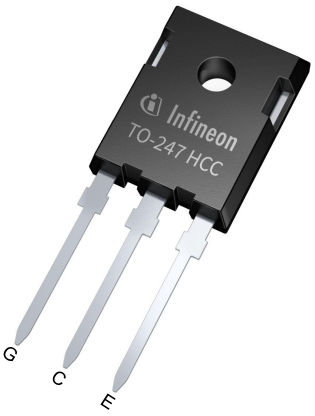
## TRENCHSTOP™ 5 WR6 technology in enhanced creepage and clearance package offers improved reliability against package contamination

### Features

- $V_{CE}$ = 650 V
- $I_C$ = 40 A
- Pin-to-pin creepage distance > 4.8 mm
- Pin-to-pin clearance distance > 3.4 mm
- Monolithic diode optimized for PFC and welding applications
- Stable temperature behavior
- Very low $V_{CEsat}$ and low $E_{off}$
- Easy parallel switching capability based on positive temperature coefficient of $V_{CEsat}$
- Low temperature dependence of $V_{CEsat}$ and $E_{sw}$
- Product spectrum and PSpice Models: http://www.infineon.com/igbt/




Lead-free
Green
Halogen-free
RoHS

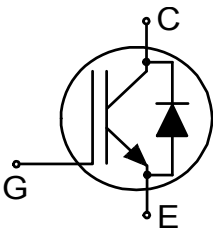
### Potential applications

- PFC
- Welding
- ZCS applications

### Product validation

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

### Description




| Type | Package | Marking |
|---|---|---|
| IKWH40N65WR6 | PG-TO247-3-STD-NN4.8 | H40EWR6 |

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# 1 Package

**Table 1 Characteristic values**

| Parameter | Symbol | Note or test condition | Values | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Internal emitter inductance measured 5 mm (0.197 in.) from case | $L_E$ | | | 13 | | nH |
| 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 |
| Mounting torque | $M$ | M3 screw, Maximum of mounting process: 3 | | | 0.6 | Nm |
| Thermal resistance, junction-ambient | $R_{th(j-a)}$ | | | | 40 | K/W |
| IGBT thermal resistance, junction-case | $R_{th(j-c)}$ | | | | 0.9 | K/W |
| Diode thermal resistance, junction-case | $R_{th(j-c)}$ | | | | 4.2 | K/W |

# 2 IGBT

**Table 2 Maximum rated values**

| Parameter | Symbol | Note or test condition | | Values | Unit |
|---|---|---|---|---|---|
| Collector-emitter voltage | $V_{CE}$ | $T_{vj} \geq 25$ °C | | 650 | V |
| DC collector current, limited by $T_{vjmax}$ | $I_C$ | | $T_c = 25$ °C | 70 | A |
| | | | $T_c = 100$ °C | 45 | |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$ | $I_{Cpulse}$ | | | 120 | A |
| Turn-off safe operating area | | $V_{CE} \leq 650$ V, $T_{vj} \leq 175$ °C | | 120 | A |
| Gate-emitter voltage | $V_{GE}$ | | | ±20 | V |
| Transient gate-emitter voltage | $V_{GE}$ | $t_p \leq 10$ µs, $D < 0.01$ | | ±30 | V |
| Power dissipation | $P_{tot}$ | | $T_c = 25$ °C | 175 | W |
| | | | $T_c = 100$ °C | 78 | |

**Table 3 Characteristic values**

| Parameter | Symbol | Note or test condition | Values | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Collector-emitter breakdown voltage | $V_{BRCES}$ | $I_C = 0.2$ mA, $V_{GE}=0$ V | 650 | | | 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 A, $V_{GE}$ = 15 V | $T_{vj}$ = 25 °C | | 1.55 | 1.85 | V |
| | | | $T_{vj}$ = 175 °C | | 1.8 | | |
| Gate-emitter threshold voltage | $V_{GEth}$ | $I_C$ = 0.4 mA, $V_{CE}$ = $V_{GE}$ | | 3.2 | 4 | 4.8 | V |
| Zero gate-voltage collector current | $I_{CES}$ | $V_{CE}$ = 650 V, $V_{GE}$=0 V | $T_{vj}$ = 25 °C | | | 40 | µA |
| | | | $T_{vj}$ = 175 °C | | 0.5 | | mA |
| Gate-emitter leakage current | $I_{GES}$ | $V_{CE}$=0 V, $V_{GE}$ = 20 V | | | | 100 | nA |
| Transconductance | $g_{fs}$ | $I_C$ = 40 A, $V_{CE}$ = 20 V | | | 89 | | S |
| Input capacitance | $C_{ies}$ | $V_{CE}$ = 25 V, $V_{GE}$=0 V, $f$ = 100 kHz | | | 2890 | | pF |
| Output capacitance | $C_{oes}$ | $V_{CE}$ = 25 V, $V_{GE}$=0 V, $f$ = 100 kHz | | | 28 | | pF |
| Reverse transfer capacitance | $C_{res}$ | $V_{CE}$ = 25 V, $V_{GE}$=0 V, $f$ = 100 kHz | | | 11 | | pF |
| Gate charge | $Q_G$ | $I_C$ = 40 A, $V_{GE}$ = 15 V, $V_{CC}$ = 520 V | | | 117 | | nC |
| Turn-on delay time | $t_{d(on)}$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 37 | | ns |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 34 | | |
| Rise time (inductive load) | $t_r$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 24 | | ns |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 25 | | |
| Turn-off delay time | $t_{d(off)}$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 353 | | ns |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 401 | | |
| Fall time (inductive load) | $t_f$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 23 | | ns |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 18 | | |
| Turn-on energy | $E_{on}$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 1.09 | | mJ |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 1.23 | | |

**(table continues...)**

**Table 3 (continued) Characteristic values**

| Parameter | Symbol | Note or test condition | | Values | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| Turn-off energy | $E_{off}$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 0.57 | | mJ |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 0.89 | | |
| Total switching energy | $E_{ts}$ | $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_{G(on)}$ = 27 Ω, $R_{G(off)}$ = 27 Ω, $L_\sigma$ = 30 nH, $C_\sigma$ = 26 pF | $T_{vj}$ = 25 °C, $I_C$ = 40 A | | 1.66 | | mJ |
| | | | $T_{vj}$ = 175 °C, $I_C$ = 40 A | | 2.12 | | |
| Operating junction temperature | $T_{vj}$ | | | -40 | | 175 | °C |

*Note: Electrical Characteristic, at $T_{vj}$ = 25°C, unless otherwise specified.*

# 3 Diode

**Table 4 Maximum rated values**

| Parameter | Symbol | Note or test condition | | Values | Unit |
|---|---|---|---|---|---|
| Repetitive peak reverse voltage | $V_{RRM}$ | $T_{vj}$ ≥ 25 °C | | 650 | V |
| Diode forward current, limited by $T_{vjmax}$ | $I_F$ | | $T_c$ = 25 °C | 20 | A |
| | | | $T_c$ = 100 °C | 11 | |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ | $I_{Fpulse}$ | | | 40 | A |

**Table 5 Characteristic values**

| Parameter | Symbol | Note or test condition | | Values | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| Diode forward voltage | $V_F$ | $I_F$ = 10 A | $T_{vj}$ = 25 °C | | 1.3 | 1.6 | V |
| | | | $T_{vj}$ = 175 °C | | 1.3 | | |
| Diode reverse recovery time | $t_{rr}$ | $V_R$ = 400 V | $T_{vj}$ = 25 °C, $I_F$ = 20 A, $-di_F/dt$ = 1460 A/µs | | 79 | | ns |
| | | | $T_{vj}$ = 175 °C, $I_F$ = 20 A, $-di_F/dt$ = 1350 A/µs | | 104 | | |

**(table continues...)**

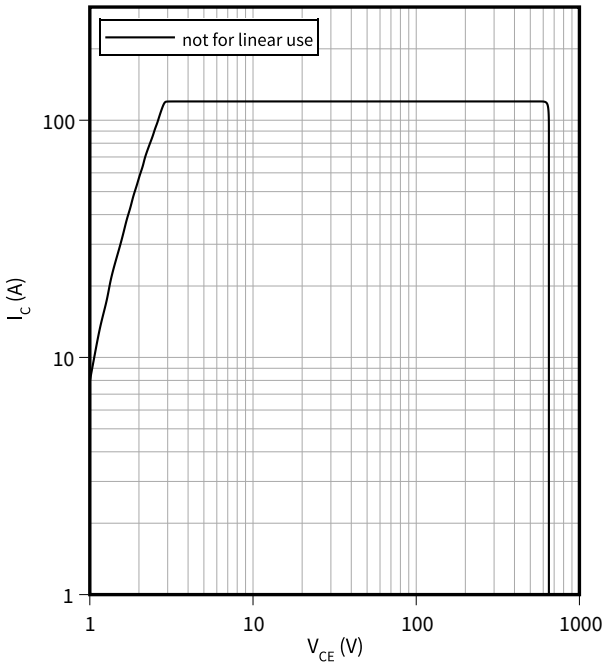
**Table 5 (continued) Characteristic values**

| Parameter | Symbol | Note or test condition | | Values | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| Diode reverse recovery charge | $Q_{rr}$ | $V_R$ = 400 V | $T_{vj}$ = 25 °C, $I_F$ = 20 A, $-di_F/dt$ = 1460 A/µs | | 1.4 | | µC |
| | | | $T_{vj}$ = 175 °C, $I_F$ = 20 A, $-di_F/dt$ = 1350 A/µs | | 2.5 | | |
| Diode peak reverse recovery current | $I_{rrm}$ | $V_R$ = 400 V | $T_{vj}$ = 25 °C, $I_F$ = 20 A, $-di_F/dt$ = 1460 A/µs | | 24.7 | | A |
| | | | $T_{vj}$ = 175 °C, $I_F$ = 20 A, $-di_F/dt$ = 1350 A/µs | | 38.3 | | |
| Diode peak rate of fall of reverse recovery current | $di_{rr}/dt$ | $V_R$ = 400 V | $T_{vj}$ = 25 °C, $I_F$ = 20 A, $-di_F/dt$ = 1460 A/µs | | 383 | | A/µs |
| | | | $T_{vj}$ = 175 °C, $I_F$ = 20 A, $-di_F/dt$ = 1350 A/µs | | 821 | | |
| Operating junction temperature | $T_{vj}$ | | | -40 | | 175 | °C |

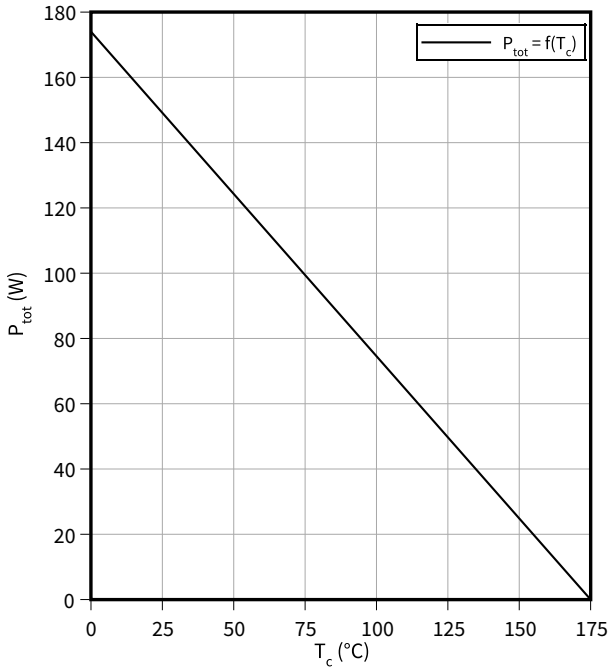
*Note: For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.*

# 4 Characteristics diagrams

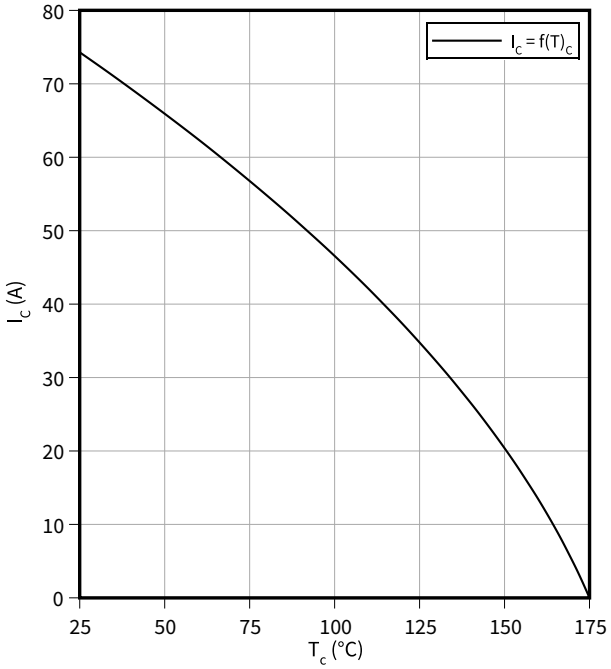
**Reverse bias safe operating area**
$I_C = f(V_{CE})$
$T_{vj} \leq 175\ °C$, $T_c = 25\ °C$, $V_{GE} = 15\ V$



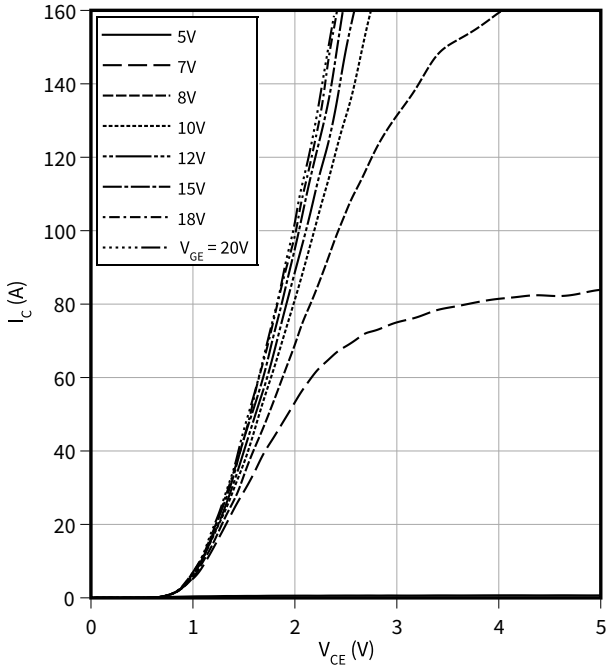

**Power dissipation as a function of case temperature**
$P_{tot} = f(T_c)$
$T_{vj} \leq 175\ °C$




**Collector current as a function of case temperature**
$I_C = f(T_c)$
$T_{vj} \leq 175\ °C$, $V_{GE} \geq 15\ V$



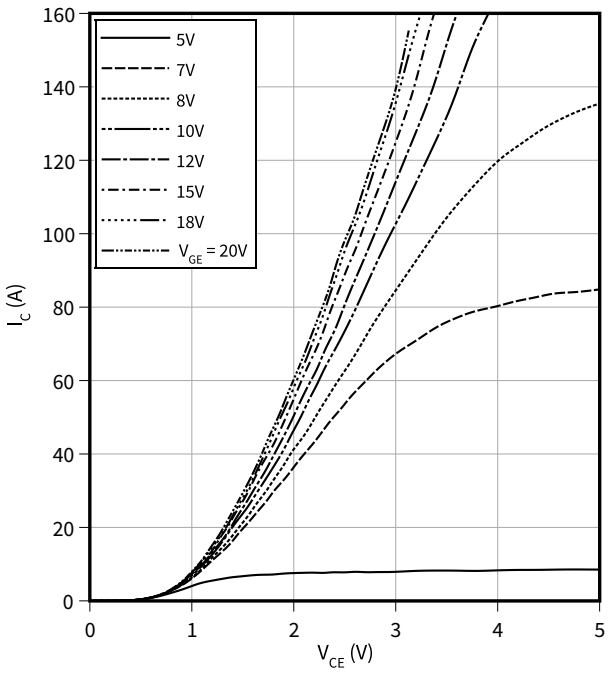

**Typical output characteristic**
$I_C = f(V_{CE})$
$T_{vj} = 25\ °C$



**4 Characteristics diagrams**

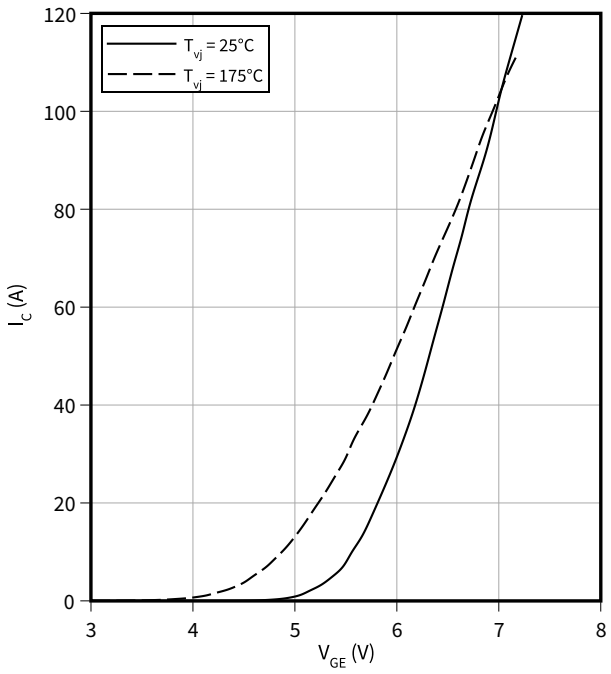
### Typical output characteristic

$I_C = f(V_{CE})$
$T_{vj} = 175\ °C$



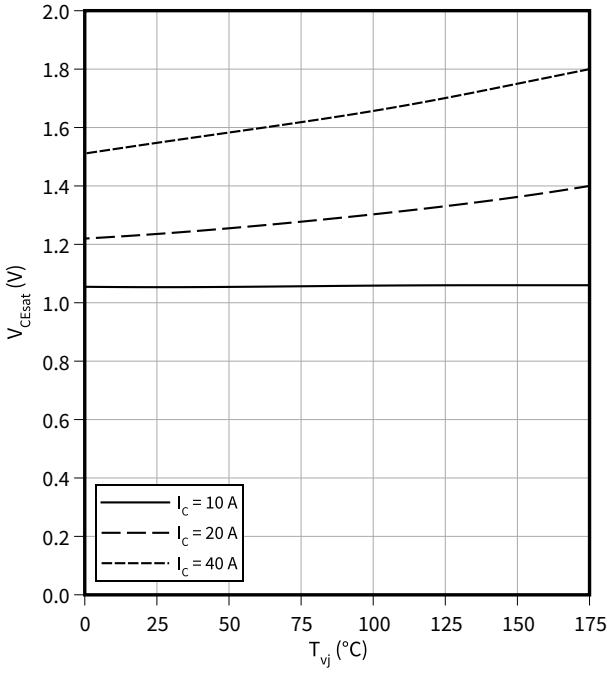

### Typical transfer characteristic

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



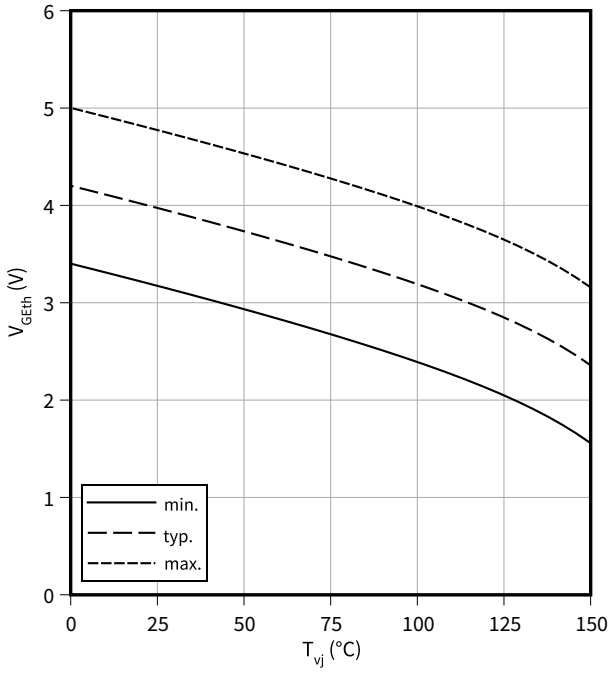

### Typical collector-emitter saturation voltage as a function of junction temperature

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




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

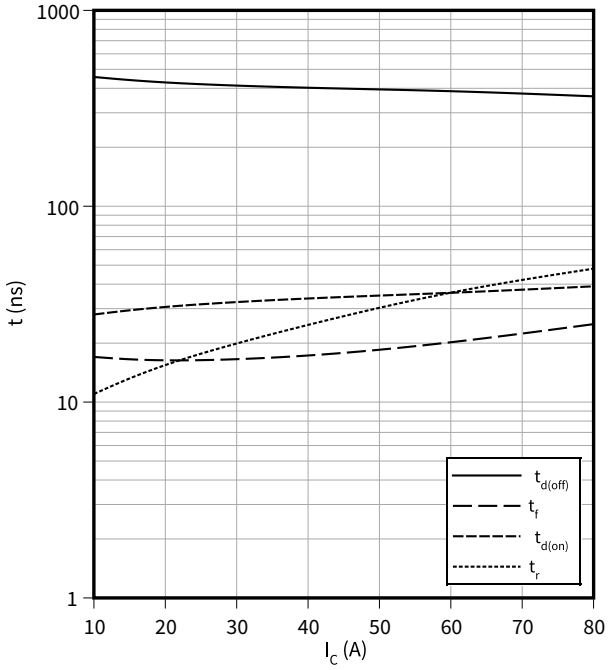
$V_{GEth} = f(T_{vj})$
$I_C = 0.4\ mA$



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

$t = f(I_C)$

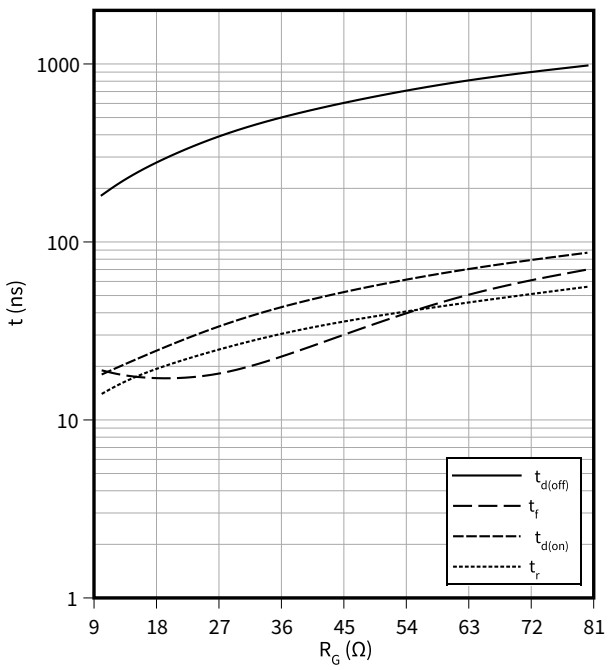
$V_{CC}$ = 400 V, $T_{vj}$ = 175 °C, $V_{GE}$ = 0/15 V, $R_G$ = 27 Ω




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

$t = f(R_G)$

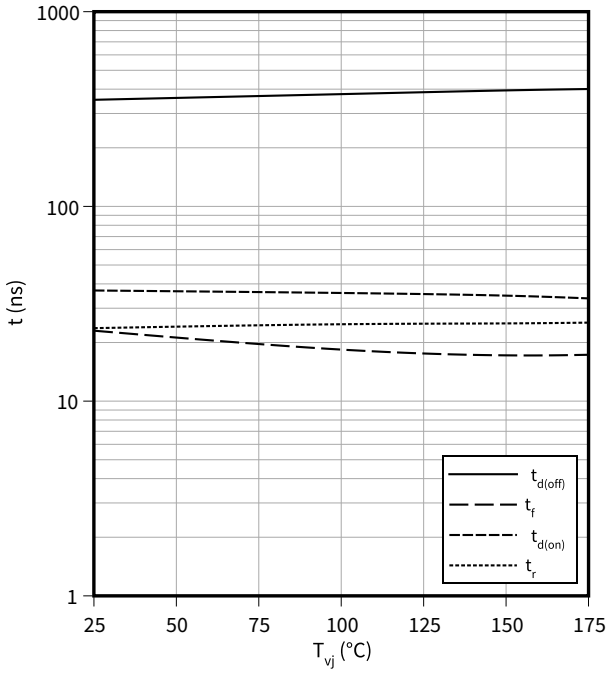
$I_C$ = 40 A, $V_{CC}$ = 400 V, $T_{vj}$ = 175 °C, $V_{GE}$ = 0/15 V




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

$t = f(T_{vj})$

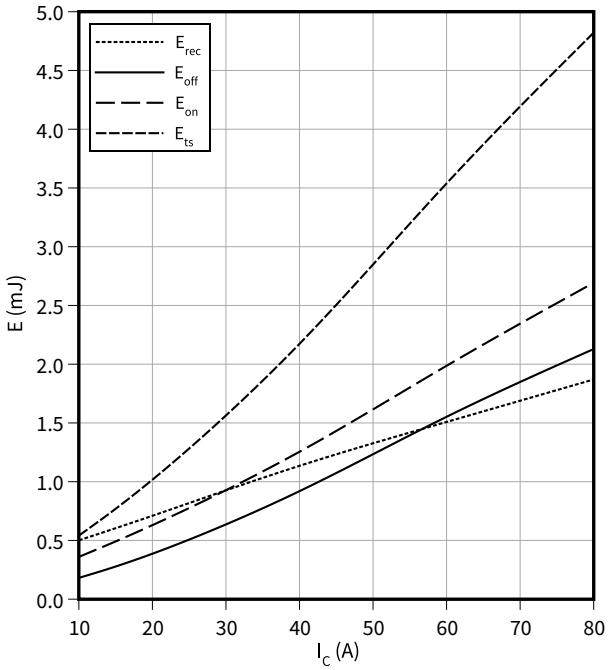
$I_C$ = 40 A, $V_{CC}$ = 400 V, $V_{GE}$ = 0/15 V, $R_G$ = 27 Ω




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

$E = f(I_C)$

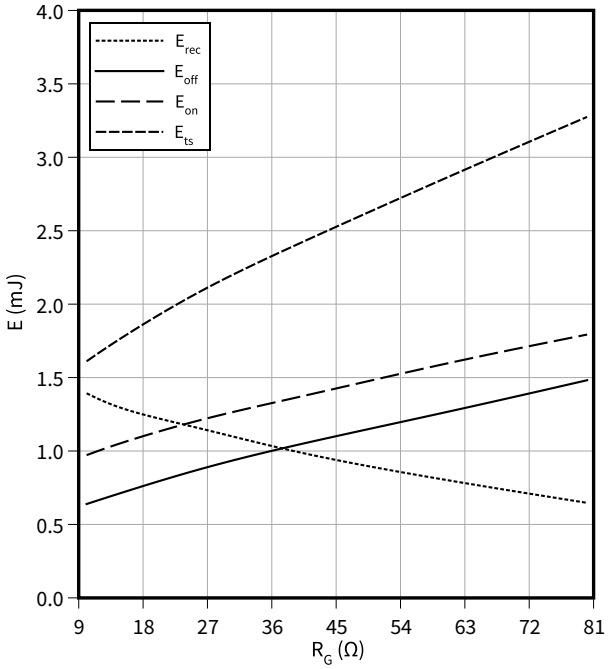
$V_{CC}$ = 400 V, $T_{vj}$ = 175 °C, $V_{GE}$ = 0/15 V, $R_G$ = 27 Ω



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

$E = f(R_G)$

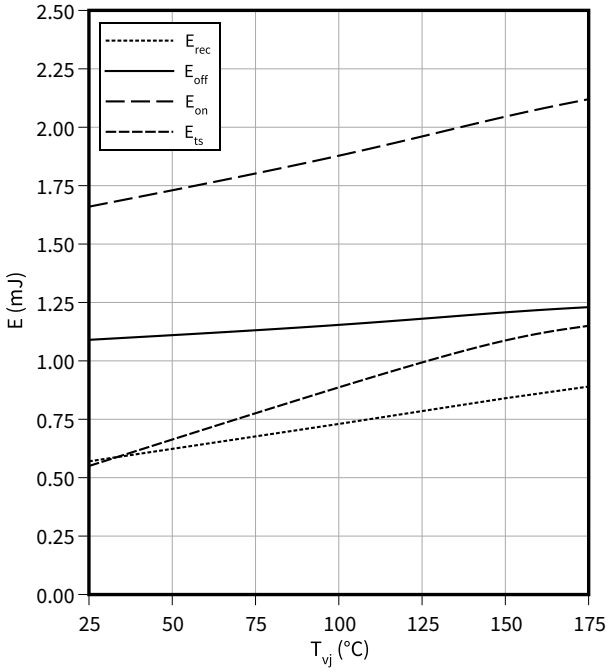
$I_C = 40\ A, V_{CC} = 400\ V, T_{vj} = 175\ °C, V_{GE} = 0/15\ V$




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

$E = f(T_{vj})$

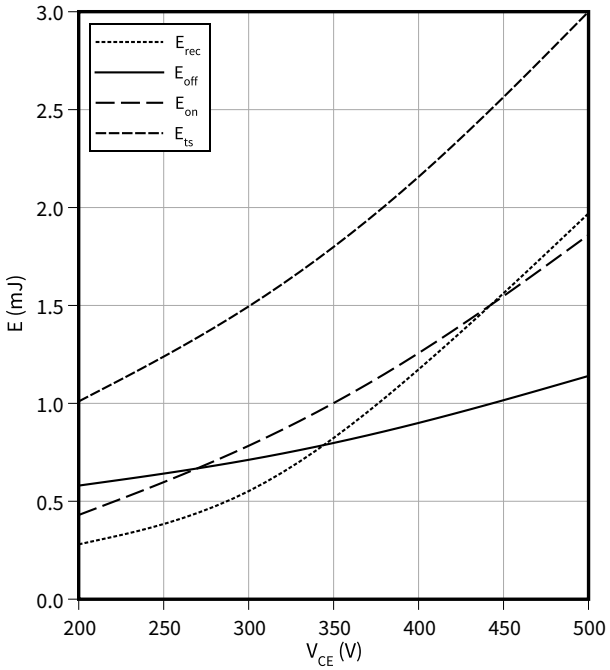
$I_C = 40\ A, V_{CC} = 400\ V, V_{GE} = 0/15\ V, R_G = 27\ Ω$




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

$E = f(V_{CE})$

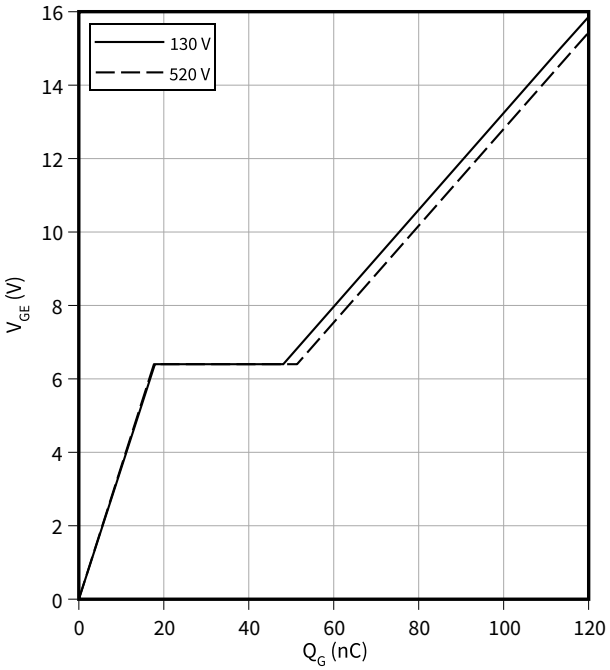
$I_C = 40\ A, T_{vj} = 175\ °C, V_{GE} = 0/15\ V, R_G = 27\ Ω$




### Typical gate charge

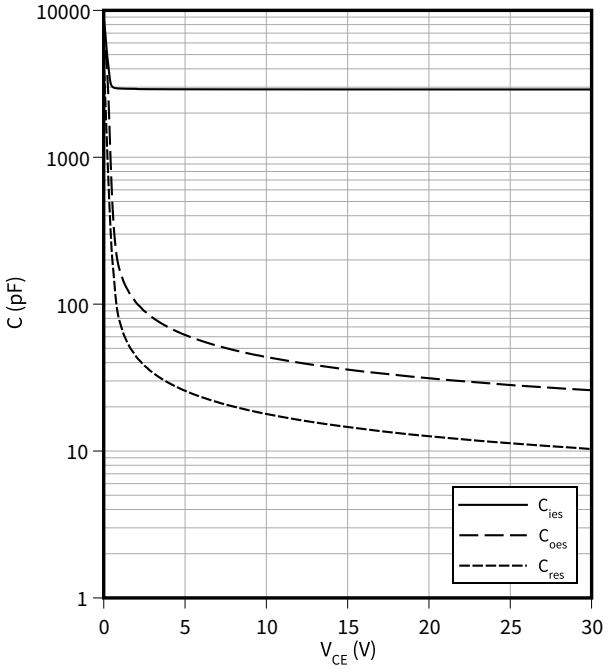
$V_{GE} = f(Q_G)$

$I_C = 40\ A$



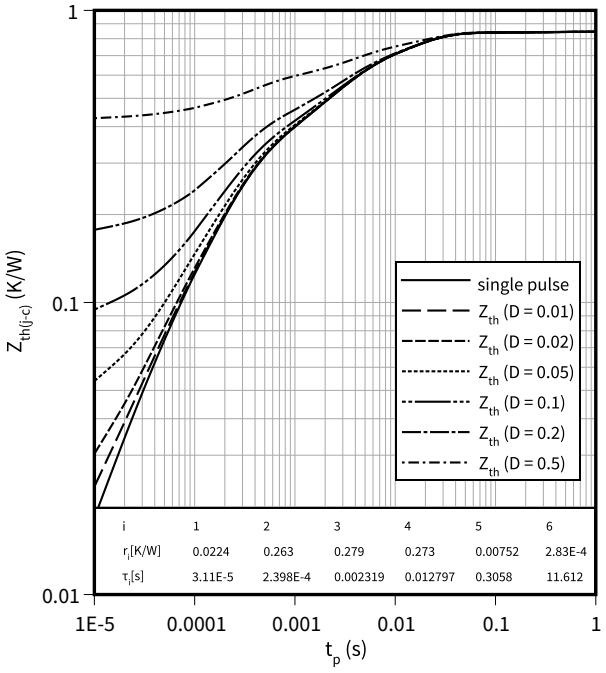
### Typical capacitance as a function of collector-emitter voltage

$C = f(V_{CE})$
$f = 100\ kHz, V_{GE} = 0\ V$



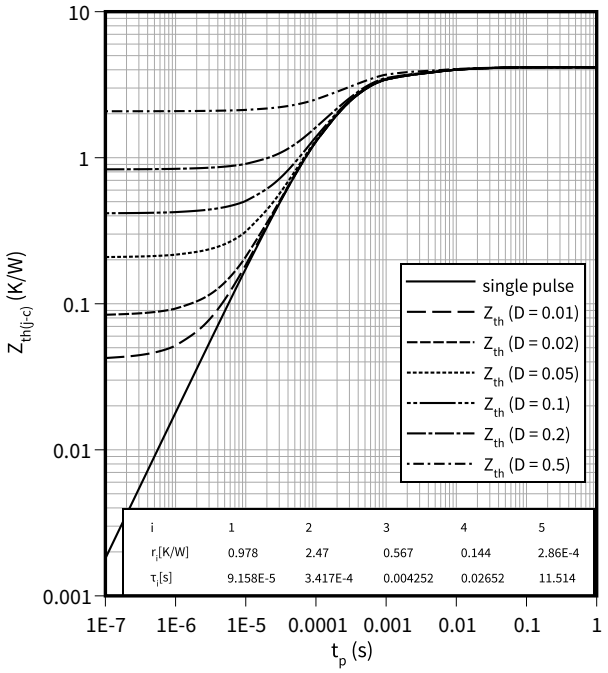

### IGBT transient thermal impedance as a function of pulse width

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



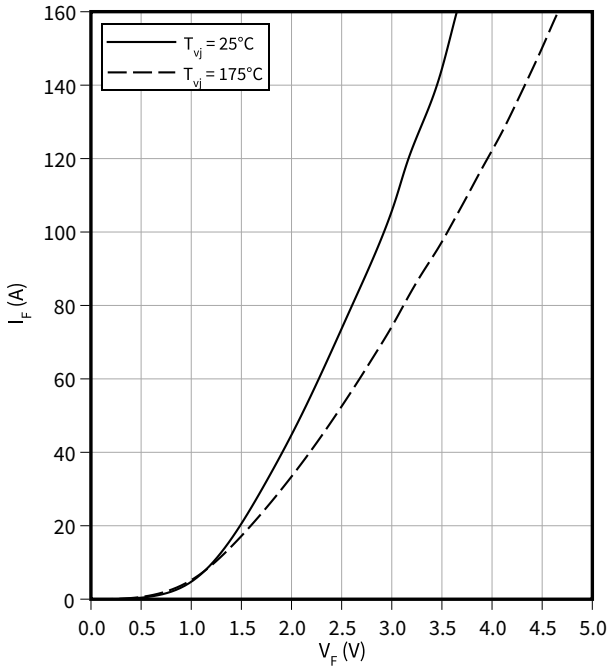

### Diode transient thermal impedance as a function of pulse width

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



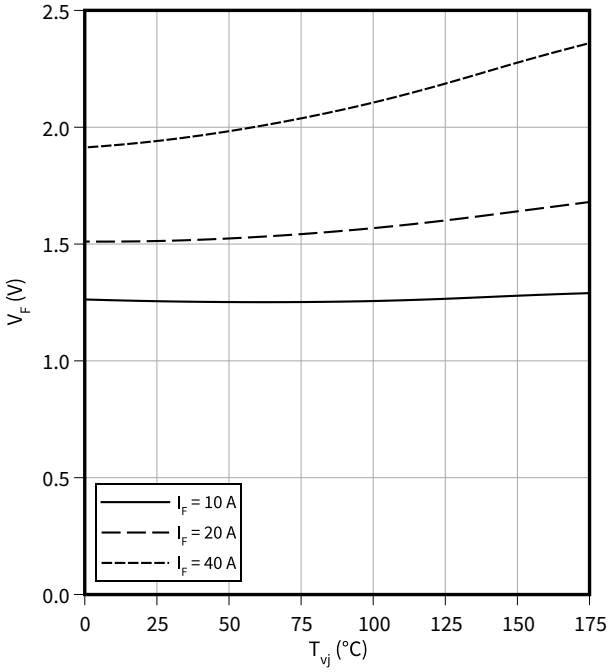

### Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



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

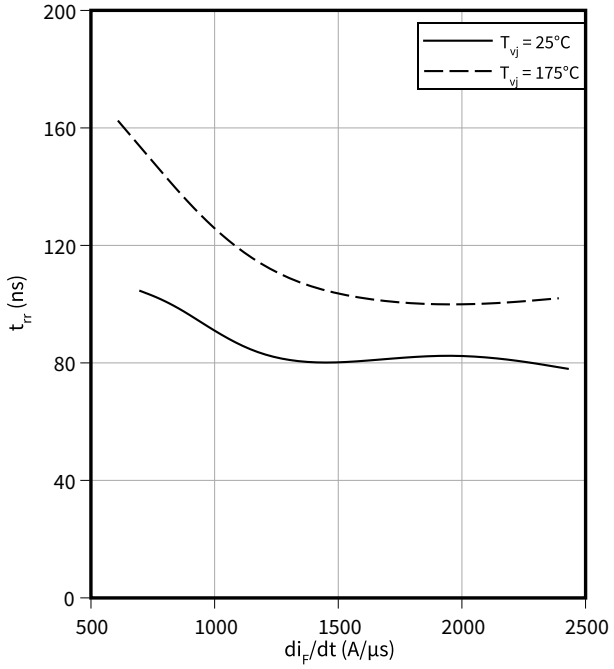
$V_F = f(T_{vj})$




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

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

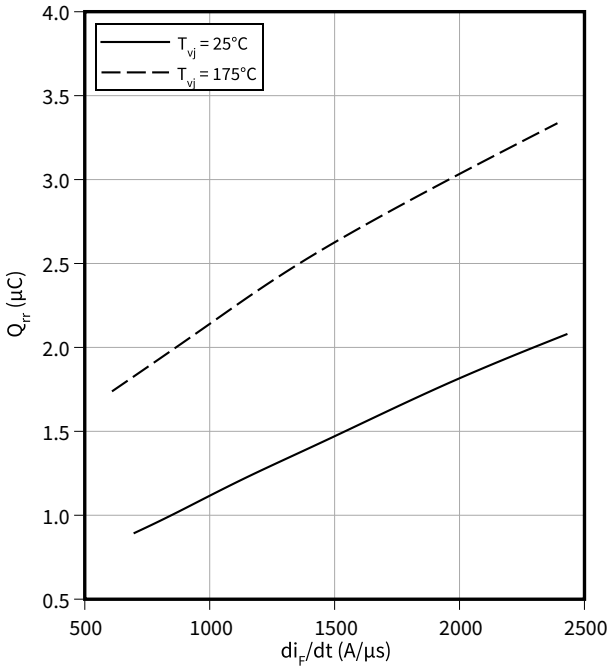
$V_R$ = 400 V, $I_F$ = 20 A




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

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

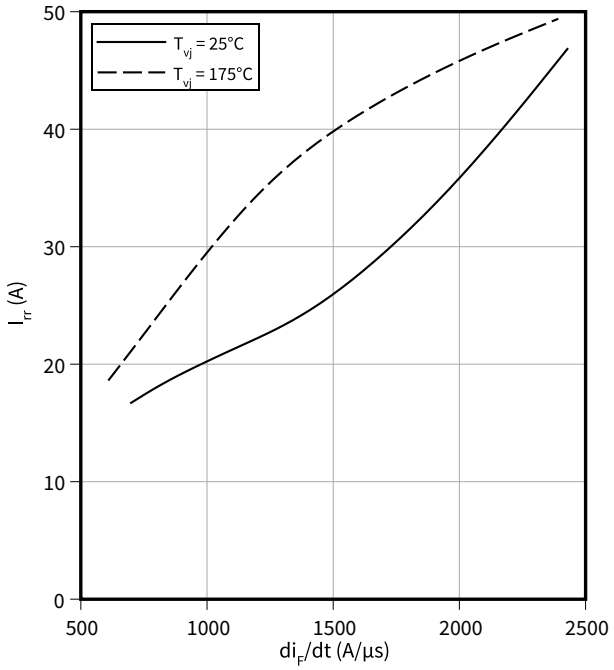
$I_F$ = 20 A, $V_R$ = 400 V




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

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

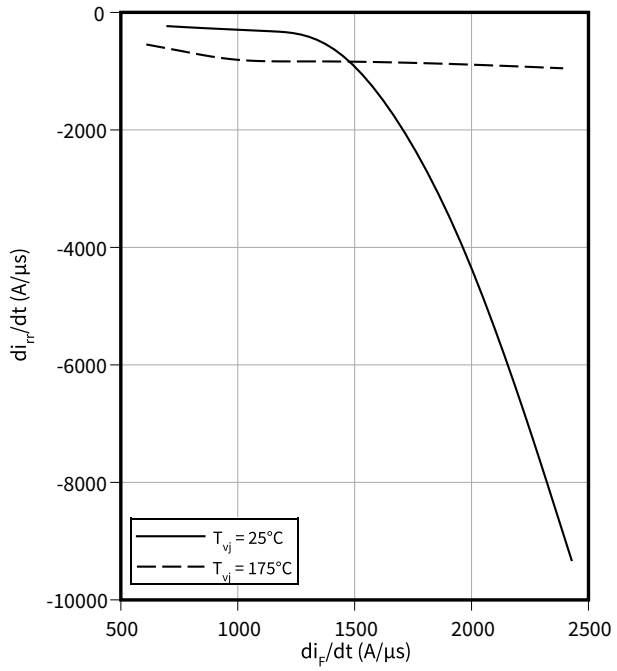
$I_F$ = 20 A, $V_R$ = 400 V



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

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

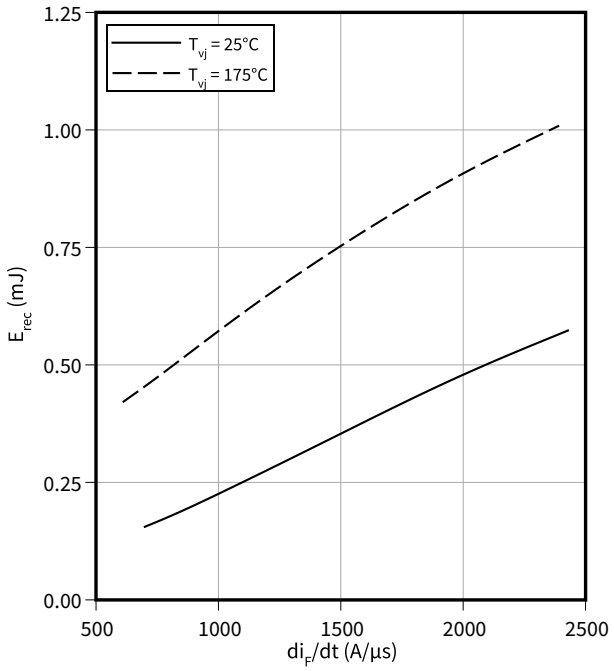
$V_R = 400\ V$, $I_F = 20\ A$




### Typical reverse energy losses as a function of diode current slope

$E_{rec} = f(di_F/dt)$

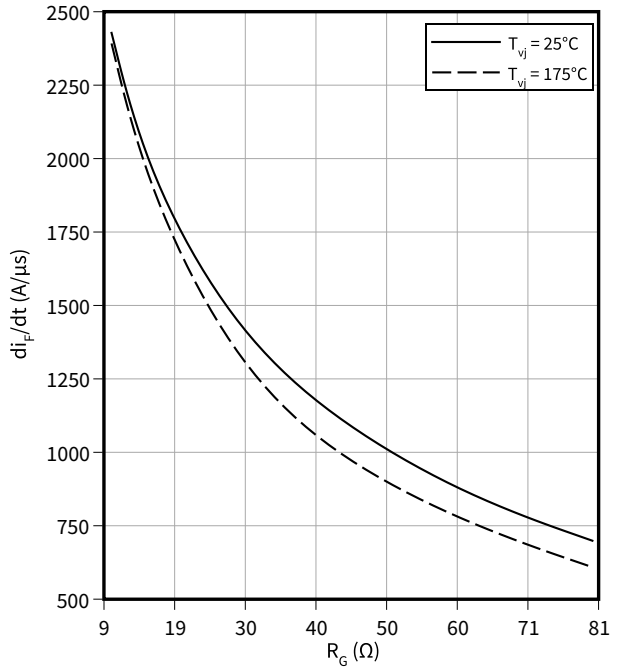
$V_R = 400\ V$, $I_F = 20\ A$




### Typical diode current slope as a function of gate resistor

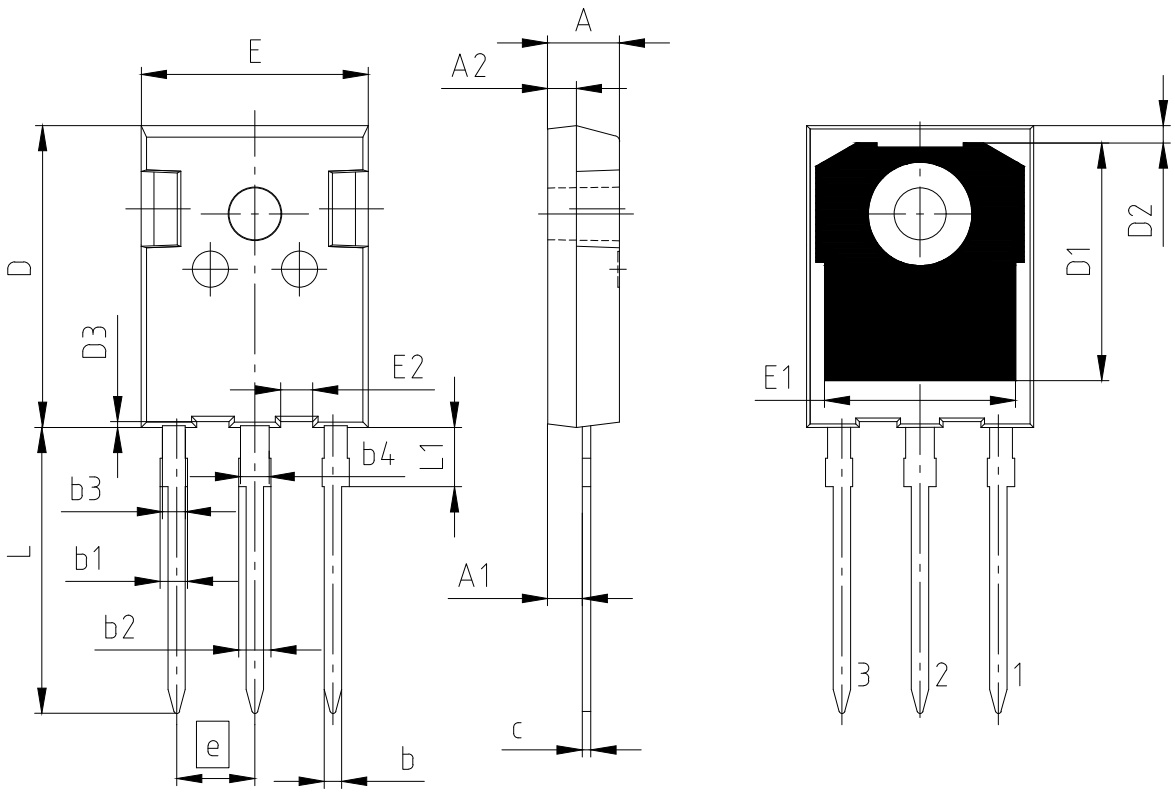
$di_F/dt = f(R_G)$

$V_R = 400\ V$, $I_F = 20\ A$



# 5 Package outlines

**PG-TO247-3-STD-NN4.8**




| PACKAGE - GROUP NUMBER: | PG-TO247-3-U04 | |
|---|---|---|
| **DIMENSIONS** | **MILLIMETERS** | |
| | MIN. | MAX. |
| **A** | 4.90 | 5.10 |
| **A1** | 2.31 | 2.51 |
| **A2** | 1.90 | 2.10 |
| **b** | 1.16 | 1.26 |
| **b1** | | 1.90 |
| **b2** | | 2.30 |
| **b3** | 1.55 | 1.65 |
| **b4** | 1.96 | 2.06 |
| **c** | 0.59 | 0.66 |
| **D** | 20.90 | 21.10 |
| **D1** | 16.25 | 16.85 |
| **D2** | 1.05 | 1.35 |
| **D3** | 0.55 | 0.65 |
| **E** | 15.70 | 15.90 |
| **E1** | 13.10 | 13.50 |
| **E2** | 2.14 | 2.34 |
| **e** | 5.44 | |
| **N** | 3 | |
| **L** | 19.80 | 20.10 |
| **L1** | 3.95 | 4.30 |

**Figure 1**

# 6 Testing conditions

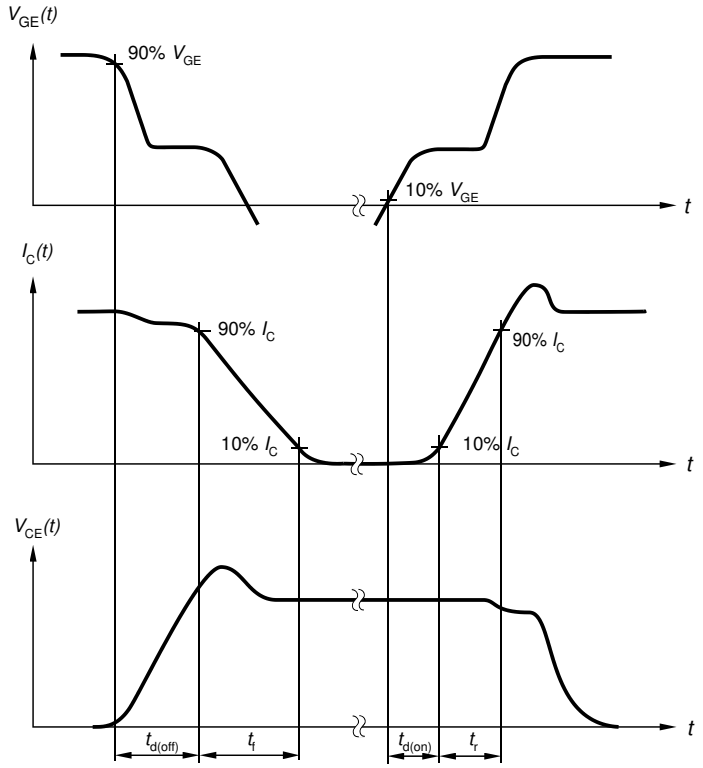



Figure A. **Definition of switching times**

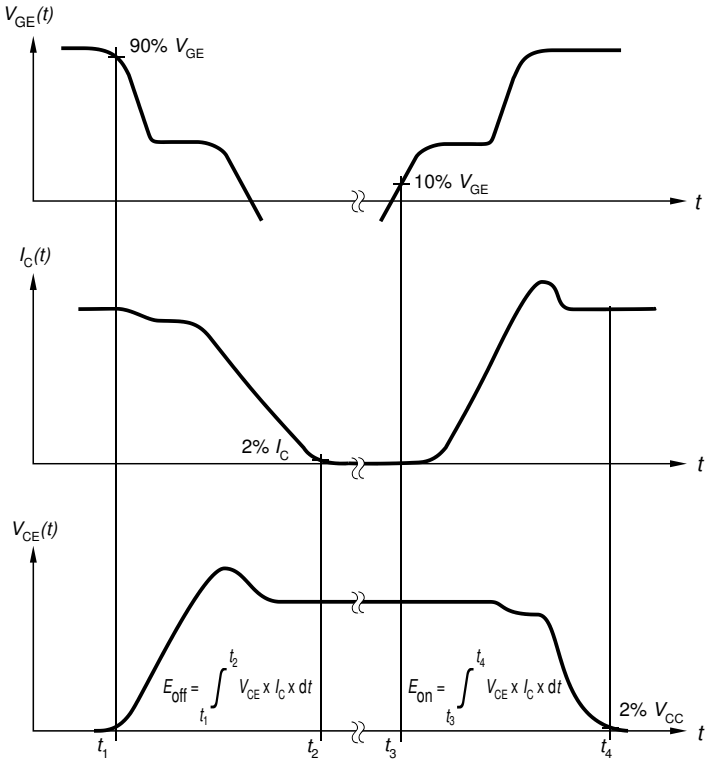



Figure B. **Definition of switching losses**

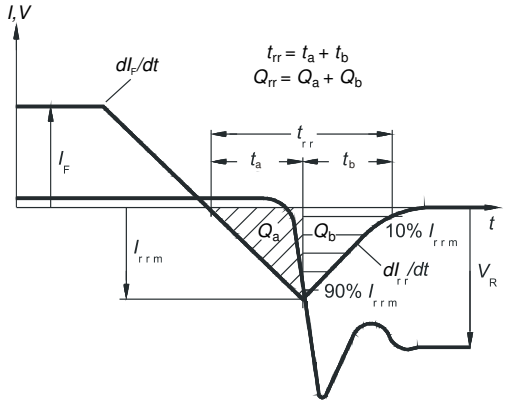



Figure C. **Definition of diode switching characteristics**

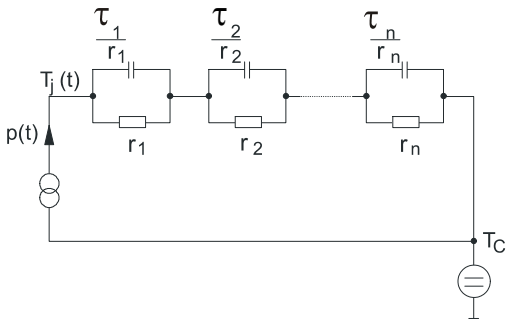



Figure D. **Thermal equivalent circuit**

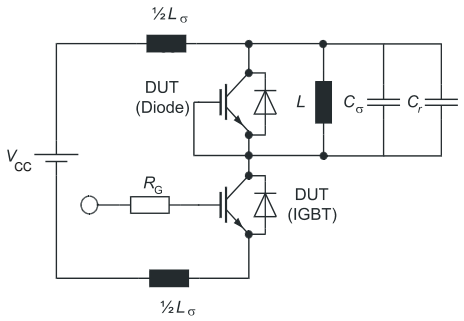



Figure E. **Dynamic test circuit**
Parasitic inductance $L_\sigma$,
parasitic capacitor $C_\sigma$,
relief capacitor $C_r$,
(only for ZVT switching)

**Figure 2**

## Revision history

| Document revision | Date of release | Description of changes |
|---|---|---|
| 1.00 | 2021-05-17 | Final datasheet |
| 1.10 | 2021-05-18 | Update of diagram E = f(Tvj) |
| 1.20 | 2021-06-29 | Update of diagram E = f($T_{vj}$) |
| 1.30 | 2022-12-06 | Update of “DC collector current, limited by $T_{vjmax}$” in table “Maximum rated values”, for 25°C and 100°C<br>Transient gate-emitter voltage $V_{GE}$ in table “Maximum rated values” of IGBT changed to ±30V<br>Update of diagram “Collector current as a function of case temperature”, $I_C = f(T_c)$<br>"Forward bias safe operating area” diagram renamed to “Reverse bias safe operating area”<br>Correction of package outline dimensions<br>Change package name to marketing name<br>Editorial changes |

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