

## Reverse-Conducting IGBT with monolithic body diode

### Features

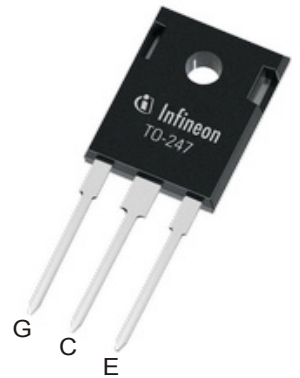
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>
- Easy parallel switching capability due to positive temperature coefficient in  $V_{CEsat}$
- High ruggedness and stable temperature behavior
- Low EMI
- Pb-free lead plating; RoHS compliant
- Powerful monolithic reverse-conducting diode with low forward voltage
- Very low  $V_{CEsat}$  and low  $E_{off}$
- Very tight parameter distribution

### Potential applications

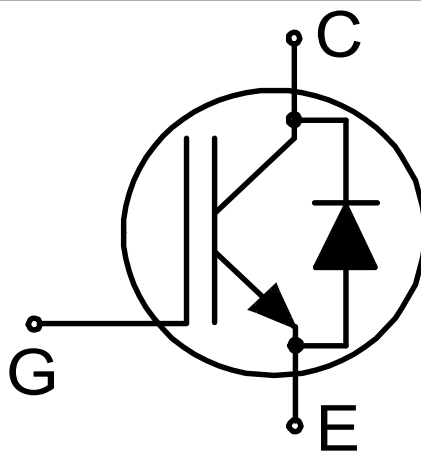
- Induction Cooking
- Microwave Ovens

### Product validation

- Product Validation: Qualified for industrial applications according to the relevant tests of JEDEC47/20/22



### Description



| Type       | Package    | Marking |
|------------|------------|---------|
| IHW40N65R6 | PG-TO247-3 | H40ER6  |

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1 Package

## 1 Package

**Table 1** Characteristic Values

| Parameter   | Symbol        | Note or test condition                            | Values |      |      | Unit |
|---|---------------|---|--------|------|------|------|
|   |               |   | Min.   | Typ. | Max. |      |
| Internal emitter inductance measured 5mm. (0.197in) from case | $L_E$         |   |        | 13.0 |      | nH   |
| Storage temperature   | $T_{stg}$     |   | -55    |      | 150  | °C   |
| Soldering temperature   |               | wave soldering 1.6mm (0.063in.) from case for 10s |        |      | 260  | °C   |
| Mounting torque , M3 screw<br>Maximum of mounting process: 3  | $M$           |   |        |      | 0.6  | Nm   |
| Thermal resistance, junction-ambient                          | $R_{th(j-a)}$ |   |        |      | 40   | K/W  |

## 2 IGBT

**Table 2** Maximum Rated Values

| Parameter  | Symbol      | Note or test condition   | Values |          |                       | Unit |
|--|-------------|--|--------|----------|-----------------------|------|
|  |             |  | Min.   | Typ.     | Max.                  |      |
| Collector-emitter voltage                              | $V_{CE}$    | $T_{vj} \geq 25\text{ °C}$   |        |          | 650                   | V    |
| DC collector current, limited by $T_{vjmax}$           | $I_C$       |  |        |          | 83.0                  | A    |
|  |             |  |        |          | $T_C = 100\text{ °C}$ |      |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpuls}$ |  |        |          | 120.0                 | A    |
| Turn-off safe operating area                           |             | $V_{CE} \leq 650\text{ V},$<br>$t_p \leq 1\text{ }\mu\text{s},$<br>$T_{vj} \leq 175\text{ °C}$ |        |          | 120.0                 | A    |
| Gate-emitter voltage                                   | $V_{GE}$    |  |        | $\pm 20$ |                       | V    |
| Transient gate-emitter voltage                         | $V_{GE}$    | $t_p = 10\text{ }\mu\text{s},$<br>$D < 0.010$  |        | $\pm 30$ |                       | V    |
| Power dissipation                                      | $P_{tot}$   |  |        |          | 210.0                 | W    |
|  |             |  |        |          | $T_C = 100\text{ °C}$ |      |

**Table 3 Characteristic Values**

| Parameter                            | Symbol               | Note or test condition   |   | Values |       |      | Unit          |
|--------------------------------------|----------------------|--|---|--------|-------|------|---------------|
|                                      |                      |  |   | Min.   | Typ.  | Max. |               |
| Collector-emitter breakdown voltage  | $V_{BRCES}$          | $I_C = 0.2 \text{ mA}$ ,<br>$V_{GE} = 0 \text{ V}$   |   | 650    |       |      | V             |
| Collector-emitter saturation voltage | $V_{CE \text{ sat}}$ | $V_{GE} = 15 \text{ V}$  | $I_C = 40.0 \text{ A}$ ,<br>$T_{vj} = 25 \text{ }^\circ\text{C}$    |        | 1.29  | 1.60 | V             |
|                                      |                      |  | $I_C = 40.0 \text{ A}$ ,<br>$T_{vj} = 175 \text{ }^\circ\text{C}$   |        | 1.50  |      |               |
| Gate-emitter threshold voltage       | $V_{GEth}$           | $I_C = 0.40 \text{ mA}$ ,<br>$V_{CE} = V_{GE}$   |   | 3.20   | 4.00  | 4.80 | V             |
| Zero gate voltage collector current  | $I_{CES}$            | $V_{GE} = 0 \text{ V}$   | $V_{CE} = 650 \text{ V}$ ,<br>$T_{vj} = 25 \text{ }^\circ\text{C}$  |        |       | 40   | $\mu\text{A}$ |
|                                      |                      |  | $V_{CE} = 650 \text{ V}$ ,<br>$T_{vj} = 175 \text{ }^\circ\text{C}$ |        | 1000  |      |               |
| Gate-emitter leakage current         | $I_{GES}$            | $V_{CE} = 0 \text{ V}$ ,<br>$V_{GE} = 20 \text{ V}$  |   |        |       | 100  | nA            |
| Transconductance                     | $g_{fs}$             | $I_C = 40.0 \text{ A}$ ,<br>$V_{CE} = 20 \text{ V}$  |   |        | 97.0  |      | S             |
| Input capacitance                    | $C_{ies}$            | $V_{CE} = 25 \text{ V}$ ,<br>$V_{GE} = 0 \text{ V}$ ,<br>$f = 1000 \text{ kHz}$  |   |        | 3990  |      | pF            |
| Output capacitance                   | $C_{oes}$            | $V_{CE} = 25 \text{ V}$ ,<br>$V_{GE} = 0 \text{ V}$ ,<br>$f = 1000 \text{ kHz}$  |   |        | 42    |      | pF            |
| Reverse transfer capacitance         | $C_{res}$            | $V_{CE} = 25 \text{ V}$ ,<br>$V_{GE} = 0 \text{ V}$ ,<br>$f = 1000 \text{ kHz}$  |   |        | 16    |      | pF            |
| Gate charge                          | $Q_G$                | $I_C = 40.0 \text{ A}$ ,<br>$V_{GE} = 15 \text{ V}$ ,<br>$V_{CE} = 520 \text{ V}$  |   |        | 159.0 |      | nC            |
| Turn-on delay time                   | $t_{don}$            | $V_{CE} = 400 \text{ V}$ ,<br>$V_{GE} = 15 \text{ V}$ ,<br>$R_{Gon} = 10.0 \text{ } \Omega$ ,<br>$R_{Goff} = 10.0 \text{ } \Omega$ ,<br>$L_\sigma = 70 \text{ nH}$ ,<br>$C_\sigma = 30 \text{ pF}$ | $T_{vj} = 25 \text{ }^\circ\text{C}$ ,<br>$I_C = 40.0 \text{ A}$    |        | 17    |      | ns            |
|                                      |                      |  | $T_{vj} = 175 \text{ }^\circ\text{C}$ ,<br>$I_C = 40.0 \text{ A}$   |        | 17    |      |               |

**Table 3 Characteristic Values (continued)**

| Parameter                  | Symbol     | Note or test condition  | Values   |      |      | Unit |
|----------------------------|------------|---|--|------|------|------|
|                            |            |   | Min.   | Typ. | Max. |      |
| Rise time (inductive load) | $t_r$      | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 19   |      | ns   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 19   |      |      |
| Turn-off delay time        | $t_{doff}$ | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 211  |      | ns   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 236  |      |      |
| Fall time (inductive load) | $t_f$      | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 15   |      | ns   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 20   |      |      |
| Turn-on energy             | $E_{on}$   | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 1.10 |      | mJ   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 1.27 |      |      |
| Turn-off energy            | $E_{off}$  | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 0.42 |      | mJ   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 0.61 |      |      |
| Total switching energy     | $E_{ts}$   | $V_{CE} = 400\text{ V},$<br>$V_{GE} = 15\text{ V},$<br>$R_{Gon} = 10.0\ \Omega,$<br>$R_{Goff} = 10.0\ \Omega,$<br>$L_\sigma = 70\text{ nH},$<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$  | 1.52 |      | mJ   |
|                            |            |   | $T_{vj} = 175\text{ }^\circ\text{C},$<br>$I_C = 40.0\text{ A}$ | 1.88 |      |      |

**Table 3** Characteristic Values (continued)

| Parameter                              | Symbol     | Note or test condition   | Values  |      |      | Unit             |
|--|------------|--|---|------|------|------------------|
|  |            |  | Min.  | Typ. | Max. |                  |
| Soft turn-off energy                   | $E_{off}$  | $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$R_{Gon} = 10.0\ \Omega$ ,<br>$R_{Goff} = 10.0\ \Omega$ ,<br>$C_r = 30\text{ nF}$ ,<br>$L_\sigma = 70\text{ nH}$ ,<br>$C_\sigma = 30\text{ pF}$ | $T_{vj} = 25\text{ }^\circ\text{C}$ ,<br>$I_C = 40.0\text{ A}$  |      | 0.18 | mJ               |
|  |            |  | $T_{vj} = 175\text{ }^\circ\text{C}$ ,<br>$I_C = 40.0\text{ A}$ |      | 0.30 |                  |
| IGBT thermal resistance, junction-case | $R_{thjc}$ |  |   |      | 0.71 | K/W              |
| Operating junction temperature         | $T_{vj}$   |  | -40   |      | 175  | $^\circ\text{C}$ |

### 3 Diode

**Table 4** Maximum Rated Values

| Parameter  | Symbol      | Note or test condition                 | Values                            |      |       | Unit |
|--|-------------|--|-----------------------------------|------|-------|------|
|  |             |  | Min.                              | Typ. | Max.  |      |
| Repetitive peak reverse voltage                    | $V_{RRM}$   | $T_{vj} \geq 25\text{ }^\circ\text{C}$ |                                   |      | 650   | V    |
| Diode forward current, limited by $T_{vjmax}$      | $I_F$       |  | $T_C = 25\text{ }^\circ\text{C}$  |      | 35.0  | A    |
|  |             |  | $T_C = 100\text{ }^\circ\text{C}$ |      | 21.0  |      |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpuls}$ |  |                                   |      | 120.0 | A    |
| Power dissipation                                  | $P_{tot}$   |  | $T_C = 25\text{ }^\circ\text{C}$  |      | 54.0  | W    |
|  |             |  | $T_C = 100\text{ }^\circ\text{C}$ |      | 27.0  |      |

**Table 5** Characteristic Values

| Parameter               | Symbol | Note or test condition | Values                               |      |      | Unit |               |
|-------------------------|--------|------------------------|--------------------------------------|------|------|------|---------------|
|                         |        |                        | Min.                                 | Typ. | Max. |      |               |
| Diode forward voltage   | $V_F$  | $I_F = 40.0\text{ A}$  | $T_{vj} = 25\text{ }^\circ\text{C}$  |      | 1.50 | 1.90 | V             |
|                         |        |                        | $T_{vj} = 175\text{ }^\circ\text{C}$ |      | 1.66 |      |               |
| Reverse leakage current | $I_R$  | $V_R = 650\text{ V}$   | $T_{vj} = 25\text{ }^\circ\text{C}$  |      |      | 40   | $\mu\text{A}$ |
|                         |        |                        | $T_{vj} = 175\text{ }^\circ\text{C}$ |      | 1000 |      |               |

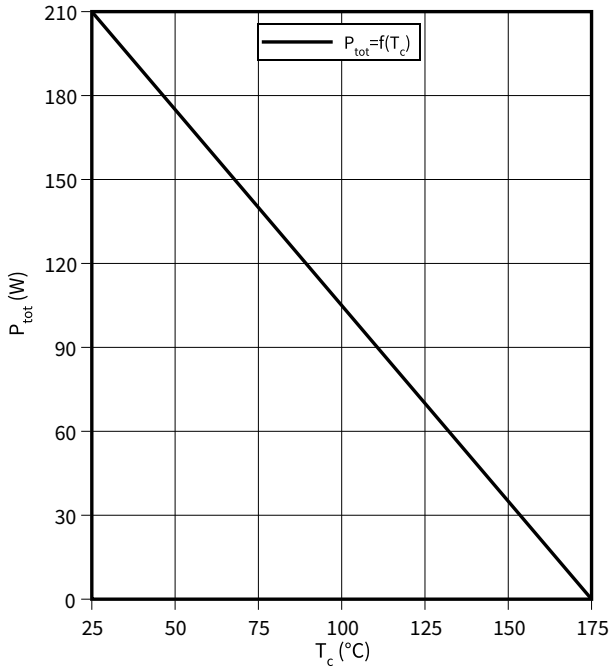
**Table 5 Characteristic Values (continued)**

| Parameter  | Symbol       | Note or test condition | Values  |      |      | Unit               |                        |
|--|--------------|------------------------|---|------|------|--------------------|------------------------|
|  |              |                        | Min.  | Typ. | Max. |                    |                        |
| Diode reverse recovery time                          | $t_{rr}$     | $V_R = 400\text{ V}$   | $T_{vj} = 25\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$  |      | 99   |                    | ns                     |
|  |              |                        | $T_{vj} = 175\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$ |      | 133  |                    |                        |
| Diode reverse recovery charge                        | $Q_{rr}$     | $V_R = 400\text{ V}$   | $T_{vj} = 25\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$  |      | 2.16 |                    | $\mu\text{C}$          |
|  |              |                        | $T_{vj} = 175\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$ |      | 3.77 |                    |                        |
| Diode peak reverse recovery current                  | $I_{rrm}$    | $V_R = 400\text{ V}$   | $T_{vj} = 25\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$  |      | 35.0 |                    | A                      |
|  |              |                        | $T_{vj} = 175\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$ |      | 46.0 |                    |                        |
| Diode peak rate off fall of reverse recovery current | $di_{rr}/dt$ | $V_R = 400\text{ V}$   | $T_{vj} = 25\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$  |      | -926 |                    | $\text{A}/\mu\text{s}$ |
|  |              |                        | $T_{vj} = 175\text{ °C}$ ,<br>$I_F = 40.0\text{ A}$ ,<br>$-di_F/dt = 1000\text{ A}/\mu\text{s}$ |      | -901 |                    |                        |
| Diode thermal resistance, junction-case              | $R_{thjc}$   |                        |   |      | 2.77 | K/W                |                        |
| Operating junction temperature                       | $T_{vj}$     |                        | -40   |      | 175  | $^{\circ}\text{C}$ |                        |

## 4 Characteristics diagrams

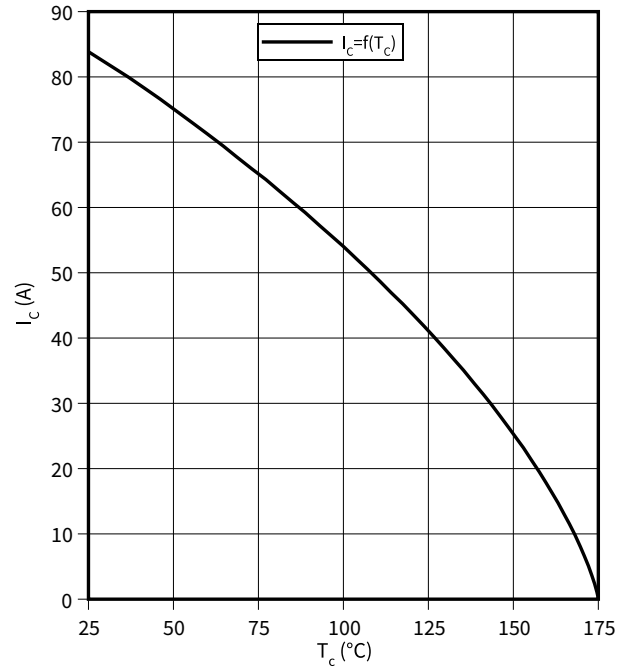
**Power dissipation as a function of case temperature, IGBT**

$P_{tot} = f(T_c)$   
 $T_{vj} \leq 175\text{ °C}$



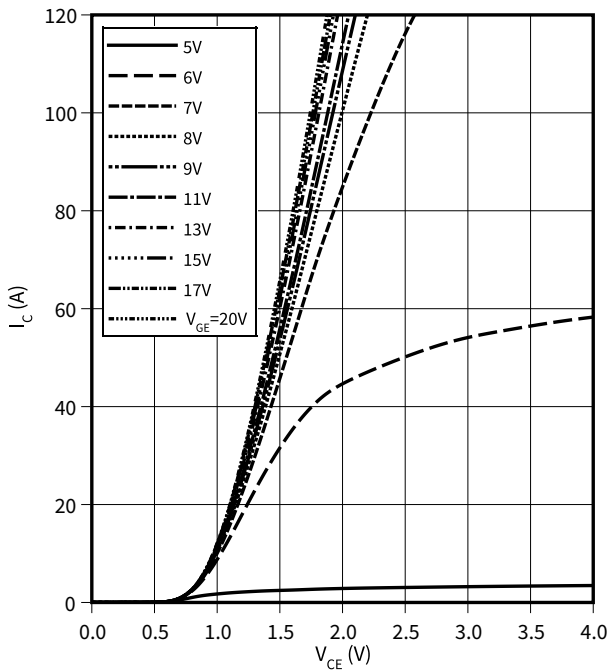
**Collector current as a function of case temperature, IGBT**

$I_C = f(T_c)$   
 $T_{vj} \leq 175\text{ °C}, V_{GE} = 15\text{ V}$



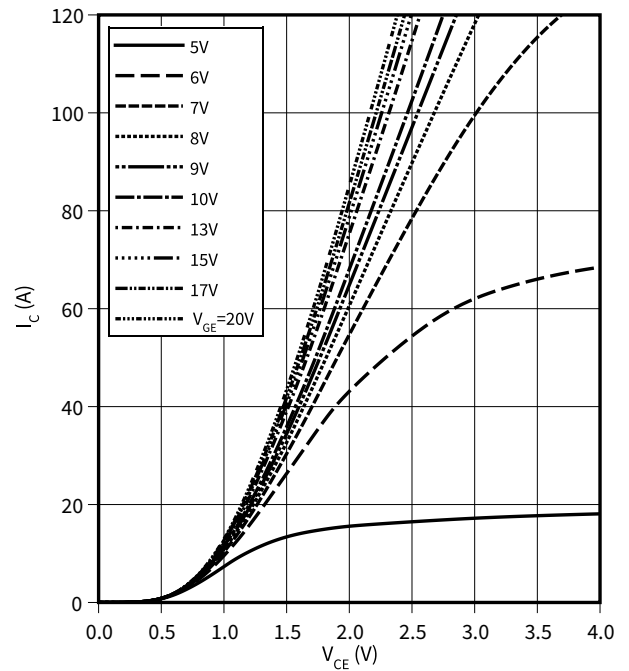
**Typical output characteristic, IGBT**

$I_C = f(V_{CE})$   
 $T_{vj} = 25\text{ °C}$



**Typical output characteristic, IGBT**

$I_C = f(V_{CE})$   
 $T_{vj} = 175\text{ °C}$

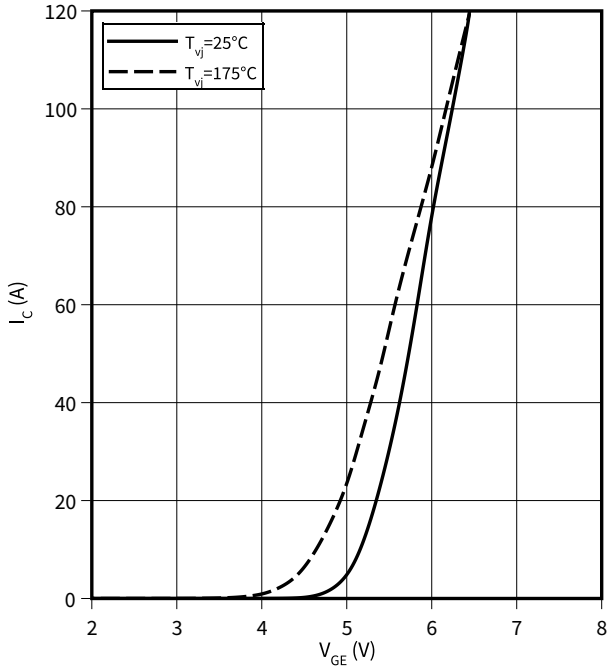




4 Characteristics diagrams

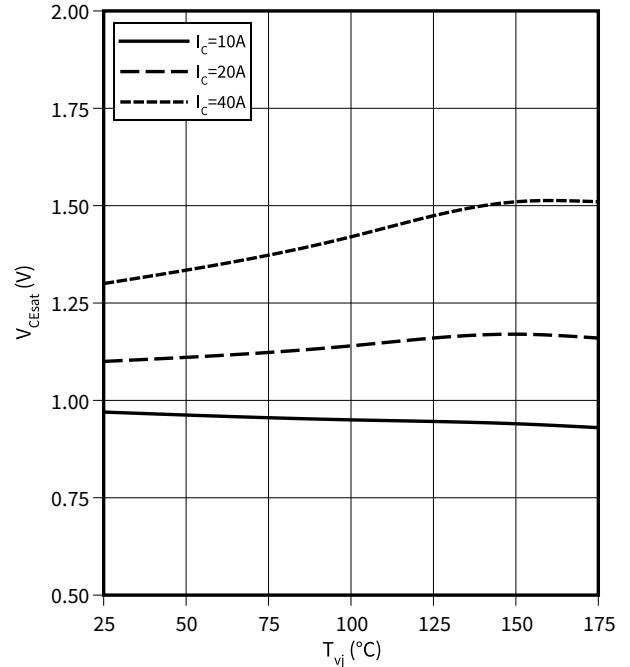
**Typical transfer characteristic, IGBT**

$I_C = f(V_{GE})$   
 $V_{CE} = 20\text{ V}$



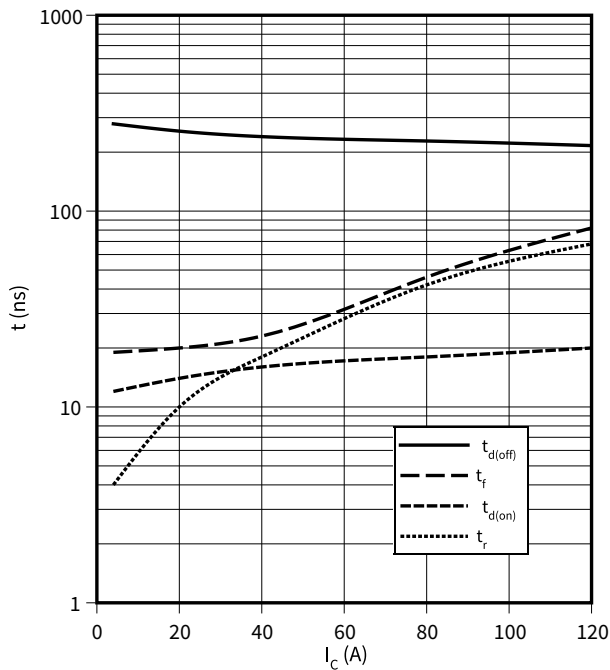
**Typical collector-emitter saturation voltage as a function of junction temperature, IGBT**

$V_{CEsat} = f(T_{vj})$   
 $V_{GE} = 15\text{ V}$



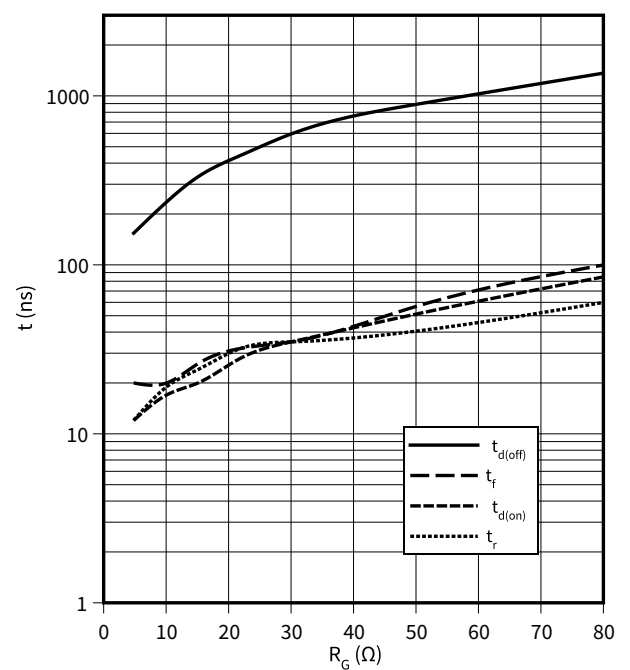
**Typical switching times as a function of collector current, IGBT**

$t = f(I_C)$   
 $R_{Goff} = 10.0\ \Omega$ ,  $V_{CE} = 400\text{ V}$ ,  $T_{vj} = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$ ,  $R_{Gon} = 10.0\ \Omega$



**Typical switching times as a function of gate resistor, IGBT**

$t = f(R_G)$   
 $I_C = 40.0\text{ A}$ ,  $V_{CE} = 400\text{ V}$ ,  $T_{vj} = 175^\circ\text{C}$ ,  $V_{GE} = 0/15\text{ V}$

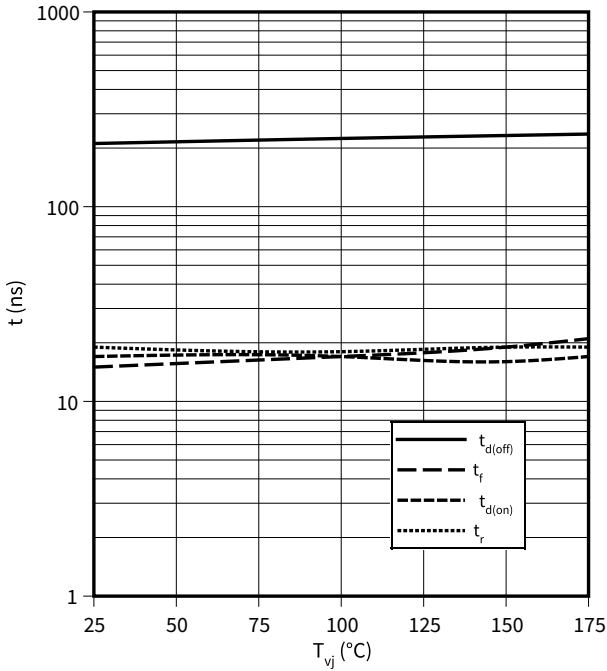


4 Characteristics diagrams

**Typical switching times as a function of junction temperature, IGBT**

$t = f(T_{vj})$

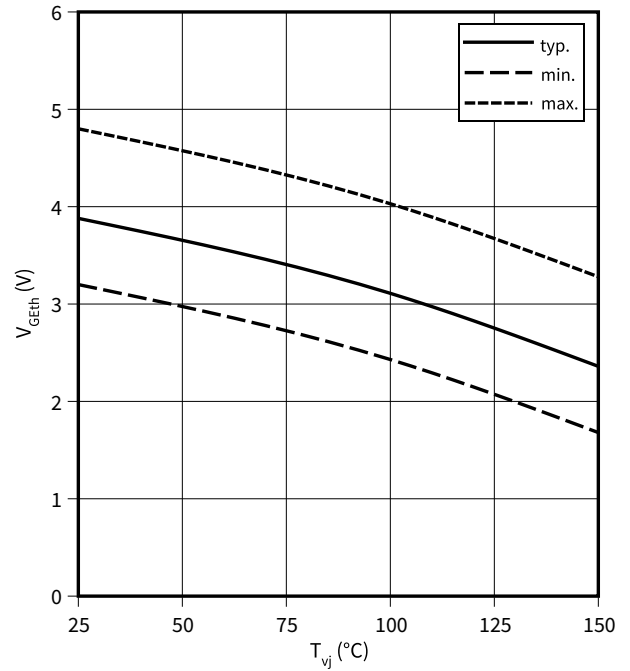
$I_C = 40.0 \text{ A}$ ,  $R_{Goff} = 10.0 \text{ } \Omega$ ,  $V_{CE} = 400 \text{ V}$ ,  $V_{GE} = 0/15 \text{ V}$ ,  $R_{Gon} = 10.0 \text{ } \Omega$



**Gate-emitter threshold voltage as a function of junction temperature, IGBT**

$V_{GEth} = f(T_{vj})$

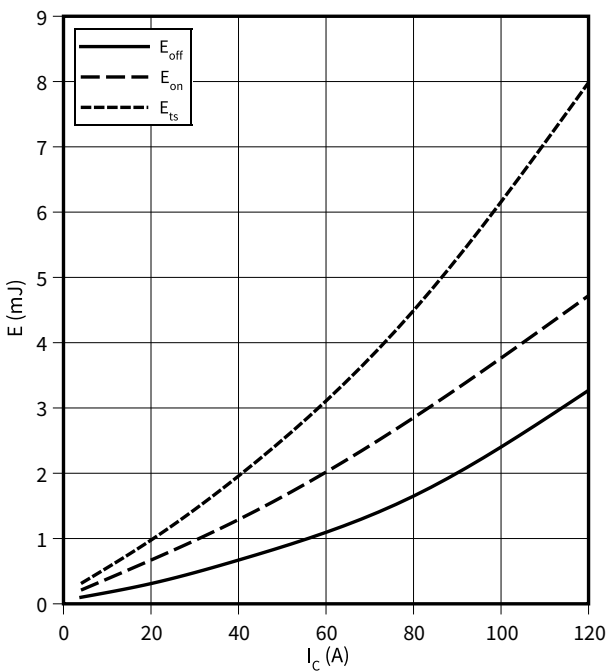
$I_C = 0.40 \text{ mA}$



**Typical switching energy losses as a function of collector current, IGBT**

$E = f(I_C)$

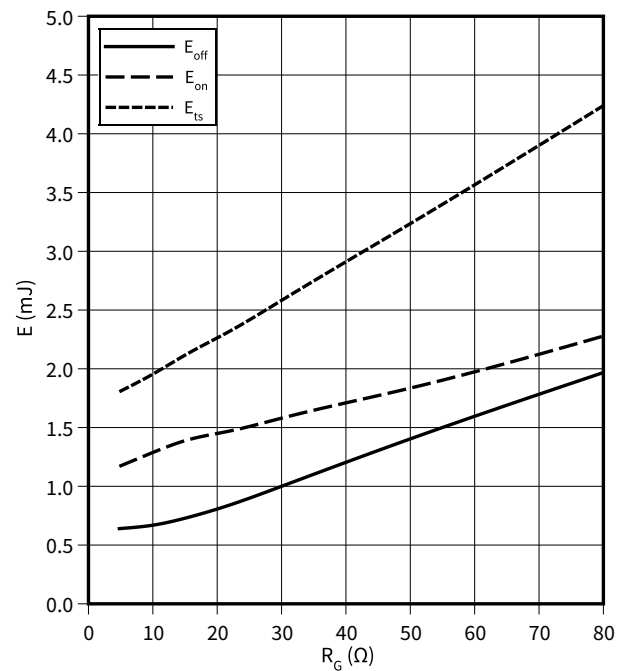
$R_{Goff} = 10.0 \text{ } \Omega$ ,  $V_{CE} = 400 \text{ V}$ ,  $T_{vj} = 175 \text{ } ^\circ\text{C}$ ,  $V_{GE} = 0/15 \text{ V}$ ,  $R_{Gon} = 10.0 \text{ } \Omega$



**Typical switching energy losses as a function of gate resistor, IGBT**

$E = f(R_G)$

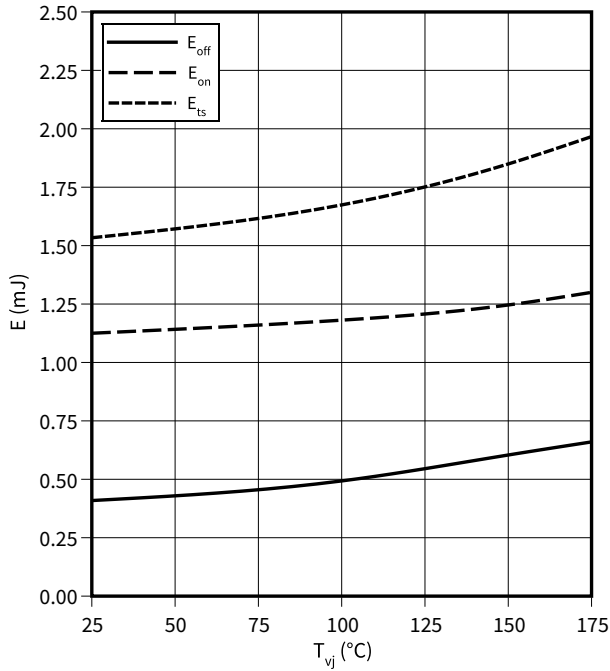
$I_C = 40.0 \text{ A}$ ,  $V_{CE} = 400 \text{ V}$ ,  $T_{vj} = 175 \text{ } ^\circ\text{C}$ ,  $V_{GE} = 0/15 \text{ V}$



4 Characteristics diagrams

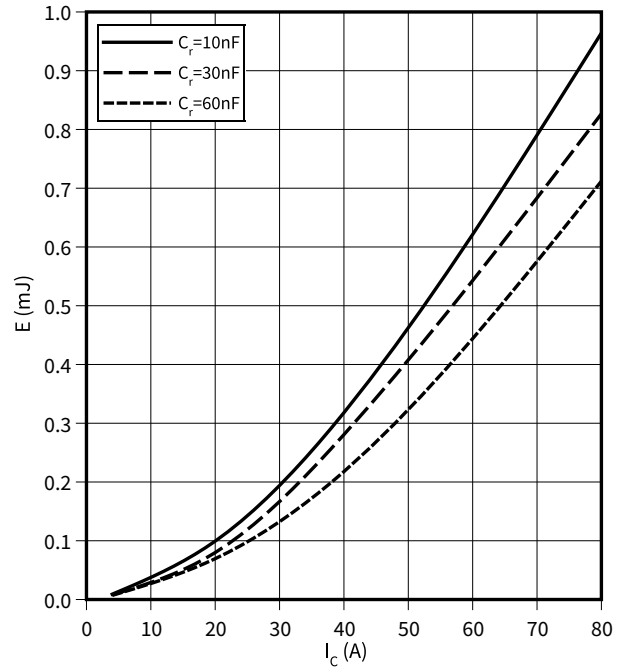
**Typical switching energy losses as a function of junction temperature, IGBT**

$E = f(T_{vj})$   
 $I_C = 40.0 \text{ A}$ ,  $R_{Goff} = 10.0 \text{ } \Omega$ ,  $V_{CE} = 400 \text{ V}$ ,  $V_{GE} = 0/15 \text{ V}$ ,  $R_{Gon} = 10.0 \text{ } \Omega$



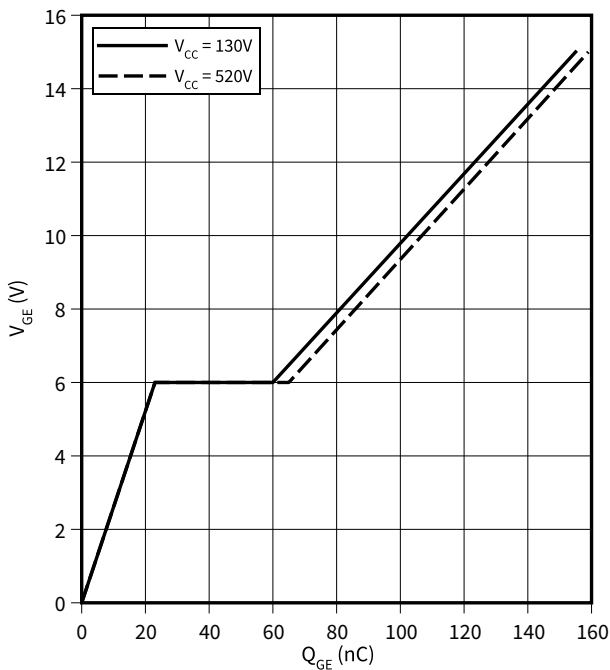
**Typical soft-switching turn-off energy loss as a function of collector current, IGBT**

$E = f(I_C)$   
 $R_{Goff} = 10.0 \text{ } \Omega$ ,  $V_{CE} = 400 \text{ V}$ ,  $V_{GE} = 15 \text{ V}$ ,  $T_{vj} = 175 \text{ } ^\circ\text{C}$ ,  $R_{Gon} = 10.0 \text{ } \Omega$



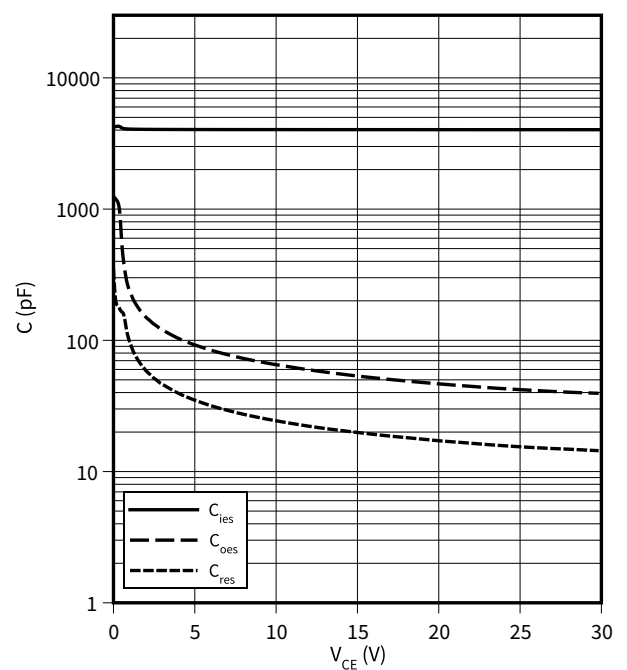
**Typical gate charge, IGBT**

$V_{GE} = f(Q_{GE})$   
 $I_C = 40.0 \text{ A}$



**Typical capacitance as a function of collector-emitter voltage, IGBT**

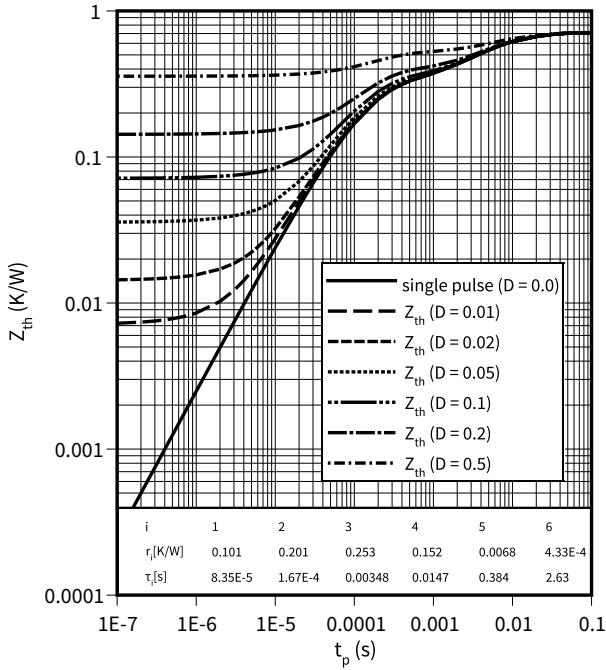
$C = f(V_{CE})$   
 $f = 1000 \text{ kHz}$ ,  $V_{GE} = 0 \text{ V}$



4 Characteristics diagrams

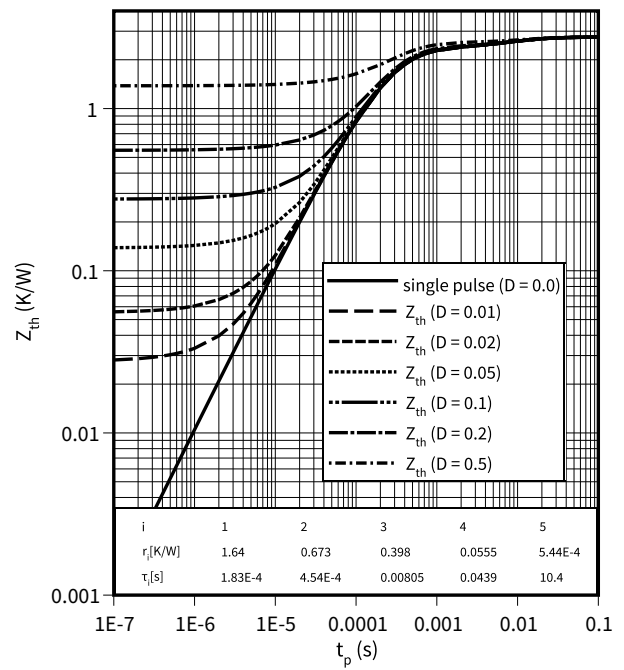
**IGBT transient thermal resistance, IGBT**

$Z_{th} = f(t_p)$   
 $D = t_p/T$



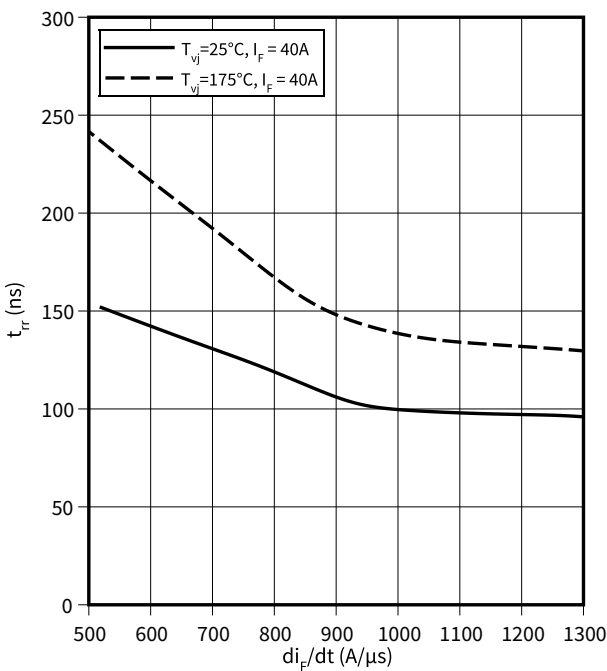
**Diode transient thermal impedance as a function of pulse width, Diode**

$Z_{th} = f(t_p)$   
 $D = t_p/T$



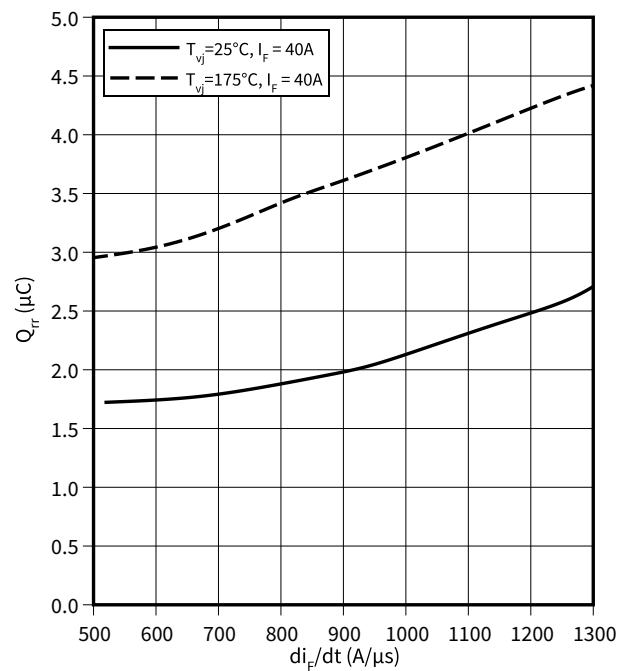
**Typical reverse recovery time as a function of diode current slope, Diode**

$t_{rr} = f(di_F/dt)$   
 $V_R = 400 V$



**Typical reverse recovery charge as a function of diode current slope, Diode**

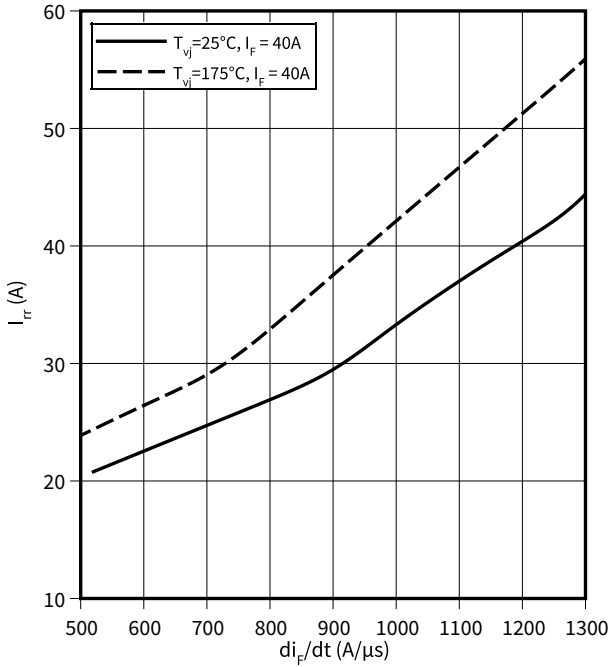
$Q_{rr} = f(di_F/dt)$   
 $V_R = 400 V$



4 Characteristics diagrams

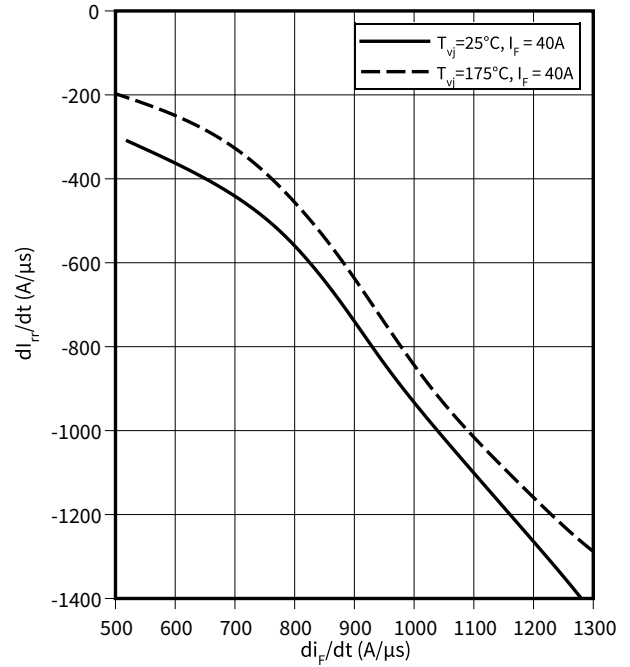
**Typical reverse recovery current as a function of diode current slope, Diode**

$I_{rr} = f(di_F/dt)$   
 $V_R = 400\text{ V}$



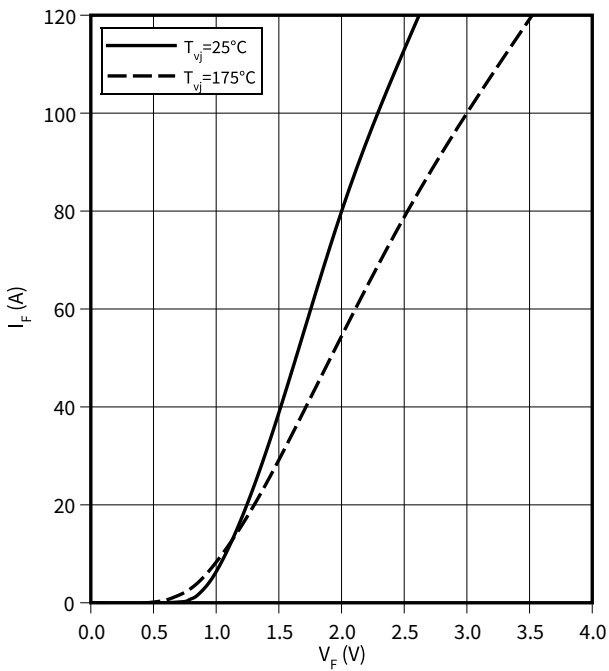
**Typical diode peak rate of fall of reverse recovery current as a function of diode current slope, Diode**

$dI_{rr}/dt = f(di_F/dt)$   
 $V_R = 400\text{ V}$



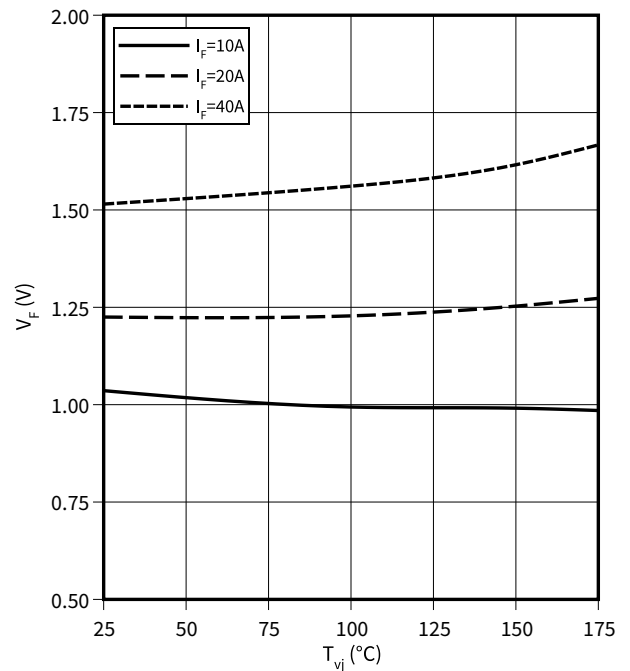
**Typical diode forward current as a function of forward voltage, Diode**

$I_F = f(V_F)$



**Typical diode forward voltage as a function of junction temperature, Diode**

$V_F = f(T_{vj})$



5 Package outlines

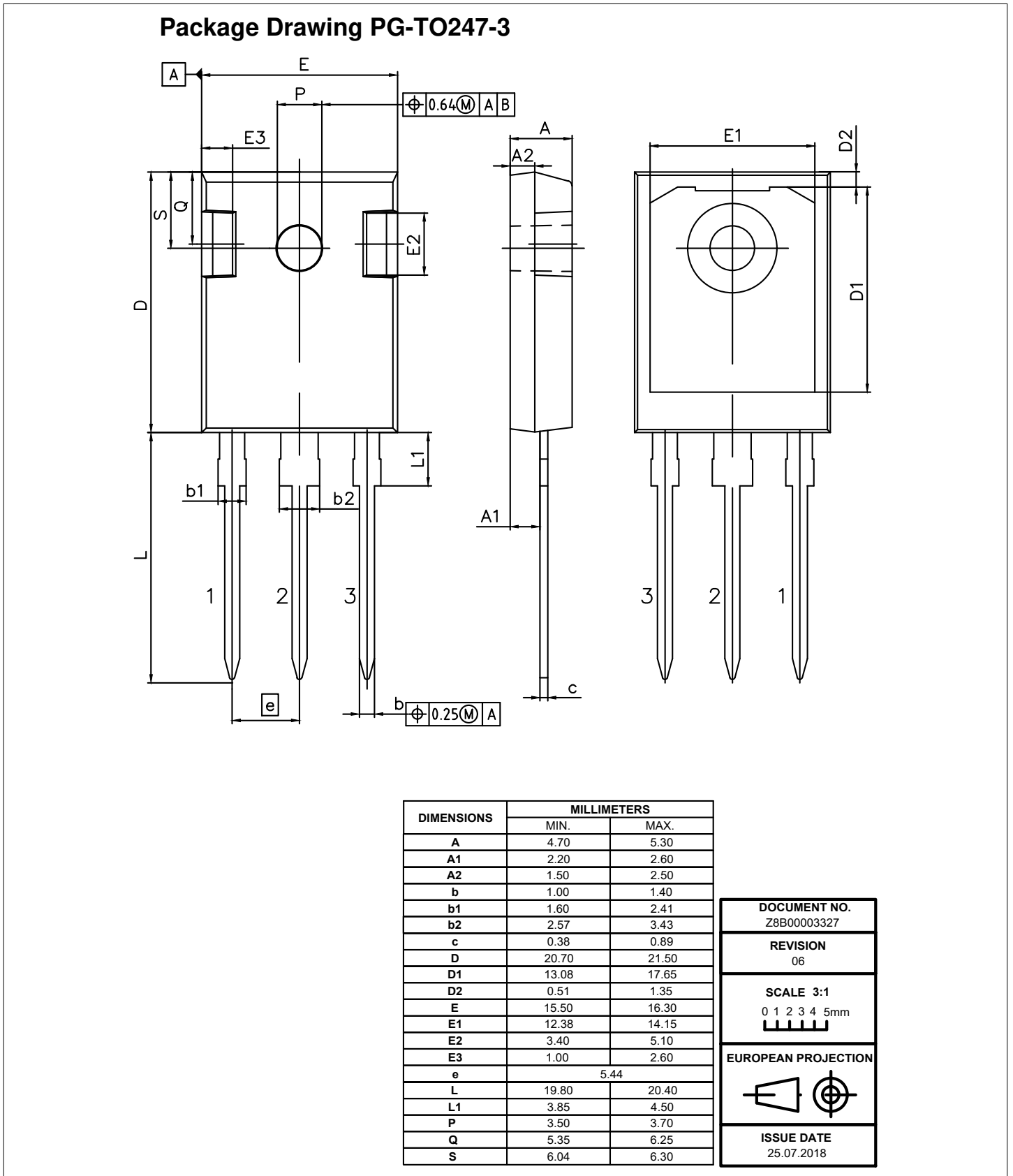


Figure 6

## 6 Testing conditions

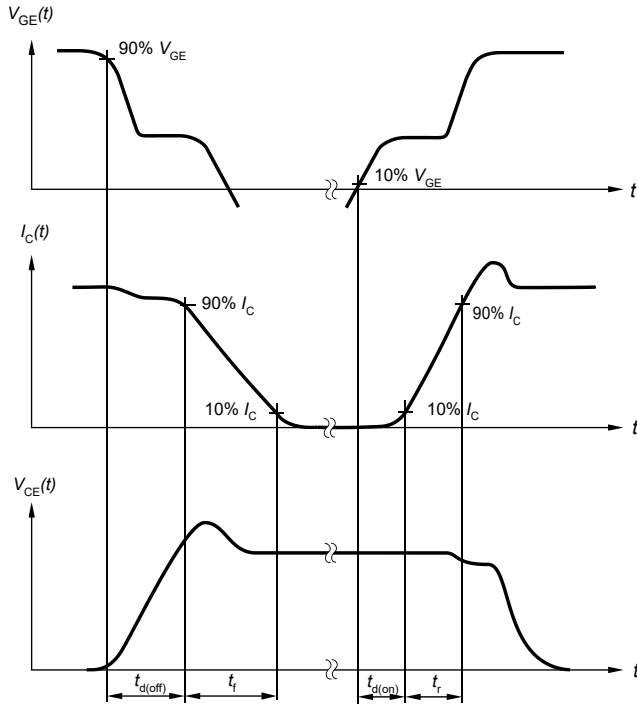


Figure A. Definition of switching times

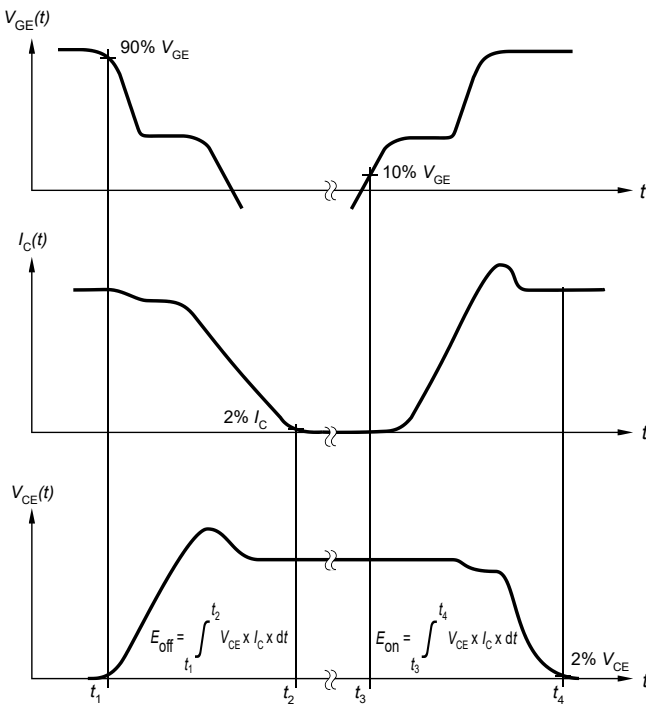


Figure B. Definition of switching losses

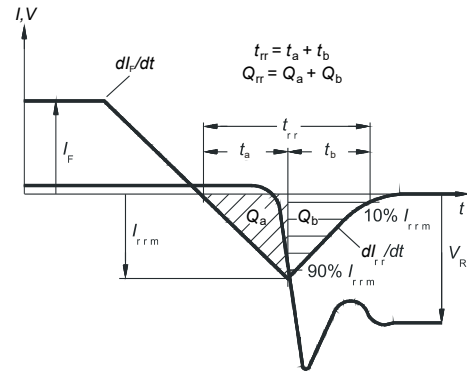


Figure C. Definition of diode switching characteristics

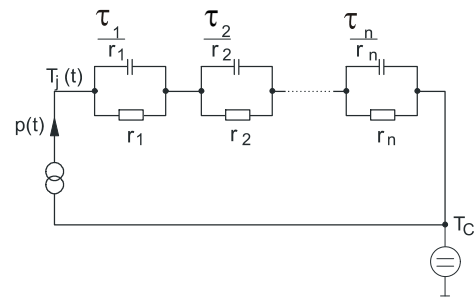


Figure D. Thermal equivalent circuit

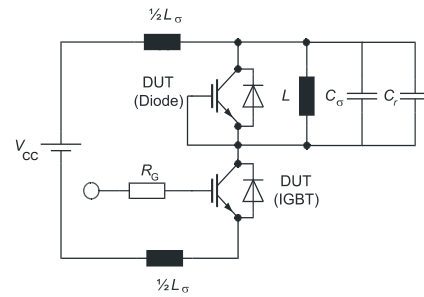


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

Figure 7

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Revision history

## Revision history

| <b>Document version</b> | <b>Date of release</b> | <b>Description of changes</b>   |
|-------------------------|------------------------|---------------------------------|
| V2.10                   | 2020-02-08             | Fixed Zth diagrams. Fixed link. |
| V1.00                   | 2020-12-21             | Final datasheet                 |



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