

## IGBT

High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology

## IGP20N65F5

650V IGBT high speed switching series fifth generation

Data sheet

Industrial Power Control

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

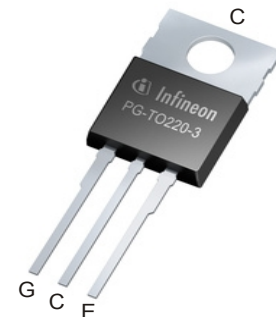
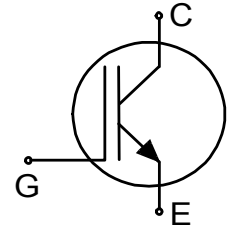
#### Features and Benefits:

High speed F5 technology offering

- Best-in-Class efficiency in hard switching and resonant topologies
- 650V breakdown voltage
- Low  $Q_g$
- 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



#### Key Performance and Package Parameters

| Type       | $V_{CE}$ | $I_C$ | $V_{CEsat}, T_{vj}=25^{\circ}C$ | $T_{vjmax}$ | Marking | Package    |
|------------|----------|-------|---------------------------------|-------------|---------|------------|
| IGP20N65F5 | 650V     | 20A   | 1.6V                            | 175°C       | G20EF5  | PG-TO220-3 |

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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>$T_C = 100^{\circ}\text{C}$            | $I_C$       | 42.0<br>21.0         | A                  |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$                                                               | $I_{Cpuls}$ | 60.0                 | A                  |
| Turn off safe operating area<br>$V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$ | -           | 60.0                 | 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 $T_C = 100^{\circ}\text{C}$                        | $P_{tot}$   | 125.0<br>63.0        | 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 1.6 mm (0.063 in.) from case for 10s                                        |             | 260                  | $^{\circ}\text{C}$ |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3                                                        | $M$         | 0.6                  | Nm                 |

## Thermal Resistance

| Parameter                                   | Symbol        | Conditions | Max. Value | Unit |
|---------------------------------------------|---------------|------------|------------|------|
| <b>Characteristic</b>                       |               |            |            |      |
| IGBT thermal resistance,<br>junction - case | $R_{th(j-c)}$ |            | 1.20       | K/W  |
| Thermal resistance<br>junction - ambient    | $R_{th(j-a)}$ |            | 62         | K/W  |

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

| Parameter                            | Symbol        | Conditions                                                                                                    | Value       |                      |                | Unit    |
|--------------------------------------|---------------|---------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------|---------|
|                                      |               |                                                                                                               | min.        | typ.                 | max.           |         |
| Static Characteristic                |               |                                                                                                               |             |                      |                |         |
| Collector-emitter breakdown voltage  | $V_{(BR)CES}$ | $V_{GE} = 0V, I_C = 0.20mA$                                                                                   | 650         | -                    | -              | V       |
| Collector-emitter saturation voltage | $V_{CEsat}$   | $V_{GE} = 15.0V, I_C = 20.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 125^{\circ}C$<br>$T_{vj} = 175^{\circ}C$ | -<br>-<br>- | 1.60<br>1.80<br>1.90 | 2.10<br>-<br>- | V       |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.20mA, V_{CE} = V_{GE}$                                                                               | 3.2         | 4.0                  | 4.8            | V       |
| Zero gate voltage collector current  | $I_{CES}$     | $V_{CE} = 650V, V_{GE} = 0V$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 175^{\circ}C$                             | -<br>-      | -<br>-               | 40.0<br>4000.0 | $\mu A$ |
| Gate-emitter leakage current         | $I_{GES}$     | $V_{CE} = 0V, V_{GE} = 20V$                                                                                   | -           | -                    | 100            | nA      |
| Transconductance                     | $g_{fs}$      | $V_{CE} = 20V, I_C = 20.0A$                                                                                   | -           | 24.0                 | -              | S       |

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

| Parameter                                                            | Symbol    | Conditions                                 | Value |      |      | Unit |
|----------------------------------------------------------------------|-----------|--------------------------------------------|-------|------|------|------|
|                                                                      |           |                                            | min.  | typ. | max. |      |
| Dynamic Characteristic                                               |           |                                            |       |      |      |      |
| Input capacitance                                                    | $C_{ies}$ | $V_{CE} = 25V, V_{GE} = 0V, f = 1MHz$      | -     | 1200 | -    | pF   |
| Output capacitance                                                   | $C_{oes}$ |                                            | -     | 30   | -    |      |
| Reverse transfer capacitance                                         | $C_{res}$ |                                            | -     | 5    | -    |      |
| Gate charge                                                          | $Q_G$     | $V_{CC} = 520V, I_C = 20.0A, V_{GE} = 15V$ | -     | 48.0 | -    | nC   |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from<br>case | $L_E$     |                                            | -     | 7.0  | -    | nH   |

**Switching Characteristic, Inductive Load**

| Parameter                                             | Symbol              | Conditions                                                                                                                                                                                                                                                                                           | Value |      |      | Unit |
|-------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                                                       |                     |                                                                                                                                                                                                                                                                                                      | min.  | typ. | max. |      |
| IGBT Characteristic, at $T_{vj} = 25^{\circ}\text{C}$ |                     |                                                                                                                                                                                                                                                                                                      |       |      |      |      |
| Turn-on delay time                                    | $t_{d(\text{on})}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 10.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 32.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include “tail” and<br>diode reverse recovery. | -     | 20   | -    | ns   |
| Rise time                                             | $t_r$               |                                                                                                                                                                                                                                                                                                      | -     | 11   | -    | ns   |
| Turn-off delay time                                   | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                      | -     | 165  | -    | ns   |
| Fall time                                             | $t_f$               |                                                                                                                                                                                                                                                                                                      | -     | 17   | -    | ns   |
| Turn-on energy                                        | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                      | -     | 0.16 | -    | mJ   |
| Turn-off energy                                       | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                      | -     | 0.06 | -    | mJ   |
| Total switching energy                                | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                      | -     | 0.22 | -    | mJ   |
|                                                       |                     |                                                                                                                                                                                                                                                                                                      |       |      |      |      |
| Turn-on delay time                                    | $t_{d(\text{on})}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 2.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 32.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include “tail” and<br>diode reverse recovery.  | -     | 18   | -    | ns   |
| Rise time                                             | $t_r$               |                                                                                                                                                                                                                                                                                                      | -     | 3    | -    | ns   |
| Turn-off delay time                                   | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                      | -     | 170  | -    | ns   |
| Fall time                                             | $t_f$               |                                                                                                                                                                                                                                                                                                      | -     | 30   | -    | ns   |
| Turn-on energy                                        | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                      | -     | 0.04 | -    | mJ   |
| Turn-off energy                                       | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                      | -     | 0.02 | -    | mJ   |
| Total switching energy                                | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                      | -     | 0.06 | -    | mJ   |

**Switching Characteristic, Inductive Load**

| Parameter                                              | Symbol              | Conditions                                                                                                                                                                                                                                                                                         | Value |      |      | Unit |
|--------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                                                        |                     |                                                                                                                                                                                                                                                                                                    | min.  | typ. | max. |      |
| IGBT Characteristic, at $T_{vj} = 150^{\circ}\text{C}$ |                     |                                                                                                                                                                                                                                                                                                    |       |      |      |      |
| Turn-on delay time                                     | $t_{d(\text{on})}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 10.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 32.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | -     | 19   | -    | ns   |
| Rise time                                              | $t_r$               |                                                                                                                                                                                                                                                                                                    | -     | 13   | -    | ns   |
| Turn-off delay time                                    | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                    | -     | 200  | -    | ns   |
| Fall time                                              | $t_f$               |                                                                                                                                                                                                                                                                                                    | -     | 11   | -    | ns   |
| Turn-on energy                                         | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                    | -     | 0.26 | -    | mJ   |
| Turn-off energy                                        | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                    | -     | 0.11 | -    | mJ   |
| Total switching energy                                 | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                    | -     | 0.37 | -    | mJ   |
|                                                        |                     |                                                                                                                                                                                                                                                                                                    |       |      |      |      |
| Turn-on delay time                                     | $t_{d(\text{on})}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 2.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 32.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery.  | -     | 16   | -    | ns   |
| Rise time                                              | $t_r$               |                                                                                                                                                                                                                                                                                                    | -     | 4    | -    | ns   |
| Turn-off delay time                                    | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                    | -     | 230  | -    | ns   |
| Fall time                                              | $t_f$               |                                                                                                                                                                                                                                                                                                    | -     | 43   | -    | ns   |
| Turn-on energy                                         | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                    | -     | 0.07 | -    | mJ   |
| Turn-off energy                                        | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                    | -     | 0.02 | -    | mJ   |
| Total switching energy                                 | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                    | -     | 0.09 | -    | mJ   |

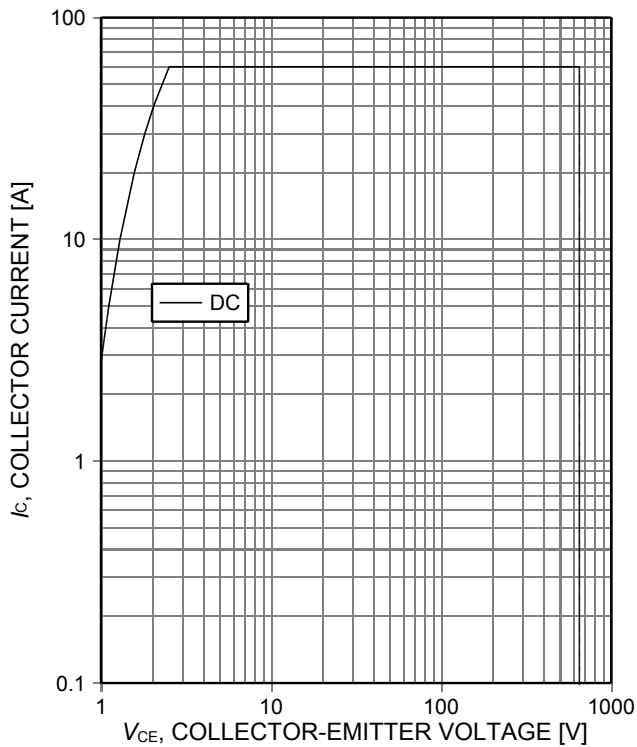


Figure 1. **Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ .  
Recommended use at  $V_{GE}\geq 7.5\text{V}$ )

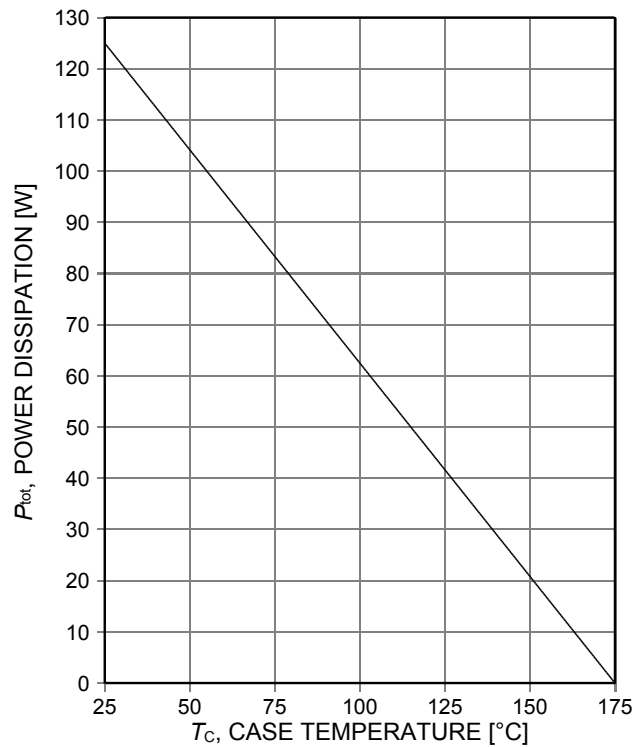


Figure 2. **Power dissipation as a function of case temperature**  
( $T_{vj}\leq 175^\circ\text{C}$ )

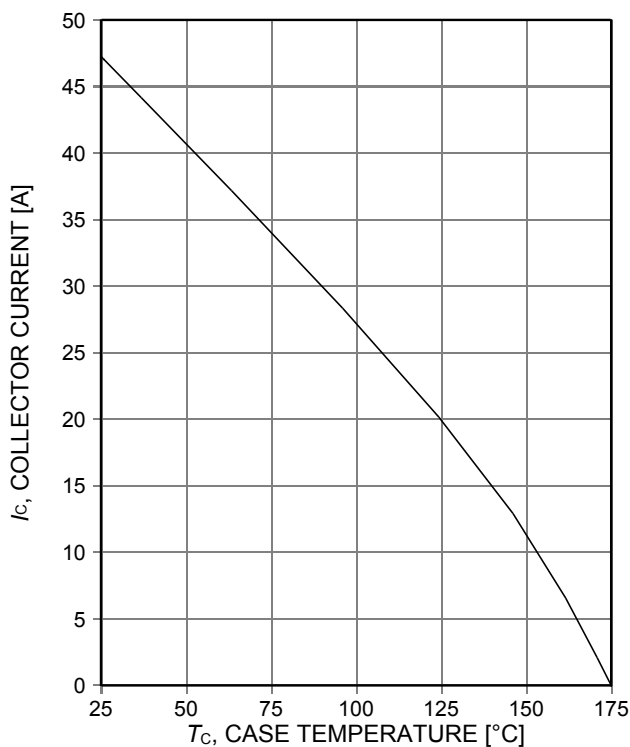


Figure 3. **Collector current as a function of case temperature**  
( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

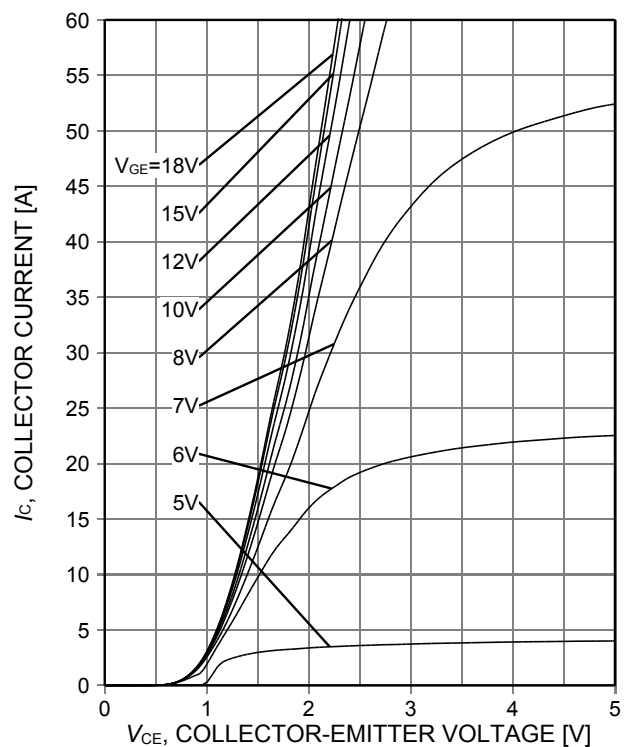


Figure 4. **Typical output characteristic**  
( $T_{vj}=25^\circ\text{C}$ )

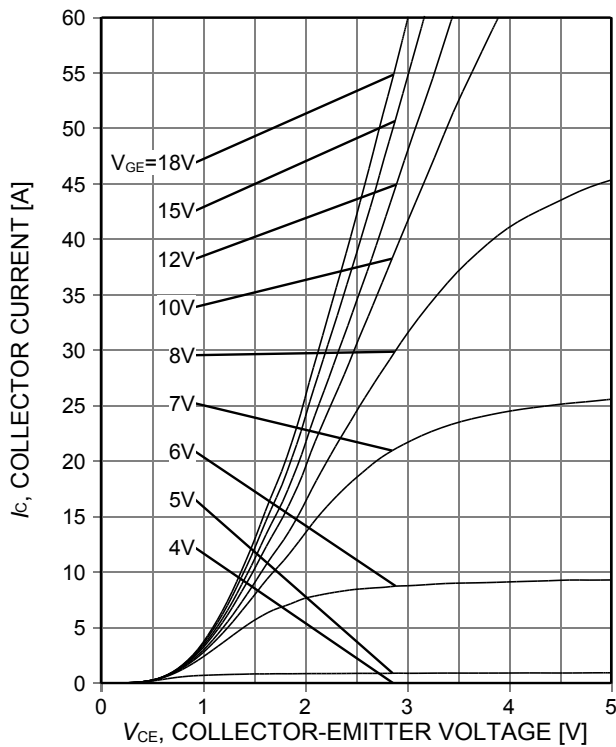


Figure 5. **Typical output characteristic**  
( $T_{Vj}=150^{\circ}\text{C}$ )

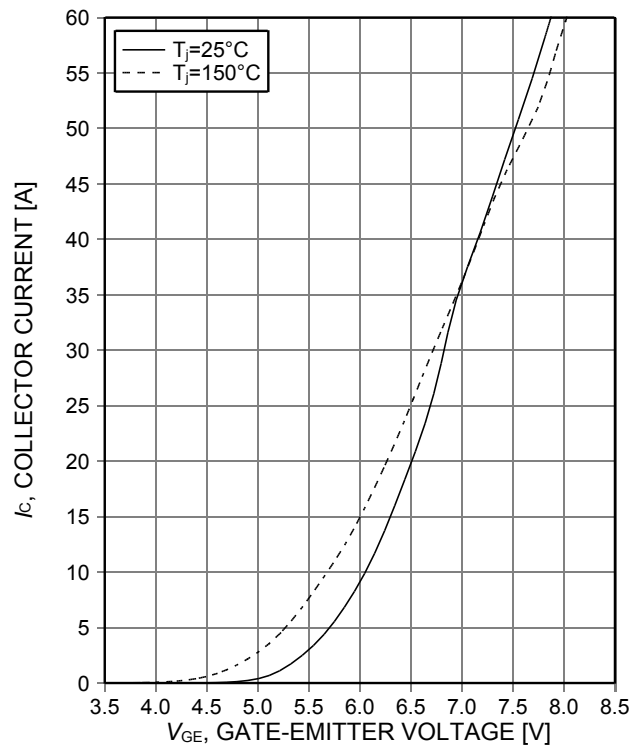


Figure 6. **Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )

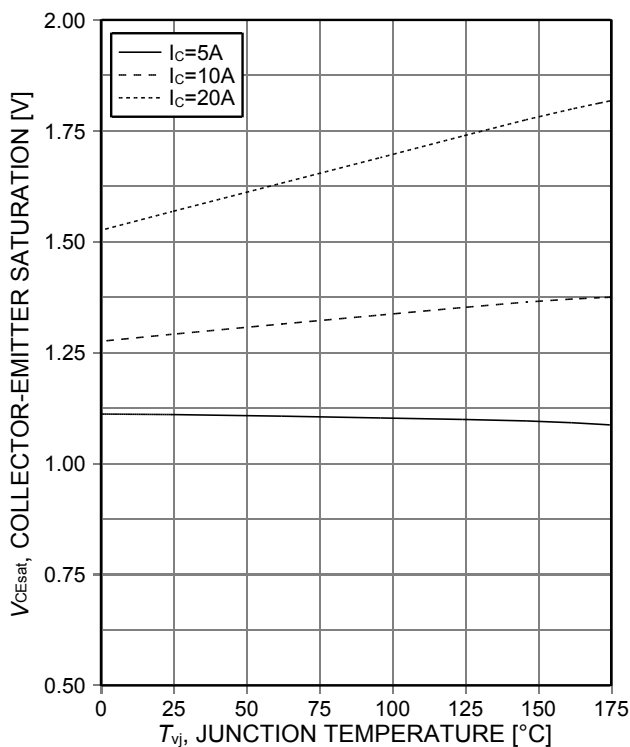


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15\text{V}$ )

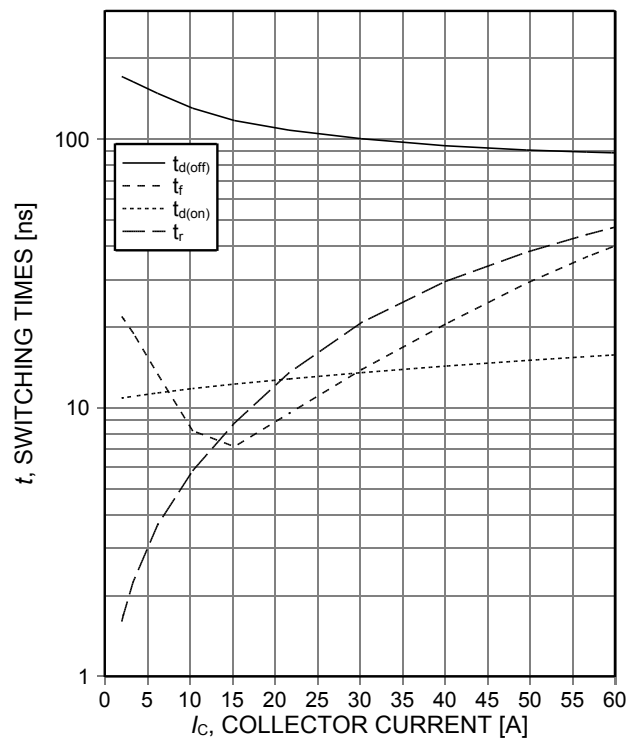


Figure 8. **Typical switching times as a function of collector current**  
(inductive load,  $T_{Vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=32\Omega$ , Dynamic test circuit in Figure E)

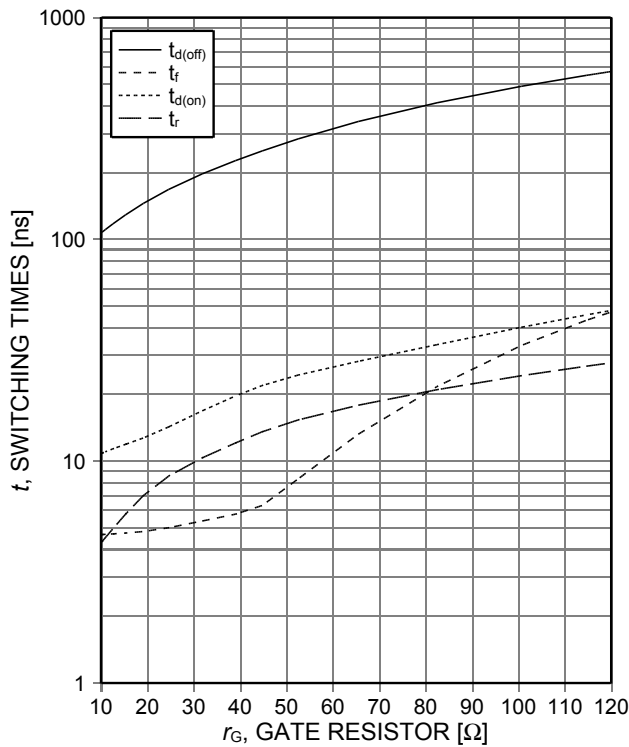


Figure 9. **Typical switching times as a function of gate resistor**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=10\text{A}$ , Dynamic test circuit in Figure E)

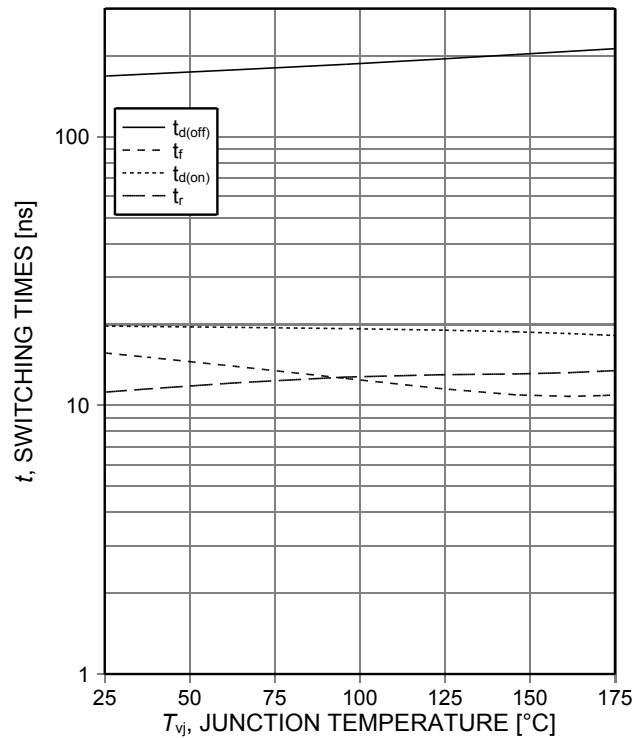


Figure 10. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=10\text{A}$ ,  $r_G=32\Omega$ , Dynamic test circuit in Figure E)

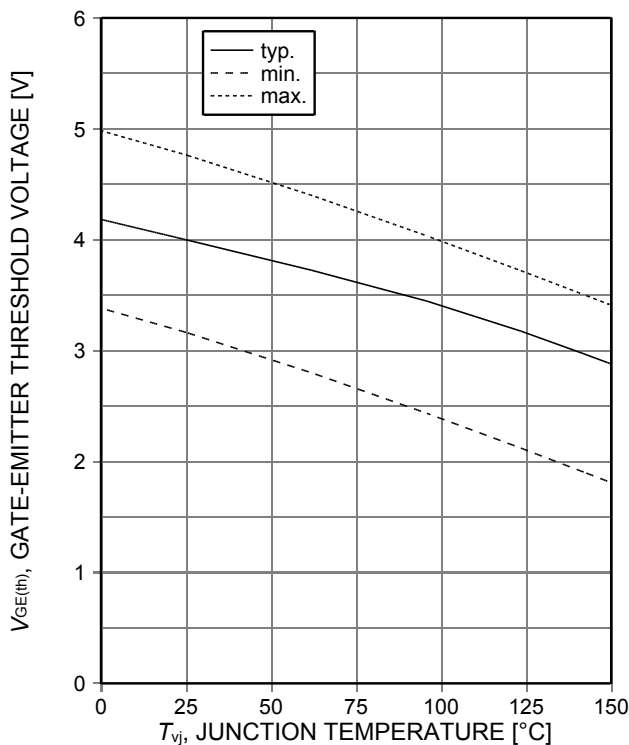


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0.2\text{mA}$ )

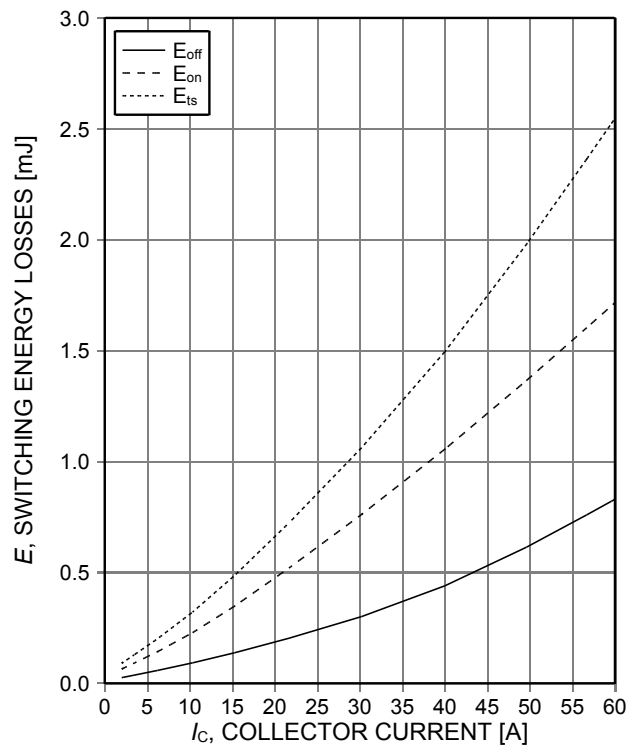


Figure 12. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=32\Omega$ , Dynamic test circuit in Figure E)

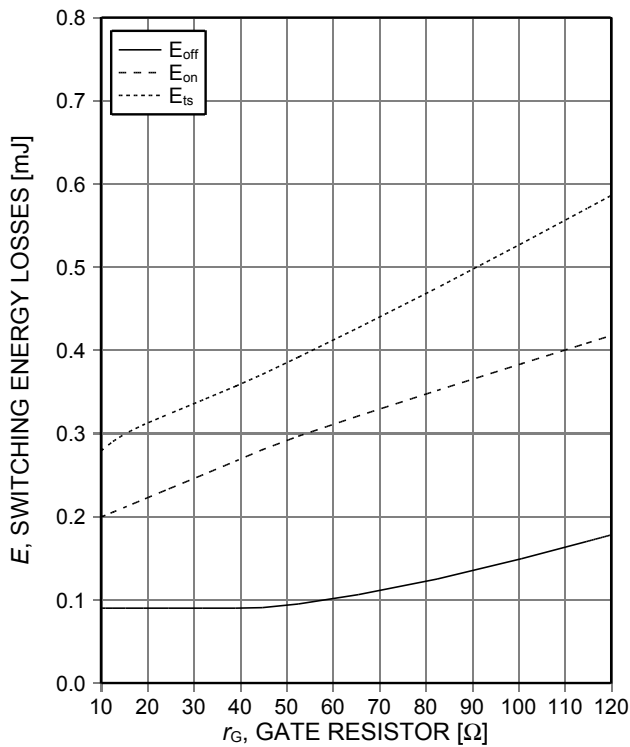


Figure 13. **Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=10\text{A}$ , Dynamic test circuit in Figure E)

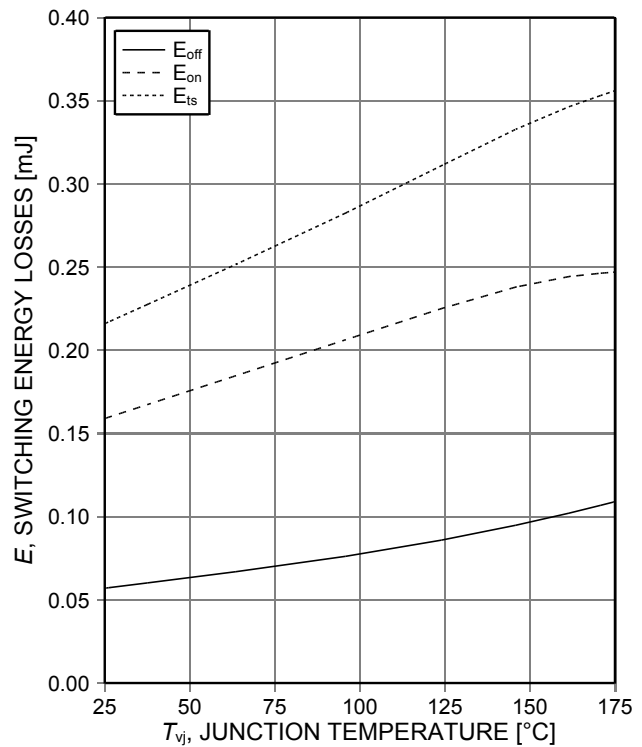


Figure 14. **Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=10\text{A}$ ,  $r_G=32\Omega$ , Dynamic test circuit in Figure E)

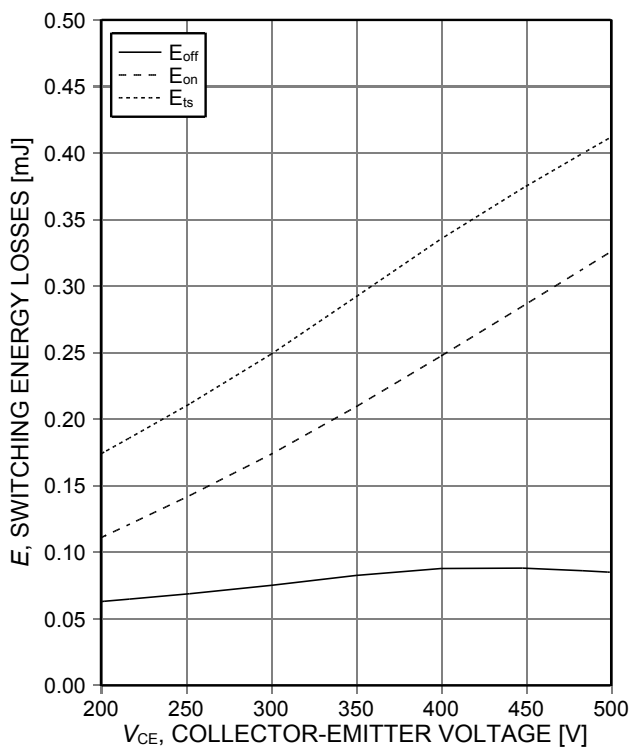


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=10\text{A}$ ,  $r_G=32\Omega$ , Dynamic test circuit in Figure E)

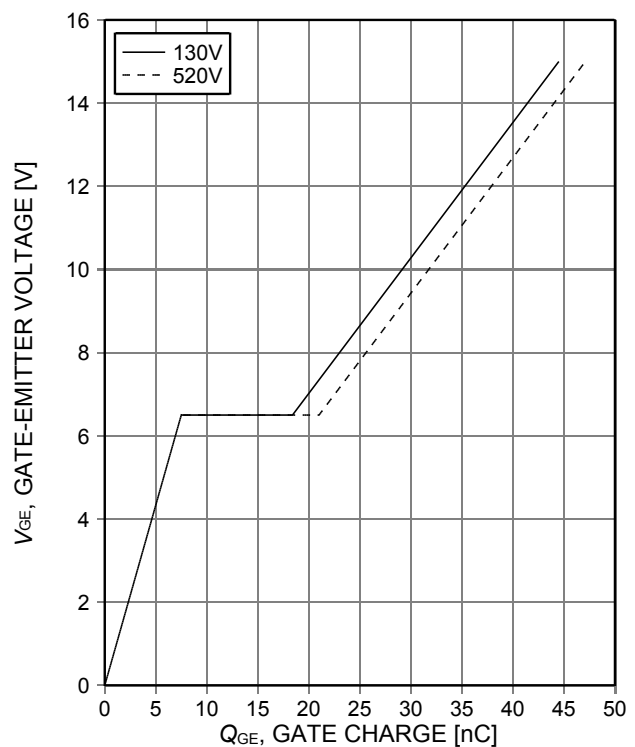


Figure 16. **Typical gate charge**  
( $I_C=20\text{A}$ )

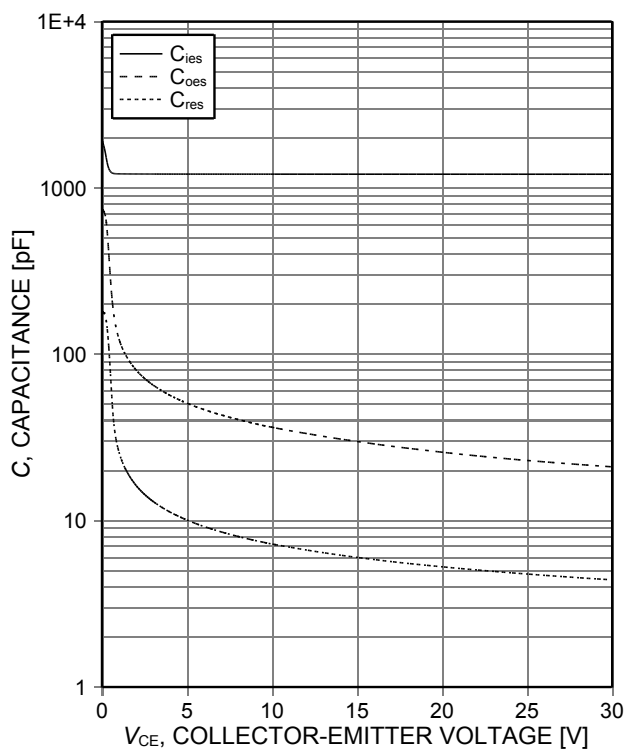


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=1MHz$ )

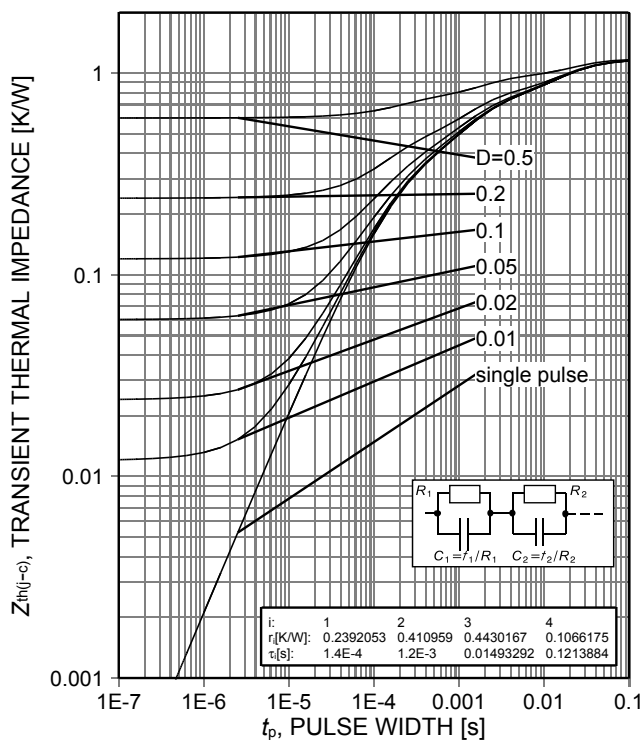
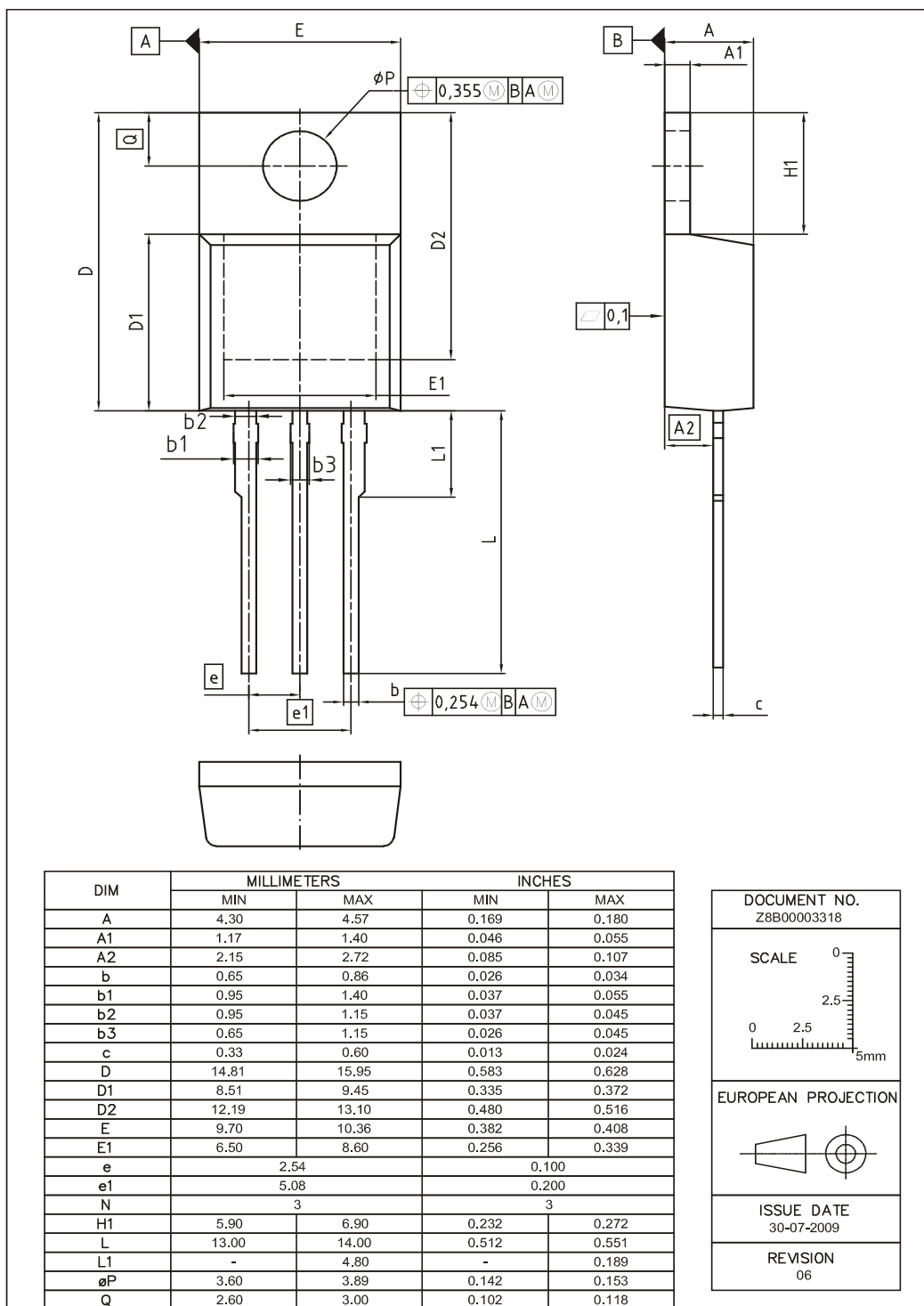
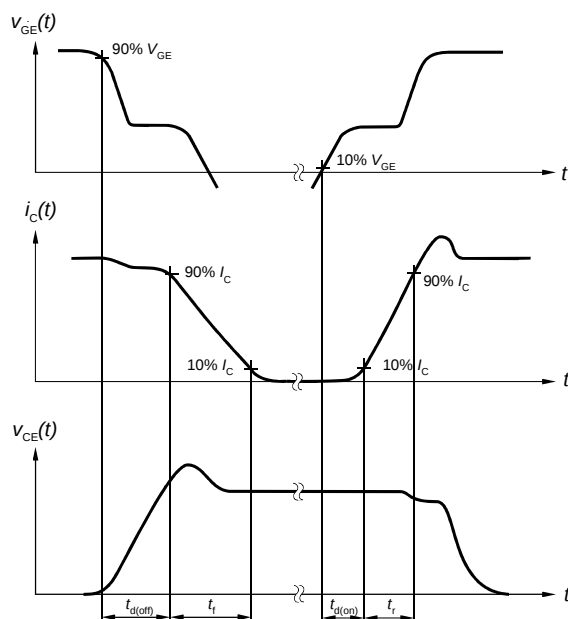


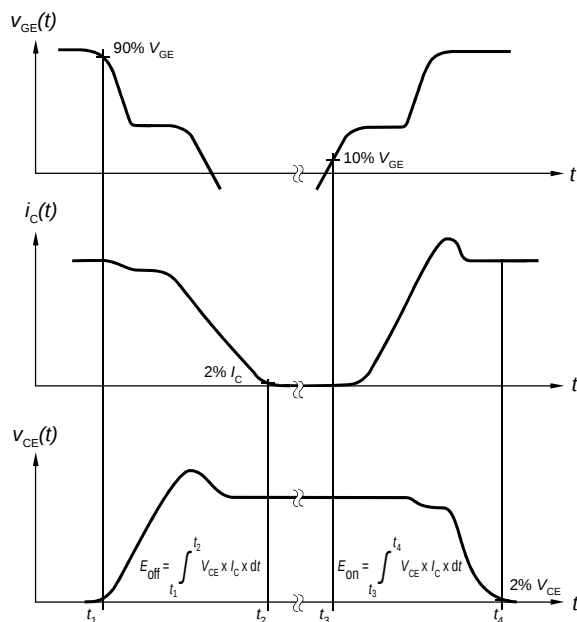
Figure 18. IGBT transient thermal impedance ( $D=t_p/T$ )

## PG-TO220-3

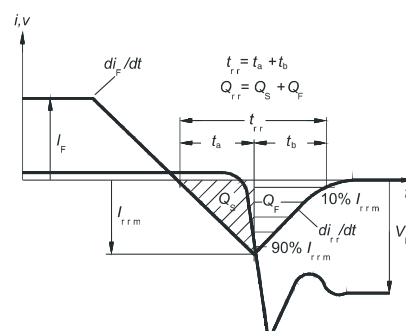




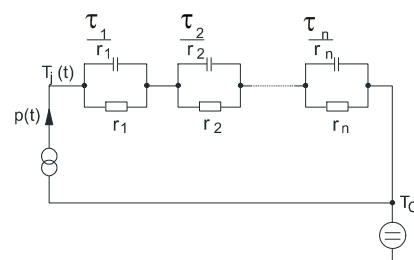
### Figure A. Definition of switching times



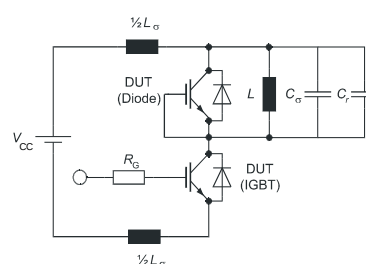
### Figure B. Definition of switching losses



### Figure C. Definition of diodes 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

IGP20N65F5

Revision: 2014-06-11, Rev. 2.1

## Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.1      | 2014-06-11 | Final data sheet                             |

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