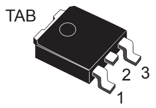
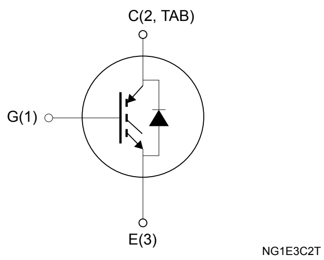
# STGD6M65DF2

Datasheet

## Trench gate field-stop, 650 V, 6 A, low-loss M series IGBT in a DPAK package




DPAK




## Features

- Maximum junction temperature: $T_J$ = 175 °C
- 6 µs of minimum short-circuit withstand time
- $V_{CE(sat)}$ = 1.55 V (typ.) at $I_C$ = 6 A
- Tight parameter distribution
- Safer paralleling
- Positive $V_{CE(sat)}$ temperature coefficient
- Low thermal resistance
- Soft and very fast-recovery antiparallel diode

## Applications

- Industrial motor control
- PFC converters, single phase input
- Uninterruptable power supplies (UPS)

## 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 link |
|---|
| STGD6M65DF2 |

| Product summary | |
|---|---|
| **Order code** | STGD6M65DF2 |
| **Marking** | G6M65DF2 |
| **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 | 12 | A |
| | Continuous collector current at $T_C$ = 100 °C | 6 | |
| $I_{CP}$ (1) | Pulsed collector current | 24 | A |
| $V_{GE}$ | Gate-emitter voltage | ±20 | V |
| $I_F$ | Continuous forward current at $T_C$ = 25 °C | 12 | A |
| | Continuous forward current at $T_C$ = 100 °C | 6 | |
| $I_{FP}$ (1) | Pulsed forward current | 24 | A |
| $P_{TOT}$ | Total power dissipation at $T_C$ = 25 °C | 88 | W |
| $T_{STG}$ | Storage temperature range | -55 to 150 | °C |
| $T_J$ | Operating junction temperature range | -55 to 175 | °C |

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

**Table 2. Thermal data**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{thJC}$ | Thermal resistance, junction-to-case IGBT | 1.7 | °C/W |
| | Thermal resistance, junction-to-case diode | 5 | |
| $R_{thJA}$ | Thermal resistance, junction-to-ambient | 100 | °C/W |

# 2 Electrical characteristics

$T_J$ = 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, $I_C$ = 6 A | | 1.55 | 2.0 | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 6 A, $T_J$ = 125 °C | | 1.9 | | |
| | | $V_{GE}$ = 15 V, $I_C$ = 6 A, $T_J$ = 175 °C | | 2.1 | | |
| $V_F$ | Forward on-voltage | $I_F$ = 6 A | | 2.6 | 3.5 | V |
| | | $I_F$ = 6 A, $T_J$ = 125 °C | | 2.3 | | |
| | | $I_F$ = 6 A, $T_J$ = 175 °C | | 2.2 | | |
| $V_{GE(th)}$ | 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 | nA |

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 | - | 530 | - | pF |
| $C_{oes}$ | Output capacitance | | - | 31 | - | pF |
| $C_{res}$ | Reverse transfer capacitance | | - | 11 | - | pF |
| $Q_g$ | Total gate charge | $V_{CC}$ = 520 V, $I_C$ = 6 A, $V_{GE}$ = 0 to 15 V (see Figure 28. Gate charge test circuit) | - | 21.2 | - | nC |
| $Q_{ge}$ | Gate-emitter charge | | - | 5.2 | - | nC |
| $Q_{gc}$ | Gate-collector charge | | - | 8.8 | - | nC |

**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, $I_C$ = 6 A, $V_{GE}$ = 15 V, $R_G$ = 22 Ω (see Figure 27. Test circuit for inductive load switching) | | 15 | - | ns |
| $t_r$ | Current rise time | | | 5.8 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 828 | - | A/μs |
| $t_{d(off)}$ | Turn-off delay time | | | 90 | - | ns |
| $t_f$ | Current fall time | | | 130 | - | ns |
| $E_{on}$ (1) | Turn-on switching energy | | | 0.036 | - | mJ |
| $E_{off}$ (2) | Turn-off switching energy | | | 0.200 | - | mJ |
| $E_{ts}$ | Total switching energy | | | 0.236 | - | mJ |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 6 A, $V_{GE}$ = 15 V, $R_G$ = 22 Ω, $T_J$ = 175 °C (see Figure 27. Test circuit for inductive load switching) | | 17 | - | ns |
| $t_r$ | Current rise time | | | 7 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 685 | - | A/μs |
| $t_{d(off)}$ | Turn-off delay time | | | 86 | - | ns |
| $t_f$ | Current fall time | | | 205 | - | ns |
| $E_{on}$ (1) | Turn-on switching energy | | | 0.064 | - | mJ |
| $E_{off}$ (2) | Turn-off switching energy | | | 0.290 | - | mJ |
| $E_{ts}$ | Total switching energy | | | 0.354 | - | 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 | $I_F$ = 6 A, $V_R$ = 400 V, $V_{GE}$ = 15 V, di/dt = 1000 A/μs (see Figure 27. Test circuit for inductive load switching) | - | 140 | - | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 210 | - | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 6.6 | - | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 430 | - | A/μs |
| $E_{rr}$ | Reverse recovery energy | | - | 16 | - | μJ |
| $t_{rr}$ | Reverse recovery time | $I_F$ = 6 A, $V_R$ = 400 V, $V_{GE}$ = 15 V, di/dt = 1000 A/μs, $T_J$ = 175 °C (see Figure 27. Test circuit for inductive load switching) | - | 200 | - | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 473 | - | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 9.6 | - | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 428 | - | A/μs |
| $E_{rr}$ | Reverse recovery energy | | - | 32 | - | μJ |

## 2.1 Electrical characteristics (curves)

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

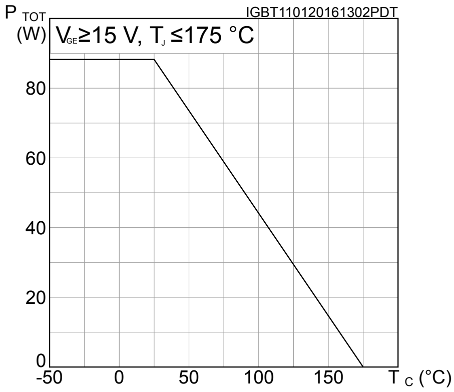



**Figure 2. Collector current vs. case temperature**

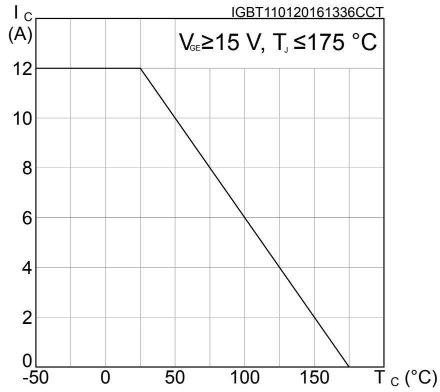



**Figure 3. Output characteristics ($T_J$ = 25 °C)**

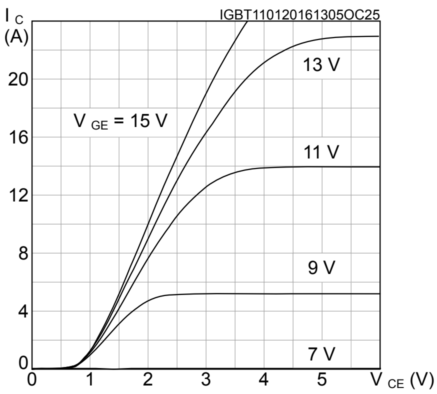



**Figure 4. Output characteristics ($T_J$ = 175 °C)**

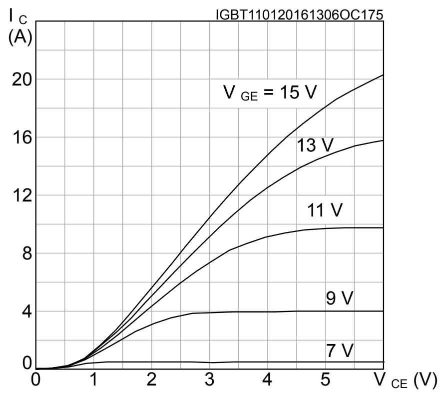



**Figure 5. $V_{CE(sat)}$ vs. junction temperature**

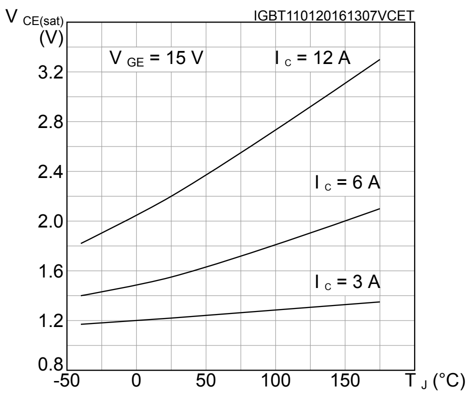



**Figure 6. $V_{CE(sat)}$ vs. collector current**

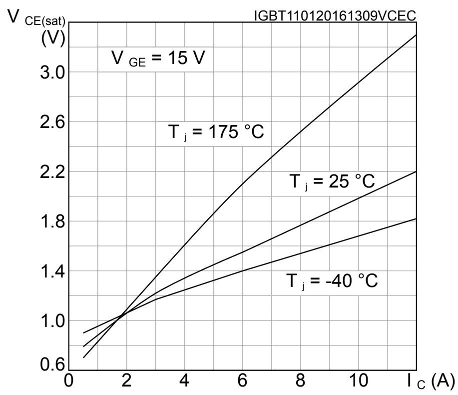


**Figure 7. Collector current vs. switching frequency**

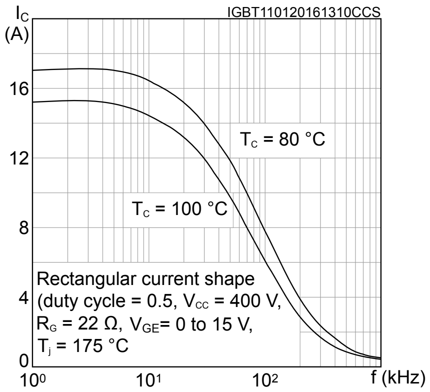



**Figure 8. Forward bias safe operating area**

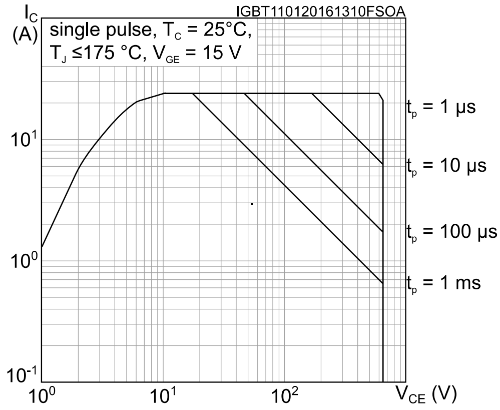



**Figure 9. Transfer characteristics**

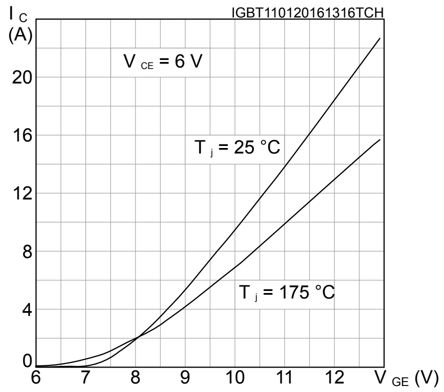



**Figure 10. Normalized $V_{GE(th)}$ vs. junction temperature**

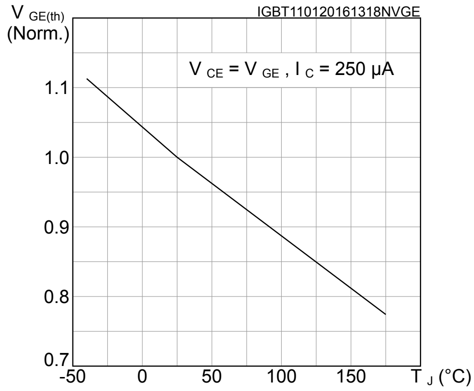



**Figure 11. Normalized $V_{(BR)CES}$ vs. junction temperature**

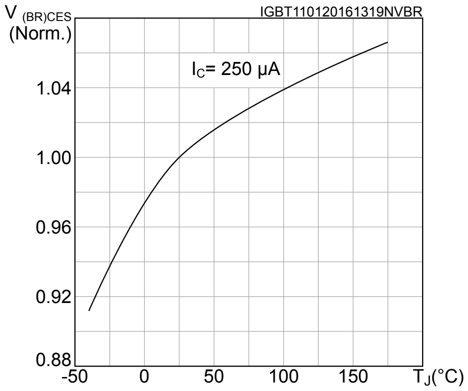



**Figure 12. Capacitance variations**

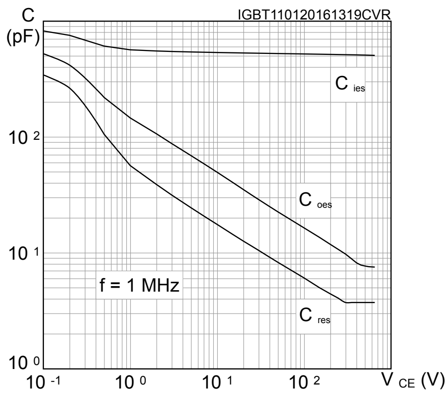


**Figure 13.** Gate charge vs. gate-emitter voltage

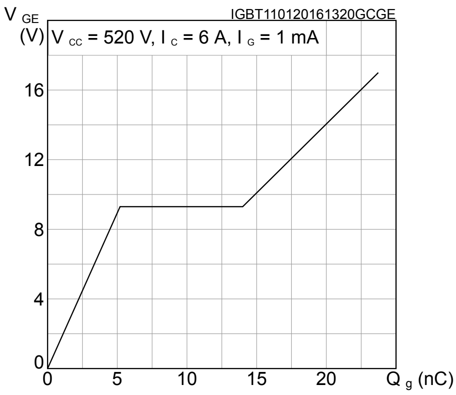



**Figure 14.** Switching energy vs. collector current

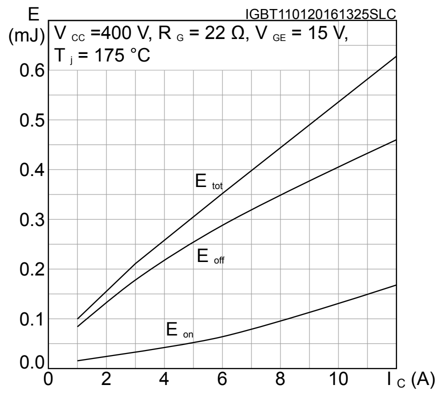



**Figure 15.** Switching energy vs. gate resistance

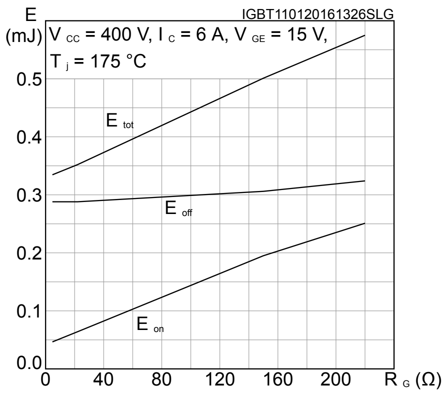



**Figure 16.** Switching energy vs. temperature

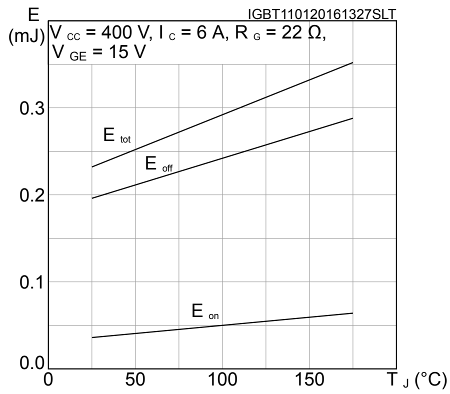



**Figure 17.** Switching energy vs. collector emitter voltage

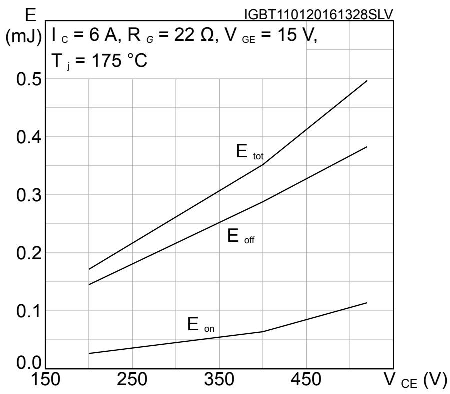



**Figure 18.** Short-circuit time and current vs. $V_{GE}$

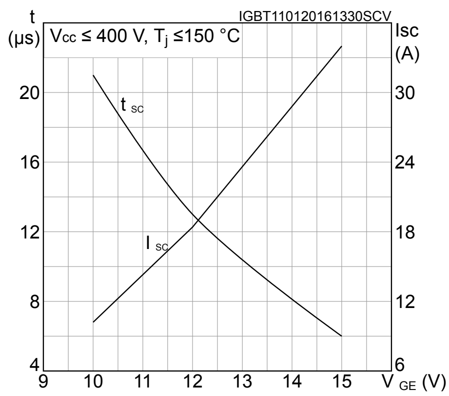


Figure 19. Switching times vs. collector current

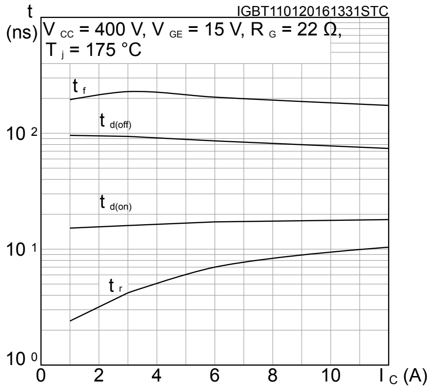



Figure 20. Switching times vs. gate resistance

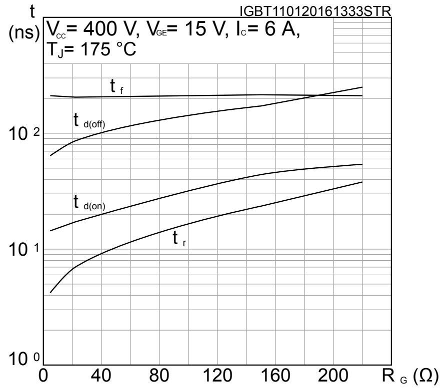



Figure 21. Reverse recovery current vs. diode current slope

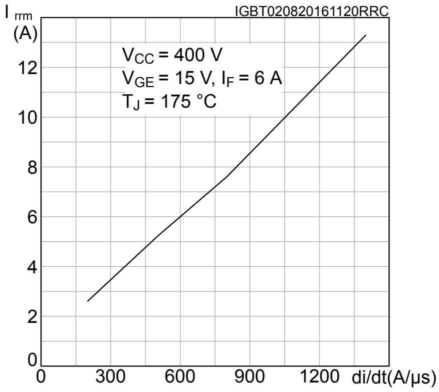



Figure 22. Reverse recovery time vs. diode current slope

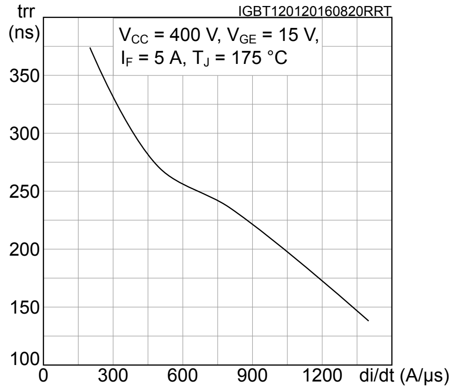



Figure 23. Reverse recovery charge vs. diode current slope

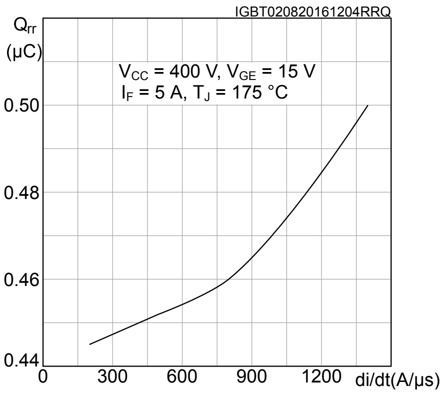



Figure 24. Reverse recovery energy vs. diode current slope

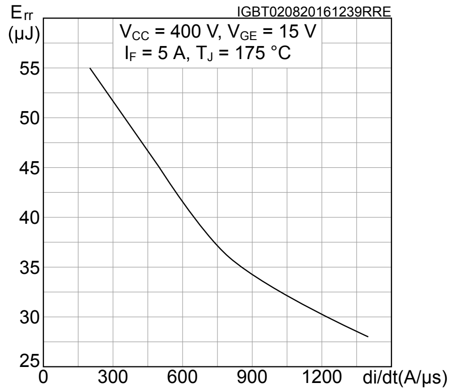


Figure 25. Thermal impedance for IGBT

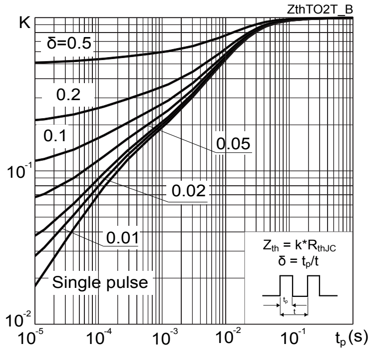
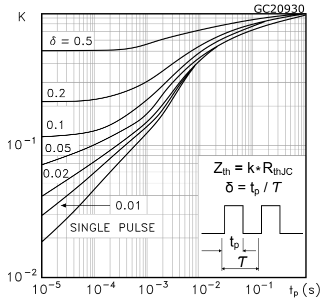



Figure 26. Thermal impedance for diode



# 3 Test circuits

Figure 27. Test circuit for inductive load switching

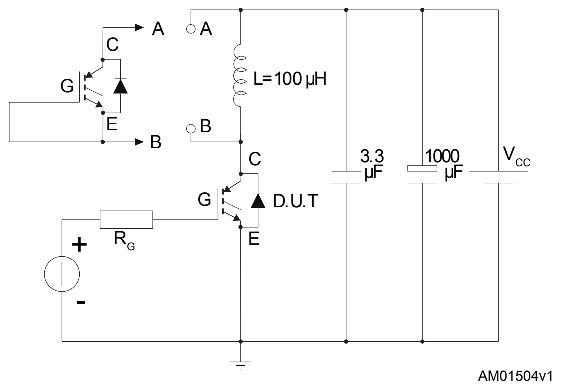



Figure 28. Gate charge test circuit

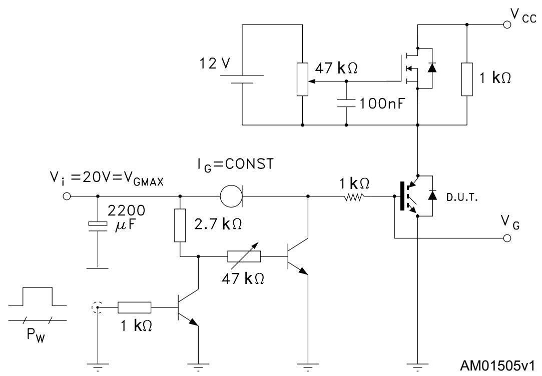



Figure 29. Switching waveform

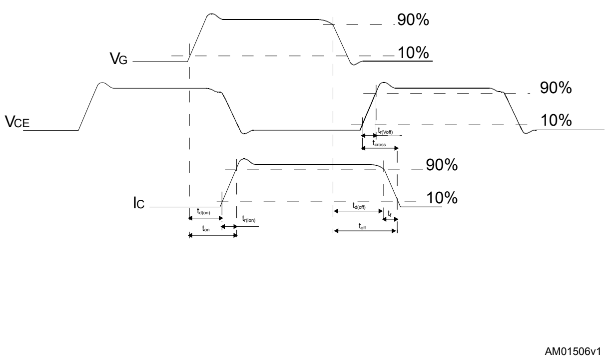
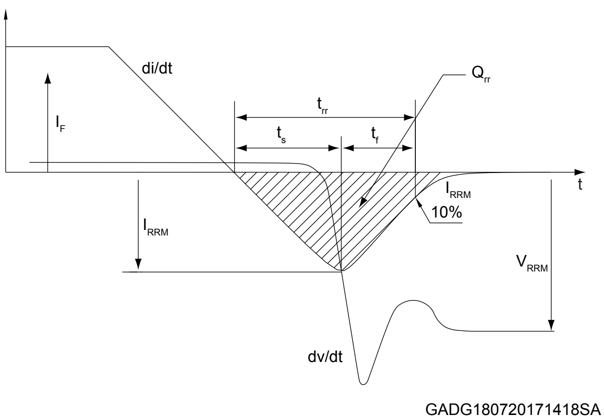



Figure 30. Diode reverse recovery waveform



# 4 Package information

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 C3 package information

**Figure 31.** DPAK (TO-252) type C3 package outline

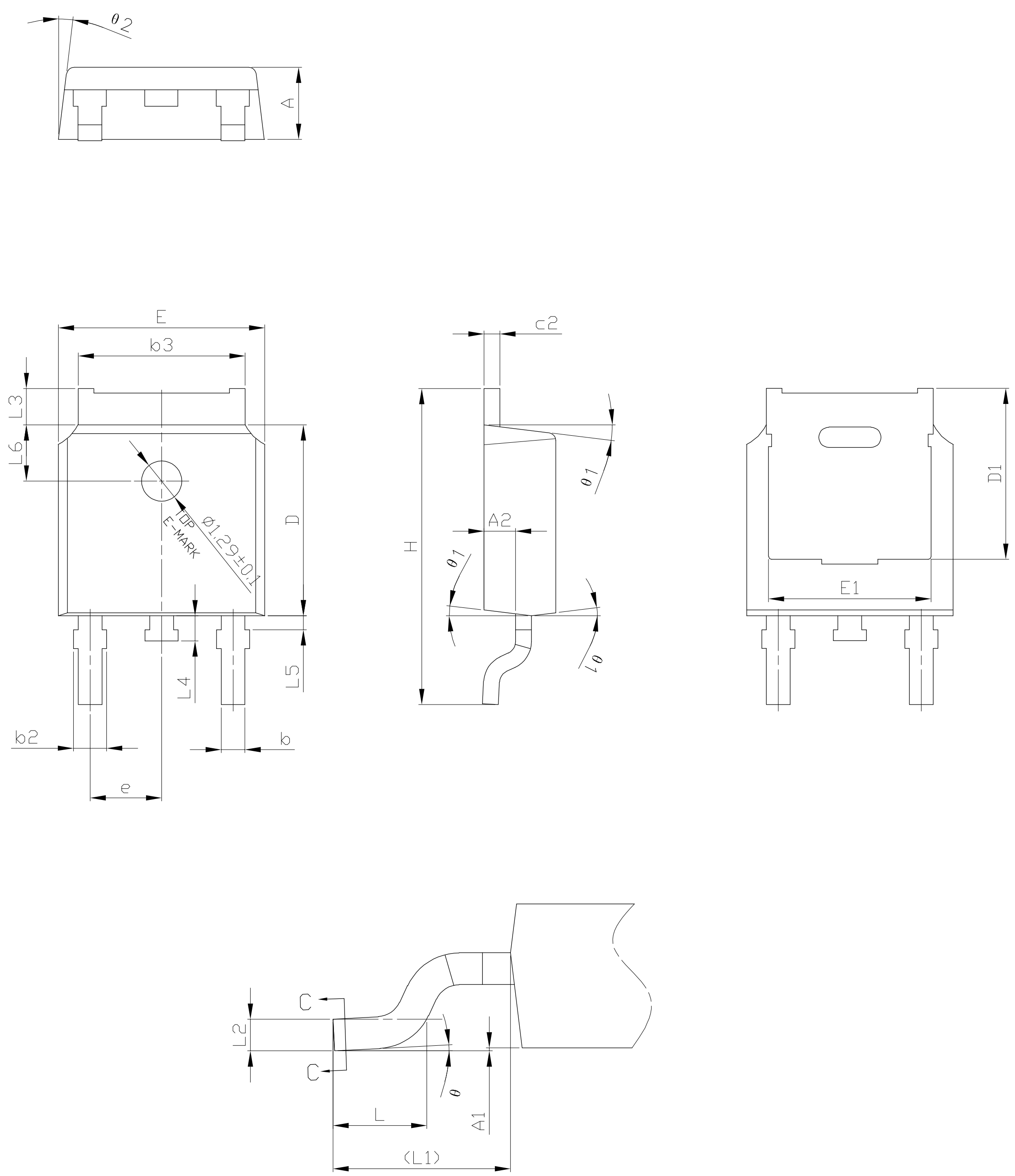



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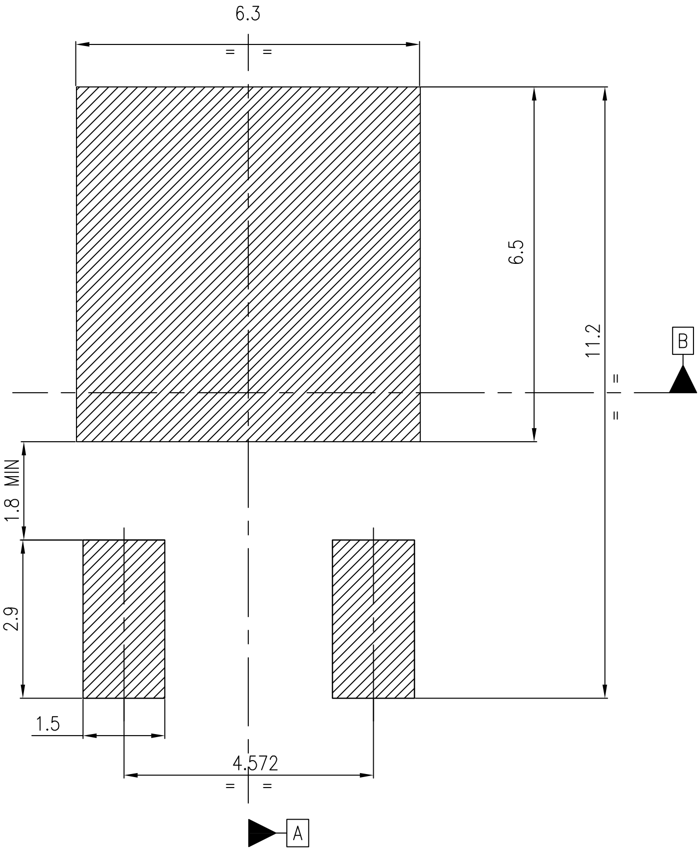
Table 7. **DPAK (TO-252) type C3 mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 2.20 | 2.30 | 2.38 |
| A1 | 0.00 | | 0.10 |
| A2 | 0.90 | 1.01 | 1.10 |
| b | 0.72 | | 0.85 |
| b2 | 0.72 | | 1.10 |
| b3 | 5.13 | 5.33 | 5.46 |
| c | 0.47 | | 0.60 |
| c2 | 0.47 | | 0.60 |
| D | 6.00 | 6.10 | 6.20 |
| D1 | 5.20 | 5.45 | 5.70 |
| E | 6.50 | 6.60 | 6.70 |
| E1 | 5.00 | 5.20 | 5.40 |
| 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 | | 0.51 BSC | |
| L3 | 0.90 | | 1.25 |
| L4 | 0.60 | 0.80 | 1.00 |
| L5 | 0.15 | | 0.75 |
| L6 | | 1.80 REF | |
| θ | 0° | | 8° |
| θ1 | 5° | 7° | 9° |
| θ2 | 5° | 7° | 9° |

**Figure 32. DPAK (TO-252) recommended footprint (dimensions are in mm)**




Notes:
1) This footprint is able to ensure insulation up to 630 Vrms (according to CEI IEC 664−1)
2) The device must be positioned within ⌖ 0.05 A B

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## 4.2 DPAK (TO-252) packing information

Figure 33. DPAK (TO-252) tape outline

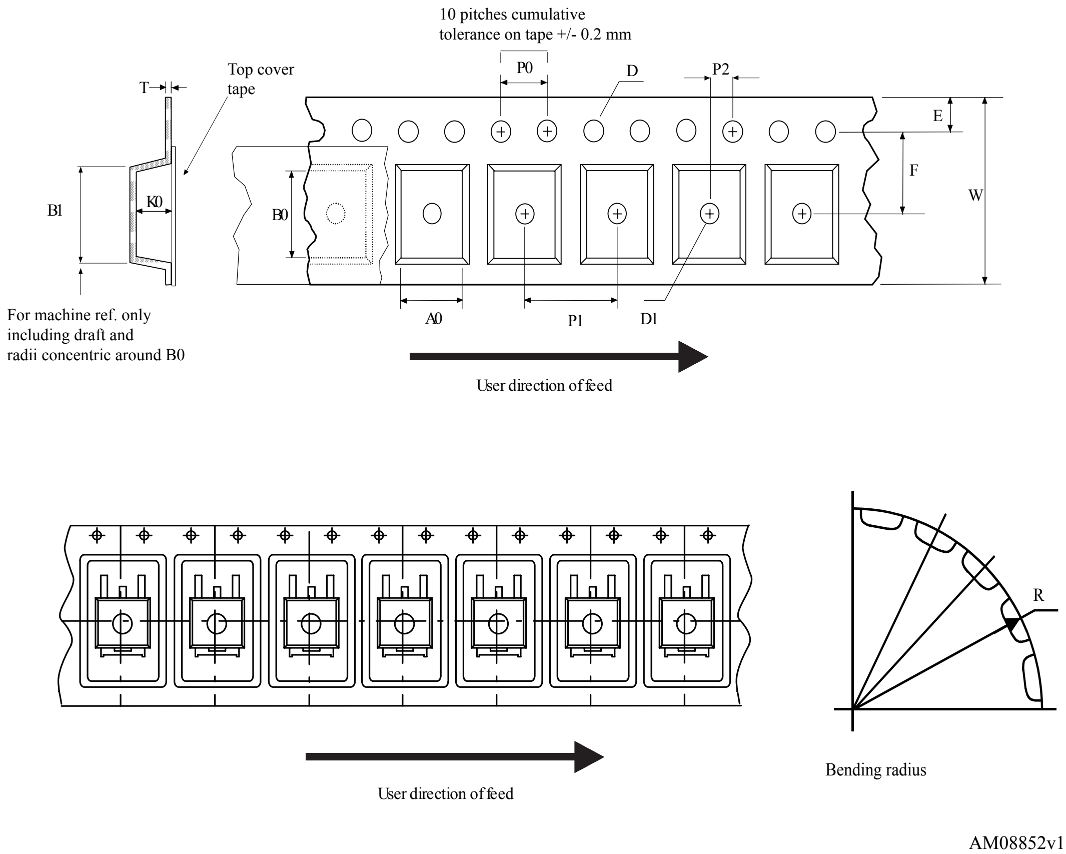

**Figure 34.** DPAK (TO-252) reel outline

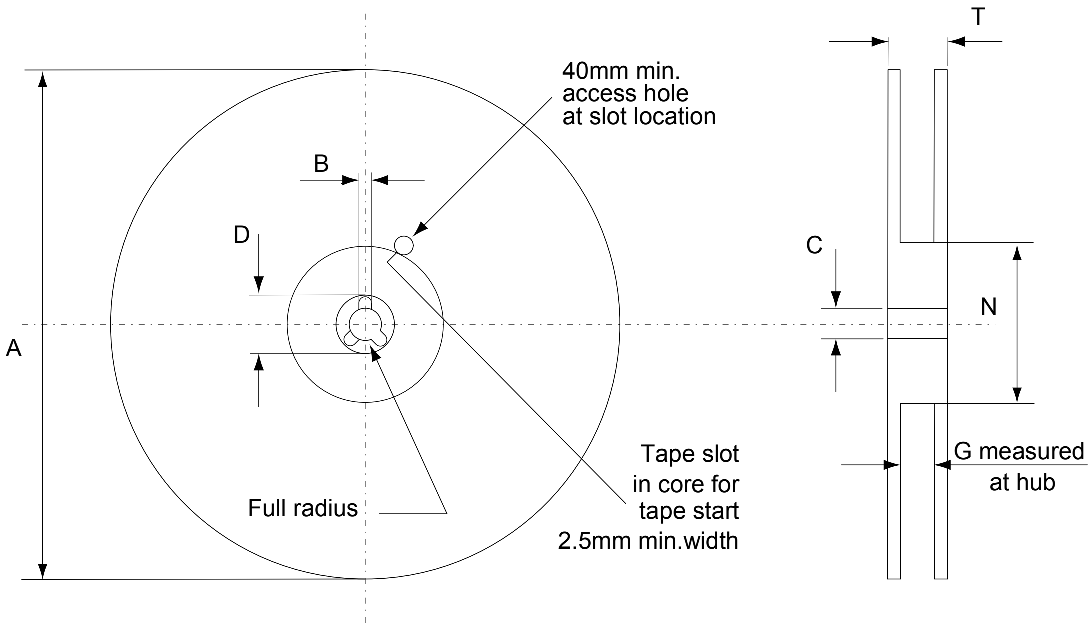


**Table 8.** DPAK (TO-252) tape and reel mechanical data

| 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 9. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 30-Nov-2015 | 1 | First release. |
| 13-Jan-2016 | 2 | Modified: *Table 4: "Static characteristics"*, *Table 5: "Dynamic characteristics"*, *Table 6: "IGBT switching characteristics (inductive load)"* and *Table 7: "Diode switching characteristics (inductive load)"*<br>Added: *Section 2.1: "Electrical characteristics (curves)"*<br>Minor text changes |
| 04-Aug-2016 | 3 | Updated: *Table 2: "Absolute maximum ratings"*, *Table 4: "Static characteristics"*, *Table 6: "IGBT switching characteristics (inductive load)"*,*Table 7: "Diode switching characteristics (inductive load)"*.<br>Updated *Figure 9: "Forward bias safe operating area"*, *Figure 12: "Normalized VGE(th) vs. junction temperature"*, *Figure 20: "Short-circuit time and current vs.* $V_{GE}$*"*,*Figure 23: "Reverse recovery current vs. diode current slope"*.<br>Changed:*Figure 25: "Reverse recovery charge vs. diode current slope"*, and *Figure 26: "Reverse recovery energy vs. diode current slope"*.<br>Document status promoted from preliminary to production data. |
| 09-Jun-2023 | 4 | Updated the entire Section 4 Package information.<br>Minor text changes. |
| 13-Jul-2023 | 5 | Minor text changes. |
| 14-May-2025 | 6 | Updated Table 3. Static characteristics.<br>Removed *Figure 10. Diode VF vs. forward current.*<br>Removed *DPAK (TO-252) type A2 package information.* |

## Contents

**1 Electrical ratings** . . . . . . . . . . . . **2**
**2 Electrical characteristics** . . . . . . . . . . . . **3**
2.1 Electrical characteristics (curves) . . . . . . . . . . . . 5
**3 Test circuits** . . . . . . . . . . . . **10**
**4 Package information** . . . . . . . . . . . . **11**
4.1 DPAK (TO-252) type C3 package information . . . . . . . . . . . . 11
4.2 DPAK (TO-252) packing information . . . . . . . . . . . . 14
**Revision history** . . . . . . . . . . . . **16**