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Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

# STGB10H60DF, STGF10H60DF, STGP10H60DF

## Trench gate field-stop IGBT, H series 600 V, 10 A high speed

**Datasheet - production data**

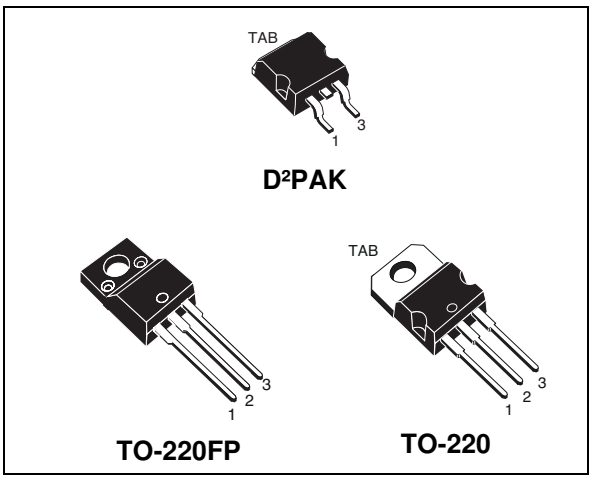
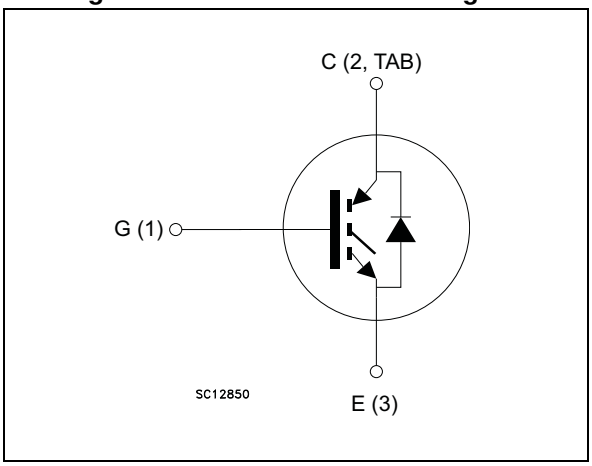



**Figure 1. Internal schematic diagram**




## Features

- High speed switching
- Tight parameters distribution
- Safe paralleling
- Low thermal resistance
- Short-circuit rated
- Ultrafast soft recovery antiparallel diode

## Applications

- Motor control
- UPS, PFC

## Description

This device is an IGBT developed using an advanced proprietary trench gate and field stop structure. This IGBT series offers the optimum compromise between conduction and switching losses, maximizing the efficiency of very high frequency converters. Furthermore, a positive $V_{CE(sat)}$ temperature coefficient and very tight parameter distribution result in easier paralleling operation.

**Table 1. Device summary**

| Order codes | Marking | Packages | Packaging |
|---|---|---|---|
| STGB10H60DF | GB10H60DF | D²PAK | Tape and reel |
| STGF10H60DF | GF10H60DF | TO-220FP | Tube |
| STGP10H60DF | GP10H60DF | TO-220 | Tube |



This is information on a product in full production. www.st.com

# Contents

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | TO-220 D²PAK | TO-220FP | Unit |
|---|---|---|---|---|
| $V_{CES}$ | Collector-emitter voltage ($V_{GE}$ = 0) | 600 | | V |
| $I_C$ | Continuous collector current at $T_C$ = 25 °C | 20 | 20(1) | A |
| | Continuous collector current at $T_C$ = 100 °C | 10 | 10(1) | A |
| $I_{CP}$ (2) | Pulsed collector current | 40 | 40(1) | A |
| $V_{GE}$ | Gate-emitter voltage | ±20 | | V |
| $I_F$ | Continuous forward current $T_C$ = 25 °C | 20 | 20(1) | A |
| | Continuous forward current at $T_C$ = 100 °C | 10 | 10(1) | |
| $I_{FP}$(2) | Pulsed forward current | 40 | 40(1) | A |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 115 | 30 | W |
| $T_{STG}$ | Storage temperature range | - 55 to 150 | | °C |
| $T_J$ | Operating junction temperature | - 55 to 175 | | |

1. Limited by maximum junction temperature.
2. Pulse width limited by maximum junction temperature.

**Table 3. Thermal data**

| Symbol | Parameter | TO-220 D²PAK | TO-220FP | Unit |
|---|---|---|---|---|
| $R_{thJC}$ | Thermal resistance junction-case IGBT | 1.3 | 5 | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 2.78 | 6.25 | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 62.5 | | °C/W |

# 2 Electrical characteristics

$T_J$ = 25 °C unless otherwise specified.

**Table 4. Static**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage ($V_{GE}$ = 0) | $I_C$ = 2 mA | 600 | | | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE}$ = 15 V, $I_C$ = 10 A | | 1.5 | 1.95 | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 10 A $T_J$ = 125 °C | | 1.65 | | |
| | | $V_{GE}$ = 15 V, $I_C$ = 10 A $T_J$ = 175 °C | | 1.7 | | |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 1 mA | 5.0 | 6.0 | 7.0 | V |
| $I_{CES}$ | Collector cut-off current ($V_{GE}$ = 0) | $V_{CE}$ = 600 V | | | 25 | µA |
| $I_{GES}$ | Gate-emitter leakage current ($V_{CE}$ = 0) | $V_{GE}$ = ± 20 V | | | 250 | nA |

**Table 5. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{ies}$ | Input capacitance | $V_{CE}$ = 25 V, f = 1 MHz, $V_{GE}$ = 0 | - | 1300 | - | pF |
| $C_{oes}$ | Output capacitance | | - | 60 | - | pF |
| $C_{res}$ | Reverse transfer capacitance | | - | 30 | - | pF |
| $Q_g$ | Total gate charge | $V_{CC}$ = 480 V, $I_C$ = 10 A, $V_{GE}$ = 15 V | - | 57 | - | nC |
| $Q_{ge}$ | Gate-emitter charge | | - | 8 | - | nC |
| $Q_{gc}$ | Gate-collector charge | | - | 27 | - | nC |

**Table 6. Switching characteristics (inductive load)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V | | 19.5 | | ns |
| $t_r$ | Current rise time | | | 6.9 | | ns |
| (di/dt)on | Turn-on current slope | | | 1170 | | A/µs |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V $T_J$ = 175 °C | | 20 | | ns |
| $t_r$ | Current rise time | | | 6.8 | | ns |
| (di/dt)on | Turn-on current slope | | | 1176 | | A/µs |
| $t_{r(Voff)}$ | Off voltage rise time | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V | | 19.6 | | ns |
| $t_{d(off)}$ | Turn-off delay time | | | 103 | | ns |
| $t_f$ | Current fall time | | | 73 | | ns |
| $t_{r(Voff)}$ | Off voltage rise time | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V $T_J$ = 175 °C | | 28 | | ns |
| $t_{d(off)}$ | Turn-off delay time | | | 104 | | ns |
| $t_f$ | Current fall time | | | 110 | | ns |
| $t_{sc}$ | Short-circuit withstand time | $V_{CC} \leq$ 360 V, $V_{GE}$ = 15 V, $R_G$ = 10 Ω | 3 | 5 | | µs |

**Table 7. Switching energy (inductive load)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Eon (1) | Turn-on switching losses | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V | - | 83 | - | µJ |
| $E_{off}$ (2) | Turn-off switching losses | | - | 140 | - | µJ |
| $E_{ts}$ | Total switching losses | | - | 223 | - | µJ |
| Eon (1) | Turn-on switching losses | $V_{CE}$ = 400 V, $I_C$ = 10 A, $R_G$ = 10 Ω, $V_{GE}$ = 15 V $T_J$ = 175 °C | - | 148 | - | µJ |
| $E_{off}$ (2) | Turn-off switching losses | | - | 214 | - | µJ |
| $E_{ts}$ | Total switching losses | | - | 362 | - | µJ |

1. Energy losses include reverse recovery of the diode.
2. Turn-off losses include also the tail of the collector current.

**Table 8. Collector-emitter diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Forward on-voltage | $I_F$ = 10 A<br>$I_F$ = 10 A, $T_J$ = 175 °C | - | 1.7<br>1.3 | 2.2 | V<br>V |
| $t_{rr}$ | Reverse recovery time | $V_r$ = 60 V; IF = 10 A;<br>$di_F/dt$ = 100 A / µs | - | 107 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 120 | | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 2.24 | | A |
| $t_{rr}$ | Reverse recovery time | $V_r$ = 60 V; IF = 10 A;<br>$di_F/dt$ = 100 A / µs<br>$T_J$ = 175 °C | - | 161 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 362 | | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 4.5 | | A |

## 2.1 Electrical characteristics (curves)

**Figure 2. Power dissipation vs. case temperature for D²PAK and TO-220**

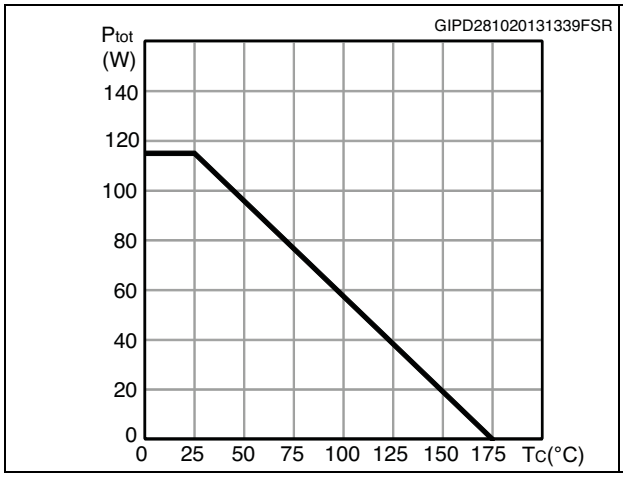



**Figure 3. Collector current vs. case temperature for D²PAK and TO-220**

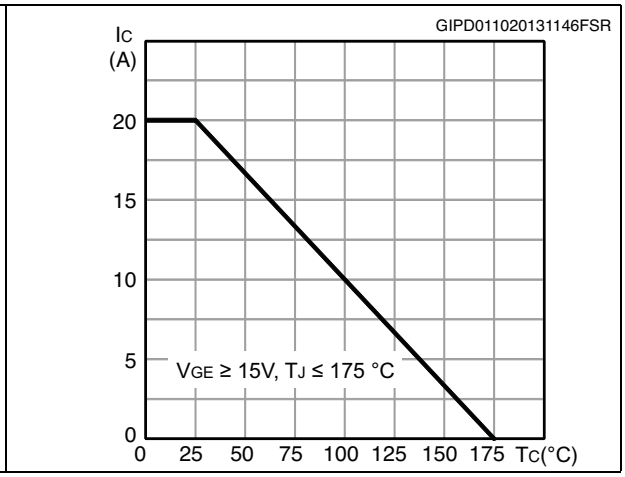



**Figure 4. Power dissipation vs. case temperature for TO-220FP**

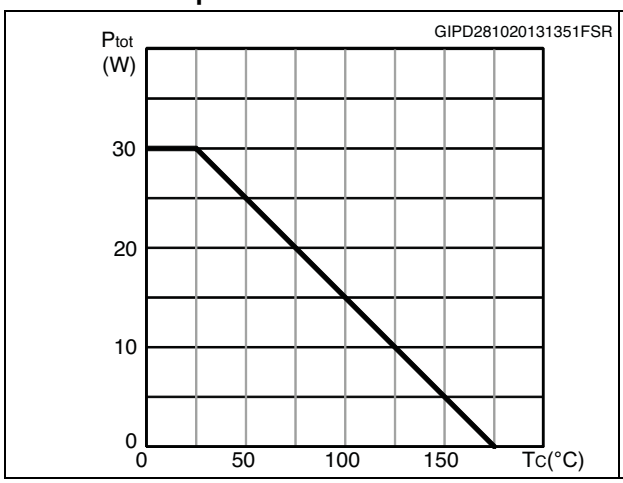



**Figure 5. Collector current vs. case temperature for TO-220FP**

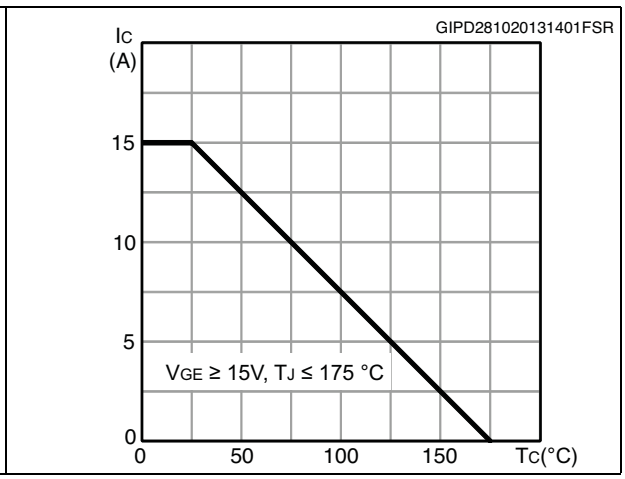



**Figure 6. Output characteristics ($T_J$ = 25°C)**

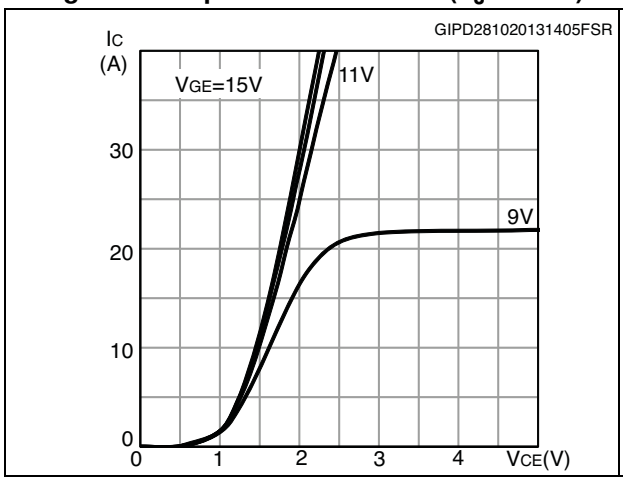



**Figure 7. Output characteristics ($T_J$ = 175°C)**

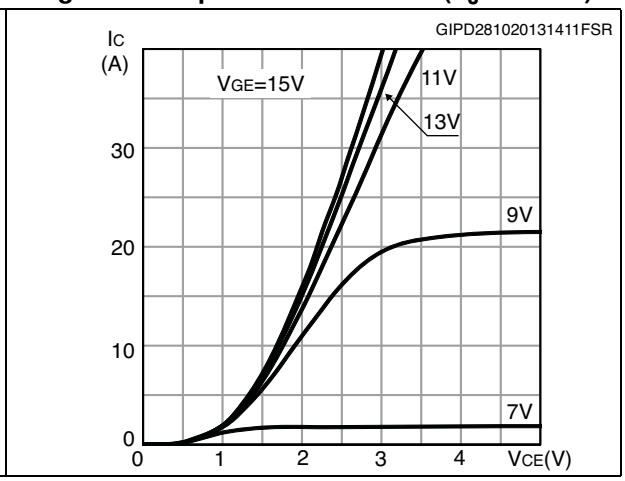


**Figure 8. $V_{CE(sat)}$ vs. junction temperature**

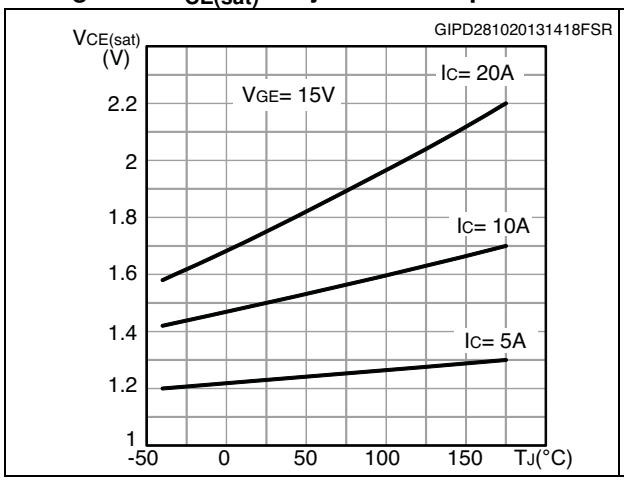



**Figure 9. $V_{CE(sat)}$ vs. collector current**

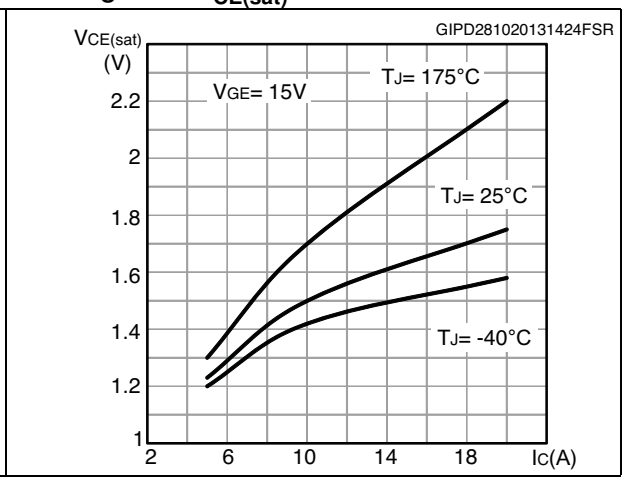



**Figure 10. Collector current vs. switching frequency for D²PAK and TO-220**

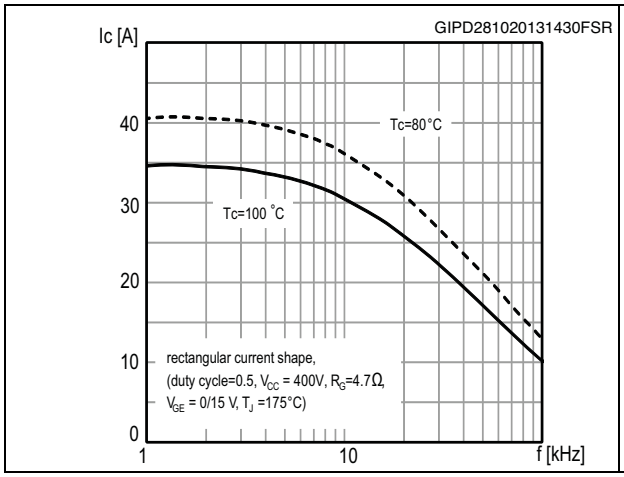



**Figure 11. Collector current vs. switching frequency for TO-220FP**

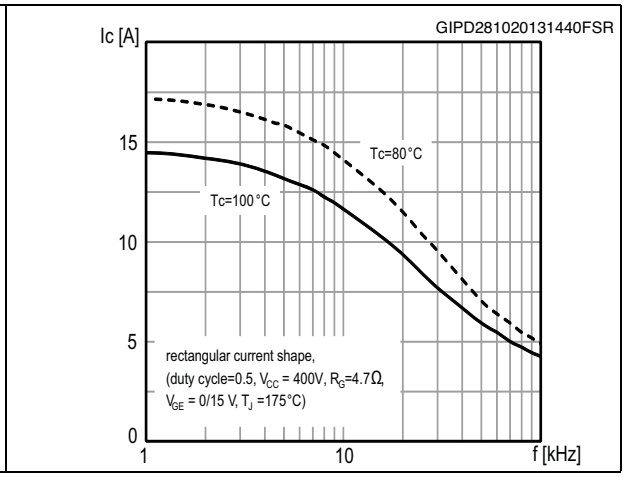



**Figure 12. Forward bias safe operating area for D²PAK and TO-220**

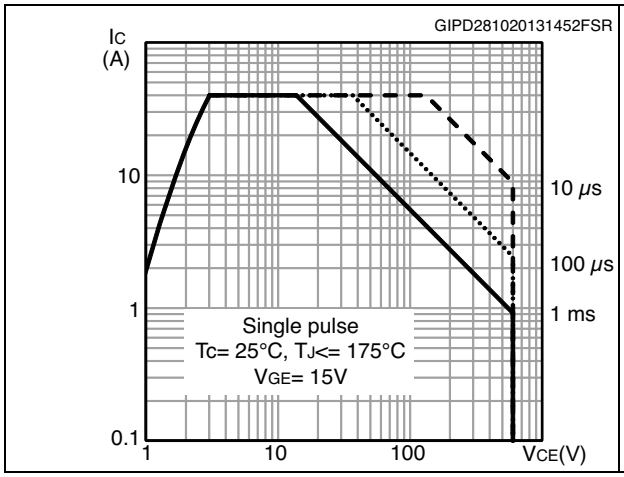



**Figure 13. Forward bias safe operating area for TO-220FP**

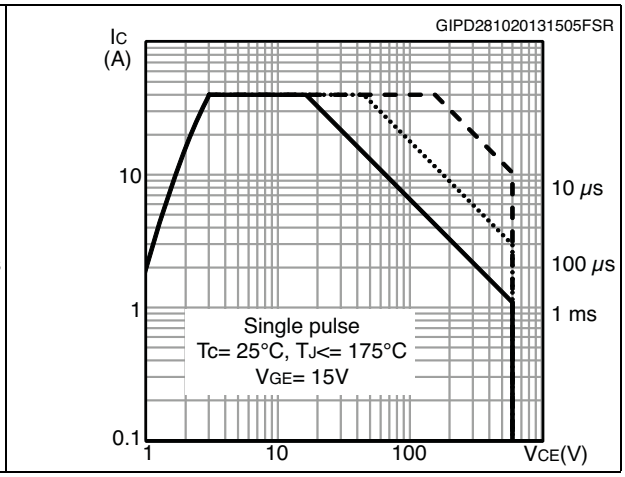


**Figure 14. Transfer characteristics**

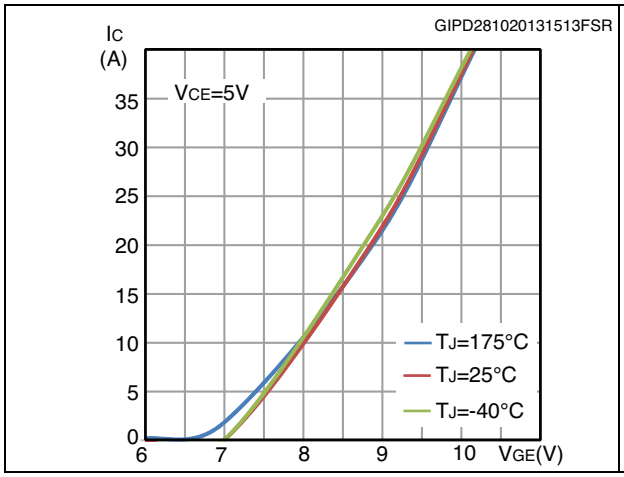



**Figure 15. Diode $V_F$ vs. forward current**

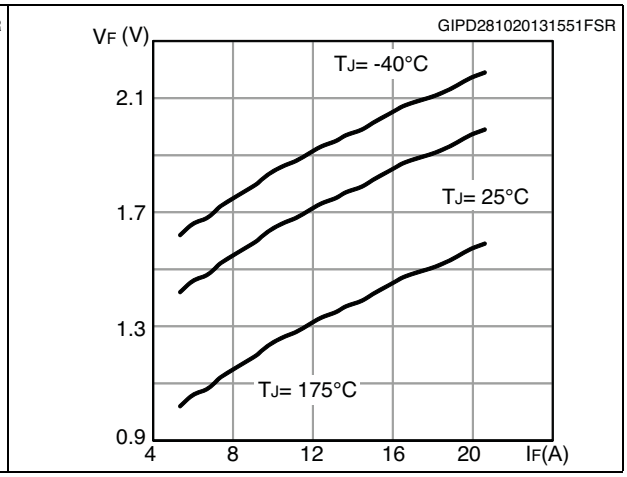



**Figure 16. Normalized $V_{GE(th)}$ vs junction temperature**

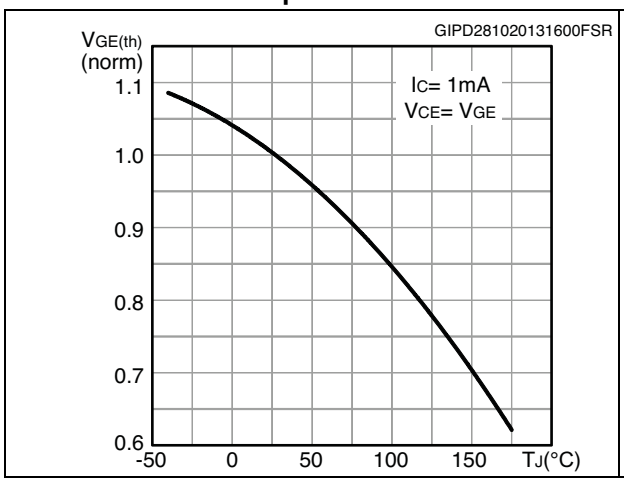



**Figure 17. Normalized $V_{(BR)CES}$ vs. junction temperature**

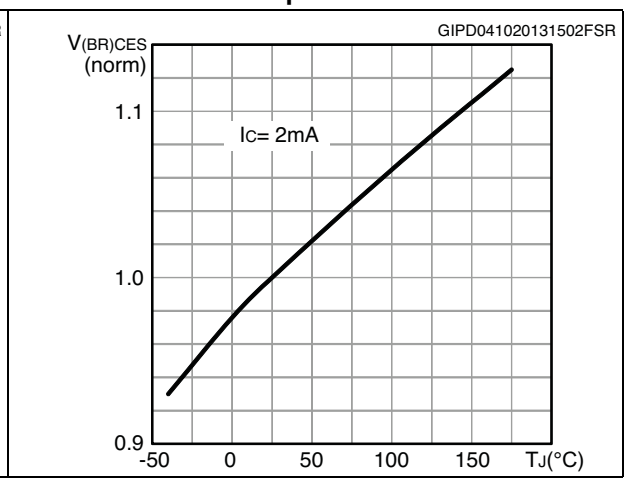



**Figure 18. Capacitance variation**

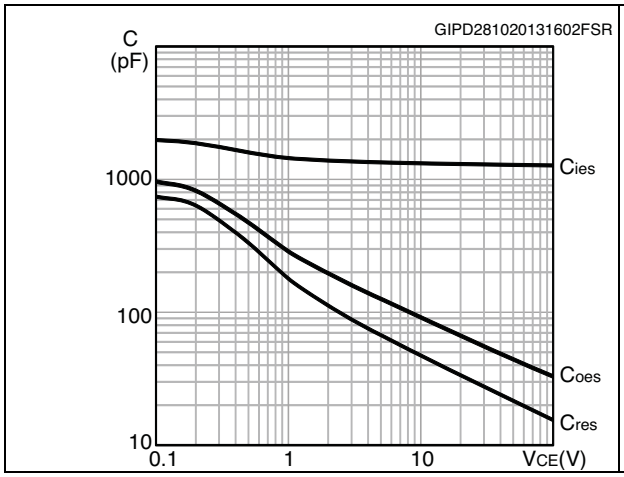



**Figure 19. Gate charge vs. gate-emitter voltage**

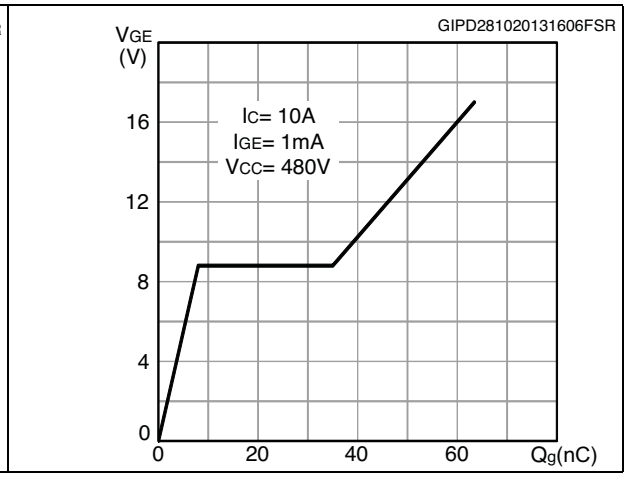


**Figure 20. Switching loss vs collector current**

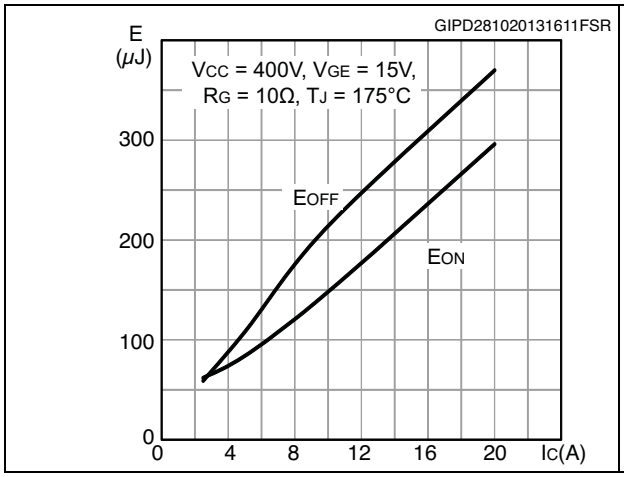



**Figure 21. Switching loss vs gate resistance**

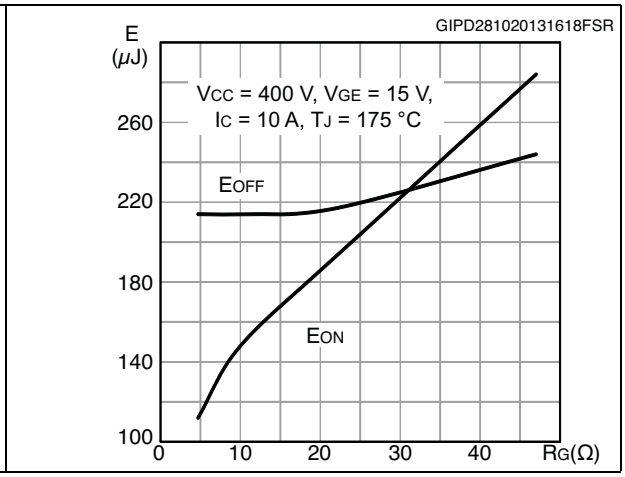



**Figure 22. Switching loss vs temperature**

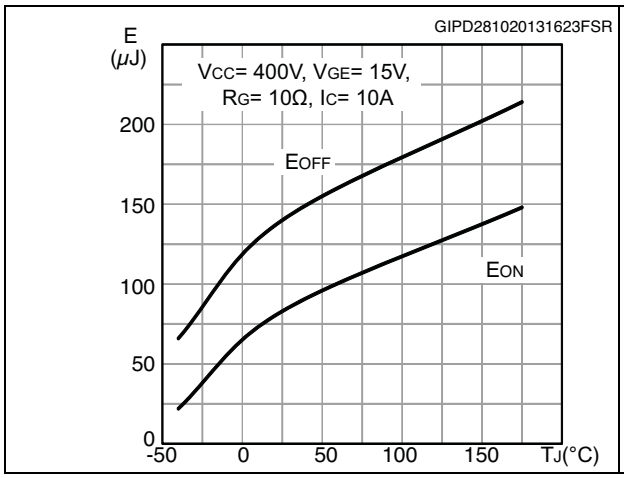



**Figure 23. Switching loss vs collector-emitter voltage**

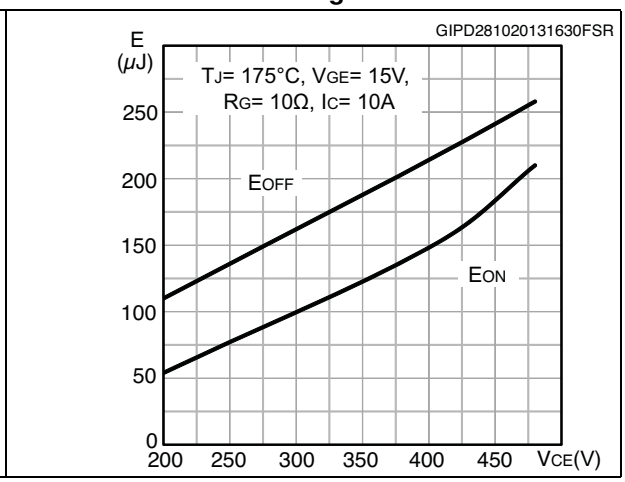


**Figure 24. Short circuit time and current vs $V_{GE}$**

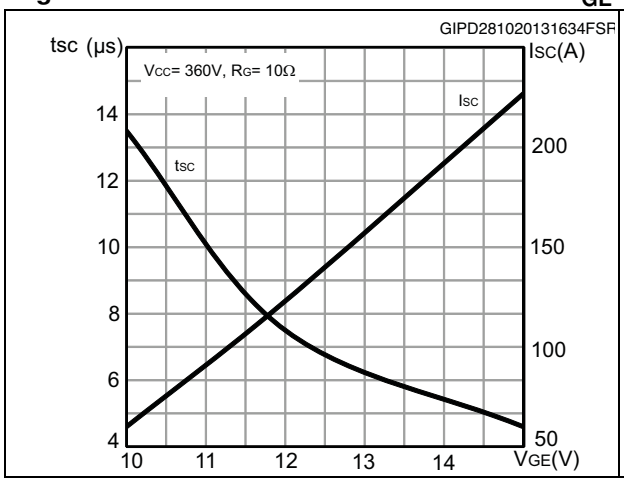



**Figure 25. Switching times vs. collector current**

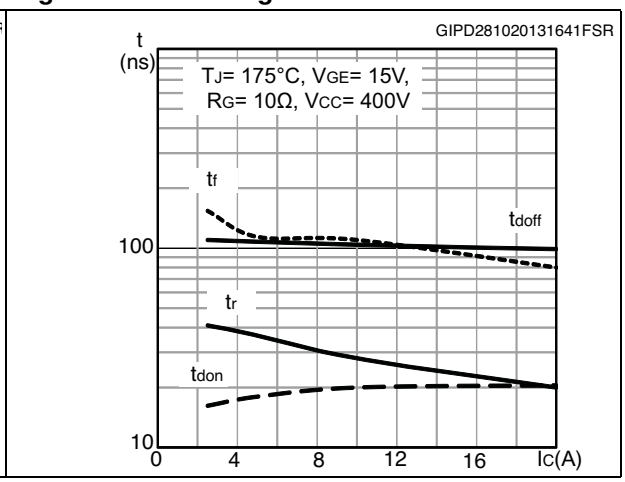



**Figure 26. Switching times vs. gate resistance**

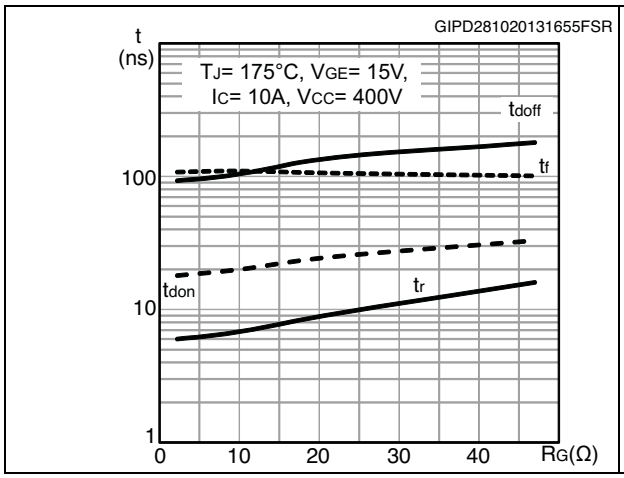



**Figure 27. Reverse recovery current vs. diode current slope**

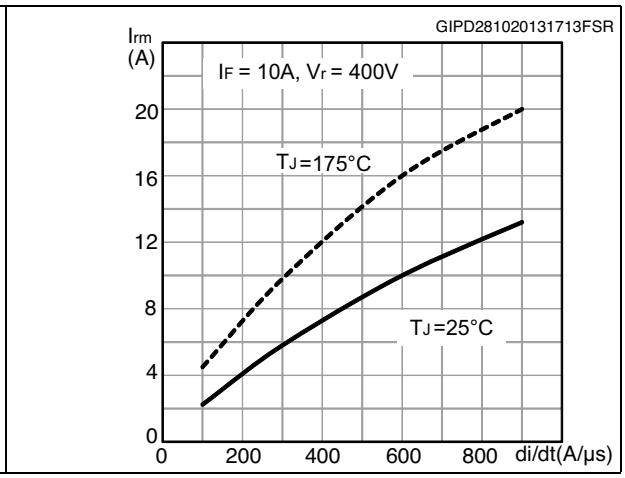



**Figure 28. Reverse recovery time vs. diode current slope**

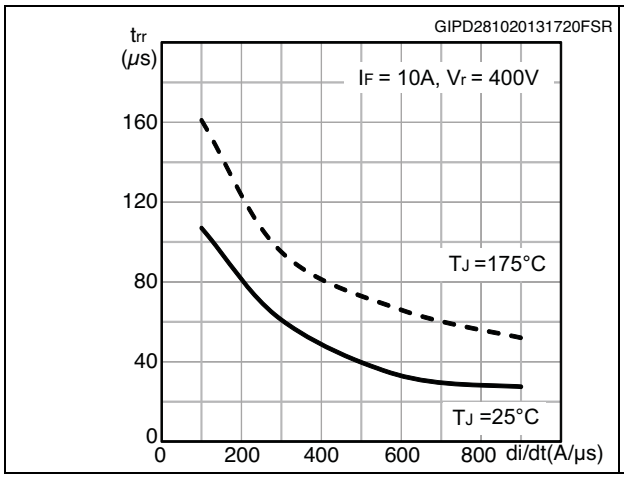



**Figure 29. Reverse recovery charge vs. diode current slope**

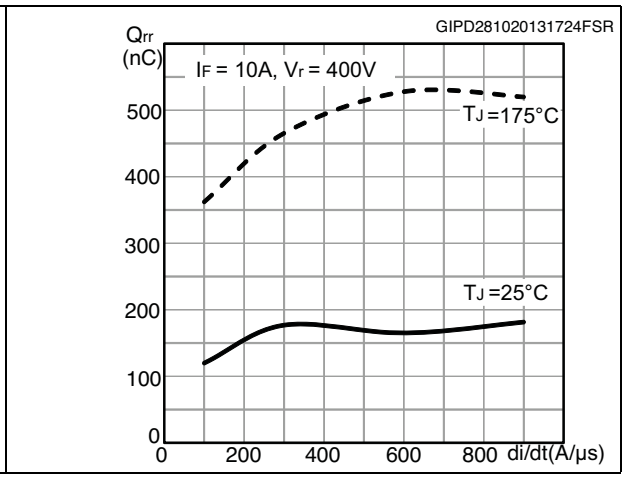


**Figure 30. Reverse recovery energy vs. diode current slope**

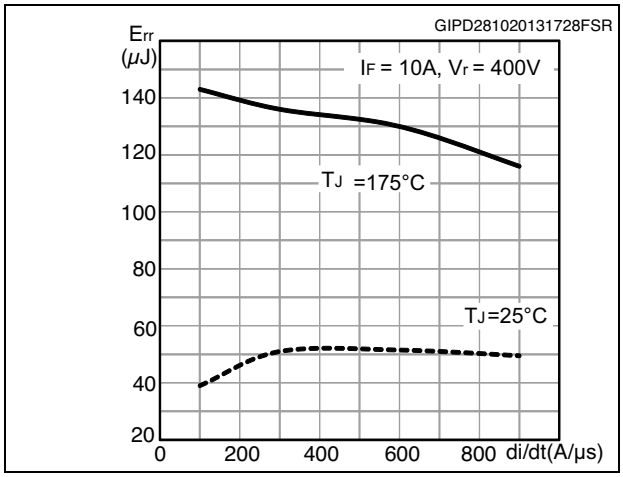


**Figure 31. Thermal impedance for IGBT**

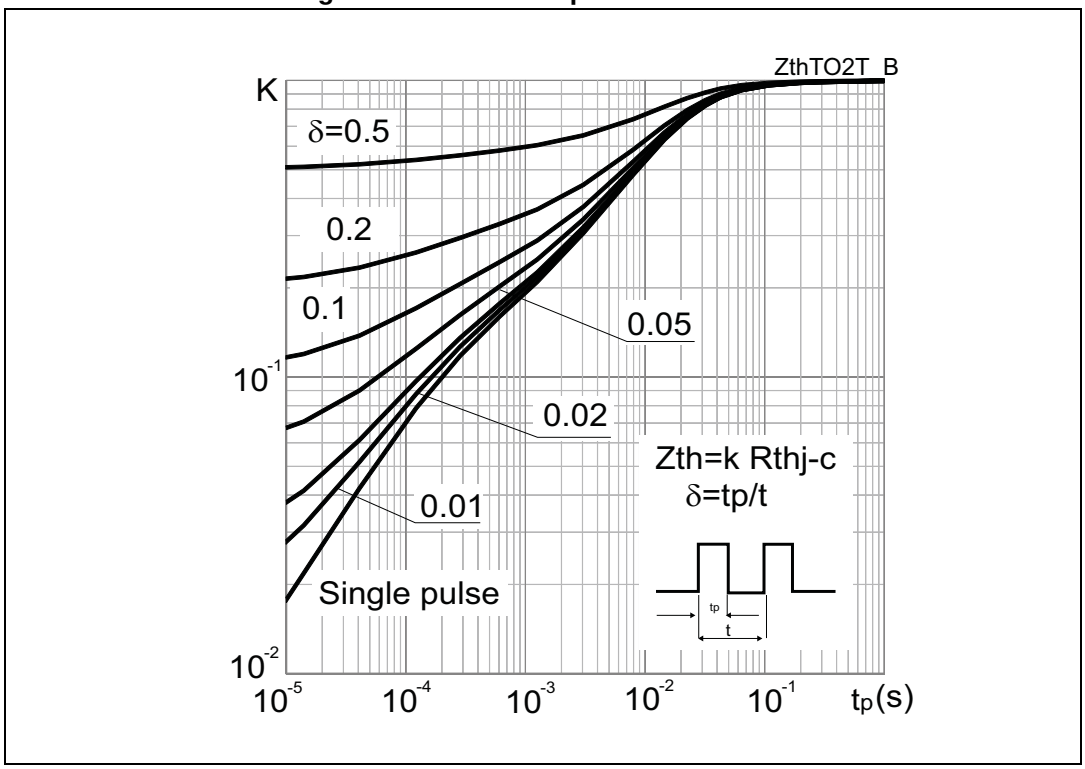
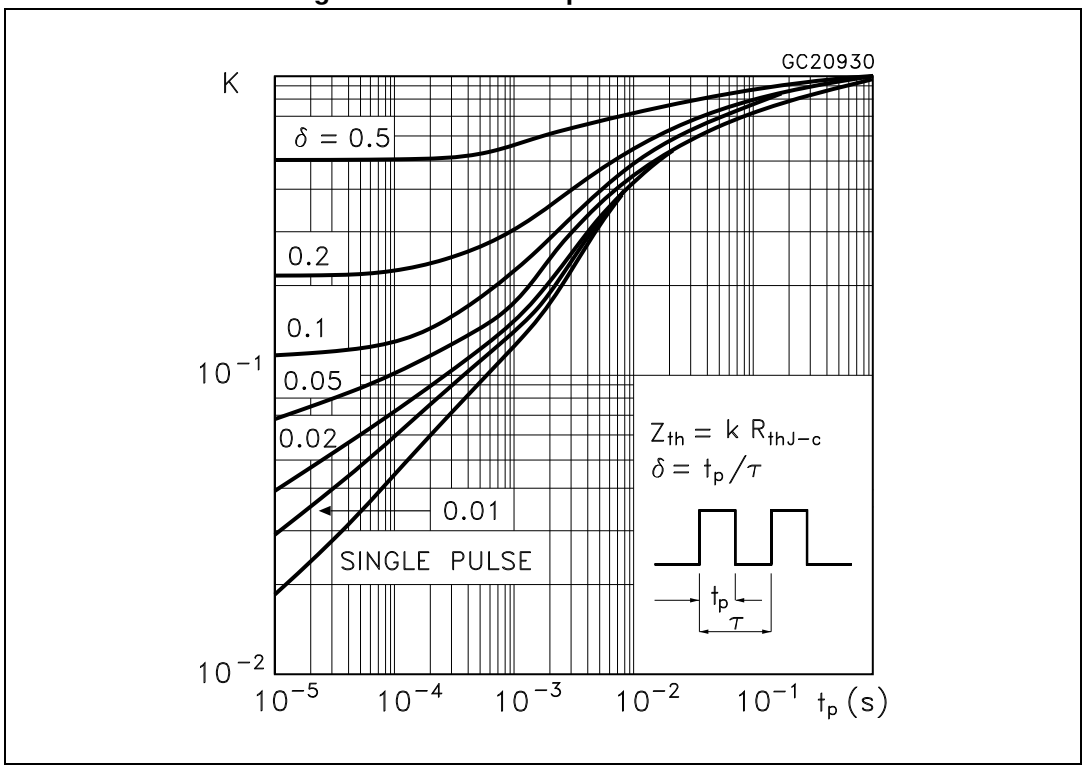



**Figure 32. Thermal impedance for diode**



# 3 Test circuits

**Figure 33. Test circuit for inductive load switching**

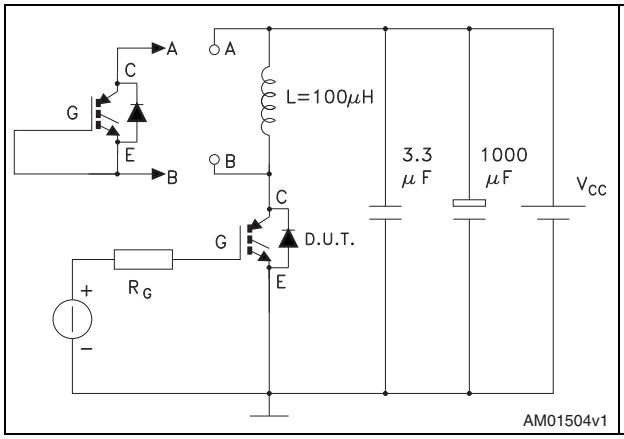



**Figure 34. Gate charge test circuit**

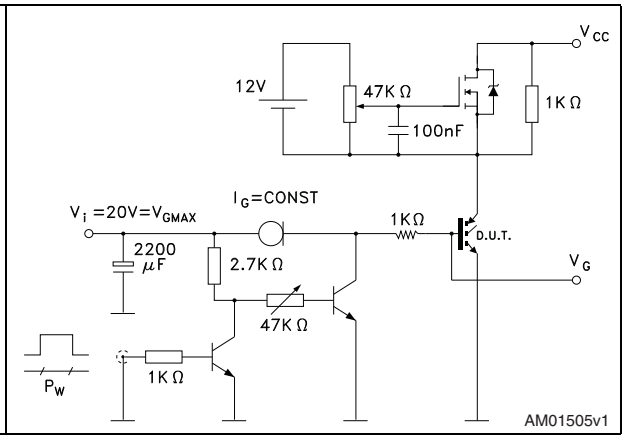



**Figure 35. Switching waveform**

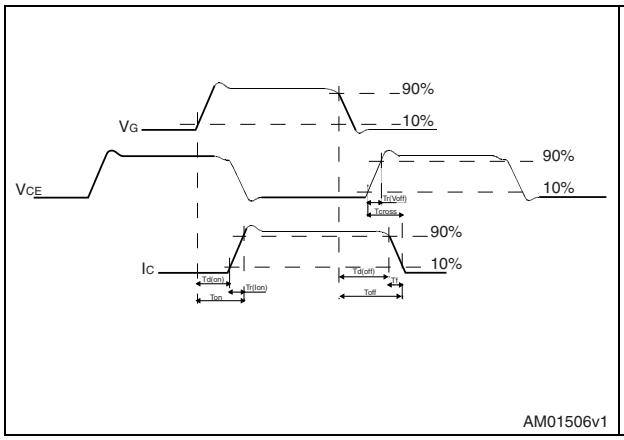
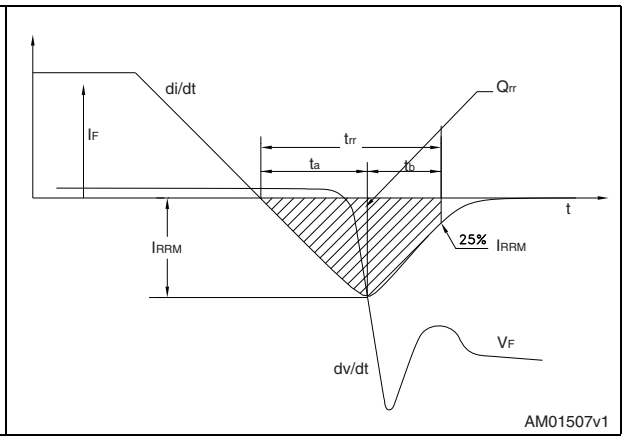



**Figure 36. Diode recovery time waveform**



# 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

**Table 9. D²PAK mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | | |
| E | 10 | | 10.40 |
| E1 | 8.50 | | |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

**Figure 37. D²PAK drawing**

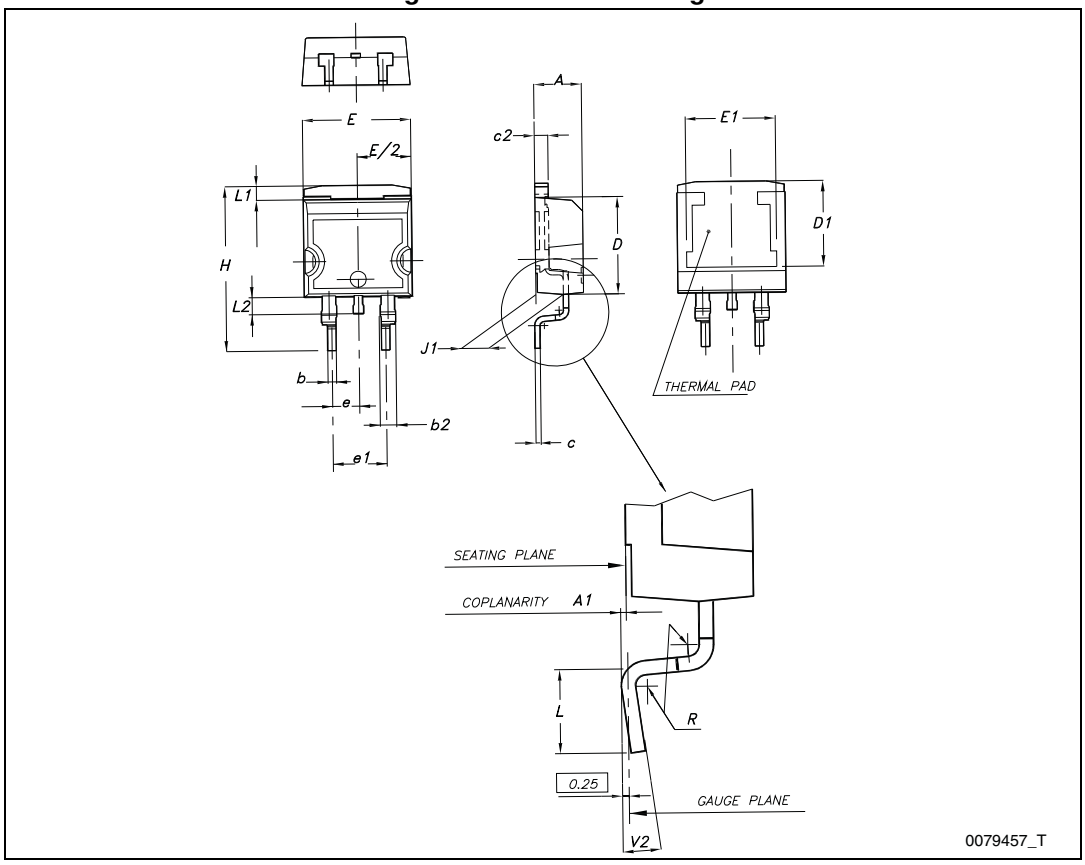
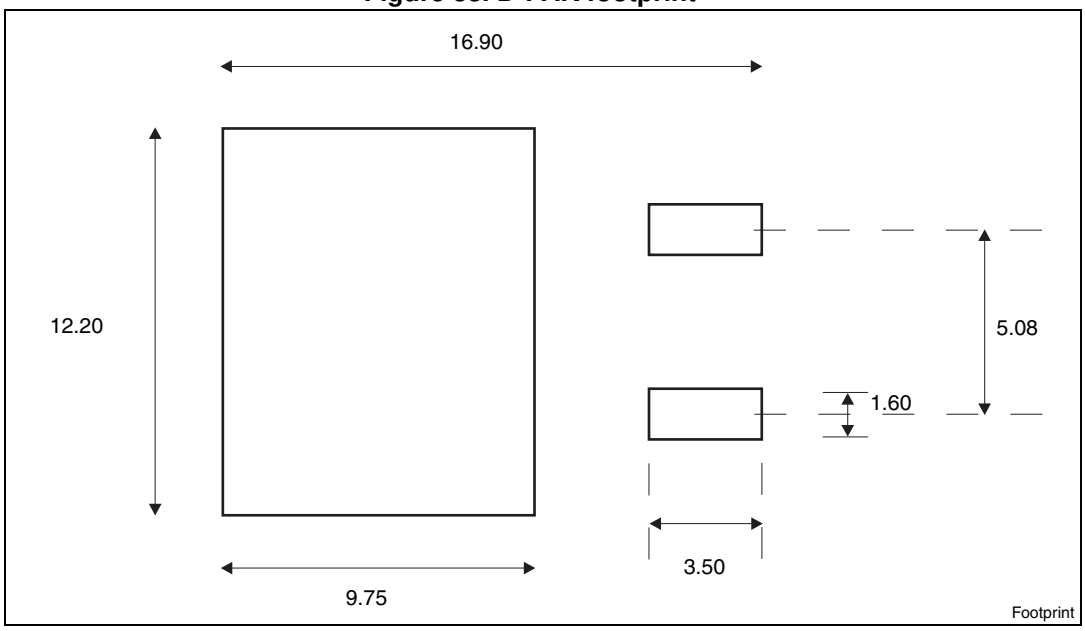



**Figure 38. D²PAK footprint[a]**




a. All dimension are in millimeters

Table 10. TO-220FP mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | | 30.6 |
| L4 | 9.8 | | 10.6 |
| L5 | 2.9 | | 3.6 |
| L6 | 15.9 | | 16.4 |
| L7 | 9 | | 9.3 |
| Dia | 3 | | 3.2 |

Figure 39. TO-220FP drawing

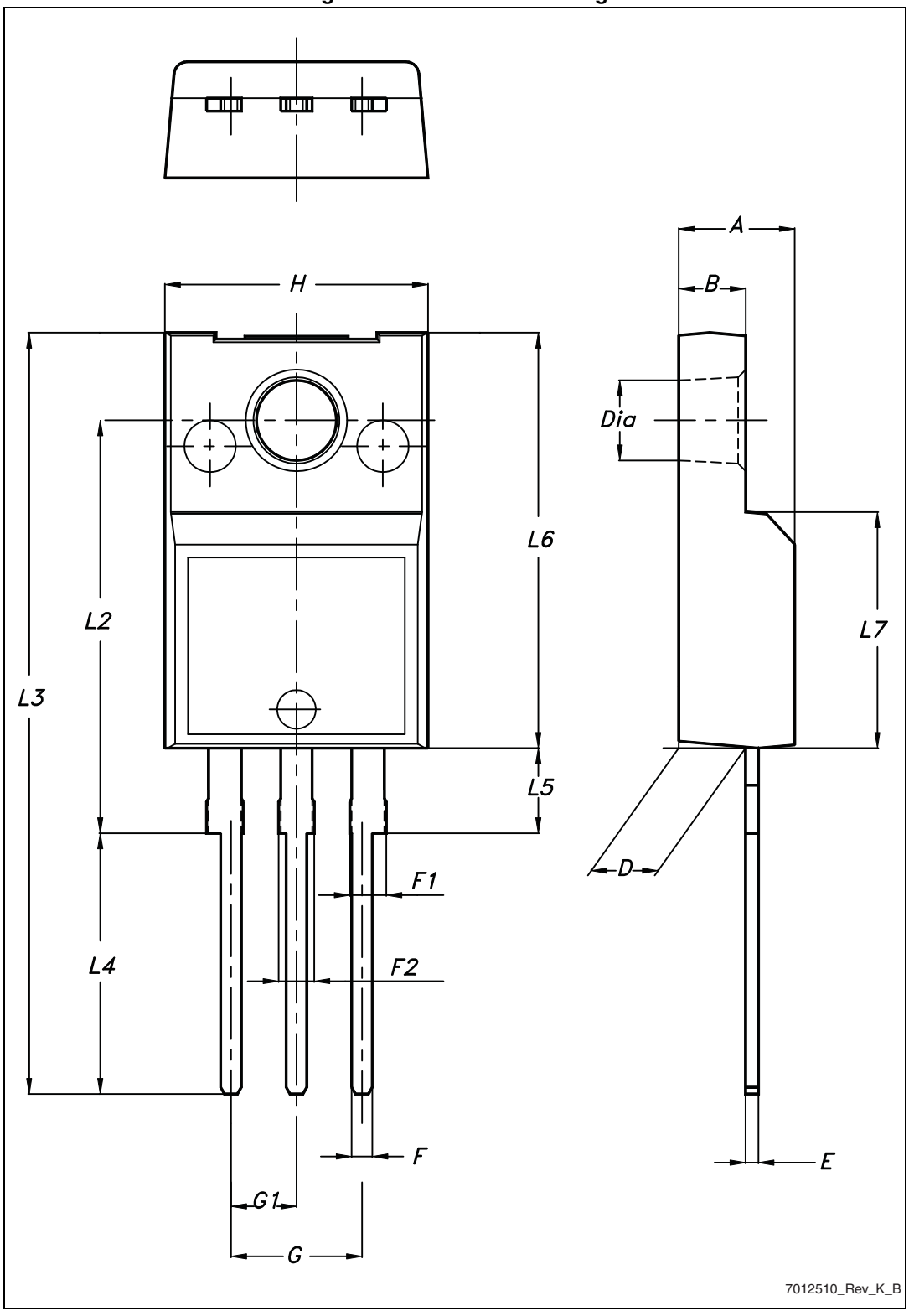
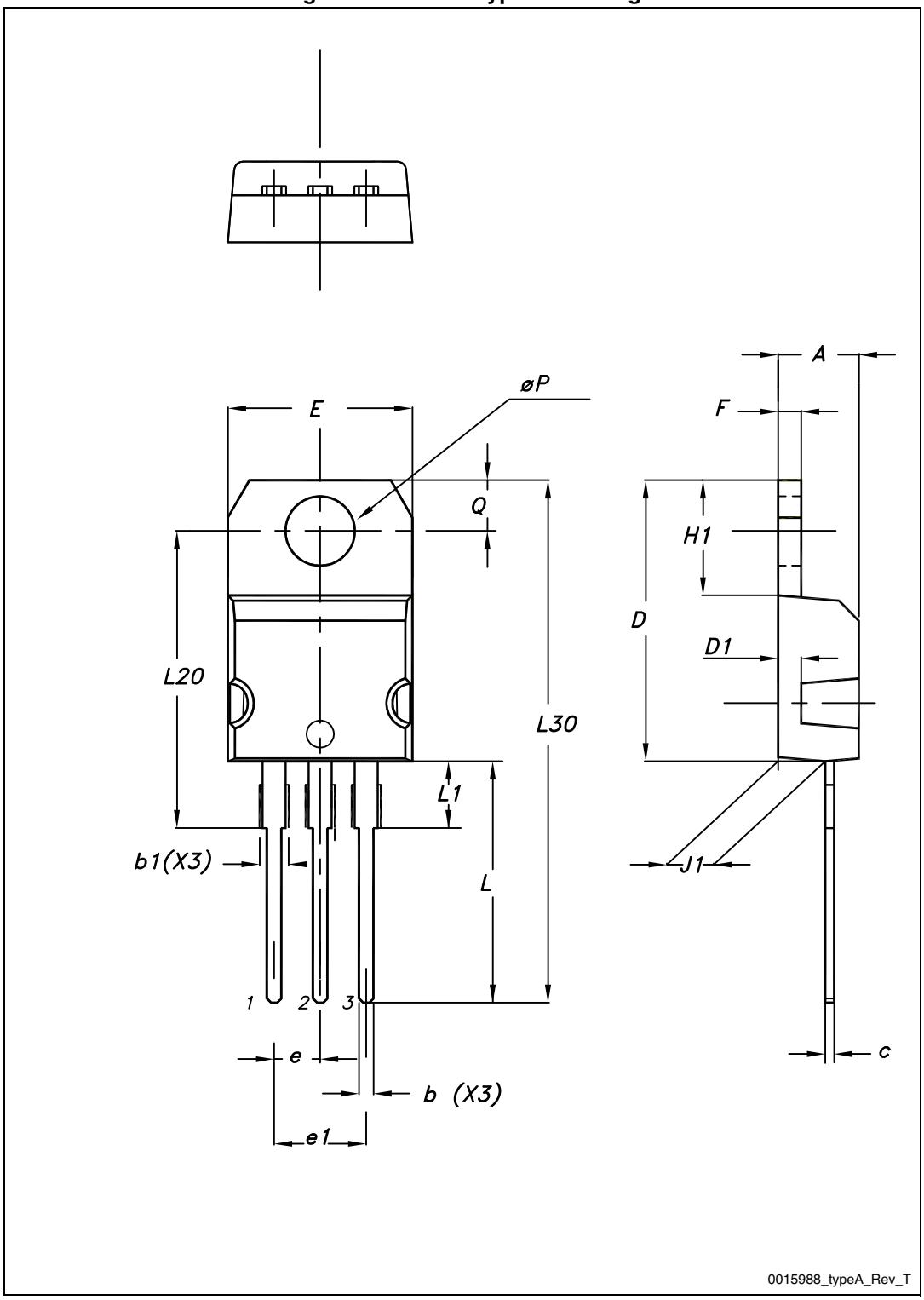


Table 11. TO-220 type A mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10 | | 10.40 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| F | 1.23 | | 1.32 |
| H1 | 6.20 | | 6.60 |
| J1 | 2.40 | | 2.72 |
| L | 13 | | 14 |
| L1 | 3.50 | | 3.93 |
| L20 | | 16.40 | |
| L30 | | 28.90 | |
| ∅P | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

Figure 40. TO-220 type A drawing



# 5 Packaging mechanical data

**Table 12. D²PAK tape and reel mechanical data**

| Tape | | | Reel | | |
|---|---|---|---|---|---|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 10.5 | 10.7 | A | | 330 |
| B0 | 15.7 | 15.9 | B | 1.5 | |
| D | 1.5 | 1.6 | C | 12.8 | 13.2 |
| D1 | 1.59 | 1.61 | D | 20.2 | |
| E | 1.65 | 1.85 | G | 24.4 | 26.4 |
| F | 11.4 | 11.6 | N | 100 | |
| K0 | 4.8 | 5.0 | T | | 30.4 |
| P0 | 3.9 | 4.1 | | | |
| P1 | 11.9 | 12.1 | Base qty | | 1000 |
| P2 | 1.9 | 2.1 | Bulk qty | | 1000 |
| R | 50 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 23.7 | 24.3 | | | |

**Figure 41. Tape**

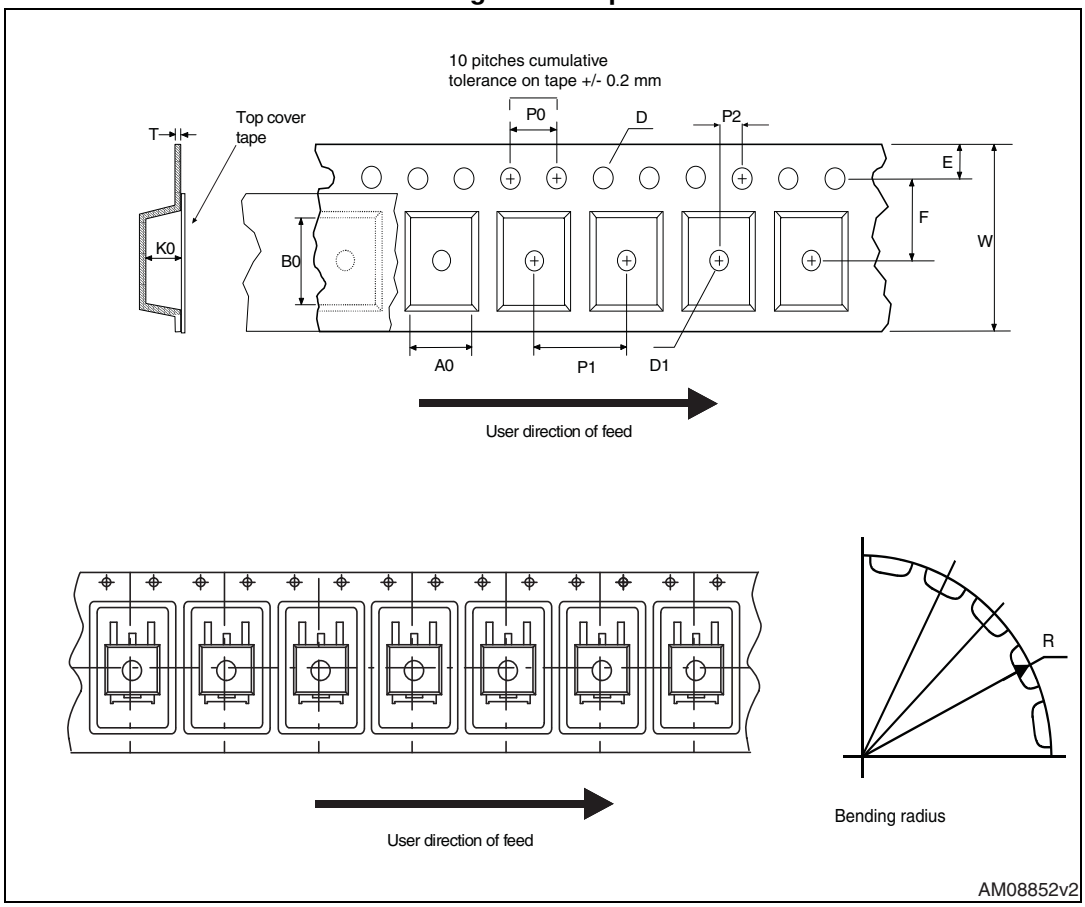
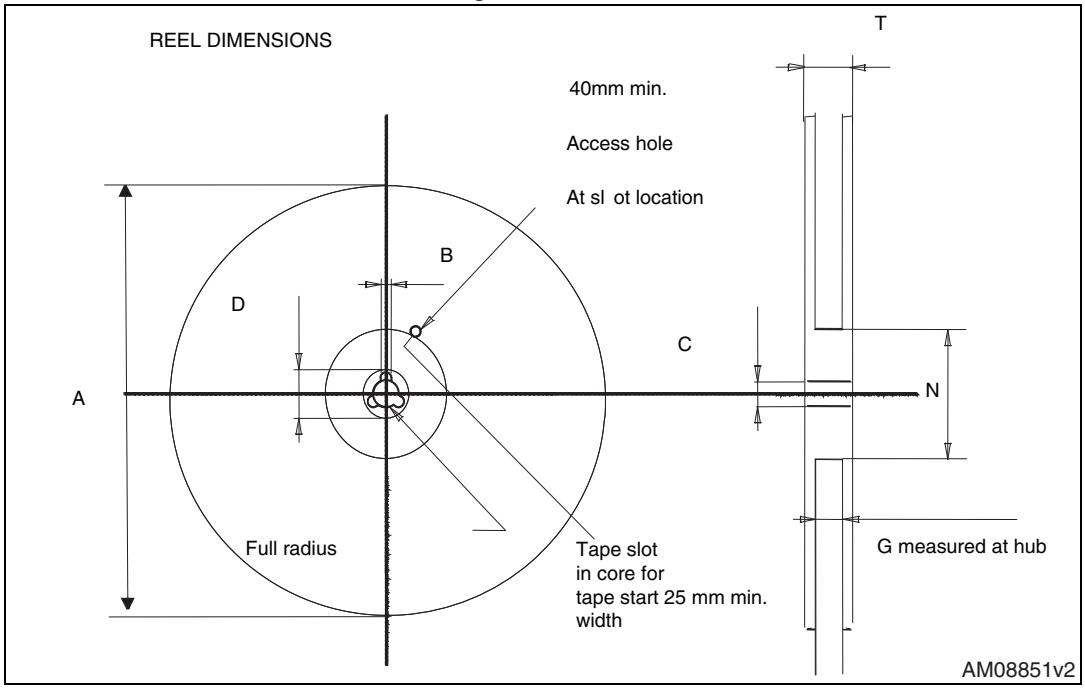



**Figure 42. Reel**



# 6 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 12-Aug-2013 | 1 | Initial release. |
| 31-Oct-2013 | 2 | Document status promoted from preliminary to production data.<br>Inserted *Section 2.1: Electrical characteristics (curves)*.<br>Minor text changes. |

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