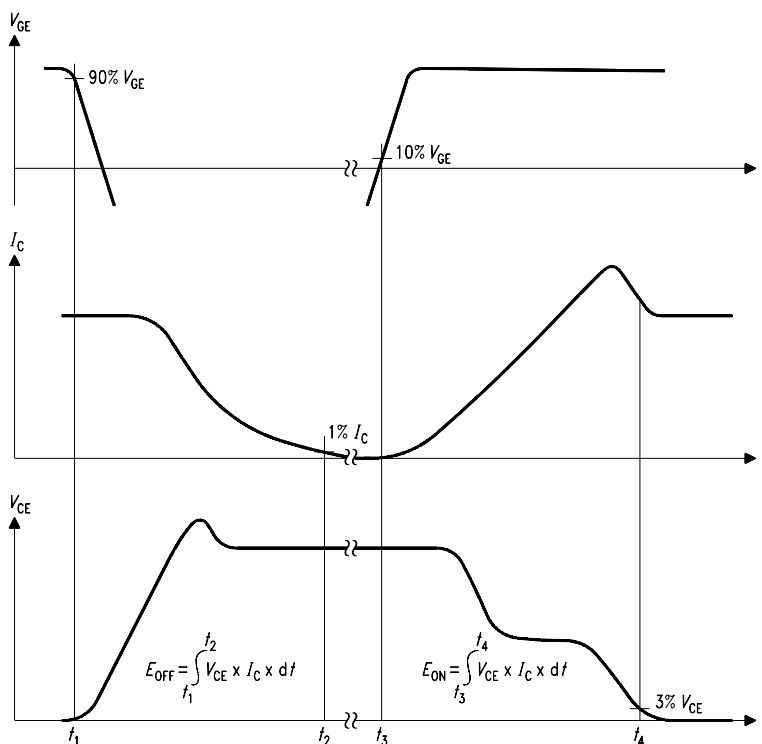
| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.90        | 5.16  | 0.193  | 0.203 |
| A1  | 2.27        | 2.53  | 0.089  | 0.099 |
| A2  | 1.85        | 2.11  | 0.073  | 0.083 |
| b   | 1.07        | 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   | 20.82       | 21.10 | 0.820  | 0.831 |
| D1  | 16.25       | 17.65 | 0.640  | 0.695 |
| D2  | 1.05        | 1.35  | 0.041  | 0.053 |
| E   | 15.70       | 16.03 | 0.618  | 0.631 |
| E1  | 13.10       | 14.15 | 0.516  | 0.557 |
| E2  | 3.68        | 5.10  | 0.145  | 0.201 |
| E3  | 1.68        | 2.60  | 0.066  | 0.102 |
| e   | 5.44        |       | 0.214  |       |
| N   | 3           |       | 3      |       |
| L   | 19.80       | 20.31 | 0.780  | 0.799 |
| L1  | 4.17        | 4.47  | 0.164  | 0.176 |
| φP  | 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 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| DOCUMENT NO.<br>Z8B00003327                                                                                  |
| SCALE<br>0 5 5 7.5mm                                                                                         |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>17-12-2007                                                                                     |
| REVISION<br>03                                                                                               |



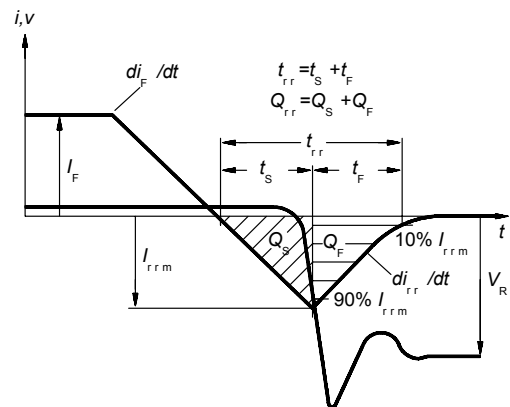
**Figure A. Definition of switching times**

SIS00053

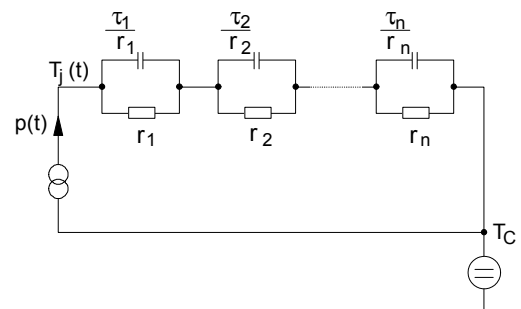


**Figure B. Definition of switching losses**

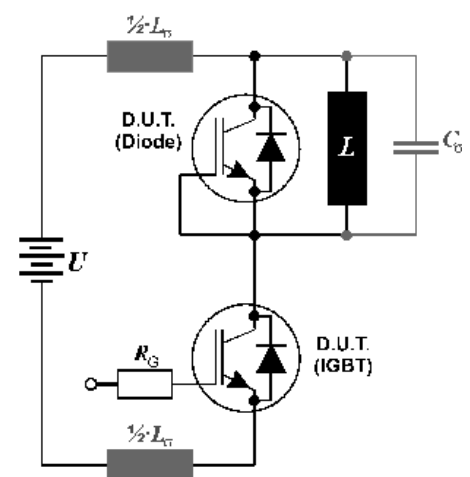
SIS00050



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



**Figure D. Thermal equivalent circuit**



**Figure E. Dynamic test circuit**  
Leakage inductance  $L_{\sigma} = 180\text{nH}$   
and Stray capacity  $C_{\sigma} = 250\text{pF}$ .

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