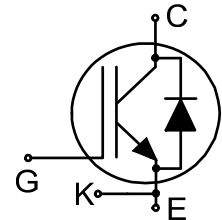


## Hybrid CoolSiC™ IGBT

TRENCHSTOP™ 5 H5 IGBT co-packed with half-rated 6<sup>th</sup> generation CoolSiC™ Schottky barrier diode

## Features and Benefits:

- Ultra-low switching losses due to the combination of TRENCHSTOP™ 5 and CoolSiC™ technology as well as the Kelvin emitter pin
- Benchmark efficiency in hard switching topologies
- Plug-and-play replacement of pure silicon devices
- Simplified PCB design due to the optimized pin-out of the four-pin package
- Improved wave soldering quality due to the increased clearance of the Kelvin emitter and gate pins
- 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/>



## Potential Applications:

- Industrial Power Supplies
  - Industrial SMPS
  - Industrial UPS
- Energy Generation
  - Solar String Inverter
- Energy Distribution
  - Energy Storage
- Infrastructure – Charge
  - Charger

## Product Validation:

Qualified for applications listed above based on the test conditions in the relevant tests of JEDEC20/22

## Package pin definition:

- Pin C & backside - collector
- Pin E - emitter
- Pin K - Kelvin emitter
- Pin G - gate



## Key Performance and Package Parameters

| Type         | $V_{CE}$ | $I_C$ | $V_{CEsat}, T_{vj}=25^{\circ}C$ | $T_{vjmax}$ | Marking | Package      |
|--------------|----------|-------|---------------------------------|-------------|---------|--------------|
| IKZA40N65RH5 | 650V     | 40A   | 1.65V                           | 175°C       | K40ERH5 | PG-TO247-4-3 |

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## Hybrid CoolSiC™ IGBT

## 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 $T_{vjmax}$                                                               | $I_{Cpuls}$ | 160.0                | A                  |
| Turn off safe operating area<br>$V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$ | -           | 160.0                | A                  |
| Diode forward current, limited by $T_{vjmax}$<br>$T_c = 25^{\circ}\text{C}$<br>$T_c = 100^{\circ}\text{C}$           | $I_F$       | 27.5<br>18.5         | A                  |
| Diode pulsed current, $t_p$ limited by $T_{vjmax}$ <sup>1)</sup>                                                     | $I_{Fpuls}$ | 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 $T_c = 100^{\circ}\text{C}$                        | $P_{tot}$   | 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                                          |             | 260                  | $^{\circ}\text{C}$ |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3                                                        | $M$         | 0.6                  | Nm                 |

## Thermal Resistance

| Parameter                                    | Symbol               | Conditions | Value |      |      | Unit |
|----------------------------------------------|----------------------|------------|-------|------|------|------|
|                                              |                      |            | min.  | typ. | max. |      |
| R <sub>th</sub> Characteristics              |                      |            |       |      |      |      |
| IGBT thermal resistance,<br>junction - case  | R <sub>th(j-c)</sub> |            | -     | -    | 0.60 | K/W  |
| Diode thermal resistance,<br>junction - case | R <sub>th(j-c)</sub> |            | -     | -    | 1.80 | K/W  |
| Thermal resistance<br>junction - ambient     | R <sub>th(j-a)</sub> |            | -     | -    | 40   | K/W  |

<sup>1)</sup> Pulse current level depends on  $T_{vj}$  of diode chip, see also Fig. "Maximum pulse current as a function of junction temperature"

## Hybrid CoolSiC™ IGBT

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

| Parameter                            | Symbol       | Conditions                                                                                                    | Value       |                      |                | Unit    |
|--------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------|---------|
|                                      |              |                                                                                                               | min.        | typ.                 | max.           |         |
| Static Characteristic                |              |                                                                                                               |             |                      |                |         |
| Collector-emitter saturation voltage | $V_{CEsat}$  | $V_{GE} = 15.0V, I_C = 40.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 125^{\circ}C$<br>$T_{vj} = 175^{\circ}C$ | -<br>-<br>- | 1.65<br>1.85<br>1.95 | 2.10<br>-<br>- | V       |
| Diode forward voltage                | $V_F$        | $V_{GE} = 0V, I_F = 16.0A$<br>$T_{vj} = 25^{\circ}C$<br>$T_{vj} = 125^{\circ}C$<br>$T_{vj} = 175^{\circ}C$    | -<br>-<br>- | 1.35<br>1.55<br>1.65 | 1.50<br>-<br>- | V       |
| Gate-emitter threshold voltage       | $V_{GE(th)}$ | $I_C = 0.40mA, V_{CE} = V_{GE}$                                                                               | 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>2000            | 600<br>-       | $\mu A$ |
| Zero gate voltage collector current  | $I_{CES}$    | $V_{CE} = 480V, V_{GE} = 0V$<br>$T_{vj} = 25^{\circ}C$                                                        | -           | -                    | 16             | $\mu A$ |
| Gate-emitter leakage current         | $I_{GES}$    | $V_{CE} = 0V, V_{GE} = 20V$                                                                                   | -           | -                    | 100            | nA      |
| Transconductance                     | $g_{fs}$     | $V_{CE} = 20V, I_C = 40.0A$                                                                                   | -           | 50.0                 | -              | 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<br>f = 250kHz                | -     | 2190 | -    | pF   |
| Output capacitance                                                   | C <sub>oes</sub> |                                                                          | -     | 265  | -    |      |
| Reverse transfer capacitance                                         | C <sub>res</sub> |                                                                          | -     | 8    | -    |      |
| Gate charge                                                          | Q <sub>G</sub>   | V <sub>CC</sub> = 520V, I <sub>C</sub> = 40.0A,<br>V <sub>GE</sub> = 15V | -     | 95.0 | -    | nC   |
| Internal emitter inductance<br>measured 5mm (0.197 in.) from<br>case | L <sub>E</sub>   |                                                                          | -     | 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                                    | $t_{d(\text{on})}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 20.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$R_{G(\text{on})} = 15.0\Omega$ , $R_{G(\text{off})} = 15.0\Omega$ ,<br>$L_{\sigma} = 30\text{nH}$ , $C_{\sigma} = 30\text{pF}$<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                                   | $t_{d(\text{off})}$ |                                                                                                                                                                                                                                                                                                                                                                  | -     | 165  | -    | ns   |
| Fall time                                             | $t_f$               |                                                                                                                                                                                                                                                                                                                                                                  | -     | 13   | -    | ns   |
| Turn-on energy                                        | $E_{\text{on}}$     |                                                                                                                                                                                                                                                                                                                                                                  | -     | 0.14 | -    | mJ   |
| Turn-off energy                                       | $E_{\text{off}}$    |                                                                                                                                                                                                                                                                                                                                                                  | -     | 0.12 | -    | mJ   |
| Total switching energy                                | $E_{\text{ts}}$     |                                                                                                                                                                                                                                                                                                                                                                  | -     | 0.26 | -    | mJ   |

## Hybrid CoolSiC™ IGBT

|                        |              |                                                                                                                                                                                                                                                                                                                                       |   |      |   |    |
|------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 25^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 5.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$R_{G(on)} = 15.0\Omega$ , $R_{G(off)} = 15.0\Omega$ ,<br>$L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include "tail" and<br>diode reverse recovery. | - | 17   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                                       | - | 4    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                                       | - | 190  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                                       | - | 25   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                                       | - | 0.03 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                                       | - | 0.05 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                                       | - | 0.08 | - | 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     | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 20.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$R_{G(on)} = 15.0\Omega$ , $R_{G(off)} = 15.0\Omega$ ,<br>$L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include "tail" and<br>diode reverse recovery. | - | 18   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                                         | - | 7    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                                         | - | 195  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                                         | - | 22   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                                         | - | 0.16 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                                         | - | 0.22 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                                         | - | 0.38 | - | mJ |

|                        |              |                                                                                                                                                                                                                                                                                                                                        |   |      |   |    |
|------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|----|
| Turn-on delay time     | $t_{d(on)}$  | $T_{vj} = 150^{\circ}\text{C}$ ,<br>$V_{CC} = 400\text{V}$ , $I_C = 5.0\text{A}$ ,<br>$V_{GE} = 0.0/15.0\text{V}$ ,<br>$R_{G(on)} = 15.0\Omega$ , $R_{G(off)} = 15.0\Omega$ ,<br>$L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$<br>$L\sigma$ , $C\sigma$ from Fig. E<br>Energy losses include "tail" and<br>diode reverse recovery. | - | 16   | - | ns |
| Rise time              | $t_r$        |                                                                                                                                                                                                                                                                                                                                        | - | 3    | - | ns |
| Turn-off delay time    | $t_{d(off)}$ |                                                                                                                                                                                                                                                                                                                                        | - | 240  | - | ns |
| Fall time              | $t_f$        |                                                                                                                                                                                                                                                                                                                                        | - | 35   | - | ns |
| Turn-on energy         | $E_{on}$     |                                                                                                                                                                                                                                                                                                                                        | - | 0.04 | - | mJ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                                                                                                                                                        | - | 0.07 | - | mJ |
| Total switching energy | $E_{ts}$     |                                                                                                                                                                                                                                                                                                                                        | - | 0.11 | - | mJ |

Hybrid CoolSiC™ IGBT

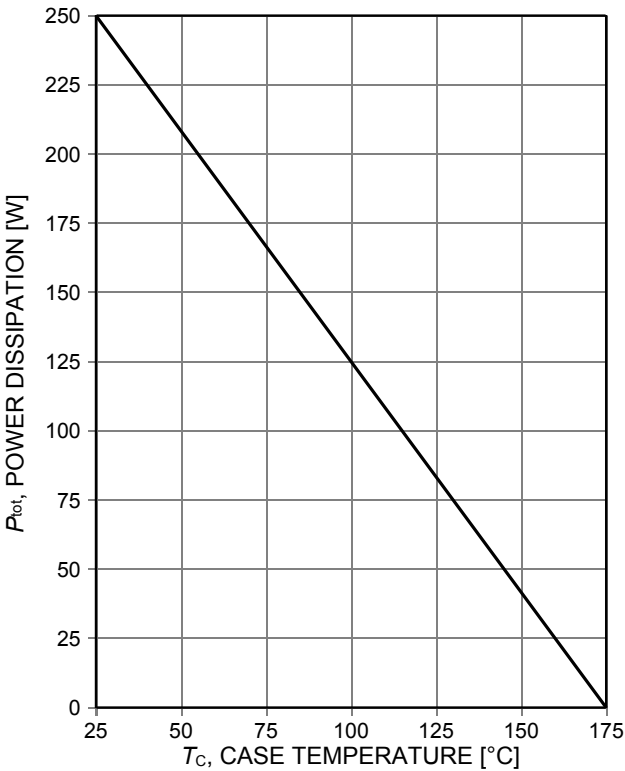


Figure 1. **Power dissipation as a function of case temperature**  
( $T_{vj} \leq 175^\circ\text{C}$ )

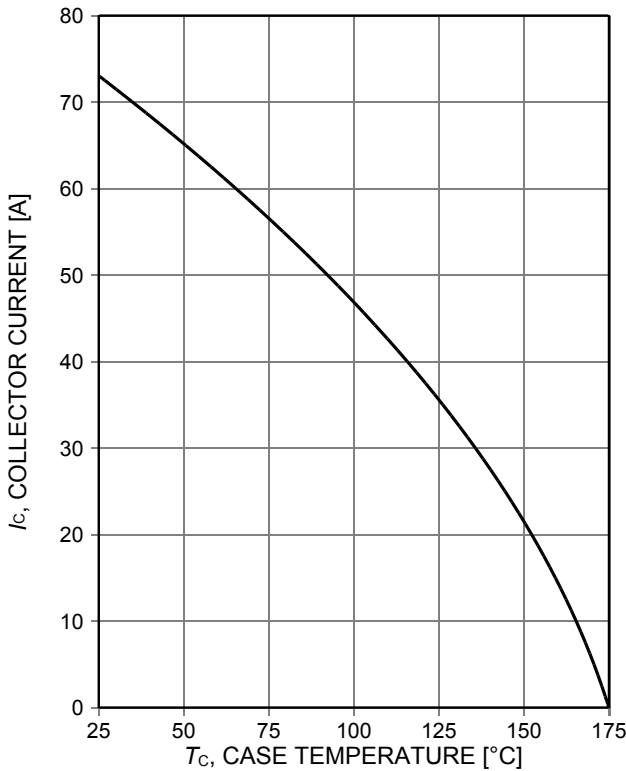


Figure 2. **Collector current as a function of case temperature**  
( $V_{GE} \geq 15\text{V}$ ,  $T_{vj} \leq 175^\circ\text{C}$ )

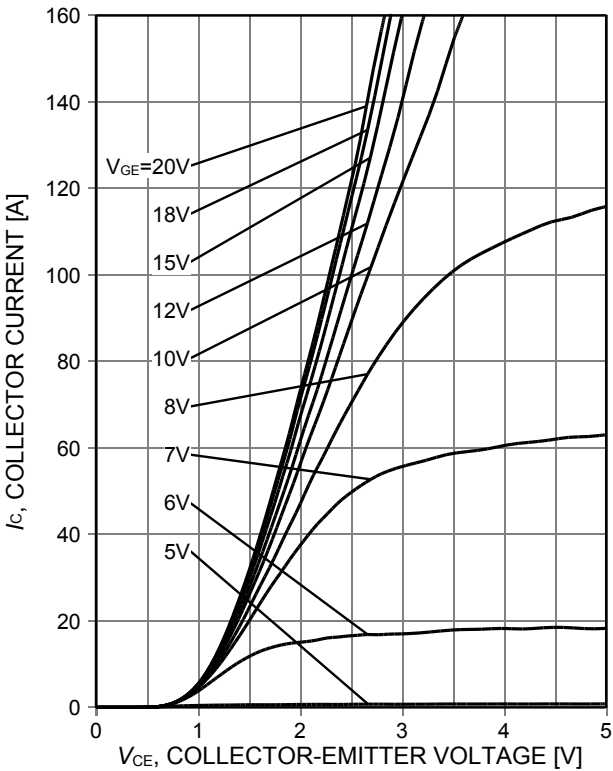


Figure 3. **Typical output characteristic**  
( $T_{vj} = 25^\circ\text{C}$ )

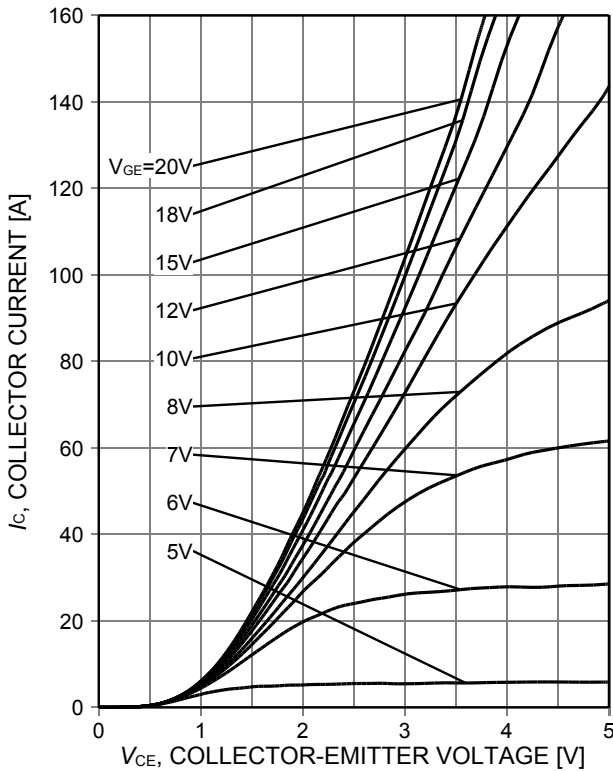


Figure 4. **Typical output characteristic**  
( $T_{vj} = 150^\circ\text{C}$ )

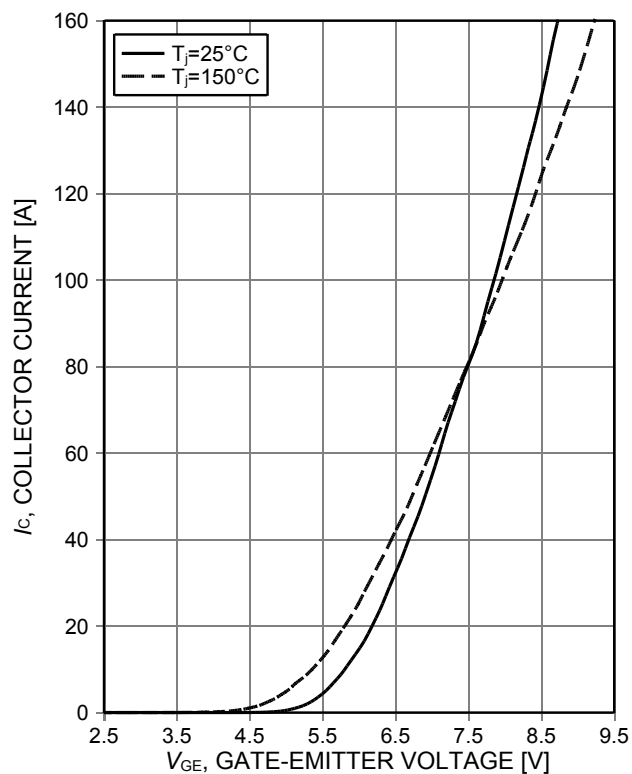


Figure 5. **Typical transfer characteristic**  
( $V_{CE}=20V$ )

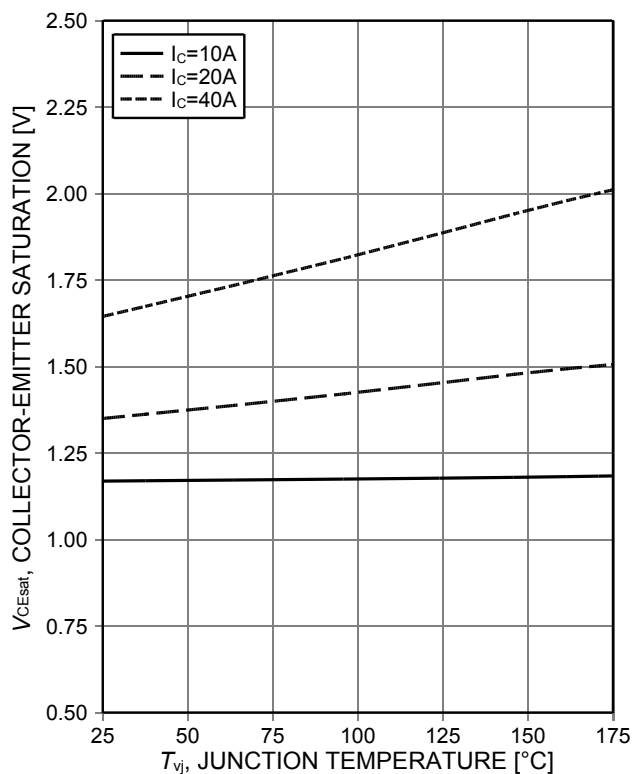


Figure 6. **Typical collector-emitter saturation voltage as a function of junction temperature**  
( $V_{GE}=15V$ )

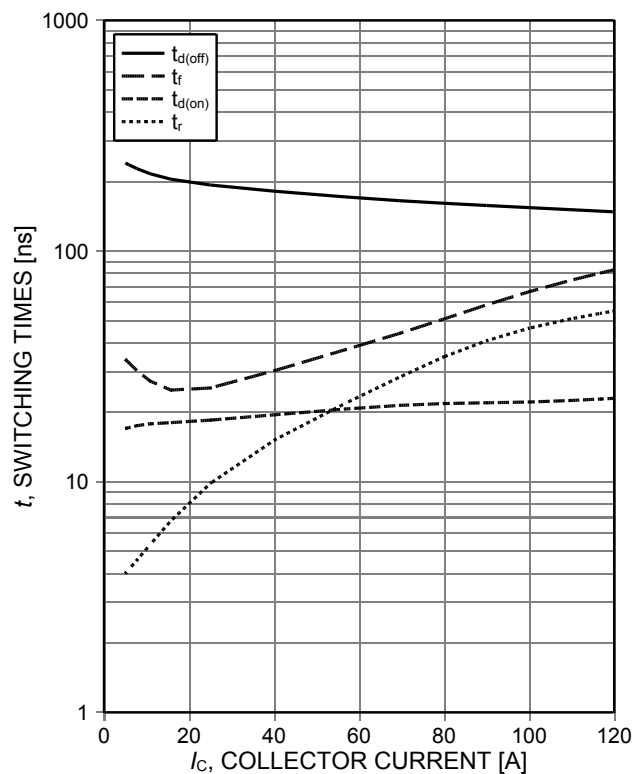


Figure 7. **Typical switching times as a function of collector current**  
(inductive load,  $T_{vj}=150^{\circ}C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $R_G=15\Omega$ , Dynamic test circuit in Figure E)

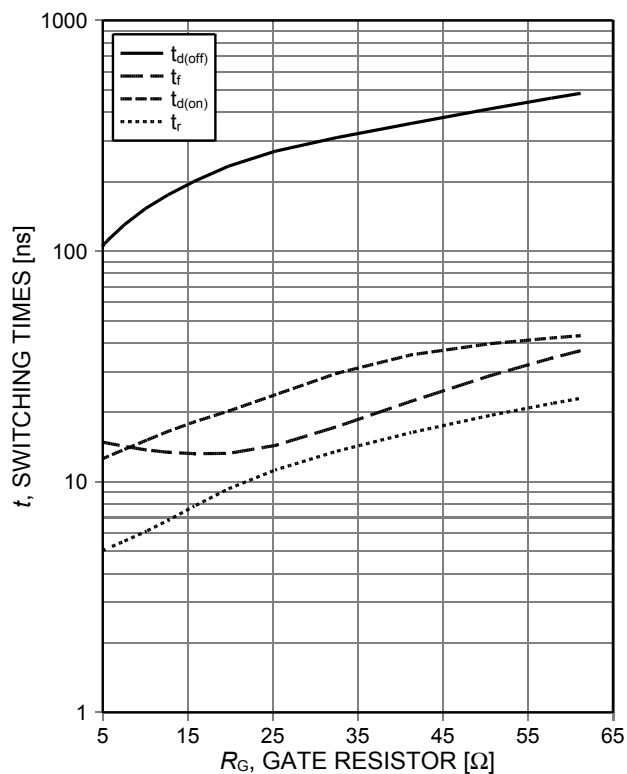


Figure 8. **Typical switching times as a function of gate resistor**  
(inductive load,  $T_{vj}=150^{\circ}C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=20A$ , Dynamic test circuit in Figure E)

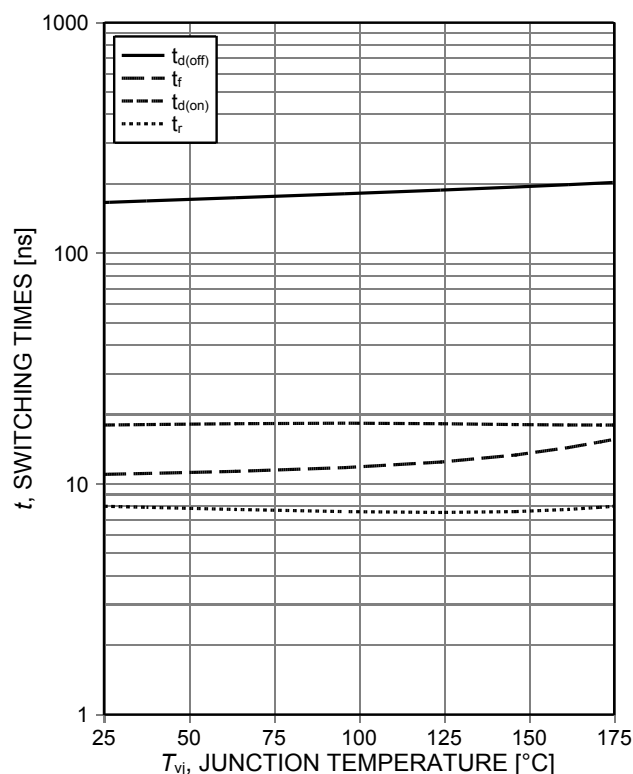


Figure 9. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=20A$ ,  $R_G=15\Omega$ , Dynamic test circuit in Figure E)

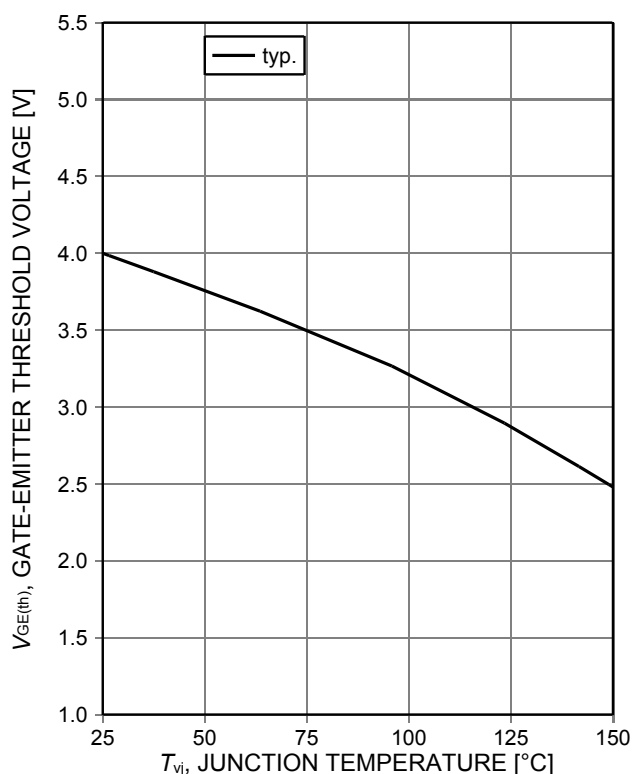


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0.4mA$ )

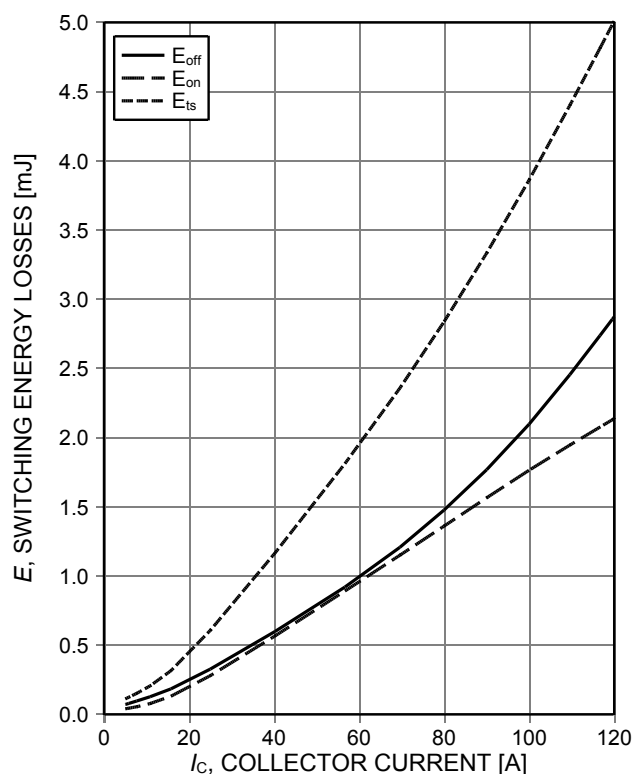


Figure 11. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=150^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $R_G=15\Omega$ , Dynamic test circuit in Figure E)

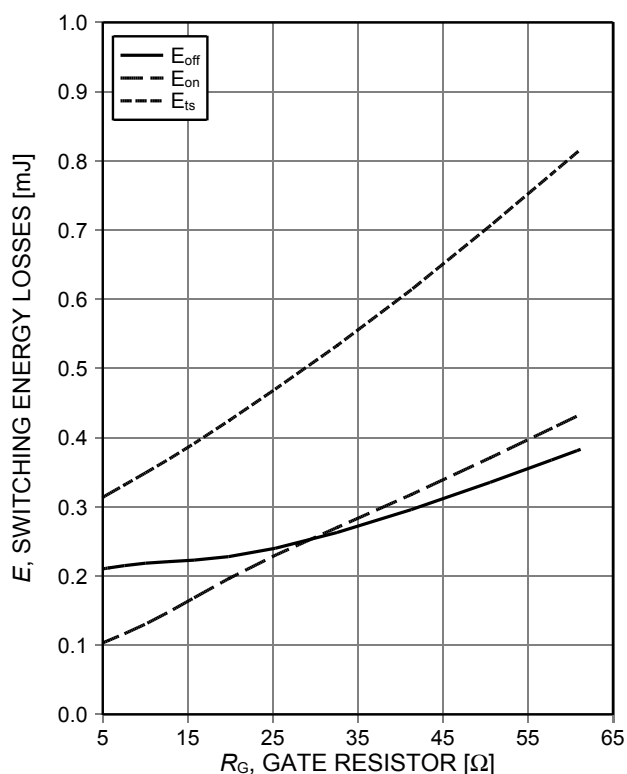


Figure 12. **Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_{vj}=150^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=20A$ , Dynamic test circuit in Figure E)

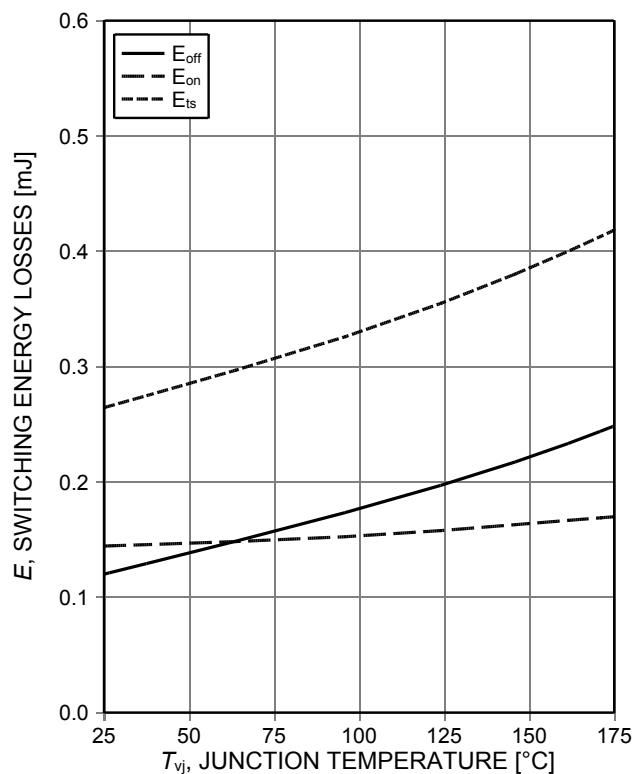


Figure 13. **Typical switching energy losses as a function of junction temperature**  
(inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=20A$ ,  $R_G=15\Omega$ , Dynamic test circuit in Figure E)

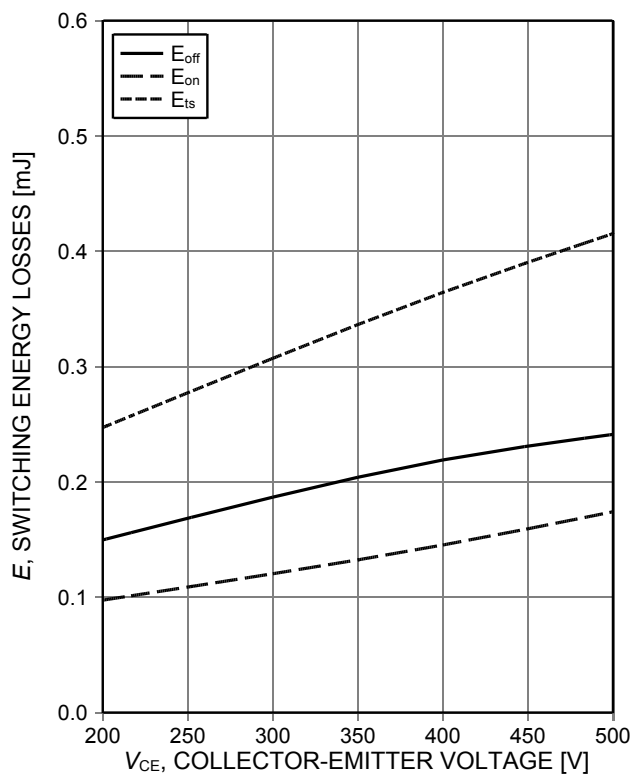


Figure 14. **Typical switching energy losses as a function of collector emitter voltage**  
(inductive load,  $T_{vj}=150^\circ C$ ,  $V_{GE}=15/0V$ ,  $I_C=20A$ ,  $R_G=15\Omega$ , Dynamic test circuit in Figure E)

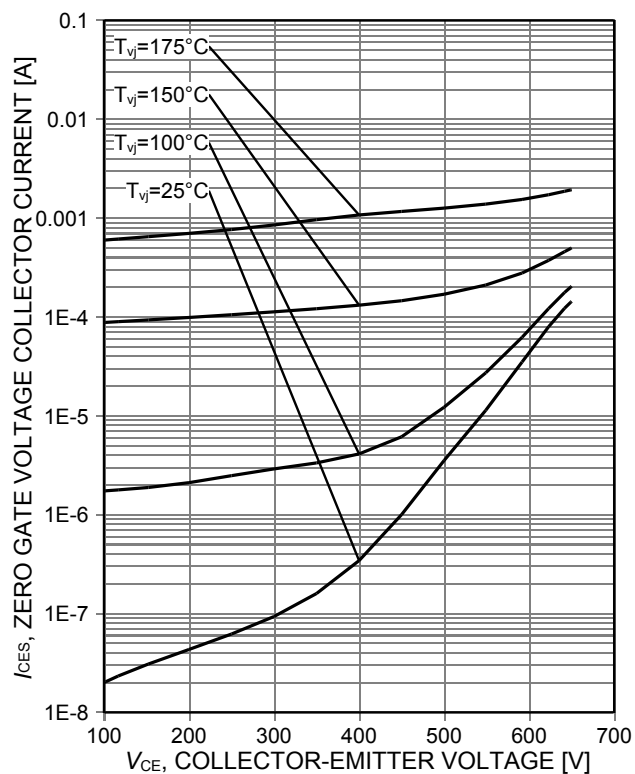


Figure 15. **Typ. reverse current vs. reverse voltage as a function of  $T_{vj}$**

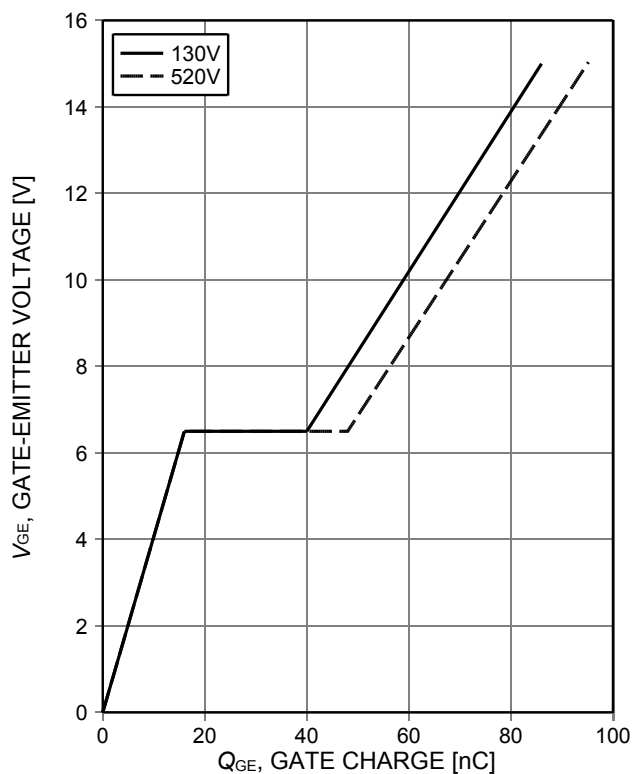


Figure 16. **Typical gate charge**  
( $I_C=40A$ )

Hybrid CoolSiC™ IGBT

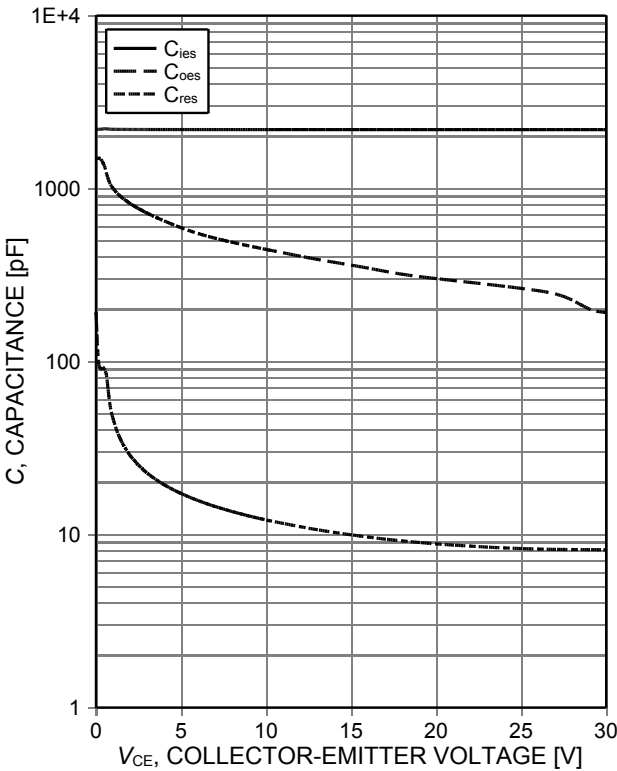


Figure 17. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V$ ,  $f=250kHz$ )

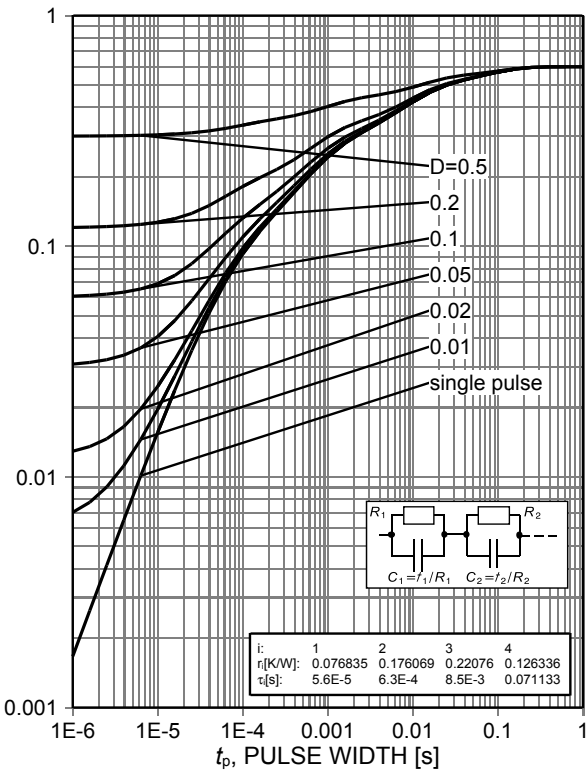


Figure 18. IGBT transient thermal resistance ( $D=t_p/T$ )

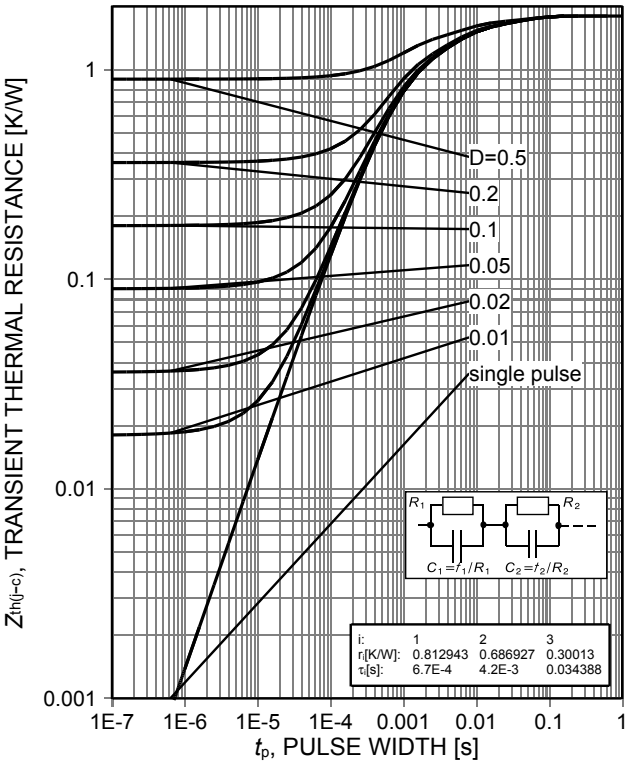


Figure 19. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

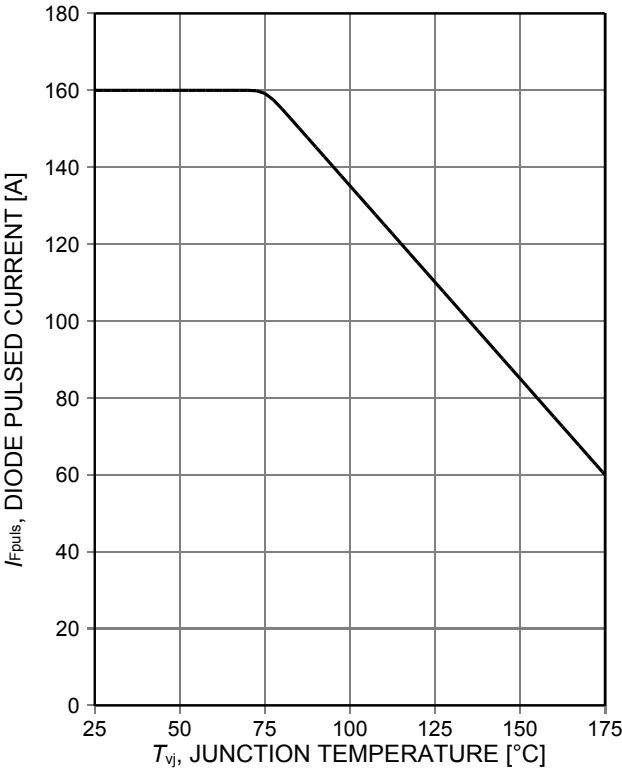


Figure 20. Maximum pulse current as a function of junction temperature

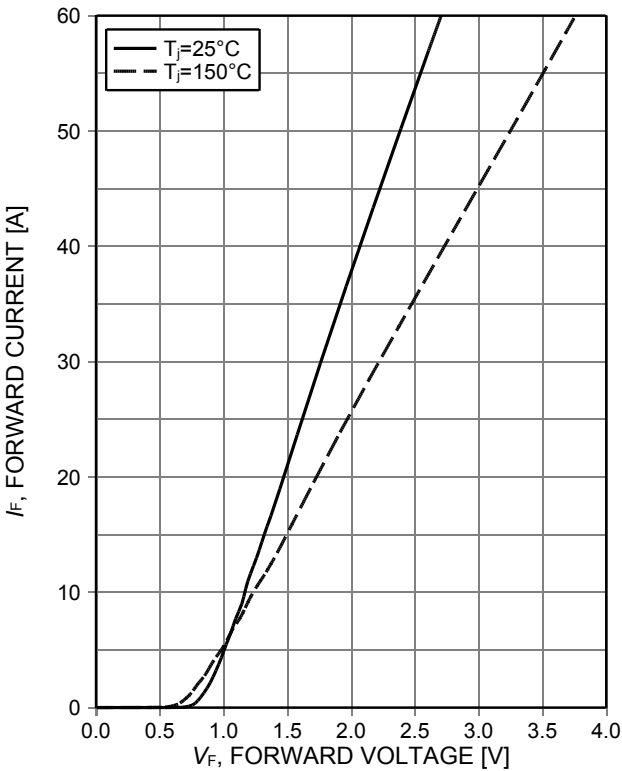


Figure 21. Typical diode forward current as a function of forward voltage

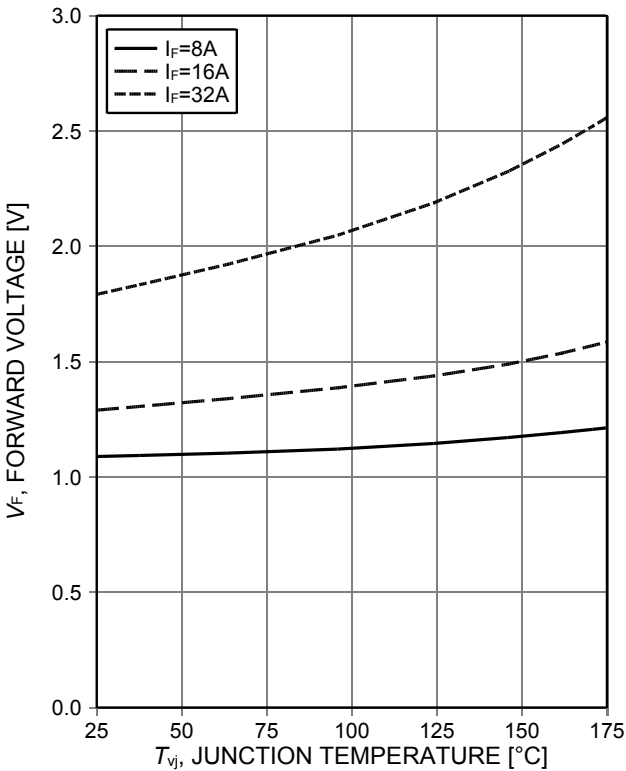
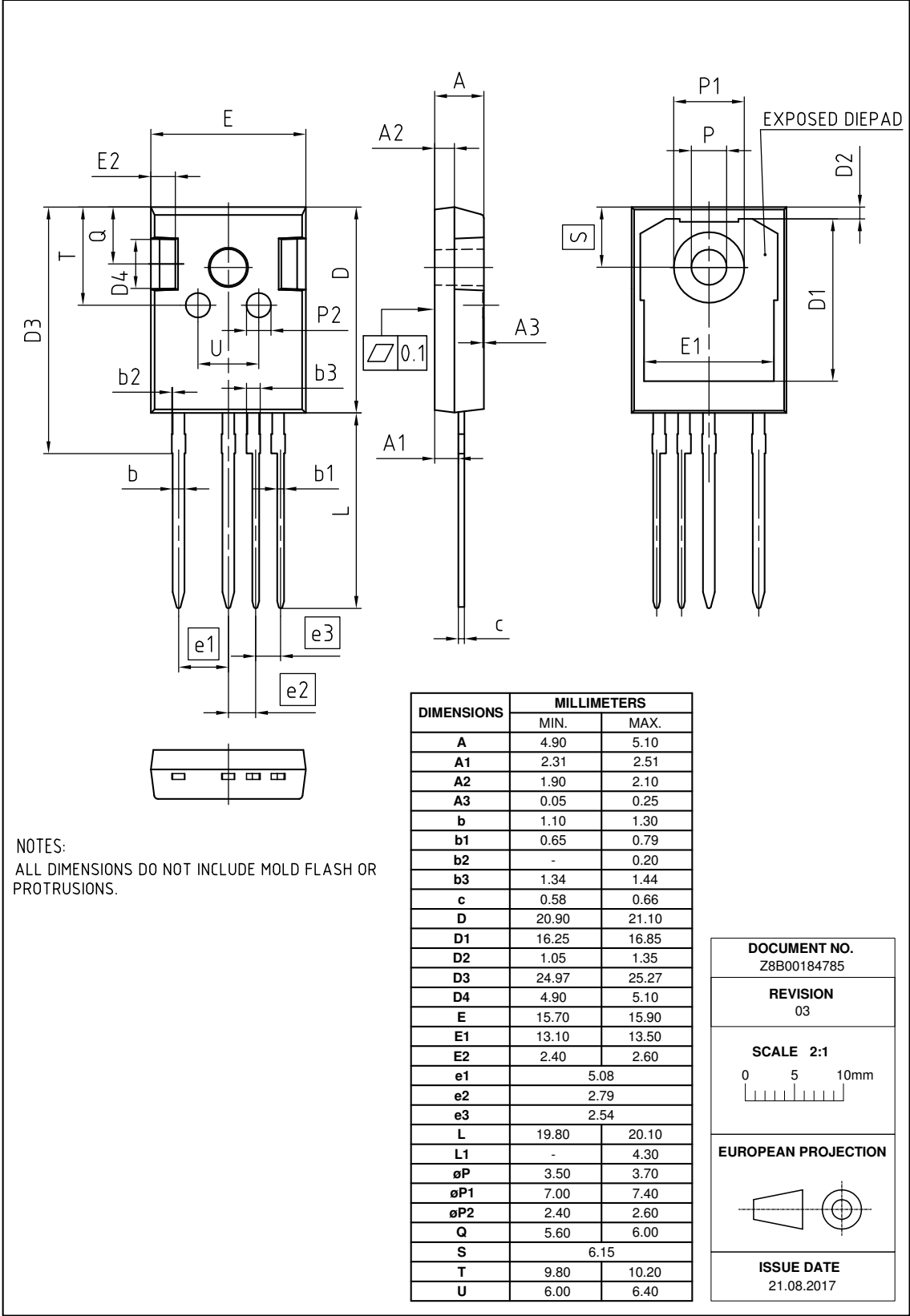


Figure 22. Typical diode forward voltage as a function of junction temperature

PG-TO247-4-3



### Testing Conditions

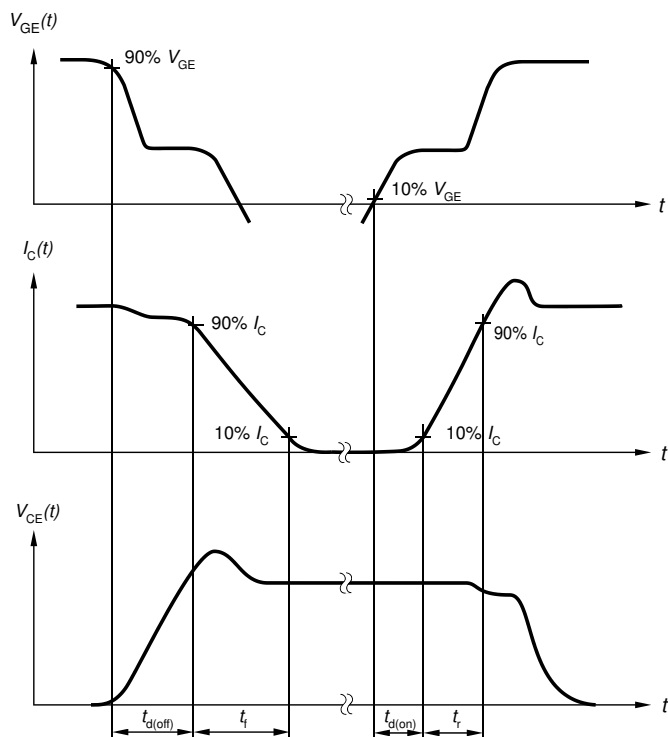


Figure A. Definition of switching times

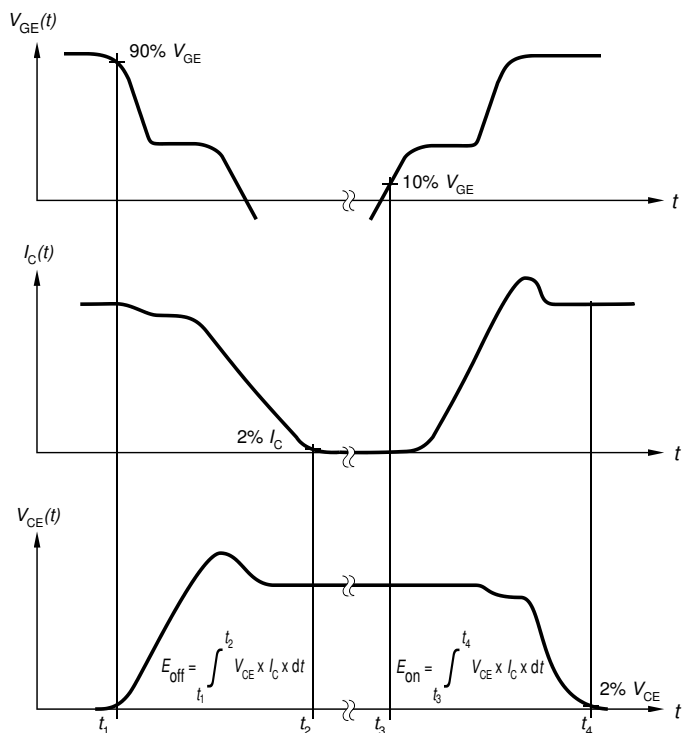


Figure B. Definition of switching losses

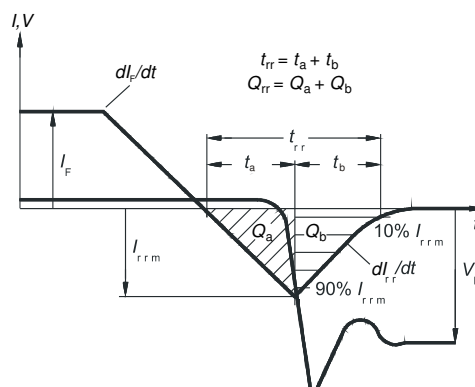


Figure C. Definition of diode switching characteristics

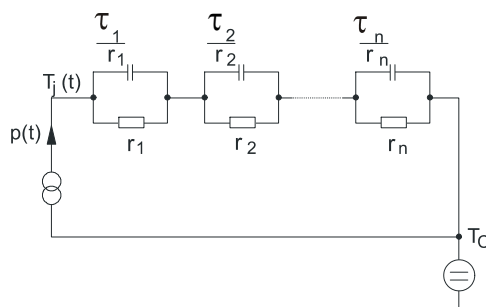


Figure D. Thermal equivalent circuit

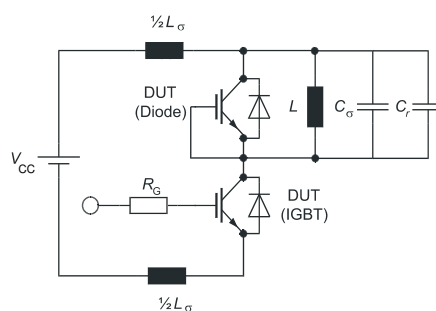


Figure E. **Dynamic test circuit**  
Parasitic inductance  $L_\sigma$ ,  
parasitic capacitor  $C_\sigma$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

### Revision History

IKZA40N65RH5

**Revision: 2020-07-27, Rev. 2.1**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 1.1      | 2020-03-20 | Preliminary Data Sheet                       |
| 2.1      | 2020-07-27 | Final Data Sheet                             |

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