

1. General description

WG40N65HF5 uses advanced Fine Trench Field-stop IGBT technology with anti-parallel diode in TO220 package to provide extremely low $V_{CE(sat)}$, and excellent switching performance. This device offers Best-in-Class efficiency in hard switching and resonant topology.



2. Features and benefits

- Maximum junction temperature 175 °C
- Positive Temperature efficient for easy paralleling
- Very soft, fast recovery anti-parallel diode
- High switching speed
- EMI Improved Design

3. Applications

- PFC
- Solar converters
- UPS
- Welding Converters
- Mid to high range switching frequency converters

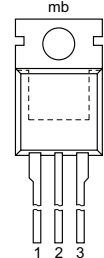
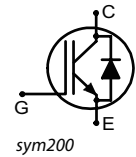
4. Quick reference data

Table 1. Quick reference data

| Symbol | Parameter | Notes | Value | | | Unit | |
|-------------------------------|--|---|-------|-----|------|------|------|
| V_{CE} | Collector-emitter voltage, $T_j \geq 25\text{ °C}$ | | 650 | | | V | |
| I_C | DC collector current, limited by $T_{j(max)}$ $T_C = 100\text{ °C}$ | | 40 | | | A | |
| Symbol | Parameter | Conditions | Notes | Min | Typ | Max | Unit |
| Static characteristics | | | | | | | |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}; I_C = 40\text{ A}; T_j = 25\text{ °C}$ | | - | 1.45 | 1.85 | V |

5. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description | Simplified outline | Graphic symbol |
|-----|--------|---------------------------------------|---|---|
| 1 | G | gate |  |  |
| 2 | C | collector | | |
| 3 | E | emitter | | |
| mb | C | mounting base; connected to collector | | |

6. Ordering information

Table 3. Ordering information

| Type number | Package Name | Orderable part number | Packing method | Small packing quantity | Package version | Package issue date |
|-------------|--------------|-----------------------|----------------|------------------------|-----------------|--------------------|
| WG40N65HF5 | TO220 | WG40N65HF5Q | Tube | 30 | SOT78 | 13-Jun-2008 |

7. Marking

Table 4. Marking codes

| Type number | Marking codes |
|-------------|----------------|
| WG40N65HF5 | WG40N 65HF5 |

8. Limiting values

Table 5. Limiting values

| Symbol | Parameter | Notes | Value | Unit |
|---------------|--|-------|-------------|------|
| V_{CE} | Collector-emitter voltage, $T_j \geq 25\text{ °C}$ | | 650 | V |
| I_C | DC collector current, limited by $T_{j(max)}$ $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$ | | 80 40 | A |
| $I_{C(puls)}$ | Pulsed collector current, t_p limited by $T_{j(max)}$ | | 120 | A |
| - | Turn off safe operating area $V_{CE} \leq 650\text{ V}$, $T_j \leq 175\text{ °C}$, $t_p = 1\text{ }\mu\text{s}$ | | 120 | A |
| I_F | Diode forward current, limited by $T_{j(max)}$ $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$ | | 80 40 | A |
| $I_{F(puls)}$ | Diode pulsed current, t_p limited by $T_{j(max)}$ | | 120 | A |
| V_{GE} | Gate-emitter voltage | | ± 20 | V |
| P_{tot} | Power dissipation $T_C = 25\text{ °C}$ Power dissipation $T_C = 100\text{ °C}$ | | 312 156 | W |
| T_{stg} | Storage temperature | | -55 to +150 | °C |
| T_{jmax} | Maximum operating junction temperature | | 175 | °C |
| - | Peak soldering temperature | | 260 | °C |
| M | Mounting Torque with washer | | 0.55 | Nm |

9. Thermal characteristics

Table 6. Thermal characteristics

| Symbol | Parameter | Conditions | Notes | Min | Typ | Max | Unit |
|---------------|--|------------|-------|-----|------|-----|------|
| $R_{th(j-c)}$ | IGBT thermal resistance from junction to case | | | - | 0.48 | - | K/W |
| $R_{th(j-c)}$ | Diode thermal resistance from junction to case | | | - | 0.94 | - | K/W |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | | | - | 60 | - | K/W |

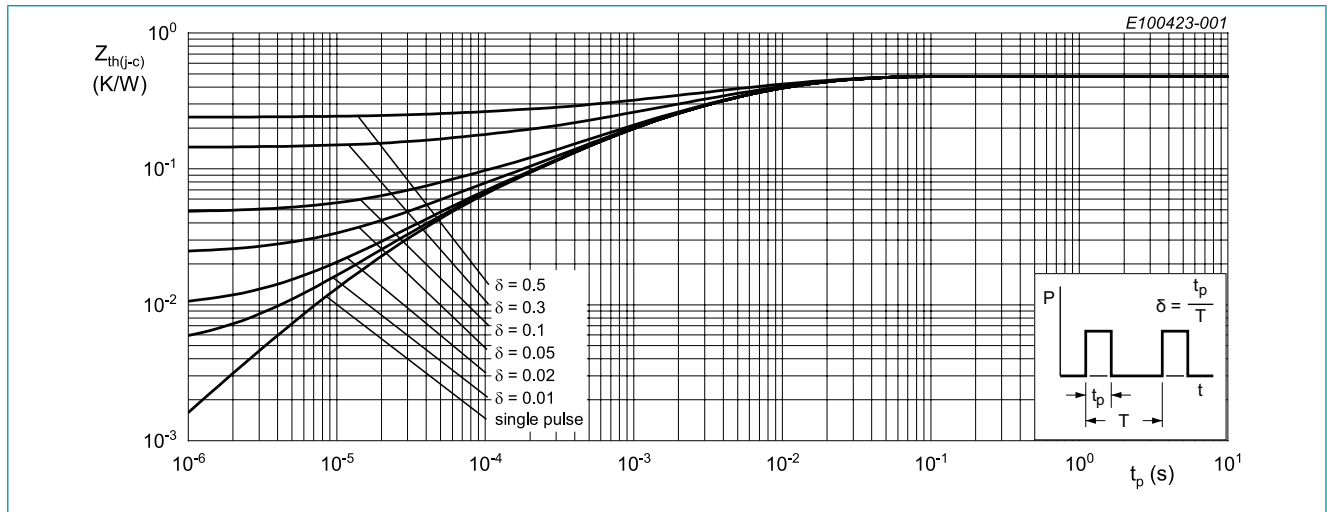


Fig. 1. Transient thermal impedance from junction to case as a function of pulse duration; IGBT

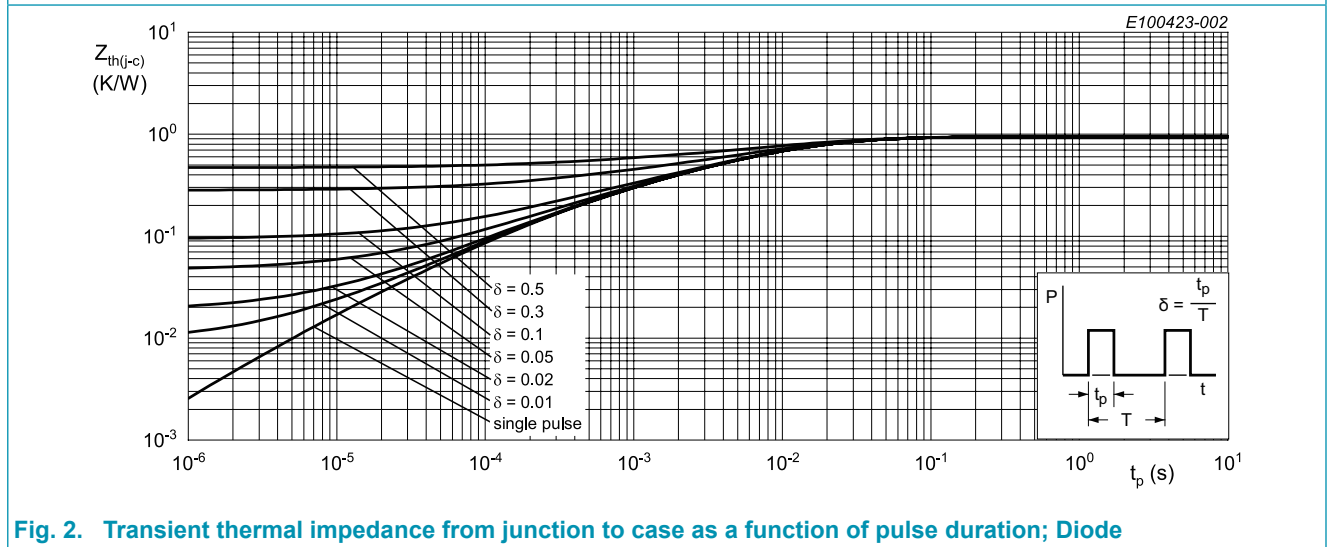


Fig. 2. Transient thermal impedance from junction to case as a function of pulse duration; Diode

10. Characteristics

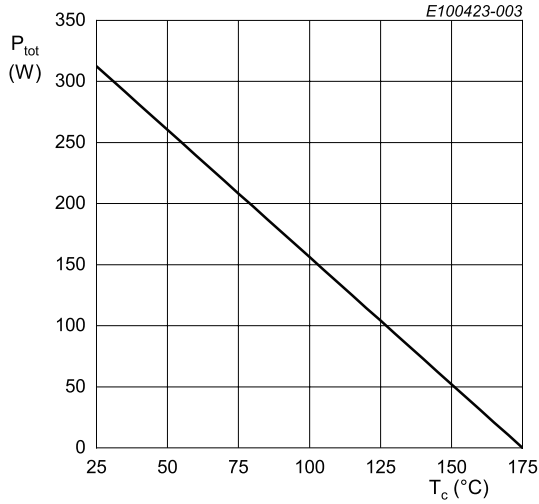
Table 7. Characteristics

| Symbol | Parameter | Conditions | Notes | Min | Typ | Max | Unit |
|--------------------------------|--------------------------------------|--|-------|-----|------|------|---------------|
| Static characteristics | | | | | | | |
| BV_{CES} | Collector-emitter breakdown voltage | $V_{GE} = 0\text{ V}; I_C = 1.0\text{ mA}$ | | 650 | - | - | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}; I_C = 40\text{ A}; T_j = 25\text{ °C}$ | | - | 1.45 | 1.85 | V |
| | | $V_{GE} = 15\text{ V}; I_C = 40\text{ A}; T_j = 175\text{ °C}$ | | - | 1.8 | - | V |
| V_F | Diode forward voltage | $V_{GE} = 0\text{ V}; I_F = 40\text{ A}; T_j = 25\text{ °C}$ | | - | 2.1 | - | V |
| | | $V_{GE} = 0\text{ V}; I_F = 40\text{ A}; T_j = 175\text{ °C}$ | | - | 1.7 | - | V |
| $V_{GE(th)}$ | Gate-emitter threshold voltage | $I_C = 400\text{ }\mu\text{A}; V_{CE} = V_{GE}$ | | 3.6 | 4.3 | 5.0 | V |
| I_{CES} | Zero gate voltage collector current | $V_{CE} = 650\text{ V}; V_{GE} = 0\text{ V}; T_j = 25\text{ °C}$ | | - | - | 100 | μA |
| | | $V_{CE} = 650\text{ V}; V_{GE} = 0\text{ V}; T_j = 175\text{ °C}$ | | - | - | 1 | mA |
| g_{fs} | Transconductance | $V_{CE} = 20\text{ V}; I_C = 40\text{ A}$ | | - | 42 | - | S |
| Dynamic characteristics | | | | | | | |
| C_{ies} | Input capacitance | $V_{CE} = 40\text{ V}; V_{GE} = 0\text{ V}; f = 1\text{ MHz}; T_j = 25\text{ °C}$ | | - | 3180 | - | pF |
| C_{oes} | Output capacitance | | | - | 39 | - | pF |
| C_{res} | Reverse transfer capacitance | | | - | 14 | - | pF |
| Q_G | Gate charge | $V_{CC} = 520\text{ V}; I_C = 40\text{ A}; V_{GE} = 15\text{ V}; T_j = 25\text{ °C}$ | | - | 124 | - | nC |

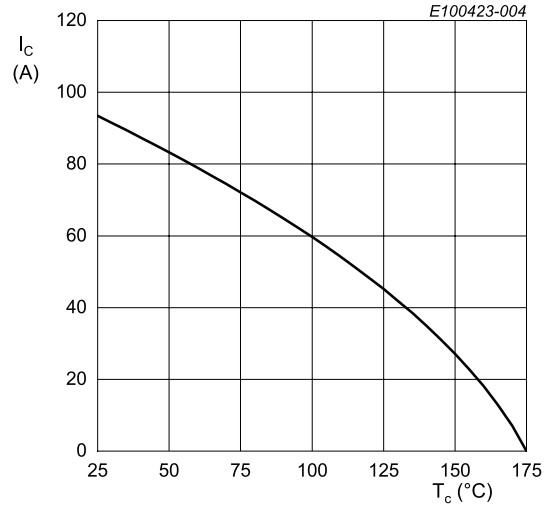
11. Switching Characteristics

Table 8. Switching Characteristics, Inductive Load

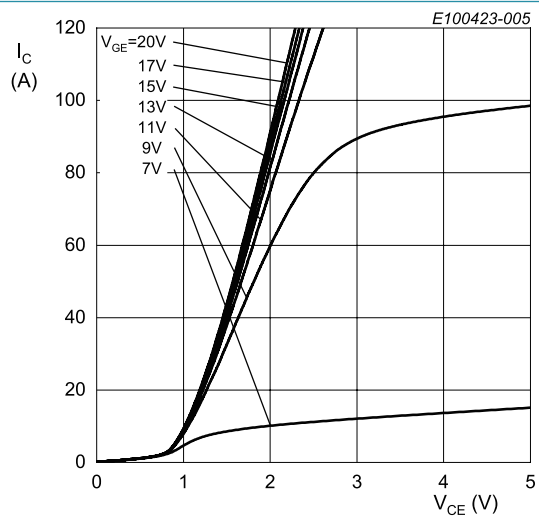
| Symbol | Parameter | Conditions | Notes | Min | Typ | Max | Unit |
|------------------------------|-------------------------------|--|-------|-----|------|-----|------|
| IGBT characteristics | | | | | | | |
| $t_{d(on)}$ | Turn-on delay time | $T_J = 25\text{ }^\circ\text{C};$ $V_{CC} = 400\text{ V}; I_C = 40\text{ A}; V_{GE} = 15\text{V} / 0\text{V};$ $R_G = 10\ \Omega$ | | - | 41 | - | nS |
| t_r | Rise time | | | - | 35 | - | nS |
| $t_{d(off)}$ | Turn-off delay time | | | - | 173 | - | nS |
| t_f | Fall time | | | - | 27 | - | nS |
| E_{on} | Turn-on energy | | | - | 0.95 | - | mJ |
| E_{off} | Turn-off energy | | | - | 0.35 | - | mJ |
| E_{ts} | Total switching energy | | | - | 1.3 | - | mJ |
| $t_{d(on)}$ | Turn-on delay time | $T_J = 175\text{ }^\circ\text{C};$ $V_{CC} = 400\text{ V}; I_C = 40\text{ A}; V_{GE} = 15\text{V} / 0\text{V};$ $R_G = 10\ \Omega$ | | - | 36 | - | nS |
| t_r | Rise time | | | - | 34 | - | nS |
| $t_{d(off)}$ | Turn-off delay time | | | - | 201 | - | nS |
| t_f | Fall time | | | - | 37 | - | nS |
| E_{on} | Turn-on energy | | | - | 1.4 | - | mJ |
| E_{off} | Turn-off energy | | | - | 0.5 | - | mJ |
| E_{ts} | Total switching energy | | | - | 1.9 | - | mJ |
| Diode characteristics | | | | | | | |
| t_{rr} | Reverse recovery time | $T_J = 25\text{ }^\circ\text{C};$ $V_R = 400\text{ V}; I_F = 40\text{ A}; di_F/dt = 950\text{A/us}$ | | - | 43 | - | nS |
| Q_r | Reverse recovery charge | | | - | 380 | - | nC |
| I_{RM} | Reverse recovery peak current | | | - | 15.8 | - | A |
| t_{rr} | Reverse recovery time | $T_J = 175\text{ }^\circ\text{C};$ $V_R = 400\text{ V}; I_F = 40\text{ A}; di_F/dt = 950\text{A/us}$ | | - | 109 | - | nS |
| Q_r | Reverse recovery charge | | | - | 1414 | - | nC |
| I_{RM} | Reverse recovery peak current | | | - | 25.1 | - | A |



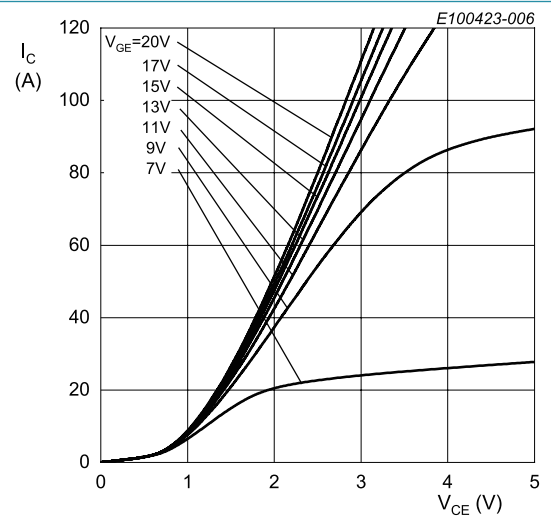
$T_j \leq 175 \text{ }^\circ\text{C}$
Fig. 3. Power dissipation as a function of case temperature



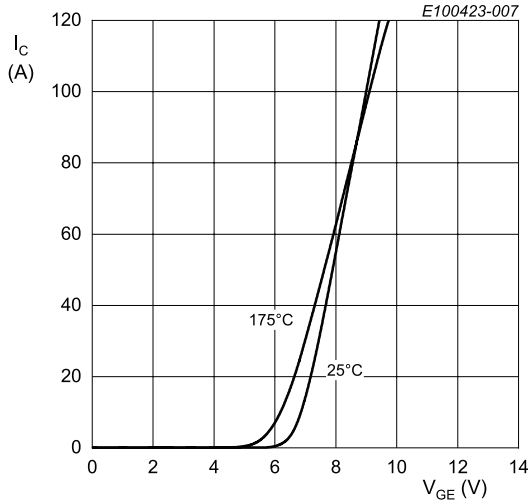
$V_{GE} \geq 15 \text{ V}; T_j \leq 175 \text{ }^\circ\text{C}$
Fig. 4. Collector current as a function of case temperature



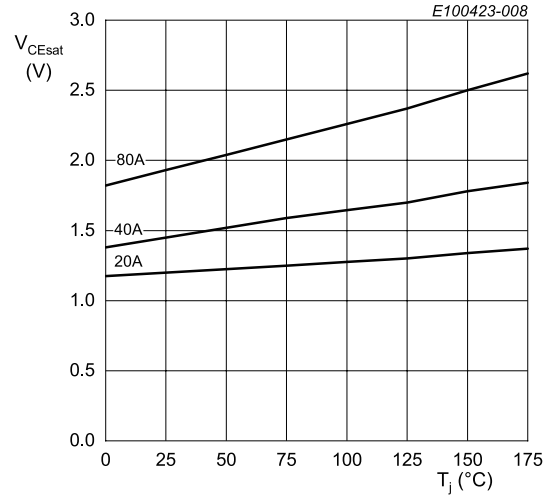
$T_j = 25 \text{ }^\circ\text{C}$
Fig. 5. Typical output characteristic



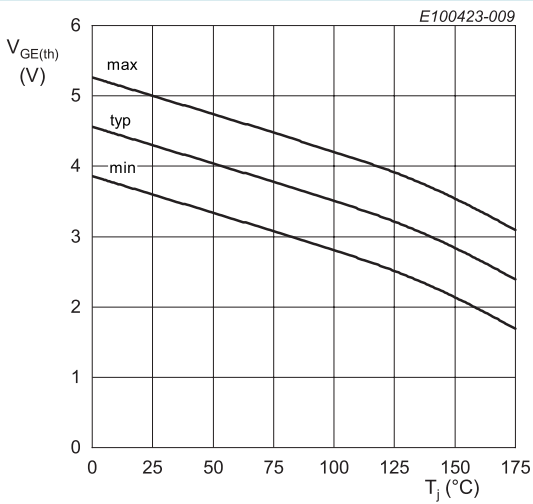
$T_j = 175 \text{ }^\circ\text{C}$
Fig. 6. Typical output characteristic



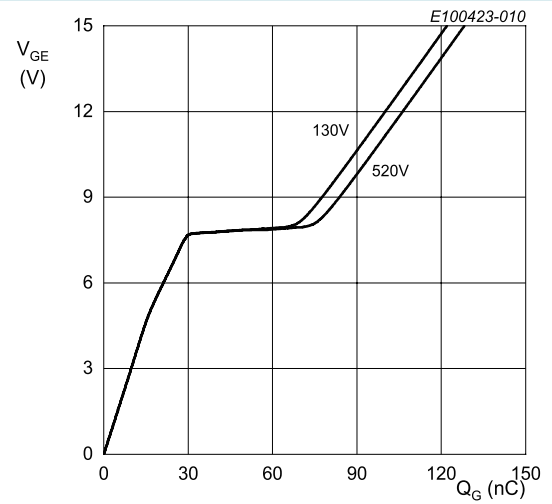
$V_{CE} = 20\text{ V}$
Fig. 7. Typical transfer characteristic



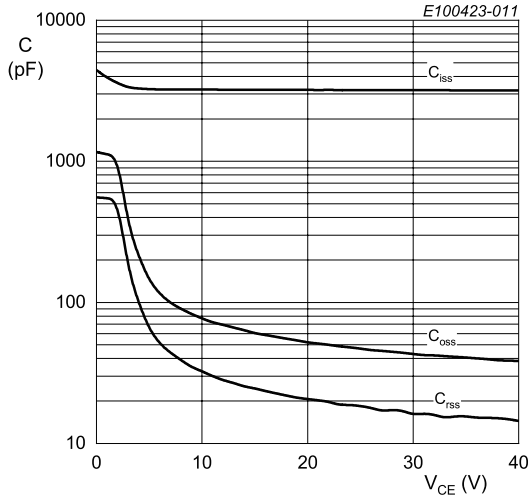
$V_{GE} = 15\text{ V}$
Fig. 8. Typical collector-emitter saturation voltage as a function of junction temperature



$I_C = 400\ \mu\text{A}$
Fig. 9. Gate-emitter threshold voltage as a function of junction temperature



$I_C = 40\text{ A}$
Fig. 10. Typical gate charge



$V_{GE} = 0 \text{ V}; f = 1 \text{ MHz}$

Fig. 11. Typical capacitance as a function of collector-emitter voltage

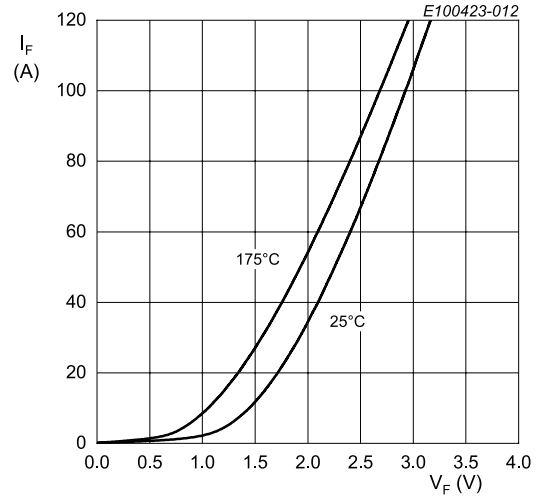
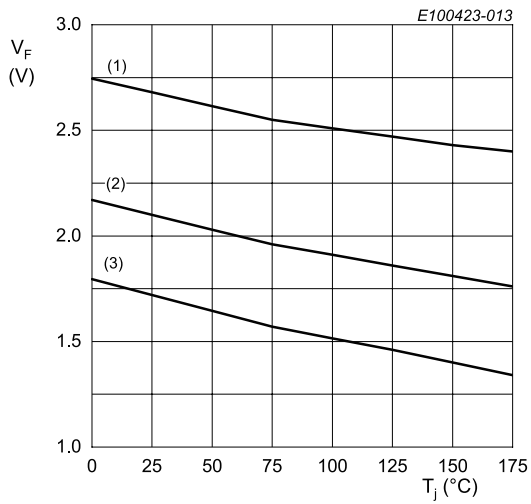
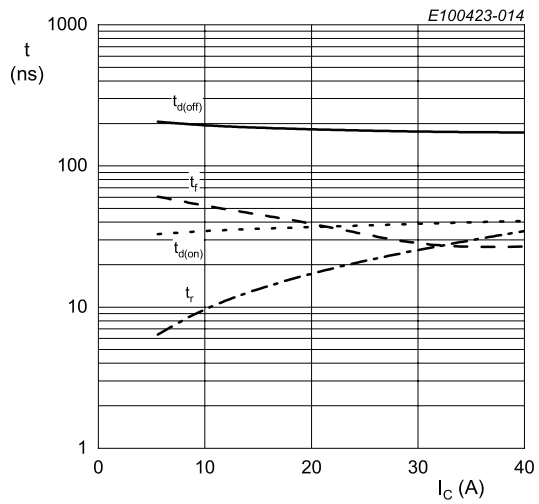


Fig. 12. Typical diode forward current as a function of forward voltage



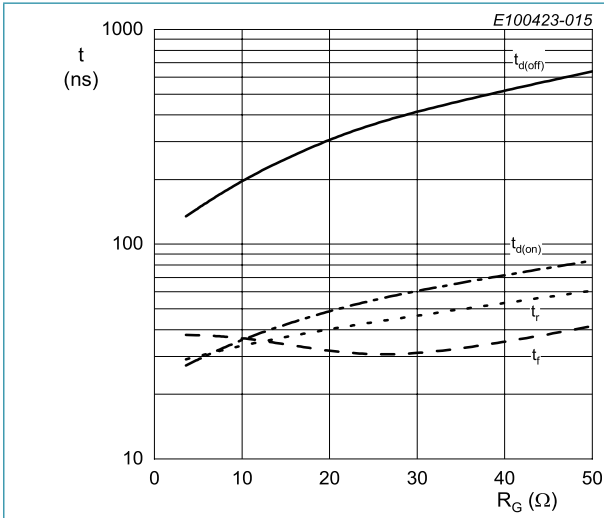
- (1) $I_F = 80 \text{ A}$
- (2) $I_F = 40 \text{ A}$
- (3) $I_F = 20 \text{ A}$

Fig. 13. Typical diode forward voltage as a function of junction temperature



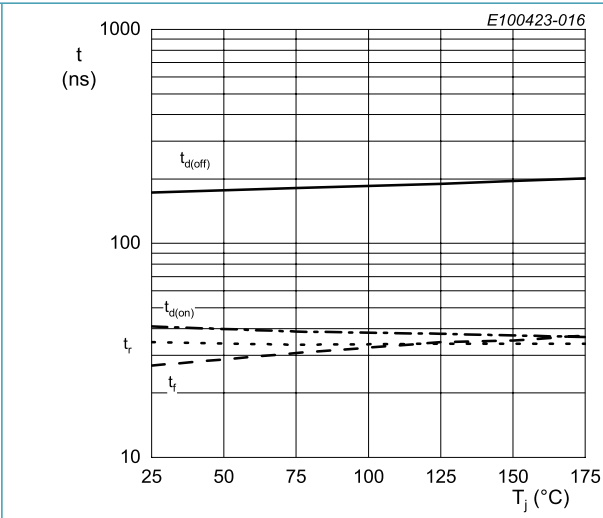
$R_g = 10 \text{ } \Omega; V_{GE} = 15\text{V}/0\text{V}; T_j = 175 \text{ } ^\circ\text{C};$
 $V_{CE} = 400 \text{ V};$ inductive load

Fig. 14. Typical switching times as a function of collector current



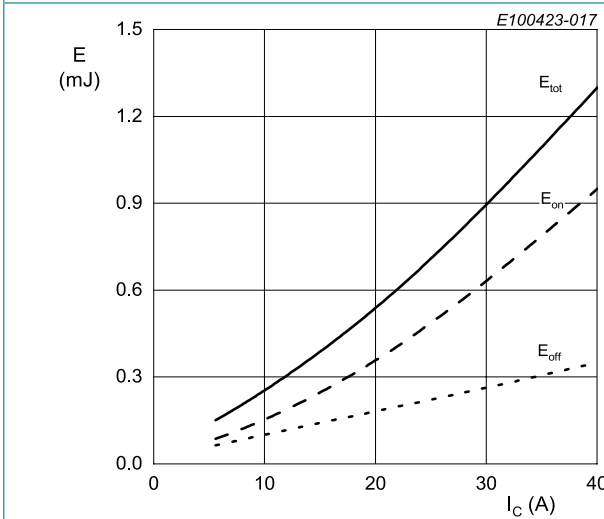
$I_C = 40\text{ A}$; $V_{GE} = 15\text{V}/0\text{V}$; $T_J = 175\text{ }^\circ\text{C}$;
 $V_{CE} = 400\text{ V}$; inductive load

Fig. 15. Typical switching times as a function of gate resistance



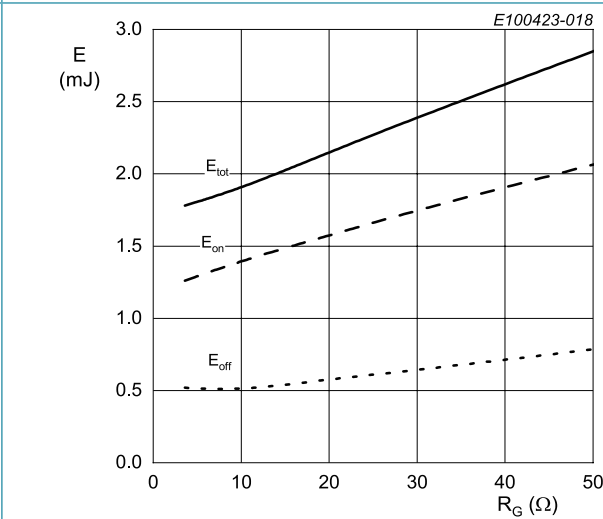
$I_C = 40\text{ A}$; $V_{GE} = 15\text{V}/0\text{V}$; $R_g = 10\text{ }\Omega$;
 $V_{CE} = 400\text{ V}$; inductive load

Fig. 16. Typical switching times as a function of junction temperature



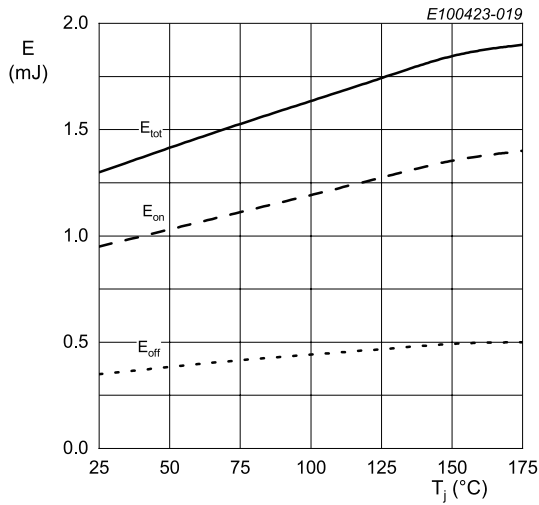
$R_g = 10\text{ }\Omega$; $V_{GE} = 15\text{V}/0\text{V}$; $T_J = 175\text{ }^\circ\text{C}$;
 $V_{CE} = 400\text{ V}$; inductive load

Fig. 17. Typical switching energy losses as a function of collector current



$I_C = 40\text{ A}$; $V_{GE} = 15\text{V}/0\text{V}$; $T_J = 175\text{ }^\circ\text{C}$;
 $V_{CE} = 400\text{ V}$; inductive load

Fig. 18. Typical switching energy losses as a function of gate resistance



$I_C = 40\text{ A}$; $V_{GE} = 15\text{V}/0\text{V}$; $R_g = 10\ \Omega$;
 $V_{CE} = 400\text{ V}$; inductive load

Fig. 19. Typical switching energy losses as a function of junction temperature

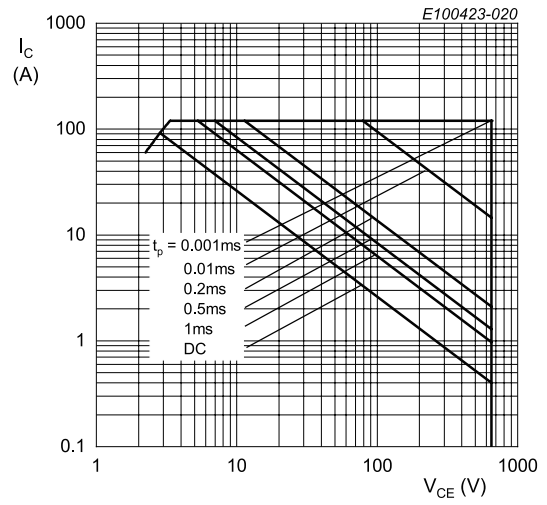


Fig. 20. Forward bias safe operating area

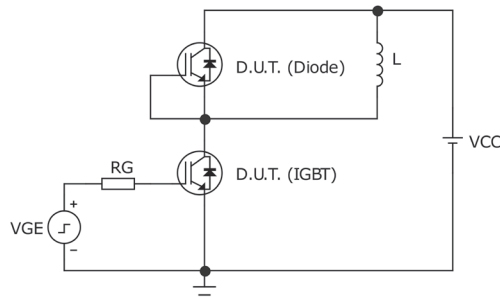


Fig. 21. Test circuit for inductive load switching

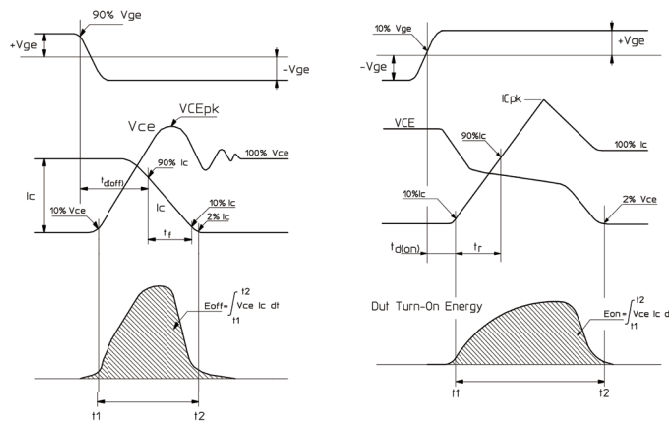
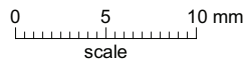
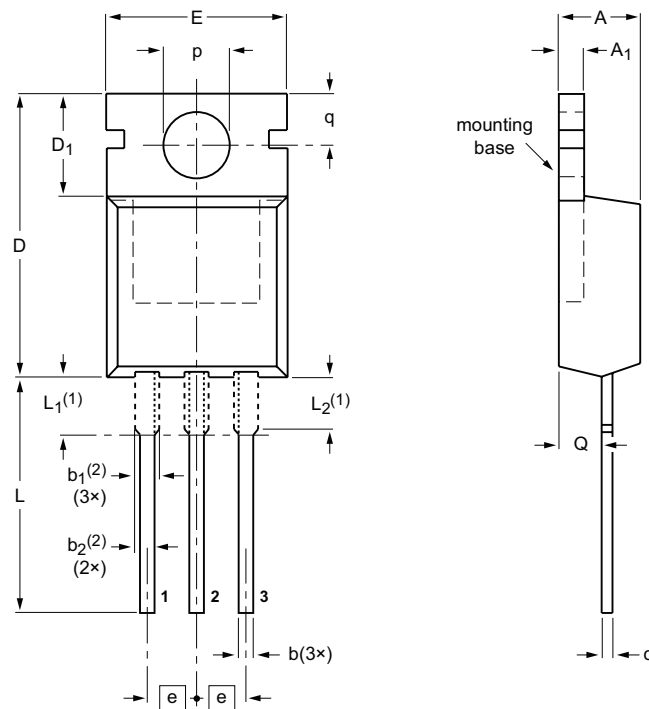


Fig. 22. Definition of switching times and losses

12. Package outline

Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB

SOT78



DIMENSIONS (mm are the original dimensions)

| UNIT | A | A ₁ | b | b ₁ (2) | b ₂ (2) | c | D | D ₁ | E | e | L | L ₁ (1) | L ₂ (1) max. | p | q | Q |
|------|------------|----------------|------------|--------------------|--------------------|------------|--------------|----------------|-------------|------|--------------|--------------------|----------------------------|------------|------------|------------|
| mm | 4.7 4.1 | 1.40 1.25 | 0.9 0.6 | 1.6 1.0 | 1.3 1.0 | 0.7 0.4 | 16.0 15.2 | 6.6 5.9 | 10.3 9.7 | 2.54 | 15.0 12.8 | 3.30 2.79 | 3.0 | 3.8 3.5 | 3.0 2.7 | 2.6 2.2 |

Notes

1. Lead shoulder designs may vary.
2. Dimension includes excess dambar.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|--------------------|------------|-----------------|-------|--|------------------------|----------------------|
| | IEC | JEDEC | JEITA | | | |
| SOT78 | | 3-lead TO-220AB | SC-46 | | | 08-04-23 08-06-13 |

13. Legal information

Data sheet status

| Document status [1][2] | Product status [3] | Definition |
|--------------------------------|--------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
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Date of release: 09 October 2025
