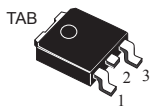
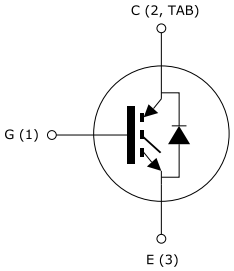
# STGD4M65DF2

Datasheet

## Trench gate field-stop, 650 V, 4 A, M series low-loss IGBT




**DPAK**




## Features

- 6 µs of short-circuit withstand time
- $V_{CE(sat)}$ = 1.6 V (typ.) @ $I_C$ = 4 A
- Tight parameter distribution
- Safer paralleling
- Low thermal resistance
- Soft and very fast recovery antiparallel diode

## Applications

- Motor control
- UPS
- PFC

## Description

This device is an IGBT developed using an advanced proprietary trench gate field-stop structure. The device is part of the M series IGBTs, which represent an optimal balance between inverter system performance and efficiency where the low-loss and the short-circuit functionality is essential. Furthermore, the positive $V_{CE(sat)}$ temperature coefficient and the tight parameter distribution result in safer paralleling operation.

| Product status |
|---|
| STGD4M65DF2 |

| Product summary | |
|---|---|
| **Order code** | STGD4M65DF2 |
| **Marking** | G4M65DF2 |
| **Package** | DPAK |
| **Packing** | Tape and reel |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-emitter voltage ($V_{GE}$ = 0 V) | 650 | V |
| $I_C$ | Continuous collector current at $T_C$ = 25 °C | 8 | A |
| | Continuous collector current at $T_C$ = 100 °C | 4 | A |
| $I_{CP}$ (1) | Pulsed collector current | 16 | A |
| $V_{GE}$ | Gate-emitter voltage | ±20 | V |
| $I_F$ | Continuous forward current at $T_C$ = 25 °C | 8 | A |
| | Continuous forward current at $T_C$ = 100 °C | 4 | A |
| $I_{FP}$ (1) | Pulsed forward current | 16 | A |
| $P_{TOT}$ | Total power dissipation at $T_C$ = 25 °C | 68 | W |
| $T_{STG}$ | Storage temperature range | - 55 to 150 | °C |
| $T_J$ | Operating junction temperature range | - 55 to 175 | °C |

1. *Pulse width limited by maximum junction temperature.*

**Table 2. Thermal data**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{thJC}$ | Thermal resistance junction-case IGBT | 2.2 | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 5 | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 100 | °C/W |

# 2 Electrical characteristics

$T_C$ = 25 °C unless otherwise specified

**Table 3. Static characteristics**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage | $V_{GE}$ = 0 V, $I_C$ = 250 µA | 650 | | | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE}$ = 15 V, $I_C$ = 4 A | | 1.6 | 2.1 | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 4 A, $T_J$ = 125 °C | | 1.9 | | |
| | | $V_{GE}$ = 15 V, $I_C$ = 4 A, $T_J$ = 175 °C | | 2.1 | | |
| $V_F$ | Forward on-voltage | $I_F$ = 4 A | | 1.9 | | V |
| | | $I_F$ = 4 A, $T_J$ = 125 °C | | 1.7 | | |
| | | $I_F$ = 4 A, $T_J$ = 175 °C | | 1.6 | | |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 250 µA | 5 | 6 | 7 | V |
| $I_{CES}$ | Collector cut-off current | $V_{GE}$ = 0 V, $V_{CE}$ = 650 V | | | 25 | µA |
| $I_{GES}$ | Gate-emitter leakage current | $V_{CE}$ = 0 V, $V_{GE}$ = ± 20 V | | | ±250 | µA |

**Table 4. Dynamic characteristics**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{ies}$ | Input capacitance | $V_{CE}$= 25 V, f = 1 MHz, $V_{GE}$ = 0 V | - | 369 | - | pF |
| $C_{oes}$ | Output capacitance | | - | 24.8 | - | |
| $C_{res}$ | Reverse transfer capacitance | | - | 8 | - | |
| $Q_g$ | Total gate charge | $V_{CC}$ = 520 V, $I_C$ = 4 A, $V_{GE}$ = 0 to 15 V (see Figure 29. Gate charge test circuit) | - | 15.2 | - | nC |
| $Q_{ge}$ | Gate-emitter charge | | - | 3 | - | |
| $Q_{gc}$ | Gate-collector charge | | - | 7 | - | |

**Table 5. IGBT switching characteristics (inductive load)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 4 A, $V_{GE}$ = 15 V, $R_G$ = 47 Ω (see Figure 28. Test circuit for inductive load switching ) | | 12 | - | ns |
| $t_r$ | Current rise time | | | 6.9 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 480 | - | A/µs |
| $t_{d(off)}$ | Turn-off delay time | | | 86 | - | ns |
| $t_f$ | Current fall time | | | 120 | - | ns |
| $E_{on}$ (1) | Turn-on switching energy | | | 0.040 | - | mJ |
| $E_{off}$ (2) | Turn-off switching energy | | | 0.136 | - | mJ |
| $E_{ts}$ | Total switching energy | | | 0.176 | - | mJ |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 4 A, $V_{GE}$ = 15 V, $R_G$ = 47 Ω, $T_J$ = 175 °C (see Figure 28. Test circuit for inductive load switching) | | 11.6 | - | ns |
| $t_r$ | Current rise time | | | 8 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 410 | - | A/µs |
| $t_{d(off)}$ | Turn-off delay time | | | 85 | - | ns |
| $t_f$ | Current fall time | | | 211 | - | ns |
| $E_{on}$ (1) | Turn-on switching energy | | | 0.067 | - | mJ |
| $E_{off}$ (2) | Turn-off switching energy | | | 0.210 | - | mJ |
| $E_{ts}$ | Total switching energy | | | 0.277 | - | mJ |
| $t_{sc}$ | Short-circuit withstand time | $V_{CC}$ ≤ 400 V, $V_{GE}$ = 15 V, $T_{Jstart}$ = 150 °C | 6 | | - | µs |
| | | $V_{CC}$ ≤ 400 V, $V_{GE}$ = 13 V, $T_{Jstart}$ = 150 °C | 10 | | - | |

1. *Including the reverse recovery of the diode.*
2. *Including the tail of the collector current.*

**Table 6. Diode switching characteristics (inductive load)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{rr}$ | Reverse recovery time | $I_F$ = 4 A, $V_R$ = 400 V, $V_{GE}$ = 15 V, di/dt = 800 A/µs (see Figure 28. Test circuit for inductive load switching) | - | 133 | - | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 140 | - | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 5 | - | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 520 | - | A/µs |
| $E_{rr}$ | Reverse recovery energy | | - | 15 | - | µJ |
| $t_{rr}$ | Reverse recovery time | $I_F$ = 4 A, $V_R$ = 400 V, $V_{GE}$ = 15 V, $T_J$ = 175 °C, di/dt = 800 A/µs (see Figure 28. Test circuit for inductive load switching) | - | 236 | - | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 370 | - | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 6.6 | - | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 378 | - | A/µs |
| $E_{rr}$ | Reverse recovery energy | | - | 32 | - | µJ |

## 2.1 STGD4M65DF2 electrical characteristics (curves)

**Figure 1. Power dissipation vs. case temperature**

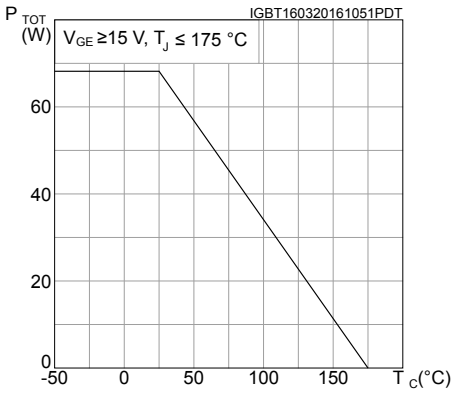



**Figure 2. Collector current vs. case temperature**

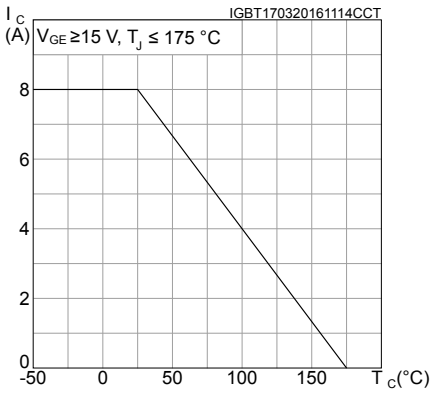



**Figure 3. Output characteristics ($T_J$ = 25 °C)**

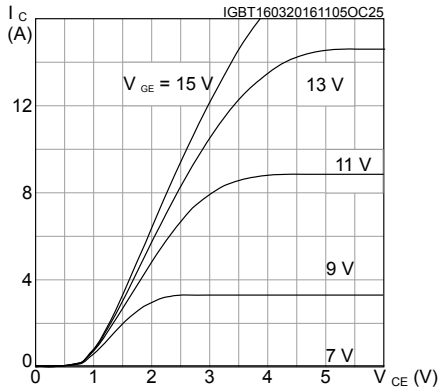



**Figure 4. Output characteristics ($T_J$ = 175 °C)**

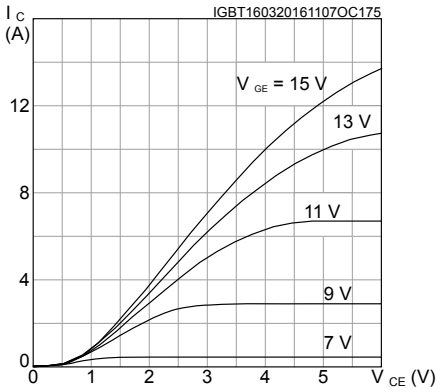



**Figure 5. $V_{CE}$(sat) vs. junction temperature**

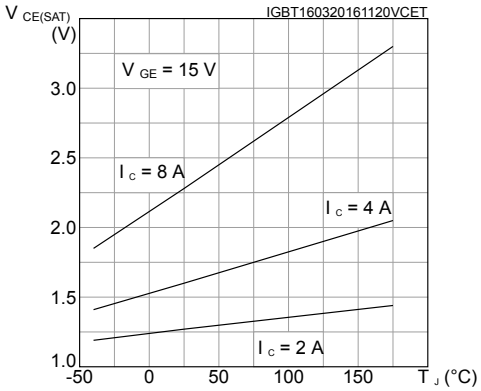



**Figure 6. $V_{CE}$(sat) vs. collector current**

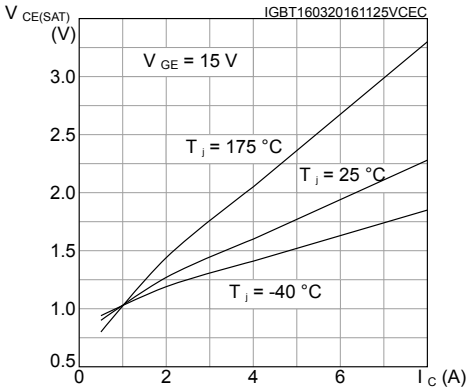


**Figure 7. Collector current vs. switching frequency**

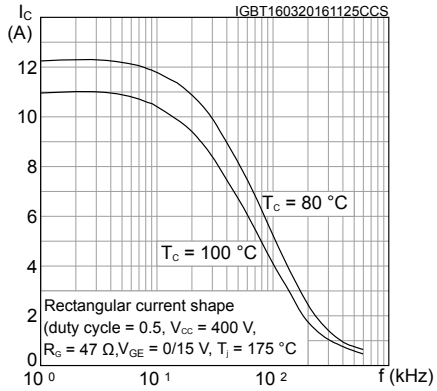



**Figure 8. Forward bias safe operating area**

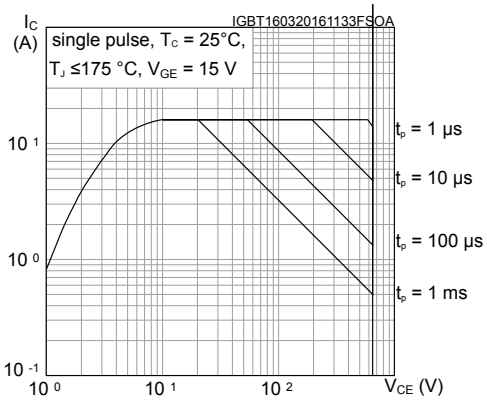



**Figure 9. Transfer characteristics**

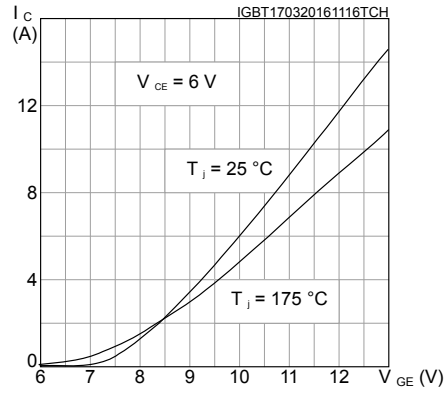



**Figure 10. Diode $V_F$ vs. forward current**

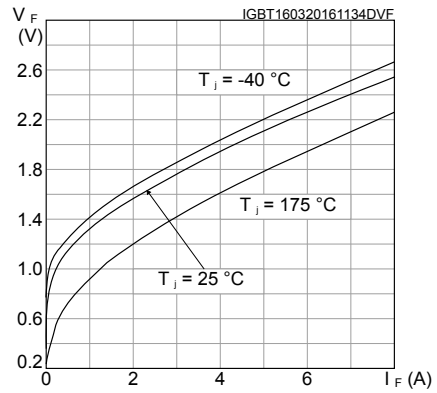



**Figure 11. Normalized $V_{GE(th)}$ vs. junction temperature**

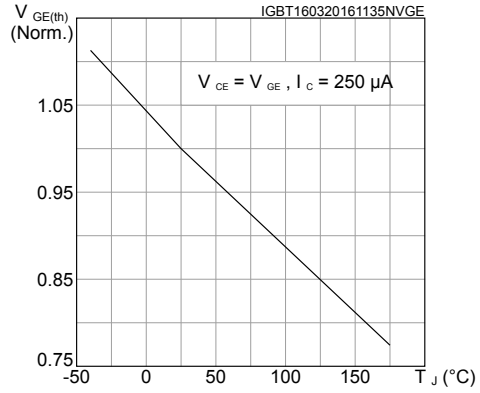



**Figure 12. Normalized $V_{(BR)CES}$ vs. junction temperature**

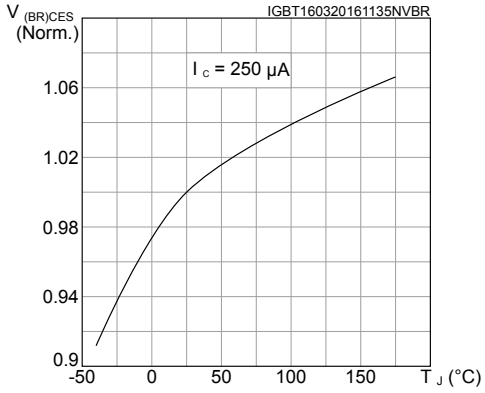


**Figure 13. Capacitance variations**

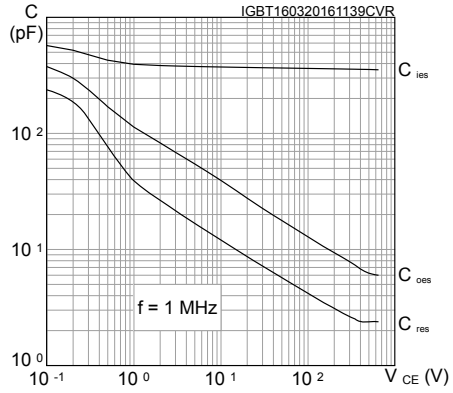



**Figure 14. Gate charge vs. gate-emitter voltage**

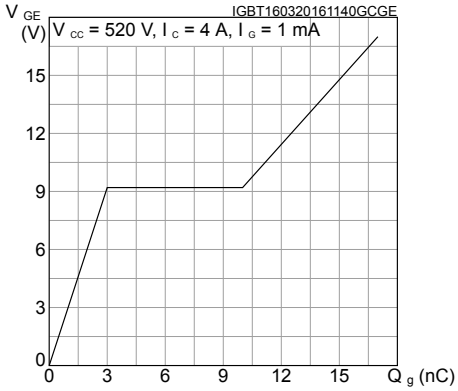



**Figure 15. Switching energy vs. collector current**

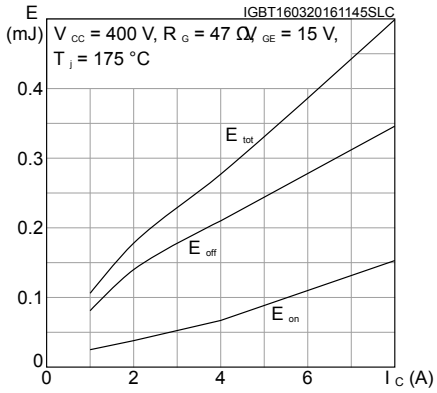



**Figure 16. Switching energy vs. gate resistance**

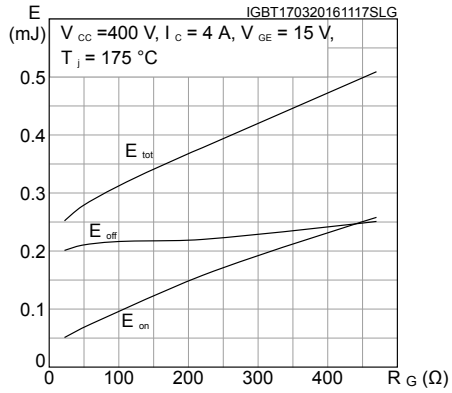



**Figure 17. Switching energy vs. temperature**

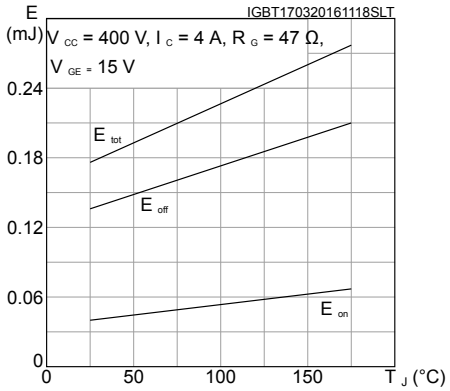



**Figure 18. Switching energy vs. collector emitter voltage**

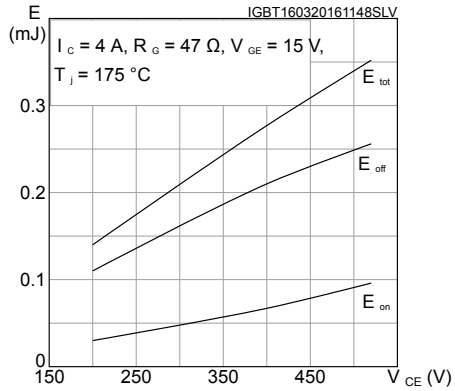


**Figure 19. Short-circuit time and current vs. $V_{GE}$**

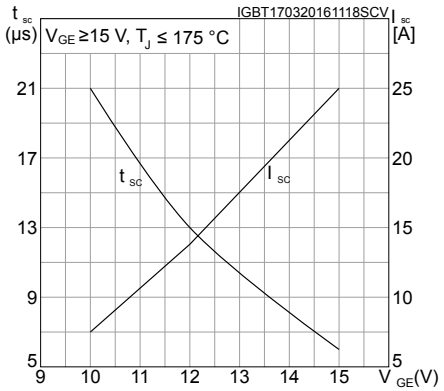



**Figure 20. Switching times vs. collector current**

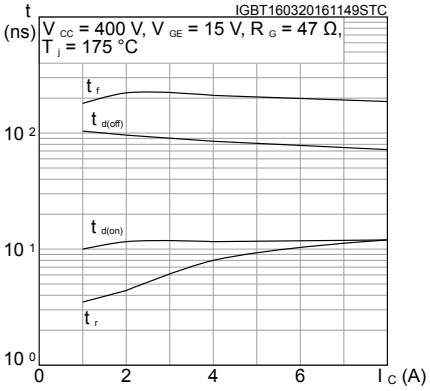



**Figure 21. Switching times vs. gate resistance**

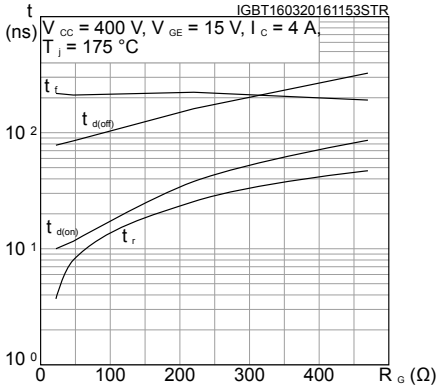



**Figure 22. Reverse recovery current vs. diode current slope**

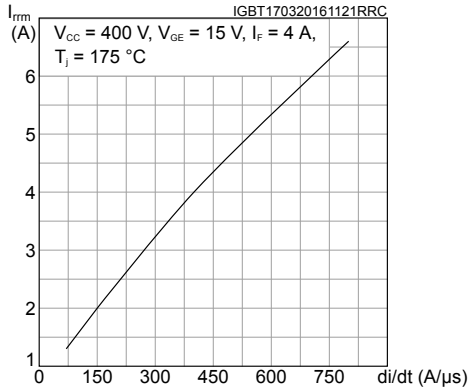



**Figure 23. Reverse recovery time vs. diode current slope**

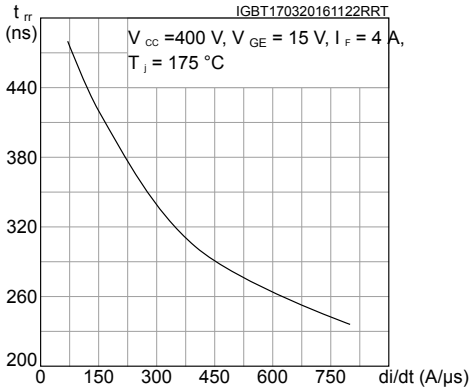



**Figure 24. Reverse recovery charge vs. diode current slope**

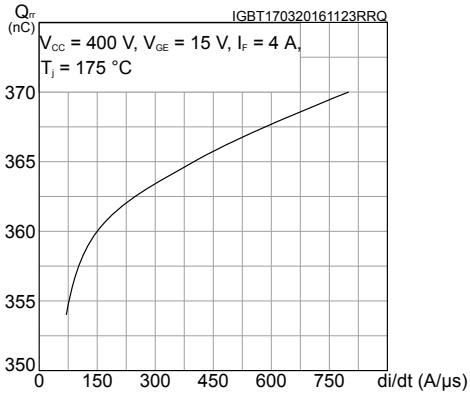


**Figure 25. Reverse recovery energy vs. diode current slope**

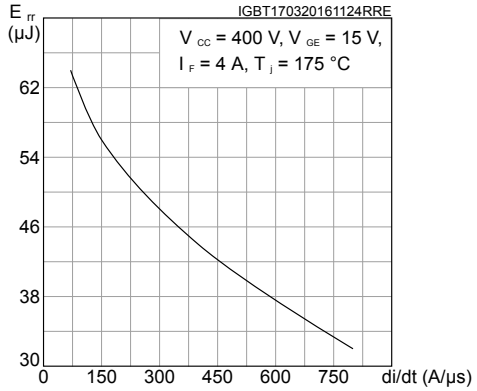



**Figure 26. Thermal impedance for IGBT**

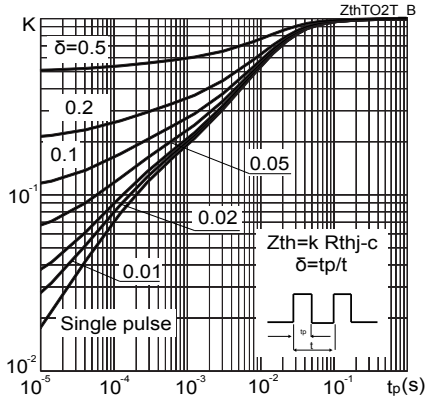
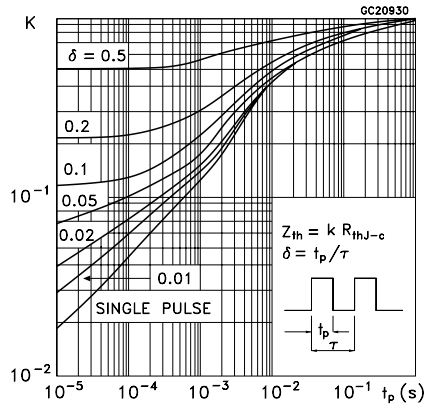



**Figure 27. Thermal impedance for diode**



# 3 Test circuits

**Figure 28. Test circuit for inductive load switching**

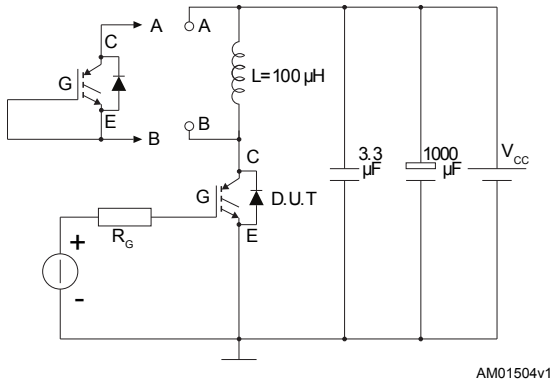



**Figure 29. Gate charge test circuit**

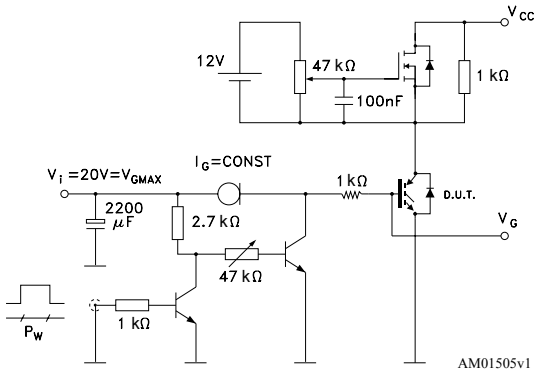



**Figure 30. Switching waveform**

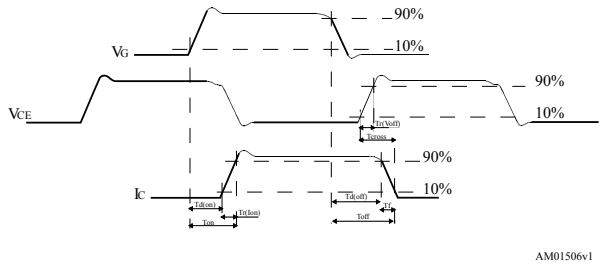
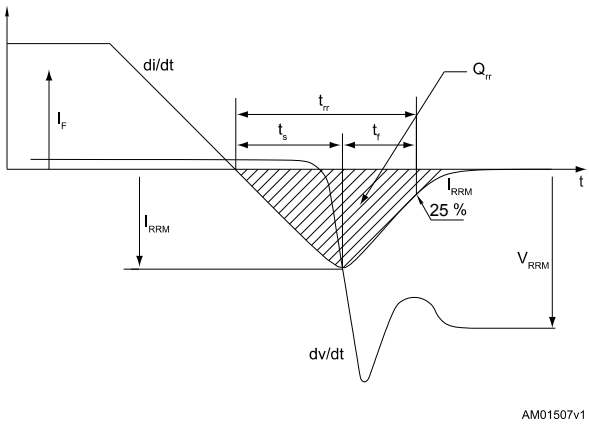



**Figure 31. Diode reverse recovery waveform**



# 4 Package information

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.

## 4.1 DPAK (TO-252) type A2 package information

Figure 32. **DPAK (TO-252) type A2 package outline**

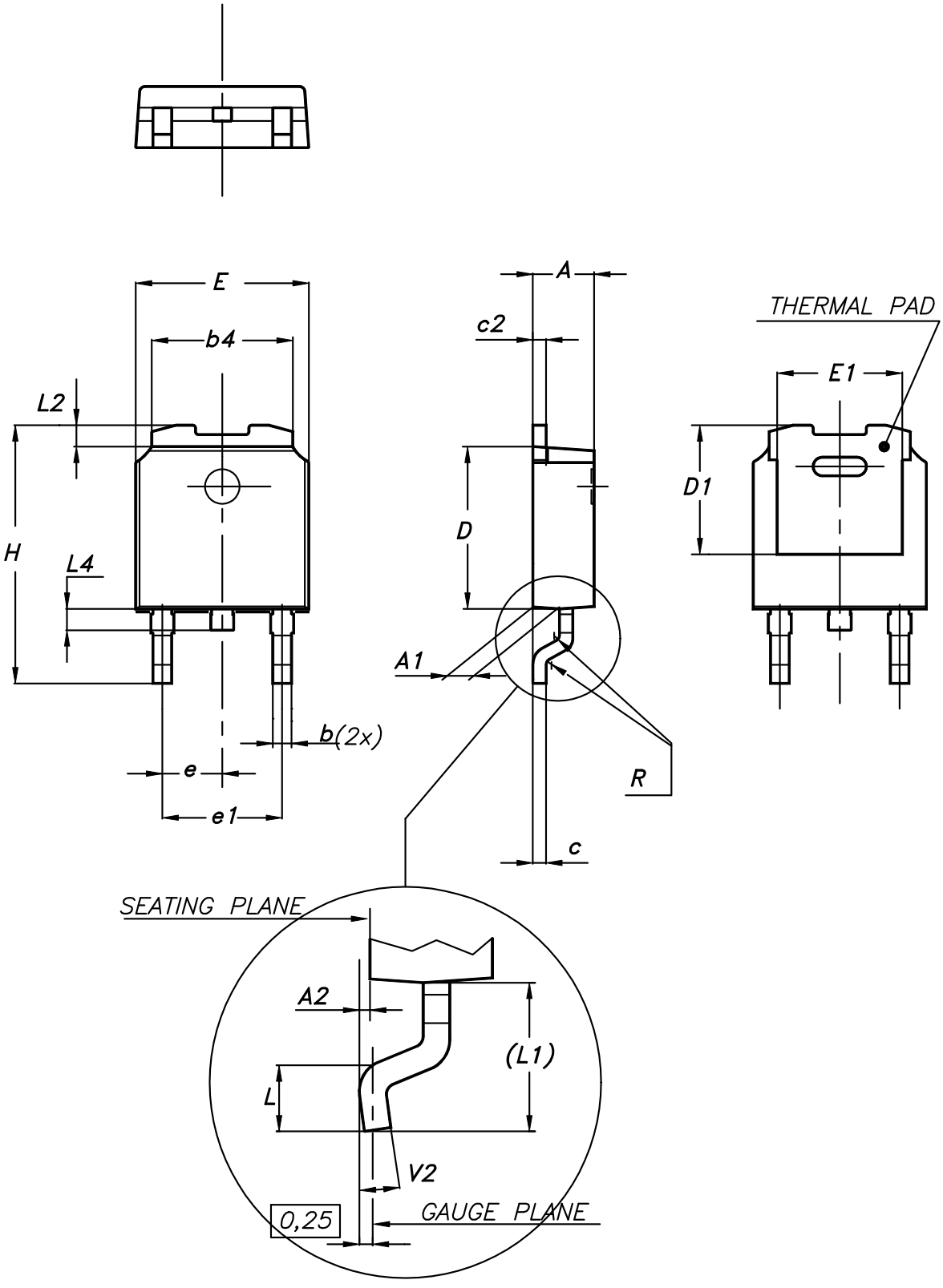
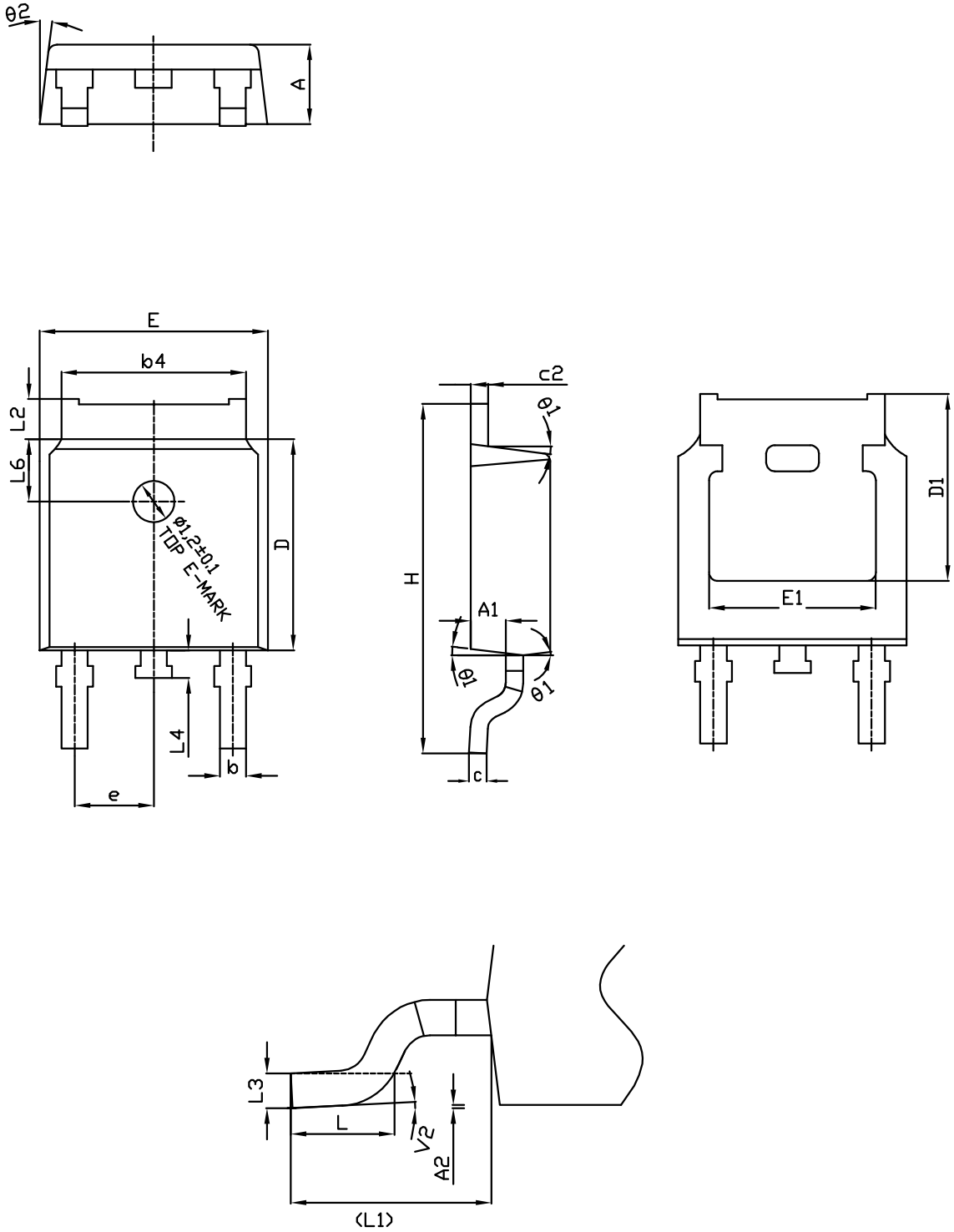


Table 7. **DPAK (TO-252) type A2 mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.20 | | 2.40 |
| A1 | 0.90 | | 1.10 |
| A2 | 0.03 | | 0.23 |
| b | 0.64 | | 0.90 |
| b4 | 5.20 | | 5.40 |
| c | 0.45 | | 0.60 |
| c2 | 0.48 | | 0.60 |
| D | 6.00 | | 6.20 |
| D1 | 4.95 | 5.10 | 5.25 |
| E | 6.40 | | 6.60 |
| E1 | 5.10 | 5.20 | 5.30 |
| e | 2.159 | 2.286 | 2.413 |
| e1 | 4.445 | 4.572 | 4.699 |
| H | 9.35 | | 10.10 |
| L | 1.00 | | 1.50 |
| L1 | 2.60 | 2.80 | 3.00 |
| L2 | 0.65 | 0.80 | 0.95 |
| L4 | 0.60 | | 1.00 |
| R | | 0.20 | |
| V2 | 0° | | 8° |

## 4.2 DPAK (TO-252) type C2 package information

Figure 33. **DPAK (TO-252) type C2 package outline**

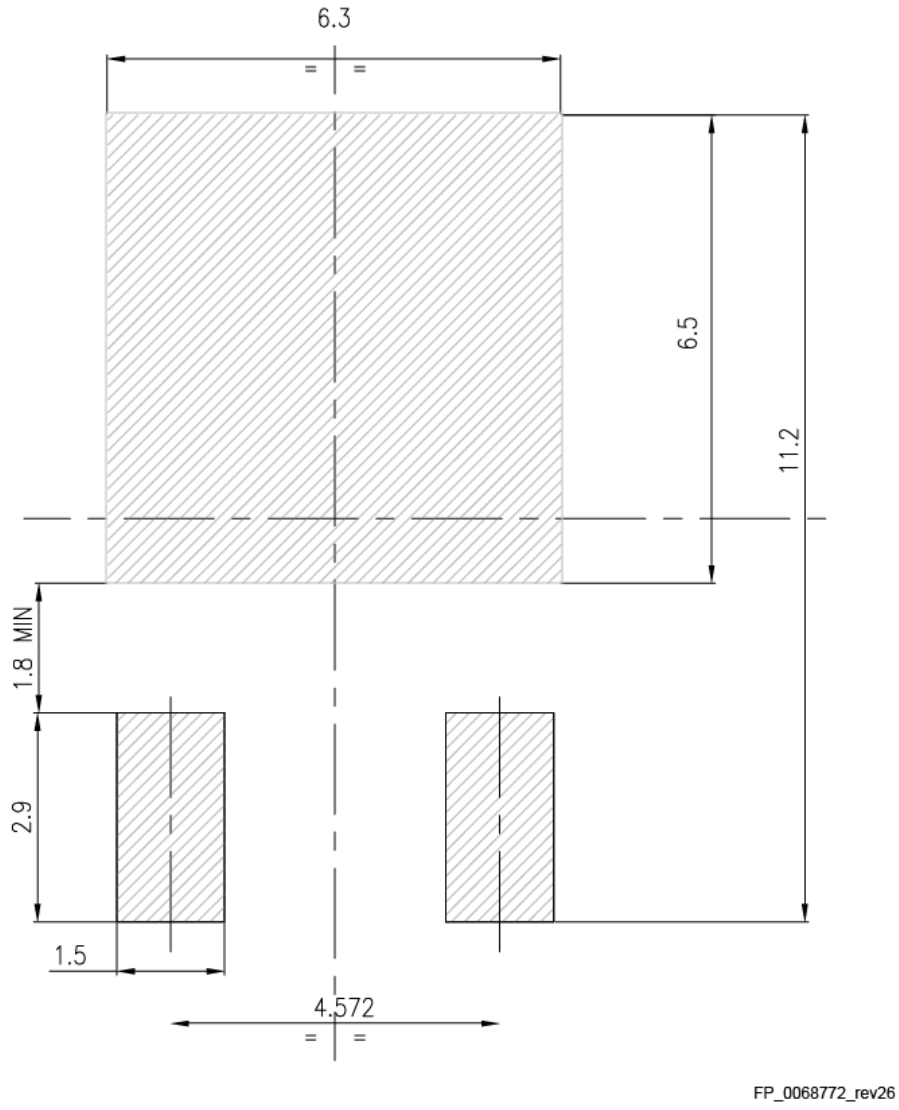



0068772_type-C2_rev26

**Table 8. DPAK (TO-252) type C2 mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.20 | 2.30 | 2.38 |
| A1 | 0.90 | 1.01 | 1.10 |
| A2 | 0.00 | | 0.10 |
| b | 0.72 | | 0.85 |
| b4 | 5.13 | 5.33 | 5.46 |
| c | 0.47 | | 0.60 |
| c2 | 0.47 | | 0.60 |
| D | 6.00 | 6.10 | 6.20 |
| D1 | 5.10 | | 5.60 |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 5.20 | | 5.50 |
| e | 2.186 | 2.286 | 2.386 |
| H | 9.80 | 10.10 | 10.40 |
| L | 1.40 | 1.50 | 1.70 |
| L1 | | 2.90 REF | |
| L2 | 0.90 | | 1.25 |
| L3 | | 0.51 BSC | |
| L4 | 0.60 | 0.80 | 1.00 |
| L6 | | 1.80 BSC | |
| θ1 | 5° | 7° | 9° |
| θ2 | 5° | 7° | 9° |
| V2 | 0° | | 8° |

Figure 34. **DPAK (TO-252) recommended footprint (dimensions are in mm)**



## 4.3 DPAK (TO-252) packing information

Figure 35. **DPAK (TO-252) tape outline**

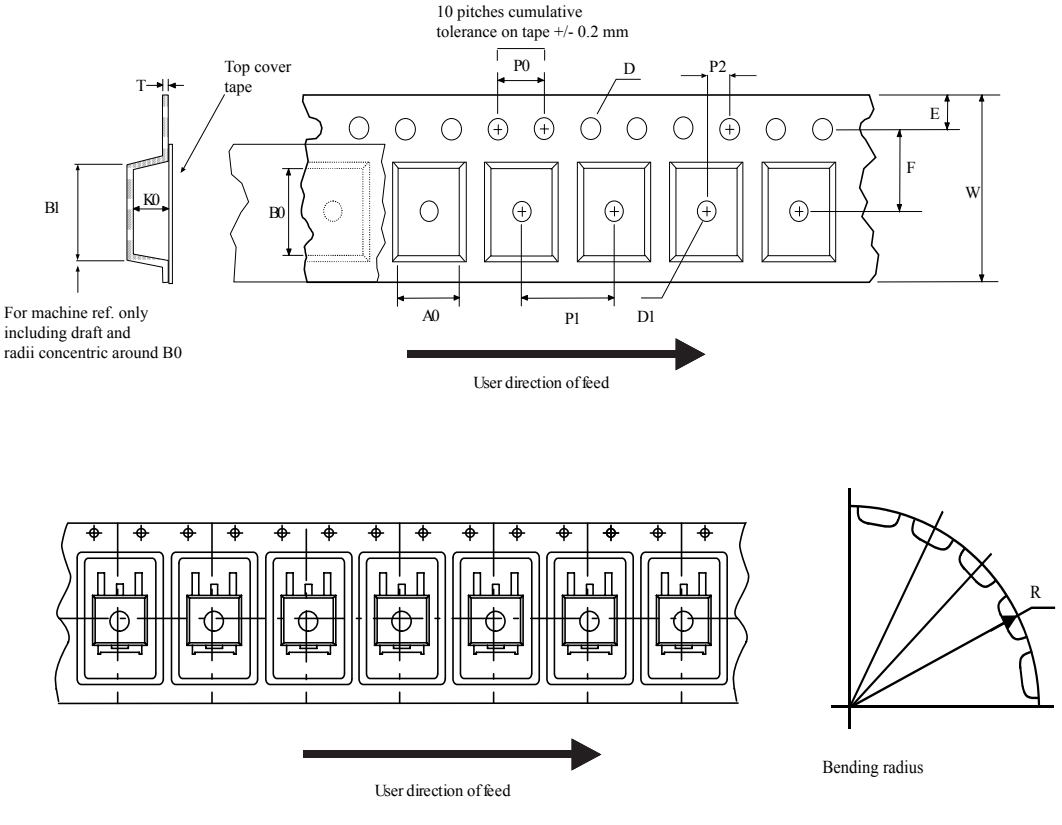


Figure 36. **DPAK (TO-252) reel outline**

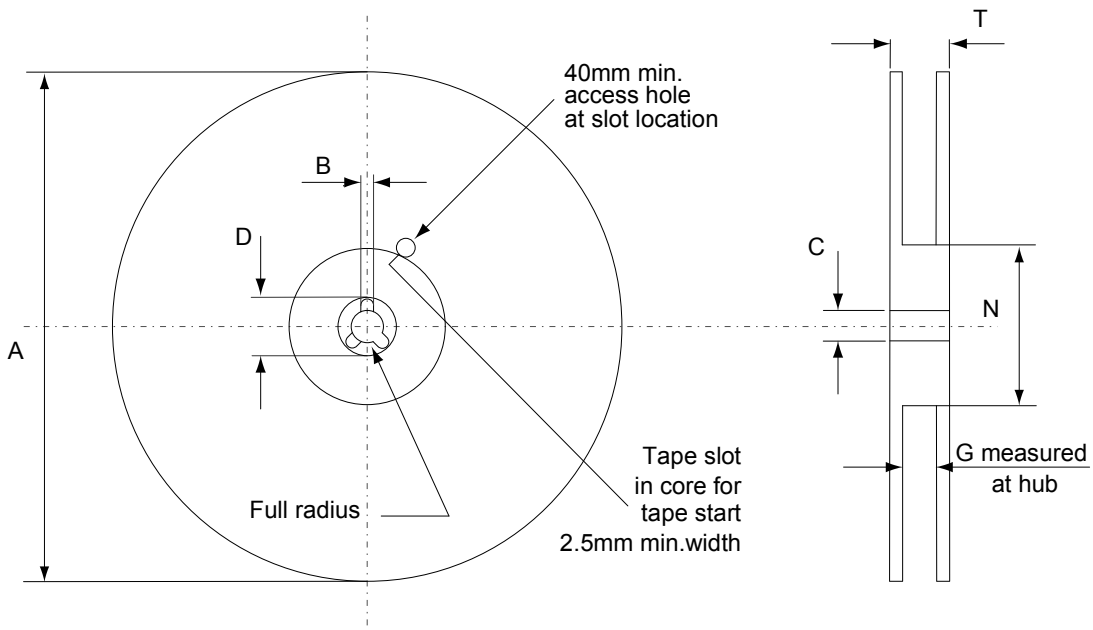



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Table 9. **DPAK (TO-252) tape and reel mechanical data**

| Tape | | | Reel | | |
|---|---|---|---|---|---|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 6.8 | 7 | A | | 330 |
| B0 | 10.4 | 10.6 | B | 1.5 | |
| B1 | | 12.1 | C | 12.8 | 13.2 |
| D | 1.5 | 1.6 | D | 20.2 | |
| D1 | 1.5 | | G | 16.4 | 18.4 |
| E | 1.65 | 1.85 | N | 50 | |
| F | 7.4 | 7.6 | T | | 22.4 |
| K0 | 2.55 | 2.75 | | | |
| P0 | 3.9 | 4.1 | Base qty. | | 2500 |
| P1 | 7.9 | 8.1 | Bulk qty. | | 2500 |
| P2 | 1.9 | 2.1 | | | |
| R | 40 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 15.7 | 16.3 | | | |

## Revision history

Table 10. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 25-Nov-2015 | 1 | First release. |
| 18-Apr-2016 | 2 | Modified: features in cover page<br>Modified: Table 2: *"Absolute maximum ratings"*, Table 4: *"Static characteristics"*, Table 5: *"Dynamic characteristics"*, Table 6: *"IGBT switching characteristics (inductive load)"* and Table 7: *"Diode switching characteristics (inductive load)"* Added: Section 2.1: *"Electrical characteristics (curves)"* Minor text changes |
| 28-Apr-2016 | 3 | Modified: Table 1: *"Device summary"* in cover page<br>Minor text changes |
| 21-Nov-2016 | 4 | Updated Table 1. Absolute maximum ratings<br>Updated Figure 24. Reverse recovery charge vs. diode current slope<br>Updated Figure 31. Diode reverse recovery waveform |
| 05-Dec-2018 | 5 | Added Section 4.2 DPAK (TO-252) type C2 package information. |