

## Trench gate field-stop IGBT, V series 600 V, 40 A very high speed

Datasheet - production data

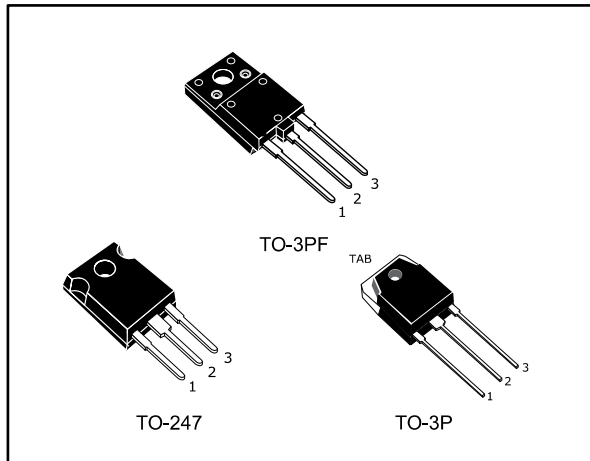
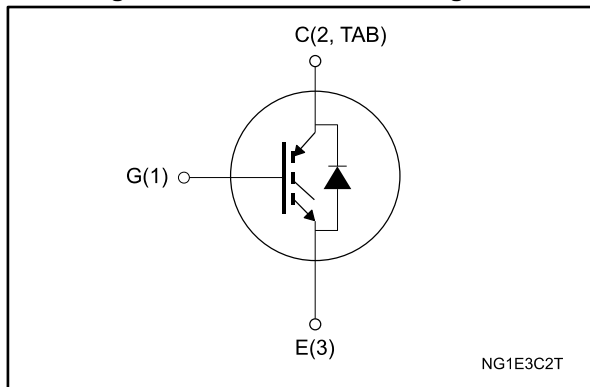


Figure 1: Internal schematic diagram



### Features

- Maximum junction temperature:  $T_J = 175\text{ }^\circ\text{C}$
- Tail-less switching off
- $V_{CE(sat)} = 1.8\text{ V (typ.) @ } I_c = 40\text{ A}$
- Tight parameters distribution
- Safe paralleling
- Low thermal resistance
- Very fast soft recovery antiparallel diode

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

Table 1: Device summary

| Order code   | Marking    | Package | Packing |
|--------------|------------|---------|---------|
| STGFW40V60DF | GFW40V60DF | TO-3PF  | Tube    |
| STGW40V60DF  | GW40V60DF  | TO-247  | Tube    |
| STGWT40V60DF | GWT40V60DF | TO-3P   | Tube    |

## Contents

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol                         | Parameter   | Value           |        | Unit |
|--------------------------------|---|-----------------|--------|------|
|                                |   | TO-247<br>TO-3P | TO-3PF |      |
| V <sub>CES</sub>               | Collector-emitter voltage (V <sub>GE</sub> = 0 V)   | 600             |        | V    |
| I <sub>C</sub>                 | Continuous collector current at T <sub>C</sub> = 25 °C  | 80              |        | A    |
|                                | Continuous collector current at T <sub>C</sub> = 100 °C   | 40              |        | A    |
| I <sub>CP</sub> <sup>(1)</sup> | Pulsed collector current  | 160             |        | A    |
| V <sub>GE</sub>                | Gate-emitter voltage  | ±20             |        | V    |
| I <sub>F</sub>                 | Continuous forward current at T <sub>C</sub> = 25 °C  | 80              |        | A    |
|                                | Continuous forward current at T <sub>C</sub> = 100 °C   | 40              |        | A    |
| I <sub>FP</sub> <sup>(1)</sup> | Pulsed forward current  | 160             |        | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C   | 283             | 62.5   | W    |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s, T <sub>C</sub> = 25 °C) | 3.5             |        | kV   |
| T <sub>STG</sub>               | Storage temperature range   | -55 to 150      |        | °C   |
| T <sub>J</sub>                 | Operating junction temperature range  | -55 to 175      |        | °C   |

**Notes:**

<sup>(1)</sup>Pulse width is limited by maximum junction temperature.

Table 3: Thermal data

| Symbol            | Parameter                              | Value           |        | Unit |
|-------------------|--|-----------------|--------|------|
|                   |  | TO-247<br>TO-3P | TO-3PF |      |
| R <sub>thJC</sub> | Thermal resistance junction-case IGBT  | 0.53            | 2.4    | °C/W |
| R <sub>thJC</sub> | Thermal resistance junction-case diode | 1.14            | 2.6    | °C/W |
| R <sub>thJA</sub> | 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  | $V_{GE} = 0\text{ V}$ , $I_C = 2\text{ mA}$                             | 600  |      |           | V             |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$                            |      | 1.8  | 2.3       | V             |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$T_J = 125\text{ °C}$ |      | 2.15 |           |               |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$T_J = 175\text{ °C}$ |      | 2.35 |           |               |
| $V_F$         | Forward on-voltage                   | $I_F = 40\text{ A}$   |      | 1.7  | 2.45      | V             |
|               |                                      | $I_F = 40\text{ A}$ , $T_J = 125\text{ °C}$                             |      | 1.4  |           |               |
|               |                                      | $I_F = 40\text{ A}$ , $T_J = 175\text{ °C}$                             |      | 1.3  |           |               |
| $V_{GE(th)}$  | Gate threshold voltage               | $V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$                                 | 5    | 6    | 7         | V             |
| $I_{CES}$     | Collector cut-off current            | $V_{GE} = 0\text{ V}$ , $V_{CE} = 0\text{ V}$                           |      |      | 25        | $\mu\text{A}$ |
| $I_{GES}$     | Gate-emitter leakage current         | $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$                      |      |      | $\pm 250$ | 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>$V_{GE} = 0\text{ V}$  | -    | 5400 | -    | pF   |
| $C_{oes}$ | Output capacitance           |   | -    | 220  | -    | pF   |
| $C_{res}$ | Reverse transfer capacitance |   | -    | 180  | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 480\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$V_{GE} = 0\text{ to }15\text{ V}$<br>(see <a href="#">Figure 35: "Gate charge test circuit"</a> ) | -    | 226  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |   | -    | 38   | -    | nC   |
| $Q_{gc}$  | Gate-collector charge        |   | -    | 95   | -    | nC   |

Table 6: IGBT switching characteristics (inductive load)

| Symbol          | Parameter                 | Test conditions  | Min. | Typ. | Max. | Unit       |
|-----------------|---------------------------|--|------|------|------|------------|
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$<br>(see <a href="#">Figure 34: "Test circuit for inductive load switching"</a> )  | -    | 52   | -    | ns         |
| $t_r$           | Current rise time         |  | -    | 17   | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |  | -    | 1850 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time       |  | -    | 208  | -    | ns         |
| $t_f$           | Current fall time         |  | -    | 20   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy  |  | -    | 456  | -    | $\mu$ J    |
| $E_{off}^{(2)}$ | Turn-off switching energy |  | -    | 411  | -    | $\mu$ J    |
| $E_{ts}$        | Total switching energy    |  | -    | 867  | -    | $\mu$ J    |
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 34: "Test circuit for inductive load switching"</a> ) | -    | 52   | -    | ns         |
| $t_r$           | Current rise time         |  | -    | 21   | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |  | -    | 1538 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off-delay time       |  | -    | 220  | -    | ns         |
| $t_f$           | Current fall time         |  | -    | 21   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy  |  | -    | 1330 | -    | $\mu$ J    |
| $E_{off}^{(2)}$ | Turn-off switching energy |  | -    | 560  | -    | $\mu$ J    |
| $E_{ts}$        | Total switching energy    |  | -    | 1890 | -    | $\mu$ J    |

**Notes:**

(1)Including the reverse recovery of the diode.

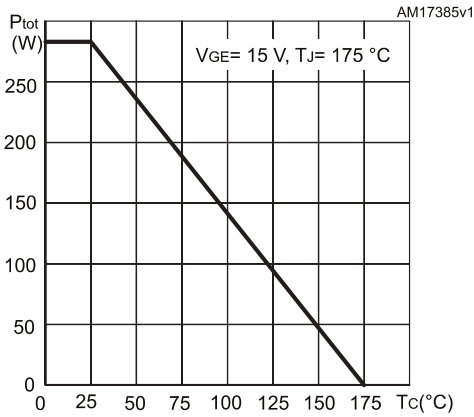
(2)Including the tail of the collector current.

Table 7: Diode switching characteristics (inductive load)

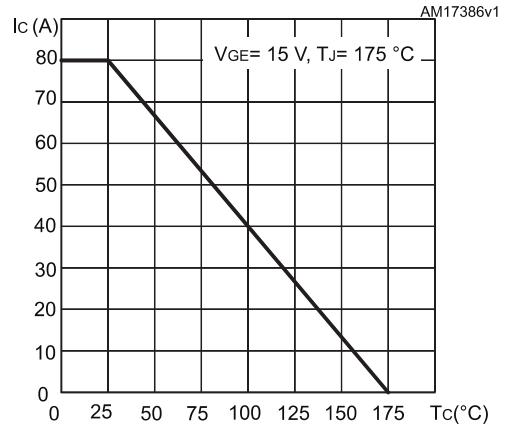
| Symbol       | Parameter  | Test conditions   | Min. | Typ. | Max. | Unit       |
|--------------|--|---|------|------|------|------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 40\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$<br>(see <a href="#">Figure 34: "Test circuit for inductive load switching"</a> )  | -    | 41   | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |   | -    | 440  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |   | -    | 21.6 | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |   | -    | 1363 | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |   | -    | 151  | -    | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 40\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 34: "Test circuit for inductive load switching"</a> ) | -    | 109  | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |   | -    | 2400 | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |   | -    | 44.4 | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |   | -    | 670  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |   | -    | 718  | -    | $\mu$ J    |

## 2.1 Electrical characteristics curves

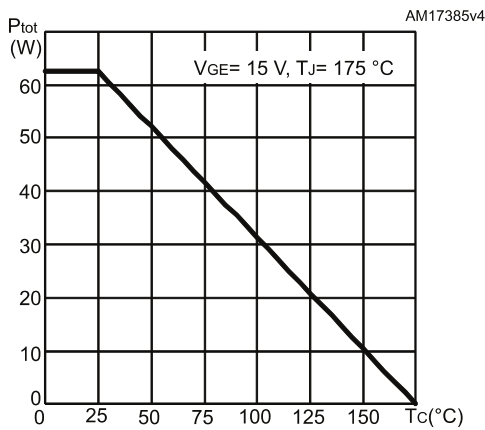
**Figure 2: Power dissipation vs case temperature for TO-247 and TO-3P**



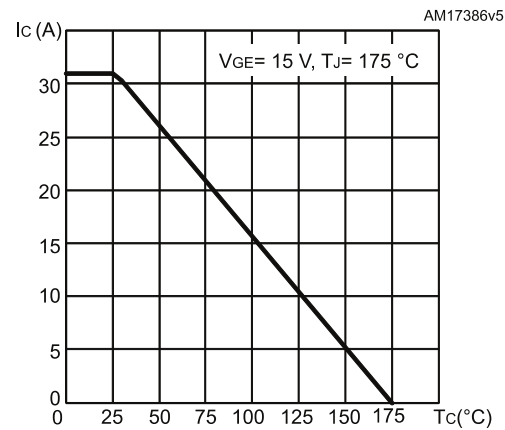
**Figure 3: Collector current vs case temperature for TO-247 and TO-3P**



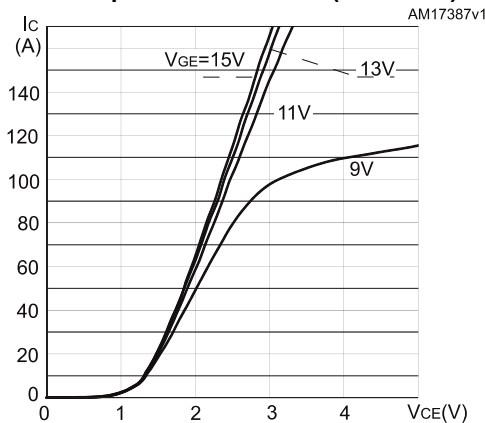
**Figure 4: Power dissipation vs case temperature for TO-3PF**



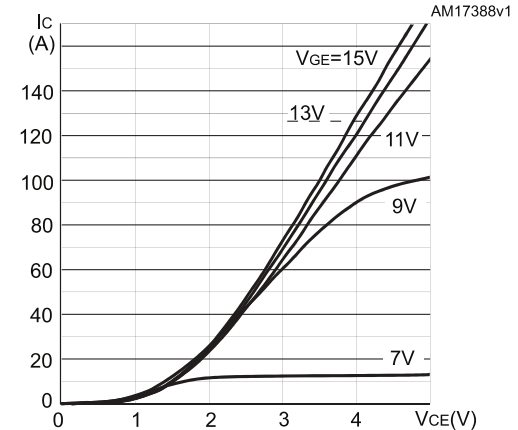
**Figure 5: Collector current vs case temperature for TO-3PF**

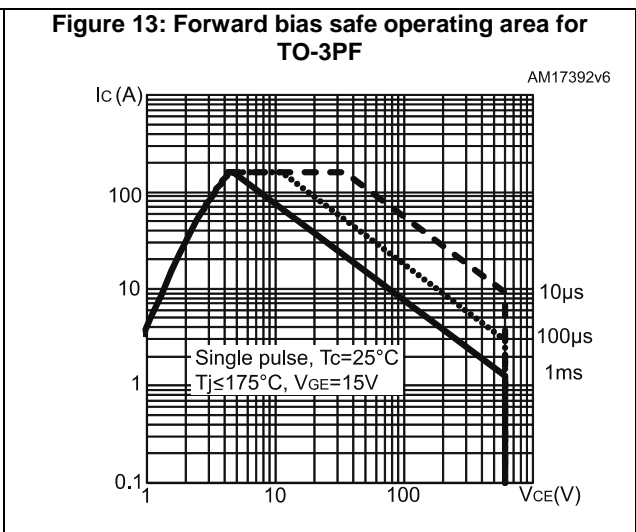
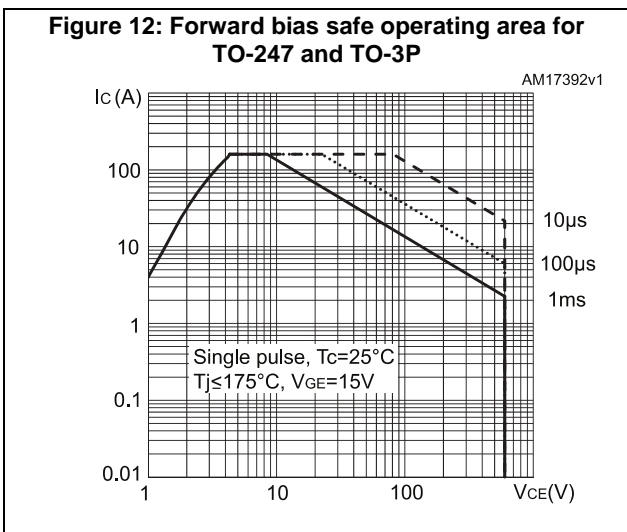
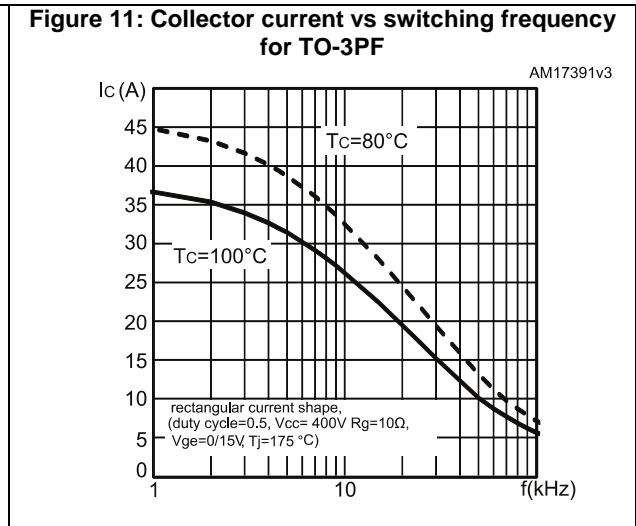
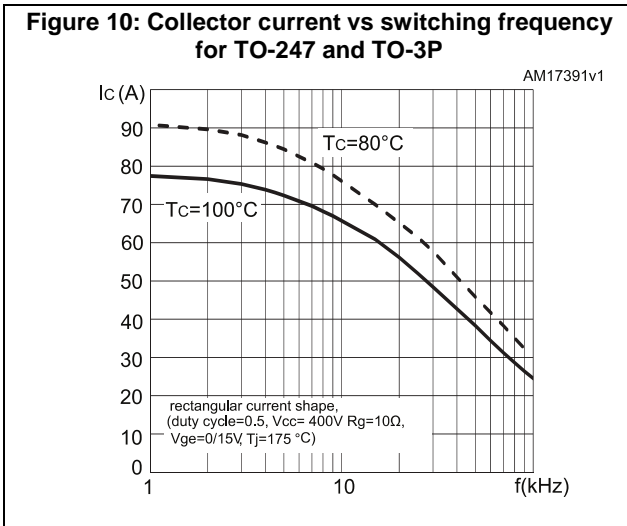
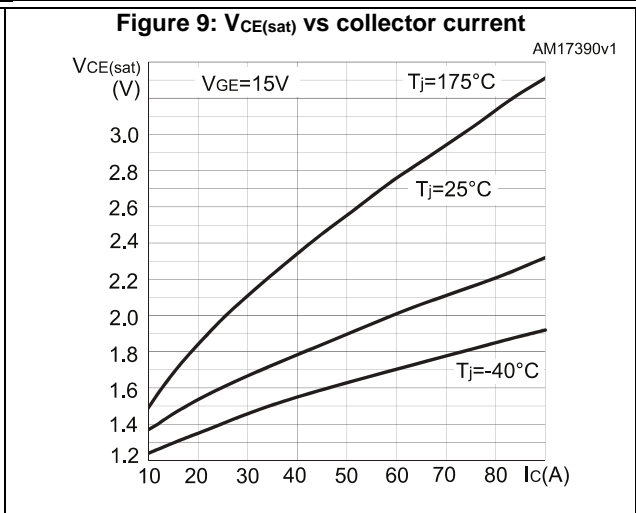
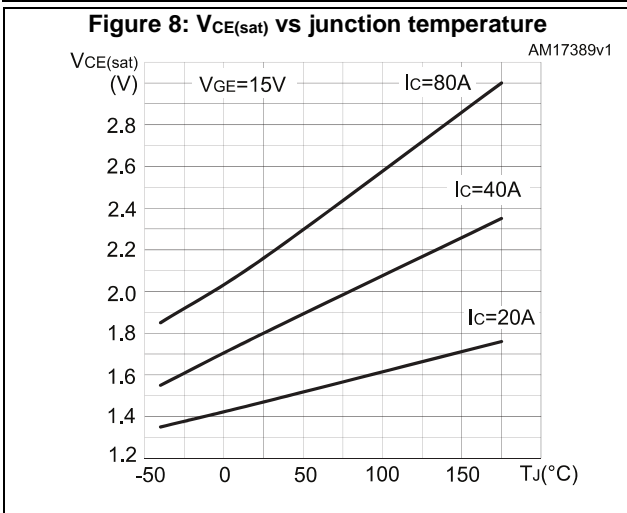


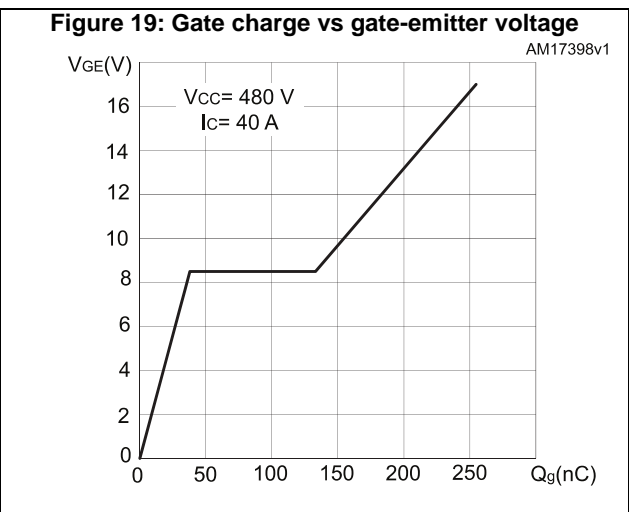
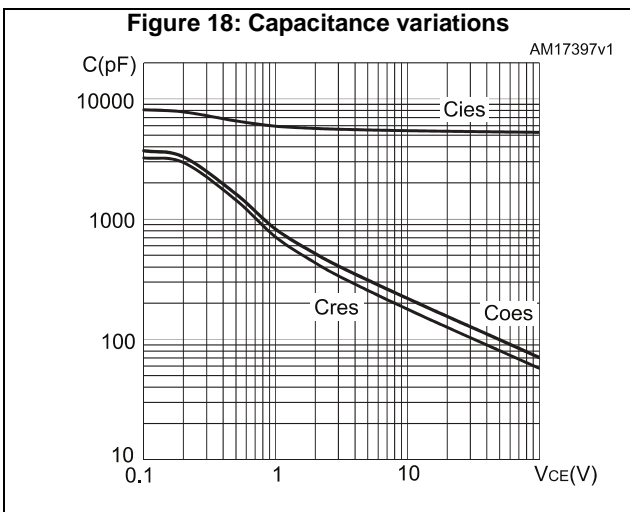
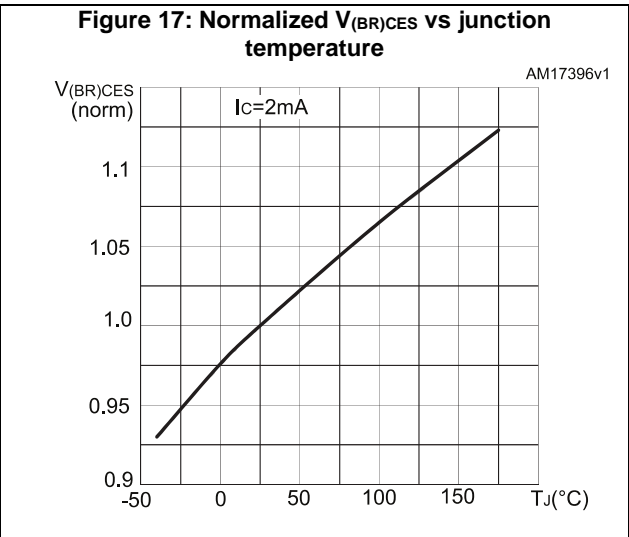
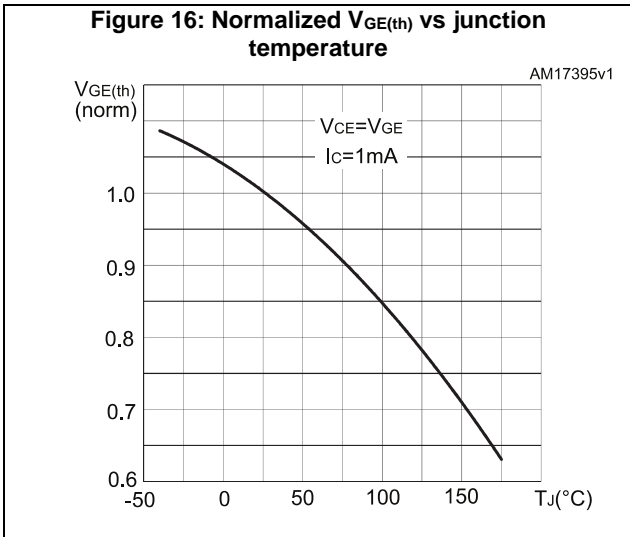
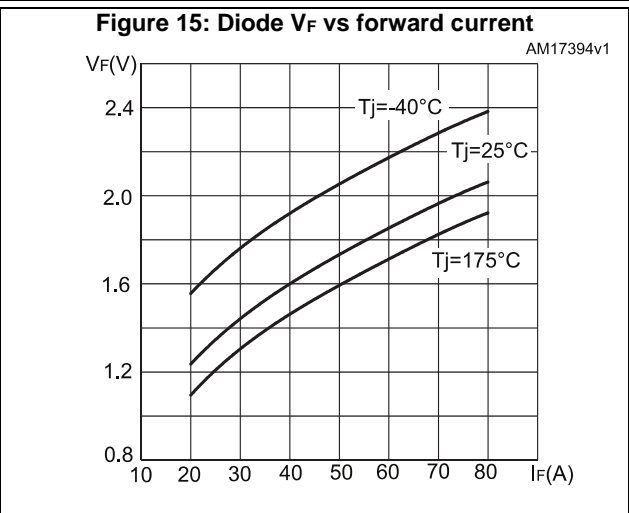
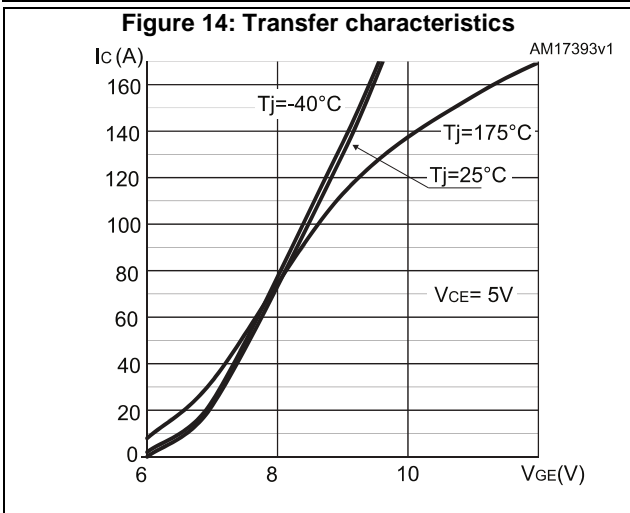
**Figure 6: Output characteristics (T<sub>J</sub> = 25 °C)**



**Figure 7: Output characteristics (T<sub>J</sub> = 175 °C)**









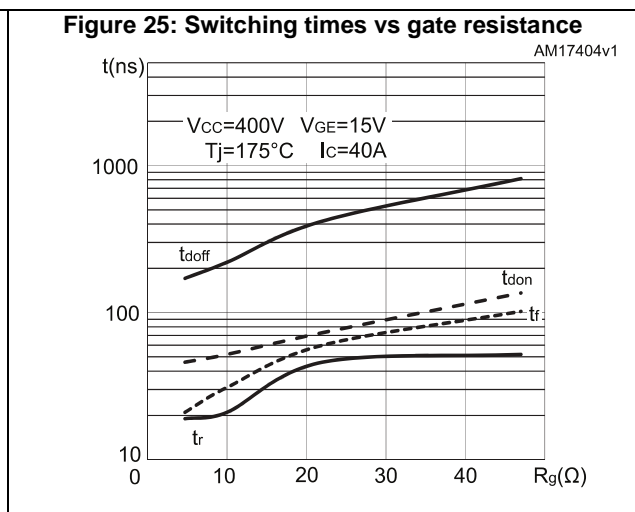
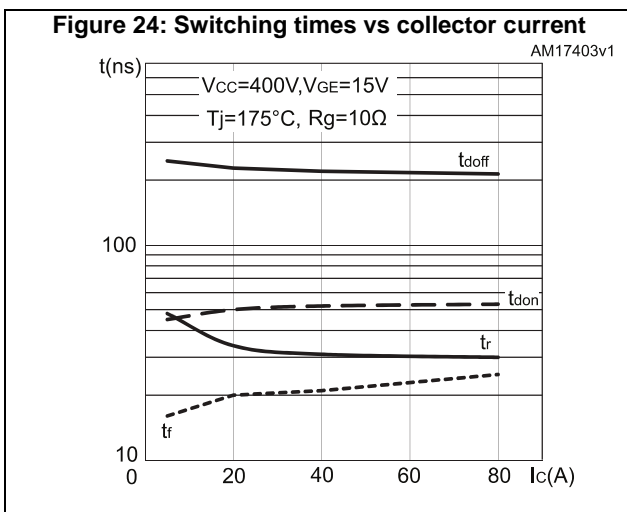
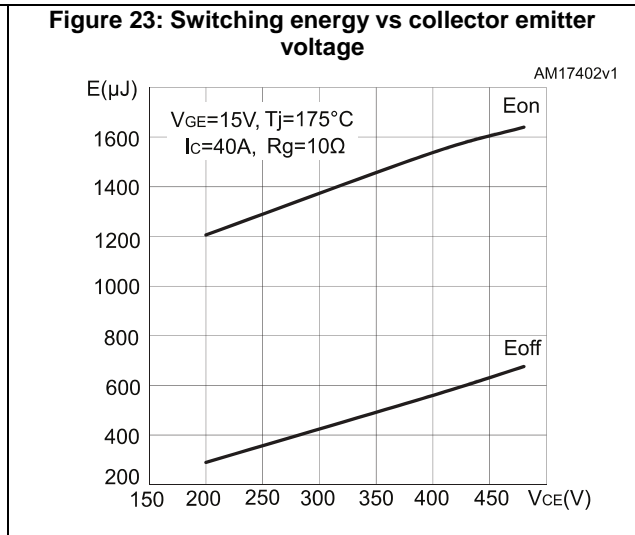
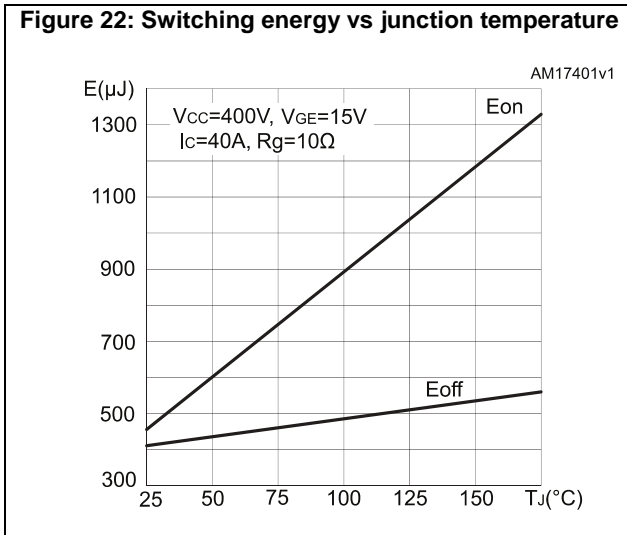
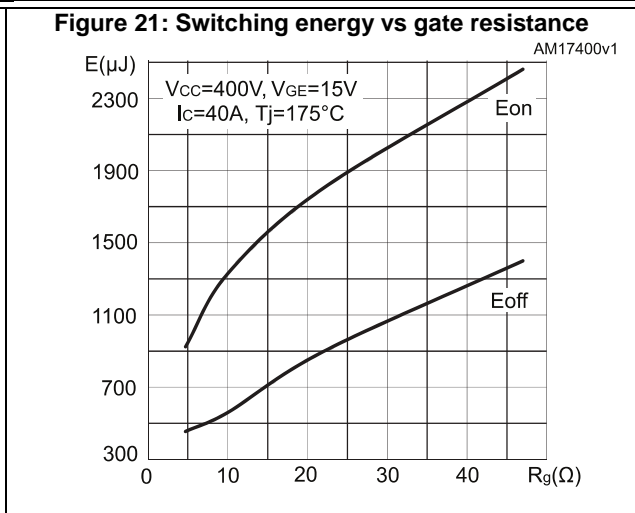
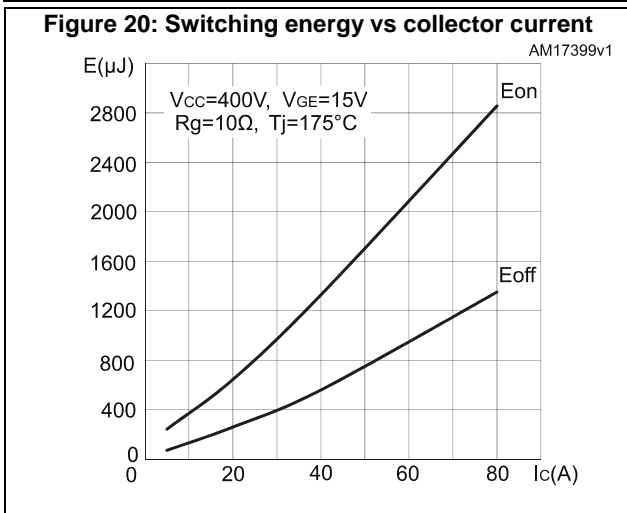


Figure 26: Reverse recovery current vs diode current slope

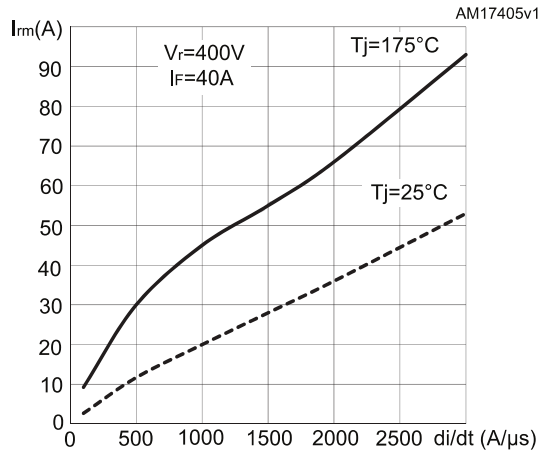


Figure 27: Reverse recovery time vs diode current slope

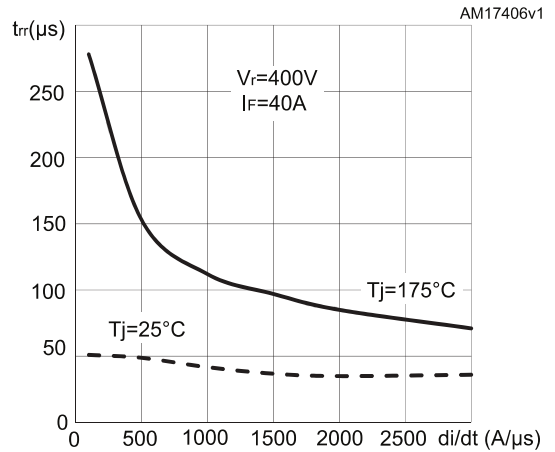


Figure 28: Reverse recovery charge vs diode current slope

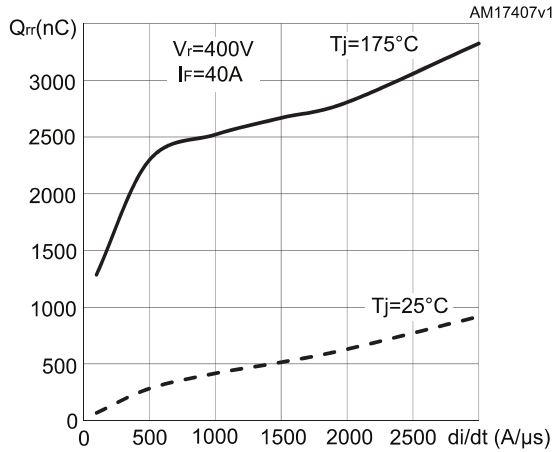


Figure 29: Reverse recovery energy vs diode current slope

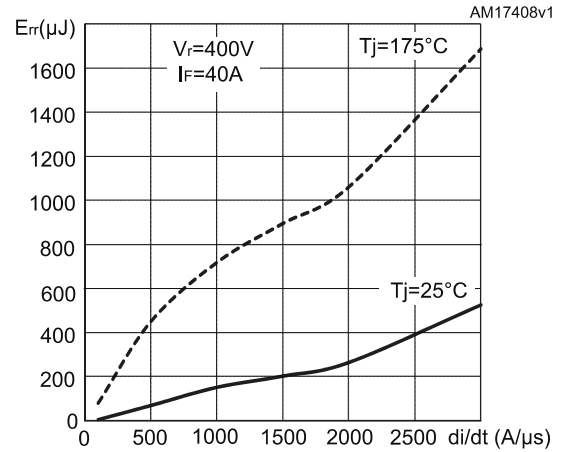


Figure 30: Thermal impedance for IGBT in TO-247 and TO-3P

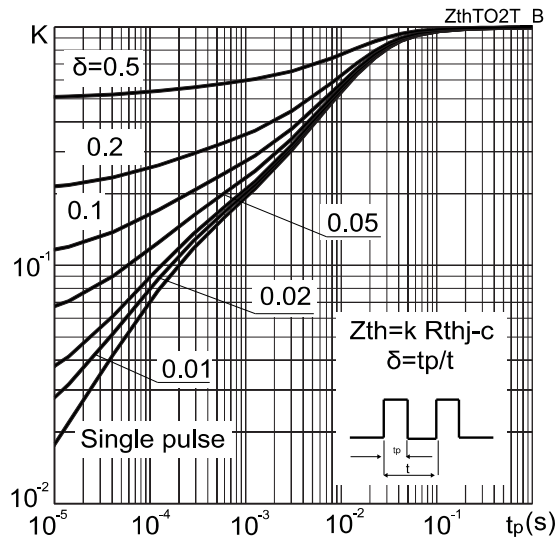


Figure 31: Thermal impedance for IGBT in TO-3PF

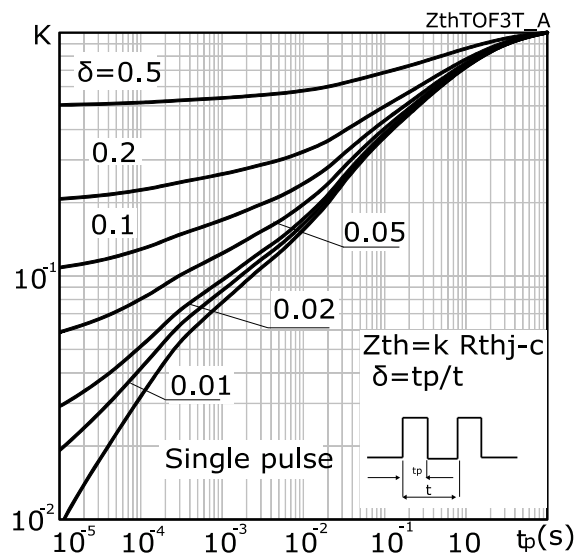


Figure 32: Thermal impedance for diode in TO-247 and TO-3P

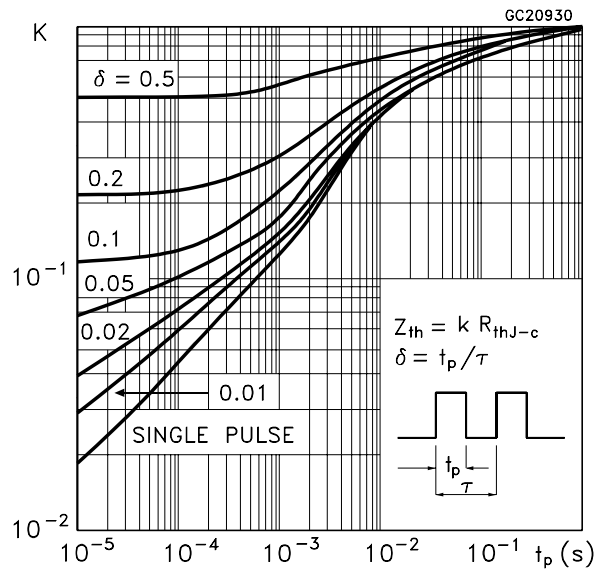
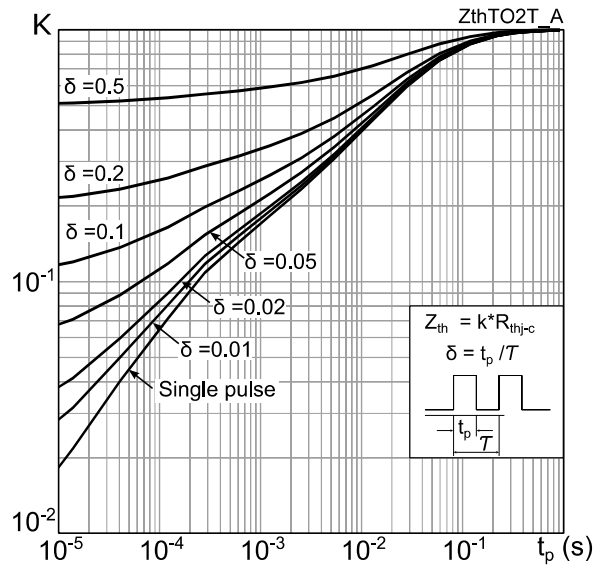
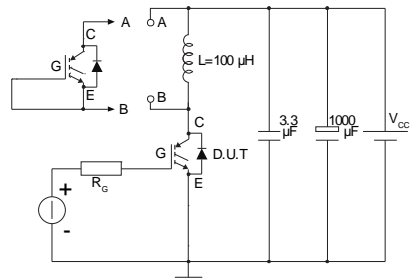


Figure 33: Thermal impedance for diode in TO-3PF



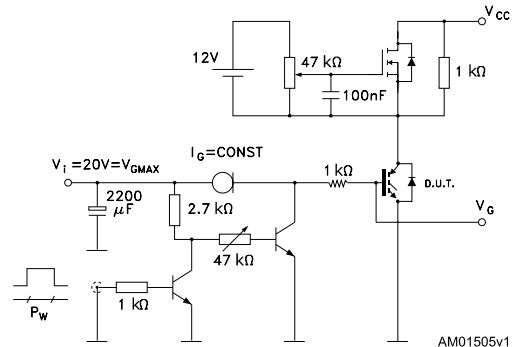
### 3 Test circuits

Figure 34: Test circuit for inductive load switching



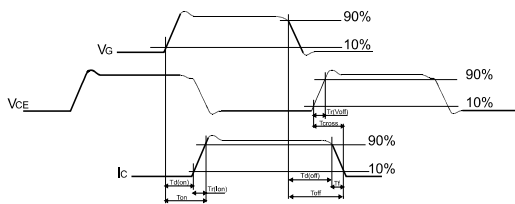
AM01504v1

Figure 35: Gate charge test circuit



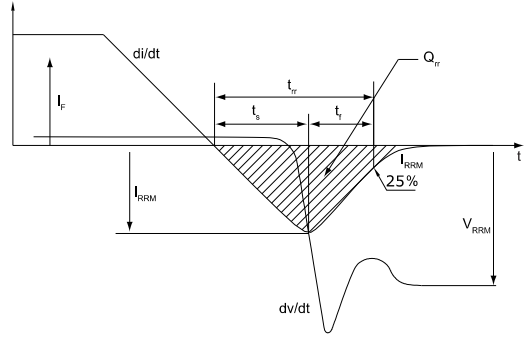
AM01505v1

Figure 36: Switching waveform



AM01506v1

Figure 37: Diode reverse recovery waveform



AM01507v1

## 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](http://www.st.com). ECOPACK® is an ST trademark.

### 4.1 TO-3PF package information

Figure 38: TO-3PF package outline

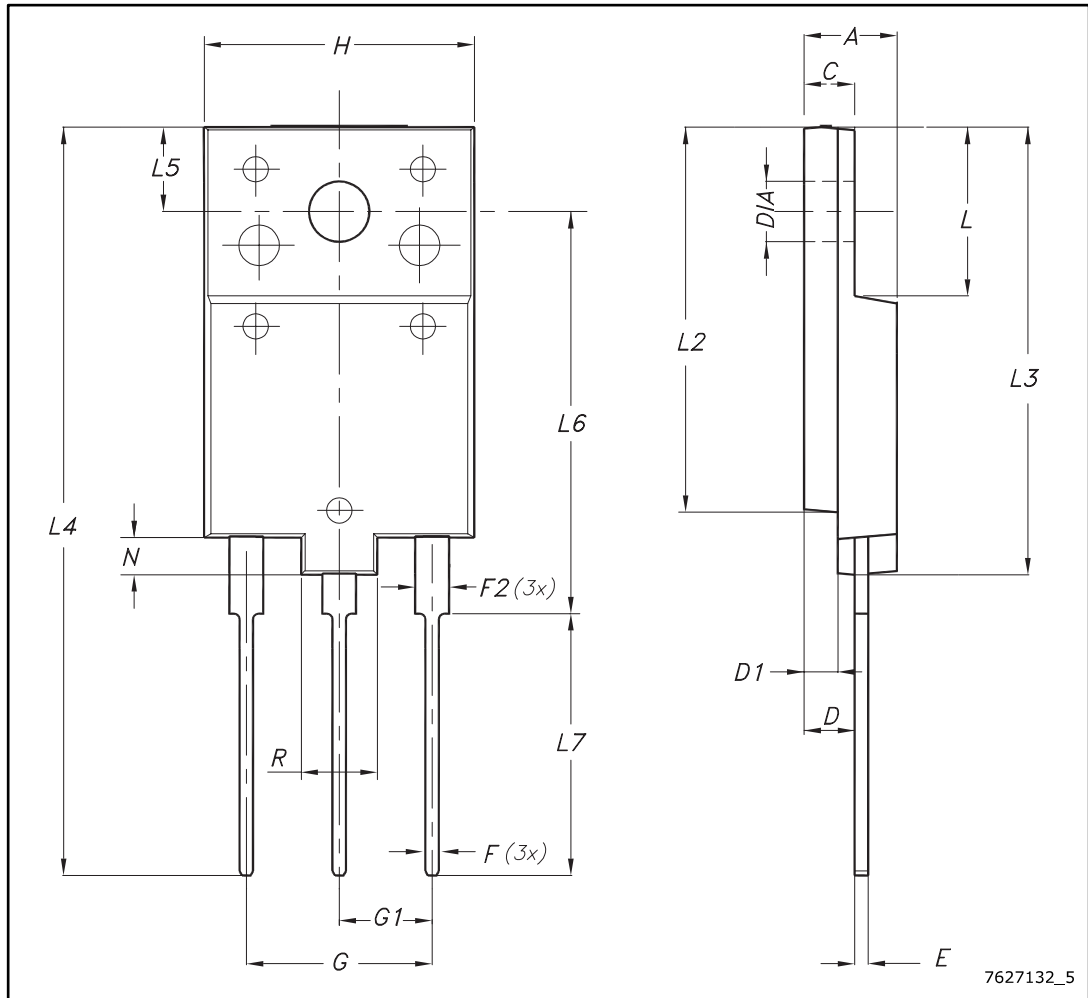


Table 8: TO-3PF mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 5.30  |      | 5.70  |
| C    | 2.80  |      | 3.20  |
| D    | 3.10  |      | 3.50  |
| D1   | 1.80  |      | 2.20  |
| E    | 0.80  |      | 1.10  |
| F    | 0.65  |      | 0.95  |
| F2   | 1.80  |      | 2.20  |
| G    | 10.30 |      | 11.50 |
| G1   |       | 5.45 |       |
| H    | 15.30 |      | 15.70 |
| L    | 9.80  | 10   | 10.20 |
| L2   | 22.80 |      | 23.20 |
| L3   | 26.30 |      | 26.70 |
| L4   | 43.20 |      | 44.40 |
| L5   | 4.30  |      | 4.70  |
| L6   | 24.30 |      | 24.70 |
| L7   | 14.60 |      | 15    |
| N    | 1.80  |      | 2.20  |
| R    | 3.80  |      | 4.20  |
| Dia  | 3.40  |      | 3.80  |

### 4.2 TO-247 package information

Figure 39: TO-247 package outline

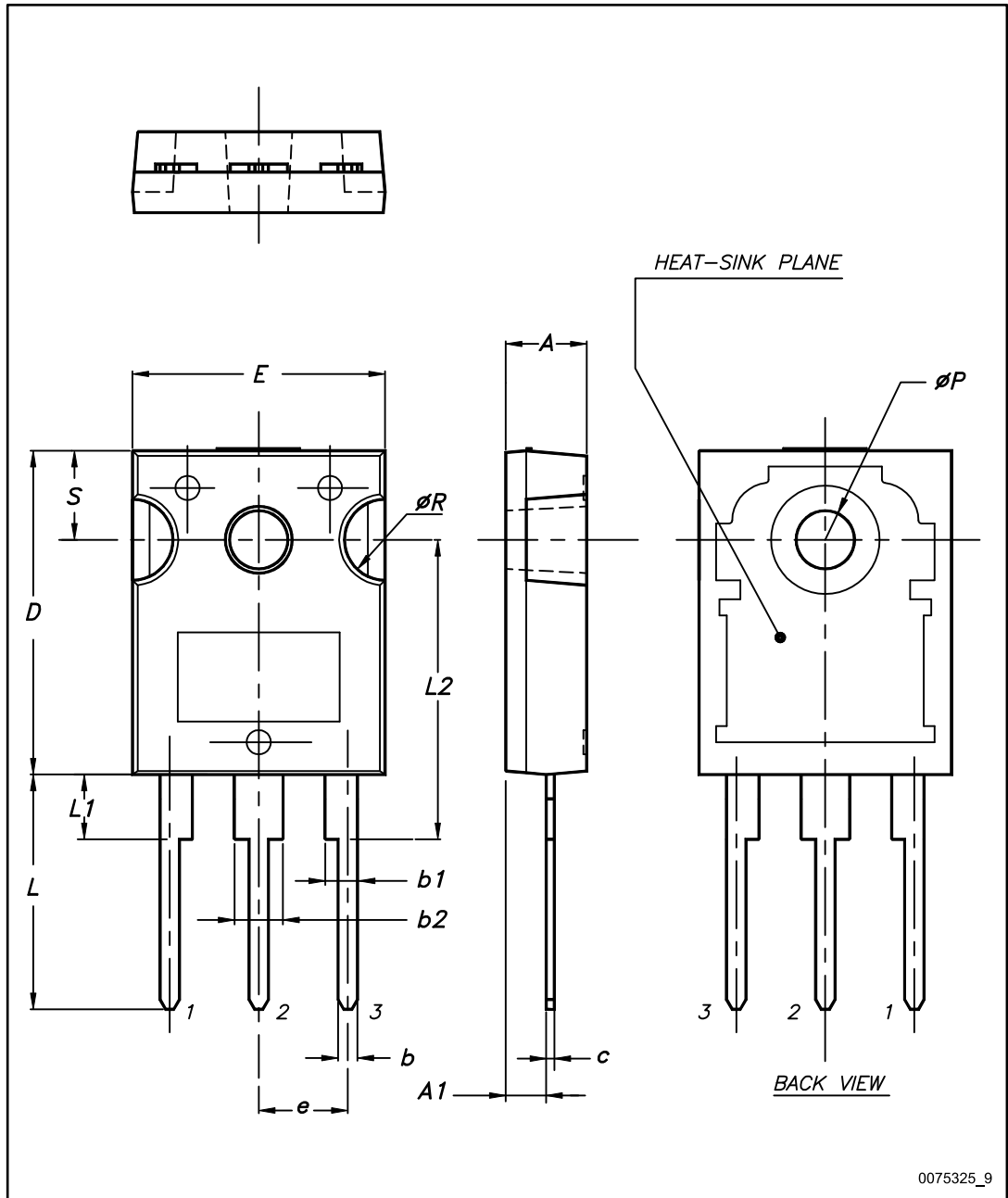




Table 9: TO-247 package mechanical data

| 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  |

### 4.3 TO-3P package information

Figure 40: TO-3P package outline



Table 10: TO-3P package mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.60  | 4.80  | 5.00  |
| A1   | 1.45  | 1.50  | 1.65  |
| A2   | 1.20  | 1.40  | 1.60  |
| b    | 0.80  | 1.00  | 1.20  |
| b1   | 1.80  | 2.00  | 2.20  |
| b2   | 2.80  | 3.00  | 3.20  |
| c    | 0.55  | 0.60  | 0.75  |
| D    | 19.70 | 19.90 | 20.10 |
| D1   | 13.70 | 13.90 | 14.10 |
| E    | 15.40 | 15.60 | 15.80 |
| E1   | 13.40 | 13.60 | 13.80 |
| E2   | 9.40  | 9.60  | 9.90  |
| e    | 5.15  | 5.45  | 5.75  |
| L    | 19.80 | 20.00 | 20.20 |
| L1   | 3.30  | 3.50  | 3.70  |
| L2   | 18.20 | 18.40 | 18.60 |
| ØP   | 3.30  | 3.40  | 3.50  |
| ØP1  | 3.10  | 3.20  | 3.30  |
| Q    | 4.80  | 5.00  | 5.20  |
| Q1   | 3.60  | 3.80  | 4     |

## 5 Revision history

Table 11: Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 20-Mar-2013 | 1        | Initial release  |
| 17-Apr-2013 | 2        | Document status promoted from preliminary data to production data.<br>Added: <i>Section 2.1: Electrical characteristics (curves)</i>   |
| 04-Jun-2013 | 3        | Added minimum and maximum values for $V_{GE(th)}$ in <i>Table 4: Static characteristics</i> .  |
| 11-Sep-2013 | 4        | Updated $V_F$ value in <i>Table 4: Static characteristics</i> .  |
| 08-Oct-2013 | 5        | Updated title, features and description in cover page.   |
| 10-Jan-2014 | 6        | Updated <i>Figure 8: <math>V_{CE(sat)}</math> vs. junction temperature</i> , <i>Figure 15: Diode <math>V_F</math> vs. forward current</i> and <i>Figure 16: Normalized <math>V_{GE(th)}</math> vs junction temperature</i> .   |
| 03-Mar-2014 | 7        | Updated test conditions in <i>Table 7: Diode switching characteristics (inductive load)</i> .  |
| 23-Apr-2014 | 8        | Added new device in TO-3PF.<br>Updated <i>Table 1: Device summary</i> , <i>Table 2: Absolute maximum ratings</i> , <i>Table 3: Thermal data</i> and <i>Section 4: Package mechanical data</i> .<br>Added <i>Figure 4: Power dissipation vs. case temperature for TO-3PF</i> , <i>Figure 5: Collector current vs. case temperature for TO-3PF</i> , <i>Figure 11: Collector current vs. switching frequency for TO-3PF</i> and <i>Figure 12: Forward bias safe operating area for TO-247 and TO-3P</i> .<br>Minor text changes. |
| 27-Oct-2017 | 9        | Updated <i>Table 3: "Thermal data"</i> .<br>Added <i>Figure 33: "Thermal impedance for diode in TO-3PF"</i> .<br>Updated <i>Section 4: "Package information"</i> .<br>Minor text changes   |

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