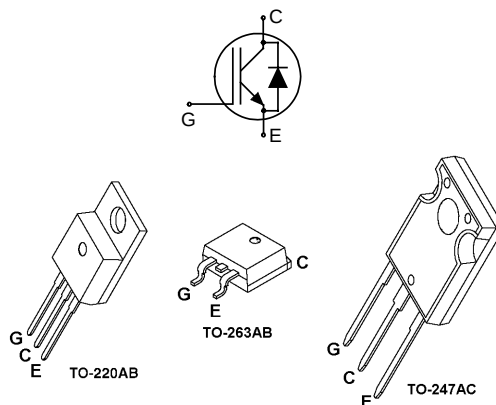


Fast S-IGBT in NPT-technology with soft, fast recovery anti-parallel EmCon diode

- 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



| Type     | $V_{CE}$ | $I_C$ | $V_{CE(sat)}$ | $T_j$ | Package  | Ordering Code |
|----------|----------|-------|---------------|-------|----------|---------------|
| SKP15N60 | 600V     | 15A   | 2.3V          | 150°C | TO-220AB | Q67040-S4251  |
| SKB15N60 |          |       |               |       | TO-263AB | Q67040-S4252  |
| SKW15N60 |          |       |               |       | TO-247AC | Q67040-S4243  |

### 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         |         |
| $T_C = 100^\circ\text{C}$                                                        |                   |            |         |
| 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         |         |
| $T_C = 100^\circ\text{C}$                                                        |                   |            |         |
| 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>1)</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      |

<sup>1)</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    | $R_{thJA}$  | TO-220AB<br>TO-247AC | 62<br>40   |      |
| SMD version, device on PCB <sup>1)</sup>     | $R_{thJA}$  | TO-263AB             | 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         | nA      |
| 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 | $L_E$         | TO-220AB<br>TO-247AC                                                             | -<br>-   | 7<br>13     | -<br>-      | nH      |
| 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>$T_i\leq 150^{\circ}C$ | -        | 150         | -           | A       |

<sup>1)</sup> Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70μm thick) copper area for collector connection. PCB is vertical without blown air.

<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>$R_G=21\Omega$ , | -     | 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

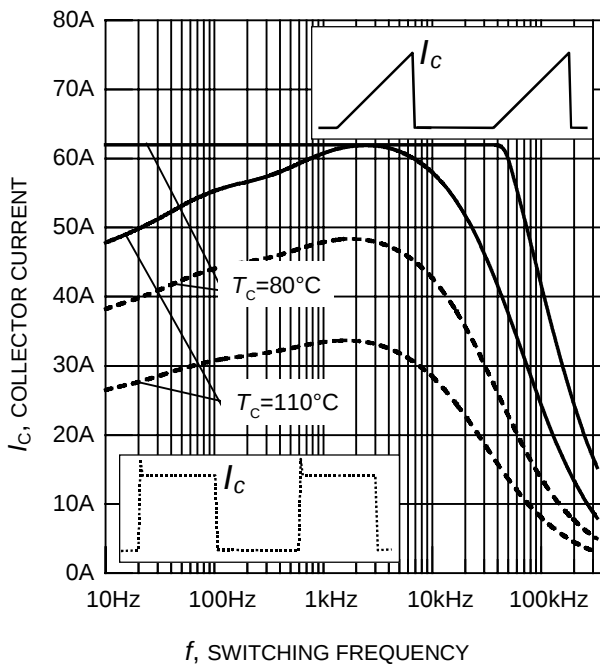
|                                                                  |              |                                                                                                         |   |     |   |                  |
|------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------|---|-----|---|------------------|
| 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>$V_{CC}=400\text{V}$ ,<br>$I_C=15\text{A}$ ,<br>$V_{GE}=0/15\text{V}$ ,<br>$R_G=21\Omega$ | -     | 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 |      |

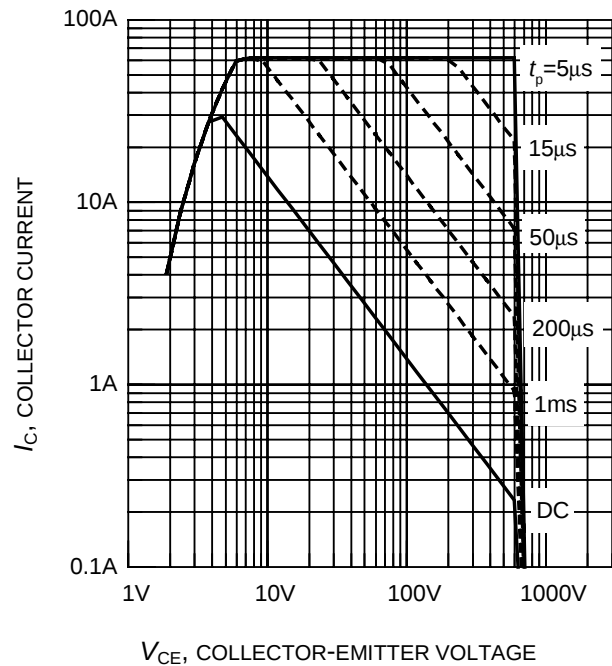
### Anti-Parallel Diode Characteristic

|                                                                  |              |                                                                                                        |   |      |   |                  |
|------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------|---|------|---|------------------|
| 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/ $\mu\text{s}$ |

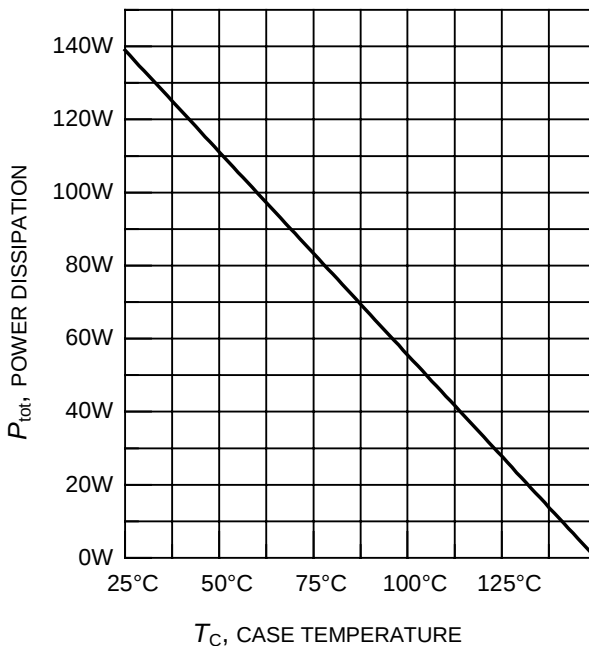


**Figure 1. Collector current as a function of switching frequency**

( $T_j \leq 150^\circ\text{C}$ ,  $D = 0.5$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 21\Omega$ )

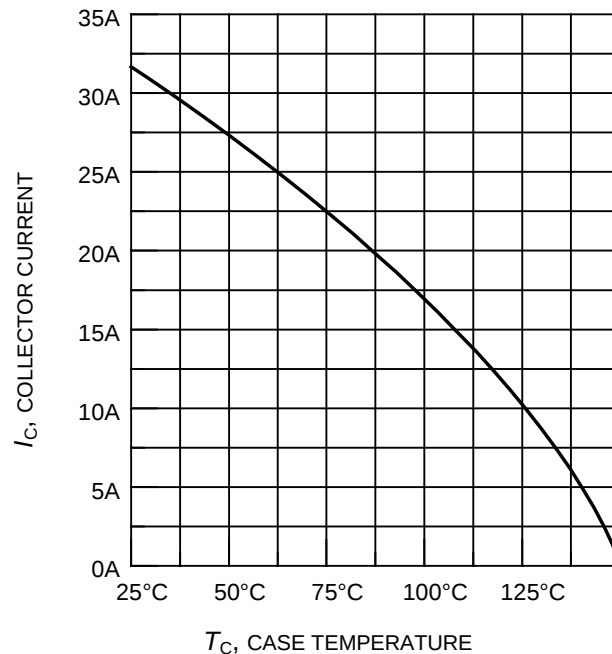


**Figure 2. Safe operating area**  
( $D = 0$ ,  $T_C = 25^\circ\text{C}$ ,  $T_j \leq 150^\circ\text{C}$ )



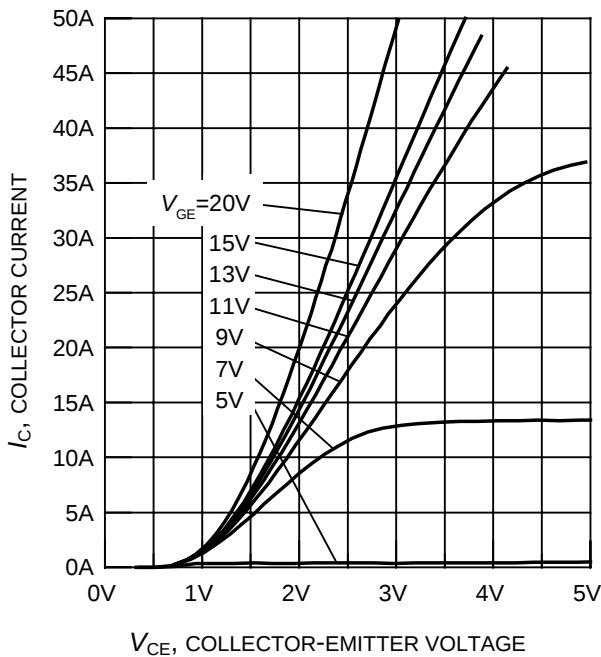
**Figure 3. Power dissipation as a function of case temperature**

( $T_j \leq 150^\circ\text{C}$ )

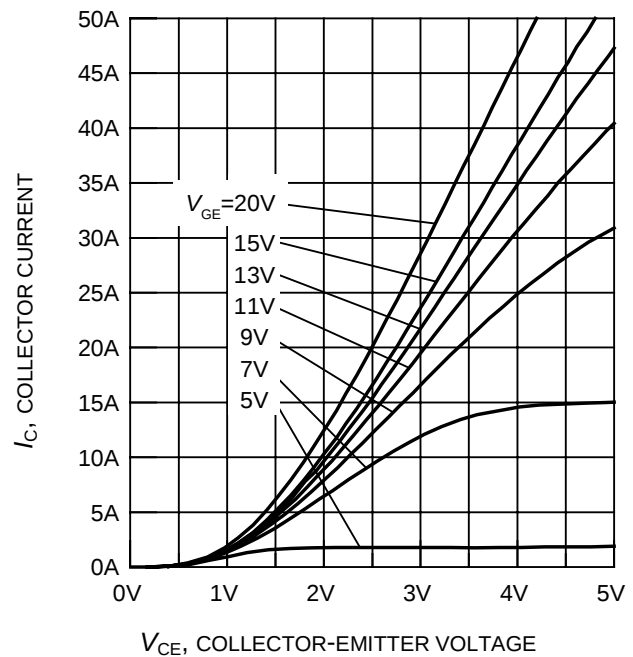


**Figure 4. Collector current as a function of case temperature**

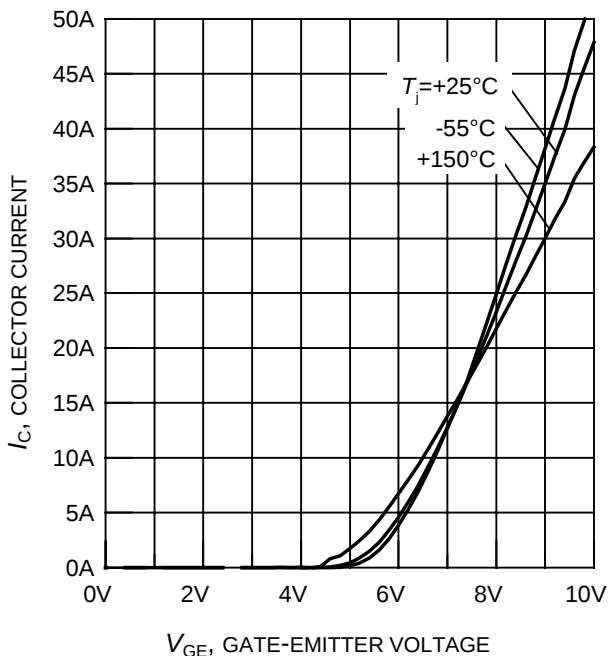
( $V_{GE} \leq 15\text{V}$ ,  $T_j \leq 150^\circ\text{C}$ )



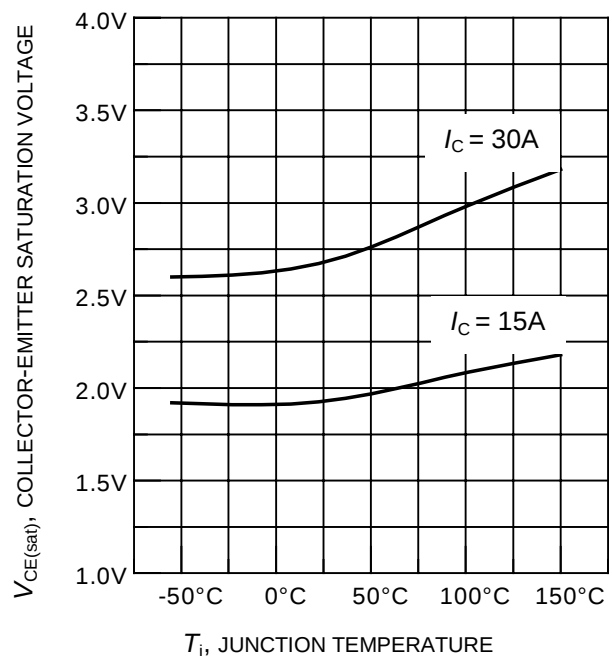
**Figure 5. Typical output characteristics**  
( $T_j = 25^\circ\text{C}$ )



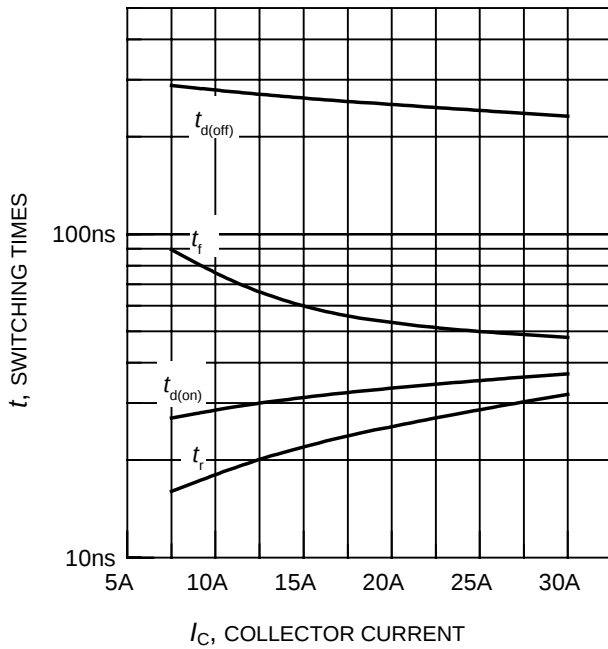
**Figure 6. Typical output characteristics**  
( $T_j = 150^\circ\text{C}$ )



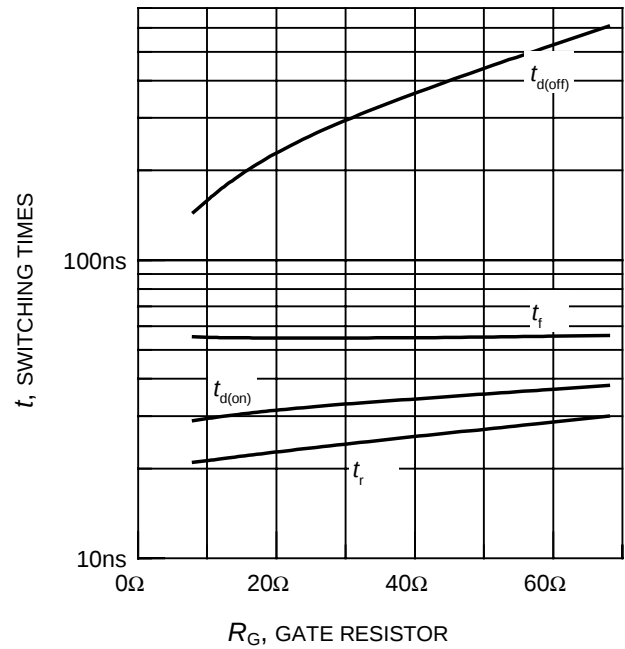
**Figure 7. Typical transfer characteristics**  
( $V_{CE} = 10\text{V}$ )



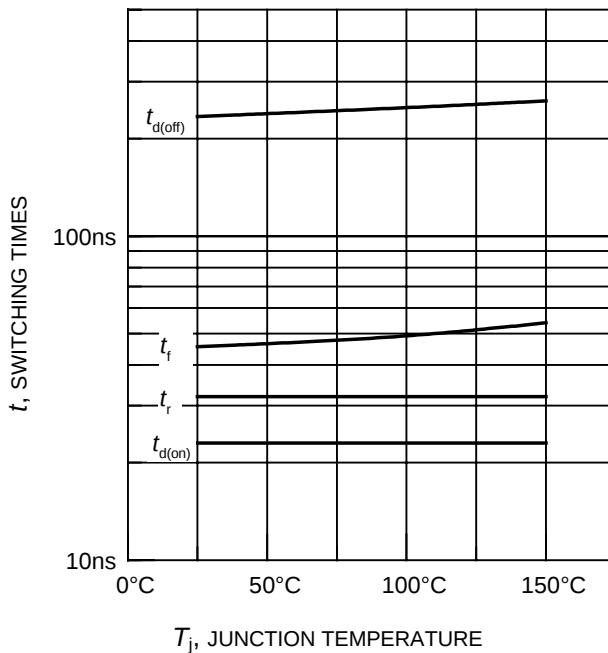
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



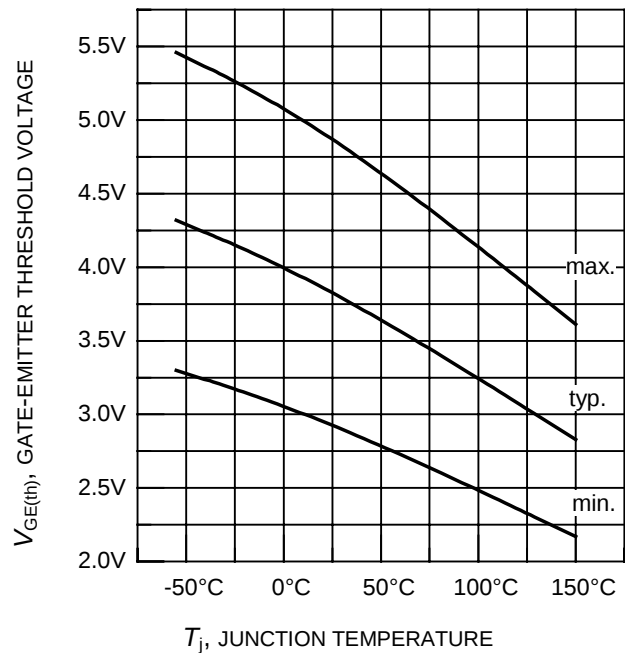
**Figure 9. Typical switching times as a function of collector current**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 21\Omega$ )



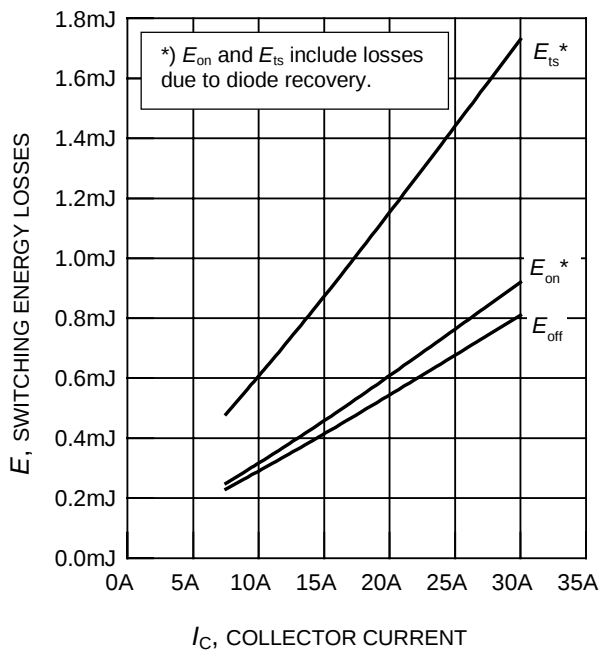
**Figure 10. Typical switching times as a function of gate resistor**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ )



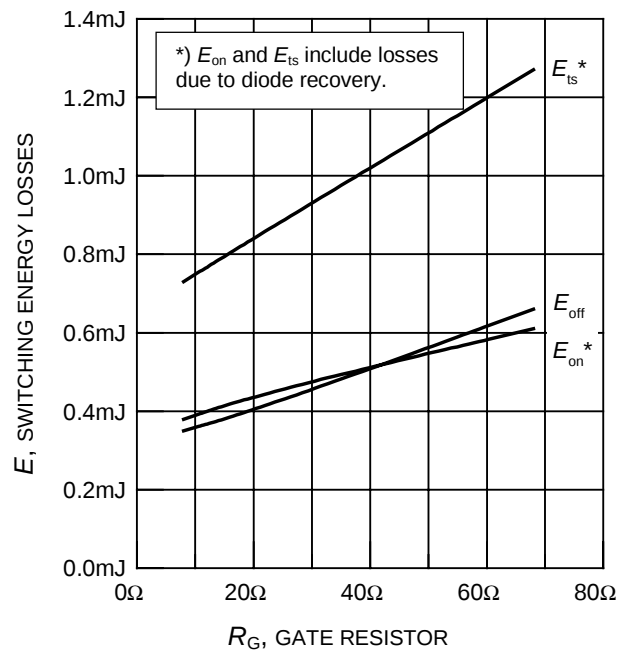
**Figure 11. Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 21\Omega$ )



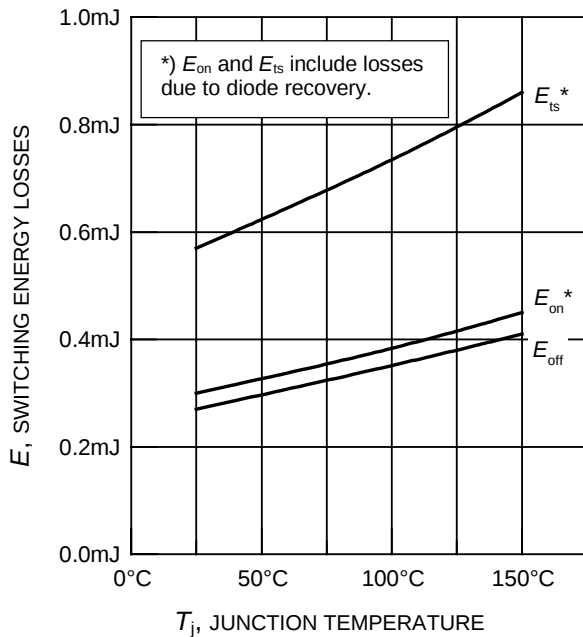
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C = 0.4\text{mA}$ )



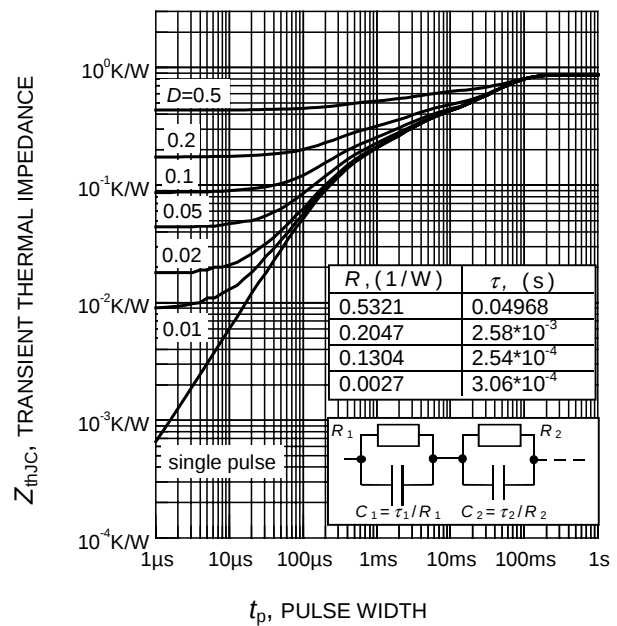
**Figure 13. Typical switching energy losses as a function of collector current**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $R_G = 21\Omega$ )



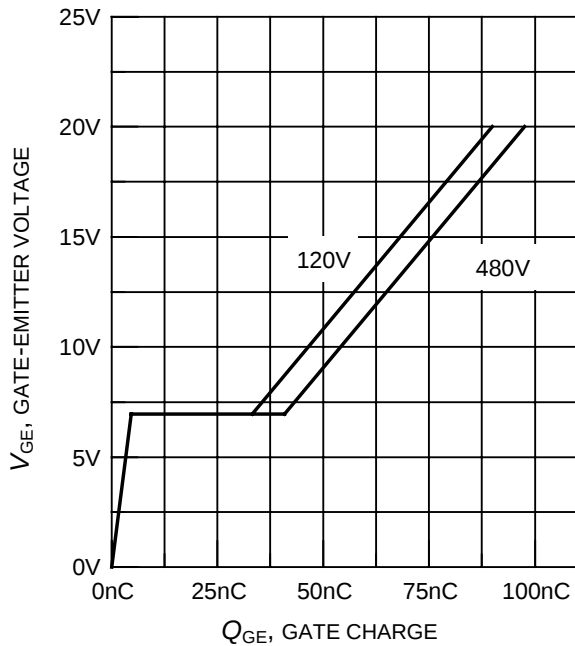
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_j = 150^\circ\text{C}$ ,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ )



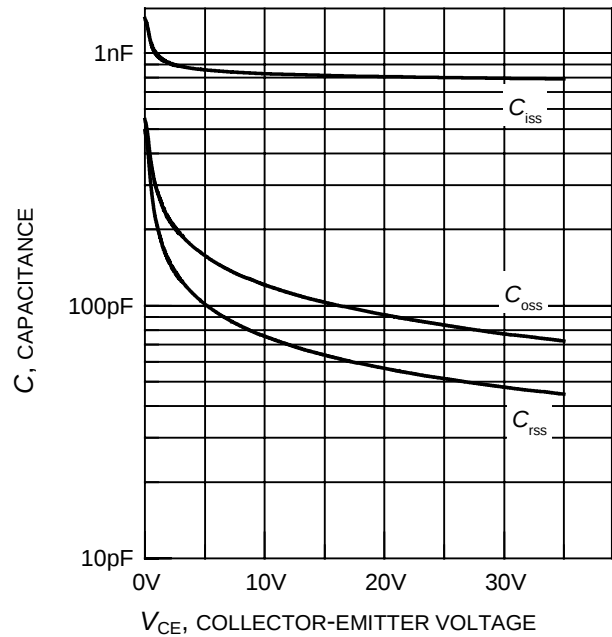
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE} = 400\text{V}$ ,  $V_{GE} = 0/+15\text{V}$ ,  $I_C = 15\text{A}$ ,  $R_G = 21\Omega$ )



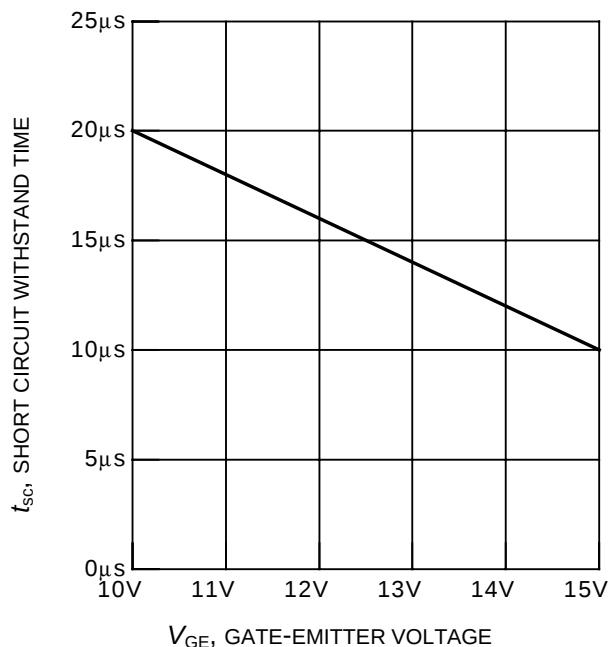
**Figure 16. IGBT transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )



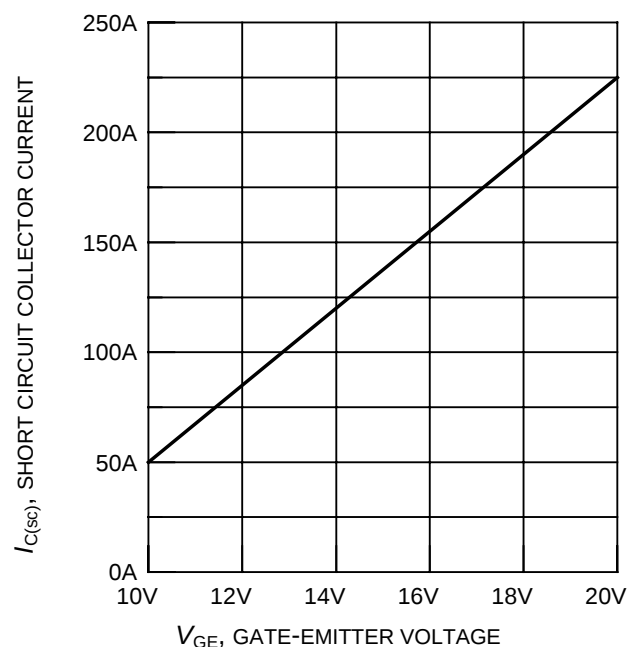
**Figure 17. Typical gate charge**  
( $I_C = 15A$ )



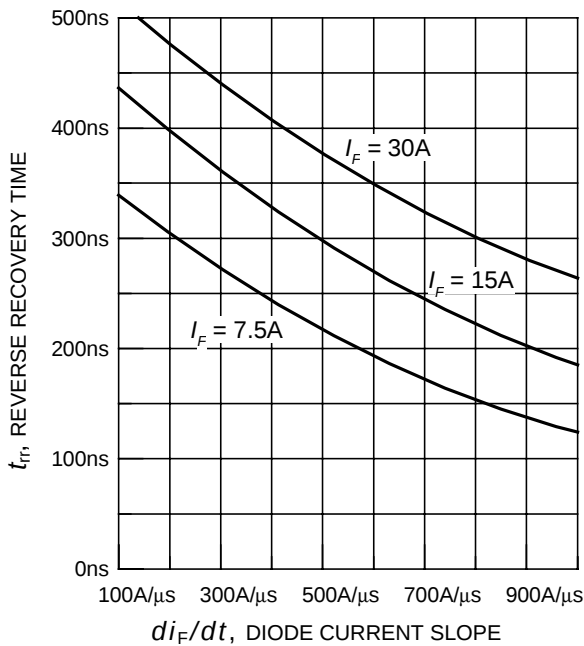
**Figure 18. Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE} = 0V$ ,  $f = 1MHz$ )



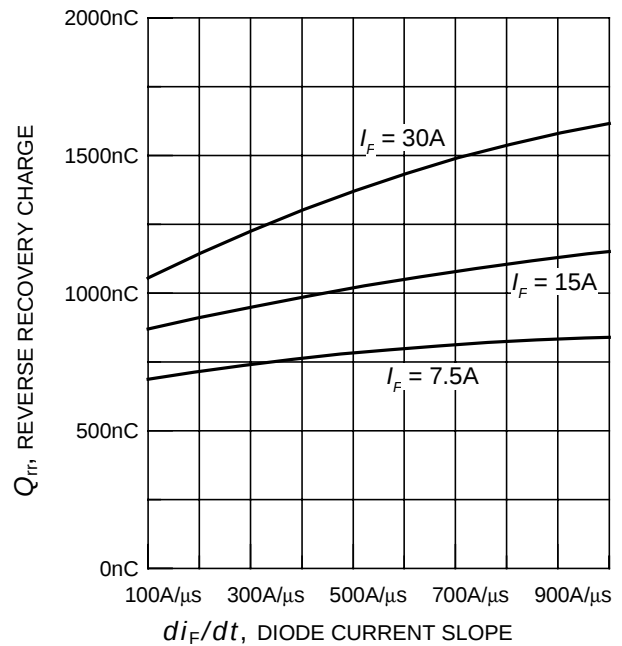
**Figure 19. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE} = 600V$ , start at  $T_j = 25^\circ C$ )



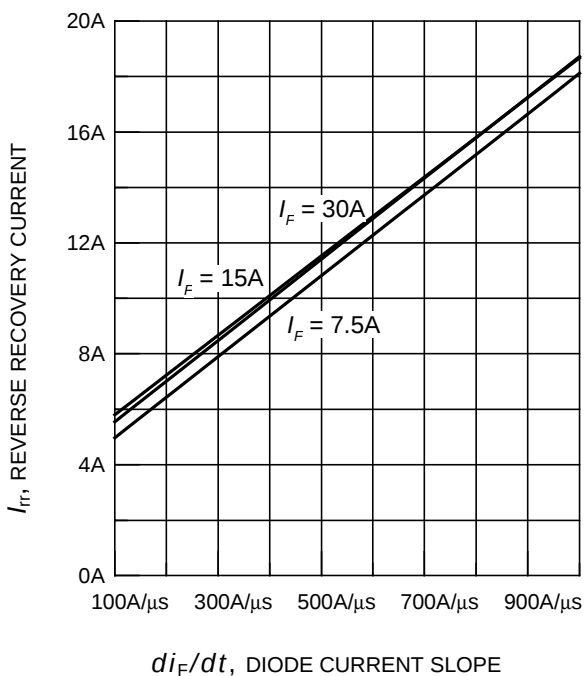
**Figure 20. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 600V$ ,  $T_j = 150^\circ C$ )



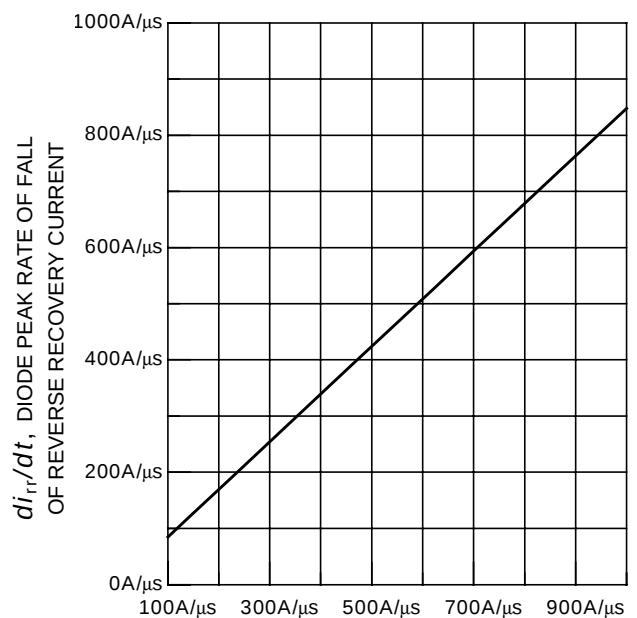
**Figure 21. Typical reverse recovery time as a function of diode current slope**  
( $V_R = 200V$ ,  $T_j = 125^\circ C$ )



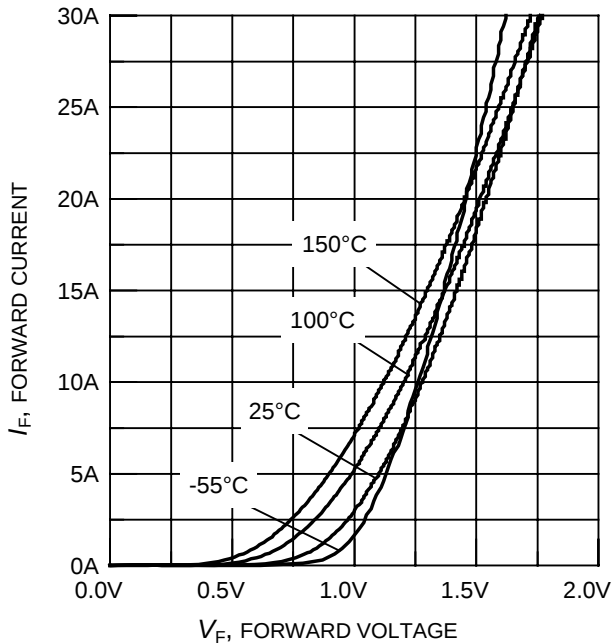
**Figure 22. Typical reverse recovery charge as a function of diode current slope**  
( $V_R = 200V$ ,  $T_j = 125^\circ C$ )



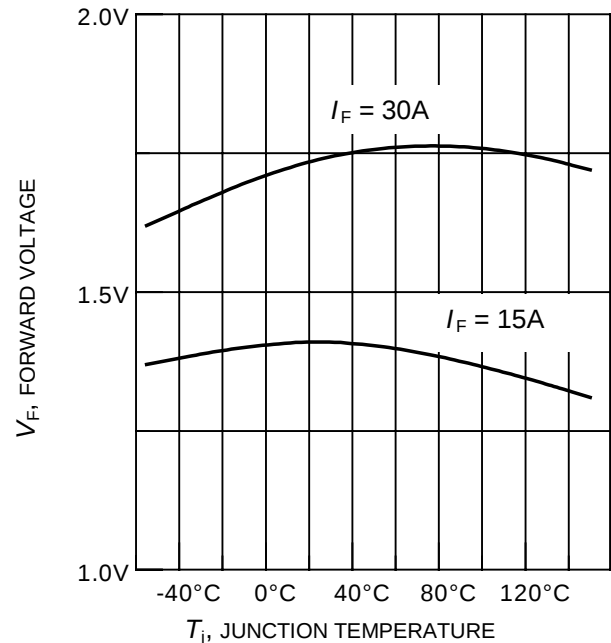
**Figure 23. Typical reverse recovery current as a function of diode current slope**  
( $V_R = 200V$ ,  $T_j = 125^\circ C$ )



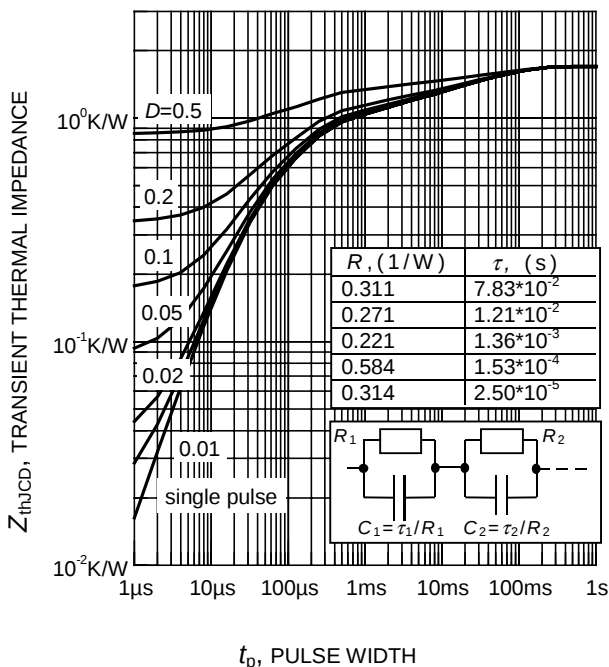
**Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R = 200V$ ,  $T_j = 125^\circ C$ )



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

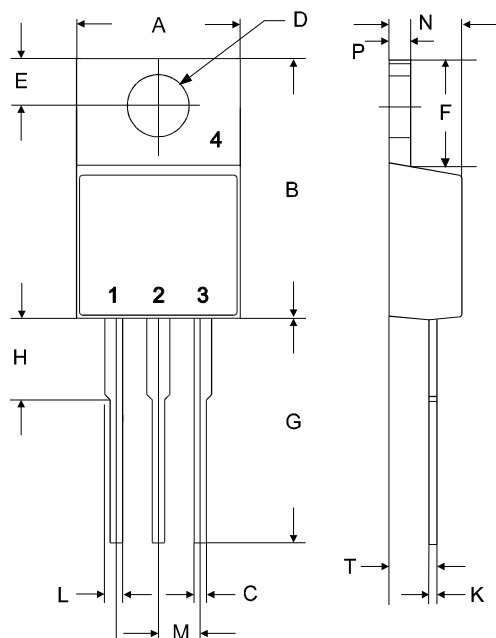


**Figure 26. Typical diode forward voltage as a function of junction temperature**



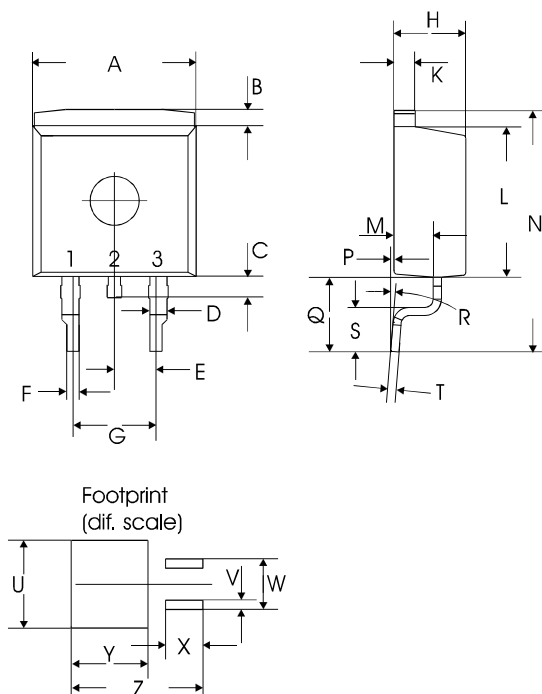
**Figure 27. Diode transient thermal impedance as a function of pulse width**  
( $D = t_p / T$ )

TO-220AB

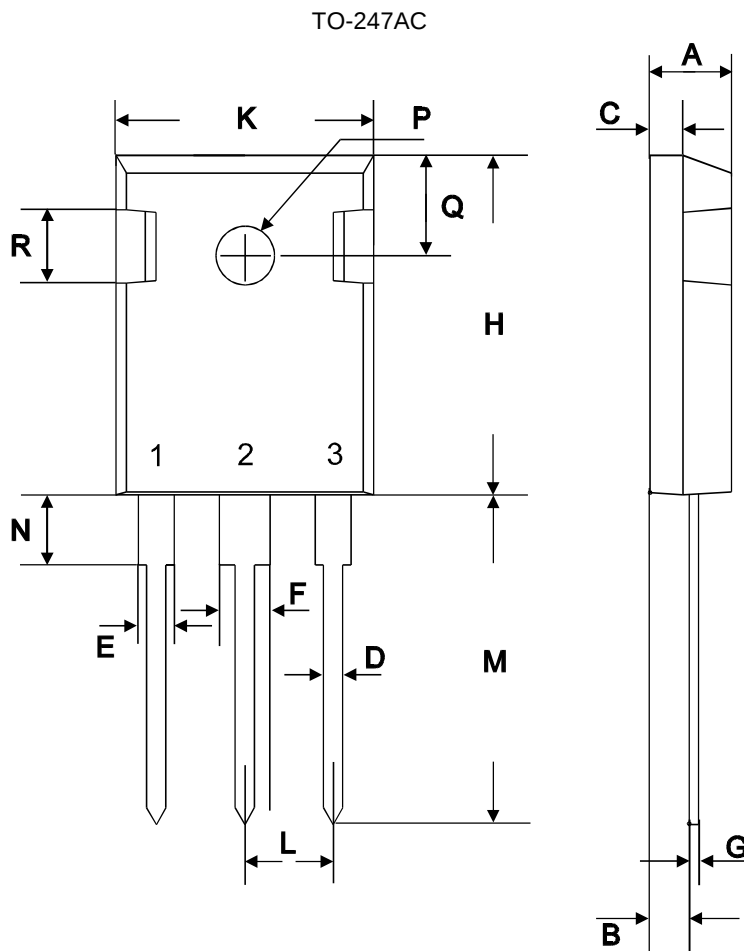


| symbol | dimensions |       |          |        |
|--------|------------|-------|----------|--------|
|        | [mm]       |       | [inch]   |        |
|        | min        | max   | min      | max    |
| A      | 9.70       | 10.30 | 0.3819   | 0.4055 |
| B      | 14.88      | 15.95 | 0.5858   | 0.6280 |
| C      | 0.65       | 0.86  | 0.0256   | 0.0339 |
| D      | 3.55       | 3.89  | 0.1398   | 0.1531 |
| E      | 2.60       | 3.00  | 0.1024   | 0.1181 |
| F      | 6.00       | 6.80  | 0.2362   | 0.2677 |
| G      | 13.00      | 14.00 | 0.5118   | 0.5512 |
| H      | 4.35       | 4.75  | 0.1713   | 0.1870 |
| K      | 0.38       | 0.65  | 0.0150   | 0.0256 |
| L      | 0.95       | 1.32  | 0.0374   | 0.0520 |
| M      | 2.54 typ.  |       | 0.1 typ. |        |
| N      | 4.30       | 4.50  | 0.1693   | 0.1772 |
| P      | 1.17       | 1.40  | 0.0461   | 0.0551 |
| T      | 2.30       | 2.72  | 0.0906   | 0.1071 |

TO-263AB (D<sup>2</sup>Pak)



| symbol | dimensions |       |             |        |
|--------|------------|-------|-------------|--------|
|        | [mm]       |       | [inch]      |        |
|        | min        | max   | min         | max    |
| A      | 9.80       | 10.20 | 0.3858      | 0.4016 |
| B      | 0.70       | 1.30  | 0.0276      | 0.0512 |
| C      | 1.00       | 1.60  | 0.0394      | 0.0630 |
| D      | 1.03       | 1.07  | 0.0406      | 0.0421 |
| E      | 2.54 typ.  |       | 0.1 typ.    |        |
| F      | 0.65       | 0.85  | 0.0256      | 0.0335 |
| G      | 5.08 typ.  |       | 0.2 typ.    |        |
| H      | 4.30       | 4.50  | 0.1693      | 0.1772 |
| K      | 1.17       | 1.37  | 0.0461      | 0.0539 |
| L      | 9.05       | 9.45  | 0.3563      | 0.3720 |
| M      | 2.30       | 2.50  | 0.0906      | 0.0984 |
| N      | 15 typ.    |       | 0.5906 typ. |        |
| P      | 0.00       | 0.20  | 0.0000      | 0.0079 |
| Q      | 4.20       | 5.20  | 0.1654      | 0.2047 |
| R      | 8° max     |       | 8° max      |        |
| S      | 2.40       | 3.00  | 0.0945      | 0.1181 |
| T      | 0.40       | 0.60  | 0.0157      | 0.0236 |
| U      | 10.80      |       | 0.4252      |        |
| V      | 1.15       |       | 0.0453      |        |
| W      | 6.23       |       | 0.2453      |        |
| X      | 4.60       |       | 0.1811      |        |
| Y      | 9.40       |       | 0.3701      |        |
| Z      | 16.15      |       | 0.6358      |        |



| symbol | dimensions |       |            |        |
|--------|------------|-------|------------|--------|
|        | [mm]       |       | [inch]     |        |
|        | min        | max   | min        | max    |
| A      | 4.78       | 5.28  | 0.1882     | 0.2079 |
| B      | 2.29       | 2.51  | 0.0902     | 0.0988 |
| C      | 1.78       | 2.29  | 0.0701     | 0.0902 |
| D      | 1.09       | 1.32  | 0.0429     | 0.0520 |
| E      | 1.73       | 2.06  | 0.0681     | 0.0811 |
| F      | 2.67       | 3.18  | 0.1051     | 0.1252 |
| G      | 0.76 max   |       | 0.0299 max |        |
| H      | 20.80      | 21.16 | 0.8189     | 0.8331 |
| K      | 15.65      | 16.15 | 0.6161     | 0.6358 |
| L      | 5.21       | 5.72  | 0.2051     | 0.2252 |
| M      | 19.81      | 20.68 | 0.7799     | 0.8142 |
| N      | 3.560      | 4.930 | 0.1402     | 0.1941 |
| ØP     | 3.61       |       | 0.1421     |        |
| Q      | 6.12       | 6.22  | 0.2409     | 0.2449 |

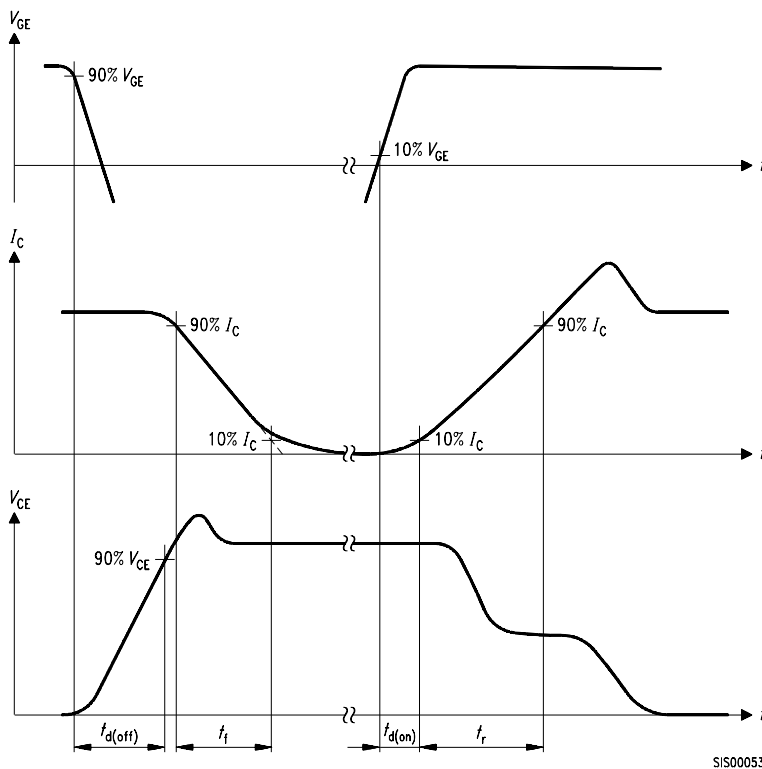


Figure A. Definition of switching times

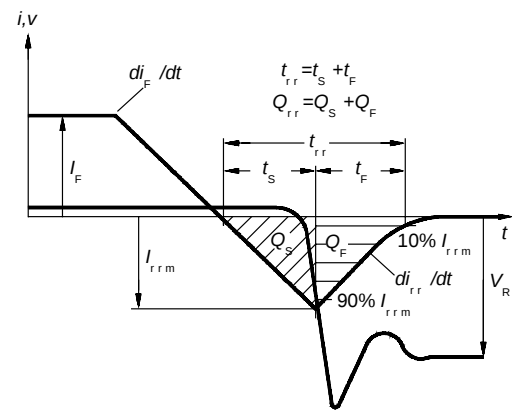


Figure C. Definition of diodes switching characteristics

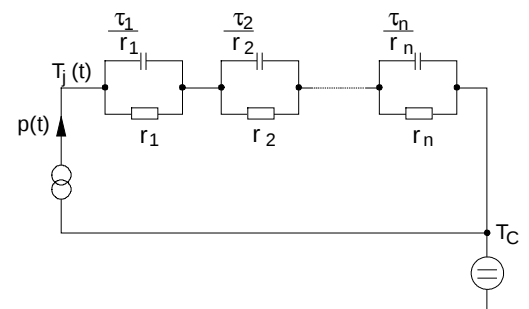


Figure D. Thermal equivalent circuit

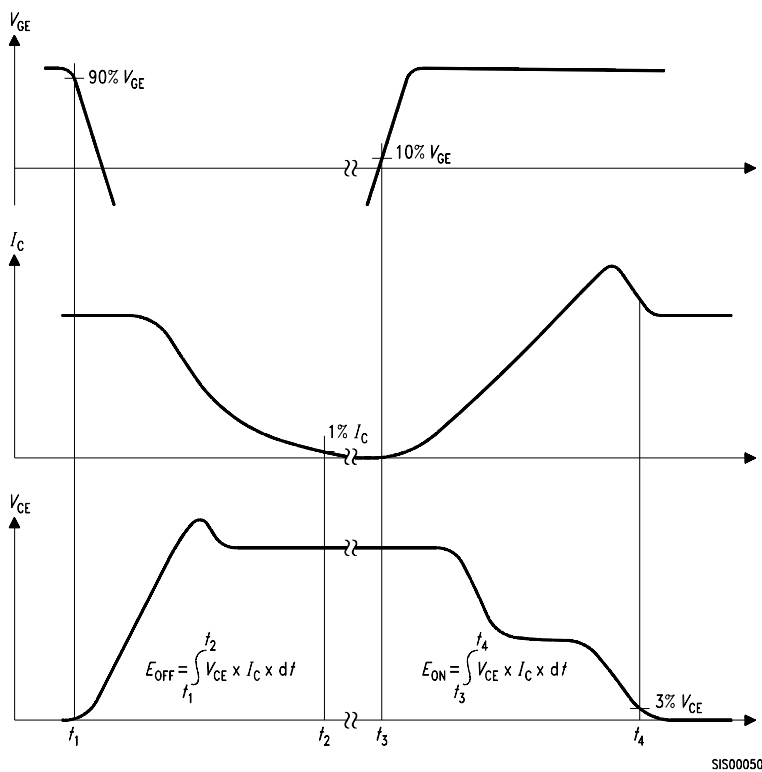


Figure B. Definition of switching losses

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