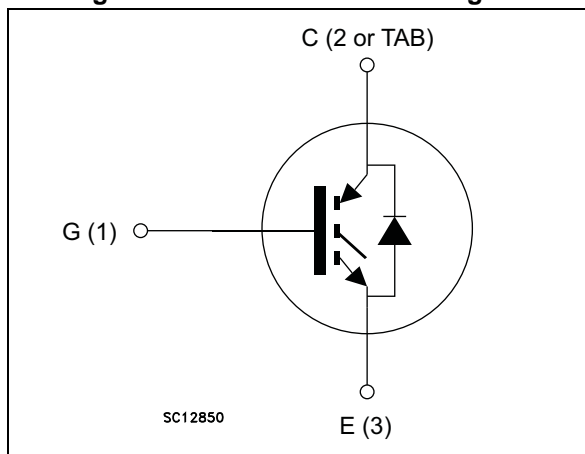


Figure 1. Internal schematic diagram



### Features

- Maximum junction temperature:  $T_J = 175\text{ °C}$
- Tail-less switching off
- $V_{CE(sat)} = 1.85\text{ V (typ.) @ } I_C = 60\text{ A}$
- Tight parameter 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

These devices are IGBTs developed using an advanced proprietary trench gate field-stop structure. These devices are part of the V series of IGBTs, which represents 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           | Packing |
|--------------|------------|-------------------|---------|
| STGW60V60DF  | GW60V60DF  | TO-247            | Tube    |
| STGWA60V60DF | G60V60DF   | TO-247 long leads | Tube    |
| STGWT60V60DF | GWT60V60DF | TO-3P             | Tube    |

# Contents

- 1      Electrical ratings ..... 3**
- 2      Electrical characteristics ..... 4**
  - 2.1    Electrical characteristics (curves) ..... 6
- 3      Test circuits ..... 11**
- 4      Package information ..... 12**
  - 4.1    TO-247 package information ..... 13
  - 4.2    TO-247 long leads package information ..... 15
  - 4.3    TO-3P package information ..... 17
- 5      Revision history ..... 19**

# 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 $T_C = 25\text{ °C}$  | 80 <sup>(1)</sup> | A    |
| $I_C$                   | Continuous collector current at $T_C = 100\text{ °C}$ | 60                | A    |
| $I_{CP}$ <sup>(2)</sup> | Pulsed collector current                              | 240               | A    |
| $V_{GE}$                | Gate-emitter voltage                                  | $\pm 20$          | V    |
| $I_F$                   | Continuous forward current at $T_C = 25\text{ °C}$    | 80 <sup>(1)</sup> | A    |
| $I_F$                   | Continuous forward current at $T_C = 100\text{ °C}$   | 60                | A    |
| $I_{FP}$ <sup>(2)</sup> | Pulsed forward current                                | 240               | A    |
| $P_{TOT}$               | Total dissipation at $T_C = 25\text{ °C}$             | 375               | W    |
| $T_{STG}$               | Storage temperature range                             | - 55 to 150       | °C   |
| $T_J$                   | Operating junction temperature range                  | - 55 to 175       | °C   |

1. Current level is limited by bond wires
2. Pulse width limited by maximum junction temperature.

**Table 3. Thermal data**

| Symbol     | Parameter                              | Value | Unit |
|------------|--|-------|------|
| $R_{thJC}$ | Thermal resistance junction-case IGBT  | 0.4   | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 1.14  | °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                 | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$                          |      | 1.85 | 2.3       | V             |
|               |  | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$<br>$T_J = 125\text{ °C}$ |      | 2.15 |           |               |
|               |  | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$<br>$T_J = 175\text{ °C}$ |      | 2.35 |           |               |
| $V_F$         | Forward on-voltage                                   | $I_F = 60\text{ A}$  |      | 2    | 2.6       | V             |
|               |  | $I_F = 60\text{ A}, T_J = 125\text{ °C}$                           |      | 1.7  |           | V             |
|               |  | $I_F = 60\text{ A}, T_J = 175\text{ °C}$                           |      | 1.6  |           | 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 ( $V_{CE} = 0$ )        | $V_{GE} = \pm 20\text{ V}$   |      |      | $\pm 250$ | 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>$V_{GE} = 0$  | -    | 8000 | -    | pF   |
| $C_{oes}$ | Output capacitance           |  | -    | 280  | -    | pF   |
| $C_{res}$ | Reverse transfer capacitance |  | -    | 170  | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 480\text{ V}, I_C = 60\text{ A},$<br>$V_{GE} = 15\text{ V},$ see <a href="#">Figure 29</a> | -    | 334  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |  | -    | 130  | -    | nC   |
| $Q_{gc}$  | Gate-collector charge        |  | -    | 58   | -    | nC   |

Table 6. IGBT switching characteristics (inductive load)

| Symbol          | Parameter                 | Test conditions  | Min. | Typ. | Max. | Unit       |
|-----------------|---------------------------|--|------|------|------|------------|
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 60\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>see <a href="#">Figure 28</a>                                     | -    | 60   | -    | ns         |
| $t_r$           | Current rise time         |  | -    | 20   | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |  | -    | 2365 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time       |  | -    | 208  | -    | ns         |
| $t_f$           | Current fall time         |  | -    | 14   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy  |  | -    | 0.75 | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy |  | -    | 0.55 | -    | mJ         |
| $E_{ts}$        | Total switching energy    |  | -    | 1.3  | -    | mJ         |
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 60\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a> | -    | 57   | -    | ns         |
| $t_r$           | Current rise time         |  | -    | 23   | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope     |  | -    | 2191 | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time       |  | -    | 216  | -    | ns         |
| $t_f$           | Current fall time         |  | -    | 27   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy  |  | -    | 1.5  | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy |  | -    | 0.8  | -    | mJ         |
| $E_{ts}$        | Total switching energy    |  | -    | 2.3  | -    | mJ         |

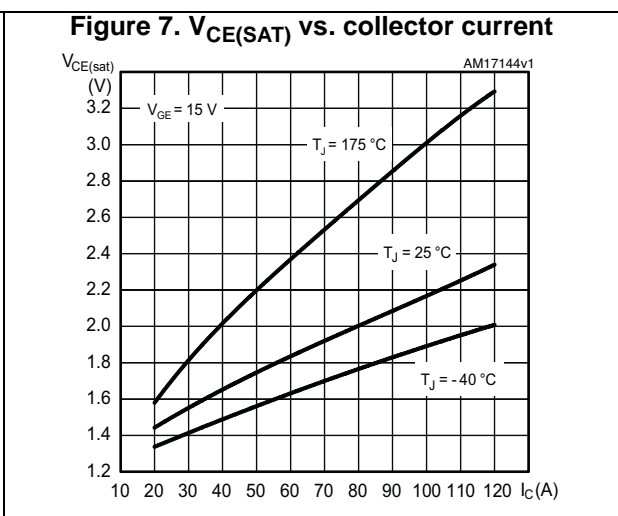
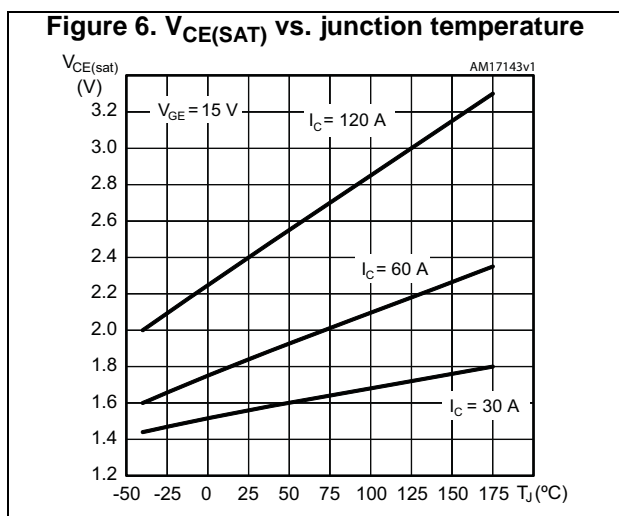
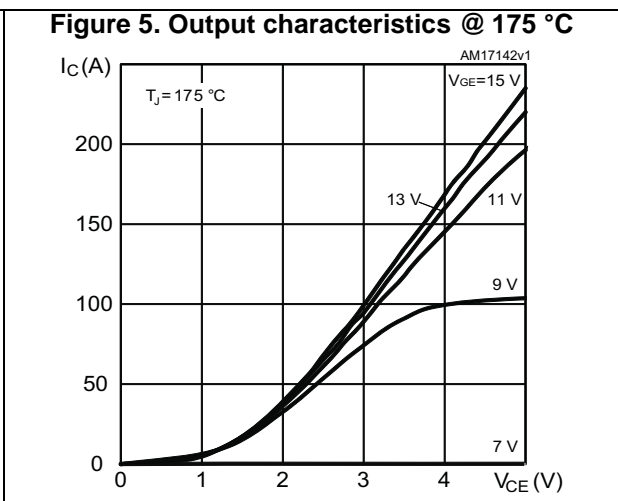
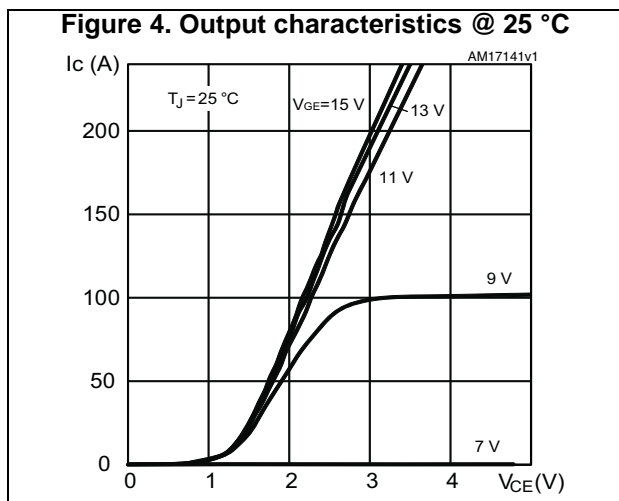
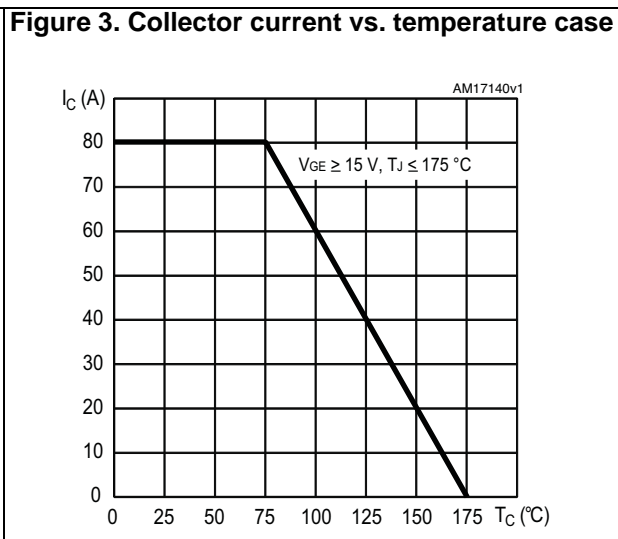
1. Including the reverse recovery of the diode.

2. Including the tail of the collector current.

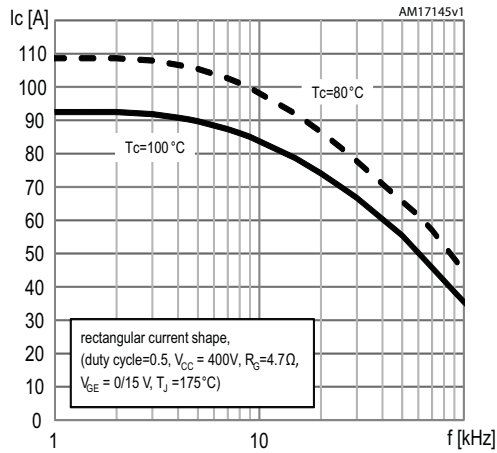
Table 7. Diode switching characteristics (inductive load)

| Symbol       | Parameter  | Test conditions  | Min. | Typ. | Max. | Unit       |
|--------------|--|--|------|------|------|------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 60\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$di_F/dt = 1000\text{ A}/\mu\text{s}$<br>see <a href="#">Figure 28</a>                                     | -    | 74   | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 703  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 19   | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 714  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 184  | -    | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 60\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>$di_F/dt = 1000\text{ A}/\mu\text{s}$<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a> | -    | 131  | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 2816 | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 43   | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 404  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 821  | -    | $\mu$ J    |

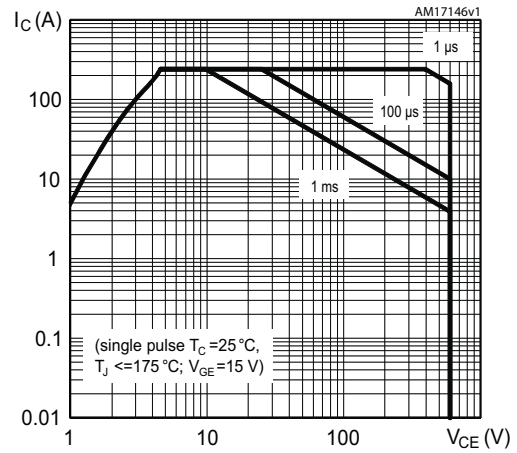
## 2.1 Electrical characteristics (curves)



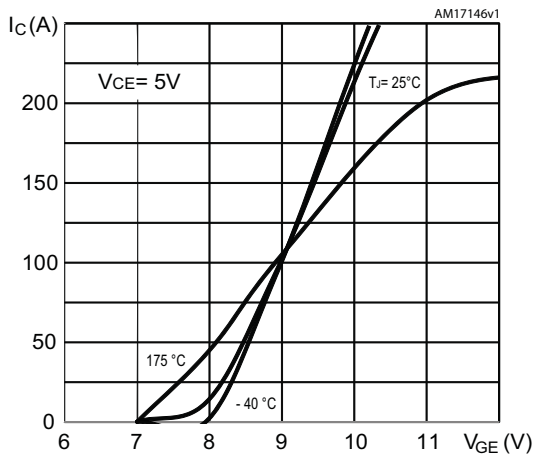
**Figure 8. Collector current vs. switching frequency**



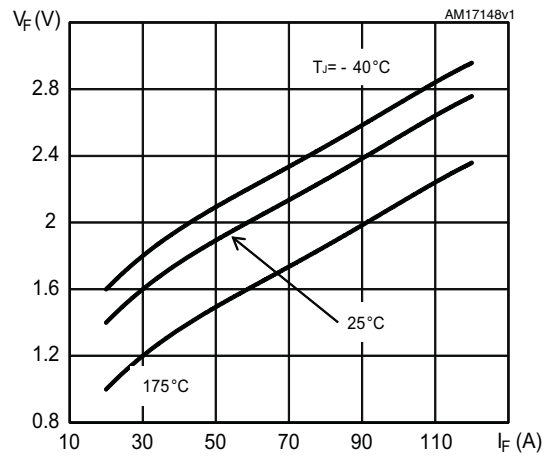
**Figure 9. Safe operating area**



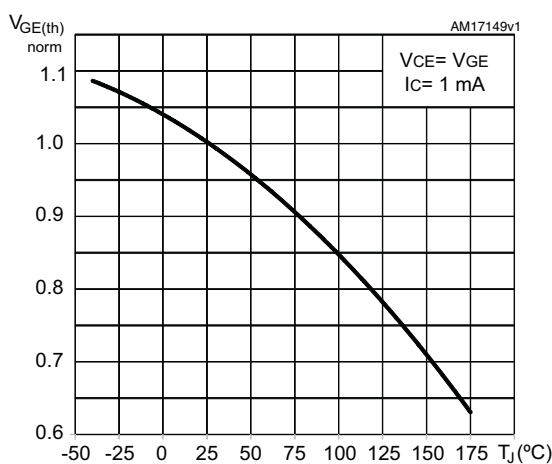
**Figure 10. Transfer characteristics**



**Figure 11. Diode VF vs. forward current**



**Figure 12. Normalized VGE(th) vs. junction temperature**



**Figure 13. Normalized V(BR)CES vs. junction temperature**

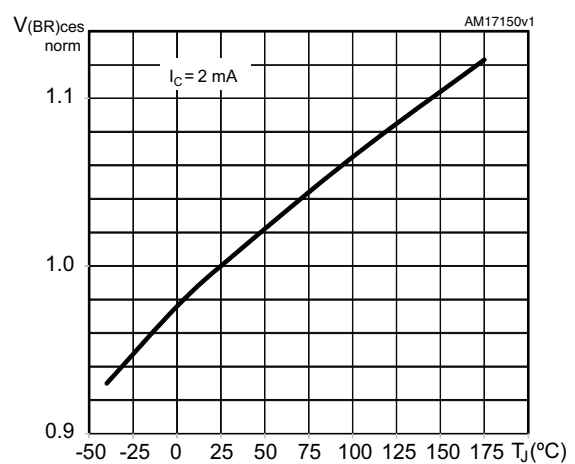






Figure 20. Switching times vs. collector current    Figure 21. Switching times vs. gate resistance

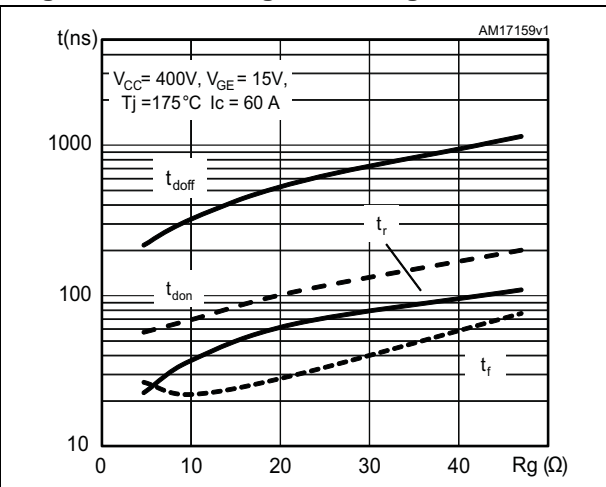
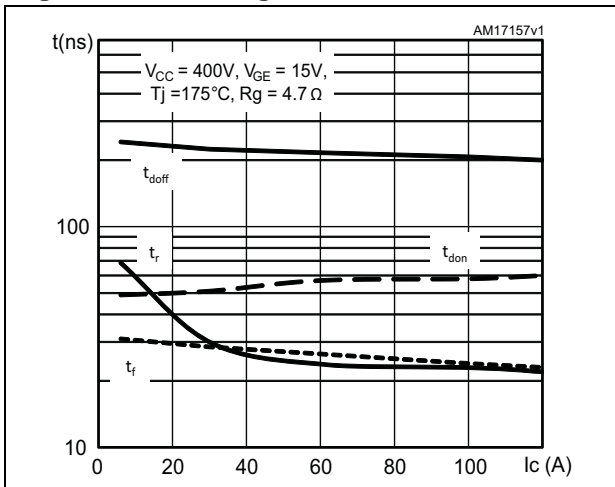


Figure 22. Reverse recovery current vs. diode current slope

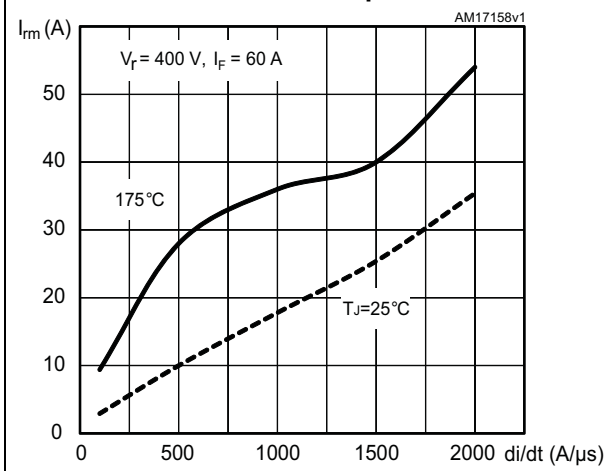


Figure 23. Reverse recovery time vs. diode current slope

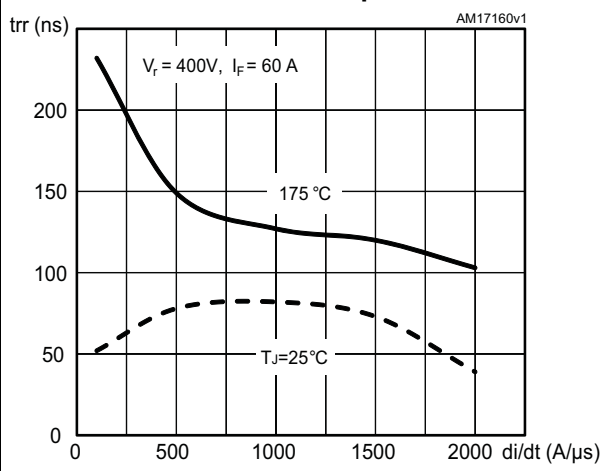


Figure 24. Reverse recovery charge vs. diode current slope

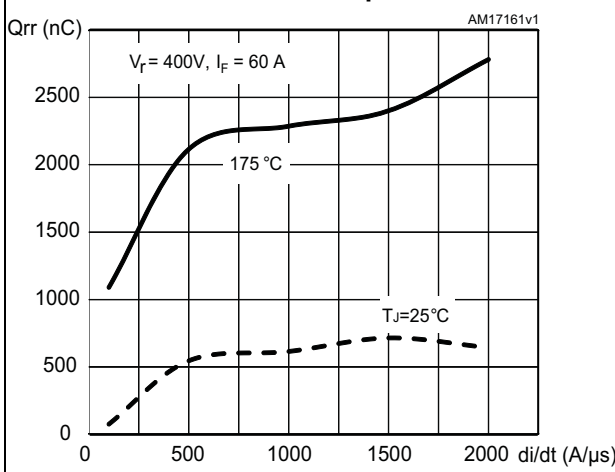


Figure 25. Reverse recovery energy vs. diode current slope

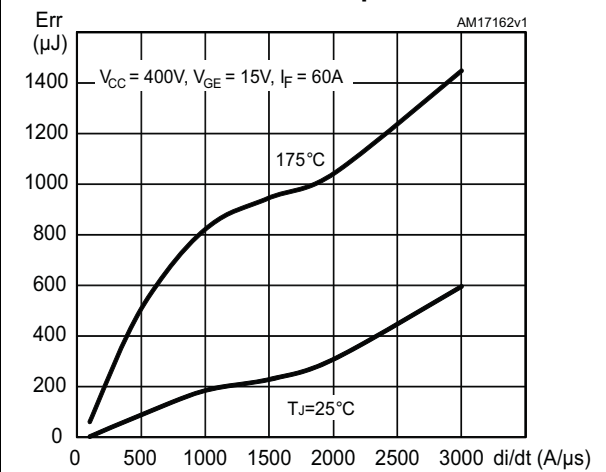


Figure 26. Thermal data for IGBT

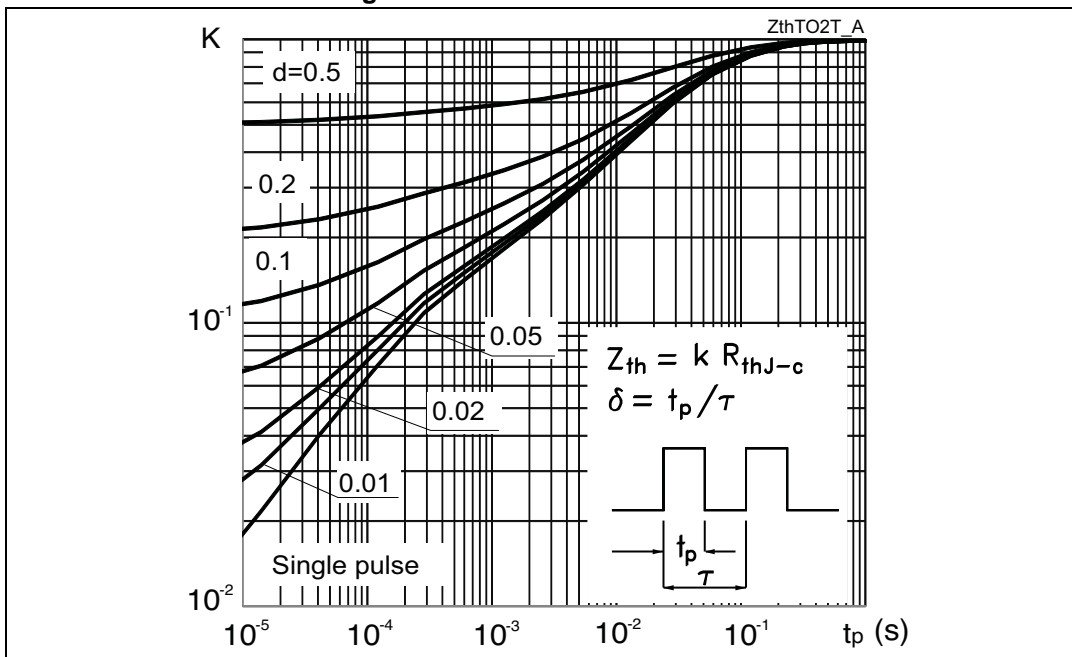
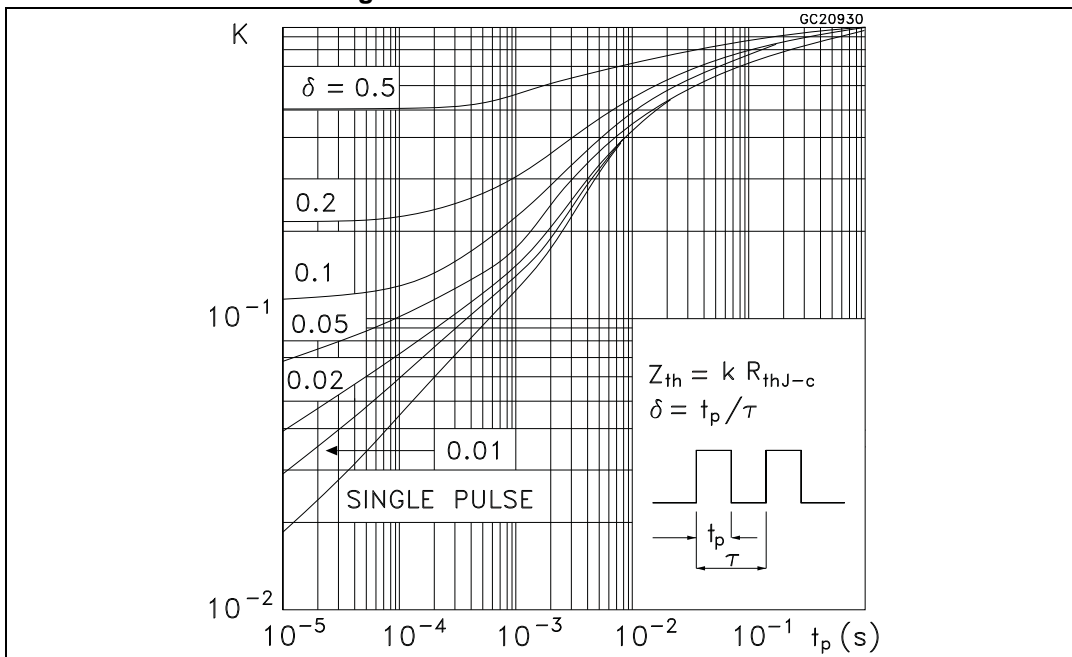
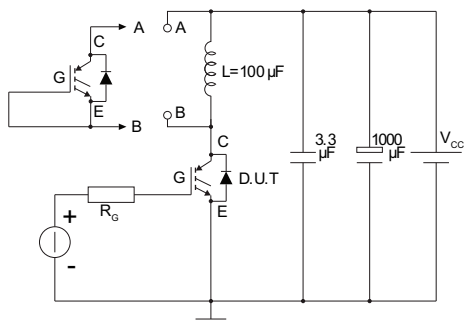


Figure 27. Thermal data for diode



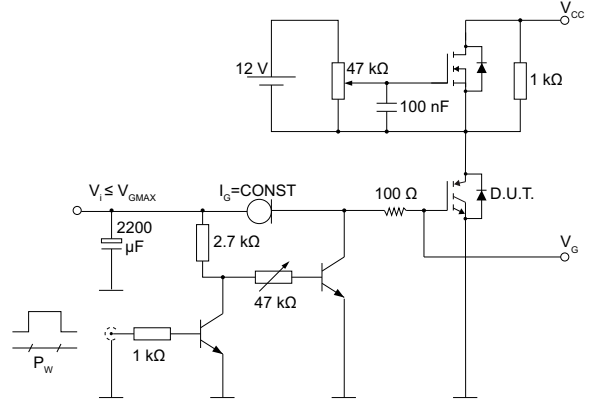
### 3 Test circuits

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



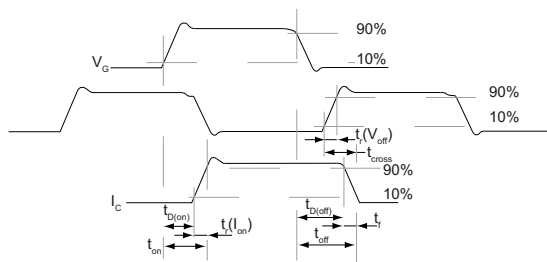
AM01504v1

**Figure 29. Gate charge test circuit**



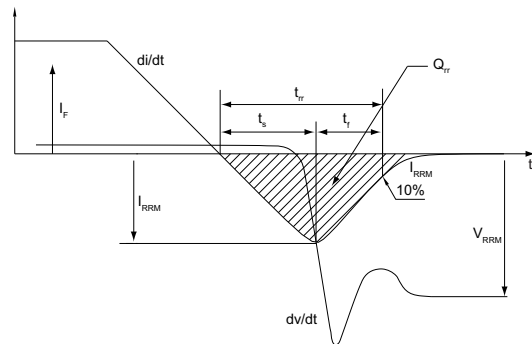
AM01505v1

**Figure 30. Switching waveform**



AM01506v1

**Figure 31. Diode recovery time waveform**



AM01507v1

## 4 Package information

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.

### 4.1 TO-247 package information

Figure 32. TO-247 package outline

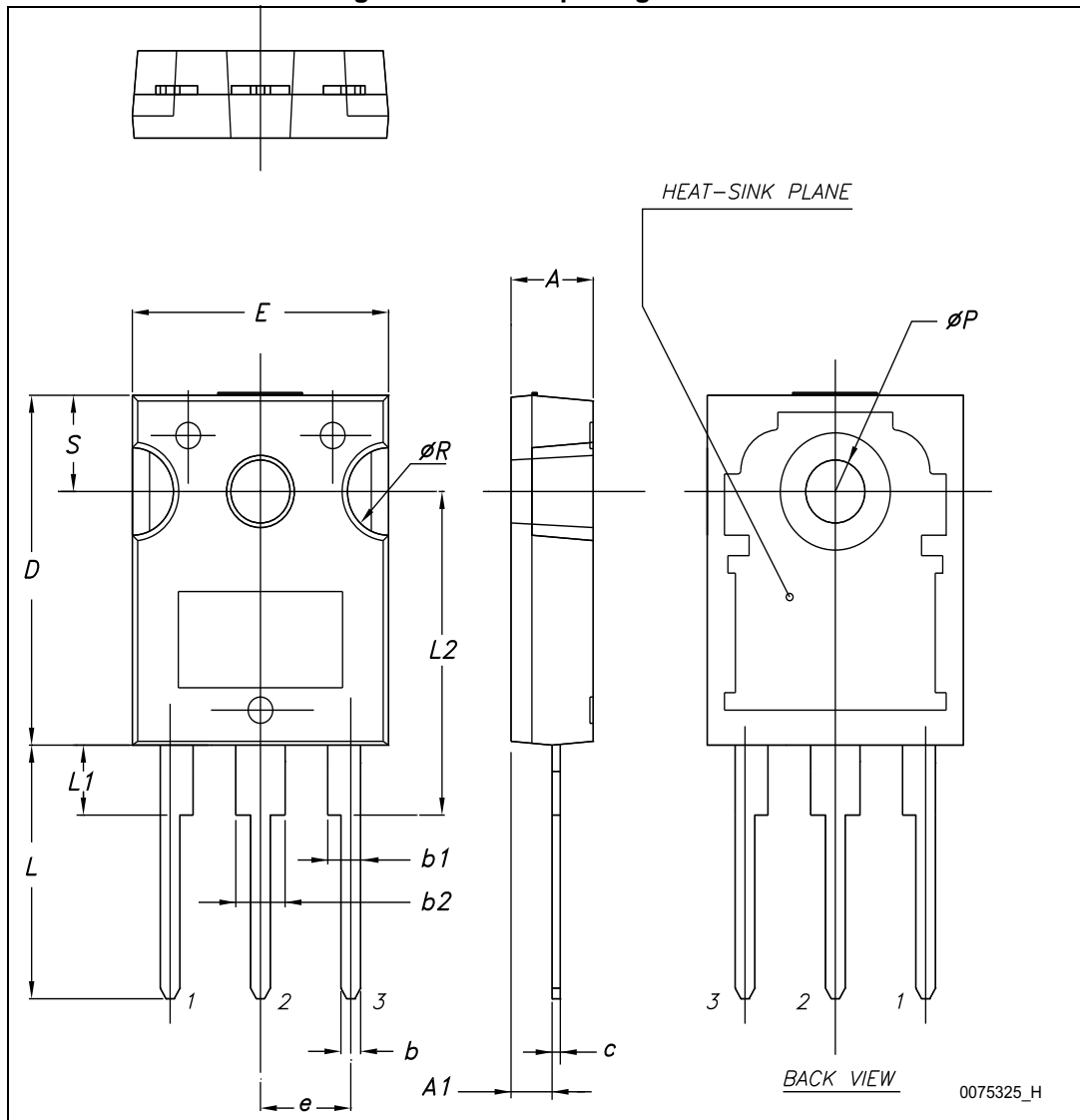


Table 8. TO-247 package mechanical data

| 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  |

### 4.2 TO-247 long leads package information

Figure 33. TO-247 long leads package outline



8463846\_A\_F

Table 9. TO-247 long leads package mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.90  | 5.00  | 5.10  |
| A1   | 2.31  | 2.41  | 2.51  |
| A2   | 1.90  | 2.00  | 2.10  |
| b    | 1.16  |       | 1.26  |
| b2   |       |       | 3.25  |
| b3   |       |       | 2.25  |
| c    | 0.59  |       | 0.66  |
| D    | 20.90 | 21.00 | 21.10 |
| E    | 15.70 | 15.80 | 15.90 |
| E2   | 4.90  | 5.00  | 5.10  |
| E3   | 2.40  | 2.50  | 2.60  |
| e    | 5.34  | 5.44  | 5.54  |
| L    | 19.80 | 19.92 | 20.10 |
| L1   |       |       | 4.30  |
| P    | 3.50  | 3.60  | 3.70  |
| Q    | 5.60  |       | 6.00  |
| S    | 6.05  | 6.15  | 6.25  |



### 4.3 TO-3P package information

Figure 34. TO-3P package outline

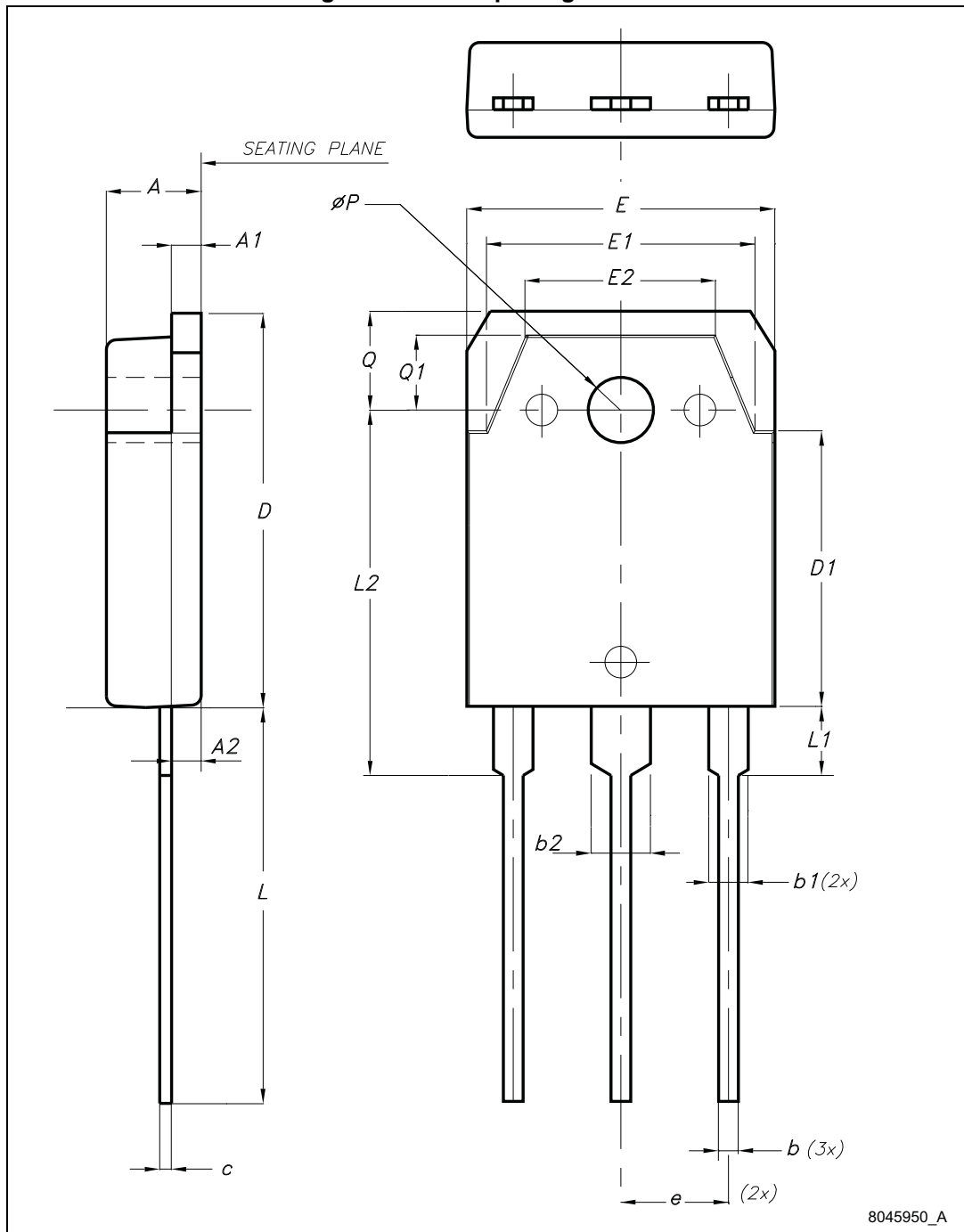


Table 10. TO-3P mechanical data

| 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  |       |

## 5 Revision history

Table 11. Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 15-Jan-2013 | 1        | Initial release.  |
| 23-Apr-2013 | 2        | Added: <ul style="list-style-type: none"> <li>– New order code STGWT60V60DF and new package mechanical data TO-3P <i>Table 9 on page 16, Figure 33 on page 15.</i></li> <li>– <i>Section 2.1: Electrical characteristics (curves) on page 6.</i></li> </ul> |
| 04-Jun-2013 | 3        | Updated <i>Table 4: Static characteristics</i> and <i>Figure 12 on page 7.</i><br>Document status changed from preliminary to production data.  |
| 21-Jun-2013 | 4        | Updated <i>Figure 3: Collector current vs. temperature case.</i>  |
| 12-Jul-2013 | 5        | Updated $R_{thJC}$ value for Diode in <i>Table 3: Thermal data.</i>   |
| 21-Oct-2013 | 6        | Updated title, features and description in cover page.  |
| 28-Sep-2016 | 7        | Added part number STGWA60V60DF and <i>TO-247 long leads package information.</i><br>Updated <i>Table 2 Table 4</i> and <i>Table 6.</i><br>Updated <i>Figure 10: Transfer characteristics.</i><br>Minor text changes.  |

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