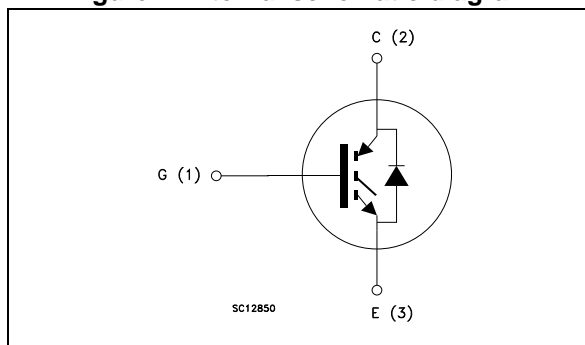


Figure 1. Internal schematic diagram



### Features

- Maximum junction temperature:  $T_J = 175\text{ °C}$
- Very high speed switching series
- Tail-less switching off
- Low saturation voltage:  $V_{CE(sat)} = 1.8\text{ V (typ.)}$  @  $I_C = 20\text{ A}$
- Tight parameters distribution
- Safe paralleling
- Low thermal resistance
- Very fast soft recovery antiparallel diode
- Lead free package

### Applications

- Photovoltaic inverters
- Uninterruptible power supply
- Welding
- Power factor correction
- Very high frequency converters

### Description

This device is an IGBT developed using an advanced proprietary trench gate and field stop structure. The device is part of the "V" series of IGBTs, which represent an optimum compromise between conduction and switching losses to maximize the efficiency of very high frequency converters. Furthermore, a positive  $V_{CE(sat)}$  temperature coefficient and very tight parameter distribution result in safer paralleling operation.

Table 1. Device summary

| Order code   | Marking    | Package            | Packaging     |
|--------------|------------|--------------------|---------------|
| STGB20V60DF  | GB20V60DF  | D <sup>2</sup> PAK | Tape and reel |
| STGP20V60DF  | GP20V60DF  | TO-220             | Tube          |
| STGW20V60DF  | GW20V60DF  | TO-247             | Tube          |
| STGWT20V60DF | GWT20V60DF | TO-3P              | Tube          |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value       | Unit |
|----------------|---|-------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0$ )            | 600         | V    |
| $I_C$          | Continuous collector current at $T_C = 25\text{ °C}$  | 40          | A    |
| $I_C$          | Continuous collector current at $T_C = 100\text{ °C}$ | 20          | A    |
| $I_{CP}^{(1)}$ | Pulsed collector current                              | 80          | A    |
| $V_{GE}$       | Gate-emitter voltage                                  | $\pm 20$    | V    |
| $I_F$          | Continuous forward current at $T_C = 25\text{ °C}$    | 40          | A    |
| $I_F$          | Continuous forward current at $T_C = 100\text{ °C}$   | 20          | A    |
| $I_{FP(1)}$    | Pulsed forward current                                | 80          | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ °C}$             | 167         | W    |
| $T_{STG}$      | Storage temperature range                             | - 55 to 150 | °C   |
| $T_J$          | Operating junction temperature                        | - 55 to 175 | °C   |

1. Pulse width limited by maximum junction temperature and turn-off within RBSOA

**Table 3. Thermal data**

| Symbol     | Parameter                              | Value | Unit |
|------------|--|-------|------|
| $R_{thJC}$ | Thermal resistance junction-case IGBT  | 0.9   | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 2.08  | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient    | 50    | °C/W |

## 2 Electrical characteristics

$T_J = 25\text{ °C}$  unless otherwise specified.

**Table 4. Static characteristics**

| Symbol        | Parameter  | Test conditions  | Min. | Typ. | Max. | Unit          |
|---------------|--|--|------|------|------|---------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage ( $V_{GE} = 0$ ) | $I_C = 2\text{ mA}$  | 600  |      |      | V             |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage                 | $V_{GE} = 15\text{ V}, I_C = 20\text{ A}$                          |      | 1.8  | 2.2  | V             |
|               |  | $V_{GE} = 15\text{ V}, I_C = 20\text{ A}$<br>$T_J = 125\text{ °C}$ |      | 2.15 |      |               |
|               |  | $V_{GE} = 15\text{ V}, I_C = 20\text{ A}$<br>$T_J = 175\text{ °C}$ |      | 2.3  |      |               |
| $V_F$         | Forward on-voltage                                   | $I_F = 20\text{ A}$  |      | 1.7  | 2.2  | V             |
|               |  | $I_F = 20\text{ A}, T_J = 125\text{ °C}$                           |      | 1.55 |      | V             |
|               |  | $I_F = 20\text{ A}, T_J = 175\text{ °C}$                           |      | 1.3  |      | V             |
| $V_{GE(th)}$  | Gate threshold voltage                               | $V_{CE} = V_{GE}, I_C = 1\text{ mA}$                               | 5    | 6    | 7    | V             |
| $I_{CES}$     | Collector cut-off current ( $V_{GE} = 0$ )           | $V_{CE} = 600\text{ V}$  |      |      | 25   | $\mu\text{A}$ |
| $I_{GES}$     | Gate-emitter leakage current ( $V_{CE} = 0$ )        | $V_{GE} = \pm 20\text{ V}$   |      |      | 250  | nA            |

**Table 5. Dynamic characteristics**

| Symbol    | Parameter                    | Test conditions  | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}, f = 1\text{ MHz},$<br>$V_{GE} = 0$  | -    | 2800 | -    | pF   |
| $C_{oes}$ | Output capacitance           |  | -    | 110  | -    | pF   |
| $C_{res}$ | Reverse transfer capacitance |  | -    | 64   | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 480\text{ V}, I_C = 20\text{ A},$<br>$V_{GE} = 15\text{ V},$ see <a href="#">Figure 29</a> | -    | 116  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |  | -    | 24   | -    | nC   |
| $Q_{gc}$  | Gate-collector charge        |  | -    | 50   | -    | nC   |

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

| Symbol          | Parameter                 | Test conditions   | Min. | Typ. | Max.    | Unit       |
|-----------------|---------------------------|---|------|------|---------|------------|
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>see <a href="#">Figure 28</a>  | -    | 38   | -       | ns         |
| $t_r$           | Current rise time         |   | -    | 10   | -       | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |   | -    | 1556 | -       | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time       |   | -    | 149  | -       | ns         |
| $t_f$           | Current fall time         |   | -    | 15   | -       | ns         |
| $E_{on}^{(1)}$  | Turn-on switching losses  |   | -    | 200  | -       | $\mu$ J    |
| $E_{off}^{(2)}$ | Turn-off switching losses |   | -    | 130  | -       | $\mu$ J    |
| $E_{ts}$        | Total switching losses    | -   | 330  | -    | $\mu$ J |            |
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a> | -    | 37   | -       | ns         |
| $t_r$           | Current rise time         |   | -    | 12   | -       | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |   | -    | 1340 | -       | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time       |   | -    | 150  | -       | ns         |
| $t_f$           | Current fall time         |   | -    | 23   | -       | ns         |
| $E_{on}^{(1)}$  | Turn-on switching losses  |   | -    | 430  | -       | $\mu$ J    |
| $E_{off}^{(2)}$ | Turn-off switching losses |   | -    | 210  | -       | $\mu$ J    |
| $E_{ts}$        | Total switching losses    | -   | 640  | -    | $\mu$ J |            |

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

**Table 7. Diode switching characteristics (inductive load)**

| Symbol       | Parameter  | Test conditions  | Min. | Typ. | Max. | Unit       |
|--------------|--|--|------|------|------|------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ , see <a href="#">Figure 28</a><br>$di/dt = 1000\text{ A}/\mu\text{s}$  | -    | 40   | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 320  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 16   | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 910  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 115  | -    | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 20\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a><br>$di/dt = 1000\text{ A}/\mu\text{s}$ | -    | 72   | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 930  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 26   | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 530  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 307  | -    | $\mu$ J    |

## 2.1 Electrical characteristics (curves)

Figure 2. Power dissipation vs. case temperature

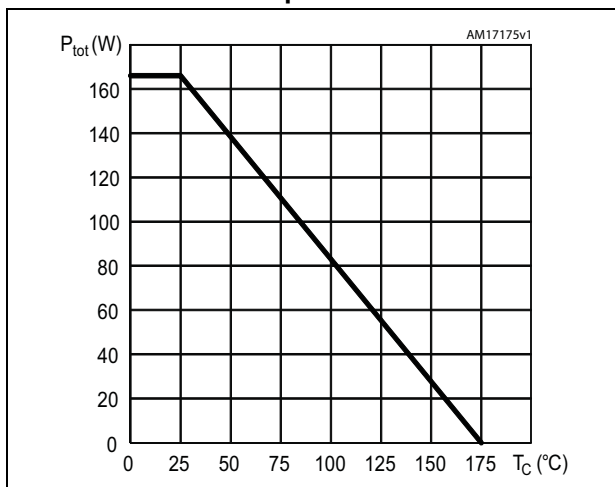


Figure 3. Collector current vs. case temperature

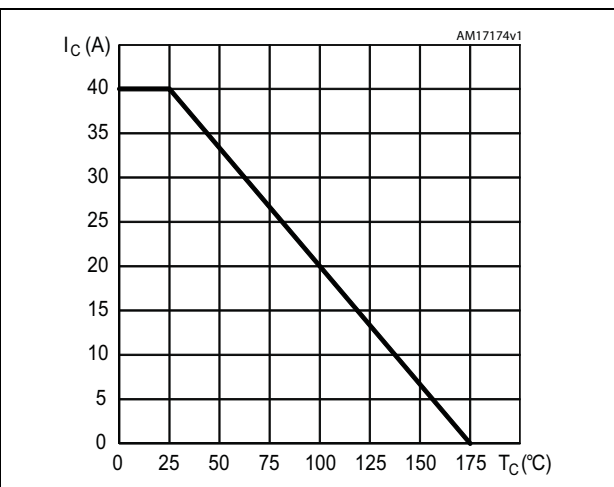


Figure 4. Output characteristics ( $T_J = 25^\circ\text{C}$ )

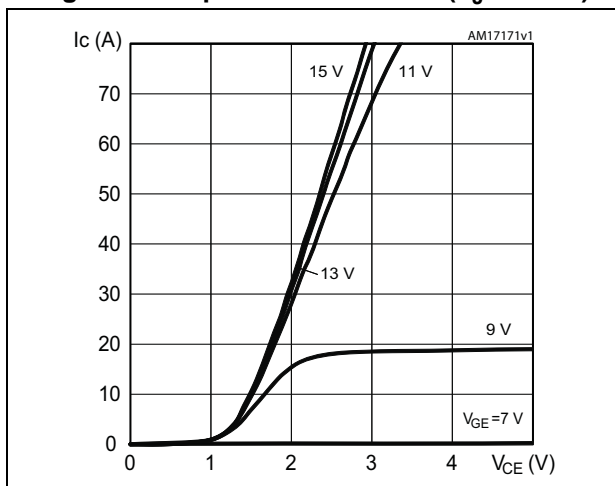


Figure 5. Output characteristics ( $T_J = 175^\circ\text{C}$ )

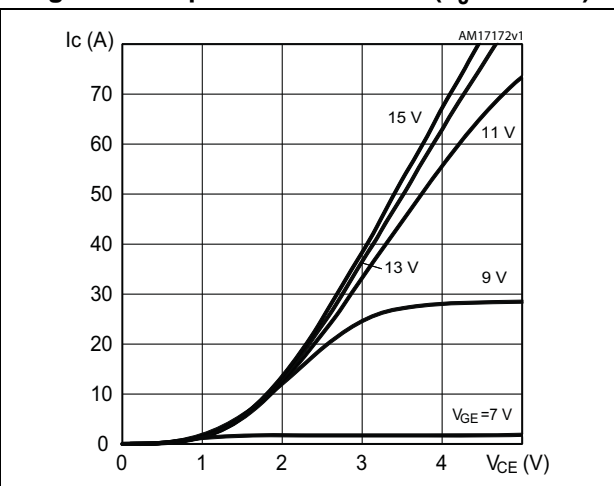


Figure 6.  $V_{CE(SAT)}$  vs. junction temperature

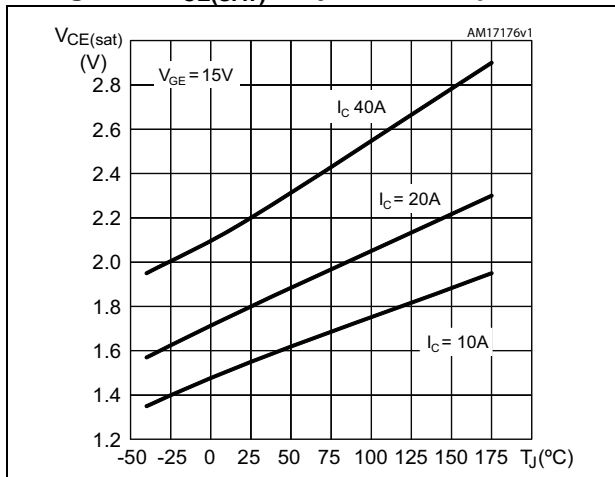


Figure 7.  $V_{CE(SAT)}$  vs. collector current

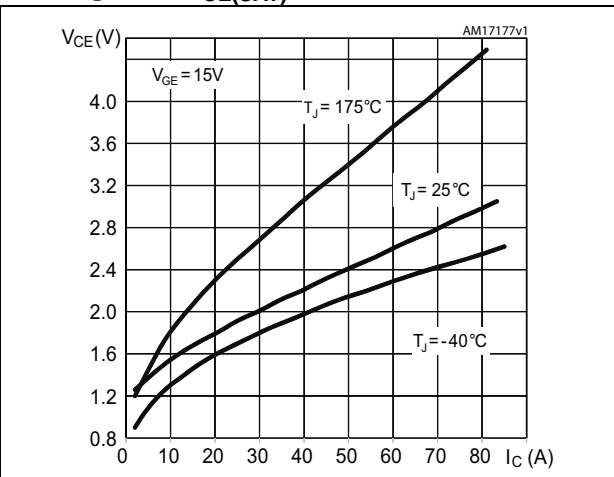


Figure 8. Collector current vs. switching frequency

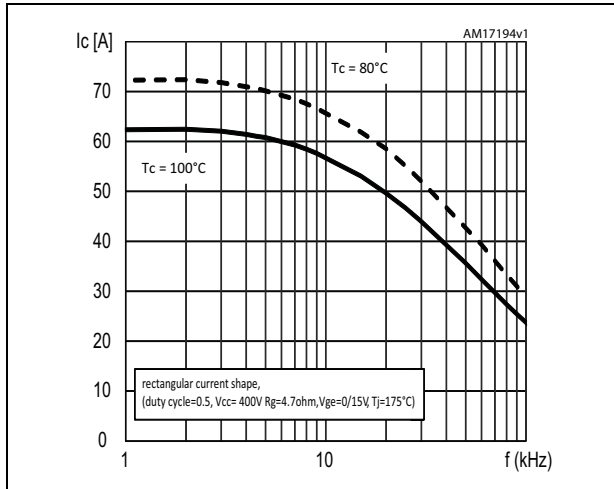


Figure 9. Forward bias safe operating area

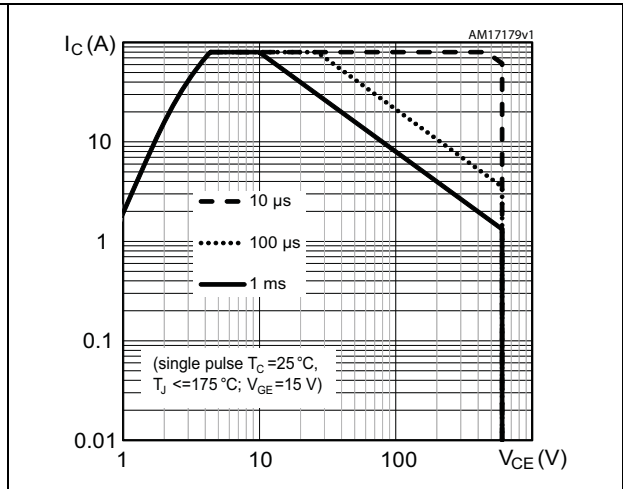


Figure 10. Transfer characteristics

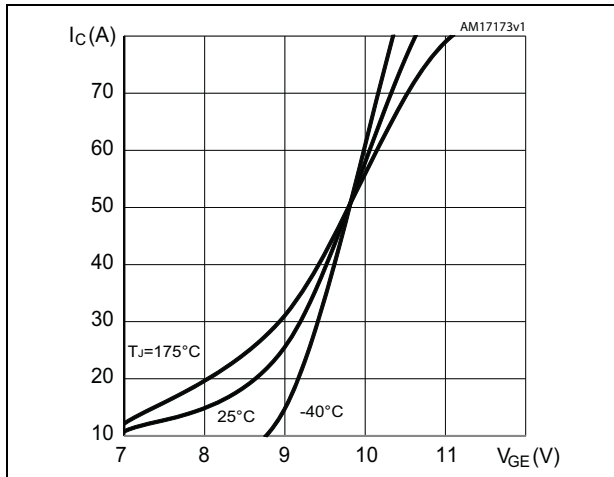


Figure 11. Diode Vf vs. forward current

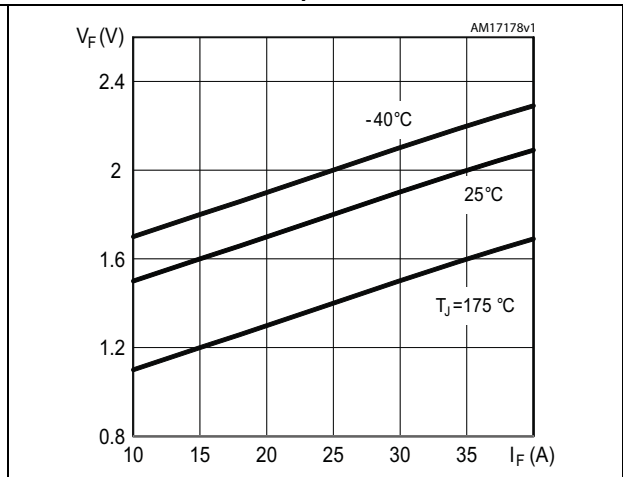


Figure 12. Normalized Vge(th) vs. junction temperature

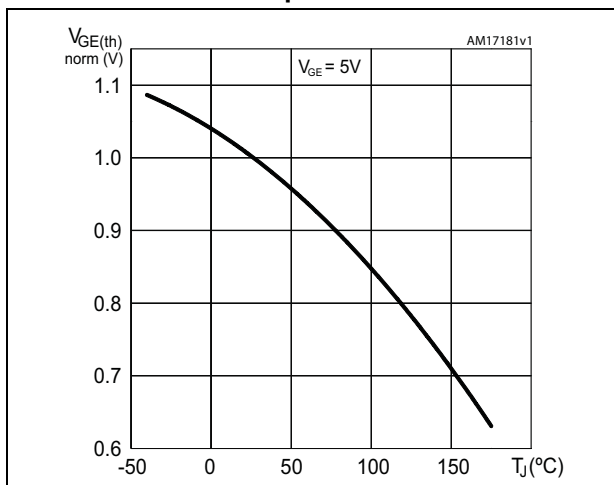


Figure 13. Normalized BVces vs. junction temperature

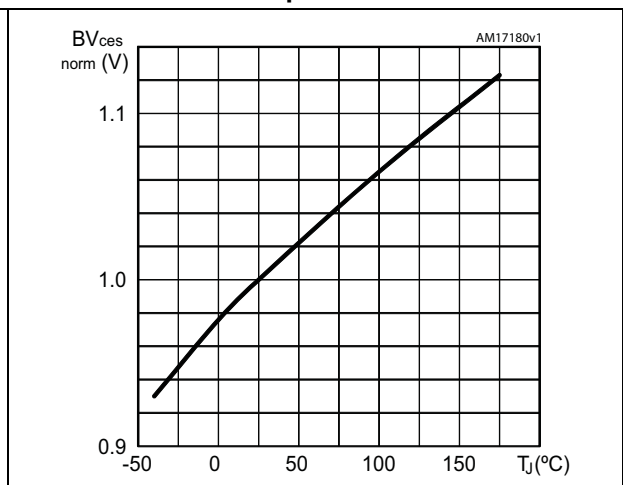


Figure 14. Capacitance variations

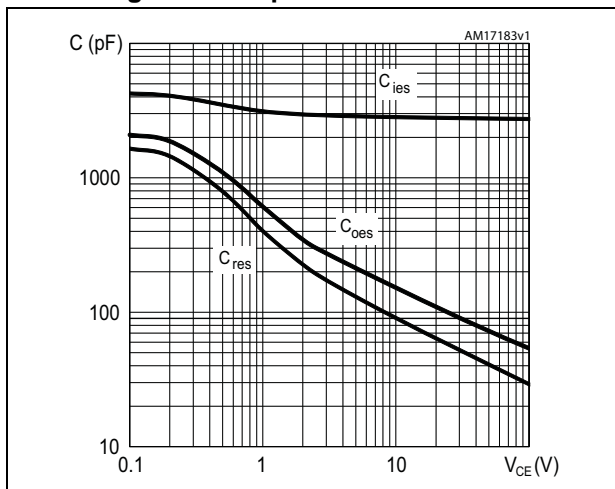


Figure 15. Gate charge vs. gate-emitter voltage

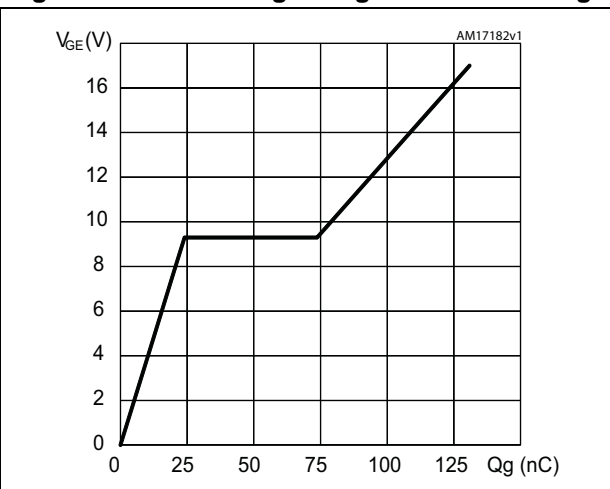


Figure 16. Switching losses vs. collector current

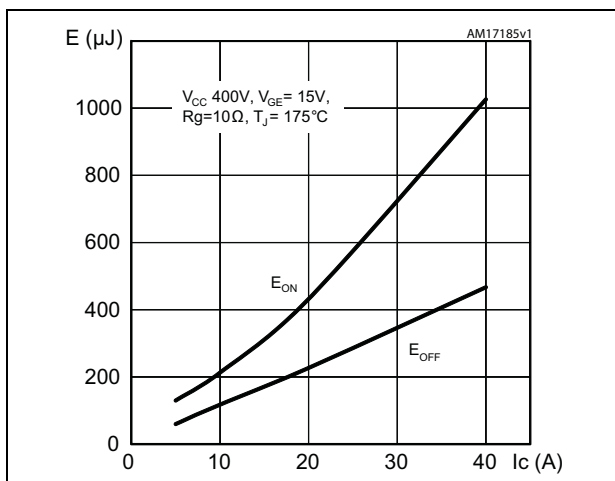


Figure 17. Switching losses vs. gate resistance

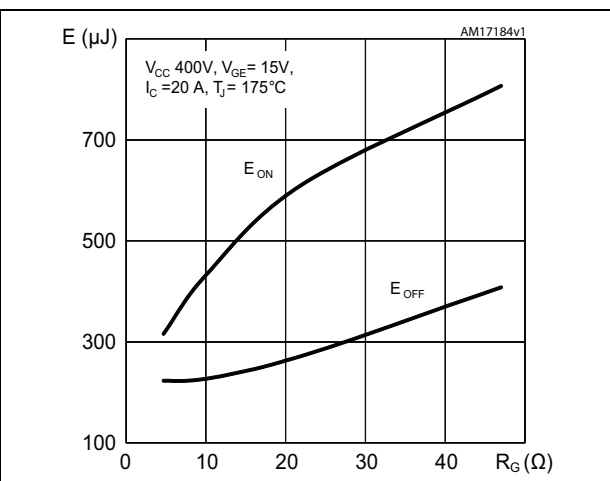


Figure 18. Switching losses vs. junction temperature

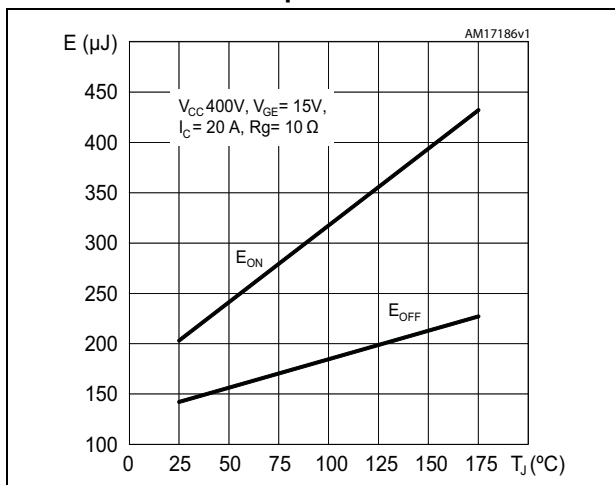


Figure 19. Switching losses vs. collector emitter voltage

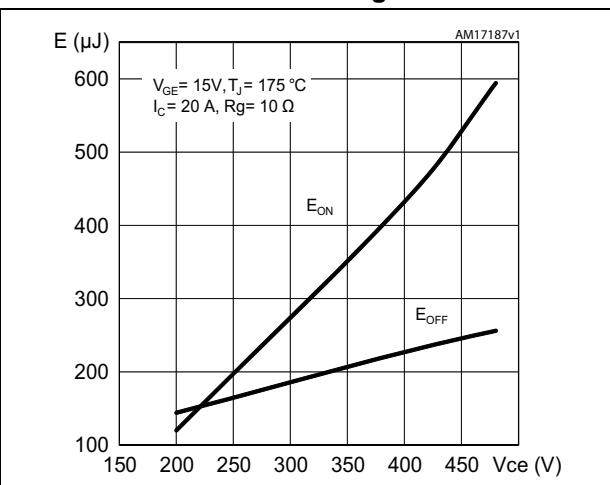




Figure 20. Switching times vs. collector current      Figure 21. Switching times vs. gate resistance

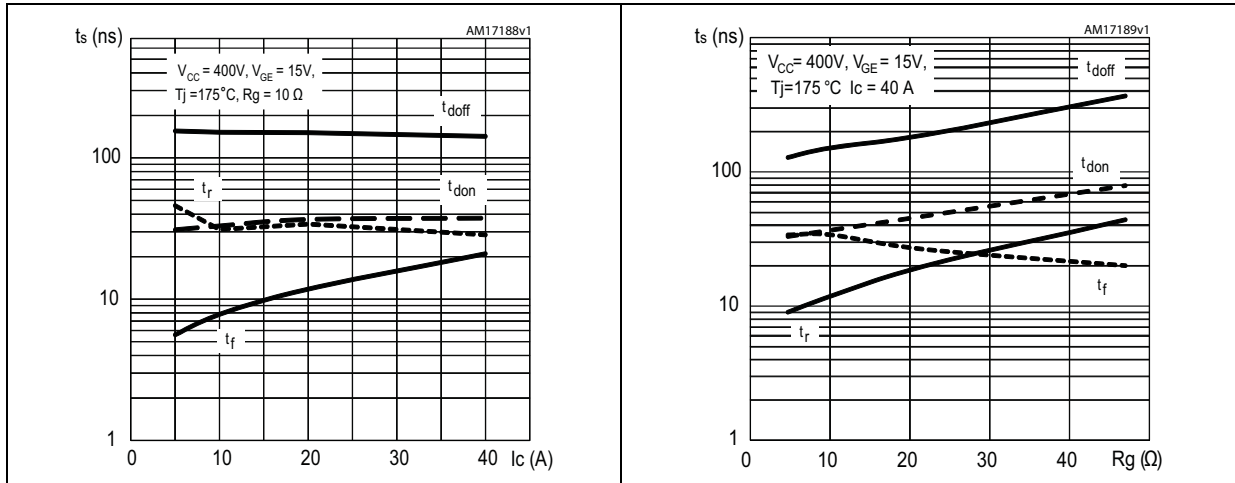


Figure 22. Reverse recovery current vs. diode current slope

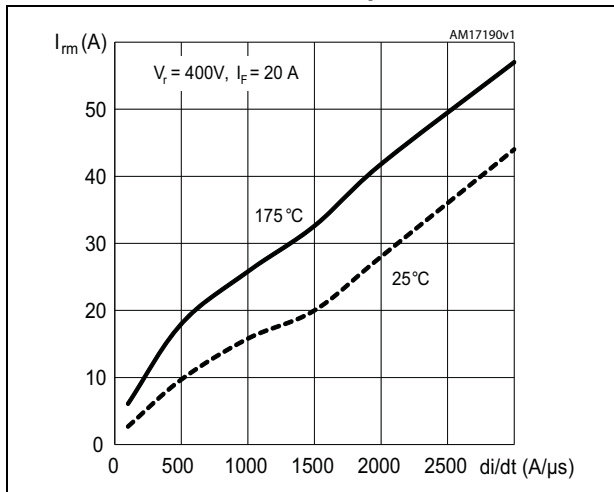


Figure 23. Reverse recovery time vs. diode current slope

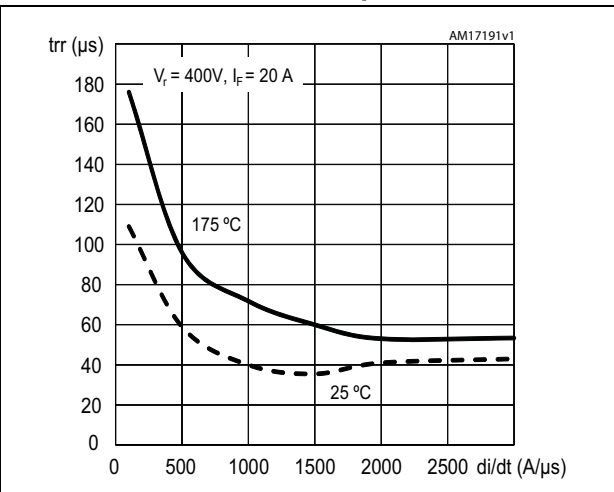


Figure 24. Reverse recovery charge vs. diode current slope

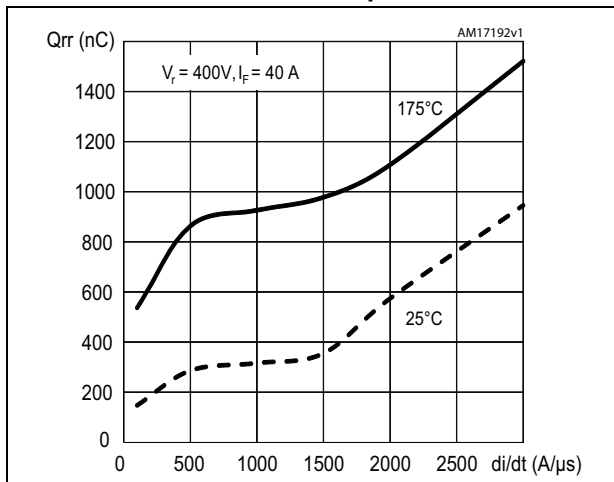


Figure 25. Reverse recovery energy vs. diode current slope

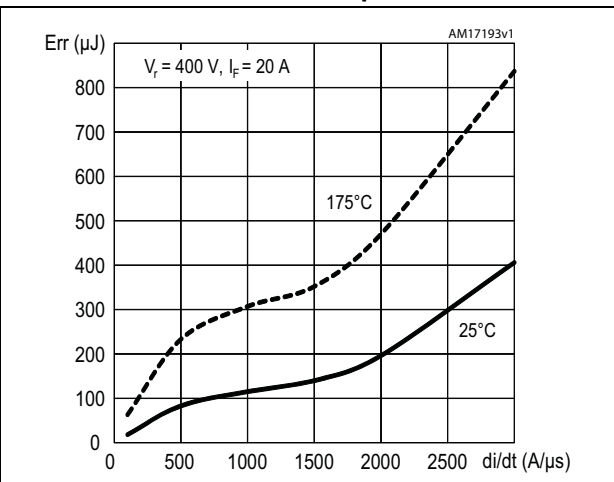


Figure 26. Thermal data for IGBT

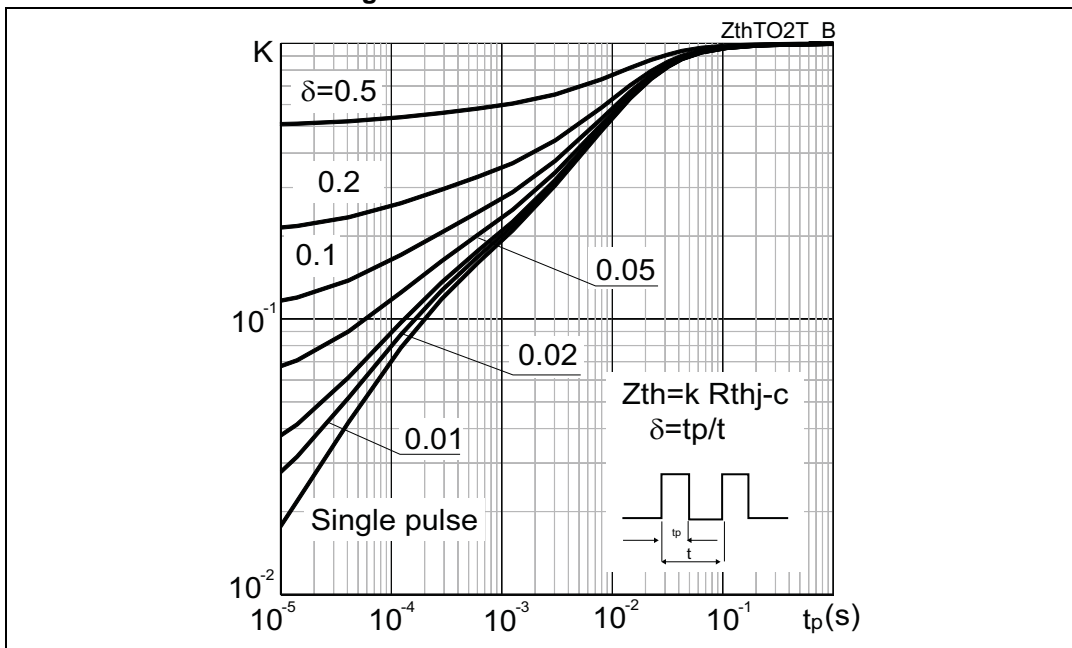
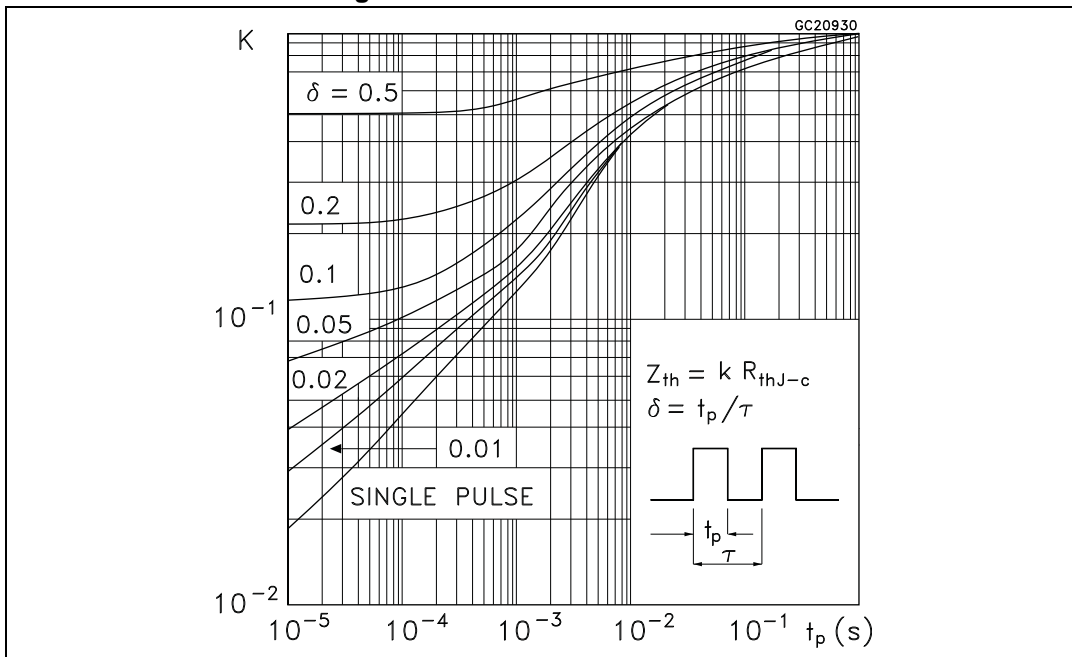


Figure 27. Thermal data for diode



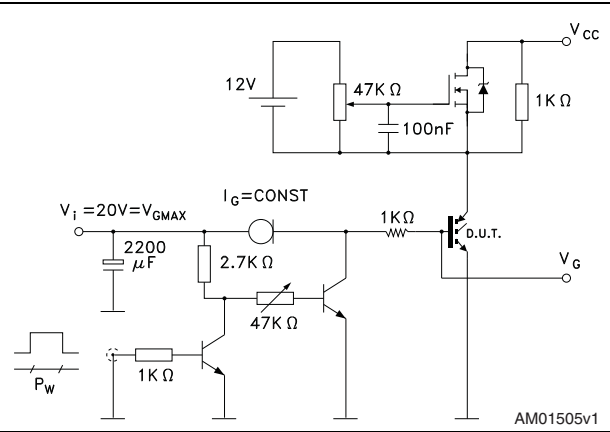
### 3 Test circuits

Figure 28. Test circuit for inductive load switching



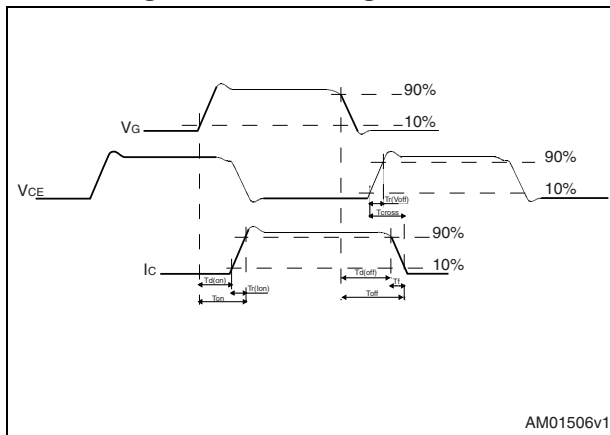
AM01504v1

Figure 29. Gate charge test circuit



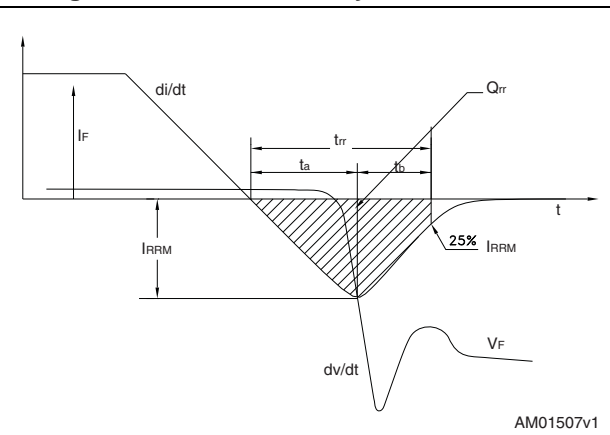
AM01505v1

Figure 30. Switching waveform



AM01506v1

Figure 31. Diode recovery time waveform



AM01507v1

## 4 Package mechanical data

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

**Table 8. 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 32. TO-220 type A drawing

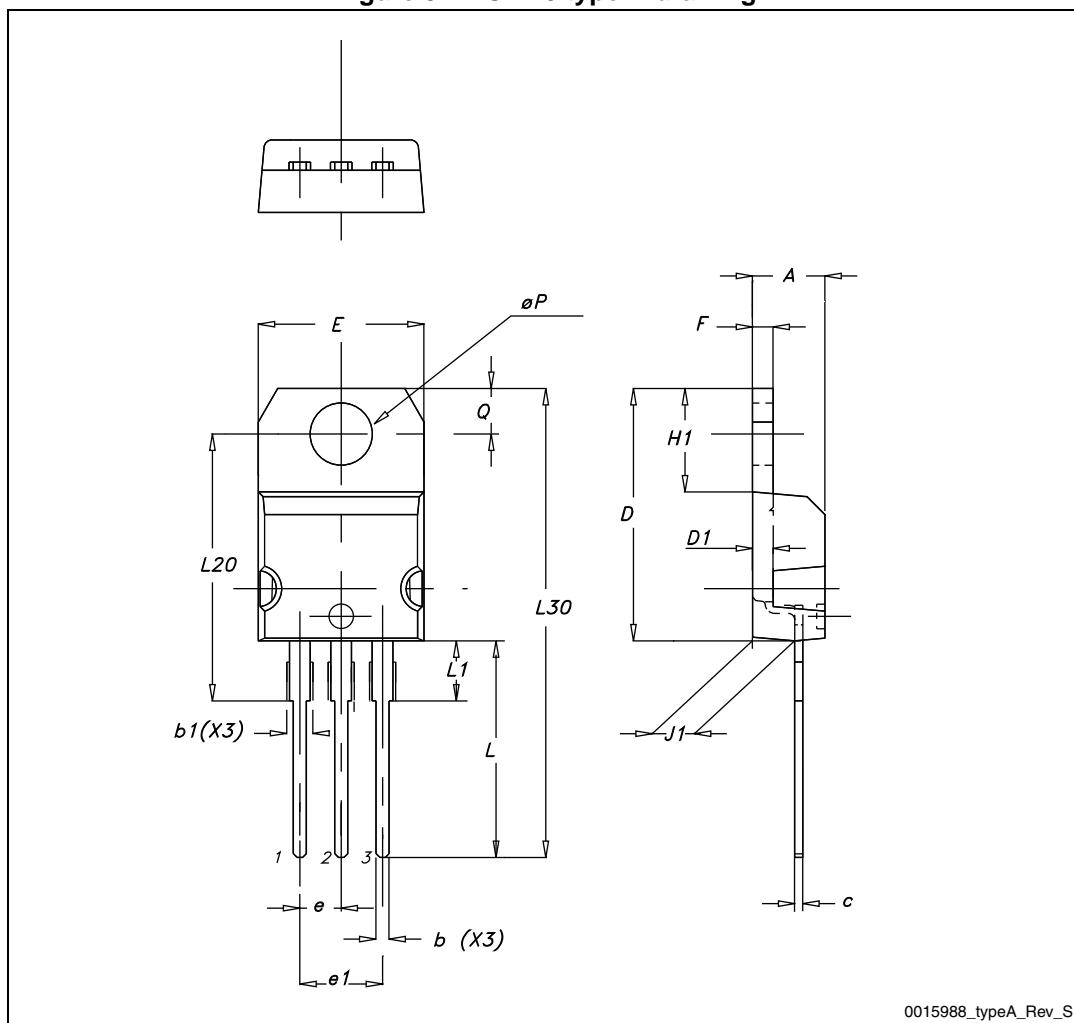


Table 9. D<sup>2</sup>PAK (TO-263) mechanical data

| 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 33. D<sup>2</sup>PAK (TO-263) drawing

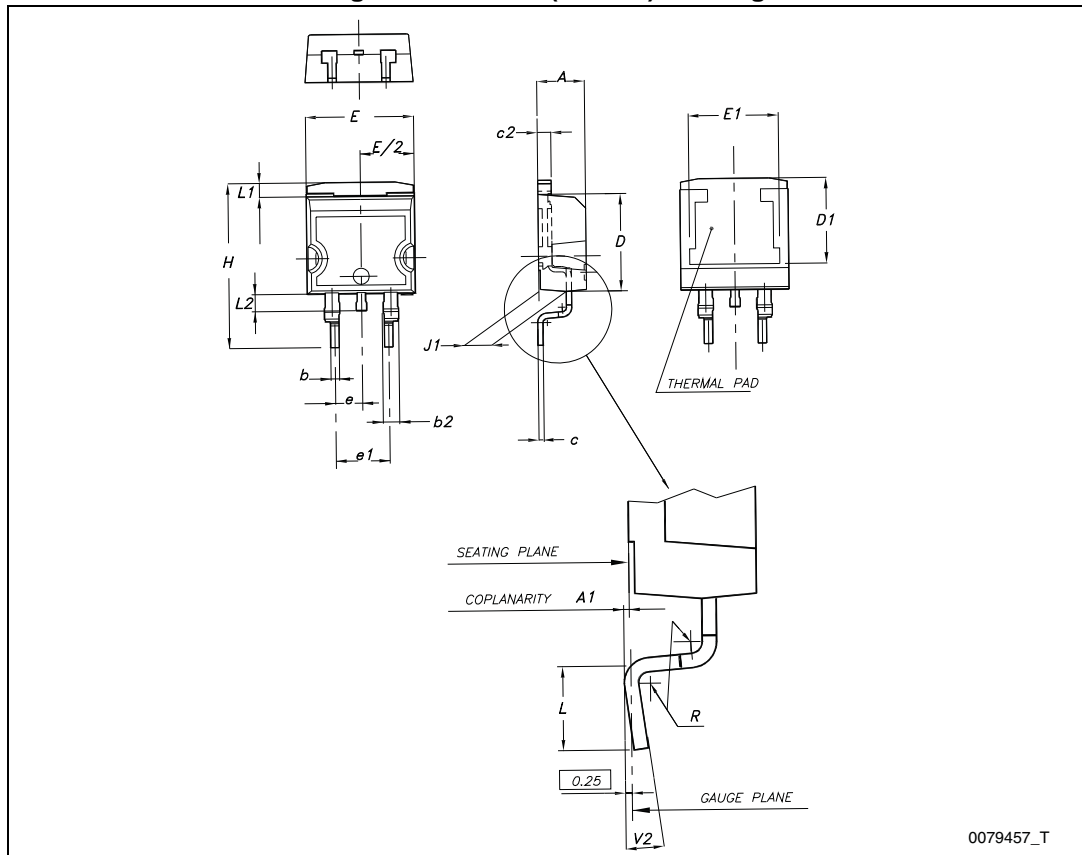
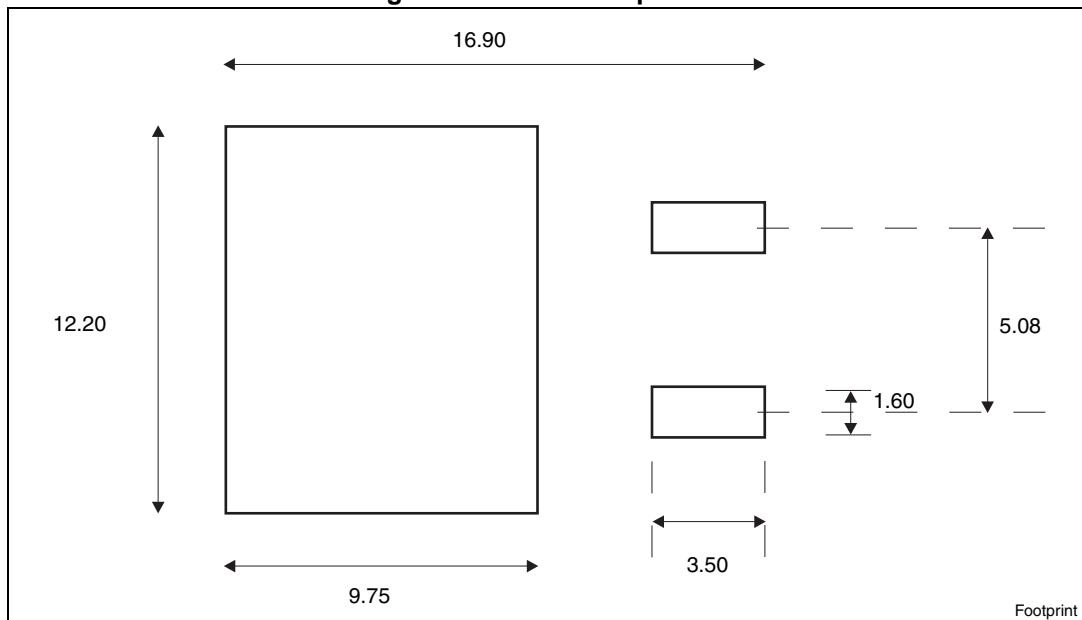


Figure 34. D<sup>2</sup>PAK footprint (a)



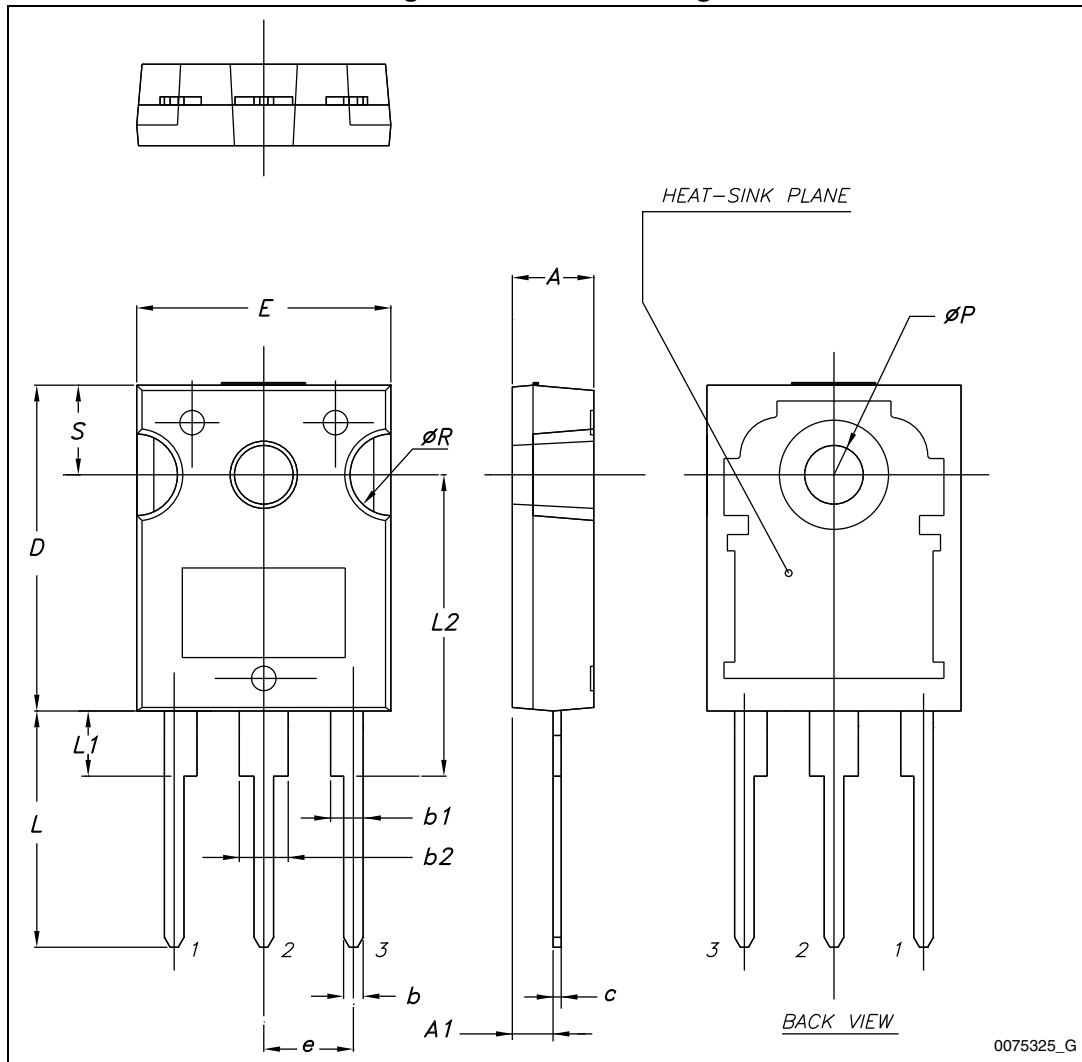
a. All dimension are in millimeters

Table 10. TO-247 mechanical data

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.85  |       | 5.15  |
| A1   | 2.20  |       | 2.60  |
| b    | 1.0   |       | 1.40  |
| b1   | 2.0   |       | 2.40  |
| b2   | 3.0   |       | 3.40  |
| c    | 0.40  |       | 0.80  |
| D    | 19.85 |       | 20.15 |
| E    | 15.45 |       | 15.75 |
| e    | 5.30  | 5.45  | 5.60  |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    | 5.30  | 5.50  | 5.70  |



Figure 35. TO-247 drawing

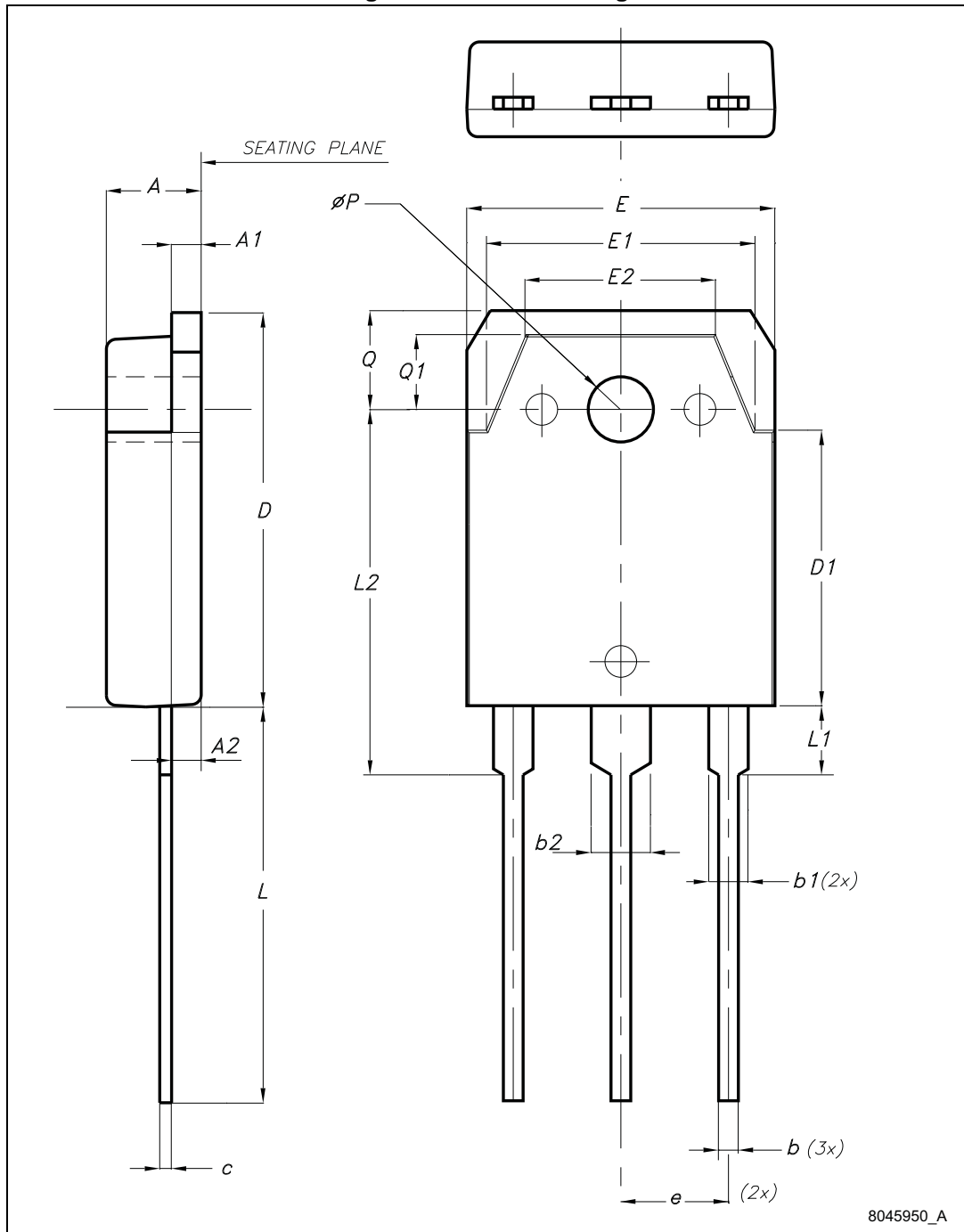


0075325\_G

Table 11. TO-3P mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.60  |       | 5     |
| A1   | 1.45  | 1.50  | 1.65  |
| A2   | 1.20  | 1.40  | 1.60  |
| b    | 0.80  | 1     | 1.20  |
| b1   | 1.80  |       | 2.20  |
| b2   | 2.80  |       | 3.20  |
| c    | 0.55  | 0.60  | 0.75  |
| D    | 19.70 | 19.90 | 20.10 |
| D1   |       | 13.90 |       |
| E    | 15.40 |       | 15.80 |
| E1   |       | 13.60 |       |
| E2   |       | 9.60  |       |
| e    | 5.15  | 5.45  | 5.75  |
| L    | 19.50 | 20    | 20.50 |
| L1   |       | 3.50  |       |
| L2   | 18.20 | 18.40 | 18.60 |
| øP   | 3.10  |       | 3.30  |
| Q    |       | 5     |       |
| Q1   |       | 3.80  |       |

Figure 36. TO-3P drawing



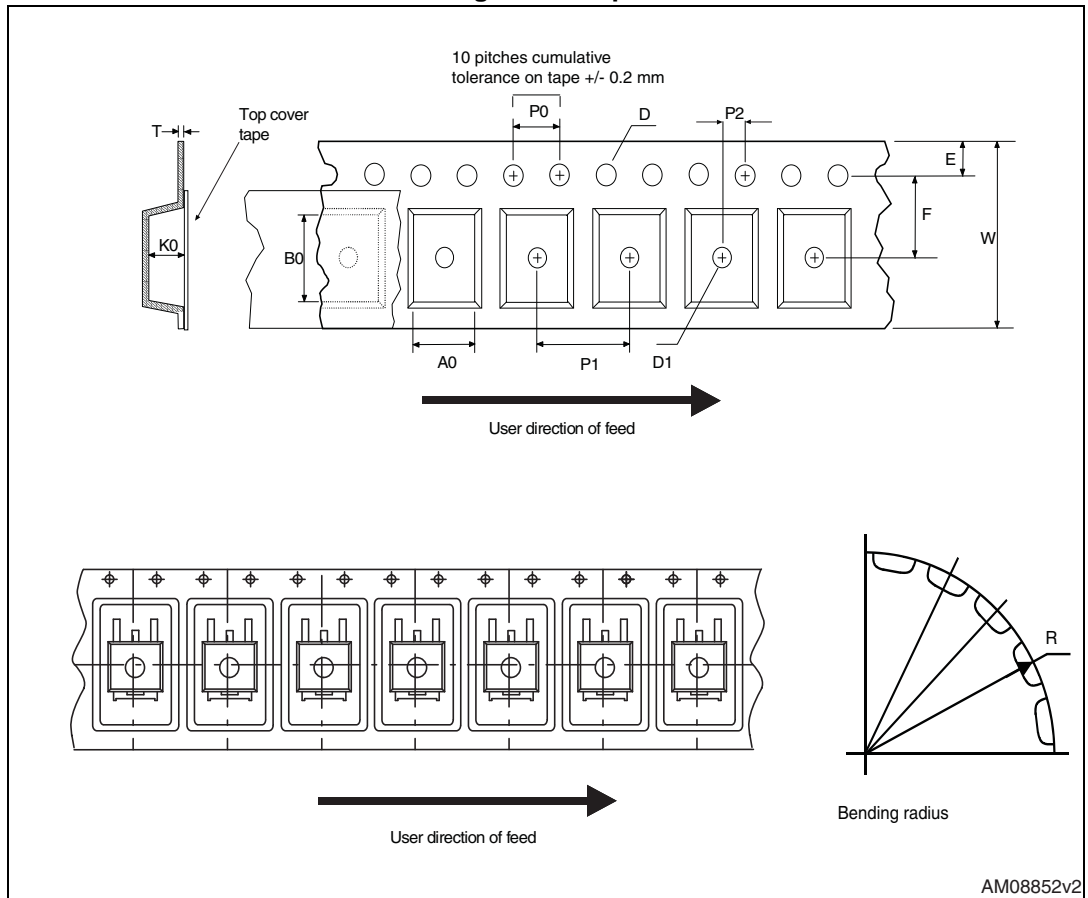
8045950\_A

## 5 Packing mechanical data

Table 12. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

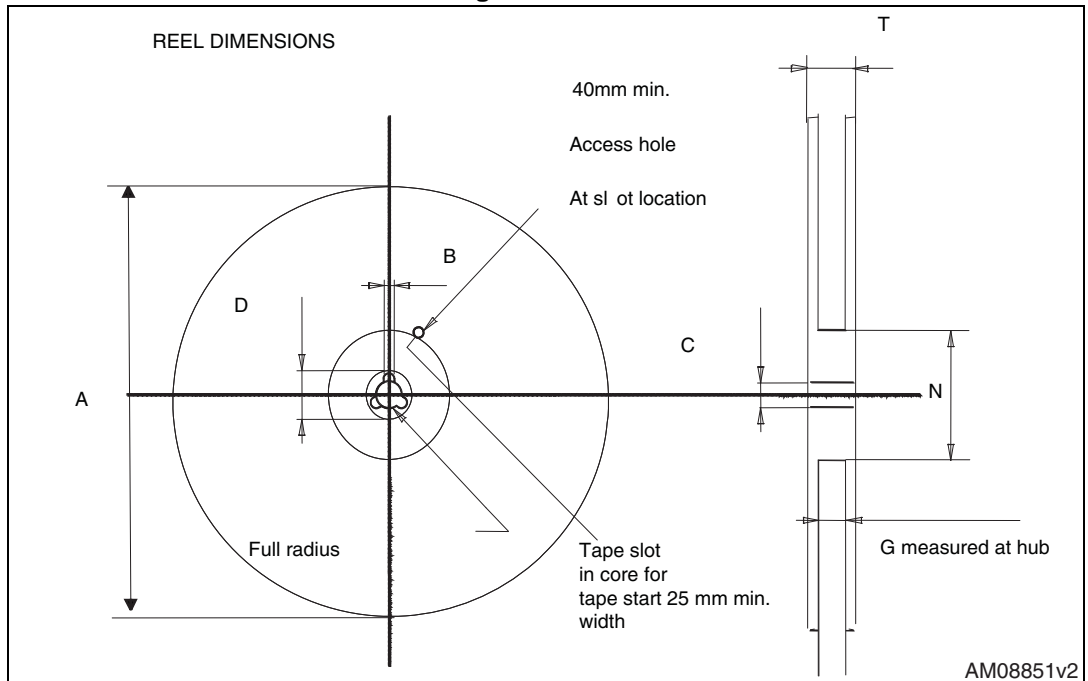
| Tape |      |      | Reel |          |      |
|------|------|------|------|----------|------|
| Dim. | mm   |      | Dim. | mm       |      |
|      | Min. | Max. |      | Min.     | Max. |
| A0   | 10.5 | 10.7 | A    |          | 330  |
| B0   | 15.7 | 15.9 | B    | 1.5      |      |
| D    | 1.5  | 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 37. Tape



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Figure 38. Reel



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## 6 Revision history

Table 13. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 12-Mar-2013 | 1        | Initial release.   |
| 16-May-2013 | 2        | Document status promoted from preliminary data to production data.<br>Added: <ul style="list-style-type: none"><li>– New root part numbers STGB20V60DF and STGP20V60DF <a href="#">Table 1 on page 1</a>.</li><li>– Package mechanical data <a href="#">Table 8 on page 12</a>, <a href="#">Table 9 on page 14</a>, <a href="#">Figure 32 on page 13</a> and <a href="#">Figure 33 on page 15</a>.</li><li>– <a href="#">Section 2.1: Electrical characteristics (curves) on page 6</a>.</li></ul> |
| 04-Jun-2013 | 3        | Added maximum value for $V_{GE(th)}$ and $V_F$ in <a href="#">Table 4: Static characteristics</a> .  |

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