

## Reverse Conduction Series

Reverse conducting IGBT with monolithic body diode

**IKW40N65WR5**

Data sheet

Industrial Power Control

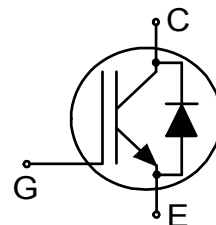
## Reverse conducting IGBT with monolithic body diode

### Features:

- Powerful monolithic diode optimized for ZCS applications
- TRENCHSTOP™ 5 technology applications offers:
  - high ruggedness, temperature stable behavior
  - very low  $V_{CEsat}$  and low  $E_{off}$
  - easy parallel switching capability due to positive temperature coefficient in  $V_{CEsat}$
- Low EMI
- Low electrical parameters depending (dependence) on temperature
- Qualified according to JESD-022 for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>

### Applications:

- Welding
- PFC
- ZCS - converters



### Key Performance and Package Parameters

| Type        | $V_{CE}$ | $I_C$ | $V_{CEsat}$ , $T_{vj}=25^{\circ}C$ | $T_{vjmax}$ | Marking | Package    |
|-------------|----------|-------|------------------------------------|-------------|---------|------------|
| IKW40N65WR5 | 650V     | 40A   | 1.4V                               | 175°C       | K40EWR5 | PG-TO247-3 |

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## Maximum Ratings

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

| Parameter                                                                                                                            | Symbol      | Value            | Unit               |
|--------------------------------------------------------------------------------------------------------------------------------------|-------------|------------------|--------------------|
| Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$                                                                          | $V_{CE}$    | 650              | V                  |
| DC collector current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}\text{C}$ value limited by bondwire<br>$T_C = 130^{\circ}\text{C}$  | $I_C$       | 80.0<br>40.0     | A                  |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$                                                                               | $I_{Cpuls}$ | 120.0            | A                  |
| Turn off safe operating area<br>$V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$                 | -           | 120.0            | A                  |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}\text{C}$ value limited by bondwire<br>$T_C = 100^{\circ}\text{C}$ | $I_F$       | 32.0<br>19.0     | A                  |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$                                                                                   | $I_{Fpuls}$ | 120.0            | A                  |
| Gate-emitter voltage                                                                                                                 | $V_{GE}$    | $\pm 20$         | V                  |
| Power dissipation $T_C = 25^{\circ}\text{C}$<br>Power dissipation $T_C = 130^{\circ}\text{C}$                                        | $P_{tot}$   | 230.0<br>115.0   | W                  |
| Operating junction temperature                                                                                                       | $T_{vj}$    | $-40 \dots +175$ | $^{\circ}\text{C}$ |
| Storage temperature                                                                                                                  | $T_{stg}$   | $-55 \dots +150$ | $^{\circ}\text{C}$ |
| Soldering temperature,<br>wave soldering 1.6mm (0.063in.) from case for 10s                                                          |             | 260              | $^{\circ}\text{C}$ |
| 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  | $R_{th(j-c)}$ |            | 0.65       | K/W  |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ |            | 2.85       | 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  | $V_{(BR)CES}$ | $V_{GE} = 0V, I_C = 0.20mA$                                                        | 650    | -            | -         | V        |
| Collector-emitter saturation voltage | $V_{CEsat}$   | $V_{GE} = 15.0V, I_C = 40.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 175^{\circ}C$ | -<br>- | 1.40<br>1.65 | 1.80<br>- | V        |
| Diode forward voltage                | $V_F$         | $V_{GE} = 0V, I_F = 20.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 175^{\circ}C$    | -<br>- | 1.40<br>1.50 | 1.90<br>- | V        |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.40mA, V_{CE} = V_{GE}$                                                    | 3.2    | 4.0          | 4.8       | V        |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE} = 650V, V_{GE} = 0V$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 175^{\circ}C$  | -<br>- | -<br>-       | 40<br>-   | $\mu A$  |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE} = 0V, V_{GE} = 20V$                                                        | -      | -            | 100       | nA       |
| Transconductance                     | $g_{fs}$      | $V_{CE} = 20V, I_C = 40.0A$                                                        | -      | 55.0         | -         | S        |
| Integrated gate resistor             | $r_G$         |                                                                                    |        | none         |           | $\Omega$ |

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

| Parameter                                                            | Symbol    | Conditions                                 | Value |       |      | Unit |
|----------------------------------------------------------------------|-----------|--------------------------------------------|-------|-------|------|------|
|                                                                      |           |                                            | min.  | typ.  | max. |      |
| Dynamic Characteristic                                               |           |                                            |       |       |      |      |
| Input capacitance                                                    | $C_{ies}$ | $V_{CE} = 25V, V_{GE} = 0V, f = 1MHz$      | -     | 4755  | -    | pF   |
| Output capacitance                                                   | $C_{oes}$ |                                            | -     | 45    | -    |      |
| Reverse transfer capacitance                                         | $C_{res}$ |                                            | -     | 20    | -    |      |
| Gate charge                                                          | $Q_G$     | $V_{CC} = 520V, I_C = 40.0A, V_{GE} = 15V$ | -     | 193.0 | -    | nC   |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from<br>case | $L_E$     |                                            | -     | 13.0  | -    | nH   |

**Switching Characteristic, Inductive Load**

| Parameter                                             | Symbol              | Conditions                                                                                                                                                                                                                                                                                                                                       | Value |      |      | Unit |
|-------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                                                       |                     |                                                                                                                                                                                                                                                                                                                                                  | min.  | typ. | max. |      |
| IGBT Characteristic, at $T_{vj} = 25^{\circ}\text{C}$ |                     |                                                                                                                                                                                                                                                                                                                                                  |       |      |      |      |
| Turn-on delay time                                    | $t_{d(\text{on})}$  | $T_{vj} = 25^{\circ}\text{C},$<br>$V_{CC} = 400\text{V}, I_C = 20.0\text{A},$<br>$V_{GE} = 0.0/15.0\text{V},$<br>$R_{G(\text{on})} = 20.0\Omega, R_{G(\text{off})} = 20.0\Omega,$<br>$L_{\sigma} = 70\text{nH}, C_{\sigma} = 30\text{pF}$<br>$L_{\sigma}, C_{\sigma}$ from Fig. E<br>Energy losses include “tail” and<br>diode reverse recovery. | -     | 42   | -    | ns   |
| Rise time                                             | $t_r$               |                                                                                                                                                                                                                                                                                                                                                  | -     | 18   | -    | ns   |
| Turn-off delay time                                   | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                                                                  | -     | 432  | -    | ns   |
| Fall time                                             | $t_f$               |                                                                                                                                                                                                                                                                                                                                                  | -     | 16   | -    | ns   |
| Turn-on energy                                        | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                                                                  | -     | 0.77 | -    | mJ   |
| Turn-off energy                                       | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                                                                  | -     | 0.16 | -    | mJ   |
| Total switching energy                                | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                                                                  | -     | 0.93 | -    | mJ   |

**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>$di_F/dt = 900\text{A}/\mu\text{s}$ | - | 112  | - | ns               |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                        | - | 1.65 | - | $\mu\text{C}$    |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                        | - | 27.0 | - | A                |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                        | - | -585 | - | A/ $\mu\text{s}$ |

**Switching Characteristic, Inductive Load**

| Parameter | Symbol | Conditions | Value |      |      | Unit |
|-----------|--------|------------|-------|------|------|------|
|           |        |            | min.  | typ. | max. |      |

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

|                        |              |                                                                                                                                                                                                                                                                                                                      |   |      |   |    |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| 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>$R_{G(on)} = 20.0\Omega, R_{G(off)} = 20.0\Omega,$<br>$L\sigma = 70\text{nH}, C\sigma = 30\text{pF}$<br>$L\sigma, C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 42   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                      | - | 21   | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                      | - | 500  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                      | - | 10   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                      | - | 0.82 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                      | - | 0.24 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                      | - | 1.06 | - | mJ |

**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>$di_F/dt = 900\text{A}/\mu\text{s}$ | - | 153   | - | ns               |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                         | - | 2.80  | - | $\mu\text{C}$    |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                         | - | 32.0  | - | A                |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                         | - | -1030 | - | A/ $\mu\text{s}$ |

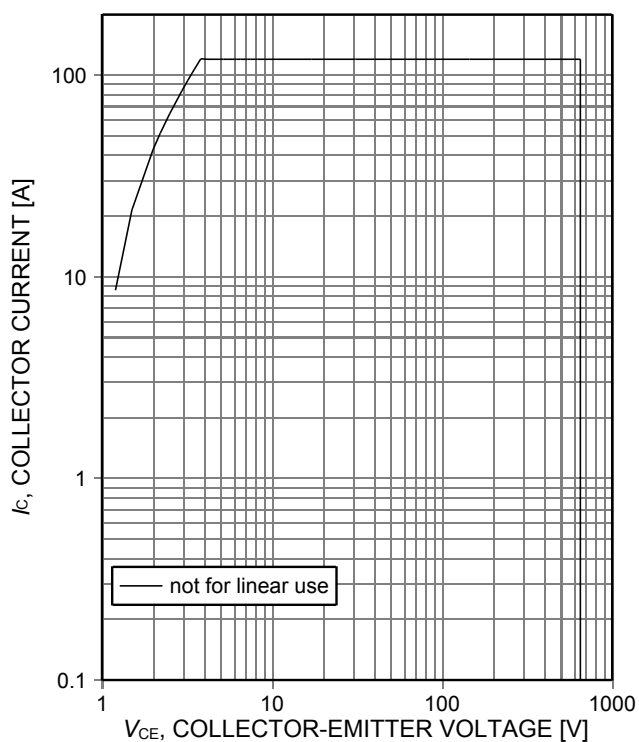


Figure 1. **Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )

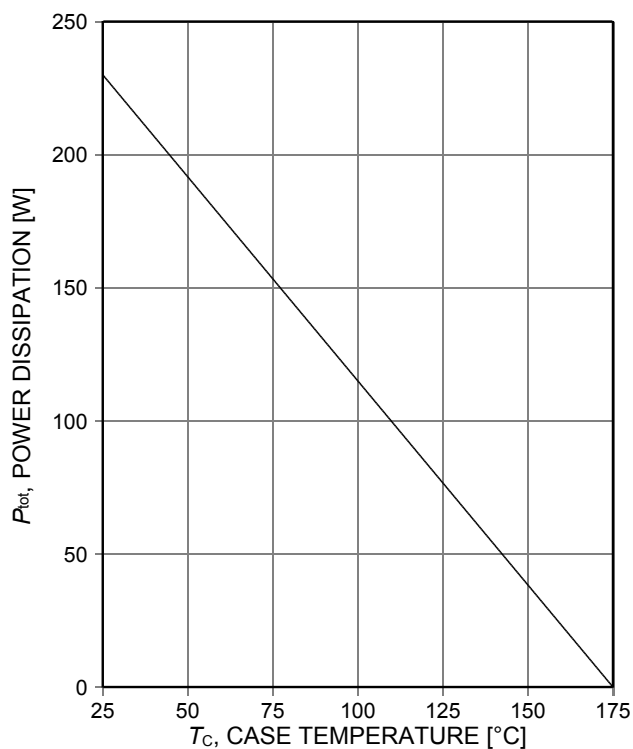


Figure 2. **Power dissipation as a function of case temperature**  
( $T_{vj}\leq 175^\circ\text{C}$ )

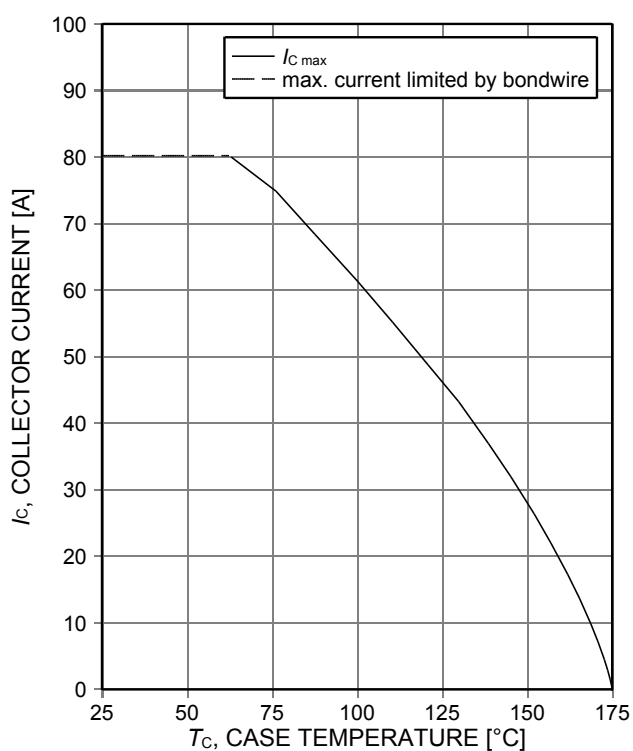


Figure 3. **Collector current as a function of case temperature**  
( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

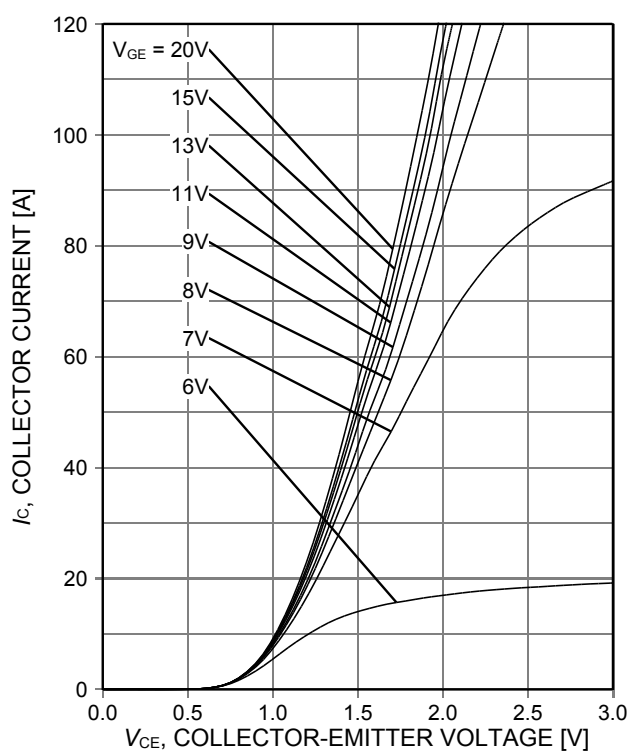


Figure 4. **Typical output characteristic**  
( $T_{vj}=25^\circ\text{C}$ )

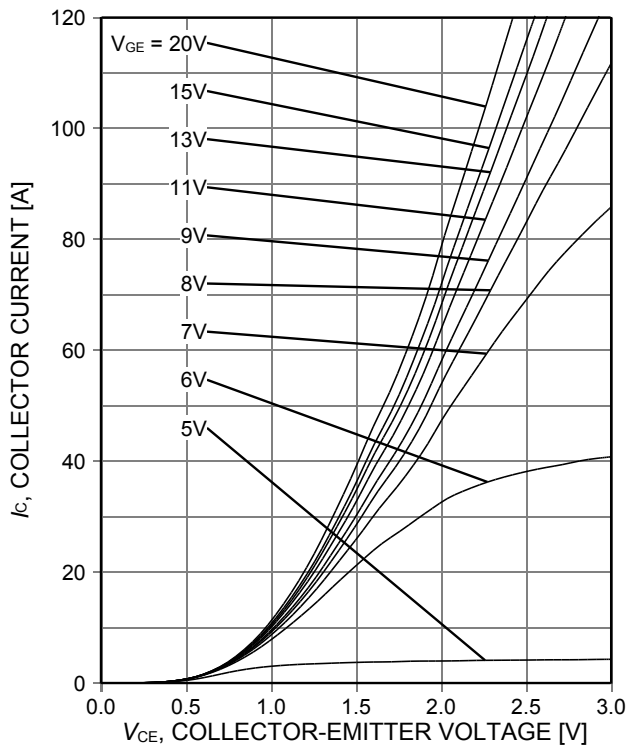


Figure 5. **Typical output characteristic**  
( $T_{vj}=175^{\circ}\text{C}$ )

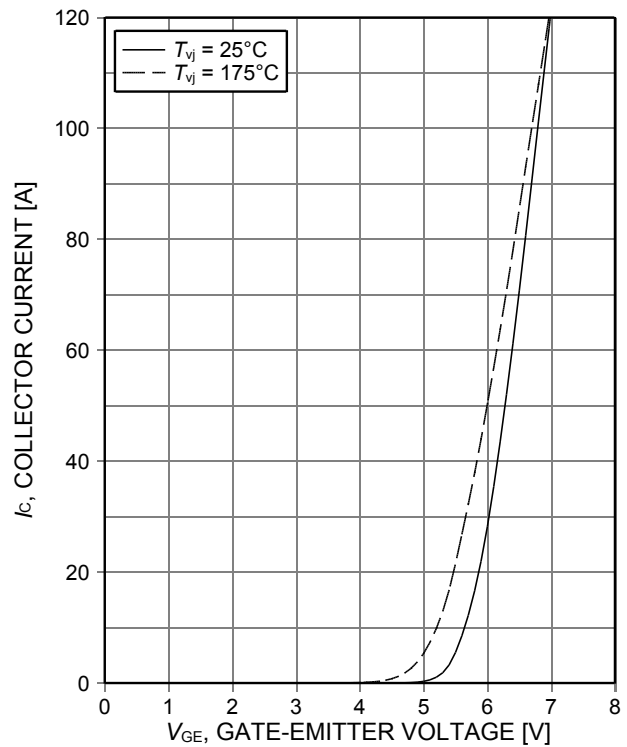


Figure 6. **Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )

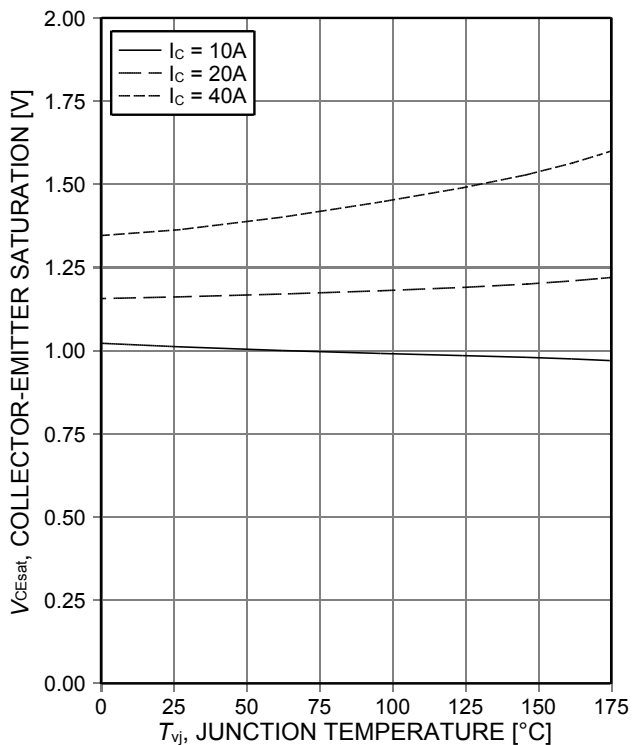


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15\text{V}$ )

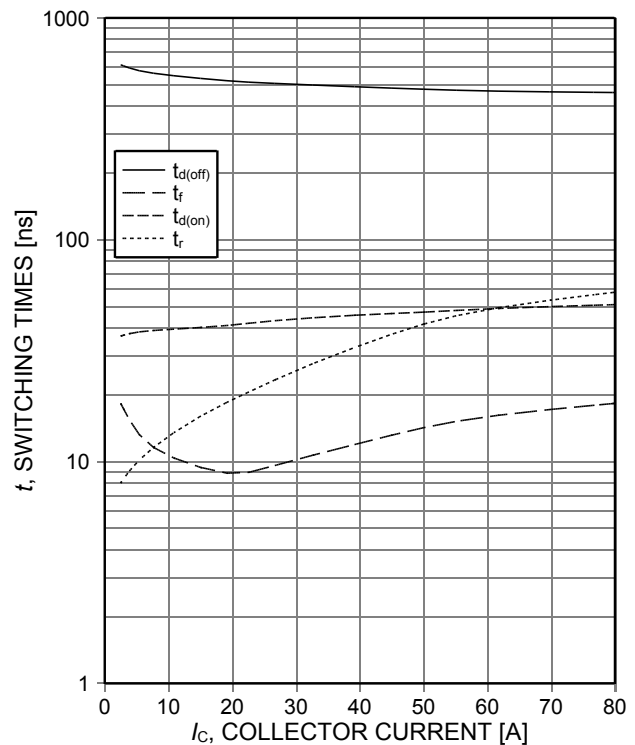


Figure 8. **Typical switching times as a function of collector current**  
(inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

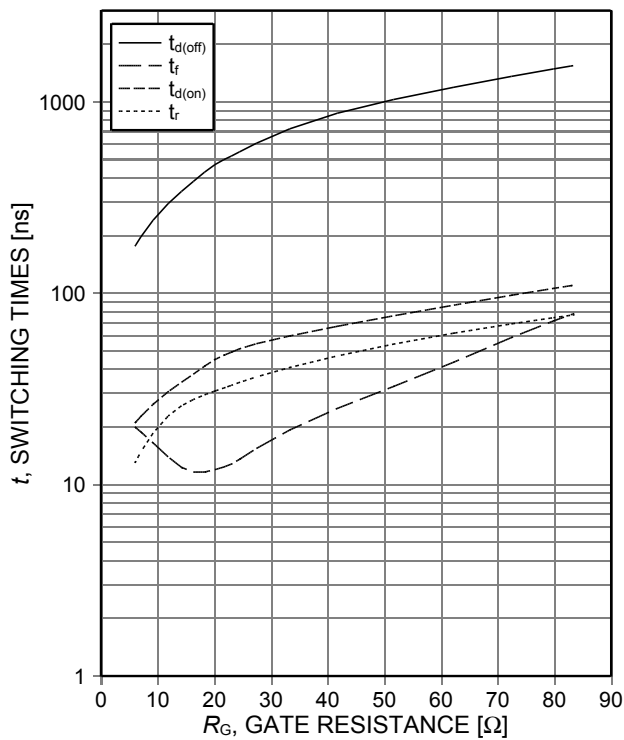


Figure 9. **Typical switching times as a function of gate resistance**  
(inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ , dynamic test circuit in Figure E)

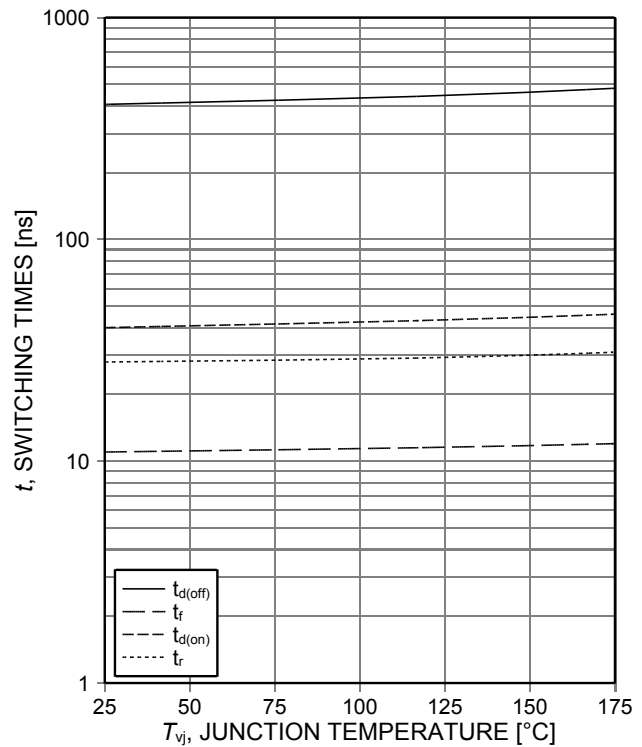


Figure 10. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

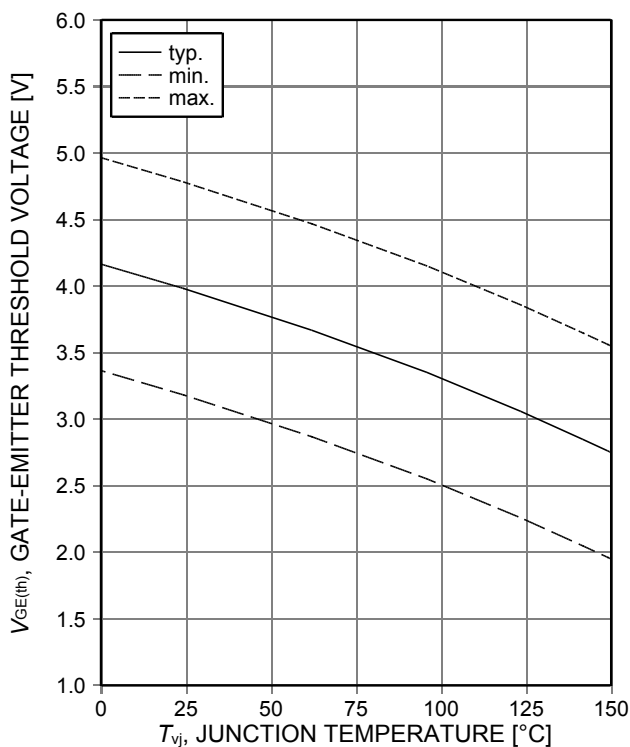


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0,4\text{mA}$ )

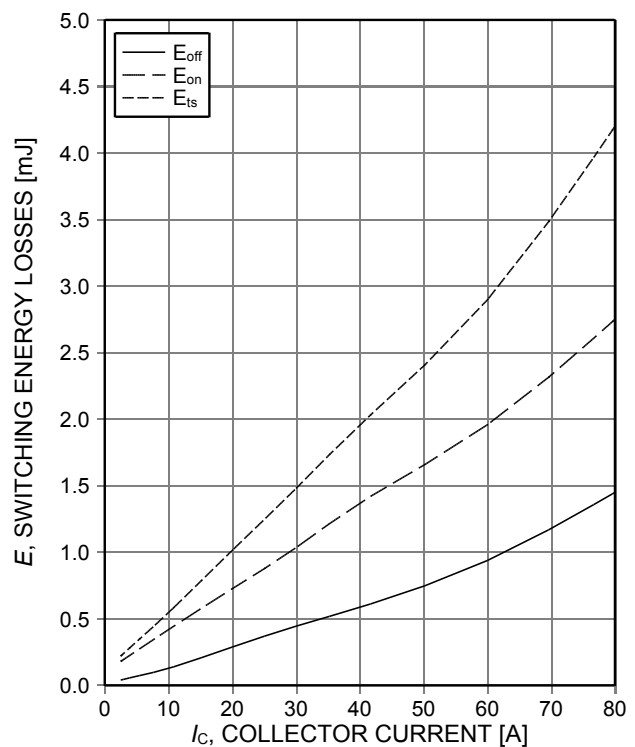


Figure 12. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

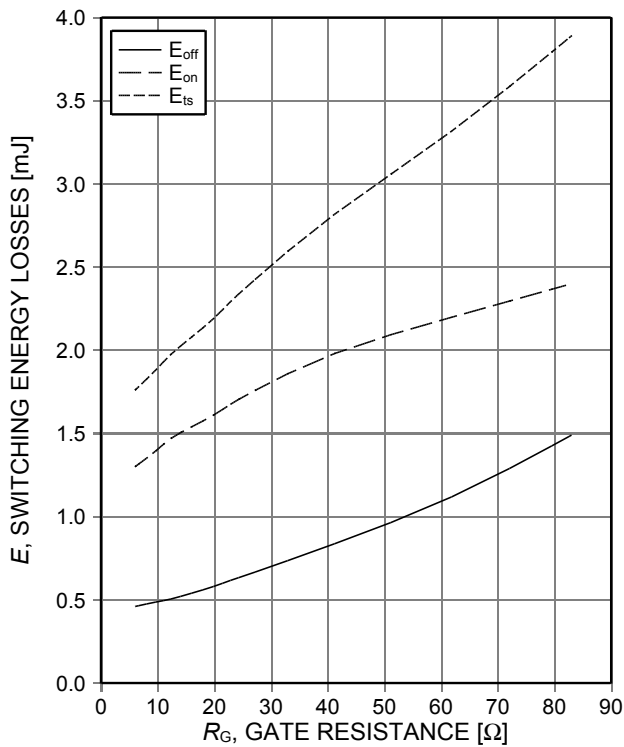


Figure 13. **Typical switching energy losses as a function of gate resistance**  
(inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=150\text{V}$ ,  $I_C=40\text{A}$ , dynamic test circuit in Figure E)

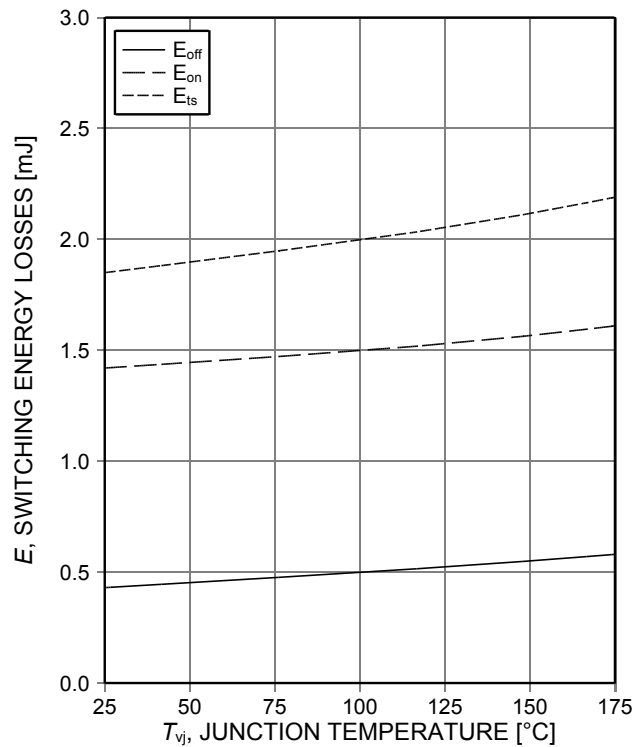


Figure 14. **Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

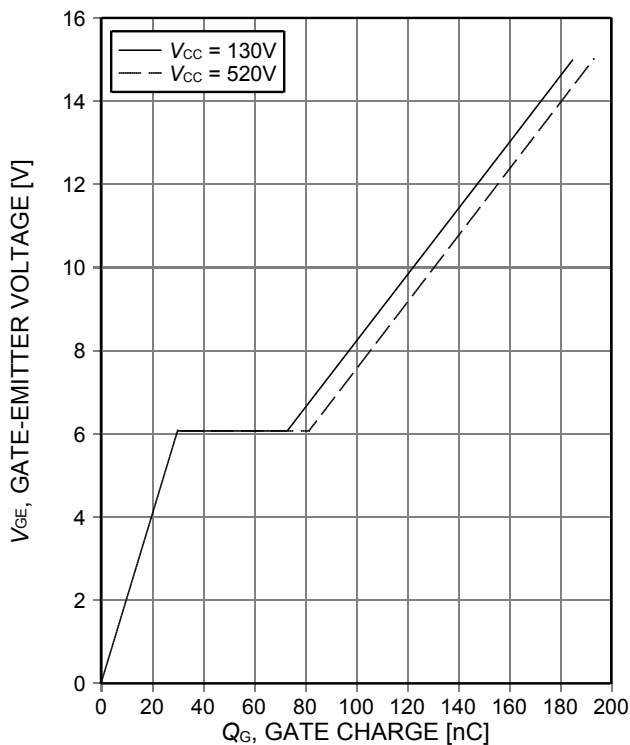


Figure 15. **Typical gate charge**  
( $I_C=40\text{A}$ )

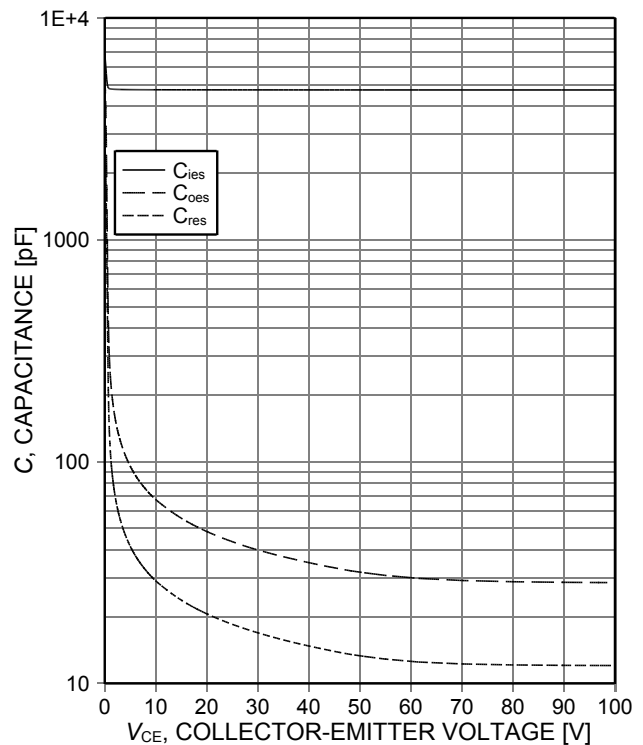


Figure 16. **Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE}=0\text{V}$ ,  $f=1\text{MHz}$ )

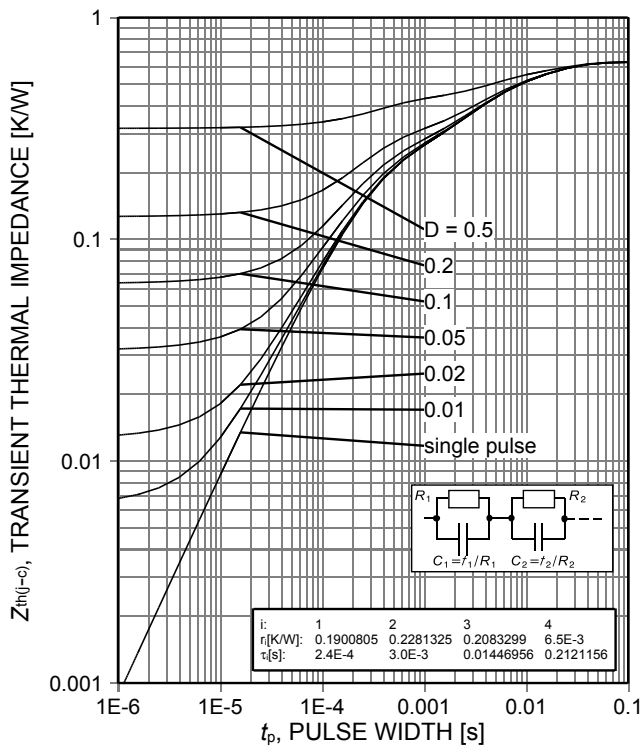


Figure 17. IGBT transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

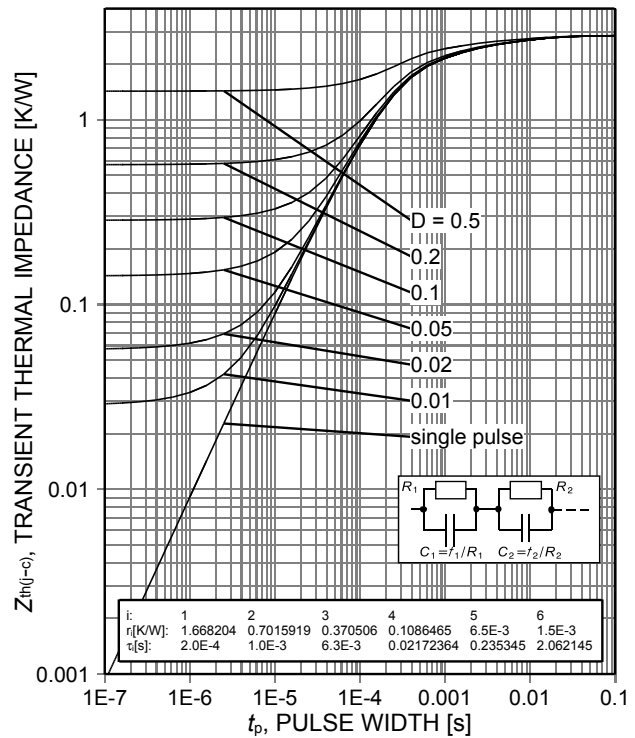


Figure 18. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

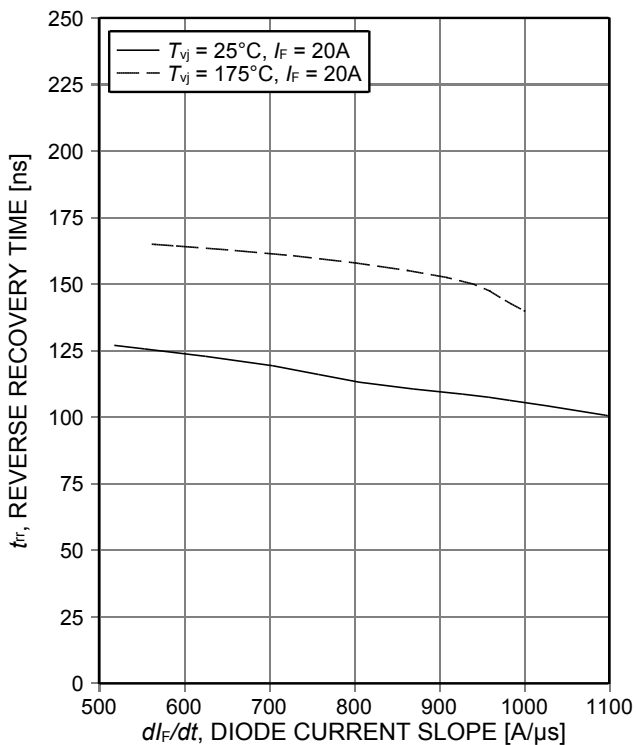


Figure 19. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

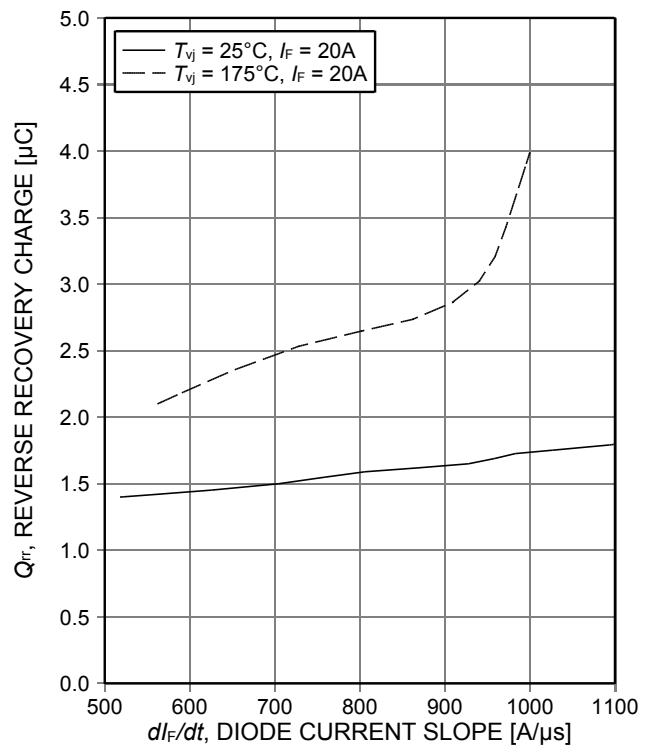


Figure 20. Typical reverse recovery charge as a function of diode current slope ( $V_R=400V$ )

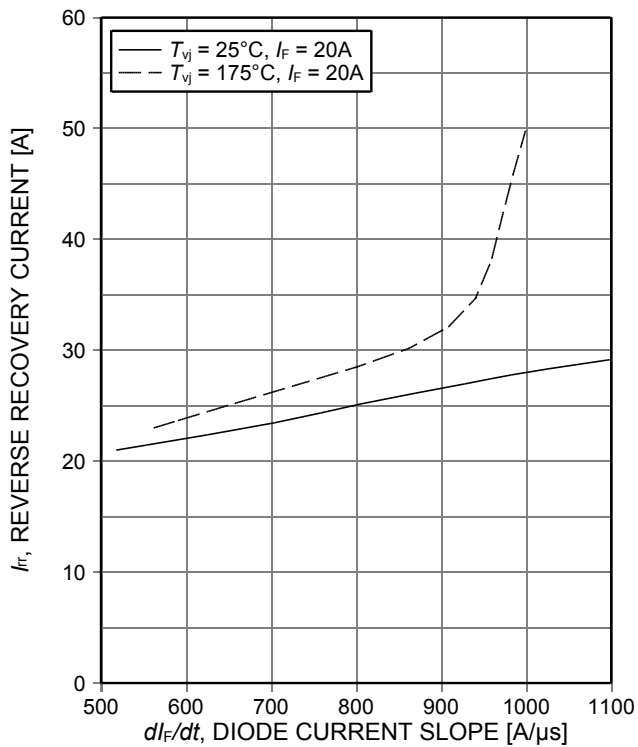


Figure 21. **Typical reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

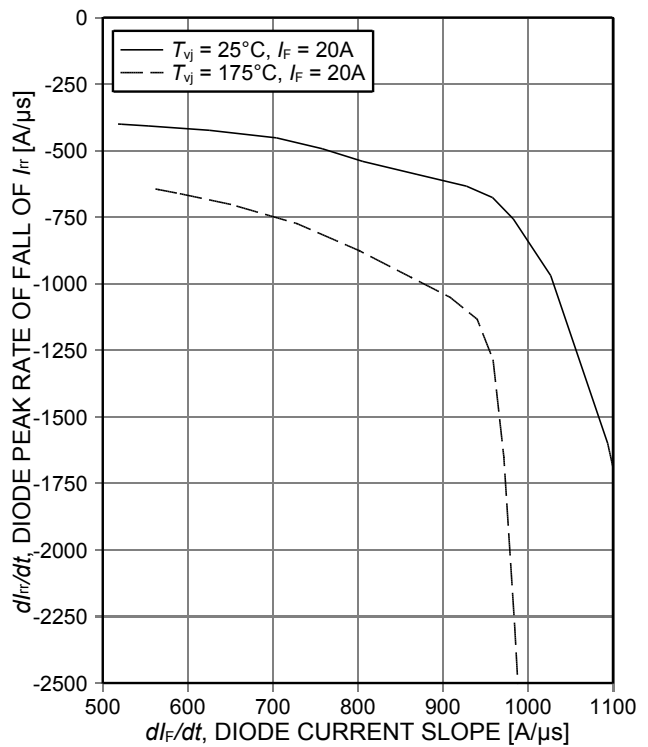


Figure 22. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

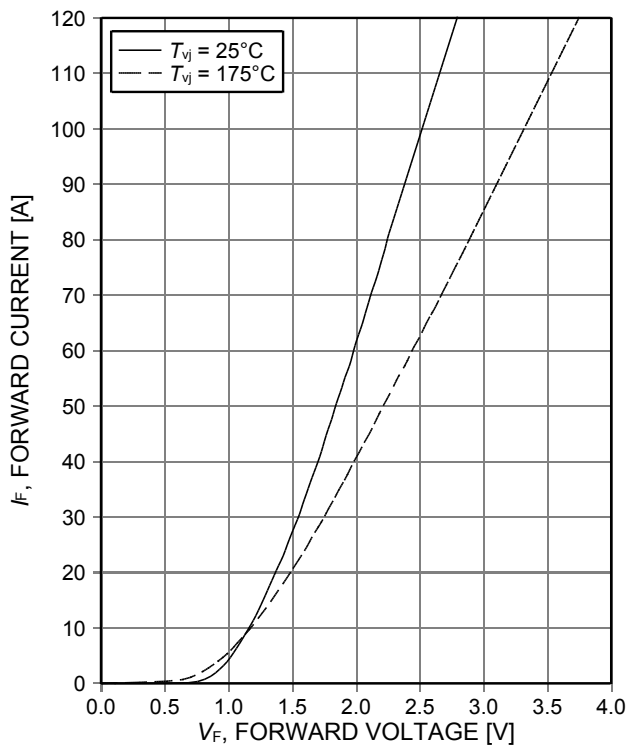


Figure 23. **Typical diode forward current as a function of forward voltage**

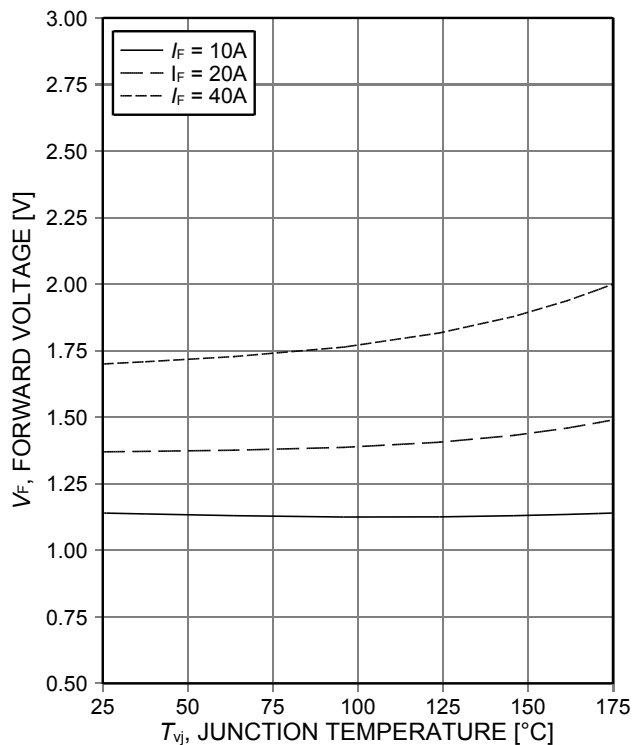
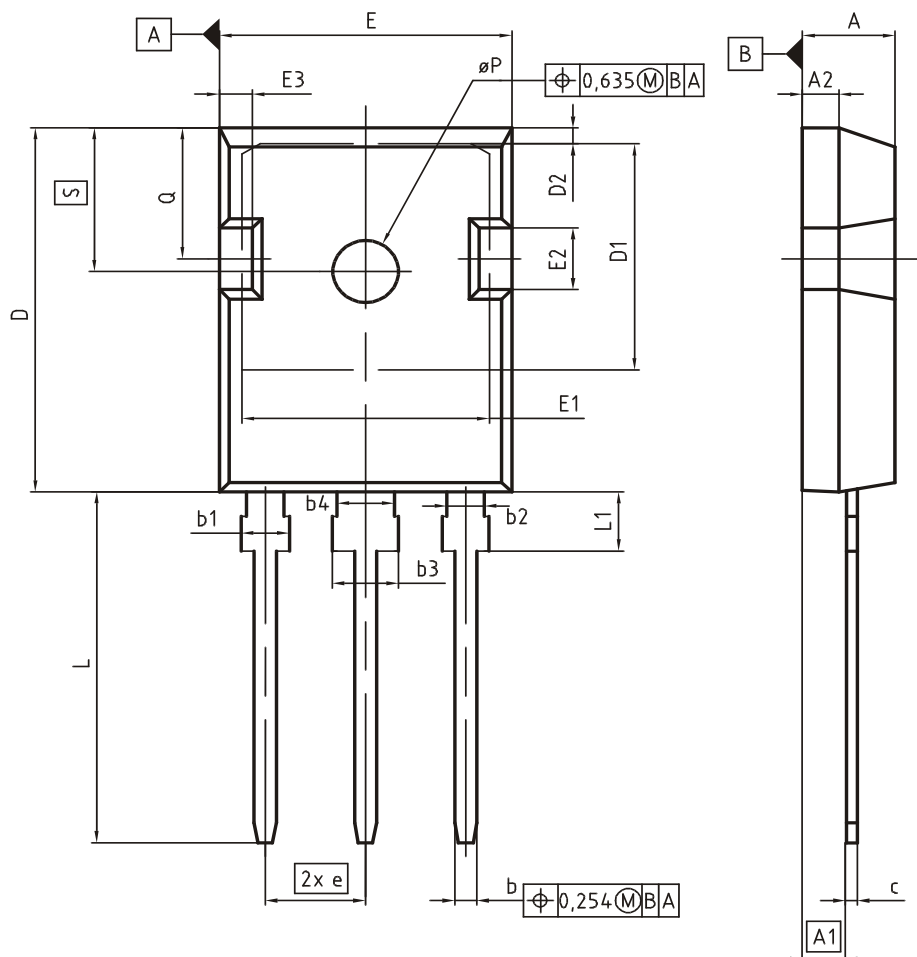
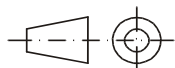


Figure 24. **Typical diode forward voltage as a function of junction temperature**

## Package Drawing PG-TO247-3



| DIM | MILLIMETERS |       | INCHES      |       |
|-----|-------------|-------|-------------|-------|
|     | MIN         | MAX   | MIN         | MAX   |
| A   | 4.83        | 5.21  | 0.190       | 0.205 |
| A1  | 2.27        | 2.54  | 0.089       | 0.100 |
| A2  | 1.85        | 2.16  | 0.073       | 0.085 |
| b   | 1.07        | 1.33  | 0.042       | 0.052 |
| b1  | 1.90        | 2.41  | 0.075       | 0.095 |
| b2  | 1.90        | 2.16  | 0.075       | 0.085 |
| b3  | 2.87        | 3.38  | 0.113       | 0.133 |
| b4  | 2.87        | 3.13  | 0.113       | 0.123 |
| c   | 0.55        | 0.68  | 0.022       | 0.027 |
| D   | 20.80       | 21.10 | 0.819       | 0.831 |
| D1  | 16.25       | 17.65 | 0.640       | 0.695 |
| D2  | 0.95        | 1.35  | 0.037       | 0.053 |
| E   | 15.70       | 16.13 | 0.618       | 0.635 |
| E1  | 13.10       | 14.15 | 0.516       | 0.557 |
| E2  | 3.68        | 5.10  | 0.145       | 0.201 |
| E3  | 1.00        | 2.60  | 0.039       | 0.102 |
| e   | 5.44 (BSC)  |       | 0.214 (BSC) |       |
| N   | 3           |       | 3           |       |
| L   | 19.80       | 20.32 | 0.780       | 0.800 |
| L1  | 4.10        | 4.47  | 0.161       | 0.176 |
| ØP  | 3.50        | 3.70  | 0.138       | 0.146 |
| Q   | 5.49        | 6.00  | 0.216       | 0.236 |
| S   | 6.04        | 6.30  | 0.238       | 0.248 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NO.</b><br>Z8B00003327                                                                                  |
| <b>SCALE</b><br>0 5 7.5mm                                                                                           |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>09-07-2010                                                                                     |
| <b>REVISION</b><br>05                                                                                               |

## Testing Conditions

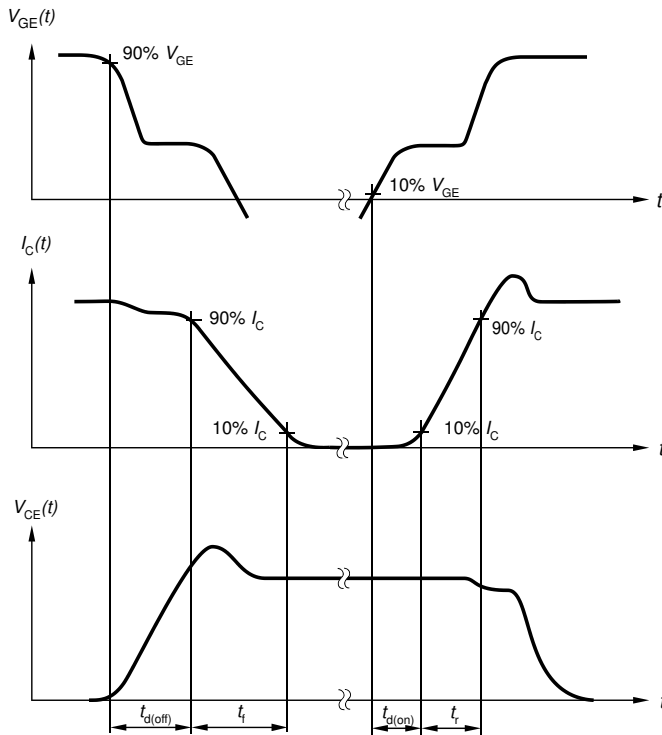


Figure A. Definition of switching times

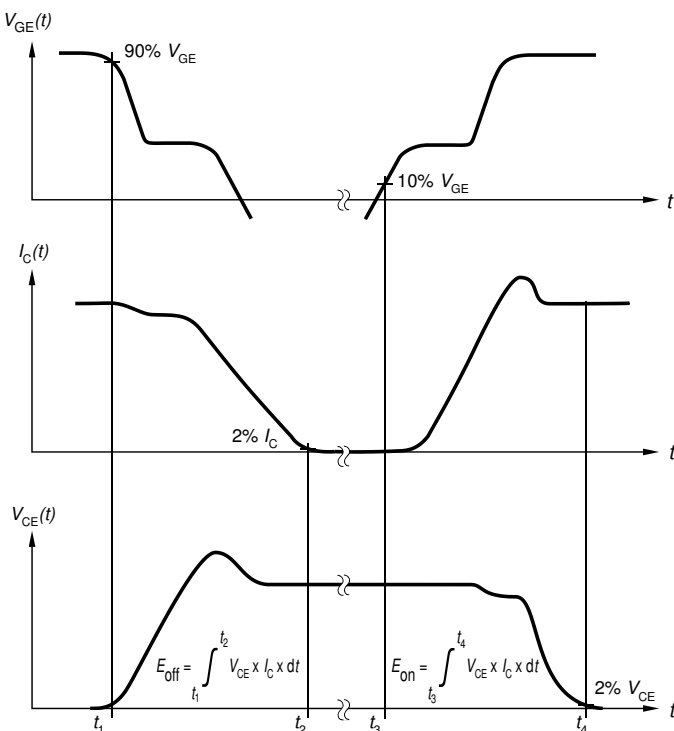


Figure B. Definition of switching losses

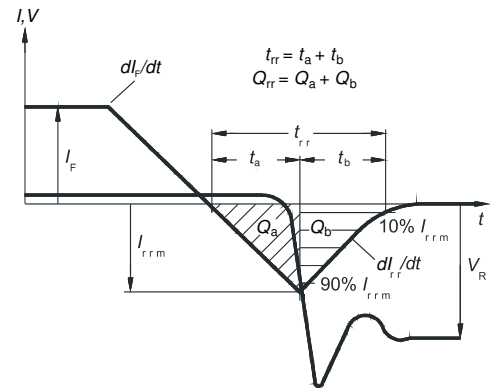


Figure C. Definition of diode switching characteristics

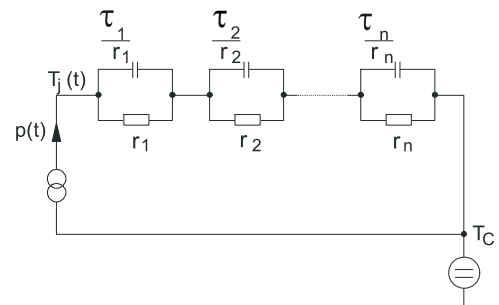


Figure D. Thermal equivalent circuit

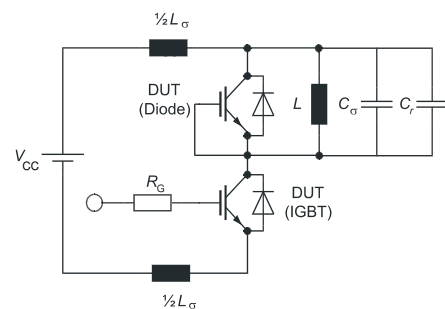


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

**Revision History**

IKW40N65WR5

**Revision: 2015-12-10, Rev. 2.1**

## Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 1.1      | 2014-12-05 | Preliminary data sheet                       |
| 1.2      | 2015-03-27 | New dynamic parameters and graphs            |
| 1.3      | 2015-05-12 | New dynamic parameters                       |
| 2.1      | 2015-12-10 | Final data sheet                             |

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