

## IGBT

High speed DuoPack IGBT in Trench and Fieldstop technology with soft, fast recovery anti-parallel diode

### IKW40N60H3

600V DuoPack IGBT and Diode  
High speed switching series third generation

Data Sheet

Industrial & Multimarket

## High speed DuoPack: IGBT in Trench and Fieldstop technology with soft, fast recovery anti-parallel diode

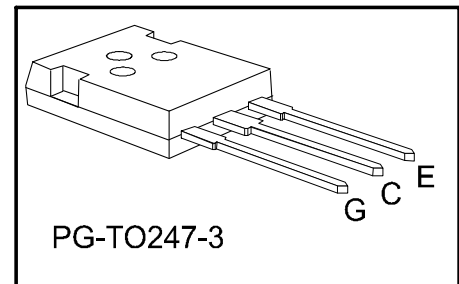
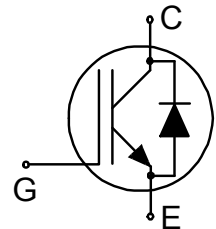
### Features:

TRENCHSTOP™ technology offering

- very low  $V_{CEsat}$
- low EMI
- Very soft, fast recovery anti-parallel diode
- maximum junction temperature 175°C
- qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant
- complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>

### Applications:

- uninterruptible power supplies
- welding converters
- converters with high switching frequency



### Key Performance and Package Parameters

| Type       | $V_{CE}$ | $I_C$ | $V_{CEsat}$ , $T_{vj}=25^{\circ}\text{C}$ | $T_{vjmax}$ | Marking | Package    |
|------------|----------|-------|-------------------------------------------|-------------|---------|------------|
| IKW40N60H3 | 600V     | 40A   | 1.95V                                     | 175°C       | K40H603 | PG-TO247-3 |

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**Maximum ratings**

| Parameter                                                                                                                                                                               | Symbol      | Value          | Unit        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|-------------|
| Collector-emitter voltage                                                                                                                                                               | $V_{CE}$    | 600            | V           |
| DC collector current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}C$<br>$T_C = 100^{\circ}C$                                                                                             | $I_C$       | 80.0<br>40.0   | A           |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$                                                                                                                                  | $I_{Cpuls}$ | 160.0          | A           |
| Turn off safe operating area $V_{CE} \leq 600V$ , $T_{vj} \leq 175^{\circ}C$                                                                                                            | -           | 160.0          | A           |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}C$<br>$T_C = 100^{\circ}C$                                                                                            | $I_F$       | 40.0<br>20.0   | A           |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$                                                                                                                                      | $I_{Fpuls}$ | 160.0          | A           |
| Gate-emitter voltage                                                                                                                                                                    | $V_{GE}$    | $\pm 20$       | V           |
| Short circuit withstand time<br>$V_{GE} = 15.0V$ , $V_{CC} \leq 400V$<br>Allowed number of short circuits < 1000<br>Time between short circuits: $\geq 1.0s$<br>$T_{vj} = 150^{\circ}C$ | $t_{SC}$    | 5              | $\mu s$     |
| Power dissipation $T_C = 25^{\circ}C$<br>Power dissipation $T_C = 100^{\circ}C$                                                                                                         | $P_{tot}$   | 306.0<br>153.0 | W           |
| Operating junction temperature                                                                                                                                                          | $T_{vj}$    | $-40...+175$   | $^{\circ}C$ |
| Storage temperature                                                                                                                                                                     | $T_{stg}$   | $-55...+150$   | $^{\circ}C$ |
| Soldering temperature,<br>wavesoldering 1.6 mm (0.063 in.) from case for 10s                                                                                                            |             | 260            | $^{\circ}C$ |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3                                                                                                                           | $M$         | 0.6            | Nm          |

**Thermal Resistance**

| Parameter                                    | Symbol        | Conditions | Max. Value | Unit |
|----------------------------------------------|---------------|------------|------------|------|
| <b>Characteristic</b>                        |               |            |            |      |
| IGBT thermal resistance,<br>junction - case  | $R_{th(j-c)}$ |            | 0.49       | K/W  |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ |            | 1.50       | K/W  |
| Thermal resistance<br>junction - ambient     | $R_{th(j-a)}$ |            | 40         | K/W  |

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

| Parameter                            | Symbol        | Conditions                      | Value |      |        | Unit    |
|--------------------------------------|---------------|---------------------------------|-------|------|--------|---------|
|                                      |               |                                 | min.  | typ. | max.   |         |
| Static Characteristic                |               |                                 |       |      |        |         |
| Collector-emitter breakdown voltage  | $V_{(BR)CES}$ | $V_{GE} = 0V, I_C = 2.00mA$     | 600   | -    | -      | V       |
| Collector-emitter saturation voltage | $V_{CEsat}$   | $V_{GE} = 15.0V, I_C = 40.0A$   | -     | 1.95 | 2.40   | V       |
|                                      |               | $T_{vj} = 25^{\circ}C$          | -     | 2.30 | -      |         |
|                                      |               | $T_{vj} = 125^{\circ}C$         | -     | 2.50 | -      |         |
|                                      |               | $T_{vj} = 175^{\circ}C$         | -     | -    | -      |         |
| Diode forward voltage                | $V_F$         | $V_{GE} = 0V, I_F = 20.0A$      | -     | 1.65 | 2.05   | V       |
|                                      |               | $T_{vj} = 25^{\circ}C$          | -     | 1.67 | -      |         |
|                                      |               | $T_{vj} = 125^{\circ}C$         | -     | 1.65 | -      |         |
|                                      |               | $T_{vj} = 175^{\circ}C$         | -     | -    | -      |         |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.58mA, V_{CE} = V_{GE}$ | 4.1   | 5.1  | 5.7    | V       |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE} = 600V, V_{GE} = 0V$    | -     | -    | 40.0   | $\mu A$ |
|                                      |               | $T_{vj} = 25^{\circ}C$          | -     | -    | 1000.0 |         |
|                                      |               | $T_{vj} = 175^{\circ}C$         | -     | -    | -      |         |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE} = 0V, V_{GE} = 20V$     | -     | -    | 100    | nA      |
| Transconductance                     | $g_{fs}$      | $V_{CE} = 20V, I_C = 40.0A$     | -     | 24.0 | -      | S       |

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

| Parameter                                                                                               | Symbol      | Conditions                                                                    | Value |       |      | Unit |
|---------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------|-------|-------|------|------|
|                                                                                                         |             |                                                                               | min.  | typ.  | max. |      |
| Dynamic Characteristic                                                                                  |             |                                                                               |       |       |      |      |
| Input capacitance                                                                                       | $C_{ies}$   | $V_{CE} = 25V, V_{GE} = 0V, f = 1MHz$                                         | -     | 2190  | -    | pF   |
| Output capacitance                                                                                      | $C_{oes}$   |                                                                               | -     | 112   | -    |      |
| Reverse transfer capacitance                                                                            | $C_{res}$   |                                                                               | -     | 64    | -    |      |
| Gate charge                                                                                             | $Q_G$       | $V_{CC} = 480V, I_C = 40.0A, V_{GE} = 15V$                                    | -     | 223.0 | -    | nC   |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from case                                       | $L_E$       |                                                                               | -     | 13.0  | -    | nH   |
| Short circuit collector current<br>Max. 1000 short circuits<br>Time between short circuits: $\geq 1.0s$ | $I_{C(SC)}$ | $V_{GE} = 15.0V, V_{CC} \leq 400V, t_{SC} \leq 5\mu s, T_{vj} = 150^{\circ}C$ | -     | 235   | -    | A    |

**Switching Characteristic, Inductive Load, at  $T_{vj} = 25^{\circ}\text{C}$** 

| Parameter              | Symbol       | Conditions                                                                                                                                                                                                                                                                                                      | Value |      |      | Unit |
|------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                                                                                                                                                 | min.  | typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                                                                                                                                                 |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 20.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 7.9\Omega$ , $L_{\sigma} = 90\text{nH}$ ,<br>$C_{\sigma} = 60\text{pF}$<br>$L_{\sigma}$ , $C_{\sigma}$ from Fig. E<br>Energy losses include “tail” and<br>diode reverse recovery. | -     | 19   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                 | -     | 33   | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                 | -     | 197  | -    | ns   |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                 | -     | 21   | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                 | -     | 1.10 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                 | -     | 0.58 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                 | -     | 1.68 | -    | mJ   |

**Anti-Parallel Diode Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$** 

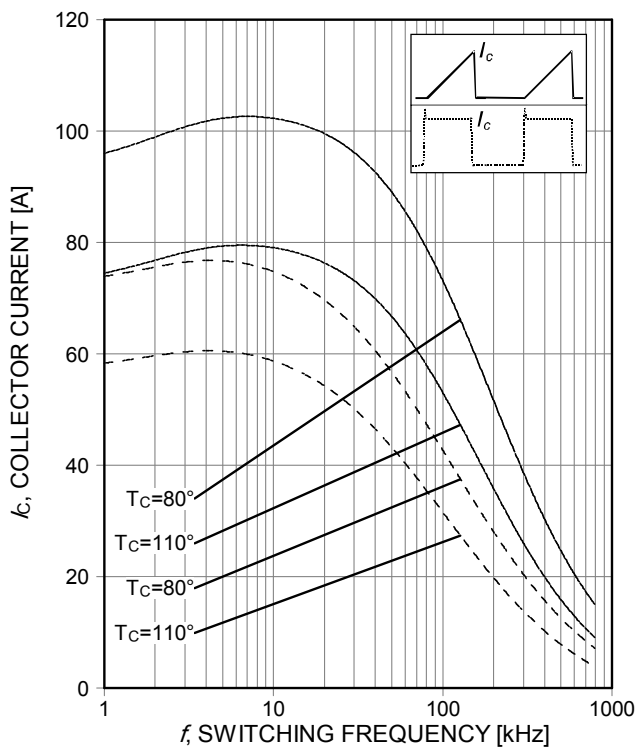
|                                                                  |              |                                                                                                                         |   |      |   |                        |
|------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 25^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 20.0\text{A},$<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 124  | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                         | - | 0.81 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                         | - | 13.6 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                         | - | -332 | - | $\text{A}/\mu\text{s}$ |

**Switching Characteristic, Inductive Load, at  $T_{vj} = 175^{\circ}\text{C}$** 

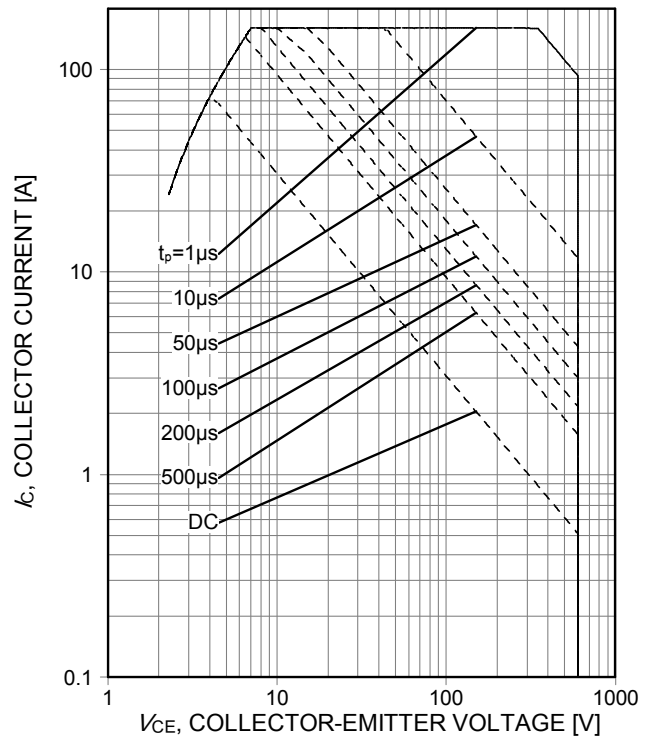
| Parameter              | Symbol       | Conditions                                                                                                                                                                                                                                                                                                    | Value |      |      | Unit |
|------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                                                                                                                                               | min.  | typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                                                                                                                                               |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 175^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 20.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 7.9\Omega$ , $L_{\sigma} = 90\text{nH}$ ,<br>$C_{\sigma} = 60\text{pF}$<br>$L_{\sigma}$ , $C_{\sigma}$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | -     | 19   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                               | -     | 29   | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                               | -     | 227  | -    | ns   |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                               | -     | 22   | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                               | -     | 1.33 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                               | -     | 0.79 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                               | -     | 2.12 | -    | mJ   |

**Anti-Parallel Diode Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$** 

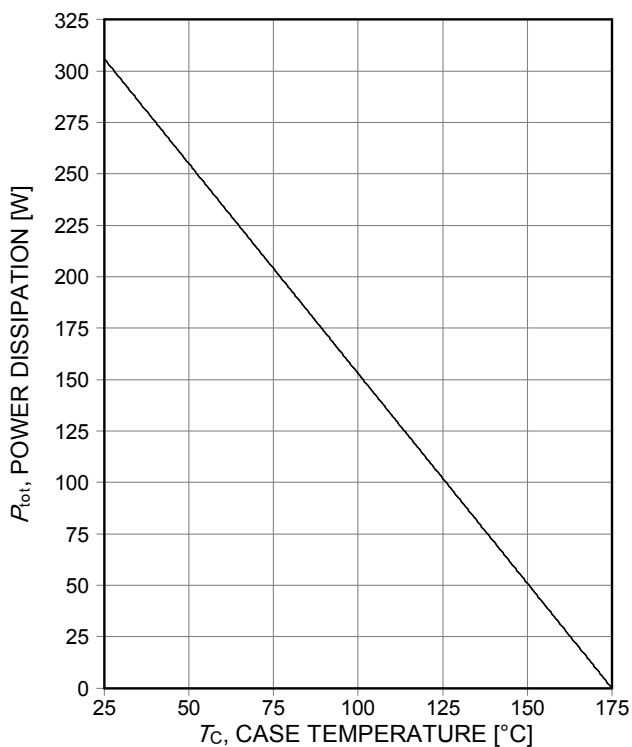
|                                                                  |              |                                                                                                                          |   |      |   |                        |
|------------------------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 175^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 20.0\text{A},$<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 190  | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                          | - | 1.70 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                          | - | 18.5 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                          | - | -290 | - | $\text{A}/\mu\text{s}$ |



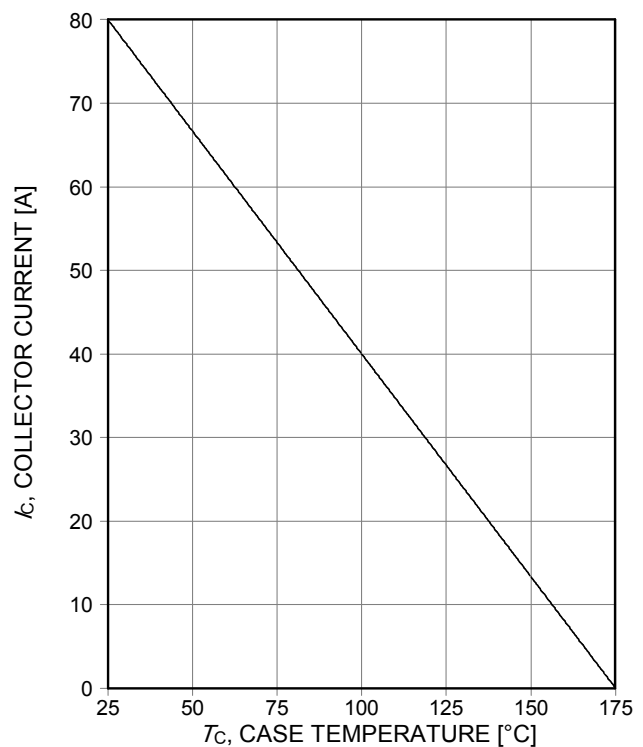
**Figure 1. Collector current as a function of switching frequency**  
( $T_j \leq 175^\circ\text{C}$ ,  $D=0.5$ ,  $V_{CE}=600\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $R_G=7,9\Omega$ )



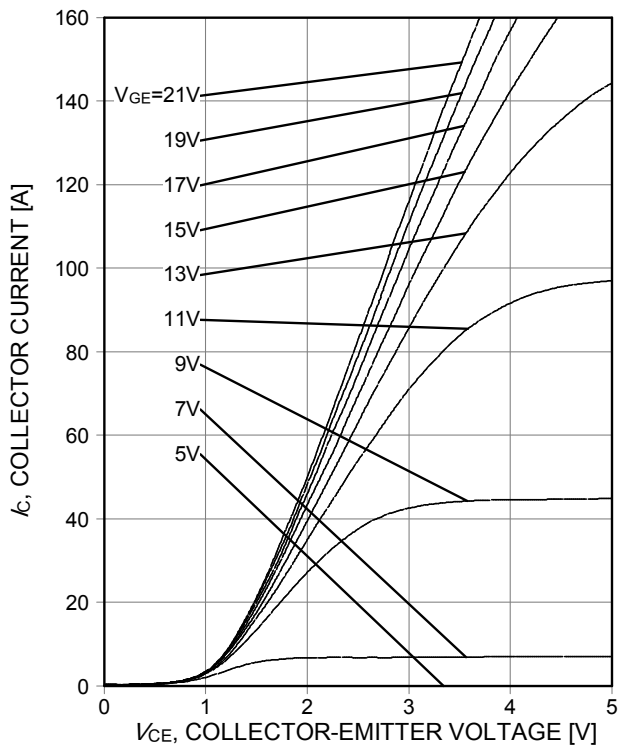
**Figure 2. Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_j \leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )



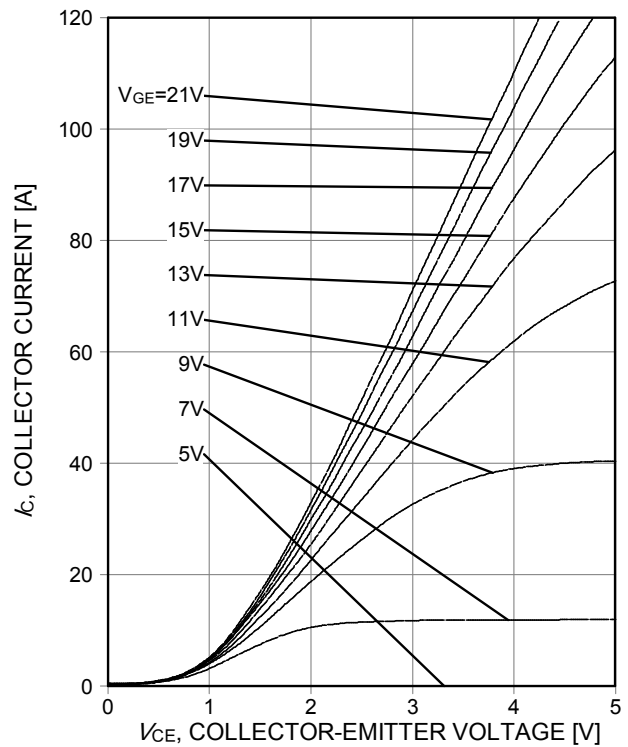
**Figure 3. Power dissipation as a function of case temperature**  
( $T_j \leq 175^\circ\text{C}$ )



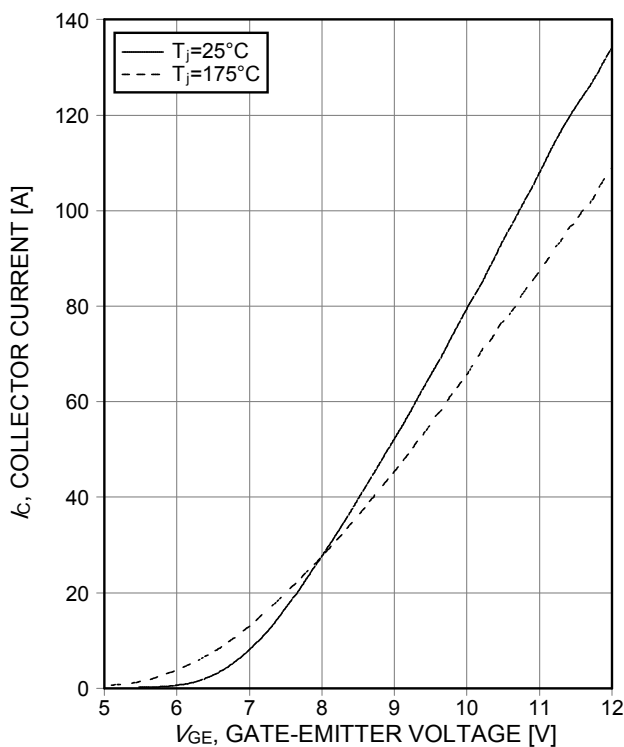
**Figure 4. Collector current as a function of case temperature**  
( $V_{GE} \geq 15\text{V}$ ,  $T_j \leq 175^\circ\text{C}$ )



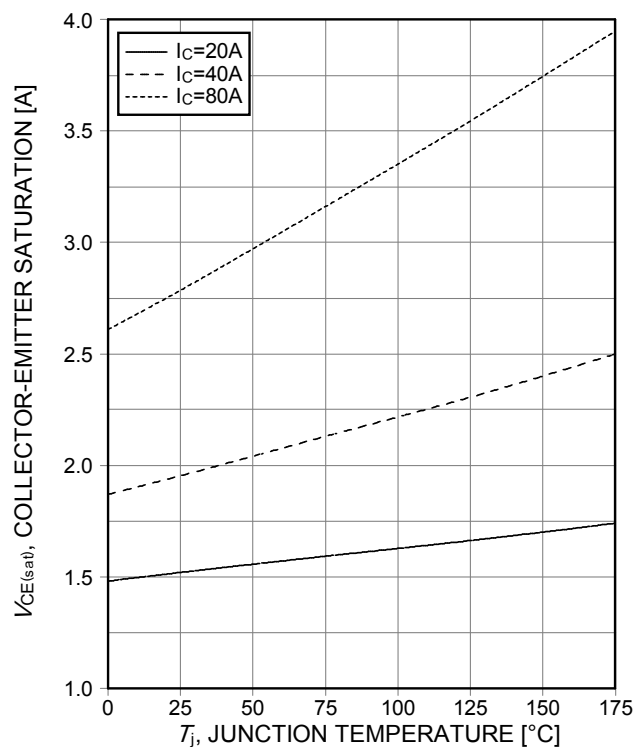
**Figure 5. Typical output characteristic**  
( $T_j = 25^\circ\text{C}$ )



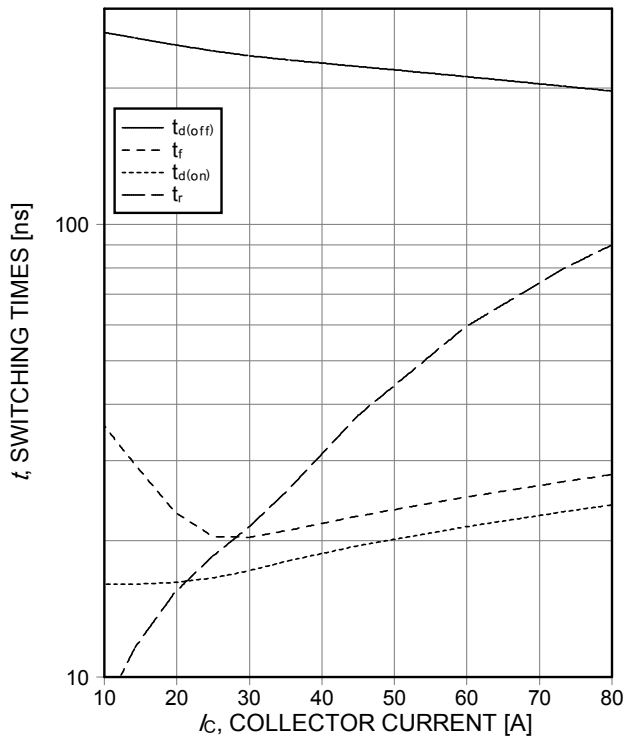
**Figure 6. Typical output characteristic**  
( $T_j = 175^\circ\text{C}$ )



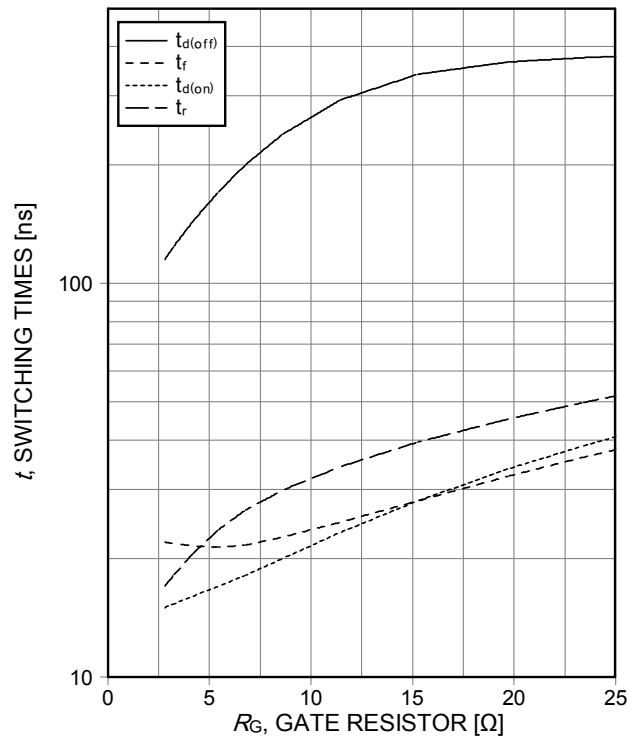
**Figure 7. Typical transfer characteristic**  
( $V_{CE} = 20\text{V}$ )



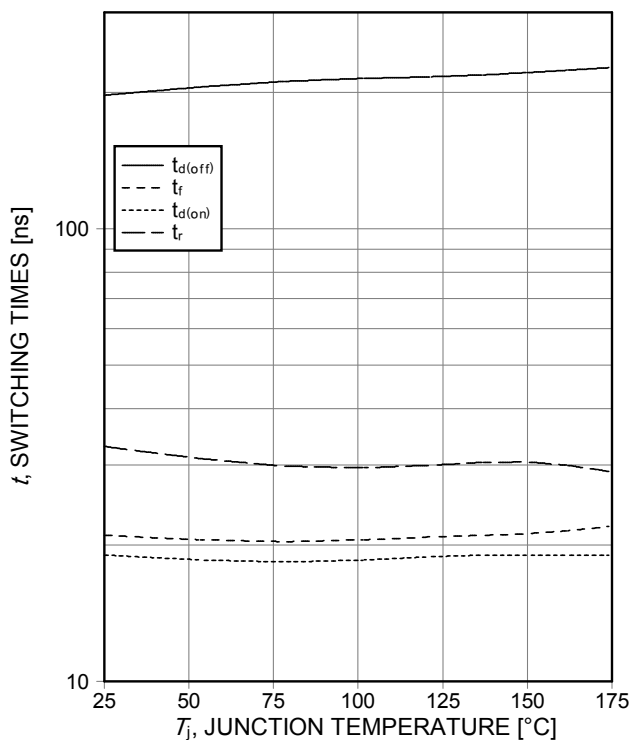
**Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE} = 15\text{V}$ )



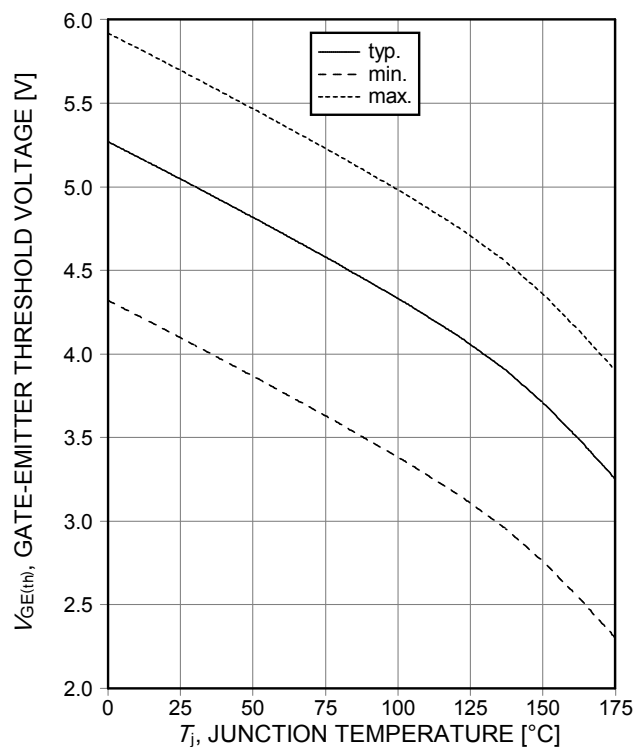
**Figure 9. Typical switching times as a function of collector current**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $R_G=7,9\Omega$ , test circuit in Fig. E)



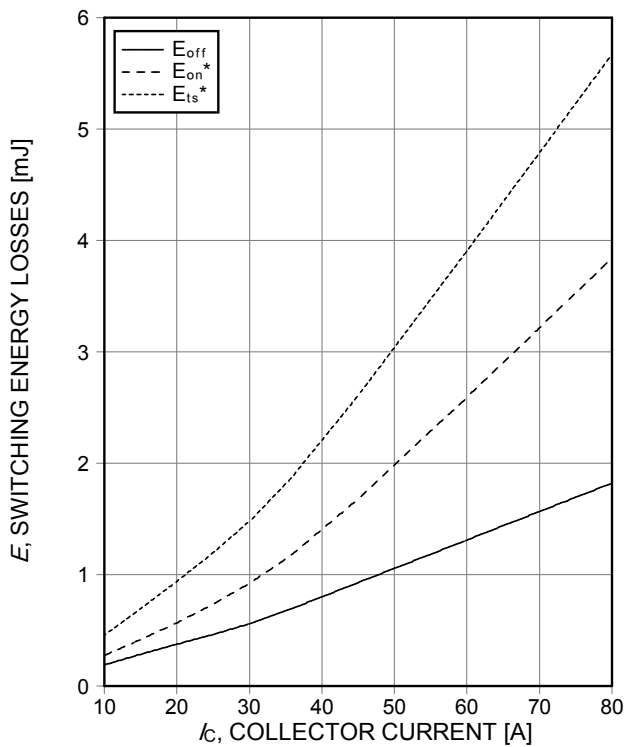
**Figure 10. Typical switching times as a function of gate resistor**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ , test circuit in Fig. E)



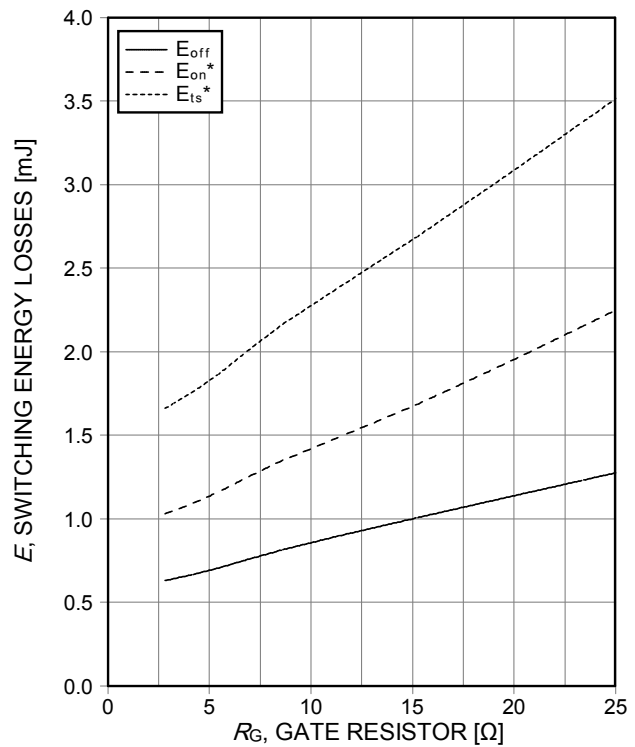
**Figure 11. Typical switching times as a function of junction temperature**  
(ind. load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ ,  $R_G=7,9\Omega$ , test circuit in Fig. E)



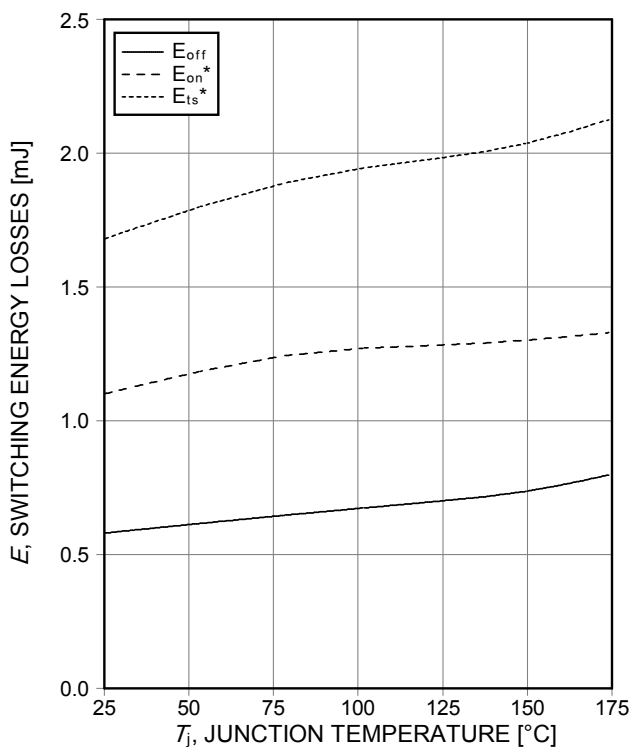
**Figure 12. Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0.58\text{mA}$ )



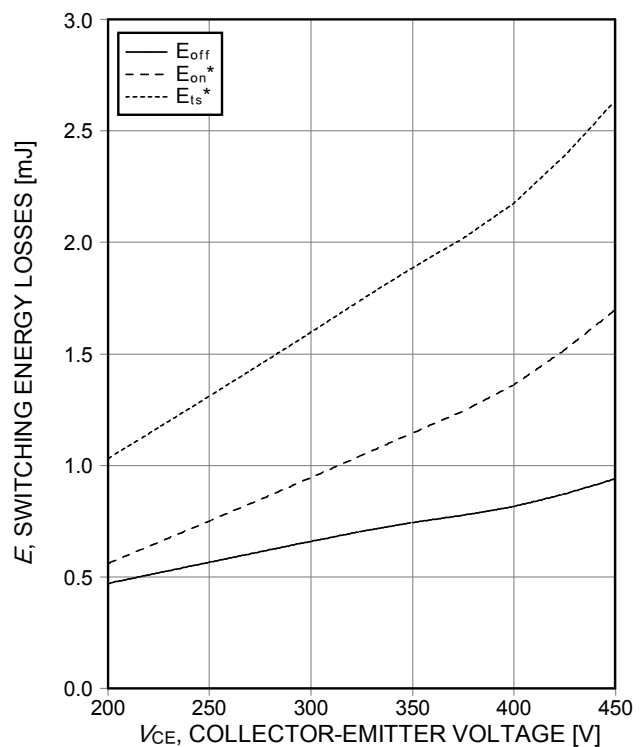
**Figure 13. Typical switching energy losses as a function of collector current**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $R_G=7,9\Omega$ , test circuit in Fig. E)



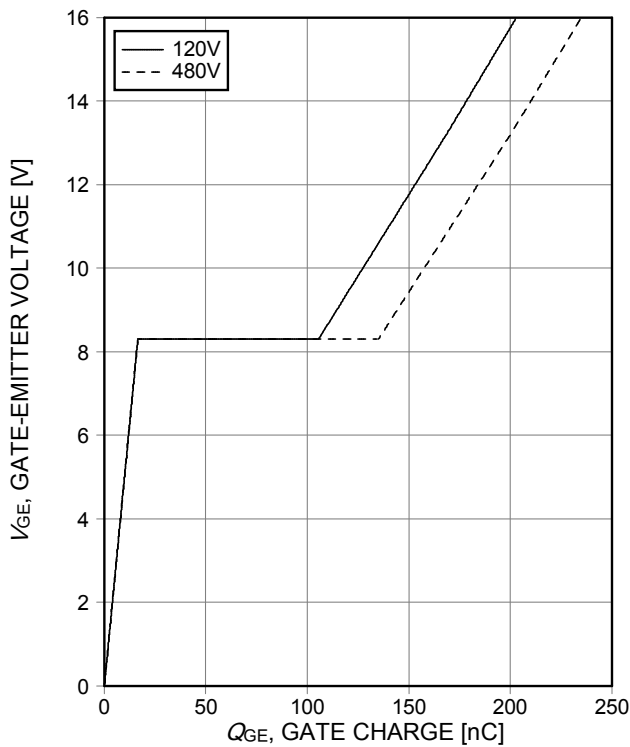
**Figure 14. Typical switching energy losses as a function of gate resistor**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ , test circuit in Fig. E)



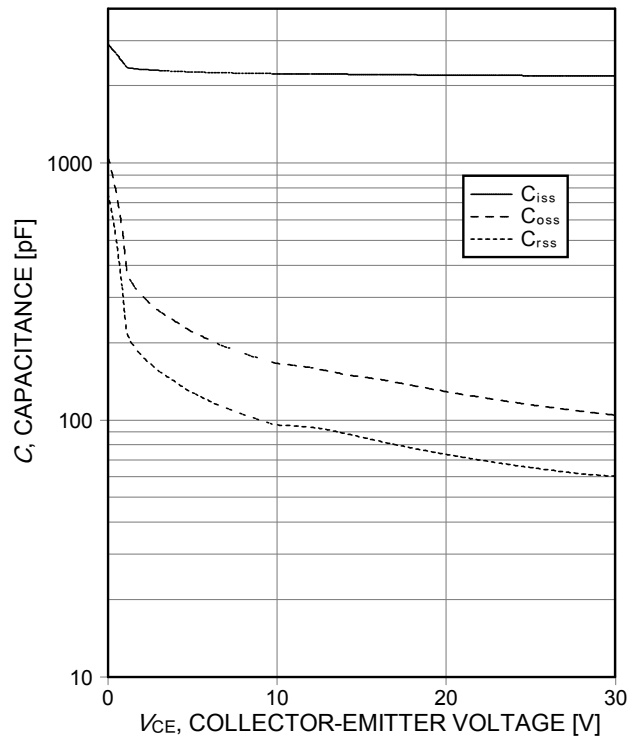
**Figure 15. Typical switching energy losses as a function of junction temperature**  
(ind load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ ,  $R_G=7,9\Omega$ , test circuit in Fig. E)



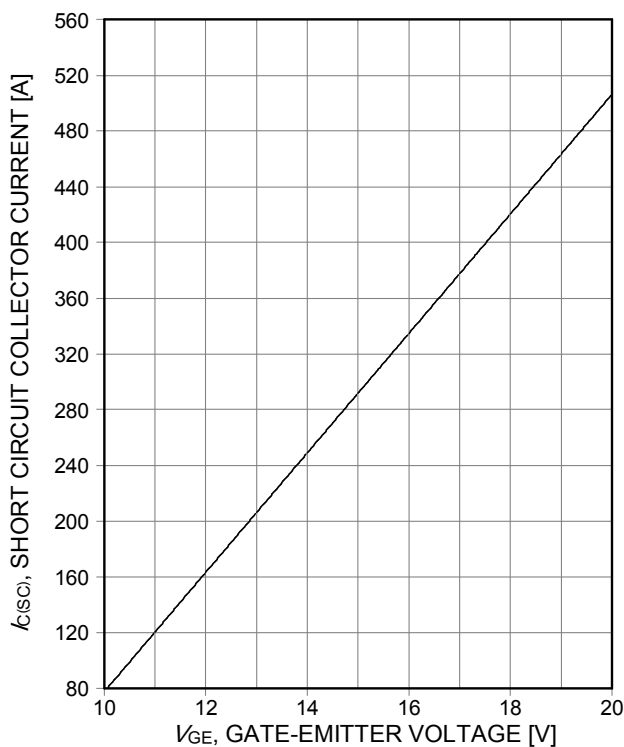
**Figure 16. Typical switching energy losses as a function of collector emitter voltage**  
(ind. load,  $T_j=175^\circ\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ ,  $R_G=7,9\Omega$ , test circuit in Fig. E)



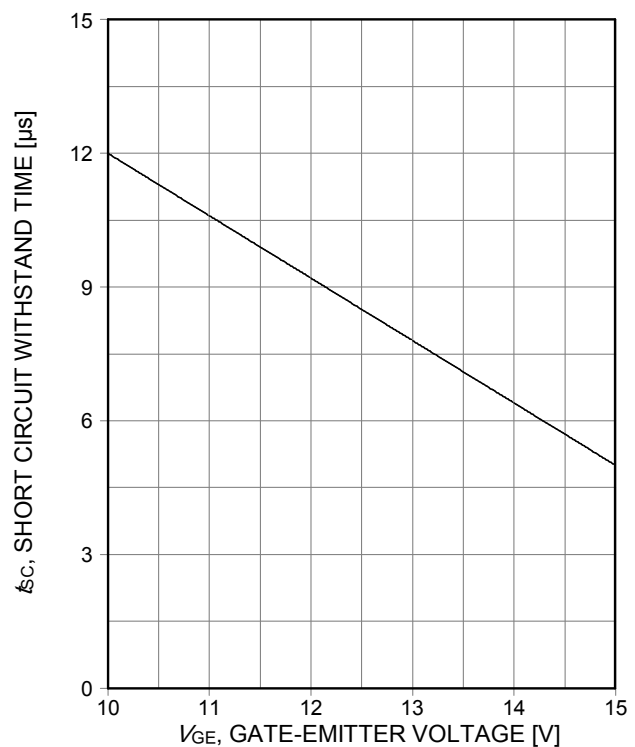
**Figure 17. Typical gate charge**  
( $I_C=40A$ )



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



**Figure 19. Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE} \leq 400V$ , start at  $T_J=25^\circ C$ )



**Figure 20. Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE} \leq 400V$ , start at  $T_J \leq 150^\circ C$ )

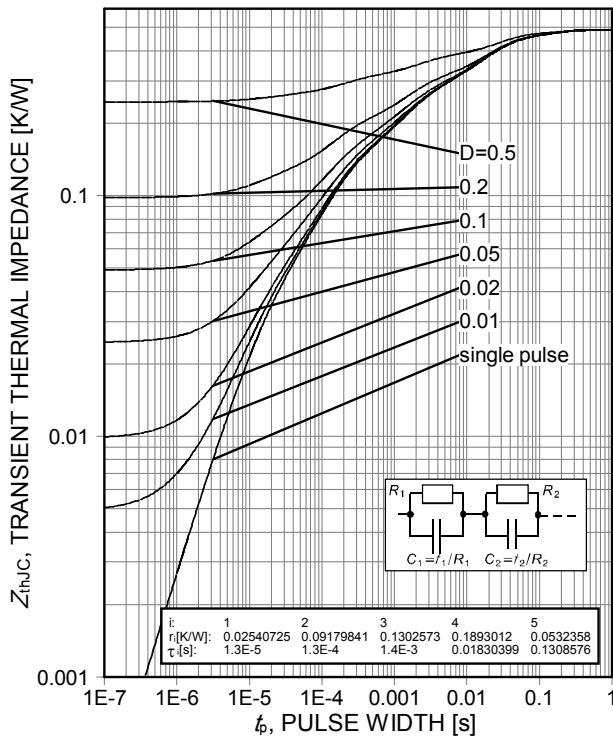


Figure 21. IGBT transient thermal impedance ( $D = t_p/T$ )

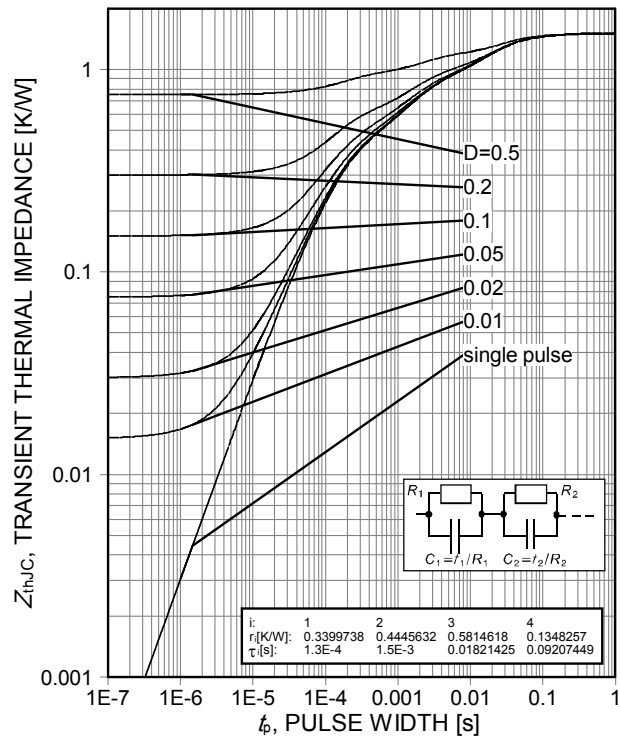


Figure 22. Diode transient thermal impedance as a function of pulse width ( $D = t_p/T$ )

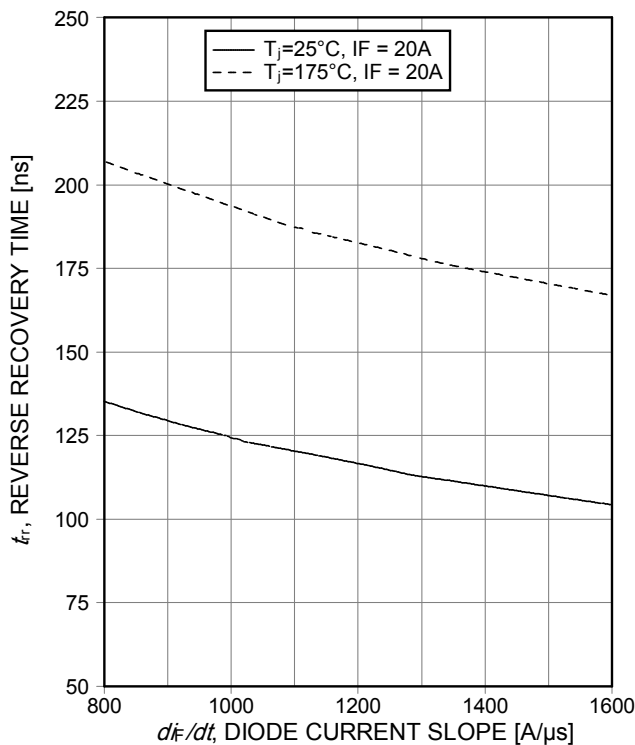


Figure 23. Typical reverse recovery time as a function of diode current slope ( $V_R = 400V$ )

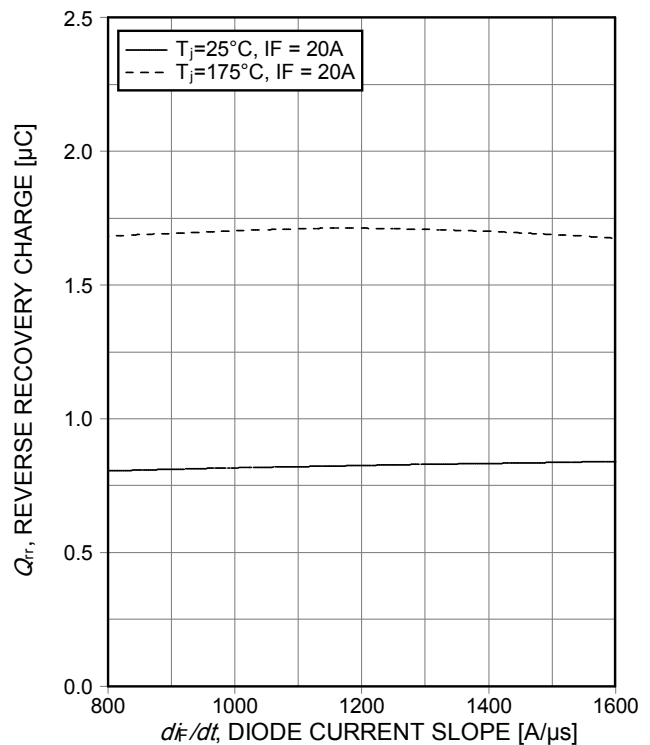
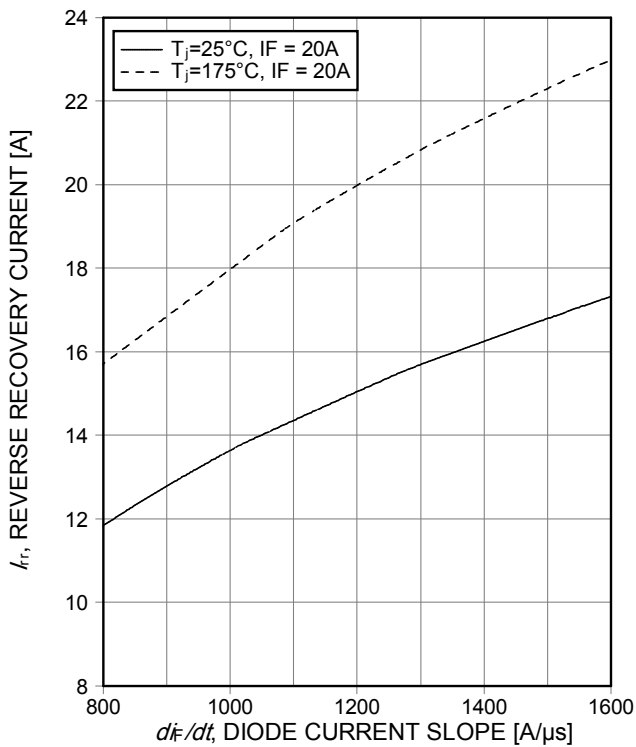
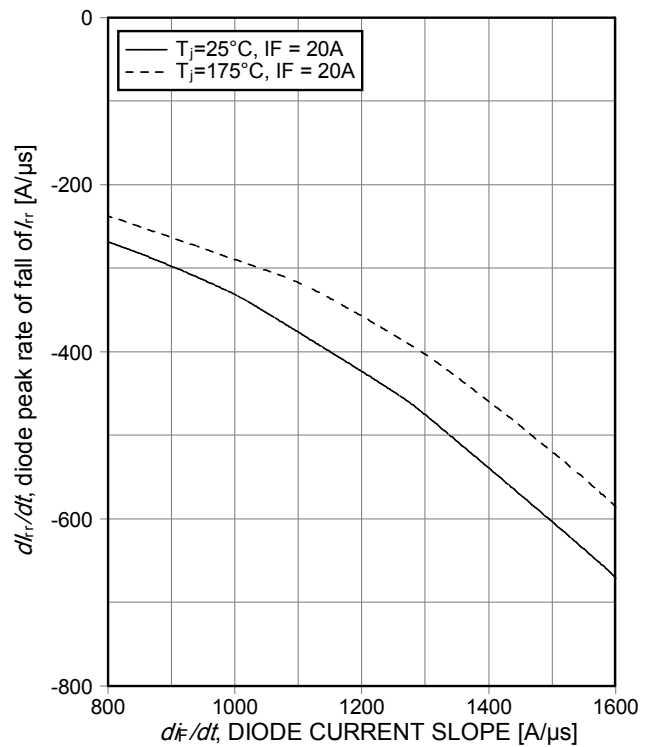


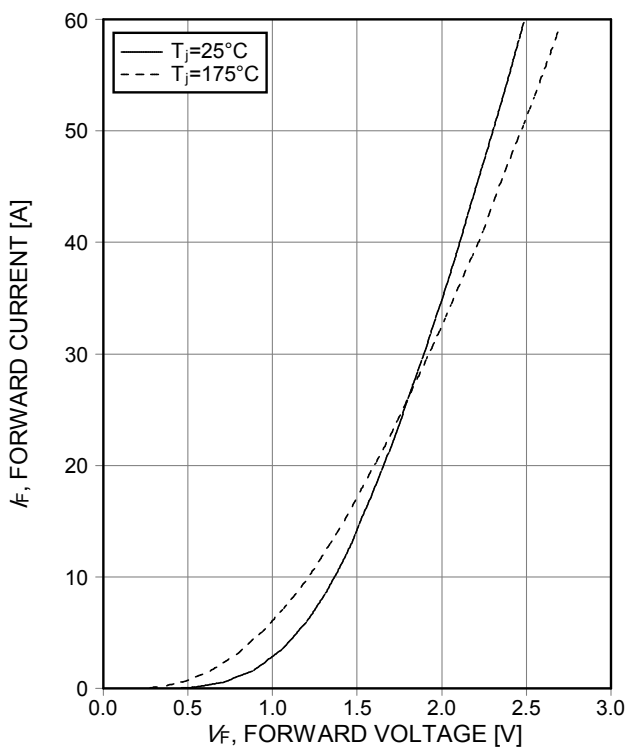
Figure 24. Typical reverse recovery charge as a function of diode current slope ( $V_R = 400V$ )



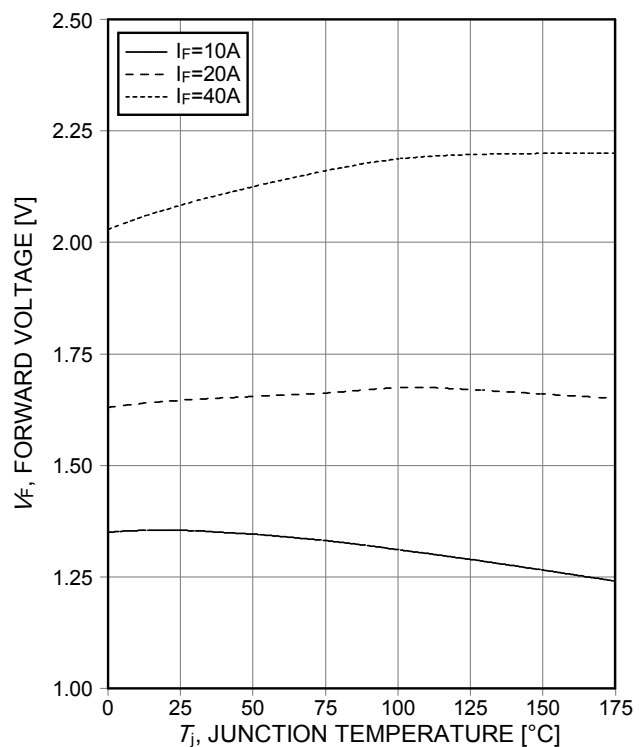
**Figure 25. Typical reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )



**Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

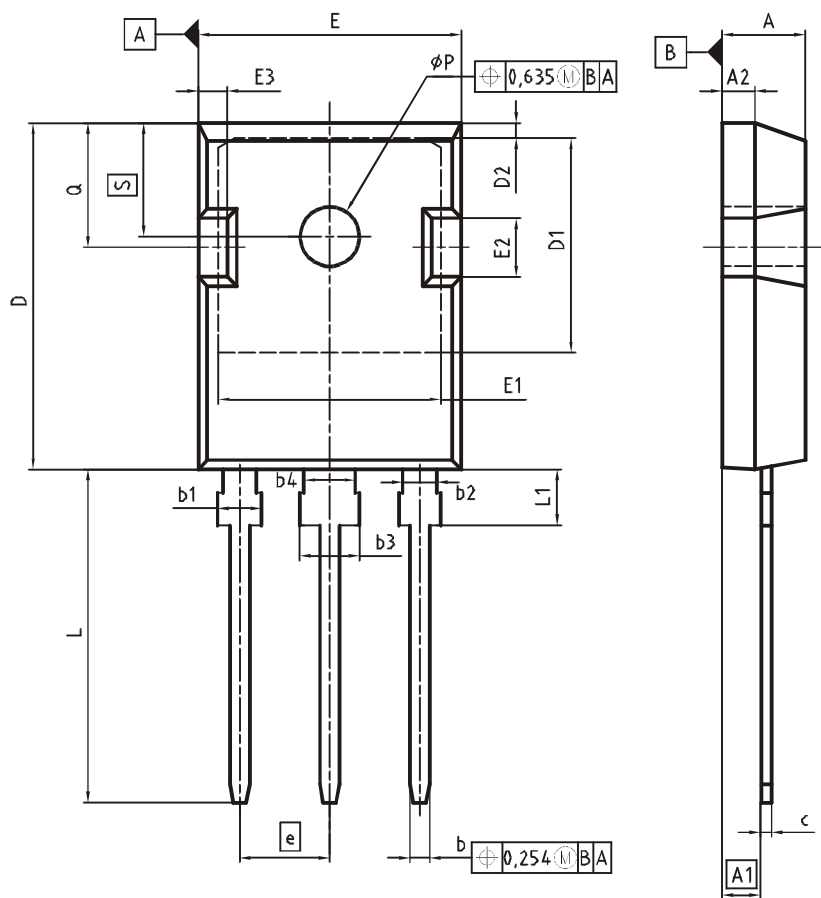


**Figure 27. Typical diode forward current as a function of forward voltage**

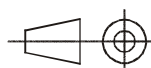


**Figure 28. Typical diode forward voltage as a function of junction temperature**

## 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        |       | 0.214  |       |
| N     | 3           |       | 3      |       |
| L     | 19.80       | 20.32 | 0.780  | 0.800 |
| L1    | 4.10        | 4.47  | 0.161  | 0.176 |
| phi P | 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>01-10-2009                                                                                     |
| REVISION<br>04                                                                                               |

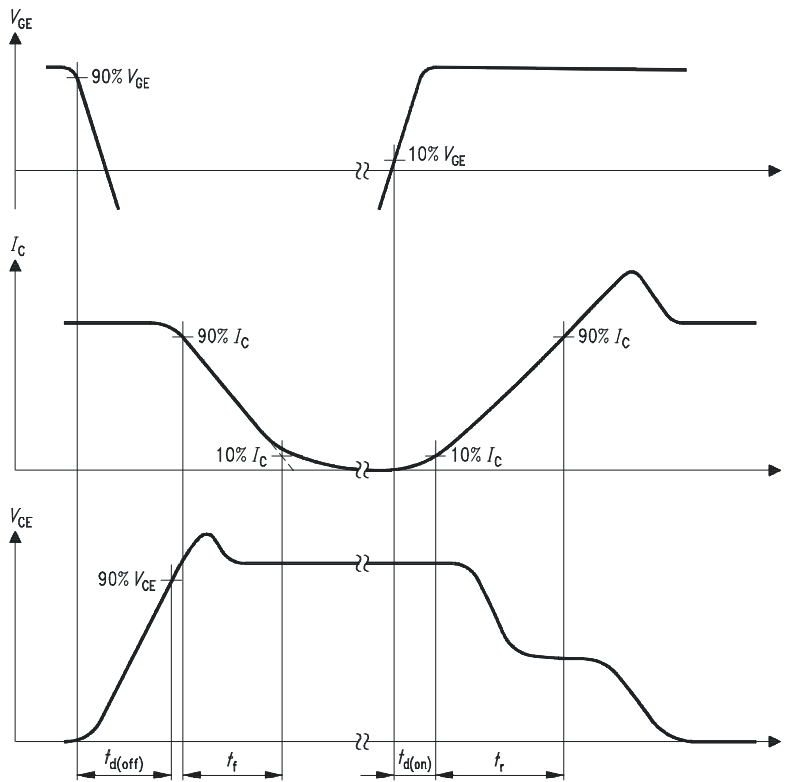


Figure A. Definition of switching times

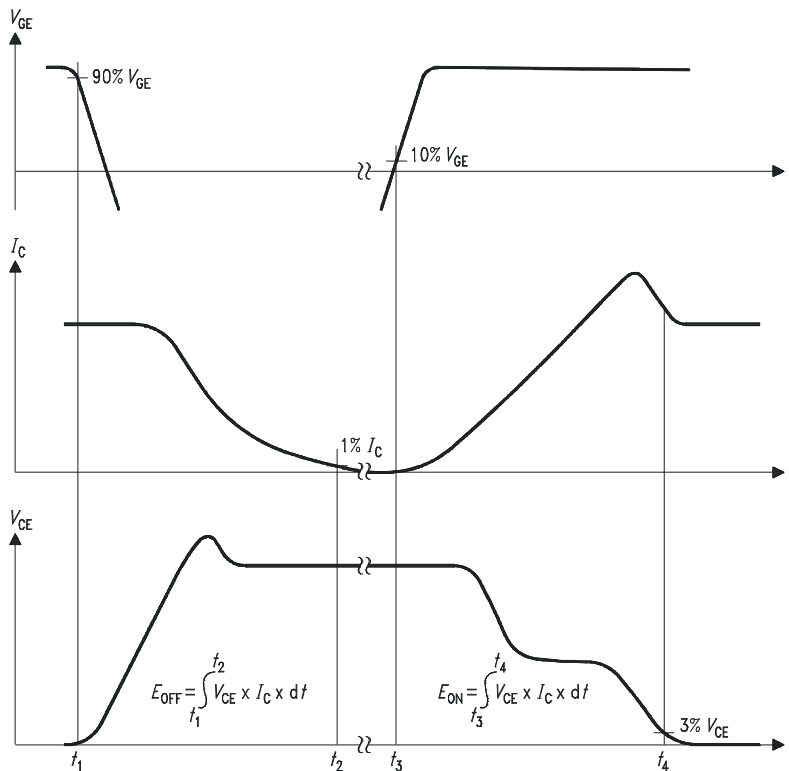


Figure B. Definition of switching losses

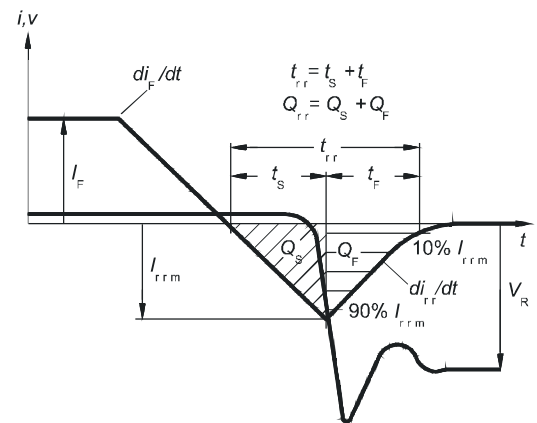


Figure C. Definition of diodes switching characteristics

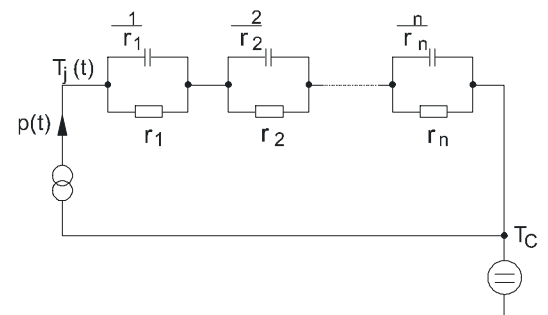


Figure D. Thermal equivalent circuit

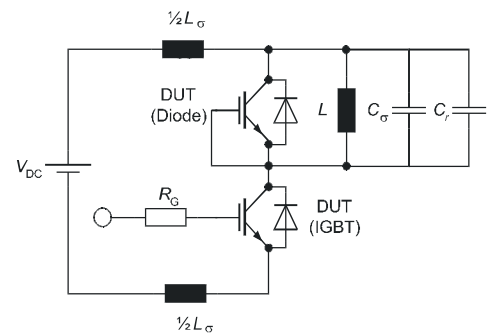


Figure E. Dynamic test circuit

Parasitic inductance  $L_\sigma$ ,  
Parasitic capacitor  $C_\sigma$ ,  
Relief capacitor  $C_r$   
(only for ZVT switching)

**Revision History**

IKW40N60H3

**Revision: 2010-06-14, Rev. 2.1**

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------|----------------------------------------------|
| 2.1      | -    | Release of final datasheet                   |

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