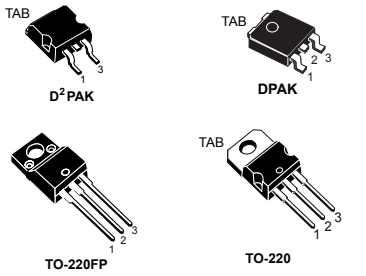
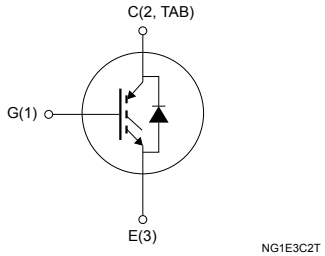
# STGB5H60DF, STGD5H60DF
# STGF5H60DF, STGP5H60DF

Datasheet

## Trench gate field-stop 600 V, 5 A high speed H series IGBT




## Features

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

## Applications

- Motor control
- UPS
- PFC

## Description

These devices are IGBTs developed using an advanced proprietary trench gate field-stop structure. These devices are part of the H series of IGBTs, which represents an optimum compromise between conduction and switching losses to maximize the efficiency of high switching frequency converters. Furthermore, a slightly positive $V_{CE(sat)}$ temperature coefficient and very tight parameter distribution result in safer paralleling operation.

| Product status link |
|---|
| STGB5H60DF |
| STGD5H60DF |
| STGF5H60DF |
| STGP5H60DF |

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | $D^2PAK$, TO-220 | DPAK | TO-220FP | |
| $V_{CES}$ | Collector-emitter voltage ($V_{GE}$ = 0) | 600 | | | V |
| $I_C$ | Continuous collector current at $T_C$ = 25 °C | 10 | | 10(1) | A |
| | Continuous collector current at $T_C$ = 100 °C | 5 | | 5(1) | |
| $I_{CP}$(2) | Pulsed collector current | 20 | | 20(1) | A |
| $V_{GE}$ | Gate-emitter voltage | ±20 | | | V |
| $I_F$ | Continuous forward current $T_C$ = 25 °C | 10 | | 10(1) | A |
| | Continuous forward current at $T_C$ = 100 °C | 5 | | 5(1) | |
| $I_{FP}$(2) | Pulsed forward current | 20 | | 20(1) | A |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; $T_c$ = 25 °C) | | | 2500 | V |
| $P_{TOT}$ | Total power dissipation at $T_C$ = 25 °C | 88 | 83 | 24 | W |
| $T_{STG}$ | Storage temperature range | -55 to 150 | | | °C |
| $T_J$ | Operating junction temperature range | -55 to 175 | | | |

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

**Table 2. Thermal data**

| Symbol | Parameter | Value | | | Unit |
|---|---|---|---|---|---|
| | | $D^2PAK$, TO-220 | DPAK | TO-220FP | |
| $R_{thJC}$ | Thermal resistance junction-case IGBT | 1.7 | 1.8 | 6.2 | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 4 | 4.5 | 7 | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 62.5 | 100 | 62.5 | °C/W |

# 2 Electrical characteristics

$T_C$ = 25 °C unless otherwise specified.

**Table 3. Static**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage | $V_{GE}$ = 0 V, $I_C$ = 2 mA | 600 | | | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE}$ = 15 V, $I_C$= 5 A | | 1.5 | 1.95 | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 5 A, $T_J$ = 125 °C | | 1.6 | | |
| | | $V_{GE}$ = 15 V, $I_C$ = 5 A, $T_J$ = 175 °C | | 1.7 | | |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 250 µA | 4.8 | 6.2 | 6.9 | V |
| $I_{CES}$ | Collector cut-off current | $V_{CE}$ = 600 V , $V_{GE}$ = 0 V | | | 25 | µA |
| $I_{GES}$ | Gate-emitter leakage current | $V_{GE}$ = ±20 V , $V_{CE}$ = 0 V | | | ±250 | nA |

**Table 4. Dynamic**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{ies}$ | Input capacitance | $V_{CE}$ = 25 V, f = 1 MHz, $V_{GE}$ = 0 V | - | 855 | - | pF |
| $C_{oes}$ | Output capacitance | | | 34 | | |
| $C_{res}$ | Reverse transfer capacitance | | | 19 | | |
| $Q_g$ | Total gate charge | $V_{CC}$ = 480 V, $I_C$ = 5 A, $V_{GE}$ = 0 to 15 V (see Figure 35. Gate charge test circuit) | - | 38 | - | nC |
| $Q_{ge}$ | Gate-emitter charge | | | 6.5 | | |
| $Q_{gc}$ | Gate-collector charge | | | 17.5 | | |

**Table 5. Switching characteristics (inductive load)**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 5 A, | | 30 | | ns |
| $t_r$ | Current rise time | $R_G$ = 47 Ω, $V_{GE}$ = 15 V | | 10.8 | | |
| (di/dt)on | Turn-on current slope | (see Figure 34. Test circuit for inductive load switching and Figure 36. Switching waveform) | | 370 | | A/µs |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 5 A, | - | 28 | - | ns |
| $t_r$ | Current rise time | $R_G$ = 47 Ω, $V_{GE}$ = 15 V, $T_J$ = 175 °C | | 11 | | |
| (di/dt)on | Turn-on current slope | (see Figure 34. Test circuit for inductive load switching and Figure 36. Switching waveform) | | 363 | | A/µs |
| $t_{r(Voff)}$ | Off voltage rise time | $V_{CE}$ = 400 V, $I_C$ = 5 A, | | 29 | | ns |
| $t_{d(off)}$ | Turn-off delay time | $R_G$ = 47 Ω, $V_{GE}$ = 15 V | | 140 | | |
| $t_f$ | Current fall time | | | 95 | | |
| $t_{r(Voff)}$ | Off voltage rise time | $V_{CE}$ = 400 V, $I_C$ = 5 A, | | 44 | | |
| $t_{d(off)}$ | Turn-off delay time | $R_G$ = 47 Ω, $V_{GE}$ = 15 V, $T_J$ = 175 °C | | 146 | | |
| $t_f$ | Current fall time | | | 134 | | |
| $t_{sc}$ | Short-circuit withstand time | $V_{CC}$ ≤ 360 V, $V_{GE}$ = 15 V, $R_G$ = 47 Ω | - | 5 | - | µs |

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

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $E_{on}$ (1) | Turn-on switching energy | $V_{CE}$ = 400 V, $I_C$ = 5 A, | | 56 | | µJ |
| $E_{off}$ (2) | Turn-off switching energy | $R_G$ = 47 Ω, $V_{GE}$ = 15 V | | 78.5 | | |
| $E_{ts}$ | Total switching energy | | | 134.5 | | |
| $E_{on}$ (1) | Turn-on switching energy | $V_{CE}$ = 400 V, $I_C$ = 5 A, | - | 87 | - | |
| $E_{off}$ (2) | Turn-off switching energy | $R_G$ = 47 Ω, $V_{GE}$ = 15 V, $T_J$ = 175 °C | | 134 | | |
| $E_{ts}$ | Total switching energy | | | 221 | | |

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

**Table 7. Collector-emitter diode**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Forward on-voltage | $I_F$ = 5 A | - | 2.1 | - | V |
| | | $I_F$ = 5 A, $T_J$ = 175 °C | | 1.65 | | |
| $t_{rr}$ | Reverse recovery time | $V_{CC}$ = 400 V; $I_F$ = 5 A; | | 134.5 | | ns |
| $Q_{rr}$ | Reverse recovery charge | $di_F/dt$ = 100 A / µs | | 48 | | nC |
| $I_{rrm}$ | Reverse recovery current | | | 1.38 | | A |
| $t_{rr}$ | Reverse recovery time | $V_{CC}$ = 400 V; $I_F$ = 5 A; | | 157 | | ns |
| $Q_{rr}$ | Reverse recovery charge | $di_F/dt$ = 100 A / µs, $T_J$ = 175 °C | | 165 | | nC |
| $I_{rrm}$ | Reverse recovery current | | | 2.4 | | A |

## 2.1 Electrical characteristics (curves)

**Figure 1. Power dissipation vs case temperature for D²PAK and TO-220**

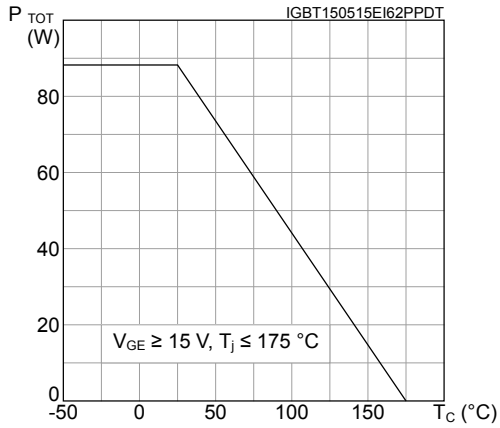



**Figure 2. Collector current vs case temperature for D²PAK, DPAK and TO-220**

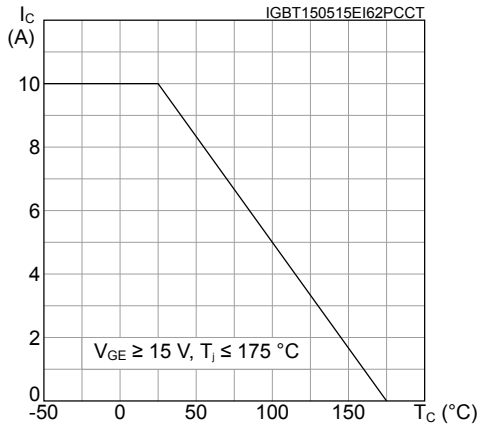



**Figure 3. Power dissipation vs case temperature for DPAK**

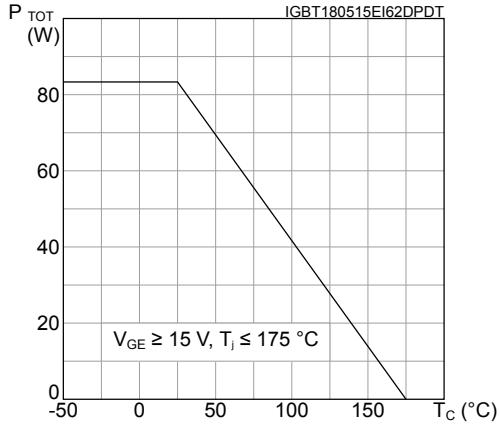



**Figure 4. Collector current vs case temperature for DPAK**

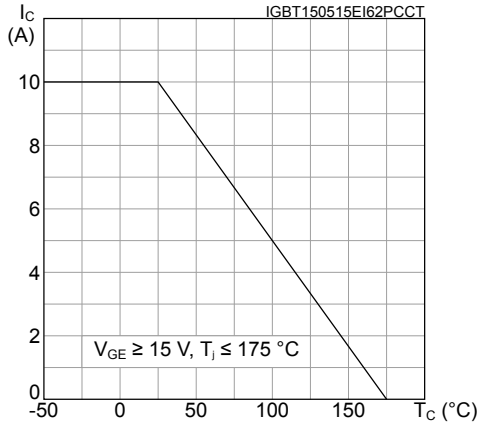



**Figure 5. Power dissipation vs case temperature for TO-220FP**

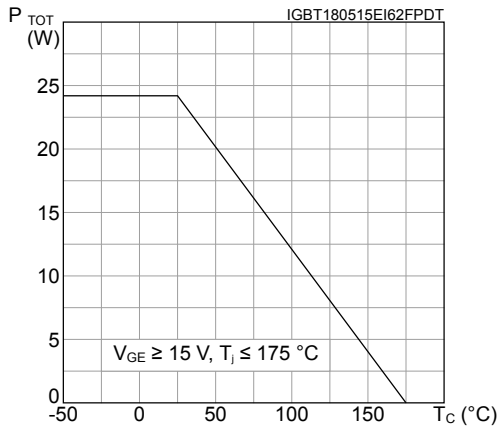



**Figure 6. Collector current vs case temperature for TO-220FP**

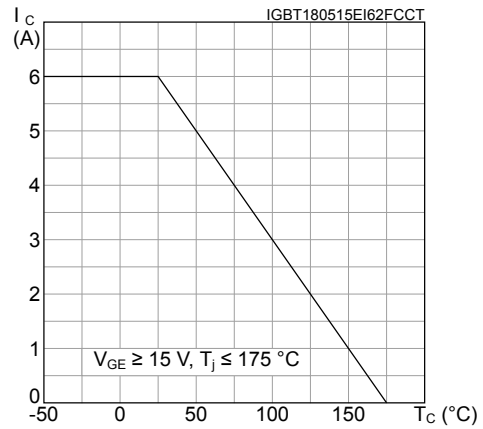


**Figure 7. Output characteristics ($T_J$ = 25°C)**

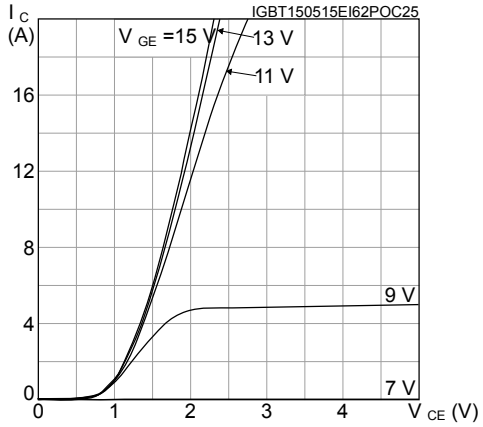



**Figure 8. Output characteristics ($T_J$ = 175°C)**

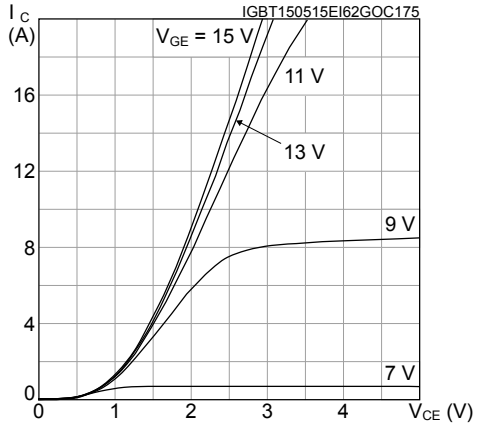



**Figure 9. $V_{CE(sat)}$ vs junction temperature**

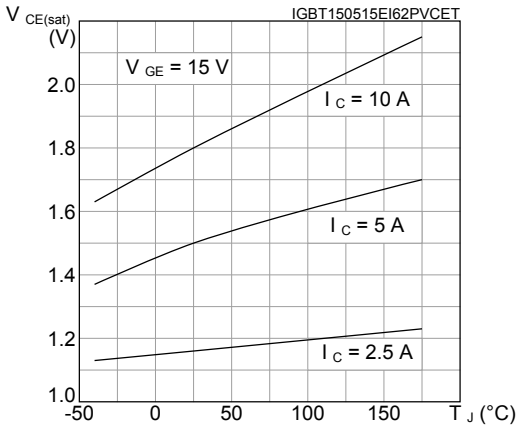



**Figure 10. $V_{CE(sat)}$ vs collector current**

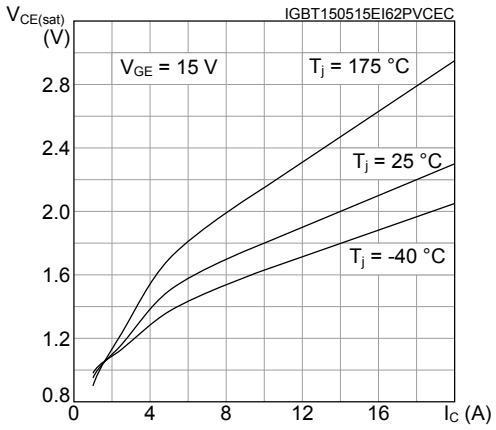



**Figure 11. Collector current vs switching frequency for D²PAK, DPAK and TO-220**

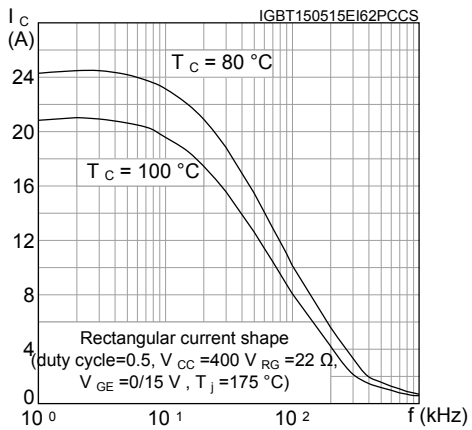



**Figure 12. Collector current vs switching frequency for TO-220FP**

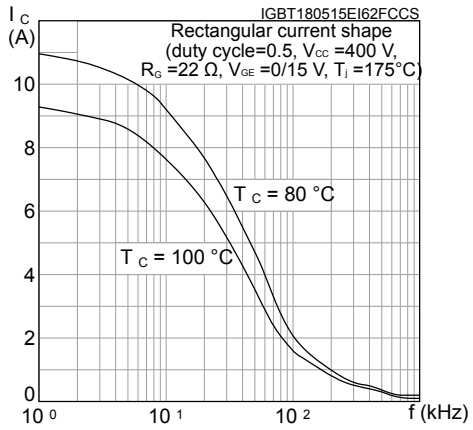


**Figure 13. Forward bias safe operating area for D²PAK, DPAK and TO-220**

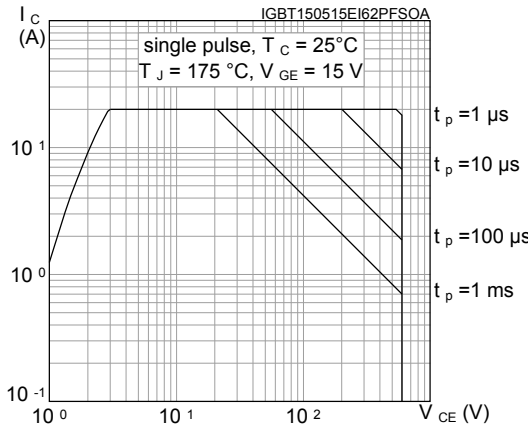



**Figure 14. Forward bias safe operating area for TO-220FP**

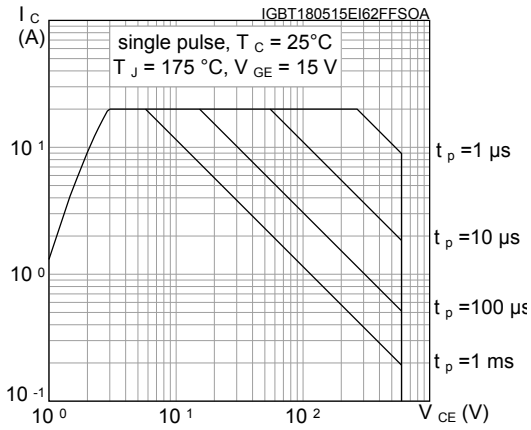



**Figure 15. Transfer characteristics**

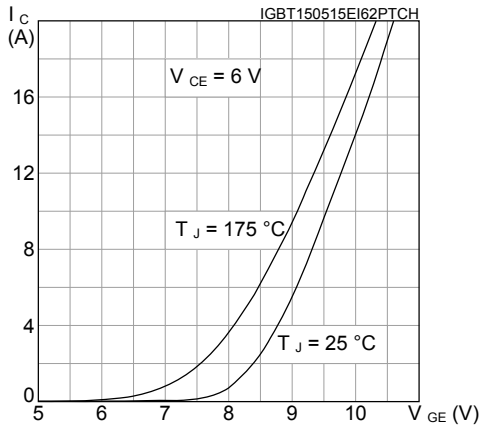



**Figure 16. Diode $V_F$ vs forward current**

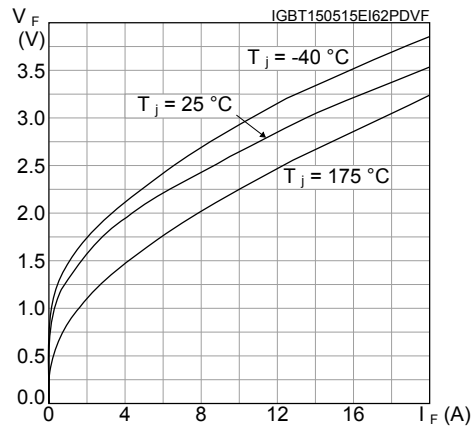



**Figure 17. Normalized $V_{GE(th)}$ vs junction temperature**

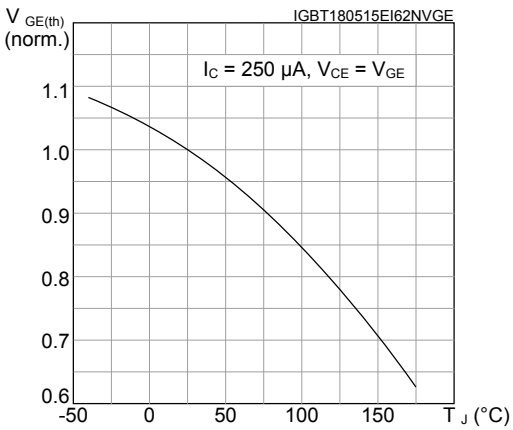



**Figure 18. Normalized $V_{(BR)CES}$ vs junction temperature**

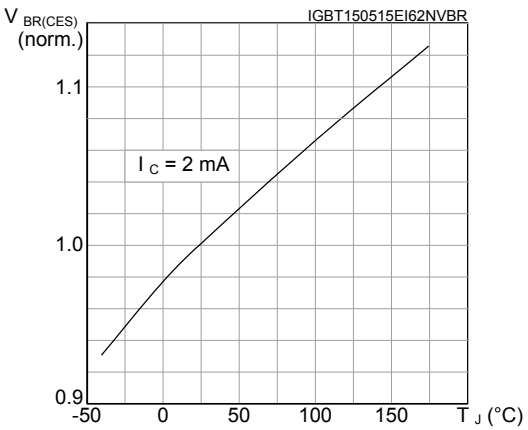


**Figure 19. Capacitance variation**

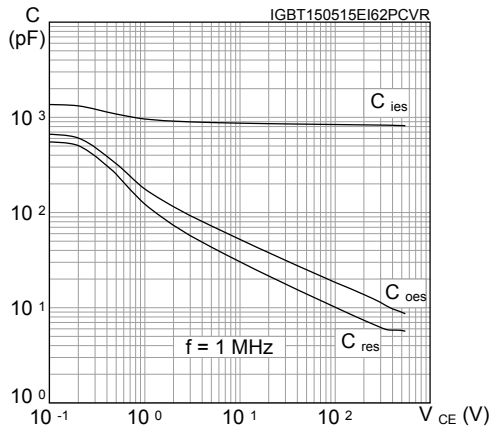



**Figure 20. Gate charge vs. gate-emitter voltage**

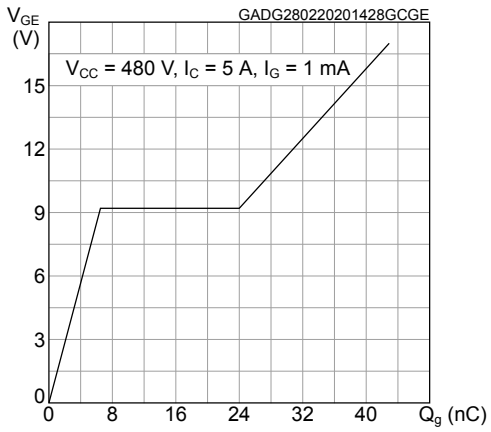



**Figure 21. Switching energy vs collector current**

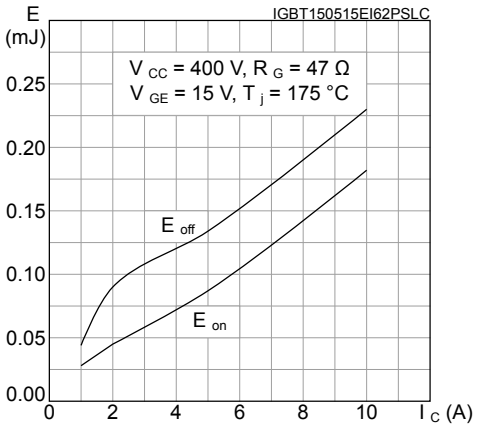



**Figure 22. Switching energy vs gate resistance**

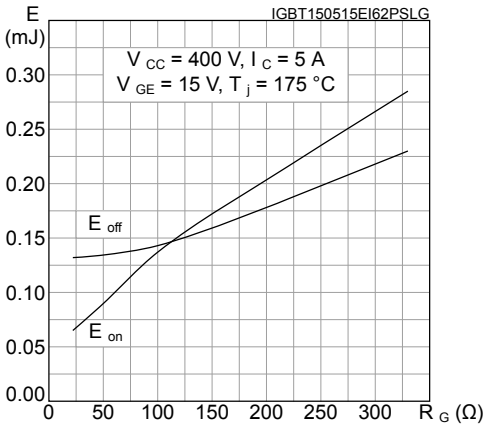



**Figure 23. Switching energy vs temperature**

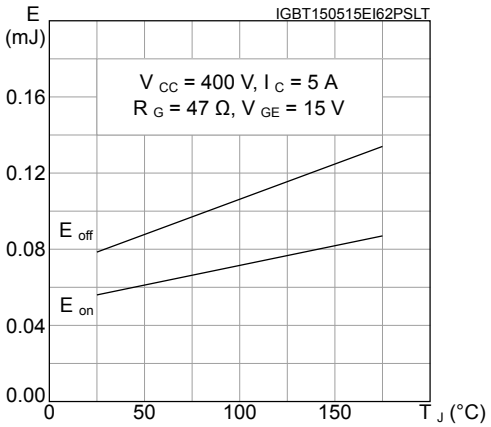



**Figure 24. Switching energy vs collector-emitter voltage**

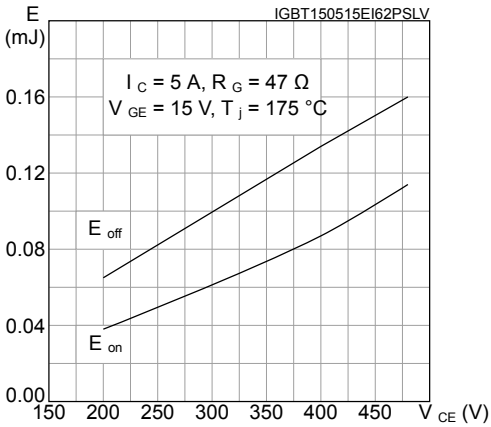


**Figure 25. Short circuit time and current vs $V_{GE}$**

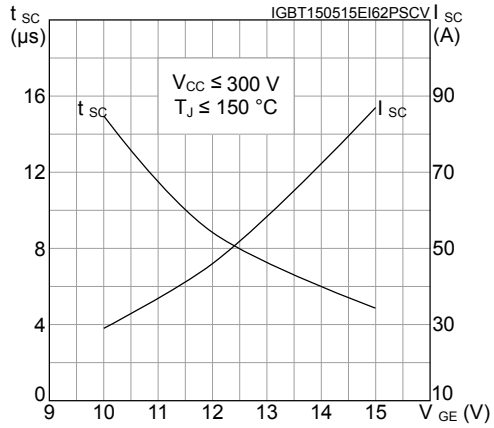



**Figure 26. Switching times vs collector current**

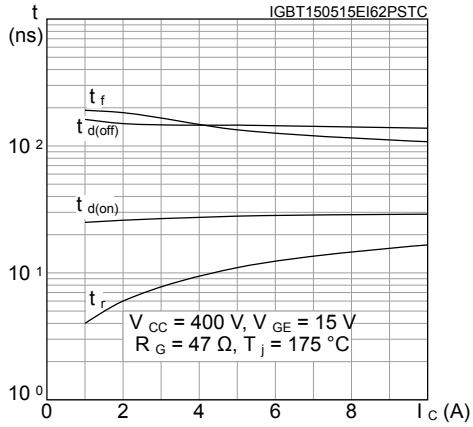



**Figure 27. Switching times vs gate resistance**

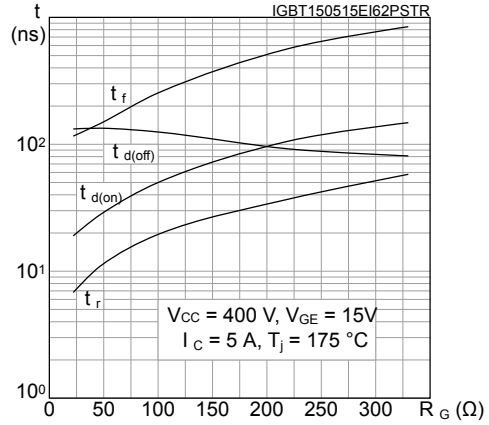



**Figure 28. Reverse recovery current vs diode current slope**

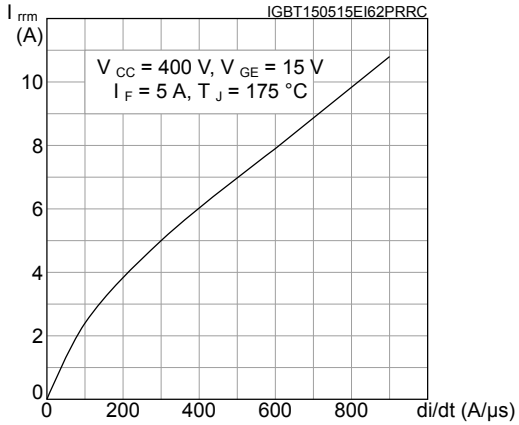



**Figure 29. Reverse recovery time vs diode current slope**

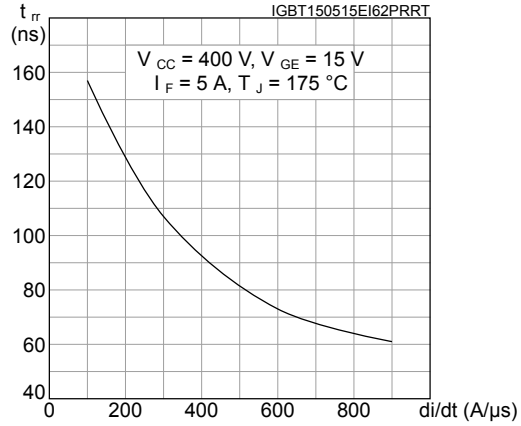



**Figure 30. Reverse recovery charge vs diode current slope**

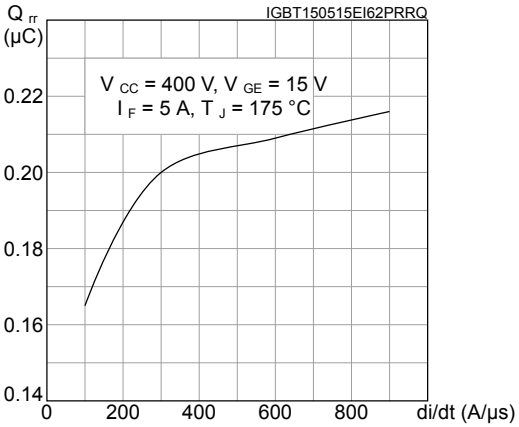


**Figure 31. Reverse recovery energy vs diode current slope**

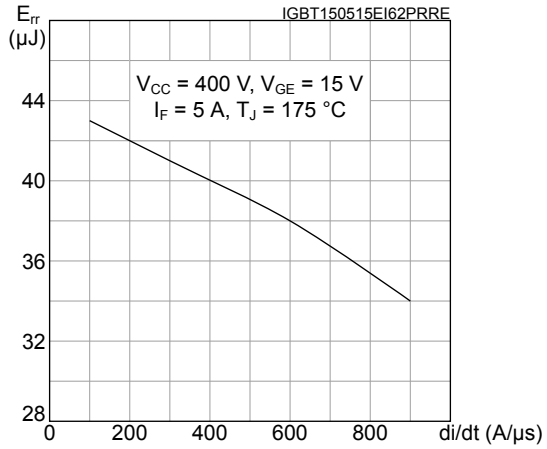



**Figure 32. Thermal impedance for D²PAK, DPAK and TO-220 IGBT**

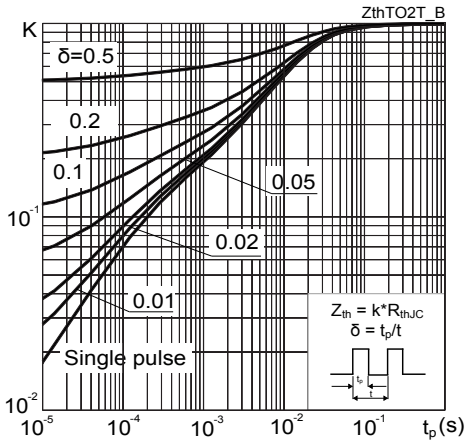
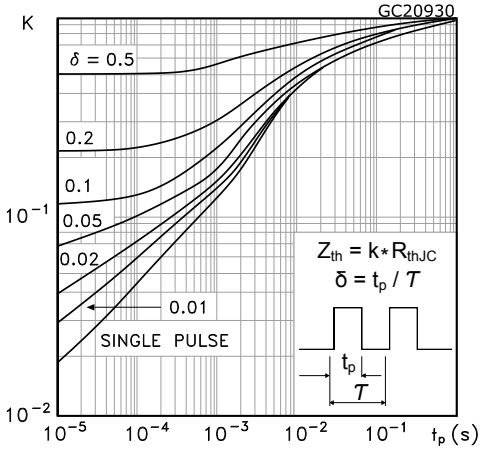



**Figure 33. Thermal impedance for D²PAK, DPAK and TO-220 diode**



# 3 Test circuits

**Figure 34. Test circuit for inductive load switching**

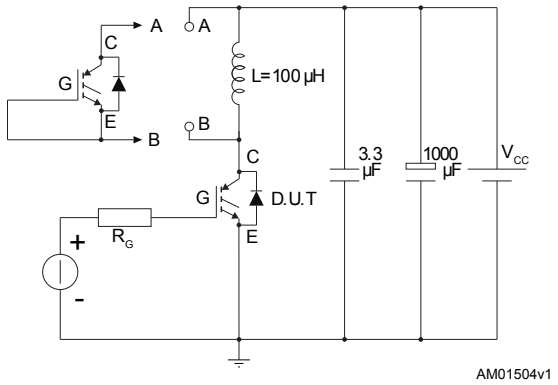



**Figure 35. Gate charge test circuit**

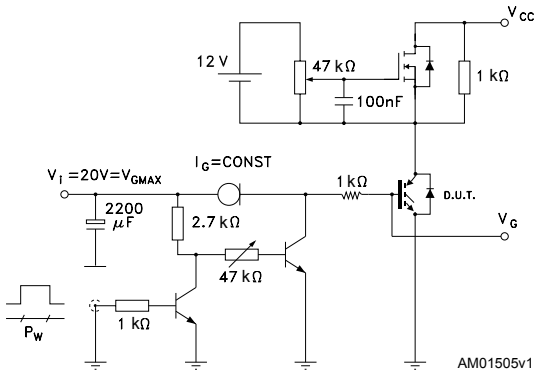



**Figure 36. Switching waveform**

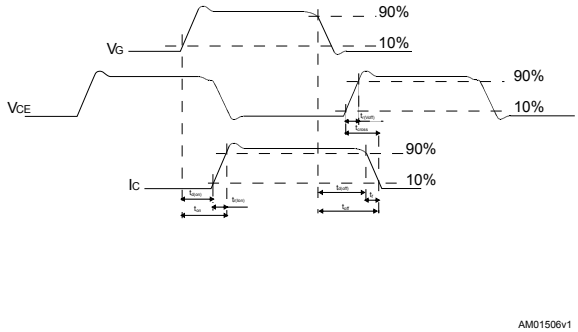
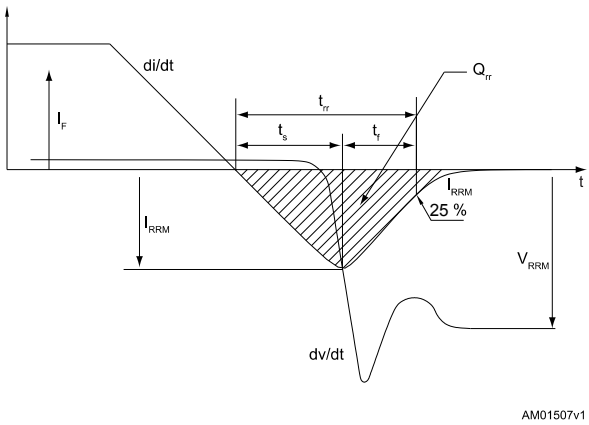



**Figure 37. Diode reverse recovery waveform**



# 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 D²PAK (TO-263) type A package information

Figure 38. **D²PAK (TO-263) type A package outline**

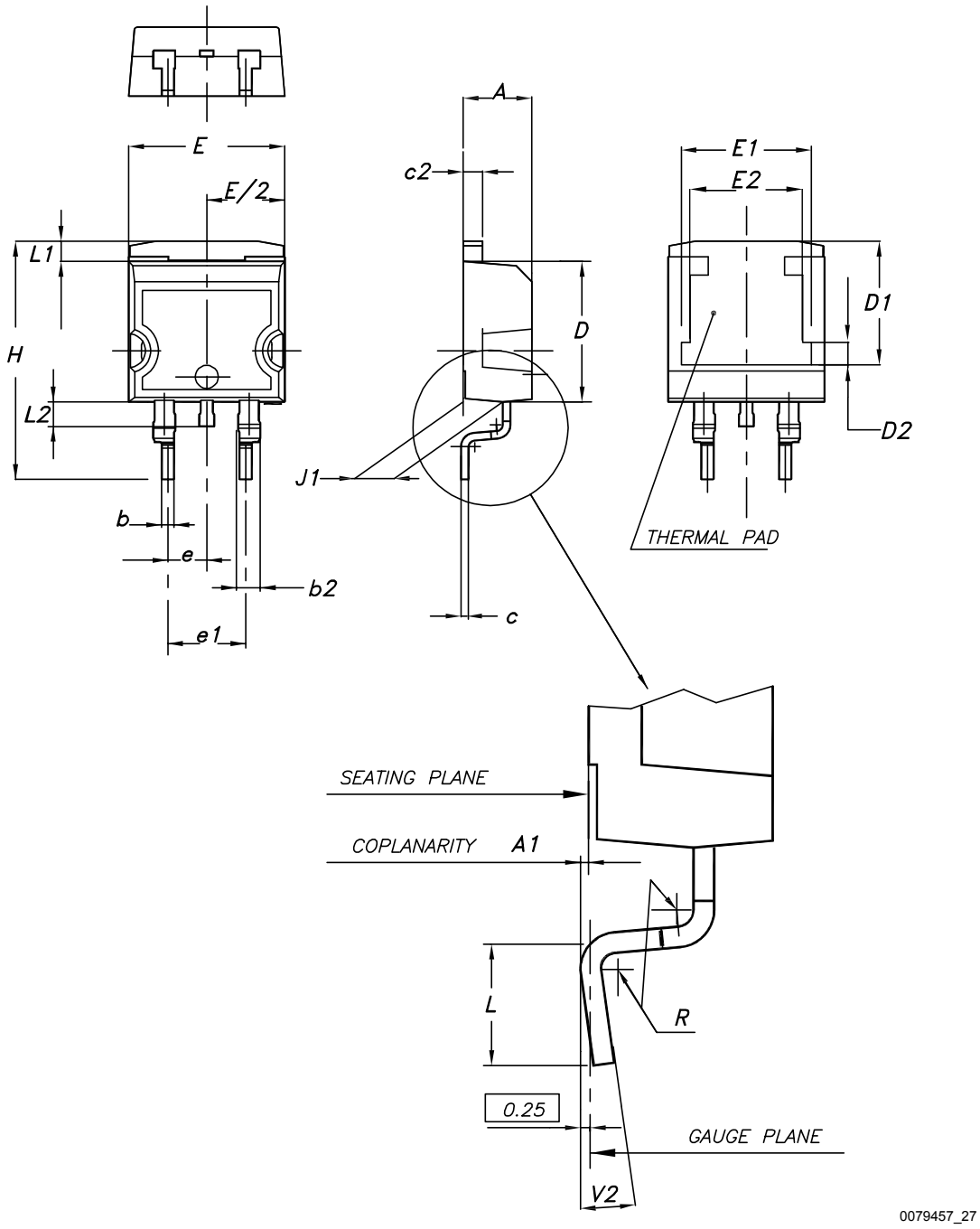
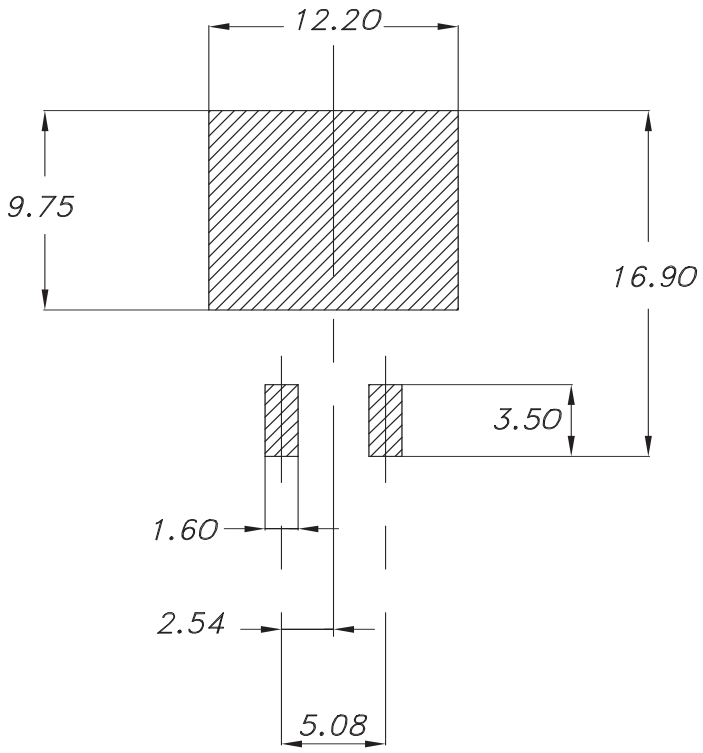


Table 8. D²PAK (TO-263) type A package mechanical data

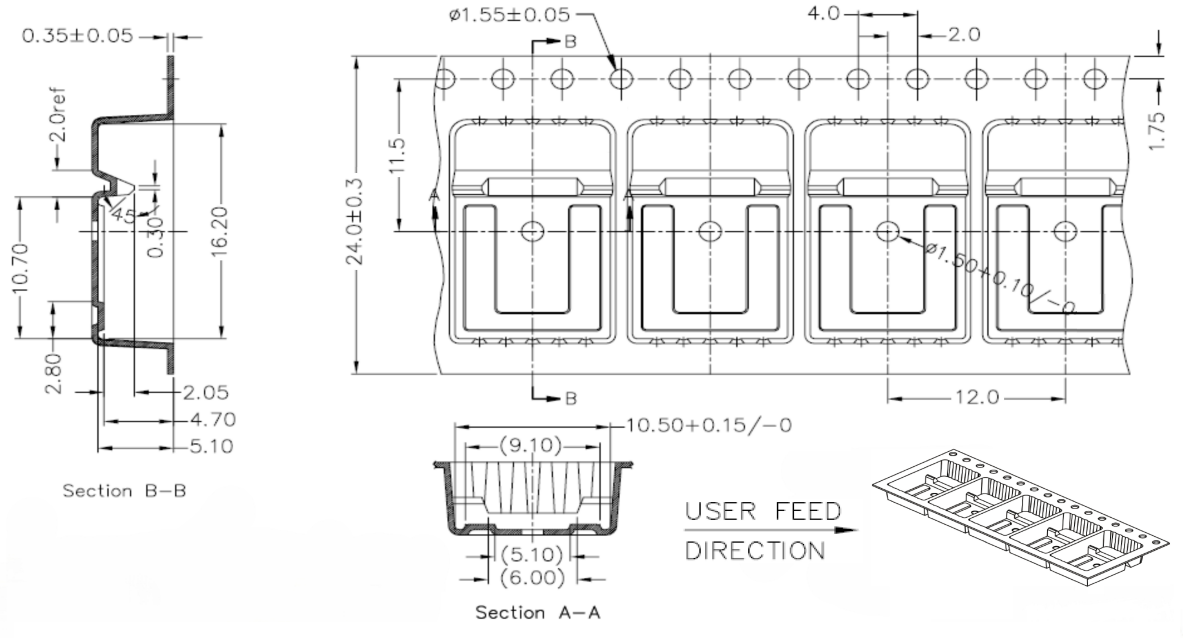
| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | 7.75 | 8.00 |
| D2 | 1.10 | 1.30 | 1.50 |
| E | 10.00 | | 10.40 |
| E1 | 8.30 | 8.50 | 8.70 |
| E2 | 6.85 | 7.05 | 7.25 |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15.00 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.40 | |
| V2 | 0° | | 8° |

Figure 39. D²PAK (TO-263) recommended footprint (dimensions are in mm)




## 4.2 D²PAK packing information

Figure 40. D²PAK tape drawing (dimensions are in mm)



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

Figure 41. **DPAK (TO-252) type A2 package outline**

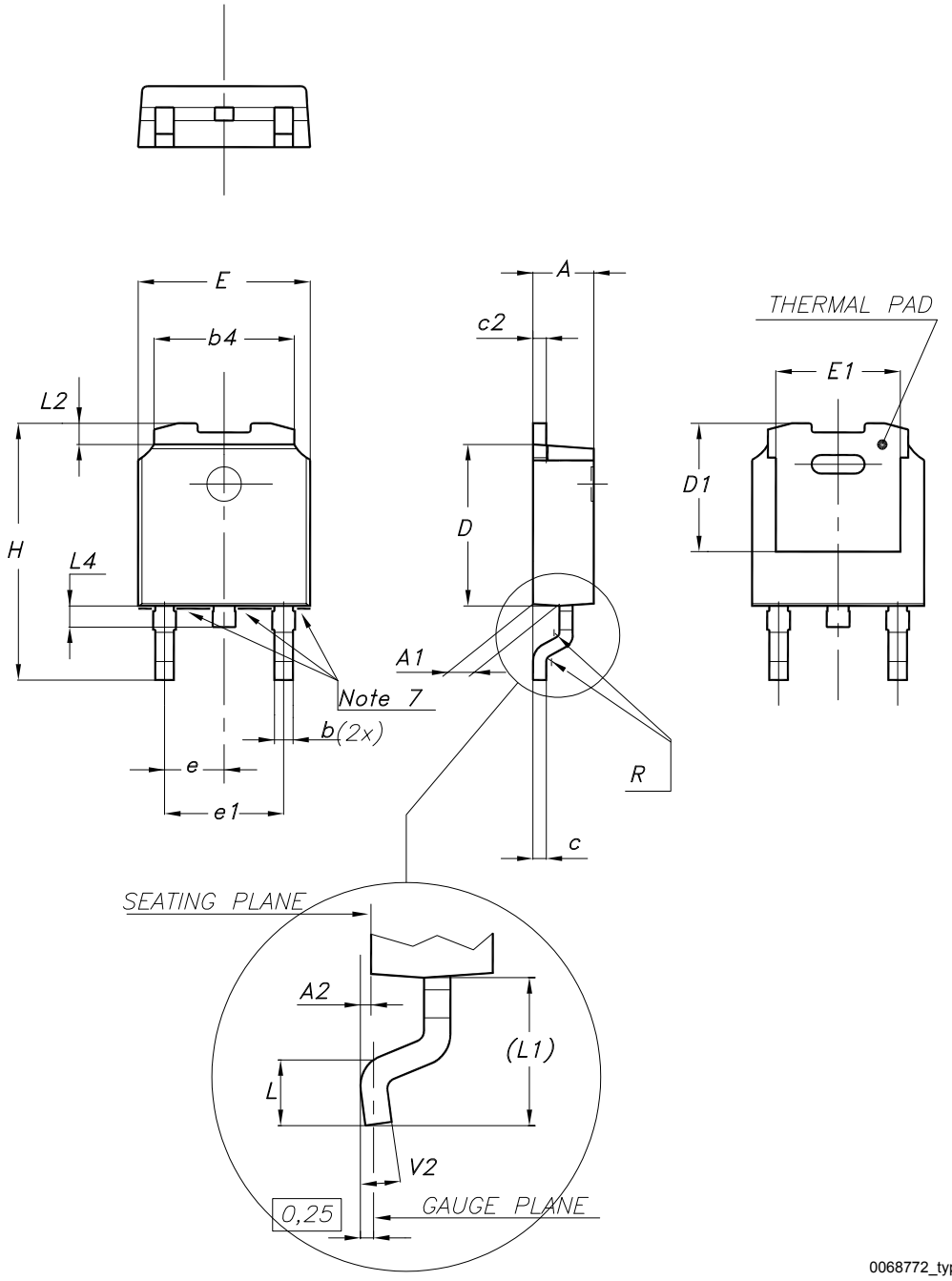
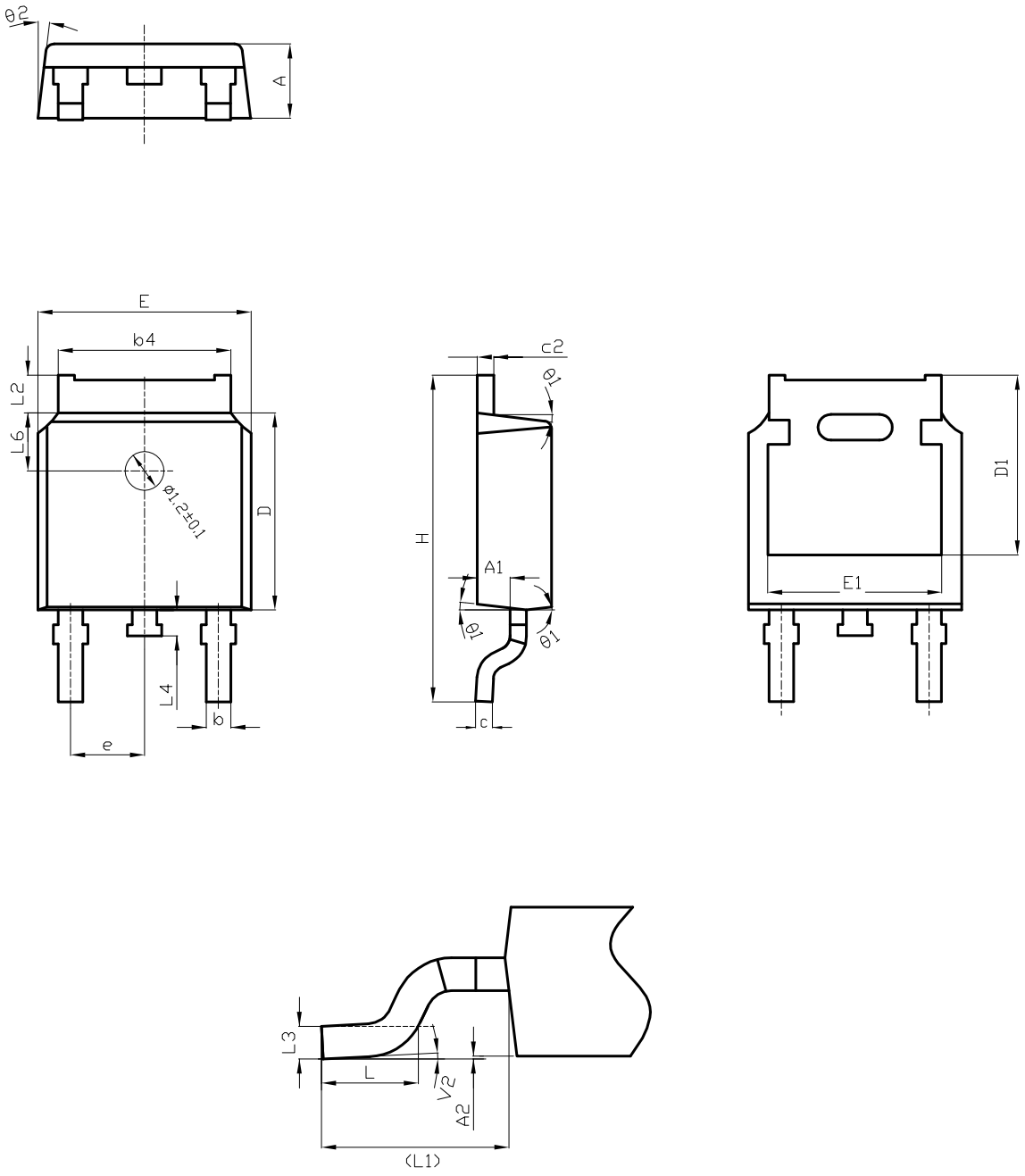


Table 9. **DPAK (TO-252) type A2 mechanical data**

| 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° |

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

Figure 42. **DPAK (TO-252) type C2 package outline**




0068772_type-C2_rev34

Table 10. **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° |

## 4.5 DPAK (TO-252) packing information

Figure 43. **DPAK (TO-252) tape outline**

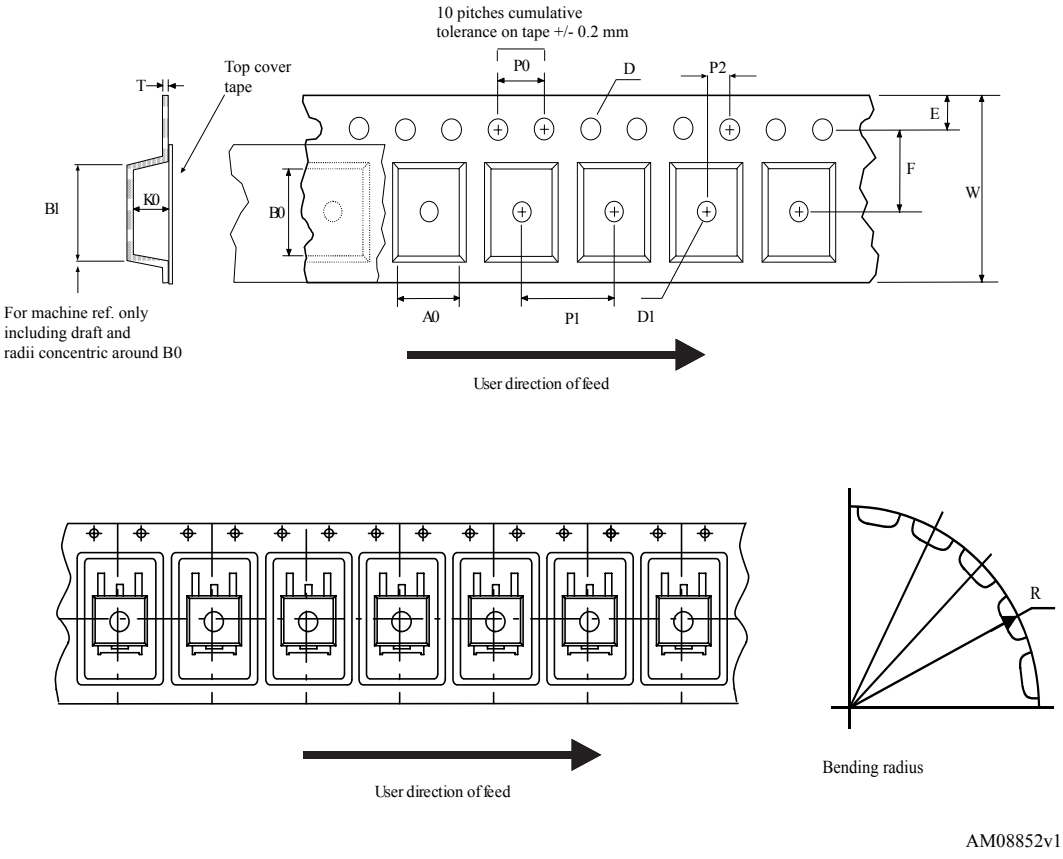
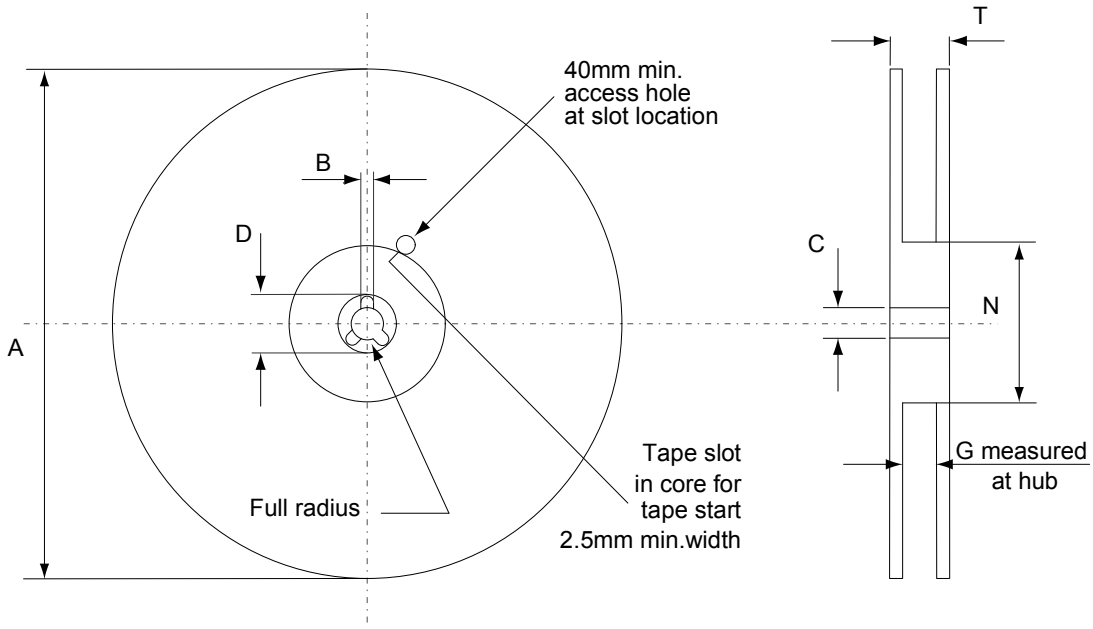


Figure 44. **DPAK (TO-252) reel outline**




AM06038v1

Table 11. **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 | | | |

## 4.6 TO-220FP type B package information

Figure 45. **TO-220FP type B package outline**

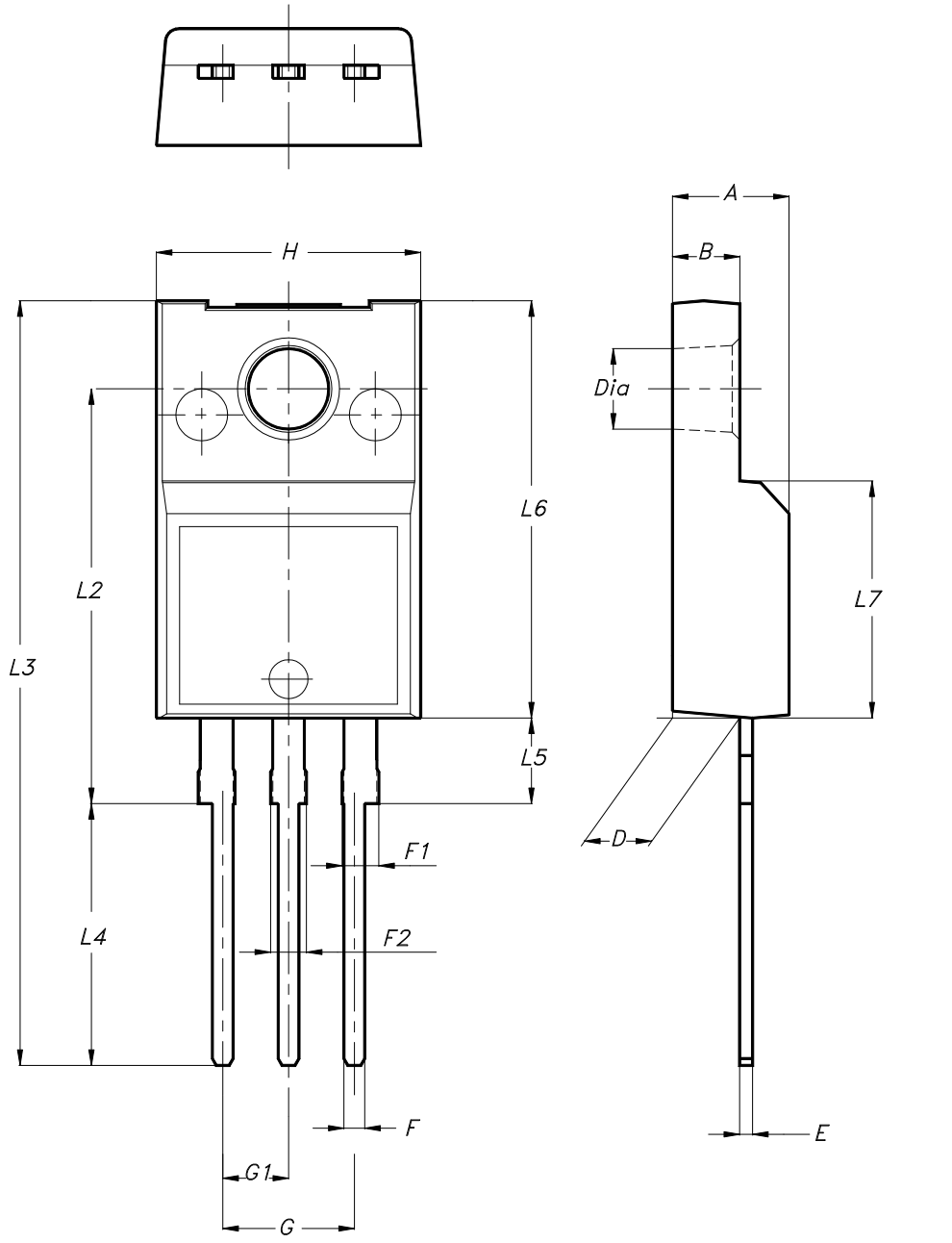


Table 12. **TO-220FP type B package mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| B | 2.50 | | 2.70 |
| D | 2.50 | | 2.75 |
| E | 0.45 | | 0.70 |
| F | 0.75 | | 1.00 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.20 |
| G1 | 2.40 | | 2.70 |
| H | 10.00 | | 10.40 |
| L2 | | 16.00 | |
| L3 | 28.60 | | 30.60 |
| L4 | 9.80 | | 10.60 |
| L5 | 2.90 | | 3.60 |
| L6 | 15.90 | | 16.40 |
| L7 | 9.00 | | 9.30 |
| Dia | 3.00 | | 3.20 |

## 4.7 TO-220 type A package information

Figure 46. **TO-220 type A package outline**

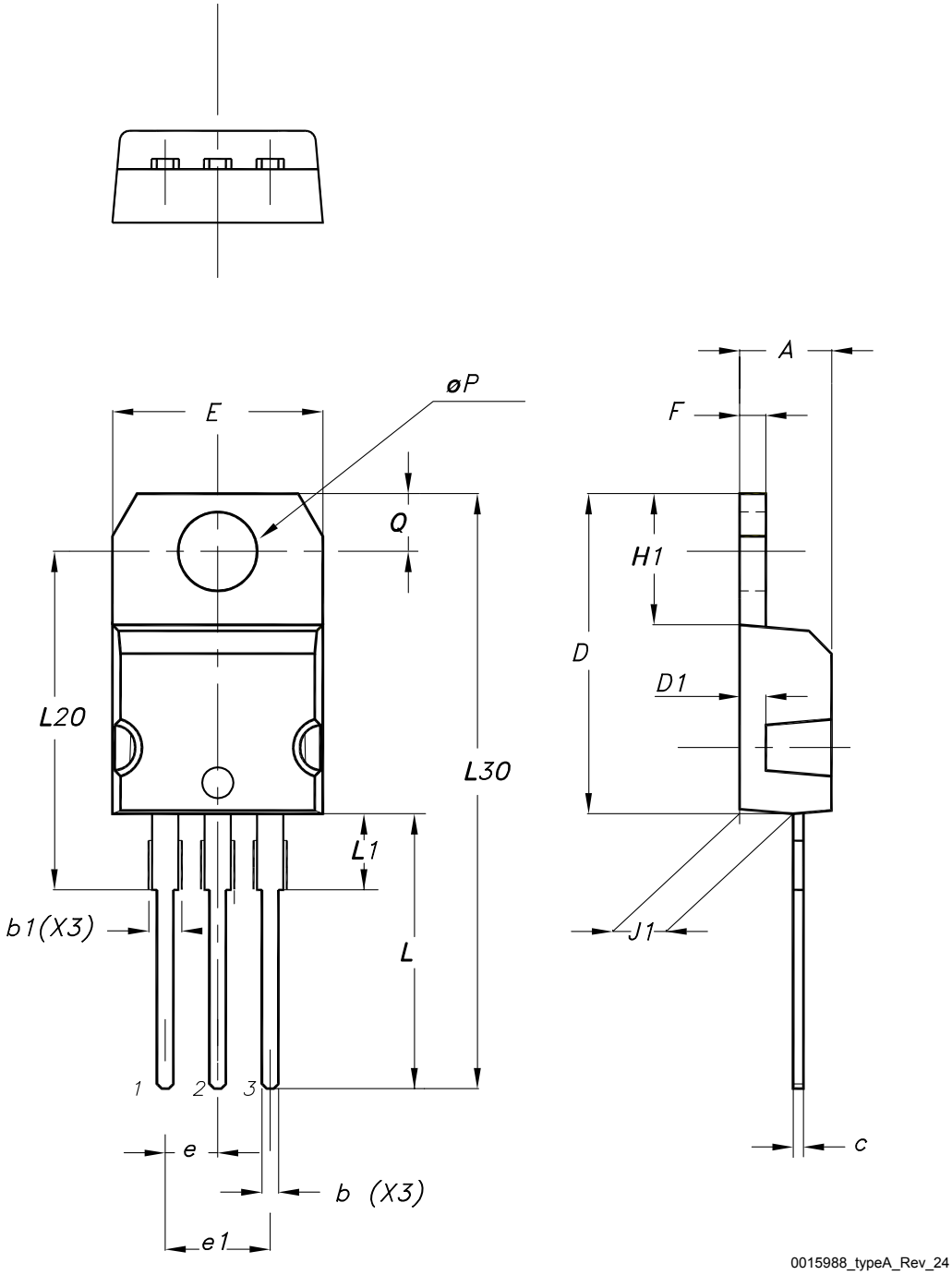


Table 13. **TO-220 type A package mechanical data**

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.55 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10.00 | | 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 | 13.00 | | 14.00 |
| L1 | 3.50 | | 3.93 |
| L20 | | 16.40 | |
| L30 | | 28.90 | |
| øP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |
| Slug flatness | | 0.03 | 0.10 |

# 5 Ordering information

Table 14. **Order codes**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STGB5H60DF | GB5H60DF | $D^2PAK$ | Tape and reel |
| STGD5H60DF | GD5H60DF | DPAK | |
| STGF5H60DF | GF5H60DF | TO-220FP | Tube |
| STGP5H60DF | GP5H60DF | TO-220 | |

## Revision history

Table 15. **Document revision history**

| Date | Version | Changes |
|---|---|---|
| 28-Nov-2014 | 1 | Initial release. |
| 23-Feb-2015 | 2 | Updated *Section 2: Electrical characteristics* and *Section 4: Package information*.<br>Minor text changes. |
| 18-May-2015 | 3 | Text and formatting changes throughout document<br>In *Section 1: Electrical ratings:*<br>- updated *Table 2* and *Table 3*<br>In *Section 2: Electrical characteristics:*<br>- updated *Table 4, Table 5, Table 6, Table 7* and *Table 8*<br>Added *Section 2.1: Electrical characteristics (curves)*<br>Updated *Section 4.2: DPAK package information*<br>Document status promoted from “preliminary data” to “production data” |
| 18-Sep-2018 | 4 | Removed maturity status indication from cover page.<br>Updated *Section 4 Package information*.<br>Minor text changes. |
| 02-Mar-2020 | 5 | Updated *Table 4. Dynamic*.<br>Updated *Figure 20. Gate charge vs. gate-emitter voltage*.<br>Minor text changes. |
| 14-May-2025 | 6 | Updated Section 4: Package information. |

# Contents