

## IGBT

High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology copacked with RAPID 1 fast and soft anti parallel diode

### IKA15N65F5

650V DuoPack IGBT and Diode  
High speed switching series fifth generation

Data sheet

High speed 5 FAST IGBT in TRENCHSTOP™ 5 technology copacked with RAPID 1 fast and soft anti parallel diode

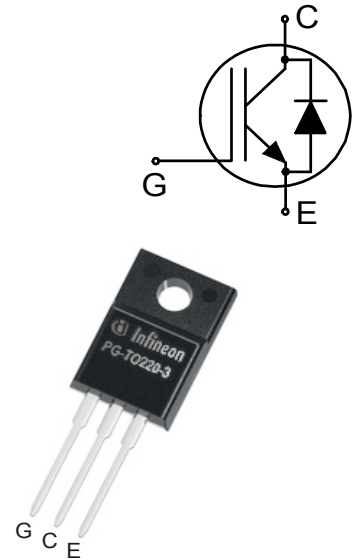
### Features and Benefits:

High speed F5 technology offering

- Best-in-Class efficiency in hard switching and resonant topologies
- 650V breakdown voltage
- Low  $Q_g$
- IGBT copacked with RAPID 1 fast and soft antiparallel diode
- 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/>

### Applications:

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



### Key Performance and Package Parameters

| Type       | $V_{CE}$ | $I_C$ | $V_{CEsat}$ , $T_{vj}=25^\circ\text{C}$ | $T_{vjmax}$ | Marking | Package       |
|------------|----------|-------|-----------------------------------------|-------------|---------|---------------|
| IKA15N65F5 | 650V     | 15A   | 1.6V                                    | 175°C       | K15F655 | PG-TO220-3 FP |

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**Maximum ratings**

| Parameter                                                                                    | Symbol      | Value                | Unit        |
|----------------------------------------------------------------------------------------------|-------------|----------------------|-------------|
| Collector-emitter voltage                                                                    | $V_{CE}$    | 650                  | V           |
| DC collector current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}C$<br>$T_C = 100^{\circ}C$  | $I_C$       | 14.0<br>8.5          | A           |
| Pulsed collector current, $t_p$ limited by $T_{vjmax}$                                       | $I_{Cpuls}$ | 45.0                 | A           |
| Turn off safe operating area $V_{CE} \leq 650V$ , $T_{vj} \leq 175^{\circ}C$                 | -           | 45.0                 | A           |
| Diode forward current, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}C$<br>$T_C = 100^{\circ}C$ | $I_F$       | 12.3<br>7.3          | A           |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$                                           | $I_{Fpuls}$ | 45.0                 | A           |
| Gate-emitter voltage<br>Transient Gate-emitter voltage ( $t_p = 10\mu s$ , $D < 0.010$ )     | $V_{GE}$    | $\pm 20$<br>$\pm 30$ | V           |
| Power dissipation $T_C = 25^{\circ}C$<br>Power dissipation $T_C = 100^{\circ}C$              | $P_{tot}$   | 33.3<br>16.7         | W           |
| Operating junction temperature                                                               | $T_{vj}$    | -40...+175           | $^{\circ}C$ |
| Storage temperature                                                                          | $T_{stg}$   | -55...+150           | $^{\circ}C$ |
| Soldering temperature,<br>wave soldering 1.6 mm (0.063 in.) from case for 10s                |             | 260                  | $^{\circ}C$ |
| Mounting torque, M2.5 screw, TO220 Fullpak<br>Maximum of mounting processes: 3               | $M$         | 0.5                  | Nm          |
| Mounting Torque, M3 Screw, other packages<br>Maximum of mounting processes: 3                |             | 0.6                  |             |
| Isolation voltage for max. 60s, TO220 Fullpak                                                | $V_{isol}$  | 2500                 | V           |

**Thermal Resistance**

| Parameter                                    | Symbol        | Conditions | Max. Value | Unit |
|----------------------------------------------|---------------|------------|------------|------|
| <b>Characteristic</b>                        |               |            |            |      |
| IGBT thermal resistance,<br>junction - case  | $R_{th(j-c)}$ |            | 4.50       | K/W  |
| Diode thermal resistance,<br>junction - case | $R_{th(j-c)}$ |            | 5.60       | K/W  |
| Thermal resistance<br>junction - ambient     | $R_{th(j-a)}$ |            | 65         | 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 | $V_{CEsat}$   | $V_{GE} = 15.0V, I_C = 15.0A$<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       |
| Diode forward voltage                | $V_F$         | $V_{GE} = 0V, I_F = 9.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 125^{\circ}C$<br>$T_{vj} = 175^{\circ}C$     | -<br>-<br>- | 1.45<br>1.40<br>1.40 | 1.80<br>-<br>- | V       |
| Gate-emitter threshold voltage       | $V_{GE(th)}$  | $I_C = 0.15mA, V_{CE} = V_{GE}$                                                                               | 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                     | $g_{fs}$      | $V_{CE} = 20V, I_C = 15.0A$                                                                                   | -           | 22.0                 | -              | 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 <sub>ies</sub> | V <sub>CE</sub> = 25V, V <sub>GE</sub> = 0V, f = 1MHz                 | -     | 930  | -    | pF   |
| Output capacitance           | C <sub>oes</sub> |                                                                       | -     | 24   | -    |      |
| Reverse transfer capacitance | C <sub>res</sub> |                                                                       | -     | 4    | -    |      |
| Gate charge                  | Q <sub>G</sub>   | V <sub>CC</sub> = 520V, I <sub>C</sub> = 15.0A, V <sub>GE</sub> = 15V | -     | 38.0 | -    | nC   |

**Switching Characteristic, Inductive Load, at  $T_{vj} = 25^{\circ}\text{C}$** 

| Parameter              | Symbol       | Conditions                                                                                                                                                                                                                                                                             | Value |      |      | Unit |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                                                                                                                        | min.  | typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                                                                                                                        |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C},$<br>$V_{CC} = 400\text{V}, I_C = 7.5\text{A},$<br>$V_{GE} = 0.0/15.0\text{V},$<br>$r_G = 39.0\Omega, L\sigma = 30\text{nH},$<br>$C\sigma = 30\text{pF}$<br>$L\sigma, C\sigma$ from Fig. E<br>Energy losses include “tail” and<br>diode reverse recovery. | -     | 17   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                        | -     | 7    | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                        | -     | 150  | -    | ns   |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                        | -     | 16   | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                        | -     | 0.13 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                        | -     | 0.04 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                        | -     | 0.17 | -    | mJ   |

|                        |              |                                                                                                                                                                                                                                                                                                  |   |      |   |    |
|------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 2.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 39.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include "tail" and diode reverse recovery. | - | 17   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                  | - | 4    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                  | - | 190  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                  | - | 10   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                  | - | 0.04 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                  | - | 0.02 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                  | - | 0.06 | - | mJ |

#### Diode Characteristic, at $T_{vj} = 25^{\circ}\text{C}$

|                                                                  |              |                                                                                                                           |   |      |   |                        |
|------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_R = 400\text{V}$ ,<br>$I_F = 7.5\text{A}$ ,<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 50   | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                           | - | 0.19 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                           | - | 8.0  | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                           | - | -190 | - | $\text{A}/\mu\text{s}$ |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_R = 400\text{V}$ ,<br>$I_F = 2.0\text{A}$ ,<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 22   | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                           | - | 0.10 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                           | - | 8.6  | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                           | - | -620 | - | $\text{A}/\mu\text{s}$ |

#### Switching Characteristic, Inductive Load, at $T_{vj} = 150^{\circ}\text{C}$

| Parameter              | Symbol       | Conditions                                                                                                                                                                                                                                                                                        | Value |      |      | Unit |
|------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
|                        |              |                                                                                                                                                                                                                                                                                                   | min.  | typ. | max. |      |
| IGBT Characteristic    |              |                                                                                                                                                                                                                                                                                                   |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 7.5\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 39.0\Omega$ , $L\sigma = 30\text{nH}$ ,<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              | $t_r$        |                                                                                                                                                                                                                                                                                                   | -     | 10   | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                   | -     | 190  | -    | ns   |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                   | -     | 5    | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                   | -     | 0.18 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                   | -     | 0.06 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                   | -     | 0.24 | -    | mJ   |
|                        |              |                                                                                                                                                                                                                                                                                                   |       |      |      |      |
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 2.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$r_G = 39.0\Omega$ , $L\sigma = 30\text{nH}$ ,<br>$C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include “tail” and diode reverse recovery. | -     | 15   | -    | ns   |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                   | -     | 4    | -    | ns   |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                   | -     | 230  | -    | ns   |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                   | -     | 30   | -    | ns   |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                   | -     | 0.06 | -    | mJ   |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                   | -     | 0.02 | -    | mJ   |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                   | -     | 0.08 | -    | mJ   |

**Diode Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$** 

|                                                                  |              |                                                                                                                         |   |      |   |                        |
|------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------|---|------|---|------------------------|
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 150^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 7.5\text{A},$<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 67   | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                         | - | 0.39 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                         | - | 9.6  | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                         | - | -140 | - | $\text{A}/\mu\text{s}$ |
| Diode reverse recovery time                                      | $t_{rr}$     | $T_{vj} = 150^{\circ}\text{C},$<br>$V_R = 400\text{V},$<br>$I_F = 2.0\text{A},$<br>$di_F/dt = 1000\text{A}/\mu\text{s}$ | - | 35   | - | ns                     |
| Diode reverse recovery charge                                    | $Q_{rr}$     |                                                                                                                         | - | 0.20 | - | $\mu\text{C}$          |
| Diode peak reverse recovery current                              | $I_{rrm}$    |                                                                                                                         | - | 10.2 | - | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ | $di_{rr}/dt$ |                                                                                                                         | - | -360 | - | $\text{A}/\mu\text{s}$ |

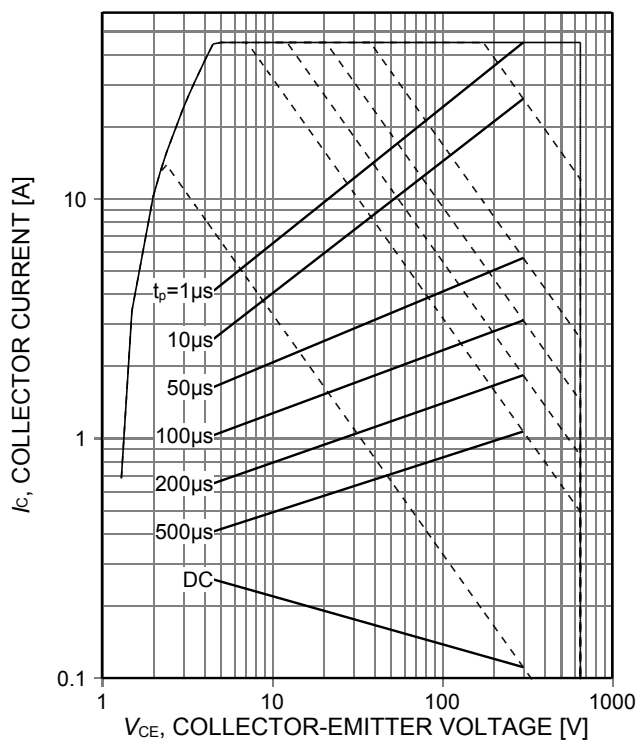


Figure 1. **Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ .  
Recommended use at  $V_{GE}\geq 7.5\text{V}$ )

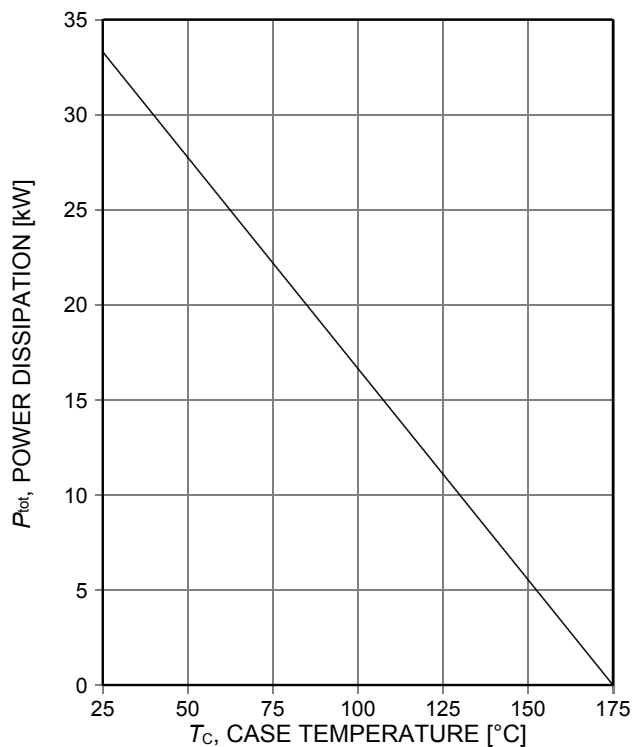


Figure 2. **Power dissipation as a function of case temperature**  
( $T_{vj}\leq 175^\circ\text{C}$ )

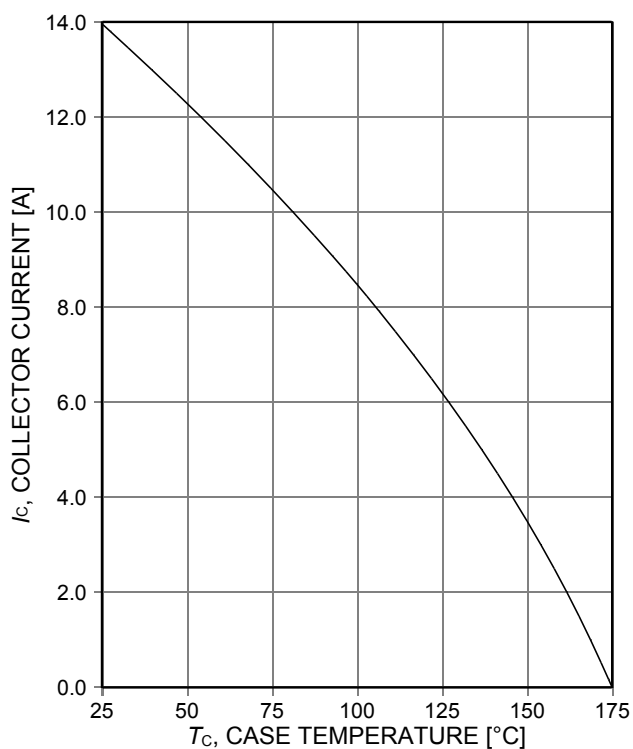


Figure 3. **Collector current as a function of case temperature**  
( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

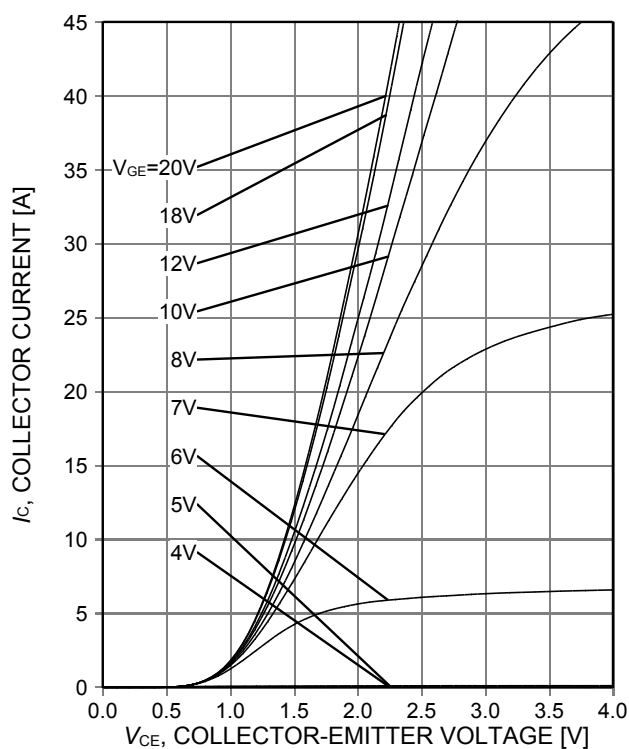


Figure 4. **Typical output characteristic**  
( $T_{vj}=25^\circ\text{C}$ )



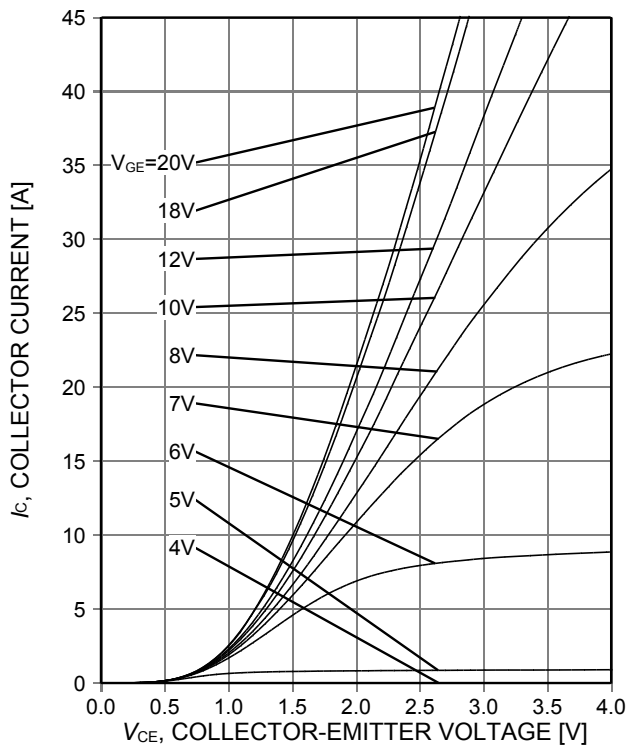


Figure 5. **Typical output characteristic**  
( $T_{vj}=150^{\circ}\text{C}$ )

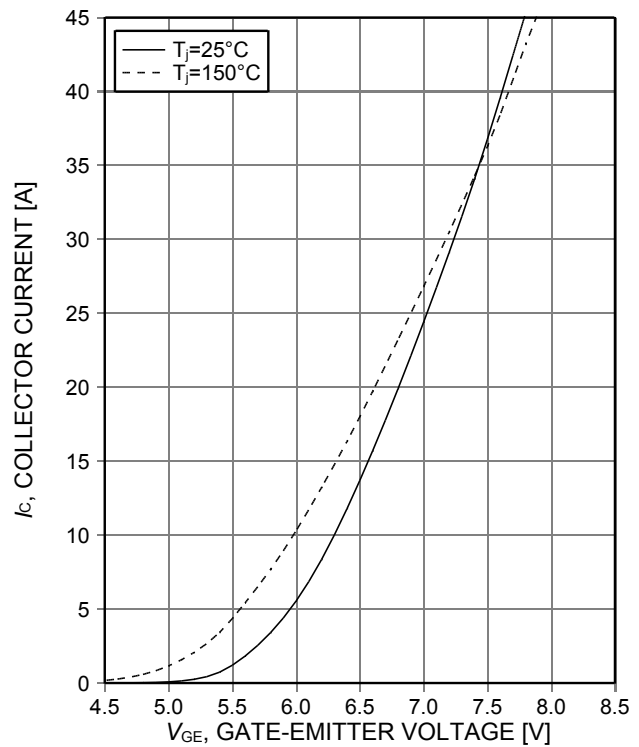


Figure 6. **Typical transfer characteristic**  
( $V_{CE}=20\text{V}$ )

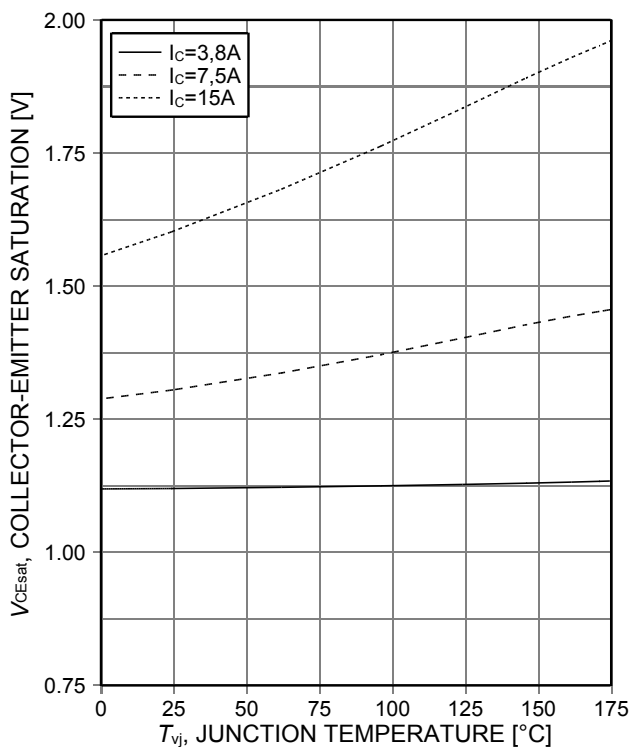


Figure 7. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15\text{V}$ )

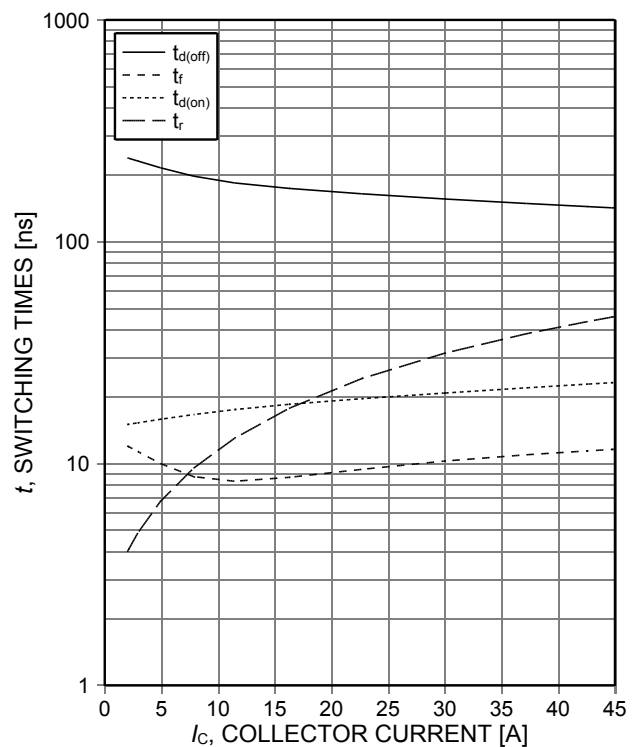


Figure 8. **Typical switching times as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=39\Omega$ , Dynamic test circuit in Figure E)

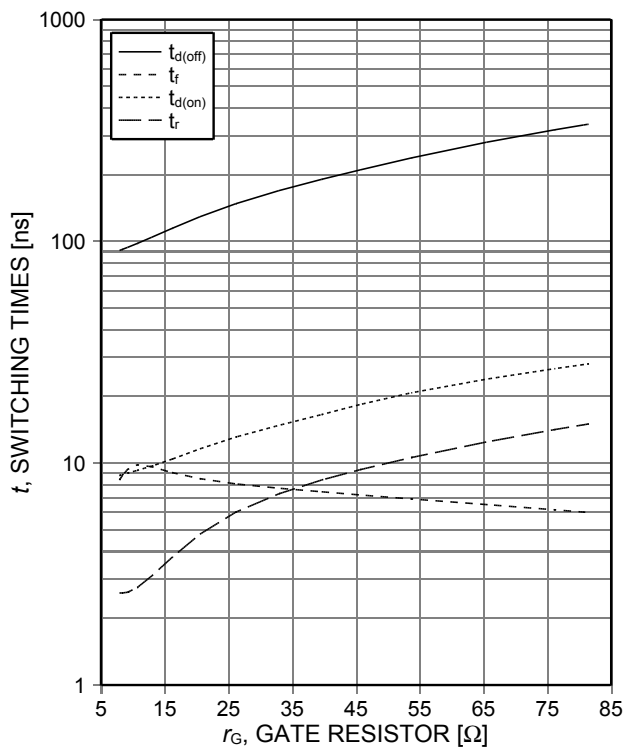


Figure 9. **Typical switching times as a function of gate resistor**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=7,5\text{A}$ , Dynamic test circuit in Figure E)

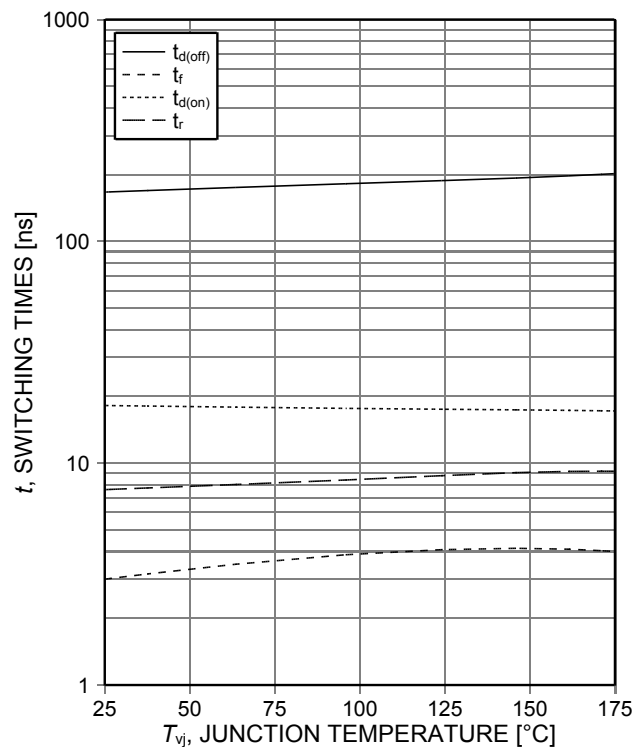


Figure 10. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=7,5\text{A}$ ,  $r_G=39\Omega$ , Dynamic test circuit in Figure E)

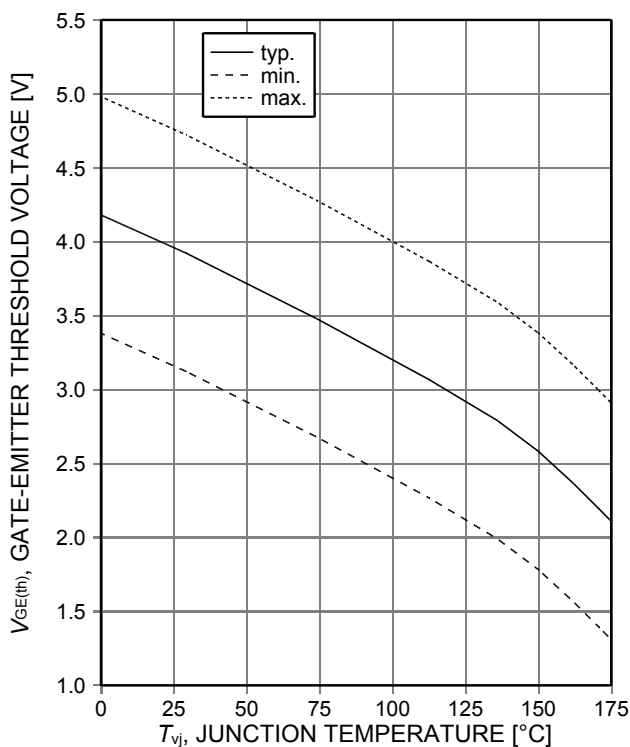


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0.15\text{mA}$ )

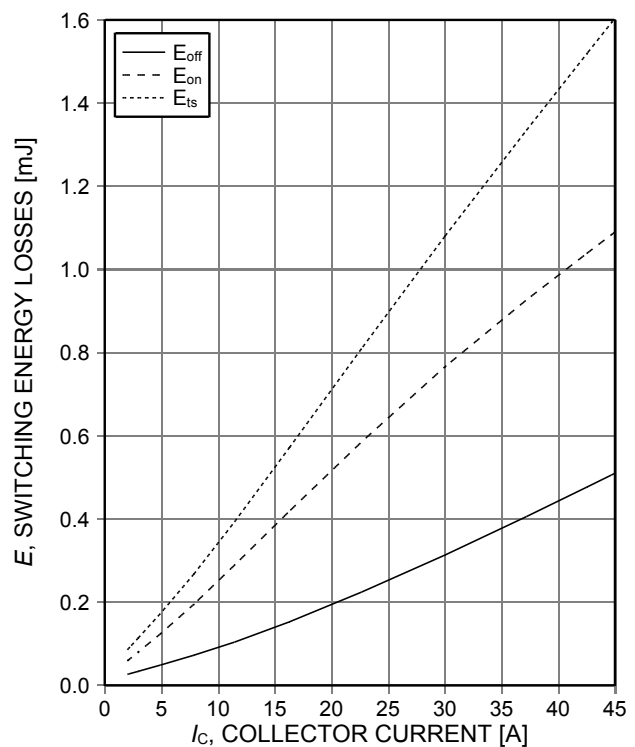


Figure 12. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=39\Omega$ , Dynamic test circuit in Figure E)

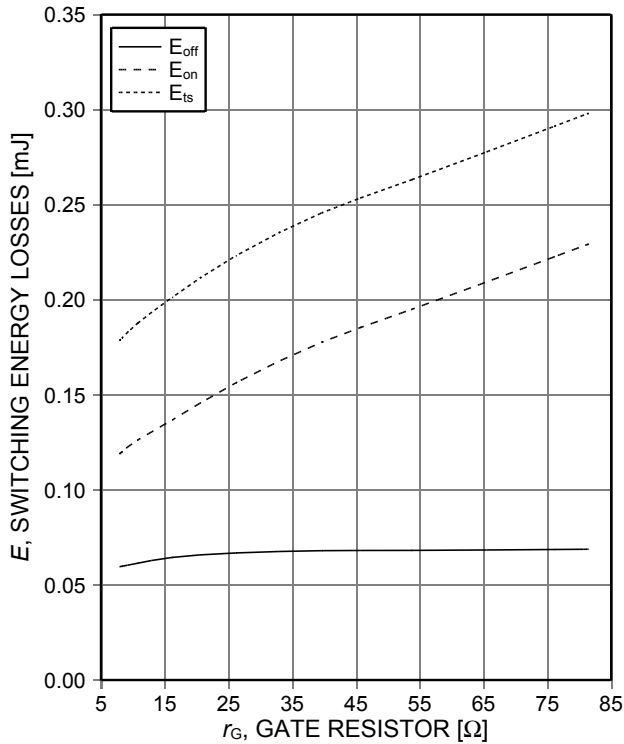


Figure 13. **Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=7,5\text{A}$ , Dynamic test circuit in Figure E)

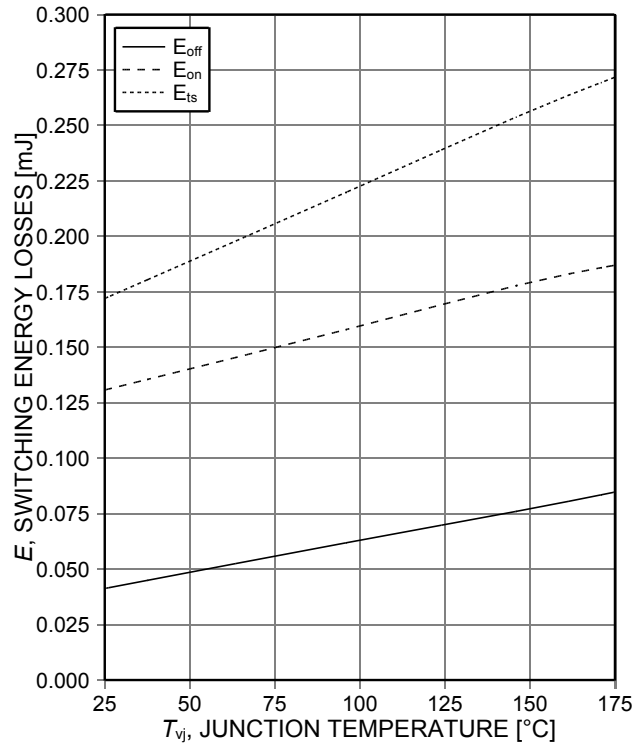


Figure 14. **Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=7,5\text{A}$ ,  $r_G=39\Omega$ , Dynamic test circuit in Figure E)

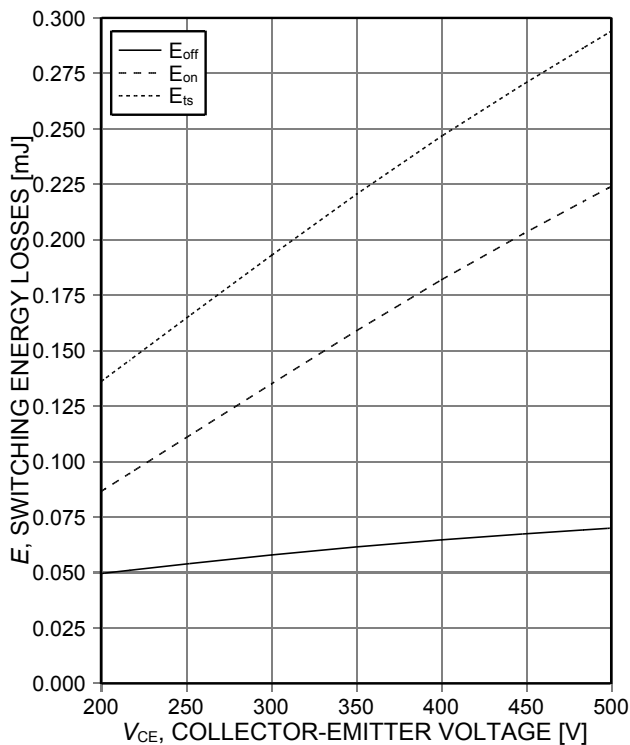


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_{vj}=150^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=7,5\text{A}$ ,  $r_G=39\Omega$ , Dynamic test circuit in Figure E)

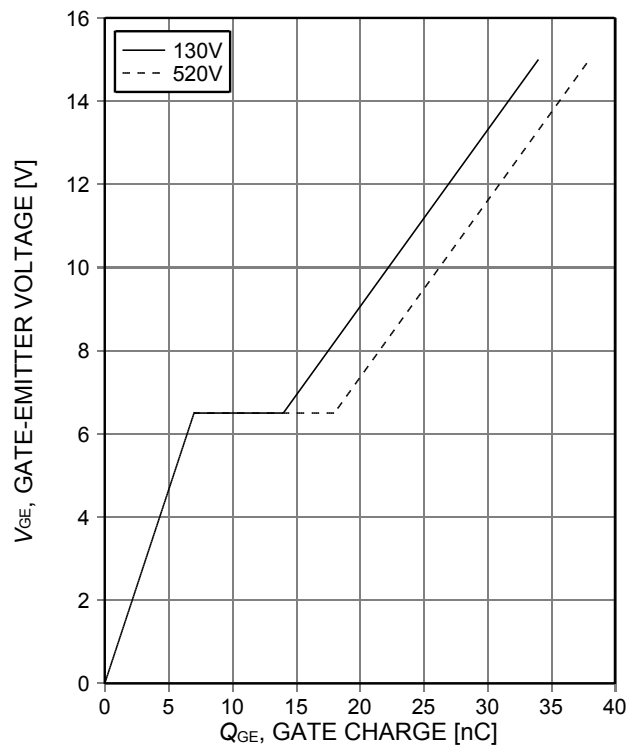


Figure 16. **Typical gate charge**  
( $I_C=15\text{A}$ )

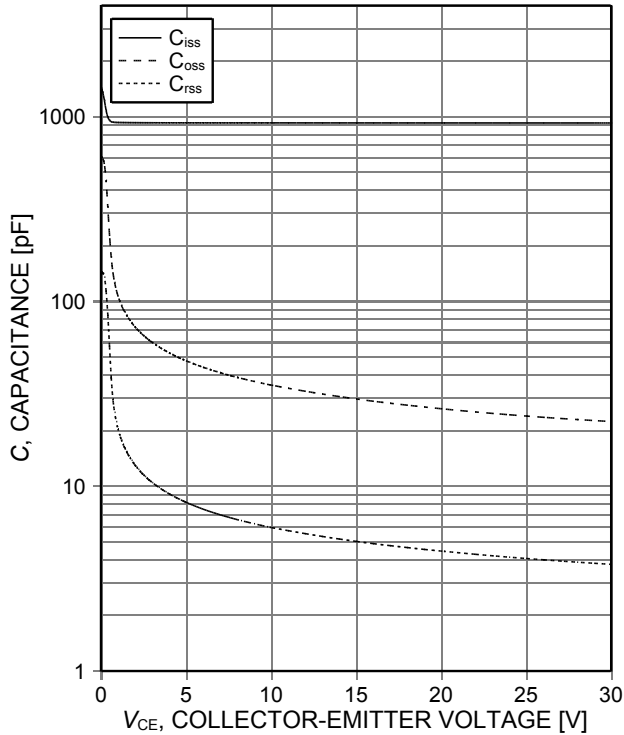


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=1MHz$ )

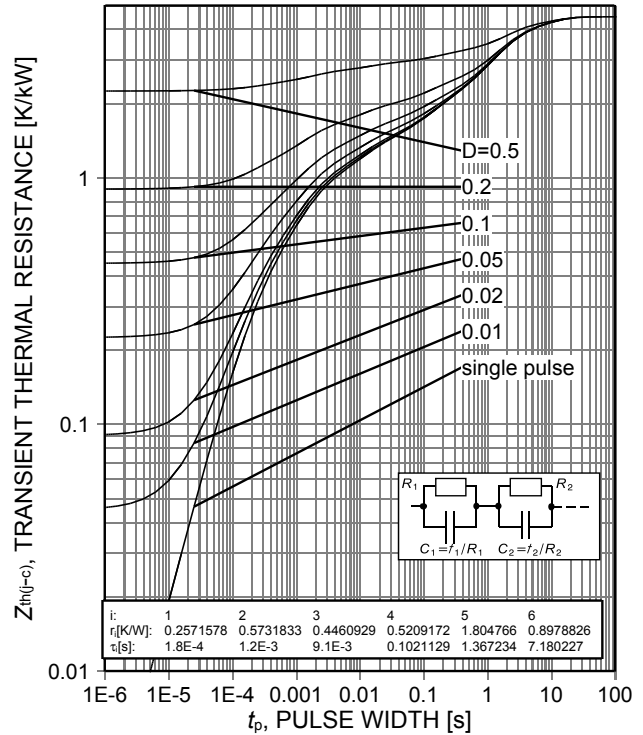


Figure 18. IGBT transient thermal resistance ( $D=t_p/T$ )

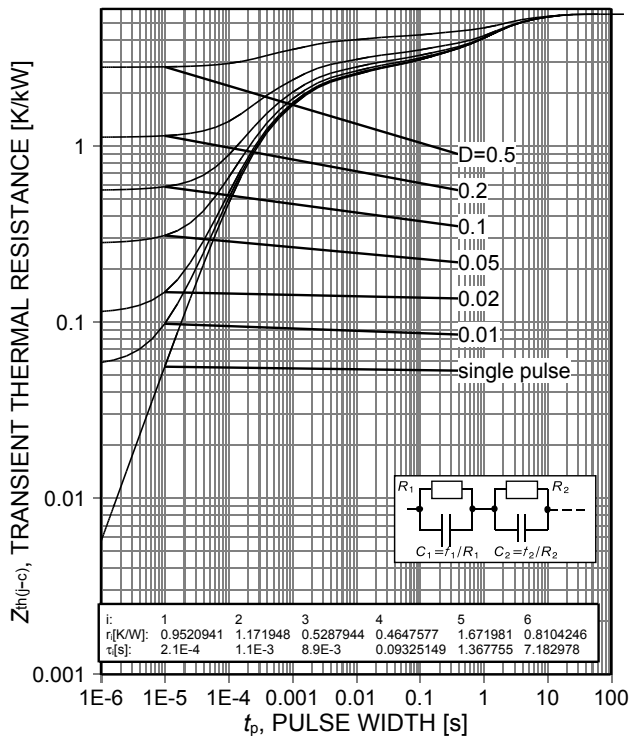


Figure 19. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

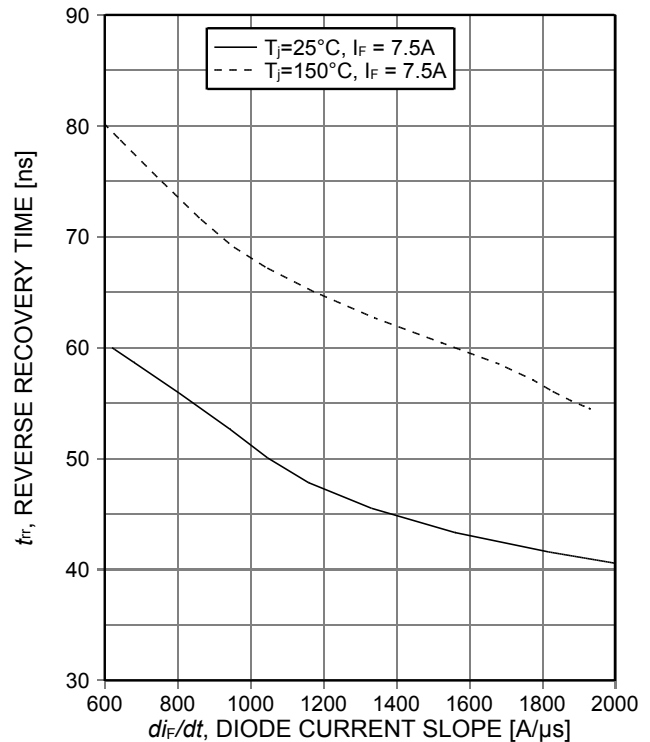


Figure 20. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

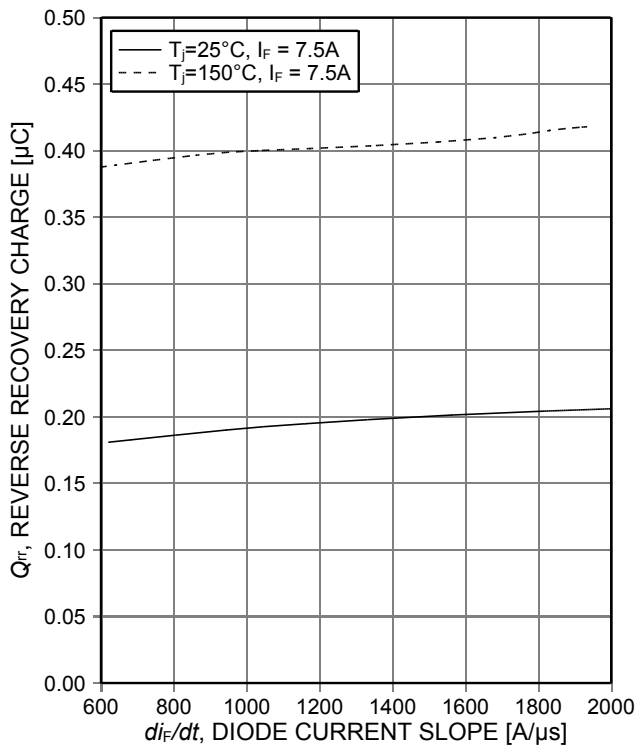


Figure 21. **Typical reverse recovery charge as a function of diode current slope**  
( $V_R=400V$ )

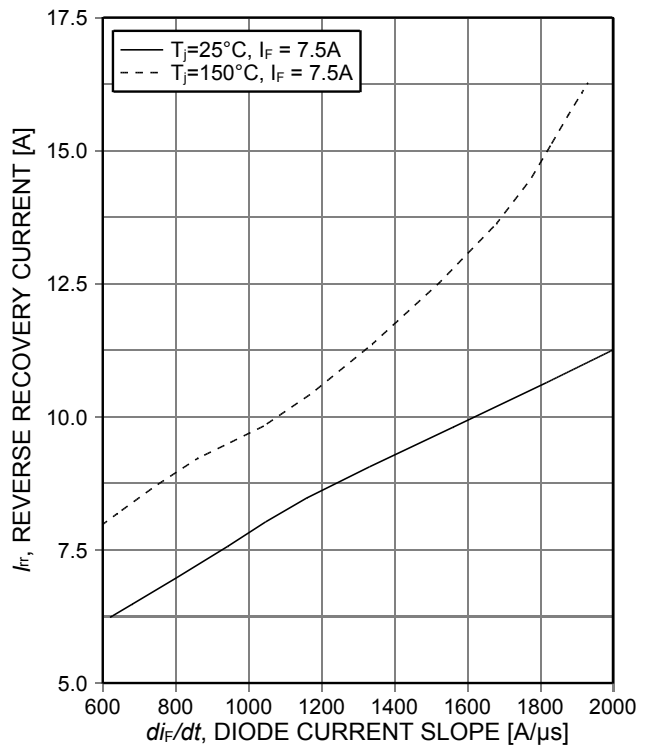


Figure 22. **Typical reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

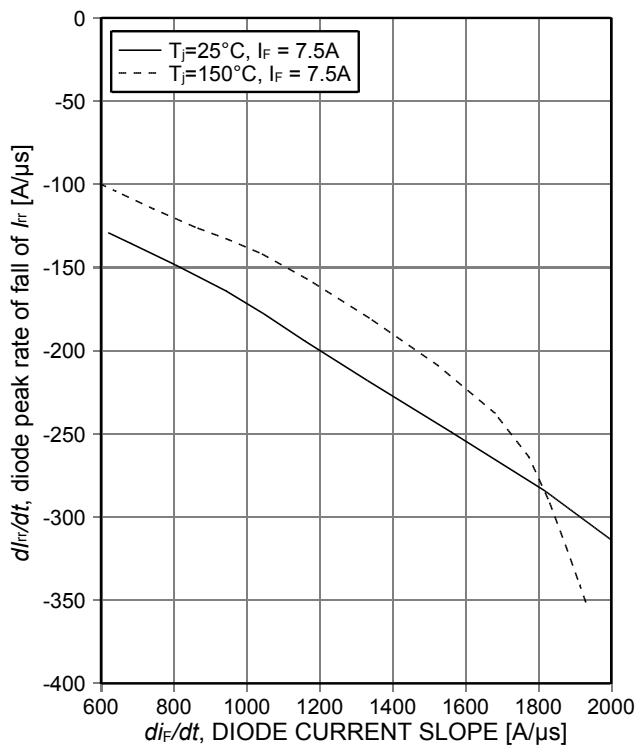


Figure 23. **Typical diode peak rate of fall of reverse recovery current as a function of diode current slope**  
( $V_R=400V$ )

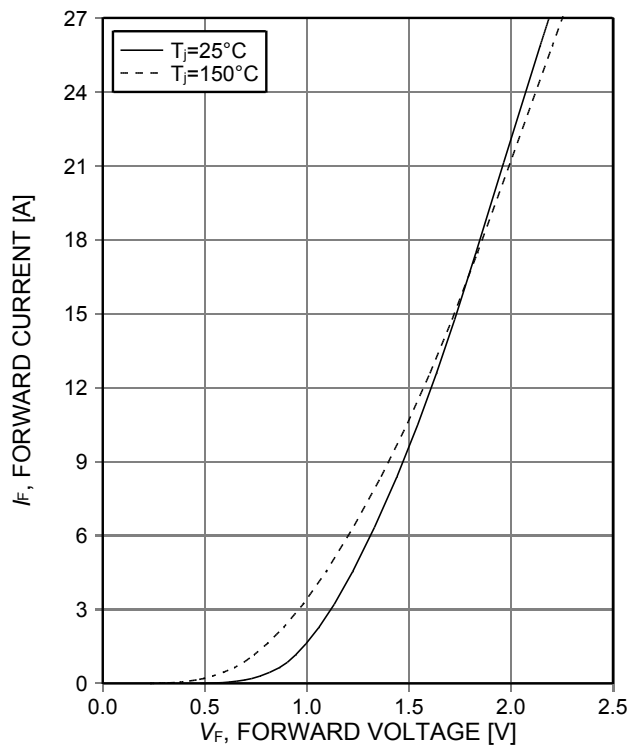


Figure 24. **Typical diode forward current as a function of forward voltage**

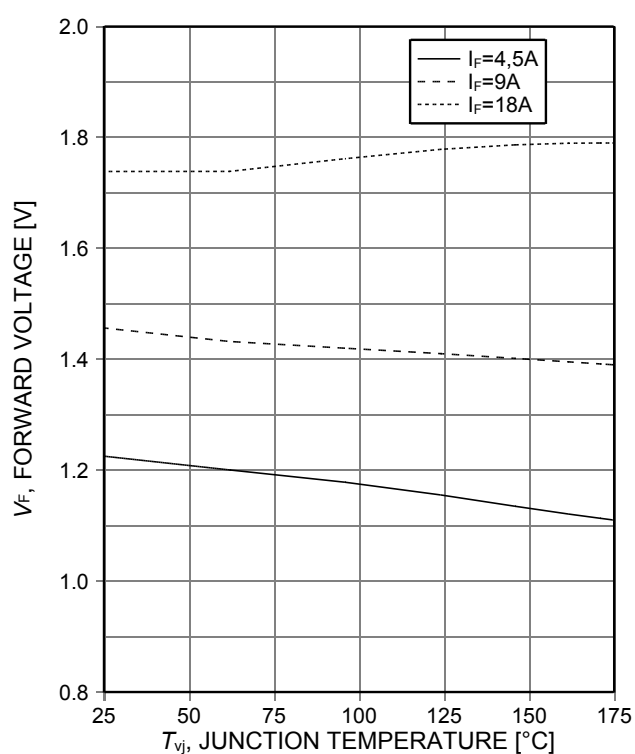
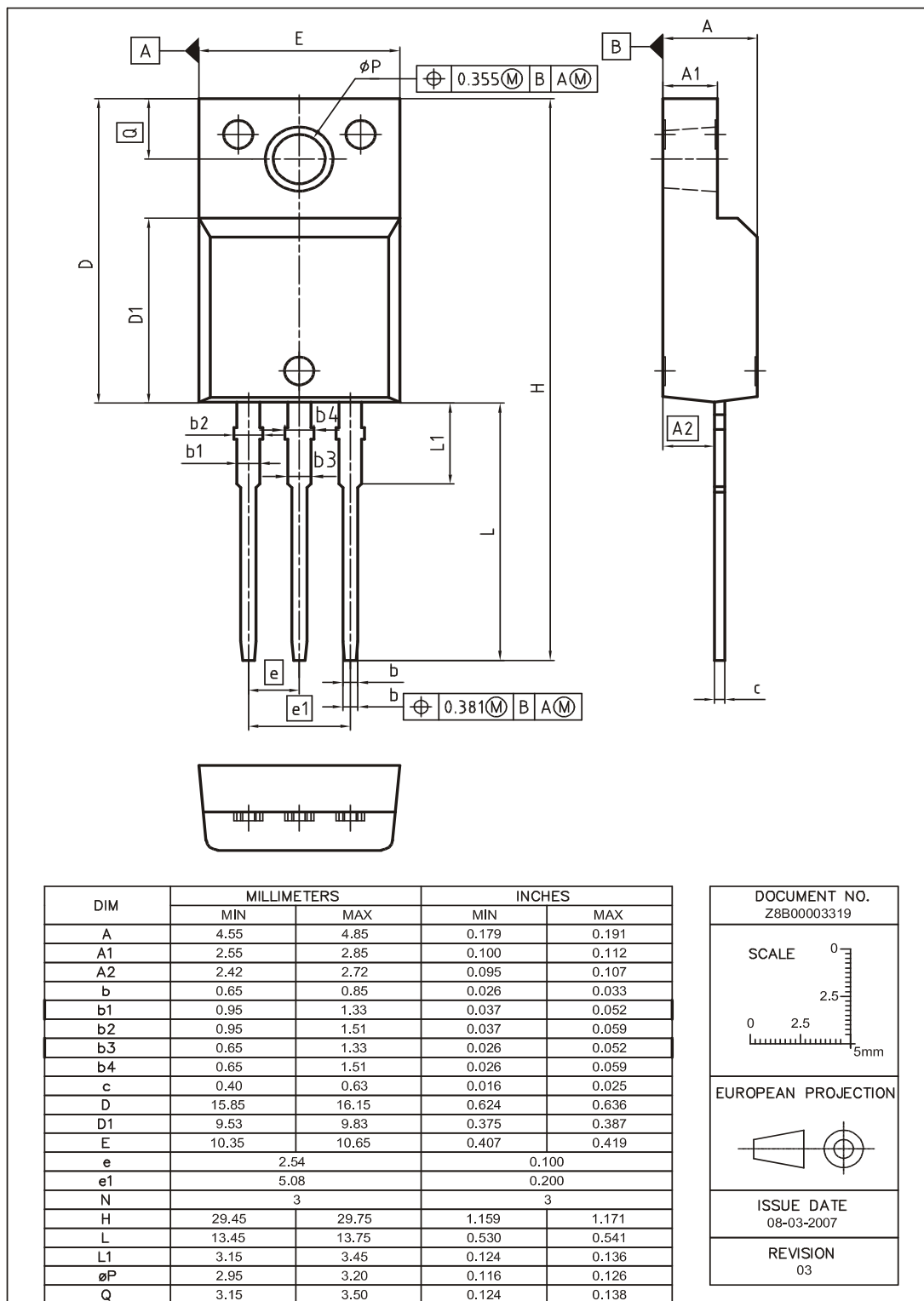


Figure 25. Typical diode forward voltage as a function of junction temperature

## PG-TO220-3-FP



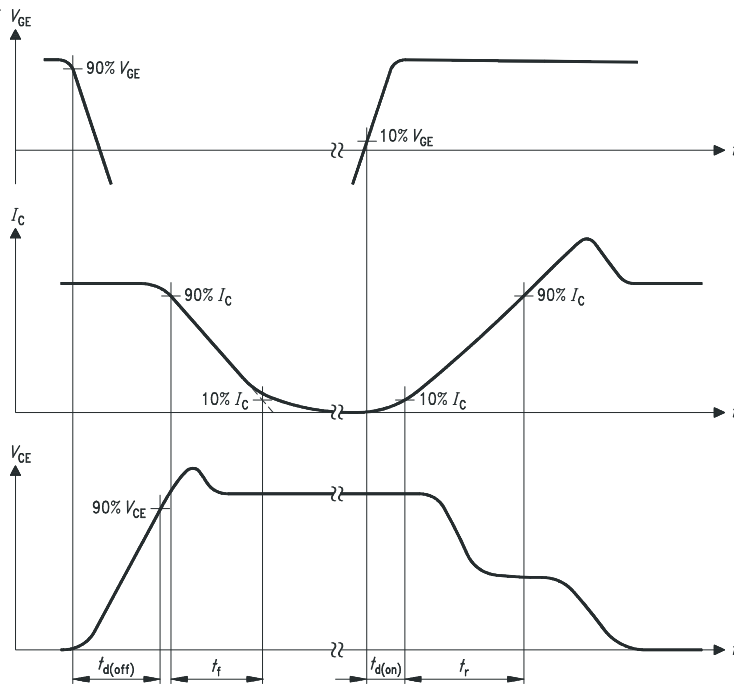


Figure A. Definition of switching times

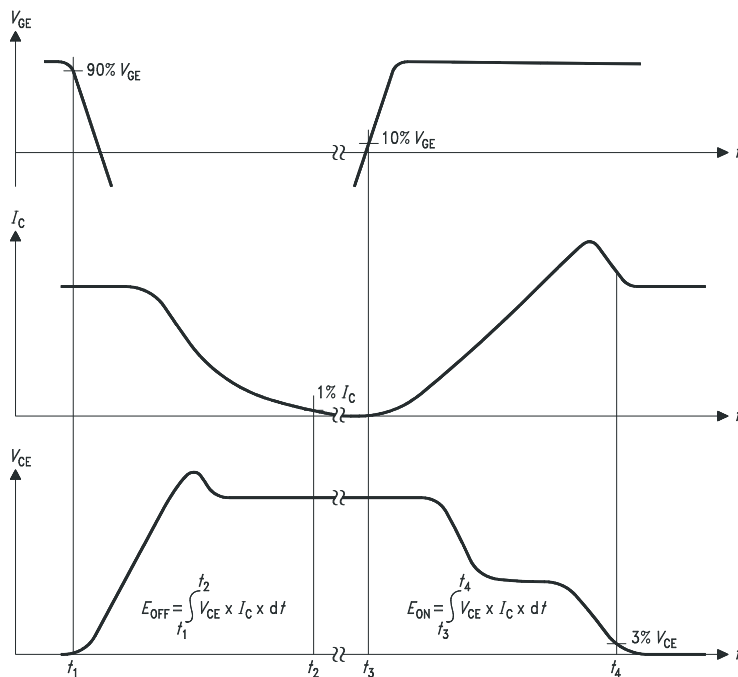


Figure B. Definition of switching losses

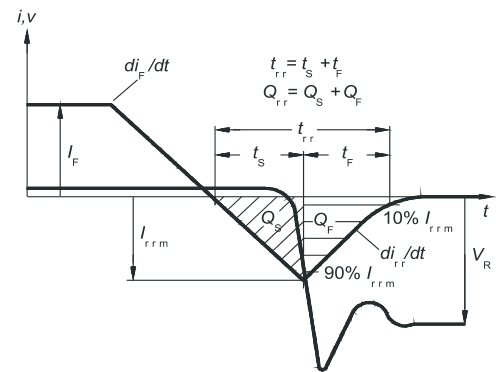


Figure C. Definition of diodes switching characteristics

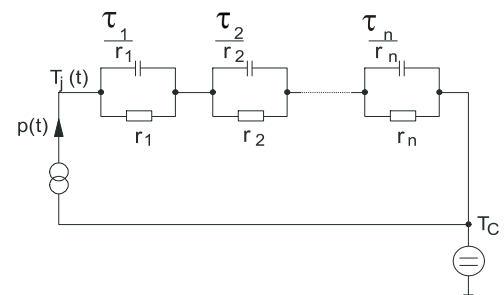
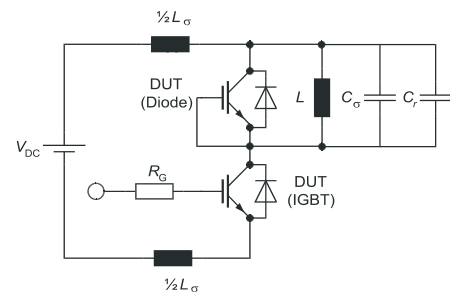


Figure D. Thermal equivalent circuit


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



**Revision History**

IKA15N65F5

**Revision: 2012-11-09, Rev. 1.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 1.1      | 2012-11-09 | Preliminary datasheet                        |

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