

## IGBT

High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology

## IGP40N65F5, IGW40N65F5

650V IGBT high speed switching series fifth generation

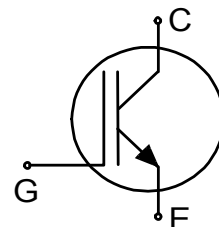
Data sheet

### High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology

#### Features and Benefits:

High speed F5 technology offering

- Best-in-Class efficiency in hard switching and resonant topologies
- 650V breakdown voltage
- Low gate charge  $Q_G$
- Ideal fit with SiC Schottky Diode in boost converters
- Maximum junction temperature 175°C
- Qualified according to JEDEC for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>



#### Target Applications:

- Solar converters
- Uninterruptible power supplies
- Welding converters
- Mid to high range switching frequency converters

#### Package pin definition:

- Pin 1 - gate
- Pin 2 & backside - collector
- Pin 3 - emitter



#### Key Performance and Package Parameters

| Type       | $V_{CE}$ | $I_C$ | $V_{CEsat}, T_{vj}=25^\circ C$ | $T_{vjmax}$ | Marking | Package    |
|------------|----------|-------|--------------------------------|-------------|---------|------------|
| IGP40N65F5 | 650V     | 40A   | 1.6V                           | 175°C       | G40EF5  | PG-TO220-3 |
| IGW40N65F5 | 650V     | 40A   | 1.6V                           | 175°C       | G40EF5  | 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>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$            | $I_C$                    | 74.0<br>46.0         | 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                  |
| Gate-emitter voltage<br>Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )                    | $V_{GE}$                 | $\pm 20$<br>$\pm 30$ | V                  |
| Power dissipation $T_C = 25^{\circ}\text{C}$<br>Power dissipation $T_C = 100^{\circ}\text{C}$                        | $P_{tot}$                | 250.0<br>125.0       | W                  |
| Operating junction temperature   | $T_{vj}$                 | -40...+175           | $^{\circ}\text{C}$ |
| Storage temperature  | $T_{stg}$                | -55...+150           | $^{\circ}\text{C}$ |
| Soldering temperature,<br>wave soldering 1.6mm (0.063in.) from case for 10s  | PG-TO220-3<br>PG-TO247-3 | 260<br>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 | $R_{th(j-c)}$ |                          | 0.60       | K/W  |
| Thermal resistance<br>junction - ambient    | $R_{th(j-a)}$ | PG-TO220-3<br>PG-TO247-3 | 62<br>40   | K/W  |

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

| Parameter                            | Symbol        | Conditions  | Value       |                      |                | Unit          |
|--------------------------------------|---------------|---|-------------|----------------------|----------------|---------------|
|                                      |               |   | min.        | typ.                 | max.           |               |
| <b>Static Characteristic</b>         |               |   |             |                      |                |               |
| Collector-emitter breakdown voltage  | $V_{(BR)CES}$ | $V_{GE} = 0\text{V}$ , $I_C = 0.20\text{mA}$  | 650         | -                    | -              | V             |
| Collector-emitter saturation voltage | $V_{CEsat}$   | $V_{GE} = 15.0\text{V}$ , $I_C = 40.0\text{A}$<br>$T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 125^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$ | -<br>-<br>- | 1.60<br>1.80<br>1.90 | 2.10<br>-<br>- | V             |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.40\text{mA}$ , $V_{CE} = V_{GE}$   | 3.2         | 4.0                  | 4.8            | V             |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE} = 650\text{V}$ , $V_{GE} = 0\text{V}$<br>$T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                    | -<br>-      | -<br>-               | 40.0<br>2000.0 | $\mu\text{A}$ |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE} = 0\text{V}$ , $V_{GE} = 20\text{V}$  | -           | -                    | 100            | nA            |
| Transconductance                     | $g_{fs}$      | $V_{CE} = 20\text{V}$ , $I_C = 40.0\text{A}$  | -           | 50.0                 | -              | S             |

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

| Parameter  | Symbol    | Conditions  | Value |             |      | Unit |
|--|-----------|---|-------|-------------|------|------|
|  |           |   | min.  | typ.        | max. |      |
| <b>Dynamic Characteristic</b>                                  |           |   |       |             |      |      |
| Input capacitance  | $C_{ies}$ | $V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$      | -     | 2500        | -    | pF   |
| Output capacitance   | $C_{oes}$ |   | -     | 40          | -    |      |
| Reverse transfer capacitance                                   | $C_{res}$ |   | -     | 9           | -    |      |
| Gate charge  | $Q_G$     | $V_{CC} = 520\text{V}, I_C = 40.0\text{A}, V_{GE} = 15\text{V}$ | -     | 95.0        | -    | nC   |
| Internal emitter inductance measured 5mm (0.197 in.) from case | $L_E$     | PG-TO220-3<br>PG-TO247-3  | -     | 7.0<br>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     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C}, V_{CC} = 400\text{V}, I_C = 20.0\text{A}, V_{GE} = 0.0/15.0\text{V}, R_{G(on)} = 15.0\Omega, R_{G(off)} = 15.0\Omega, L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$<br>Energy losses include "tail" and diode reverse recovery. | - | 19   | - | ns |
| Rise time              | $t_r$        |   | - | 13   | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |   | - | 160  | - | ns |
| Fall time              | $t_f$        |   | - | 16   | - | ns |
| Turn-on energy         | $E_{on}$     |   | - | 0.36 | - | mJ |
| Turn-off energy        | $E_{off}$    |   | - | 0.10 | - | mJ |
| Total switching energy | $E_{ts}$     |   | - | 0.46 | - | mJ |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C}, V_{CC} = 400\text{V}, I_C = 5.0\text{A}, V_{GE} = 0.0/15.0\text{V}, R_{G(on)} = 15.0\Omega, R_{G(off)} = 15.0\Omega, L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$<br>Energy losses include "tail" and diode reverse recovery.  | - | 20   | - | ns |
| Rise time              | $t_r$        |   | - | 4    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |   | - | 175  | - | ns |
| Fall time              | $t_f$        |   | - | 10   | - | ns |
| Turn-on energy         | $E_{on}$     |   | - | 0.07 | - | mJ |
| Turn-off energy        | $E_{off}$    |   | - | 0.03 | - | mJ |
| Total switching energy | $E_{ts}$     |   | - | 0.10 | - | mJ |

### Switching Characteristic, Inductive Load

| Parameter  | Symbol       | Conditions   | Value |      |      | Unit |
|--|--------------|--|-------|------|------|------|
|  |              |  | min.  | typ. | max. |      |
| <b>IGBT Characteristic, at <math>T_{vj} = 150^{\circ}\text{C}</math></b> |              |  |       |      |      |      |
| Turn-on delay time   | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C},$                          | -     | 20   | -    | ns   |
| Rise time  | $t_r$        | $V_{CC} = 400\text{V}, I_C = 20.0\text{A},$              | -     | 14   | -    | ns   |
| Turn-off delay time  | $t_{d(off)}$ | $V_{GE} = 0.0/15.0\text{V},$                             | -     | 185  | -    | ns   |
| Fall time  | $t_f$        | $R_{G(on)} = 15.0\Omega, R_{G(off)} = 15.0\Omega,$       | -     | 15   | -    | ns   |
| Turn-on energy   | $E_{on}$     | $L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$           | -     | 0.50 | -    | mJ   |
| Turn-off energy  | $E_{off}$    | $L\sigma, C\sigma$ from Fig. E                           | -     | 0.16 | -    | mJ   |
| Total switching energy   | $E_{ts}$     | Energy losses include "tail" and diode reverse recovery. | -     | 0.66 | -    | mJ   |
| Turn-on delay time   | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C},$                          | -     | 18   | -    | ns   |
| Rise time  | $t_r$        | $V_{CC} = 400\text{V}, I_C = 5.0\text{A},$               | -     | 5    | -    | ns   |
| Turn-off delay time  | $t_{d(off)}$ | $V_{GE} = 0.0/15.0\text{V},$                             | -     | 220  | -    | ns   |
| Fall time  | $t_f$        | $R_{G(on)} = 15.0\Omega, R_{G(off)} = 15.0\Omega,$       | -     | 12   | -    | ns   |
| Turn-on energy   | $E_{on}$     | $L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$           | -     | 0.14 | -    | mJ   |
| Turn-off energy  | $E_{off}$    | $L\sigma, C\sigma$ from Fig. E                           | -     | 0.05 | -    | mJ   |
| Total switching energy   | $E_{ts}$     | Energy losses include "tail" and diode reverse recovery. | -     | 0.19 | -    | mJ   |

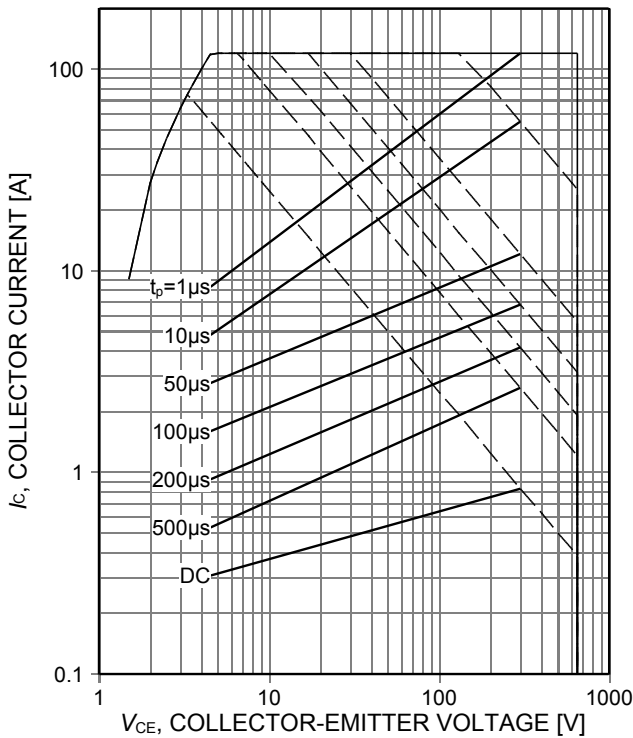


Figure 1. **Forward bias safe operating area**  
 ( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ .  
 Recommended use at  $V_{GE}\geq 7.5\text{V}$ )

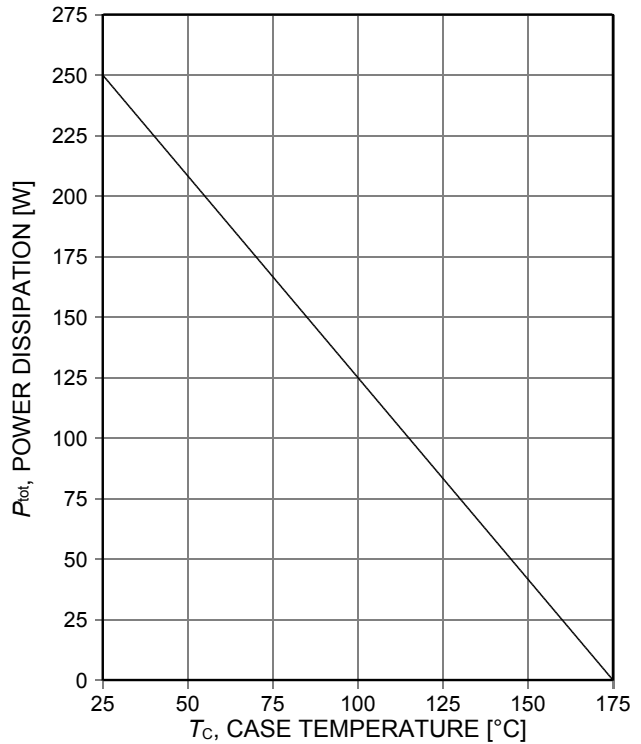


Figure 2. **Power dissipation as a function of case temperature**  
 ( $T_{vj}\leq 175^\circ\text{C}$ )

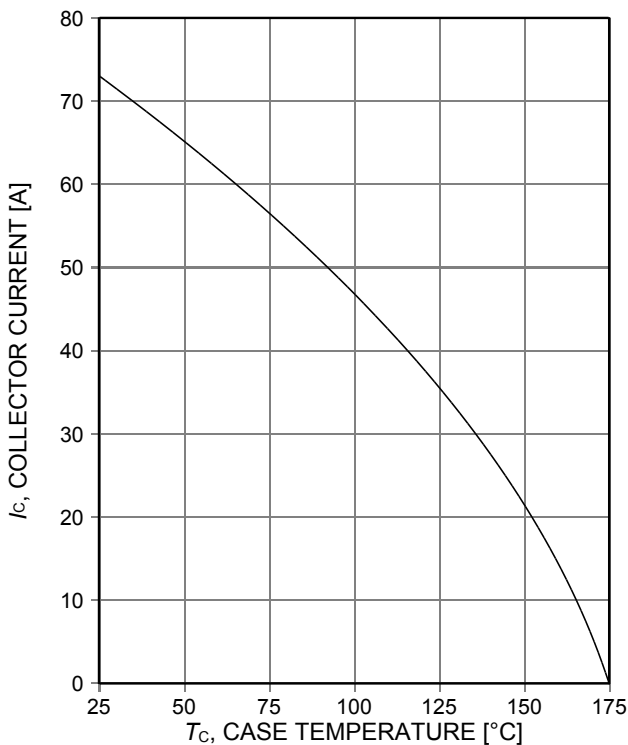


Figure 3. **Collector current as a function of case temperature**  
 ( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

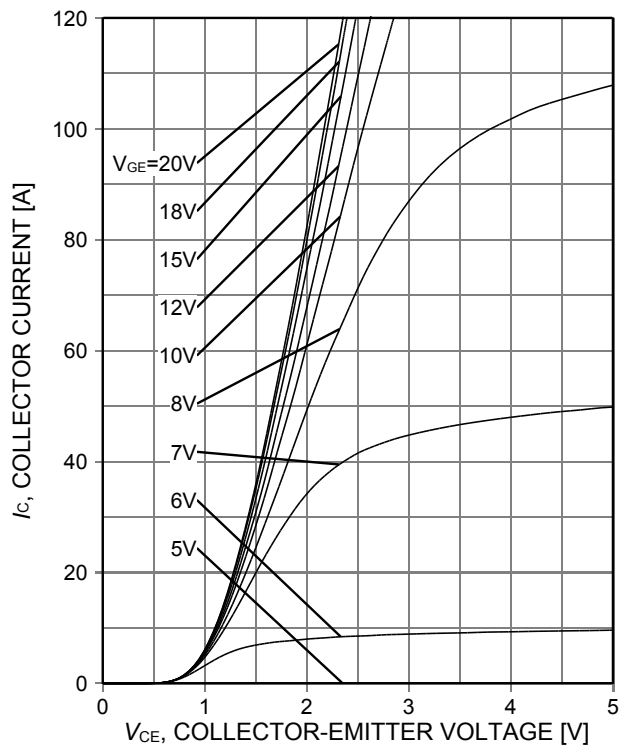


Figure 4. **Typical output characteristic**  
 ( $T_{vj}=25^\circ\text{C}$ )

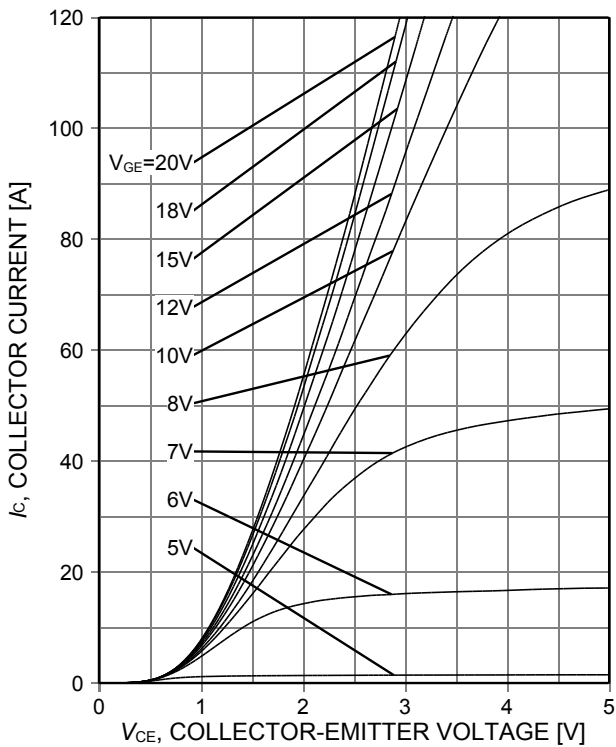


Figure 5. **Typical output characteristic**  
( $T_{vj}=150^{\circ}\text{C}$ )

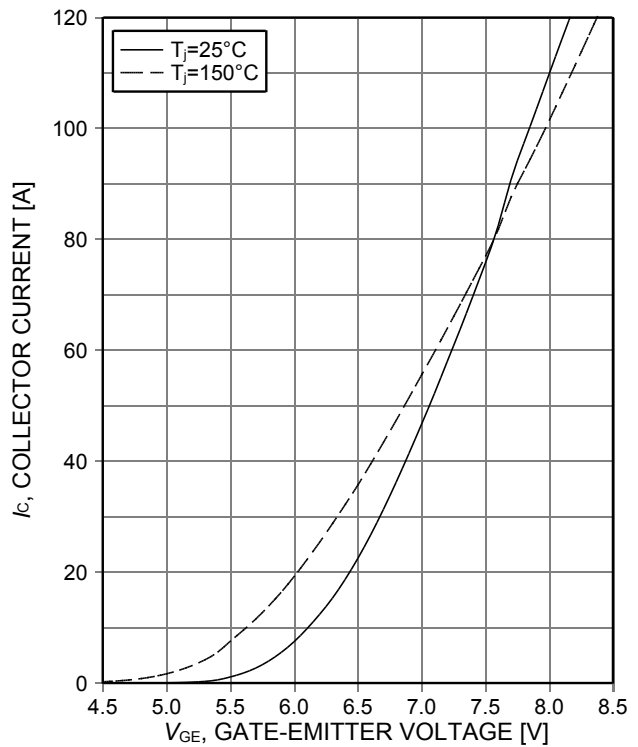


Figure 6. **Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )

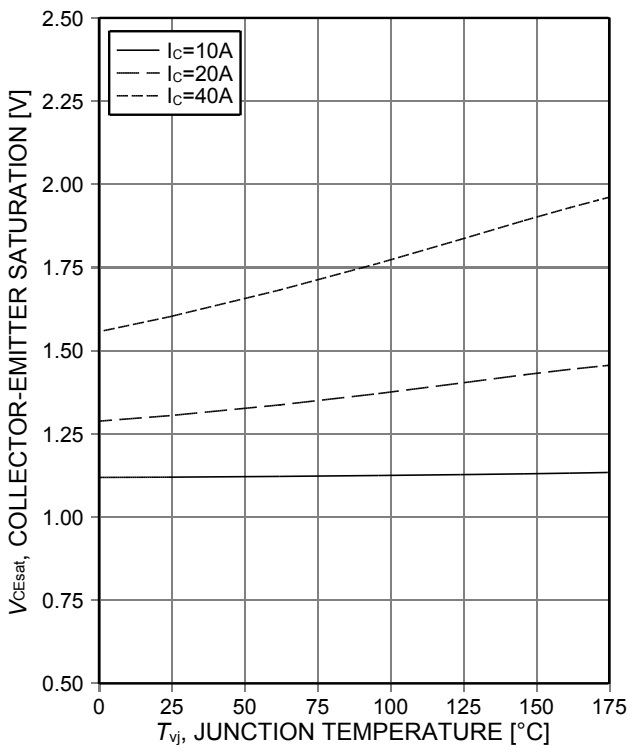


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15\text{V}$ )

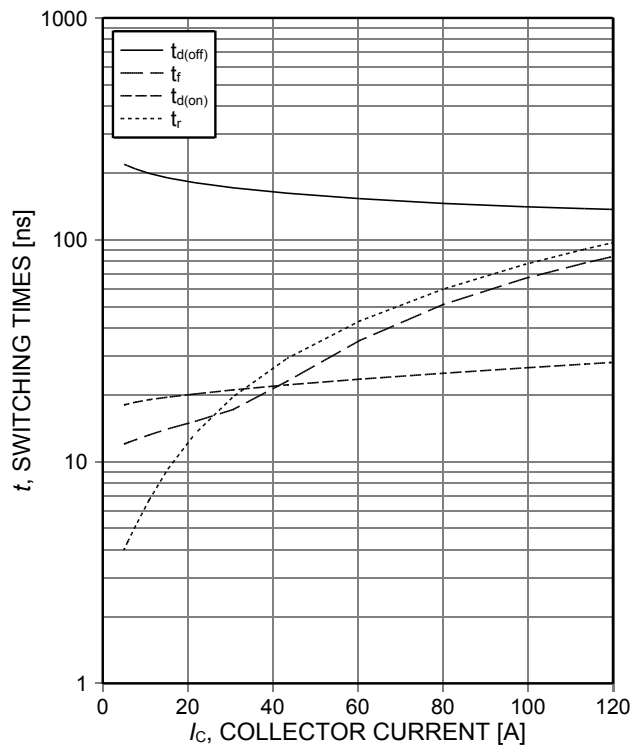


Figure 8. **Typical switching times as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=15\Omega$ , Dynamic test circuit in Figure E)



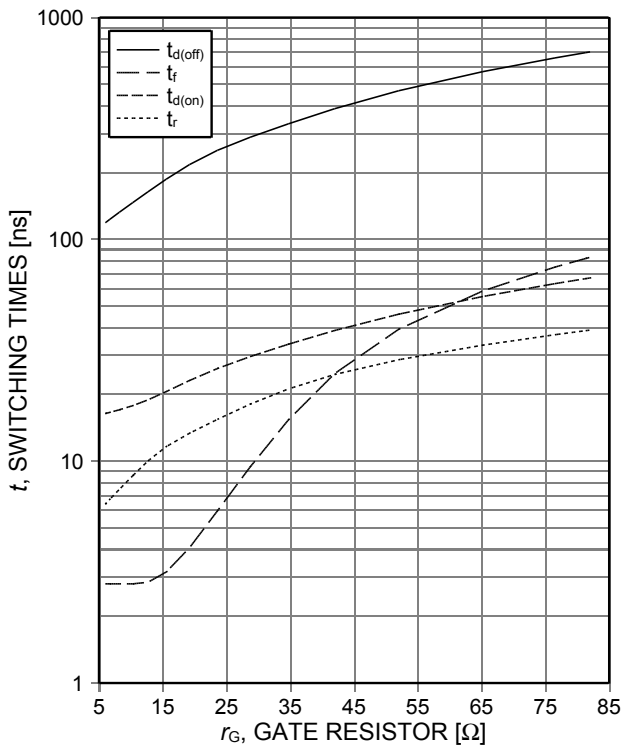


Figure 9. **Typical switching times as a function of gate resistor**  
 (inductive load,  $T_{vj}=150^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=20\text{A}$ , Dynamic test circuit in Figure E)

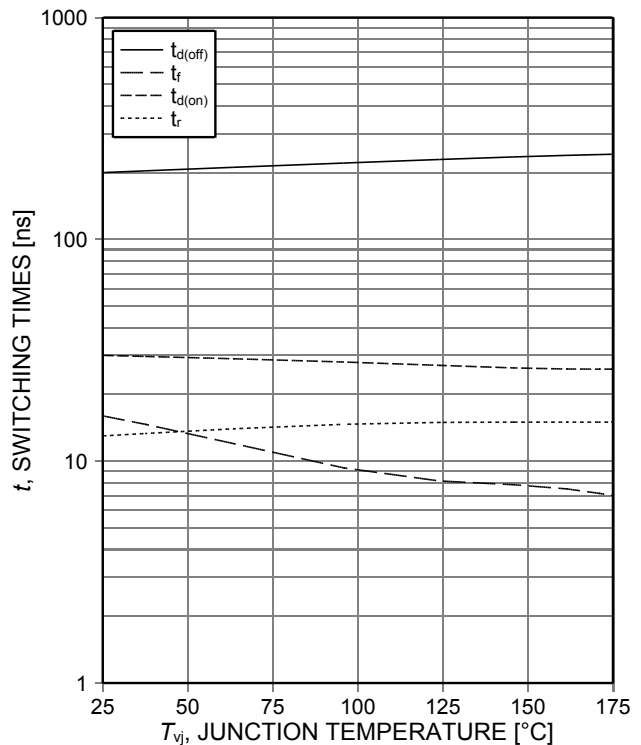


Figure 10. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=20\text{A}$ ,  $r_G=15\Omega$ , Dynamic test circuit in Figure E)

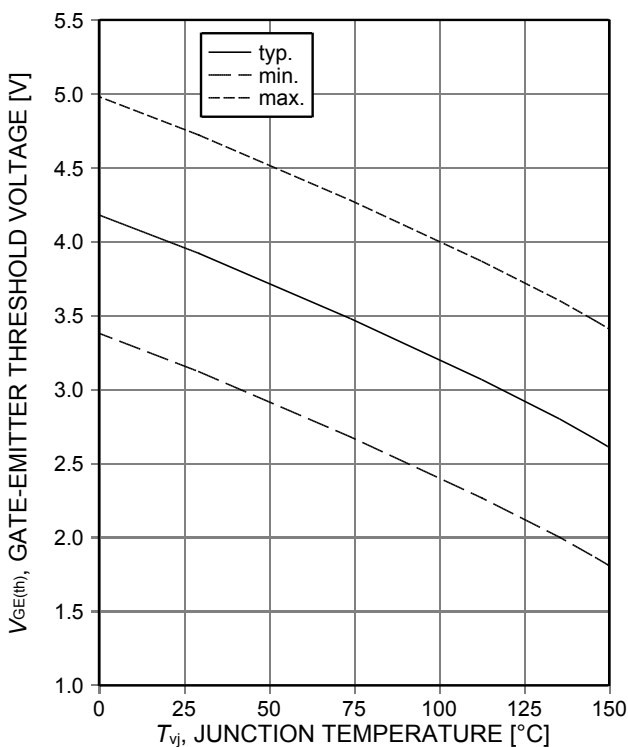


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=0.4\text{mA}$ )

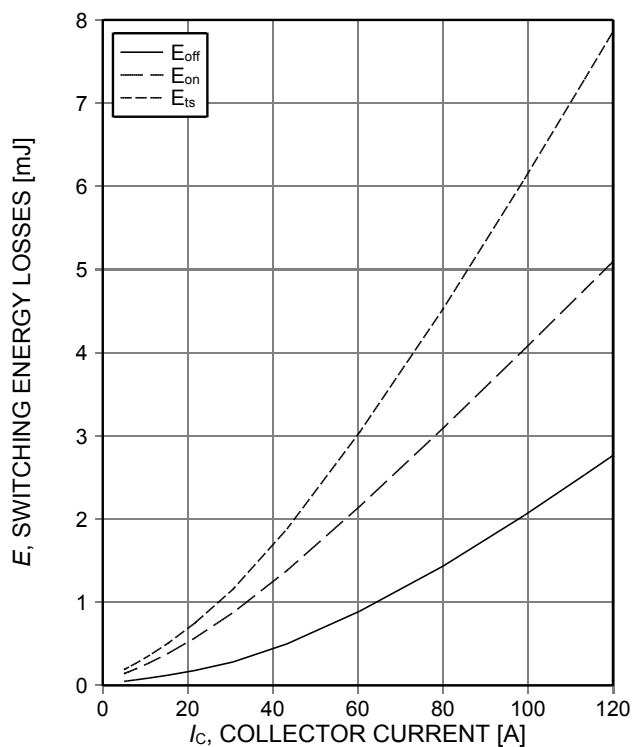


Figure 12. **Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_{vj}=150^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=15\Omega$ , Dynamic test circuit in Figure E)

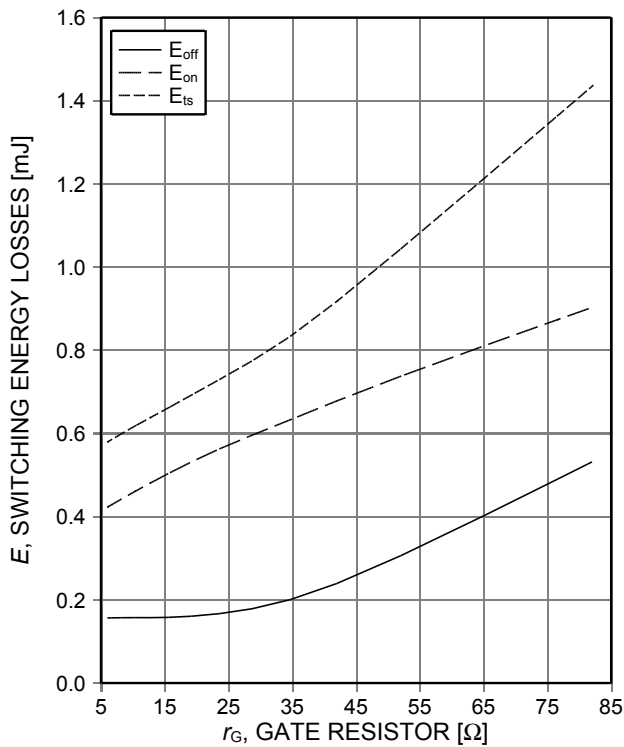


Figure 13. **Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=20\text{A}$ , Dynamic test circuit in Figure E)

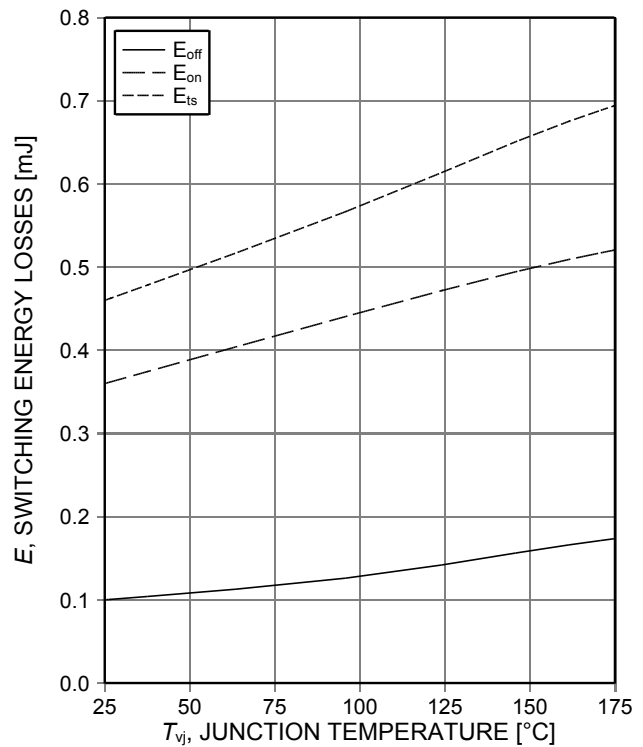


Figure 14. **Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=20\text{A}$ ,  $r_G=15\Omega$ , Dynamic test circuit in Figure E)

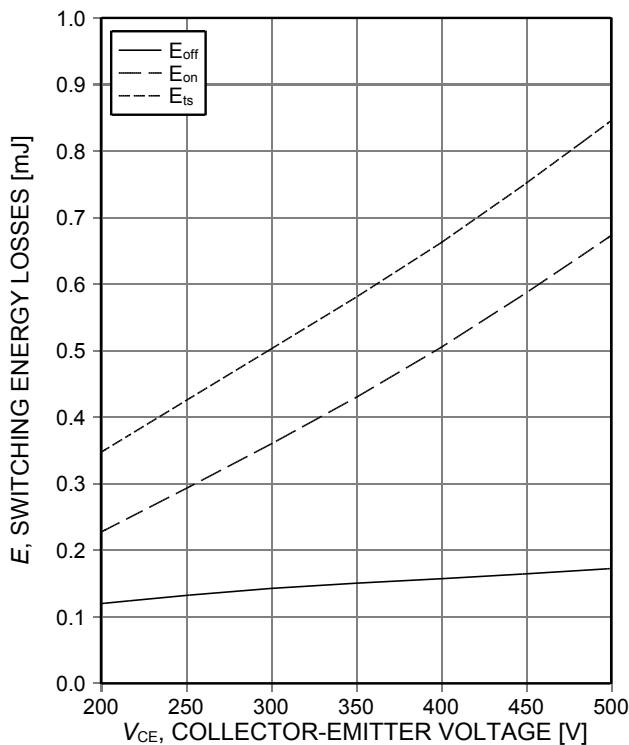


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
 (inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=20\text{A}$ ,  $r_G=15\Omega$ , Dynamic test circuit in Figure E)

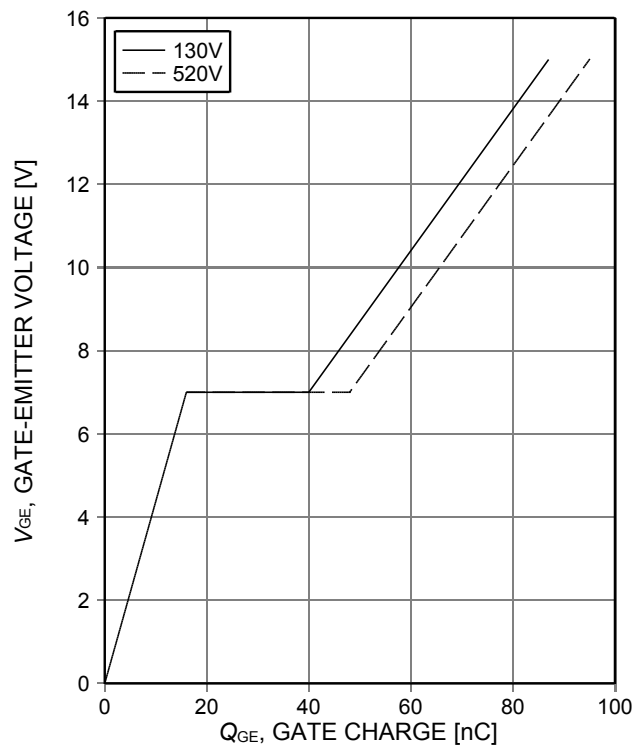


Figure 16. **Typical gate charge**  
 ( $I_C=40\text{A}$ )

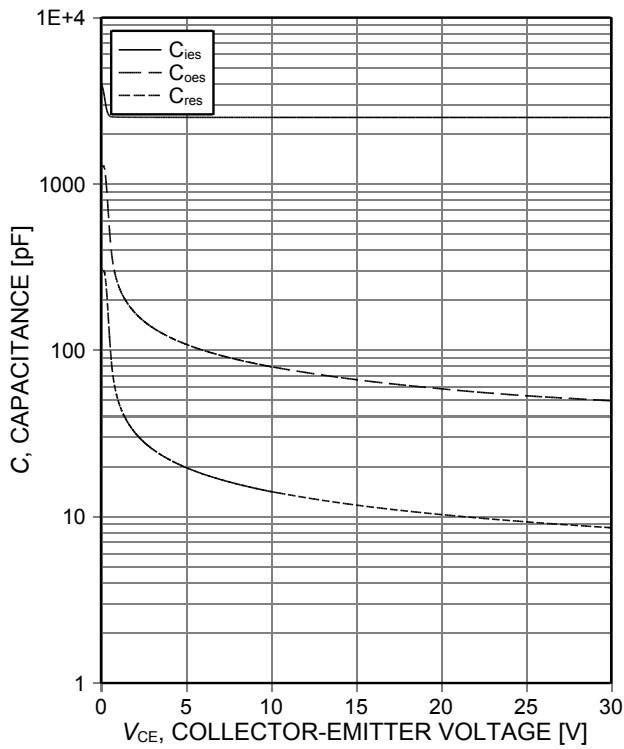


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=1MHz$ )

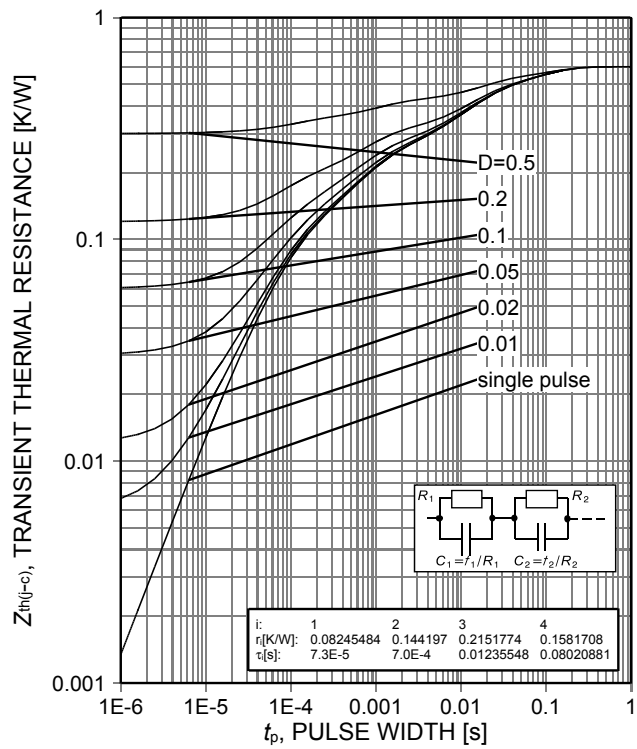
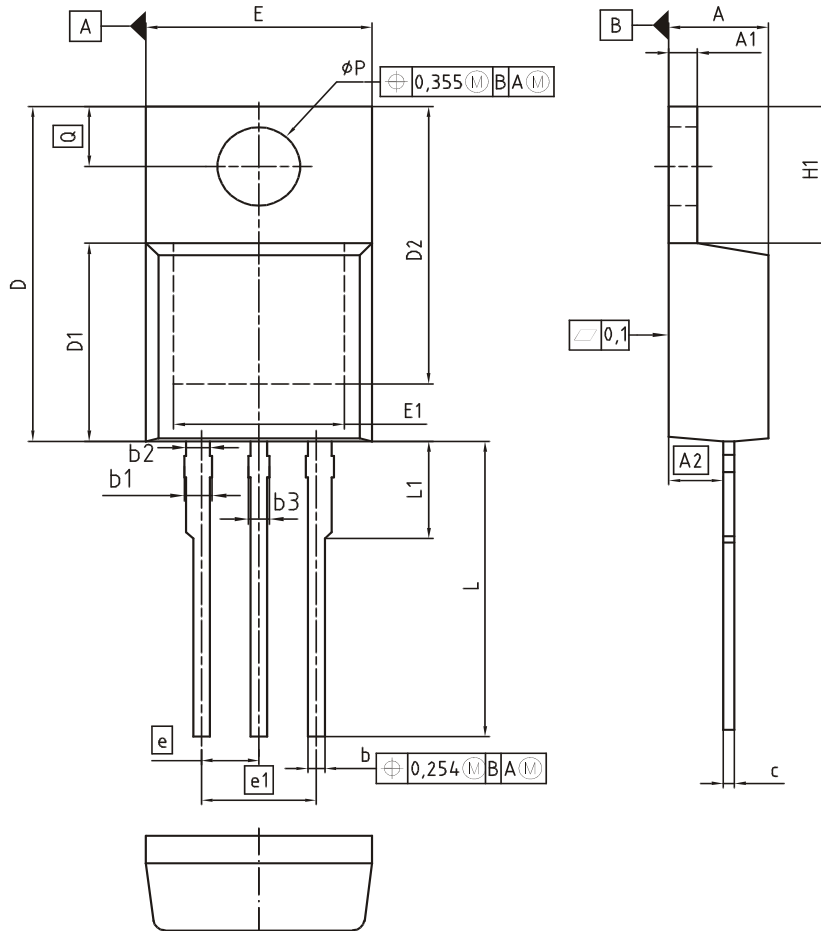


Figure 18. IGBT transient thermal resistance ( $D=t_p/T$ )

### Package Drawing PG-TO220-3



| DIM      | MILLIMETERS |       | INCHES |       |
|----------|-------------|-------|--------|-------|
|          | MIN         | MAX   | MIN    | MAX   |
| A        | 4.30        | 4.57  | 0.169  | 0.180 |
| A1       | 1.17        | 1.40  | 0.046  | 0.055 |
| A2       | 2.15        | 2.72  | 0.085  | 0.107 |
| b        | 0.65        | 0.86  | 0.026  | 0.034 |
| b1       | 0.95        | 1.40  | 0.037  | 0.055 |
| b2       | 0.95        | 1.15  | 0.037  | 0.045 |
| b3       | 0.65        | 1.15  | 0.026  | 0.045 |
| c        | 0.33        | 0.60  | 0.013  | 0.024 |
| D        | 14.81       | 15.95 | 0.583  | 0.628 |
| D1       | 8.51        | 9.45  | 0.335  | 0.372 |
| D2       | 12.19       | 13.10 | 0.480  | 0.516 |
| E        | 9.70        | 10.36 | 0.382  | 0.408 |
| E1       | 6.50        | 8.60  | 0.256  | 0.339 |
| e        | 2.54        |       | 0.100  |       |
| e1       | 5.08        |       | 0.200  |       |
| N        | 3           |       | 3      |       |
| H1       | 5.90        | 6.90  | 0.232  | 0.272 |
| L        | 13.00       | 14.00 | 0.512  | 0.551 |
| L1       | -           | 4.80  | -      | 0.189 |
| $\phi P$ | 3.60        | 3.89  | 0.142  | 0.153 |
| Q        | 2.60        | 3.00  | 0.102  | 0.118 |

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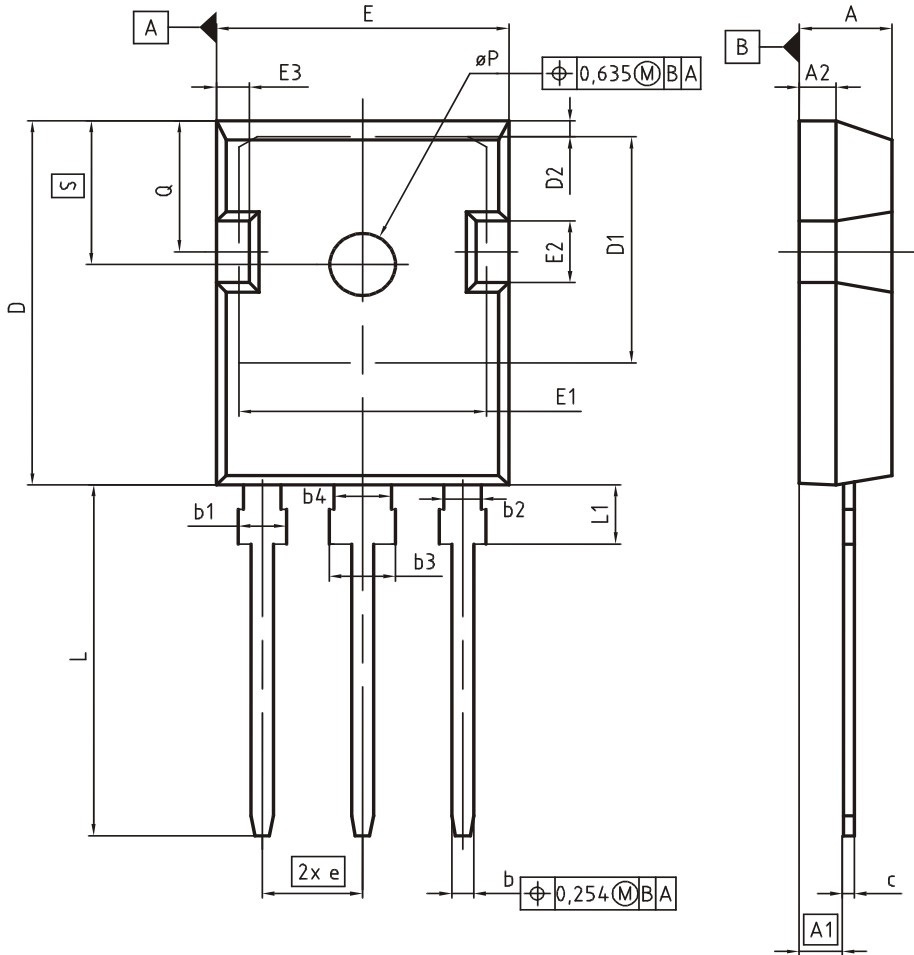
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EUROPEAN PROJECTION

ISSUE DATE  
30-07-2009

REVISION  
06

### 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 |
| $\phi P$ | 3.50        | 3.70  | 0.138       | 0.146 |
| Q        | 5.49        | 6.00  | 0.216       | 0.236 |
| S        | 6.04        | 6.30  | 0.238       | 0.248 |

**DOCUMENT NO.**  
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**EUROPEAN PROJECTION**

**ISSUE DATE**  
09-07-2010

**REVISION**  
05

### Testing Conditions

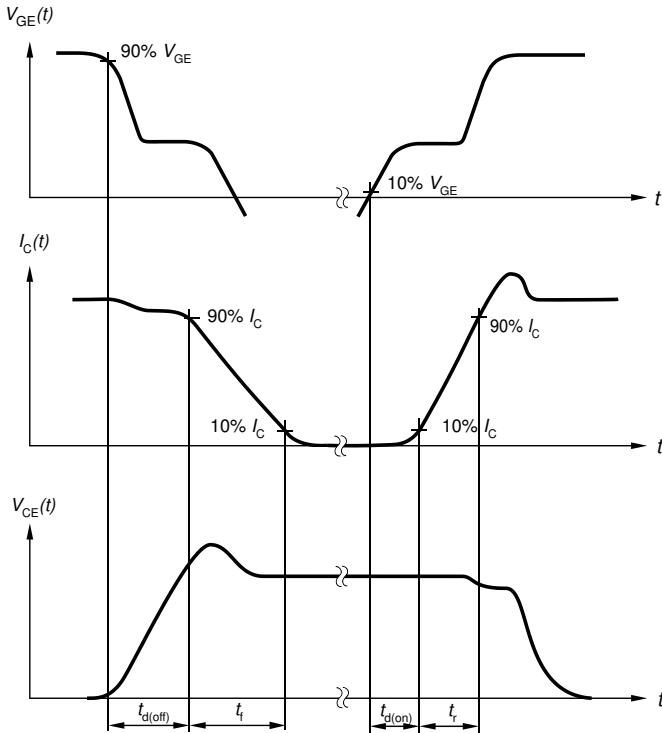


Figure A. Definition of switching times

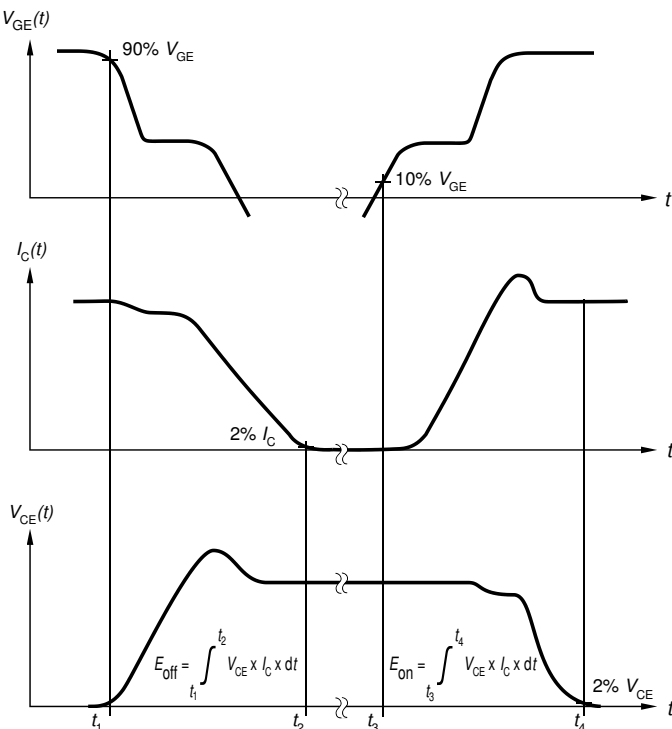


Figure B. Definition of switching losses

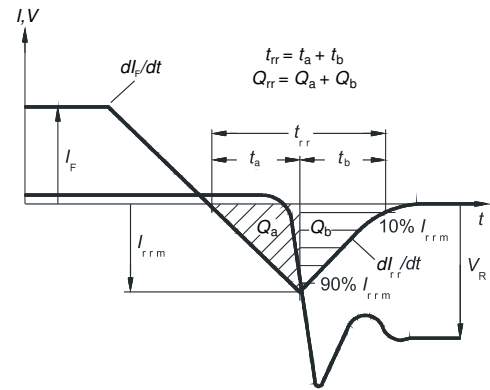


Figure C. Definition of diode switching characteristics

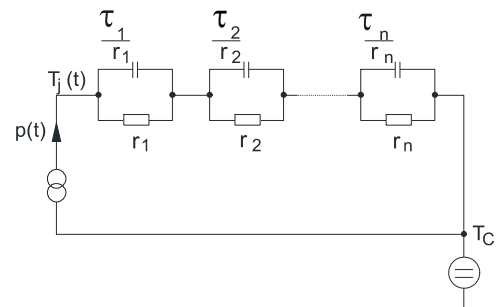


Figure D. Thermal equivalent circuit

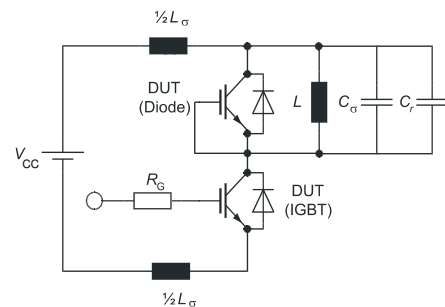


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

**Revision History**

IGP40N65F5, IGW40N65F5

**Revision: 2015-04-30, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|--|
| 1.1      | 2012-11-09 | Preliminary data sheet                       |
| 1.2      | 2013-12-16 | New Marking Pattern                          |
| 1.3      | 2014-12-04 | Minor changes Fig.1 and Fig.14               |
| 2.1      | 2015-04-30 | Final data sheet                             |

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