

### Low switching losses IGBT in Highspeed3 technology co-packed with soft, fast recovery full current rated antiparallel emitter controlled diode

#### Features

- $V_{CE} = 1200\text{ V}$
- $I_C = 40\text{ A}$
- Ultra-low loss switching losses due to Kelvin emitter pin package in combination with Highspeed3 technology
- High efficiency in hard switching and resonant topologies
- 10  $\mu\text{sec}$  short circuit withstand time at  $T_{vj} = 175^\circ\text{C}$
- Easy parallel switching capability due to positive temperature coefficient in  $V_{CEsat}$
- Low EMI
- Low gate charge  $Q_G$
- Very soft, fast recovery full current antiparallel diode
- Maximum junction temperature  $T_{vjmax} = 175^\circ\text{C}$
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>

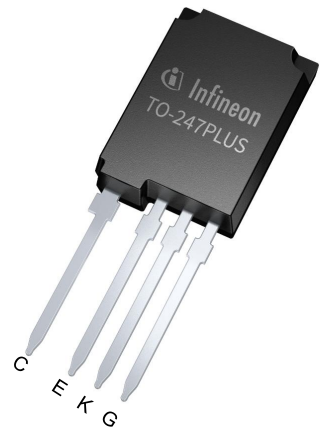
#### Potential applications

- Industrial UPS
- Charger
- Energy storage
- Three-level solar string inverter

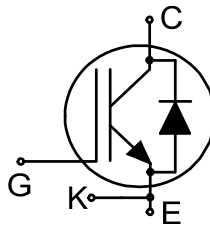
#### Product validation

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

#### Description



- Halogen-free
- Lead-free
- Green
- RoHS



| Type         | Package      | Marking |
|--------------|--------------|---------|
| IKY40N120CH3 | PG-TO247-4-2 | K40MCH3 |

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## 1 Package

**Table 1** Characteristic values

| Parameter                               | Symbol        | Note or test condition                               | Values |      |      | Unit |
|---|---------------|--|--------|------|------|------|
|   |               |  | Min.   | Typ. | Max. |      |
| Storage temperature                     | $T_{stg}$     |  | -55    |      | 150  | °C   |
| Soldering temperature                   | $T_{sold}$    | wave soldering 1.6 mm (0.063 in.) from case for 10 s |        |      | 260  | °C   |
| Thermal resistance, junction-ambient    | $R_{th(j-a)}$ |  |        |      | 40   | K/W  |
| IGBT thermal resistance, junction-case  | $R_{th(j-c)}$ |  |        |      | 0.3  | K/W  |
| Diode thermal resistance, junction-case | $R_{th(j-c)}$ |  |        |      | 0.5  | K/W  |

## 2 IGBT

**Table 2** Maximum rated values

| Parameter  | Symbol       | Note or test condition  | Values                 | Unit          |   |
|--|--------------|---|------------------------|---------------|---|
| Collector-emitter voltage                              | $V_{CE}$     | $T_{vj} \geq 25 \text{ °C}$   | 1200                   | V             |   |
| DC collector current, limited by $T_{vjmax}$           | $I_C$        | limited by bondwire   | $T_c = 25 \text{ °C}$  | 80            | A |
|  |              |   | $T_c = 134 \text{ °C}$ | 40            |   |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpulse}$ |   | 160                    | A             |   |
| Turn-off safe operating area                           |              | $V_{CE} \leq 1200 \text{ V}$ , $t_p = 1 \text{ }\mu\text{s}$ , $T_{vj} \leq 175 \text{ °C}$   | 160                    | A             |   |
| Gate-emitter voltage                                   | $V_{GE}$     |   | $\pm 20$               | V             |   |
| Transient gate-emitter voltage                         | $V_{GE}$     | $t_p \leq 10 \text{ }\mu\text{s}$ , $D < 0.01$  | $\pm 30$               | V             |   |
| Short-circuit withstand time                           | $t_{SC}$     | $V_{CC} \leq 600 \text{ V}$ , $V_{GE} = 15 \text{ V}$ , Allowed number of short circuits < 1000, Time between short circuits $\geq 1.0 \text{ s}$ , $T_{vj} = 175 \text{ °C}$ | 10                     | $\mu\text{s}$ |   |
| Power dissipation                                      | $P_{tot}$    | $T_c = 25 \text{ °C}$   | 500                    | W             |   |
|  |              | $T_c = 134 \text{ °C}$  | 136                    |               |   |

**Table 3** Characteristic values

| Parameter                           | Symbol      | Note or test condition                          | Values |      |      | Unit |
|-------------------------------------|-------------|---|--------|------|------|------|
|                                     |             |   | Min.   | Typ. | Max. |      |
| Collector-emitter breakdown voltage | $V_{BRCES}$ | $I_C = 0.5 \text{ mA}$ , $V_{GE} = 0 \text{ V}$ | 1200   |      |      | V    |

(table continues...)

**Table 3 (continued) Characteristic values**

| Parameter                            | Symbol       | Note or test condition   |   | Values |      |      | Unit          |
|--------------------------------------|--------------|--|---|--------|------|------|---------------|
|                                      |              |  |   | Min.   | Typ. | Max. |               |
| Collector-emitter saturation voltage | $V_{CEsat}$  | $I_C = 40\text{ A}, V_{GE} = 15\text{ V}$  | $T_{vj} = 25\text{ °C}$                     |        | 2    | 2.35 | V             |
|                                      |              |  | $T_{vj} = 175\text{ °C}$                    |        | 2.5  |      |               |
| Gate-emitter threshold voltage       | $V_{GETh}$   | $I_C = 1.5\text{ mA}, V_{CE} = V_{GE}$   |   | 5.1    | 5.8  | 6.5  | V             |
| Zero gate-voltage collector current  | $I_{CES}$    | $V_{CE} = 1200\text{ V}, V_{GE} = 0\text{ V}$  | $T_{vj} = 25\text{ °C}$                     |        |      | 250  | $\mu\text{A}$ |
|                                      |              |  | $T_{vj} = 175\text{ °C}$                    |        | 3000 |      |               |
| Gate-emitter leakage current         | $I_{GES}$    | $V_{CE} = 0\text{ V}, V_{GE} = 20\text{ V}$  |   |        |      | 100  | nA            |
| Transconductance                     | $g_{fs}$     | $I_C = 40\text{ A}, V_{CE} = 20\text{ V}$  |   |        | 14   |      | S             |
| Input capacitance                    | $C_{ies}$    | $V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}, f = 1000\text{ kHz}$   |   |        | 2385 |      | pF            |
| Output capacitance                   | $C_{oes}$    | $V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}, f = 1000\text{ kHz}$   |   |        | 235  |      | pF            |
| Reverse transfer capacitance         | $C_{res}$    | $V_{CE} = 25\text{ V}, V_{GE} = 0\text{ V}, f = 1000\text{ kHz}$   |   |        | 132  |      | pF            |
| Gate charge                          | $Q_G$        | $I_C = 40\text{ A}, V_{GE} = 15\text{ V}, V_{CC} = 960\text{ V}$   |   |        | 190  |      | nC            |
| Turn-on delay time                   | $t_{d(on)}$  | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_{G(on)} = 12\ \Omega, R_{G(off)} = 12\ \Omega, L_\sigma = 70\text{ nH}, C_\sigma = 67\text{ pF}$ | $T_{vj} = 25\text{ °C}, I_C = 40\text{ A}$  |        | 30   |      | ns            |
|                                      |              |  | $T_{vj} = 175\text{ °C}, I_C = 40\text{ A}$ |        | 29   |      |               |
| Rise time (inductive load)           | $t_r$        | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_{G(on)} = 12\ \Omega, R_{G(off)} = 12\ \Omega, L_\sigma = 70\text{ nH}, C_\sigma = 67\text{ pF}$ | $T_{vj} = 25\text{ °C}, I_C = 40\text{ A}$  |        | 29   |      | ns            |
|                                      |              |  | $T_{vj} = 175\text{ °C}, I_C = 40\text{ A}$ |        | 32   |      |               |
| Turn-off delay time                  | $t_{d(off)}$ | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_{G(on)} = 12\ \Omega, R_{G(off)} = 12\ \Omega, L_\sigma = 70\text{ nH}, C_\sigma = 67\text{ pF}$ | $T_{vj} = 25\text{ °C}, I_C = 40\text{ A}$  |        | 280  |      | ns            |
|                                      |              |  | $T_{vj} = 175\text{ °C}, I_C = 40\text{ A}$ |        | 375  |      |               |
| Fall time (inductive load)           | $t_f$        | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_{G(on)} = 12\ \Omega, R_{G(off)} = 12\ \Omega, L_\sigma = 70\text{ nH}, C_\sigma = 67\text{ pF}$ | $T_{vj} = 25\text{ °C}, I_C = 40\text{ A}$  |        | 26   |      | ns            |
|                                      |              |  | $T_{vj} = 175\text{ °C}, I_C = 40\text{ A}$ |        | 64   |      |               |
| Turn-on energy                       | $E_{on}$     | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_{G(on)} = 12\ \Omega, R_{G(off)} = 12\ \Omega, L_\sigma = 70\text{ nH}, C_\sigma = 67\text{ pF}$ | $T_{vj} = 25\text{ °C}, I_C = 40\text{ A}$  |        | 2.2  |      | mJ            |
|                                      |              |  | $T_{vj} = 175\text{ °C}, I_C = 40\text{ A}$ |        | 3.1  |      |               |

**(table continues...)**

**Table 3 (continued) Characteristic values**

| Parameter                      | Symbol    | Note or test condition  | Values   |      |      | Unit               |    |
|--------------------------------|-----------|---|--|------|------|--------------------|----|
|                                |           |   | Min.   | Typ. | Max. |                    |    |
| Turn-off energy                | $E_{off}$ | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V},$<br>$R_{G(on)} = 12\ \Omega,$<br>$R_{G(off)} = 12\ \Omega, L_{\sigma} = 70\text{ nH},$<br>$C_{\sigma} = 67\text{ pF}$ | $T_{vj} = 25\text{ }^{\circ}\text{C},$<br>$I_C = 40\text{ A}$  |      | 1.3  |                    | mJ |
|                                |           |   | $T_{vj} = 175\text{ }^{\circ}\text{C},$<br>$I_C = 40\text{ A}$ |      | 2.5  |                    |    |
| Total switching energy         | $E_{ts}$  | $V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V},$<br>$R_{G(on)} = 12\ \Omega,$<br>$R_{G(off)} = 12\ \Omega, L_{\sigma} = 70\text{ nH},$<br>$C_{\sigma} = 67\text{ pF}$ | $T_{vj} = 25\text{ }^{\circ}\text{C},$<br>$I_C = 40\text{ A}$  |      | 3.5  |                    | mJ |
|                                |           |   | $T_{vj} = 175\text{ }^{\circ}\text{C},$<br>$I_C = 40\text{ A}$ |      | 5.6  |                    |    |
| 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 |   |
|--|--------------|--|-------------------------------------|------|---|
| Repetitive peak reverse voltage                    | $V_{RRM}$    | $T_{vj} \geq 25\text{ }^{\circ}\text{C}$ | 1200                                | V    |   |
| Diode forward current, limited by $T_{vjmax}$      | $I_F$        |  | $T_C = 25\text{ }^{\circ}\text{C}$  | 80   | A |
|  |              |  | $T_C = 100\text{ }^{\circ}\text{C}$ | 40   |   |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpulse}$ |  | 160                                 | A    |   |

**Table 5 Characteristic values**

| Parameter                   | Symbol   | Note or test condition | Values   |      |      | Unit |    |
|-----------------------------|----------|------------------------|--|------|------|------|----|
|                             |          |                        | Min.   | Typ. | Max. |      |    |
| Diode forward voltage       | $V_F$    | $I_F = 40\text{ A}$    | $T_{vj} = 25\text{ }^{\circ}\text{C}$  |      | 1.9  | 2.3  | V  |
|                             |          |                        | $T_{vj} = 175\text{ }^{\circ}\text{C}$   |      | 1.85 |      |    |
| Diode reverse recovery time | $t_{rr}$ | $V_R = 600\text{ V}$   | $T_{vj} = 25\text{ }^{\circ}\text{C},$<br>$I_F = 40\text{ A},$<br>$-di_F/dt = 600\text{ A}/\mu\text{s}$  |      | 350  |      | ns |
|                             |          |                        | $T_{vj} = 175\text{ }^{\circ}\text{C},$<br>$I_F = 40\text{ A},$<br>$-di_F/dt = 600\text{ A}/\mu\text{s}$ |      | 550  |      |    |

(table continues...)

**Table 5 (continued) Characteristic values**

| Parameter   | Symbol       | Note or test condition |   | Values |      |      | Unit                   |
|---|--------------|------------------------|---|--------|------|------|------------------------|
|   |              |                        |   | Min.   | Typ. | Max. |                        |
| Diode reverse recovery charge                       | $Q_{rr}$     | $V_R = 600\text{ V}$   | $T_{vj} = 25\text{ °C},$<br>$I_F = 40\text{ A},$<br>$-di_F/dt = 600\text{ A}/\mu\text{s}$ |        | 3    |      | $\mu\text{C}$          |
|   |              |                        |   |        | 7.5  |      |                        |
| Diode peak reverse recovery current                 | $I_{rrm}$    | $V_R = 600\text{ V}$   | $T_{vj} = 25\text{ °C},$<br>$I_F = 40\text{ A},$<br>$-di_F/dt = 600\text{ A}/\mu\text{s}$ |        | 22   |      | A                      |
|   |              |                        |   |        | 30   |      |                        |
| Diode peak rate of fall of reverse recovery current | $di_{rr}/dt$ | $V_R = 600\text{ V}$   | $T_{vj} = 25\text{ °C},$<br>$I_F = 40\text{ A},$<br>$-di_F/dt = 600\text{ A}/\mu\text{s}$ |        | 188  |      | $\text{A}/\mu\text{s}$ |
|   |              |                        |   |        | 142  |      |                        |
| Operating junction temperature                      | $T_{vj}$     |                        |   | -40    |      | 175  | $^{\circ}\text{C}$     |

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

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

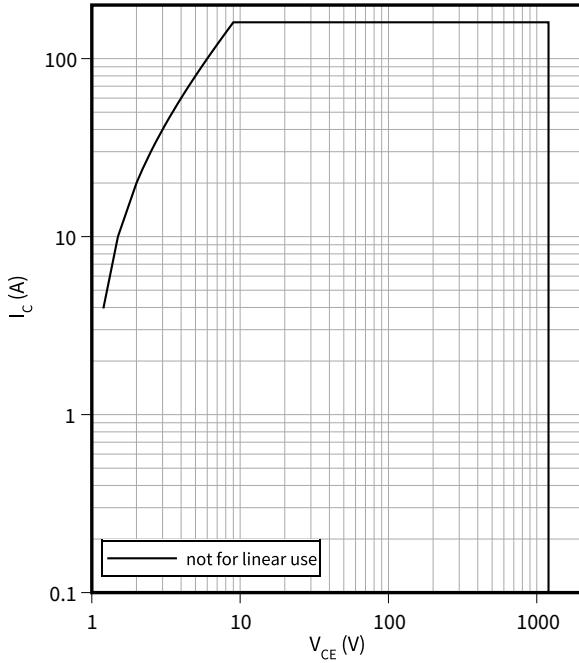
Dynamic test circuit, parasitic inductance  $L_{\sigma}$ , parasitic capacitor  $C_{\sigma}$  from Fig. E. Energy losses include “tail” and diode reverse recovery.

## 4 Characteristics diagrams

### Forward bias safe operating area

$$I_C = f(V_{CE})$$

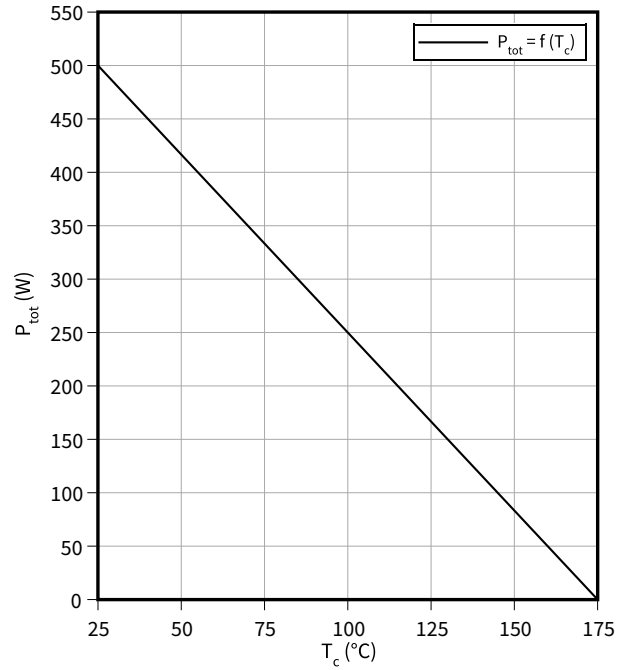
$$D = 0, T_{vj} \leq 175\text{ }^\circ\text{C}, V_{GE} = 15\text{ V}, T_c = 25\text{ }^\circ\text{C}$$



### Power dissipation as a function of case temperature

$$P_{tot} = f(T_c)$$

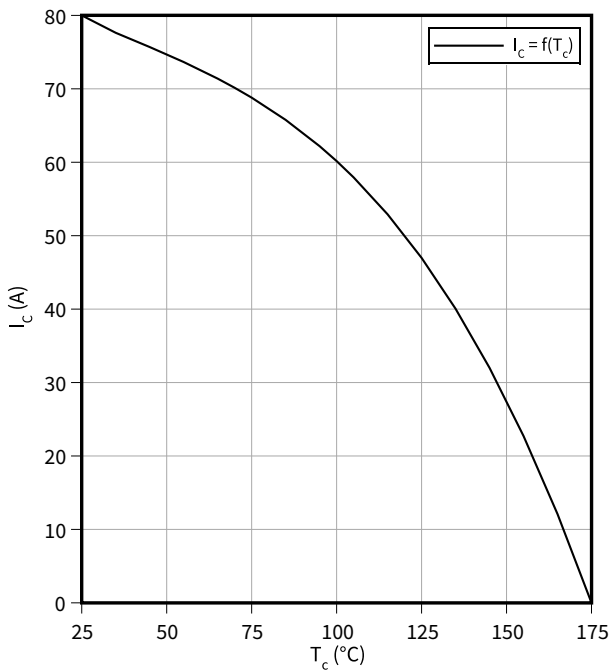
$$T_{vj} \leq 175\text{ }^\circ\text{C}$$



### Collector current as a function of case temperature

$$I_C = f(T_c)$$

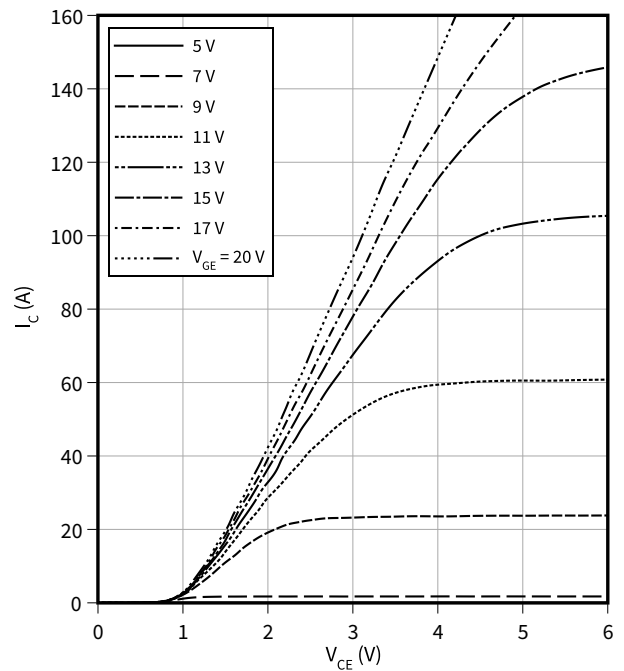
$$T_{vj} \leq 175\text{ }^\circ\text{C}, V_{GE} \geq 15\text{ V}$$



### Typical output characteristic

$$I_C = f(V_{CE})$$

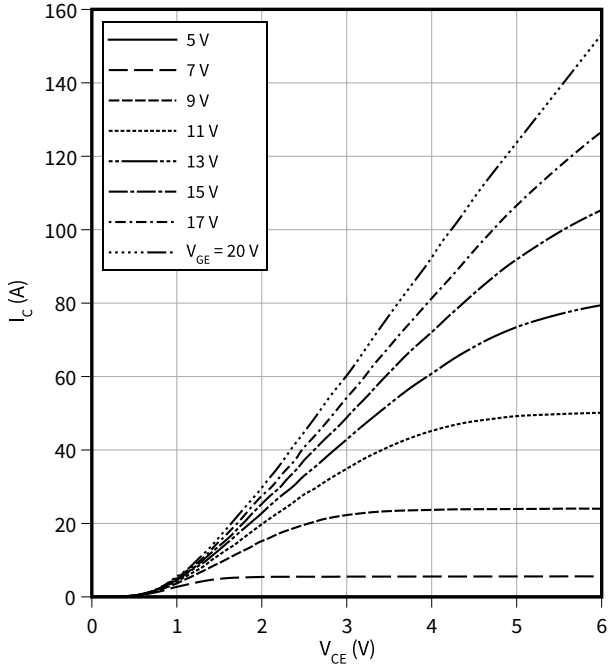
$$T_{vj} = 25\text{ }^\circ\text{C}$$



4 Characteristics diagrams

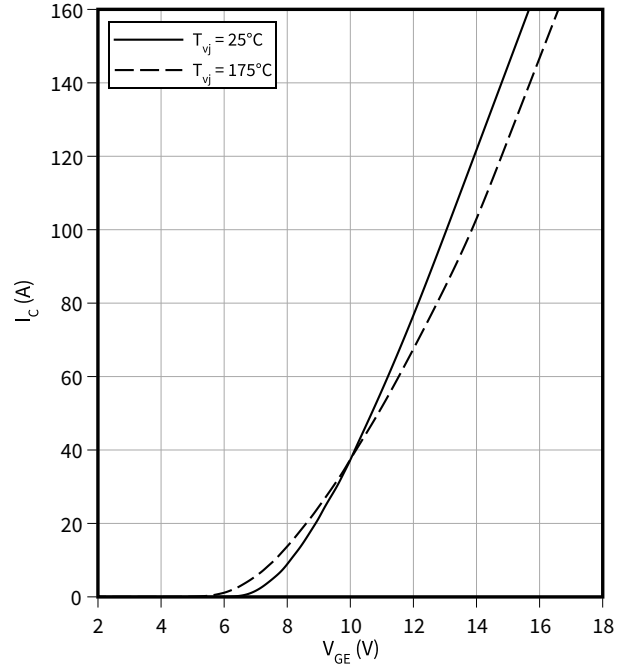
**Typical output characteristic**

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



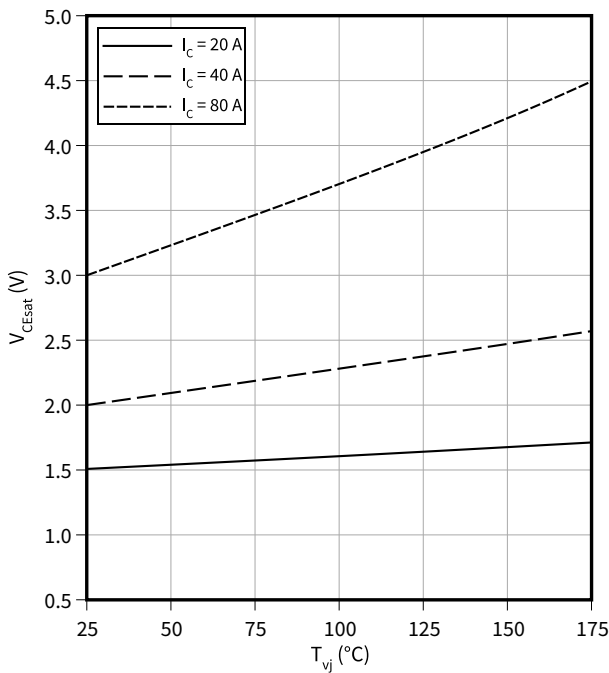
**Typical transfer characteristic**

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



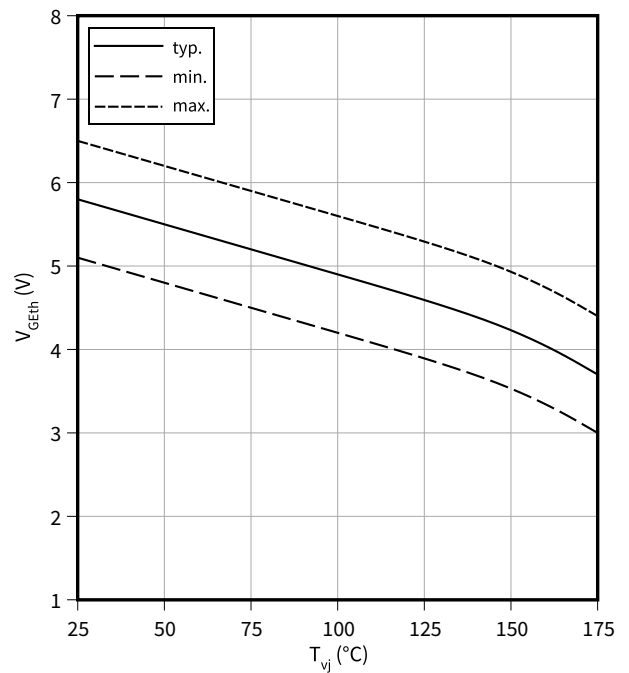
**Typical collector-emitter saturation voltage as a function of junction temperature**

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



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

$V_{Geth} = f(T_{vj})$   
 $I_C = 1.5\text{ mA}$

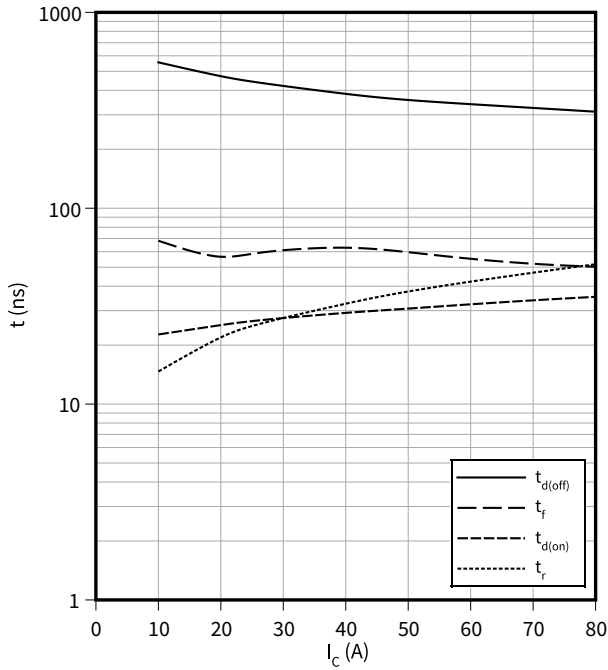


4 Characteristics diagrams

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

$t = f(I_C)$

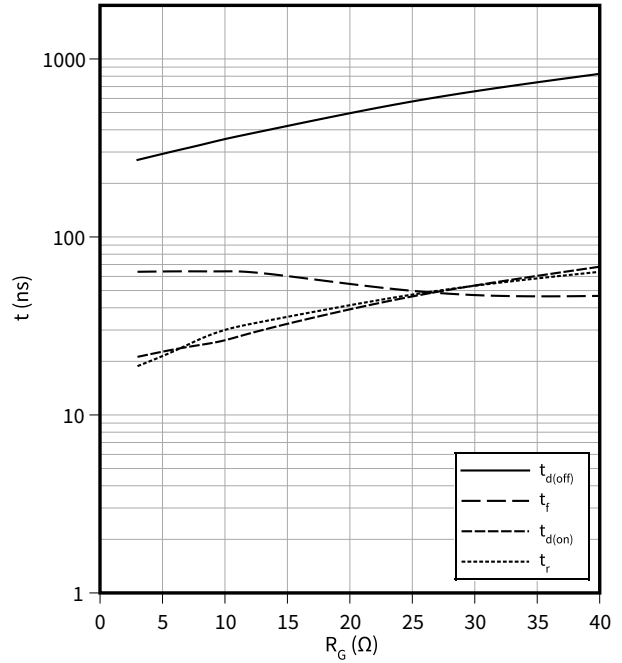
$V_{CC} = 600\text{ V}, T_{vj} = 175\text{ }^\circ\text{C}, V_{GE} = 0/15\text{ V}, R_G = 12\ \Omega$



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

$t = f(R_G)$

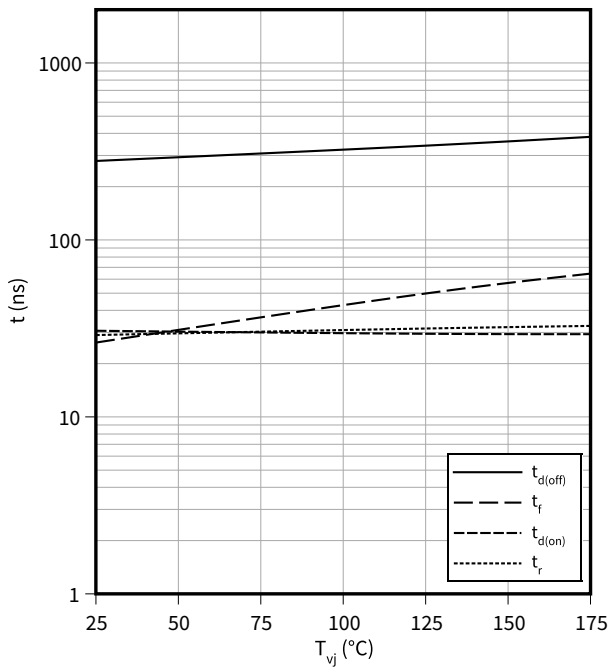
$I_C = 40\text{ A}, V_{CC} = 600\text{ V}, T_{vj} = 175\text{ }^\circ\text{C}, V_{GE} = 0/15\text{ V}$



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

$t = f(T_{vj})$

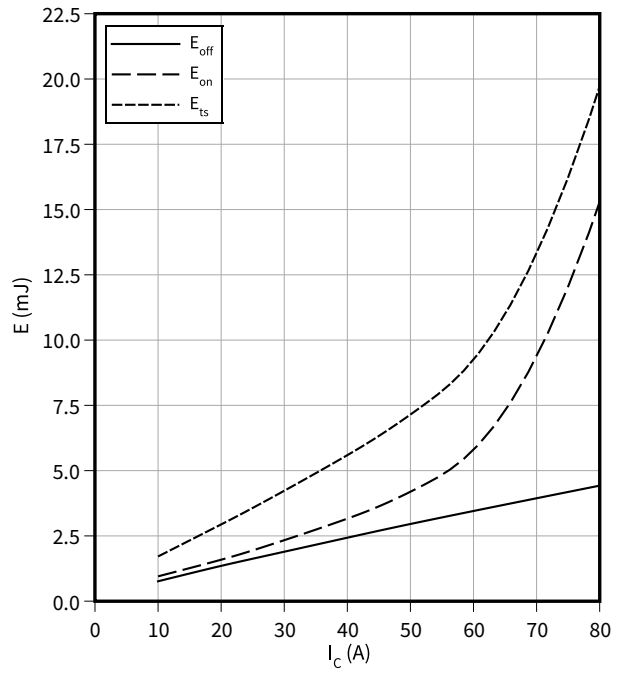
$I_C = 40\text{ A}, V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_G = 12\ \Omega$



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

$E = f(I_C)$

$V_{CC} = 600\text{ V}, T_{vj} = 175\text{ }^\circ\text{C}, V_{GE} = 0/15\text{ V}, R_G = 12\ \Omega$

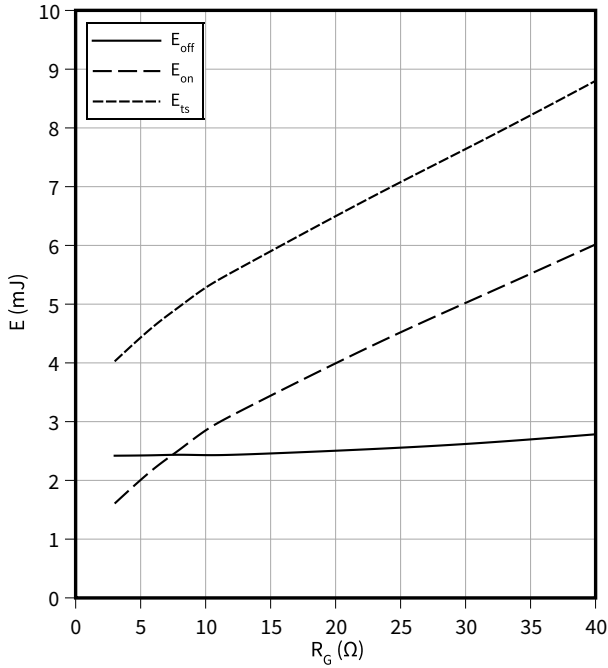


4 Characteristics diagrams

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

$E = f(R_G)$

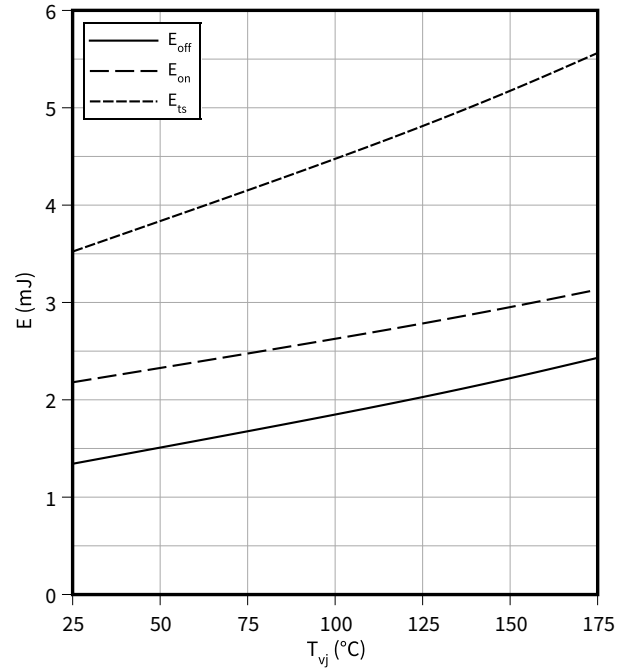
$I_C = 40\text{ A}, V_{CC} = 600\text{ V}, T_{vj} = 175\text{ }^\circ\text{C}, V_{GE} = 0/15\text{ V}$



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

$E = f(T_{vj})$

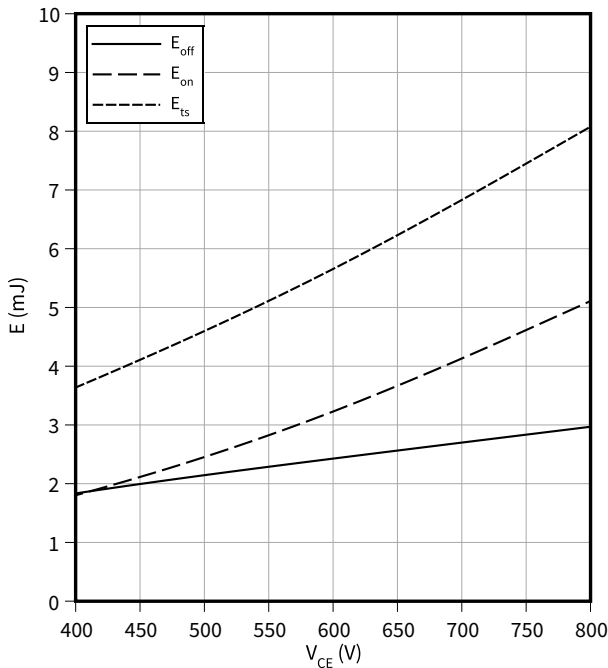
$I_C = 40\text{ A}, V_{CC} = 600\text{ V}, V_{GE} = 0/15\text{ V}, R_G = 12\text{ }^\circ\Omega$



**Typical switching energy losses as a function of collector emitter voltage**

$E = f(V_{CE})$

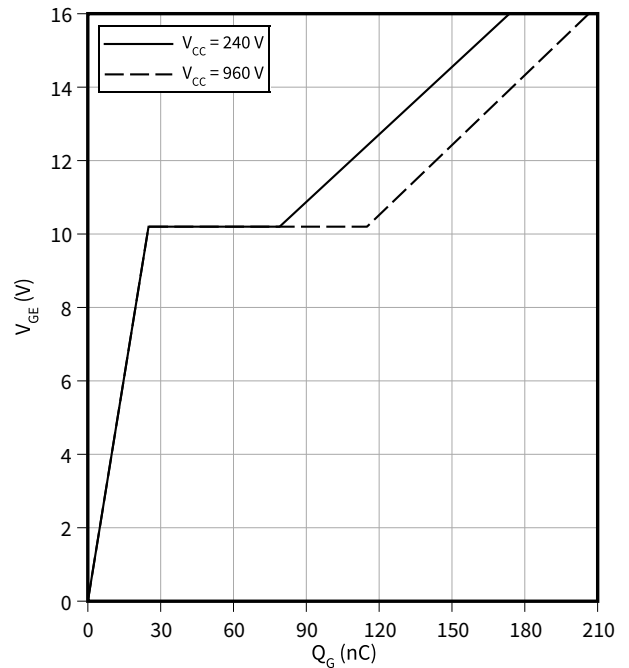
$I_C = 40\text{ A}, T_{vj} = 175\text{ }^\circ\text{C}, V_{GE} = 0/15\text{ V}, R_G = 12\text{ }^\circ\Omega$



**Typical gate charge**

$V_{GE} = f(Q_G)$

$I_C = 40\text{ A}$

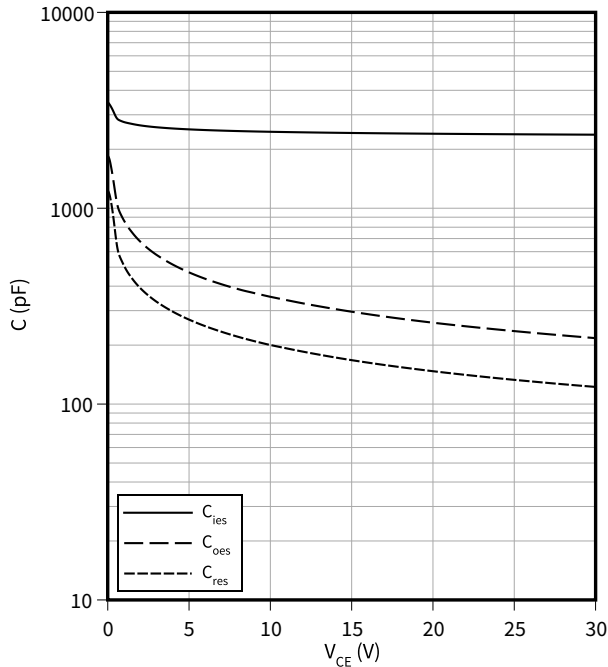


4 Characteristics diagrams

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

$C = f(V_{CE})$

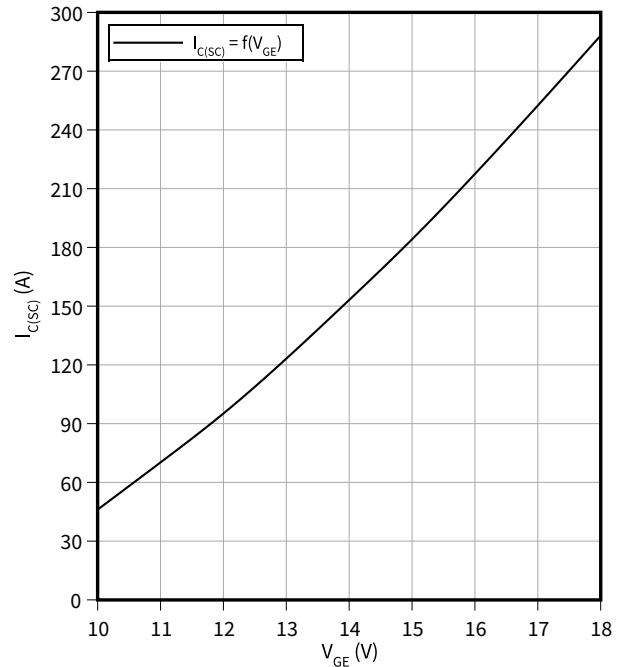
$f = 1000 \text{ kHz}, V_{GE} = 0 \text{ V}$



**Typical short circuit collector current as a function of gate-emitter voltage**

$I_{C(SC)} = f(V_{GE})$

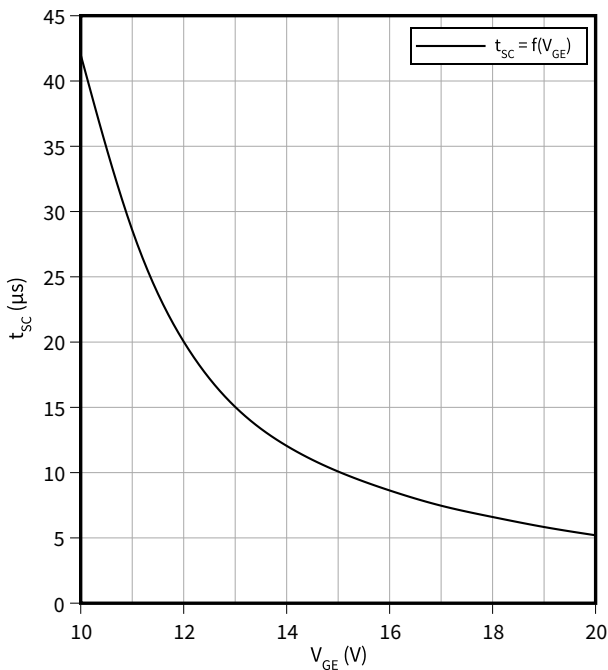
$T_{vj} \leq 175 \text{ }^\circ\text{C}, V_{CC} \leq 600 \text{ V}$



**Short circuit withstand time as a function of gate-emitter voltage**

$t_{SC} = f(V_{GE})$

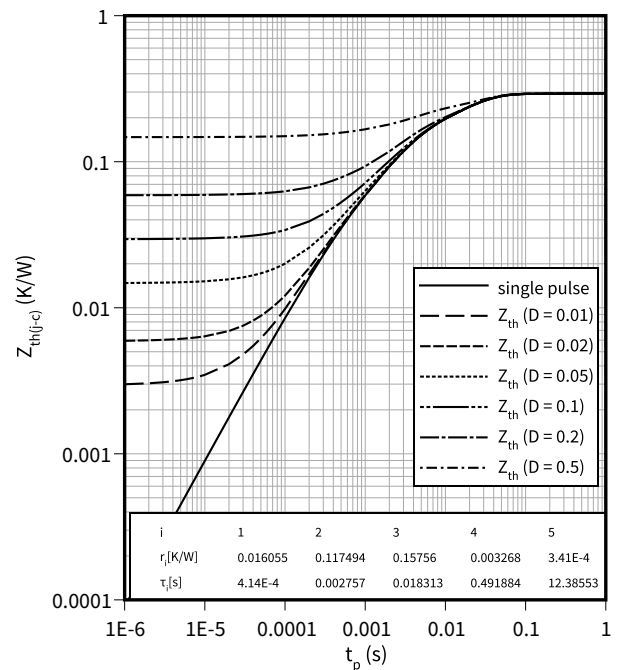
$T_{vj} \leq 175 \text{ }^\circ\text{C}, V_{CC} \leq 600 \text{ V}$



**IGBT transient thermal impedance as a function of pulse width**

$Z_{th(j-c)} = f(t_p)$

$D = t_p/T$

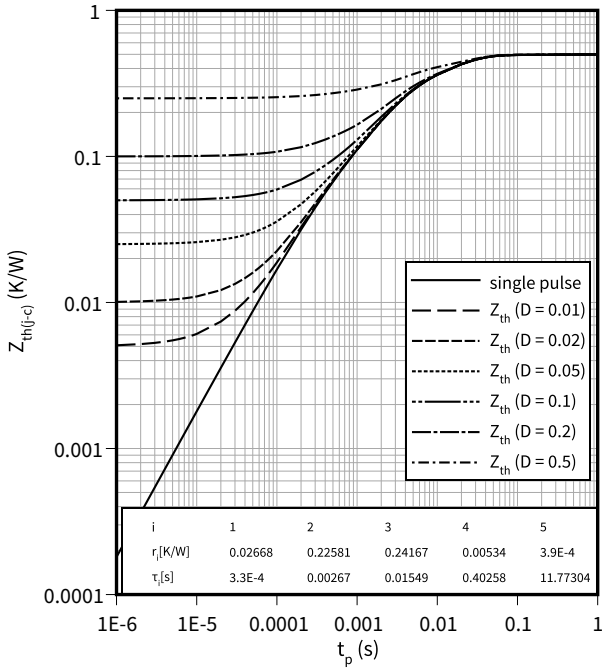


**4 Characteristics diagrams**

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

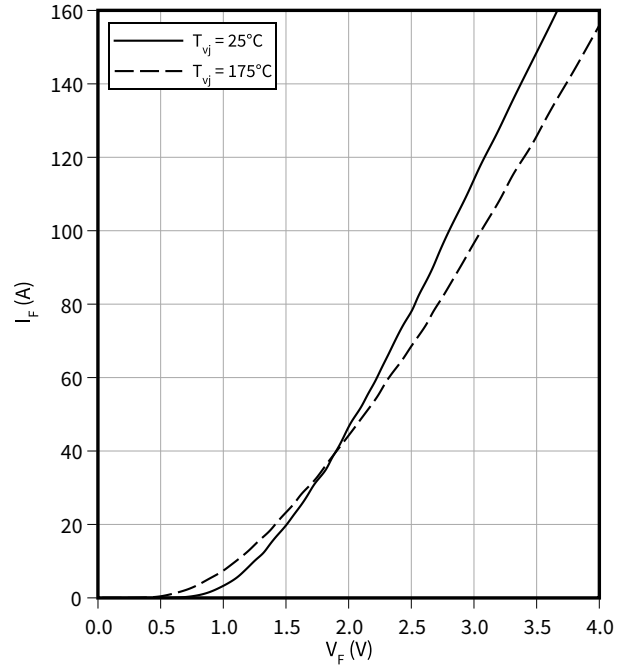
$$Z_{th(j-c)} = f(t_p)$$

$$D = t_p/T$$



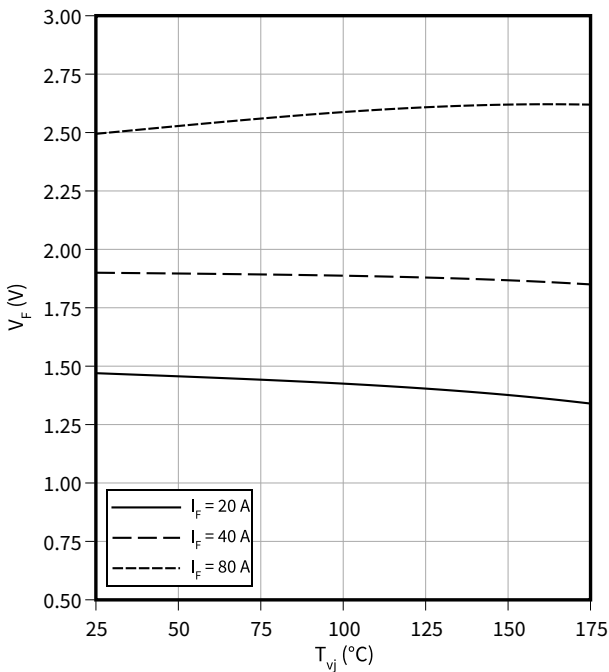
**Typical diode forward current as a function of forward voltage**

$$I_F = f(V_F)$$



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

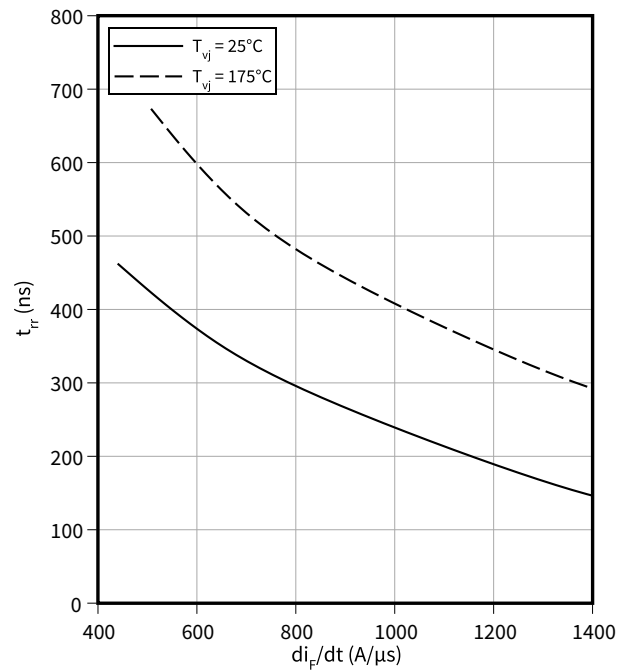
$$V_F = f(T_{vj})$$



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

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

$$V_R = 600 \text{ V}, I_F = 40 \text{ A}$$

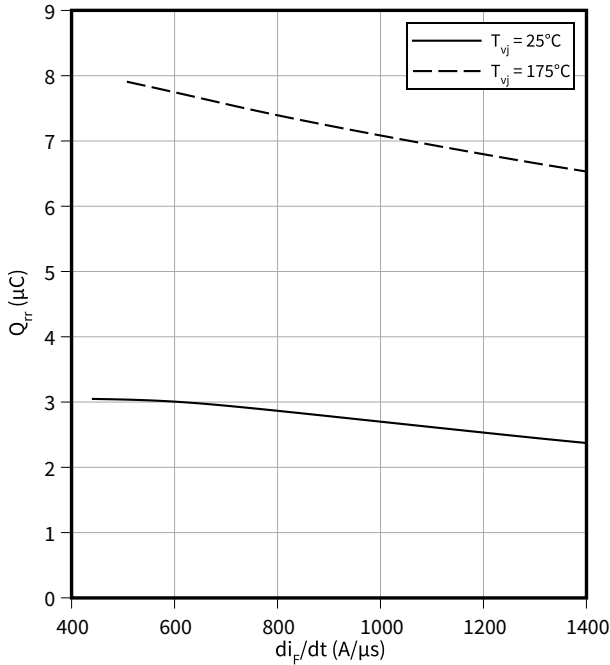


4 Characteristics diagrams

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

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

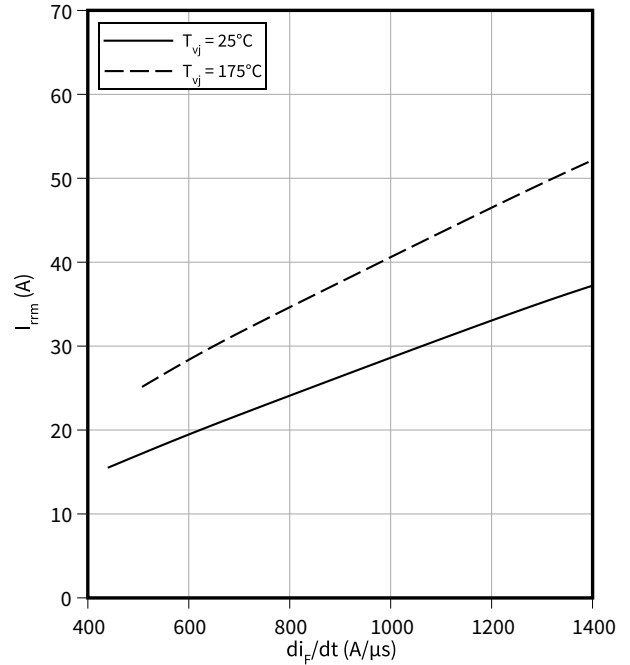
$V_R = 600\text{ V}, I_F = 40\text{ A}$



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

$I_{rrm} = f(di_F/dt)$

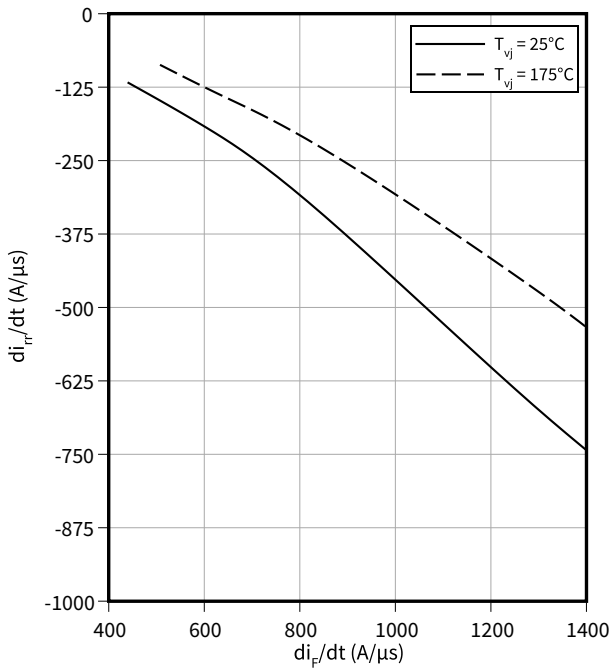
$V_R = 600\text{ V}, I_F = 40\text{ A}$



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

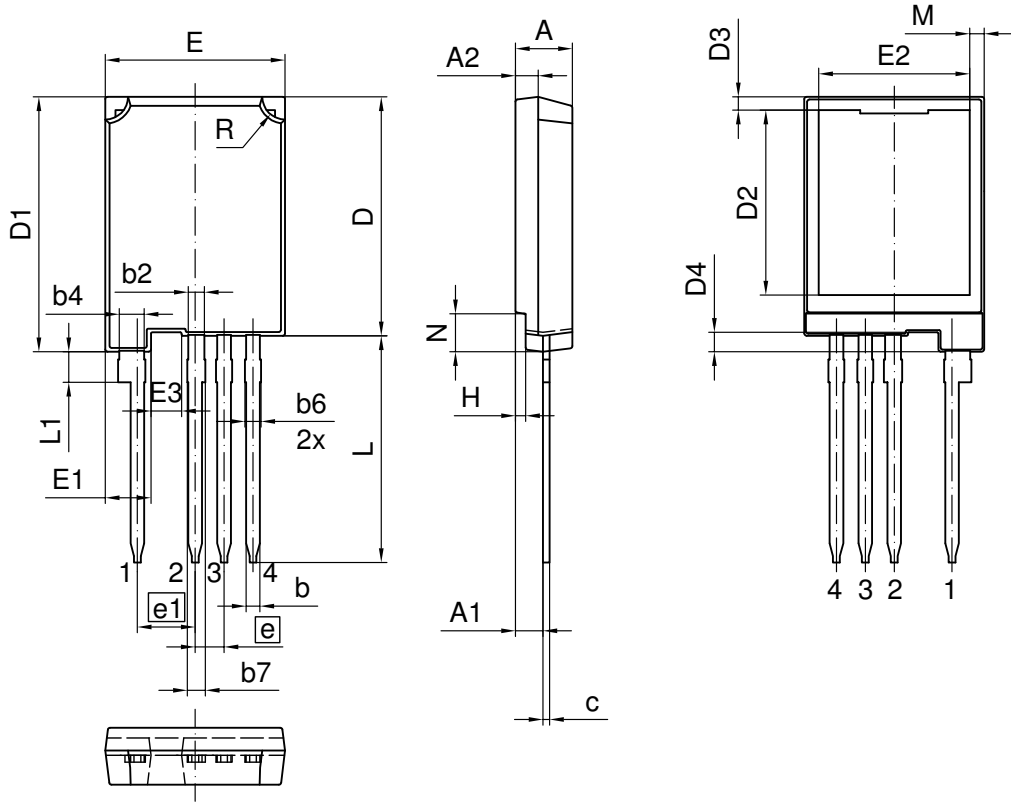
$di_{rr}/dt = f(di_F/dt)$

$V_R = 600\text{ V}, I_F = 40\text{ A}$



**5 Package outlines**

**PG-TO247-4-2**



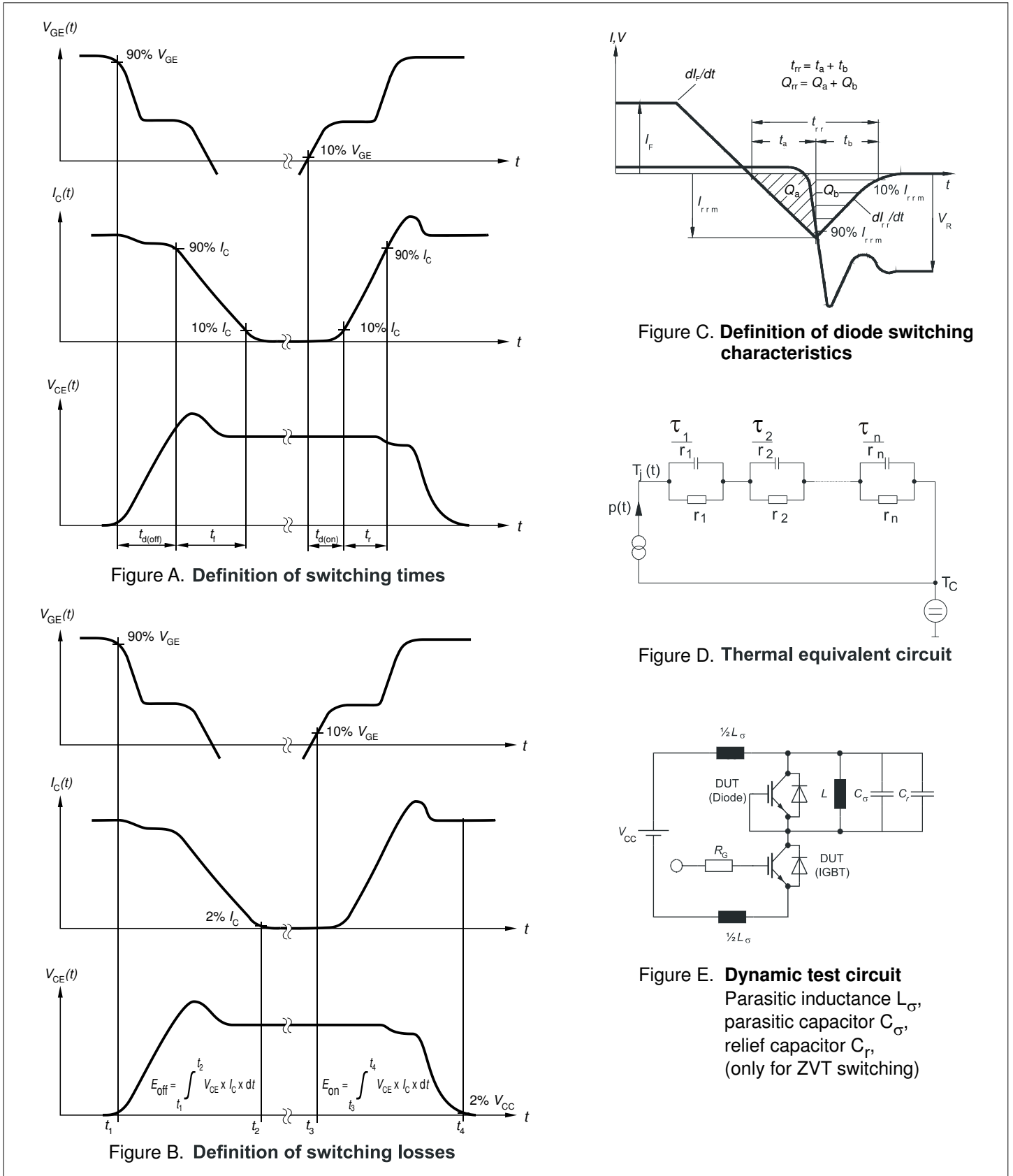
**NOTES:**  
 PACKAGE SURFACE ROUTE BETWEEN  
 PIN 1 & PIN 2 WILL BE 5.1mm MIN.  
 ALL b... AND c DIMENSIONS INCLUDING  
 PLATING EXCEPT AREA OF CUTTING

| DIMENSION | MILLIMETERS |       |
|-----------|-------------|-------|
|           | MIN.        | MAX.  |
| A         | 4.9         | 5.1   |
| A1        | 2.31        | 2.51  |
| A2        | 1.9         | 2.1   |
| b         | 1.16        | 1.29  |
| b2        | 1.36        | 1.49  |
| b4        | 2.16        | 2.29  |
| b6        | 1.16        | 1.45  |
| b7        | 1.16        | 1.65  |
| c         | 0.59        | 0.66  |
| D         | 20.9        | 21.1  |
| D1        | 22.3        | 22.5  |
| D2        | 15.95       | 16.55 |
| D3        | 1           | 1.35  |
| D4        | 1.6         | 1.8   |
| E         | 15.7        | 15.9  |
| E1        | 3.9         | 4.1   |
| E2        | 13.1        | 13.5  |
| E3        | 2.58        | 2.78  |
| e         | 2.54        |       |
| e1        | 5.08        |       |
| H         | 0.8         | 1     |
| L         | 19.8        | 20.1  |
| L1        | 2.55        | 2.85  |
| M         | 0.97        | 1.57  |
| N         | 3.24        | 3.44  |
| R         | 1.9         | 2.1   |

|                                    |
|------------------------------------|
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| <b>EUROPEAN PROJECTION</b><br>     |
| <b>ISSUE DATE</b><br>23.09.2016    |

**Figure 1**

**6 Testing conditions**



**Figure 2**

## Revision history

| Document revision | Date of release | Description of changes  |
|-------------------|-----------------|---|
| V2.1              | 2017-04-26      | Final data sheet  |
| V2.2              | 2017-06-09      | Update Figure 26  |
| V2.3              | 2019-04-15      | Update condition for V <sub>geth</sub> page 4 and Fig.11  |
| n/a               | 2020-11-30      | Datasheet migrated to a new system with a new layout and new revision number schema: target or preliminary datasheet = 0.xy; final datasheet = 1.xy |
| 1.10              | 2023-01-19      | Correction of diagram: “Typical switching energy losses as a function of junction temperature”  |

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**Document reference**

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