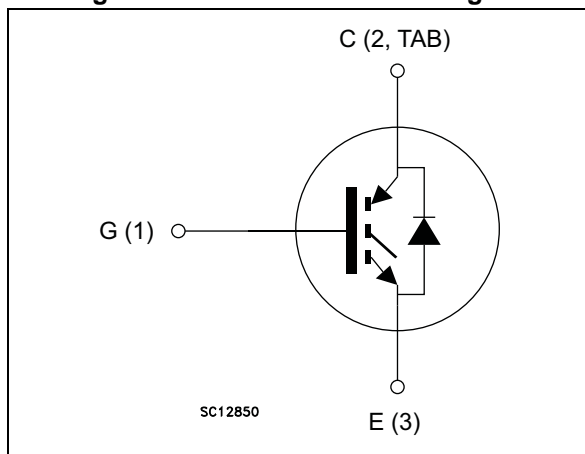


Figure 1. Internal schematic diagram



### Features

- Maximum junction temperature:  $T_J = 175\text{ °C}$
- High speed switching series
- Minimized tail current
- $V_{CE(sat)} = 1.6\text{ V (typ.) @ } I_C = 60\text{ A}$
- Tight parameters distribution
- Safe paralleling
- Low thermal resistance
- Very fast soft recovery antiparallel diode

### Applications

- Photovoltaic inverters
- High frequency converters

### Description

These are IGBT devices developed using an advanced proprietary trench gate and field-stop structure. The devices are part of the new HB series of IGBTs, which represent an optimum compromise between conduction and switching losses to maximize the efficiency of any frequency converter. Furthermore, a slightly 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 |
|---------------|-------------|-------------------|---------|
| STGW60H65DFB  | GW60H65DFB  | TO-247            | Tube    |
| STGWA60H65DFB | G60H65DFB   | TO-247 long leads | Tube    |
| STGWT60H65DFB | GWT60H65DFB | TO-3P             | Tube    |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                  | Parameter   | Value             | Unit |
|-------------------------|---|-------------------|------|
| $V_{CES}$               | Collector-emitter voltage ( $V_{GE} = 0$ )            | 650               | 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    |
| $P_{TOT}$               | Total dissipation at $T_C = 25\text{ °C}$             | 375               | W    |
| $T_{STG}$               | Storage temperature range                             | - 55 to 150       | °C   |
| $T_J$                   | Operating junction temperature                        | - 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 ( $V_{GE} = 0$ ) | $I_C = 2\text{ mA}$  | 650  |      |           | V             |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage                 | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$                          |      | 1.60 | 2         | V             |
|               |  | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$<br>$T_J = 125\text{ °C}$ |      | 1.75 |           |               |
|               |  | $V_{GE} = 15\text{ V}, I_C = 60\text{ A}$<br>$T_J = 175\text{ °C}$ |      | 1.85 |           |               |
| $V_F$         | 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 ( $V_{GE} = 0$ )           | $V_{CE} = 650\text{ V}$  |      |      | 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>$V_{GE} = 0$  | -    | 7792 | -    | pF   |
| $C_{oes}$ | Output capacitance           |  | -    | 262  | -    | pF   |
| $C_{res}$ | Reverse transfer capacitance |  | -    | 158  | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 520\text{ V}, I_C = 60\text{ A},$<br>$V_{GE} = 15\text{ V},$ see <a href="#">Figure 29</a> | -    | 306  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |  | -    | 126  | -    | 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>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>see <a href="#">Figure 28</a>                                     | -    | 66   |         | ns         |    |
| $t_r$           | Current rise time         |   | -    | 38   | -       | ns         |    |
| $(di/dt)_{on}$  | Turn-on current slope     |   | -    | 1216 |         | A/ $\mu$ s |    |
| $t_{d(off)}$    | Turn-off delay time       |   |      |      | 210     |            | ns |
| $t_f$           | Current fall time         |   | -    | 20   | -       | ns         |    |
| $E_{on}^{(1)}$  | Turn-on switching losses  |   | -    | 1590 | -       | $\mu$ J    |    |
| $E_{off}^{(2)}$ | Turn-off switching losses |   | -    | 900  | -       | $\mu$ J    |    |
| $E_{ts}$        | Total switching losses    | -   | 2490 | -    | $\mu$ J |            |    |
| $t_{d(on)}$     | Turn-on delay time        | $V_{CE} = 400\text{ V}$ , $I_C = 60\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a> | -    | 59   |         | ns         |    |
| $t_r$           | Current rise time         |   | -    | 40   | -       | ns         |    |
| $(di/dt)_{on}$  | Turn-on current slope     |   | -    | 1230 |         | A/ $\mu$ s |    |
| $t_{d(off)}$    | Turn-off delay time       |   |      |      | 242     |            | ns |
| $t_f$           | Current fall time         |   | -    | 147  | -       | ns         |    |
| $E_{on}^{(1)}$  | Turn-on switching losses  |   | -    | 2860 | -       | $\mu$ J    |    |
| $E_{off}^{(2)}$ | Turn-off switching losses |   | -    | 1255 | -       | $\mu$ J    |    |
| $E_{ts}$        | Total switching losses    | -   | 4115 | -    | $\mu$ 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                                      | $I_F = 60\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_{GE} = 15\text{ V}$ ,<br>see <a href="#">Figure 28</a>                                     | -    | 60   | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 99   | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 3.3  | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 187  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 68   | -    | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 60\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 175\text{ }^\circ\text{C}$ , see <a href="#">Figure 28</a> | -    | 310  | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |  | -    | 1550 | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |  | -    | 10   | -    | A          |
| $dl_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |  | -    | 59   | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |  | -    | 674  | -    | $\mu$ J    |

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics ( $T_J = 25^\circ\text{C}$ )

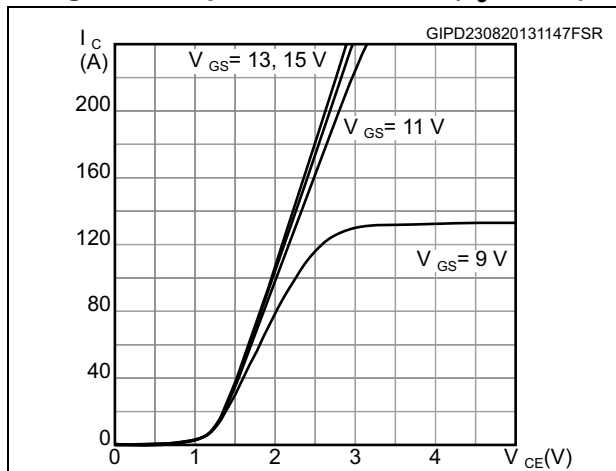


Figure 3. Output characteristics ( $T_J = 175^\circ\text{C}$ )

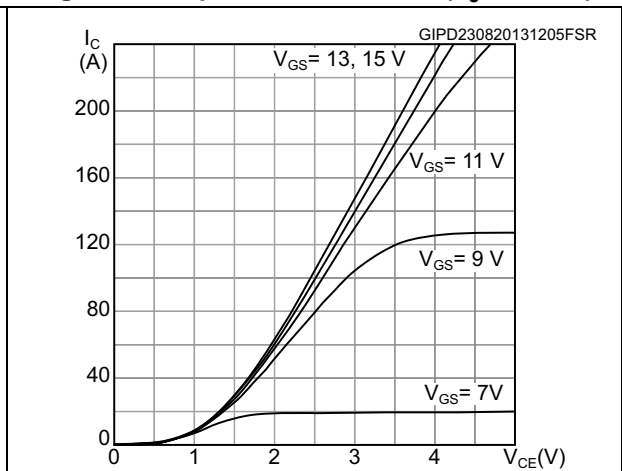


Figure 4. Transfer characteristics

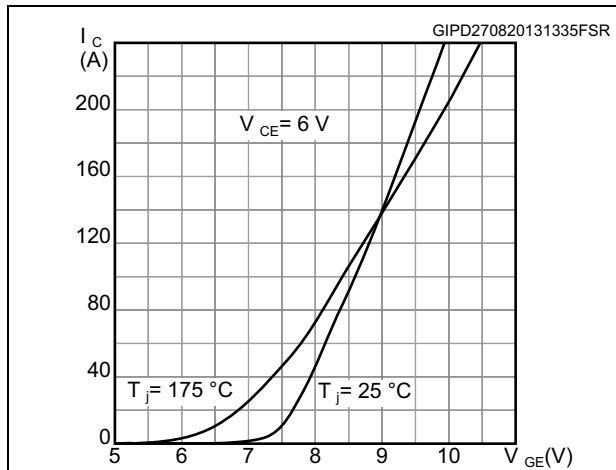


Figure 5. Collector current vs. case temperature

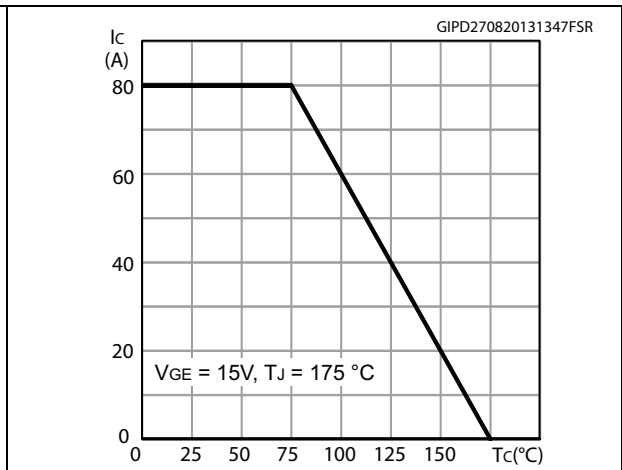


Figure 6. Power dissipation vs. case temperature

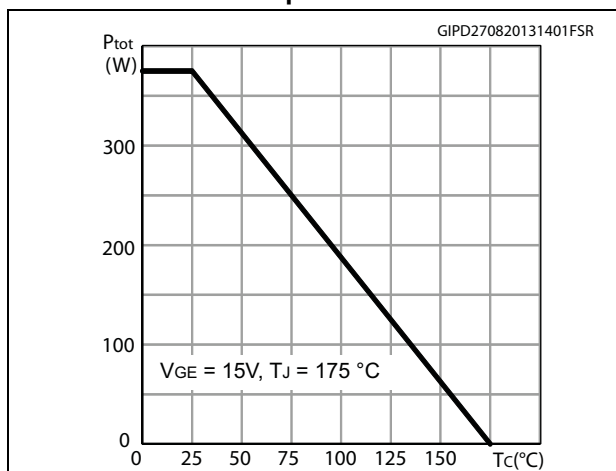


Figure 7.  $V_{CE(sat)}$  vs. junction temperature

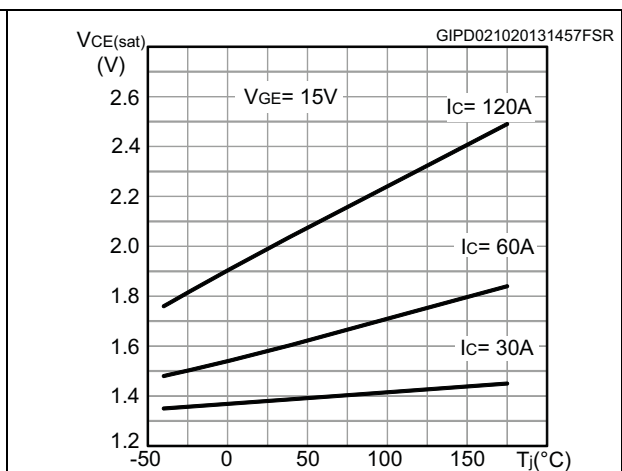


Figure 8.  $V_{CE(sat)}$  vs. collector current

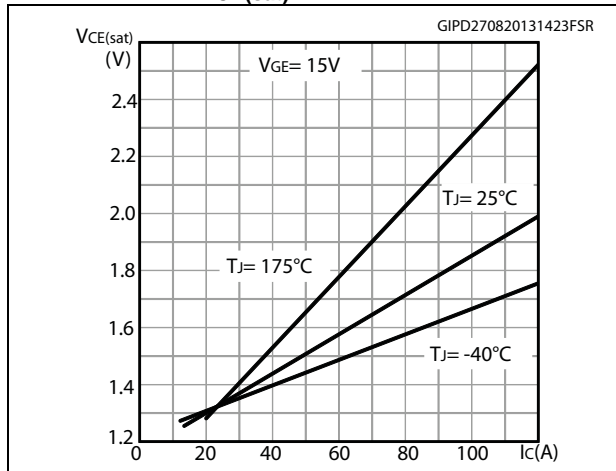


Figure 9. Forward bias safe operating area

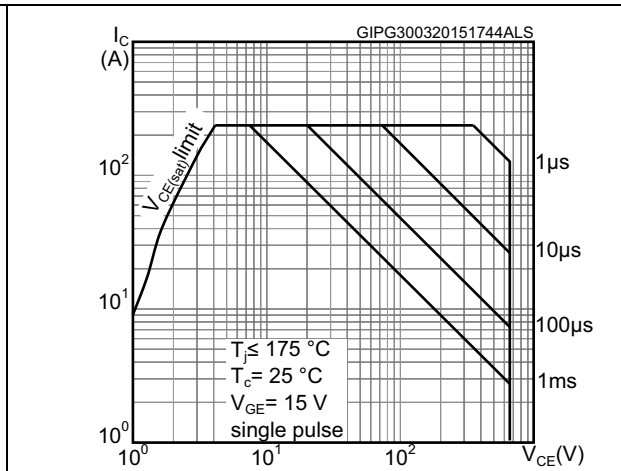


Figure 10. Diode  $V_F$  vs. forward current

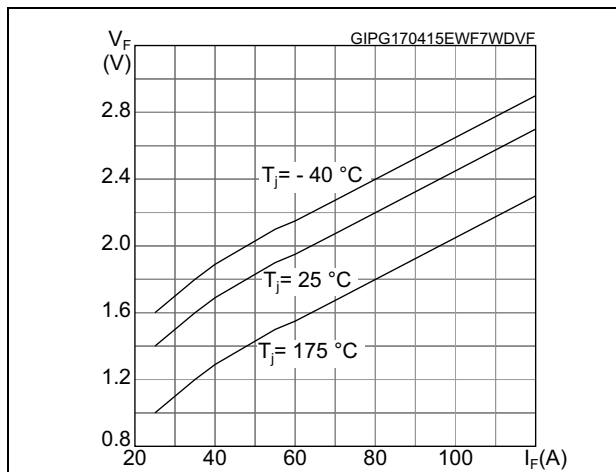


Figure 11. Normalized  $V_{(BR)CES}$  vs. junction temperature

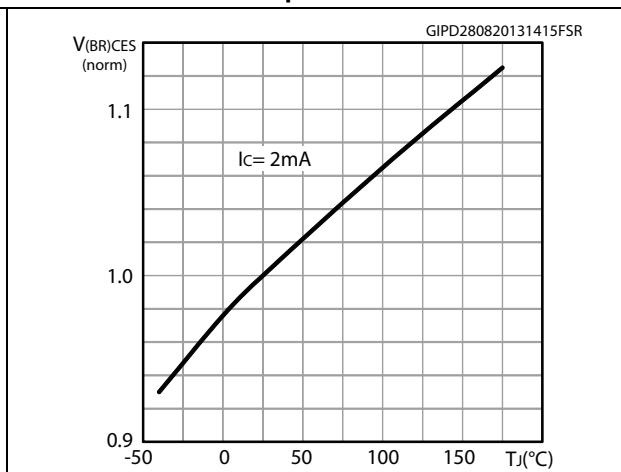


Figure 12. Normalized  $V_{GE(th)}$  vs. junction temperature

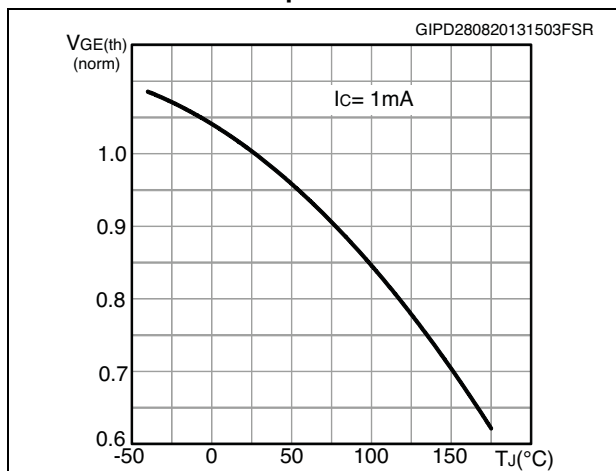


Figure 13. Gate charge vs. gate-emitter voltage

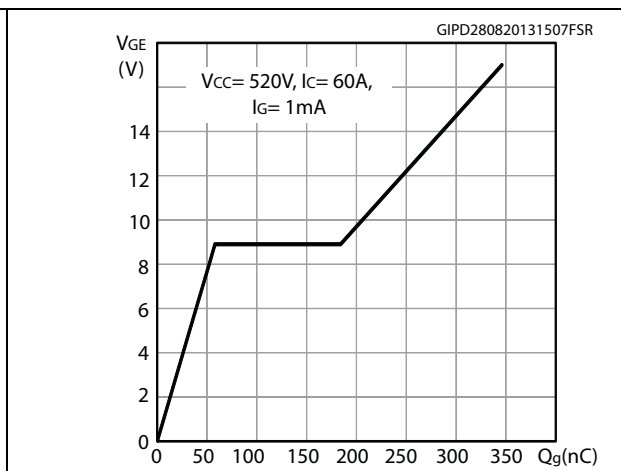


Figure 14. Switching losses vs temperature

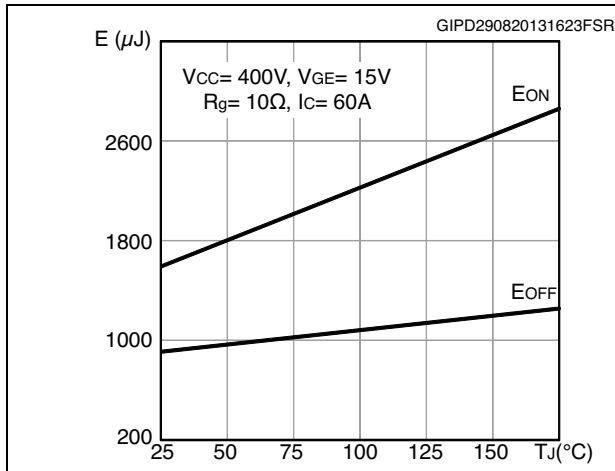


Figure 15. Switching losses vs gate resistance

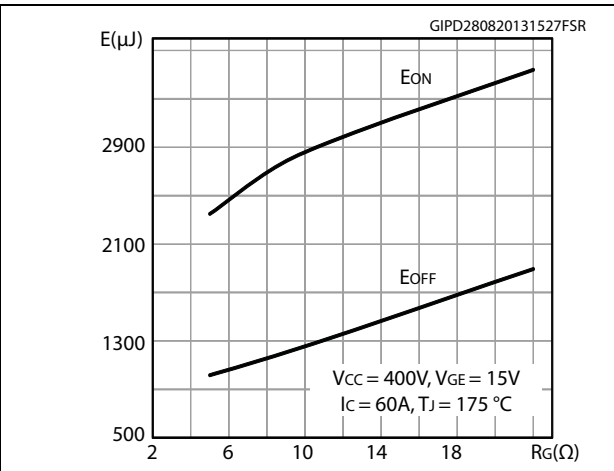


Figure 16. Switching losses vs collector current

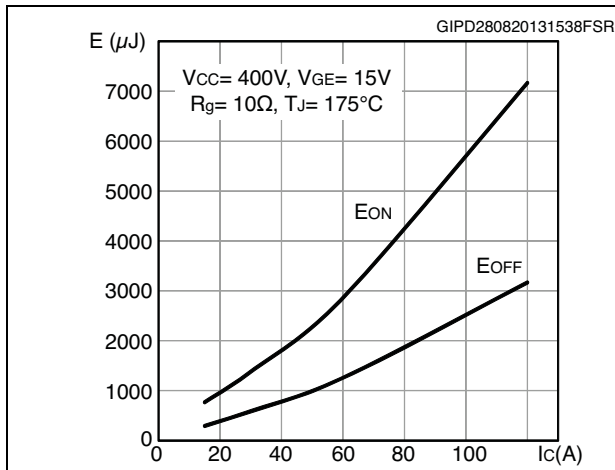


Figure 17. Switching losses vs collector emitter voltage

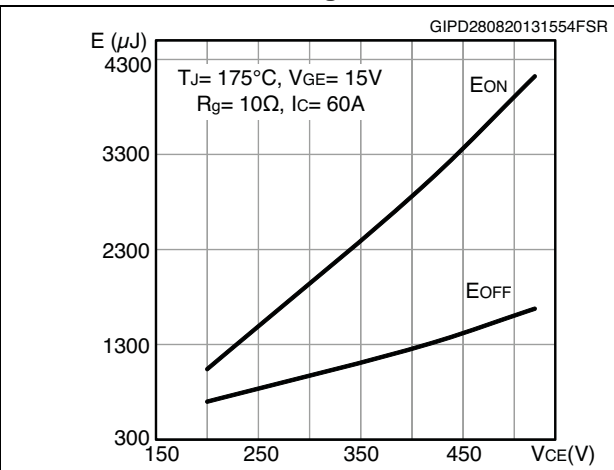


Figure 18. Switching times vs collector current

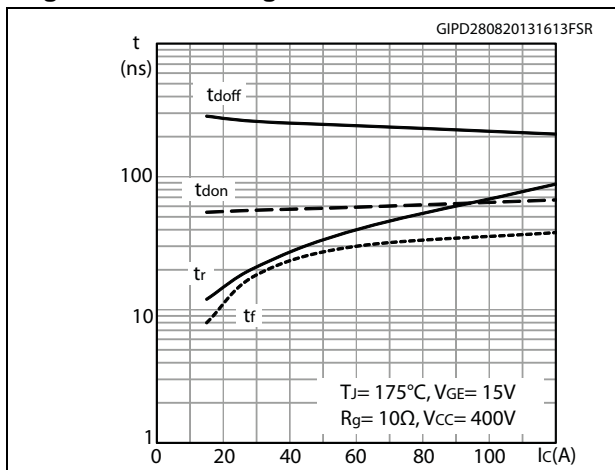


Figure 19. Switching times vs gate resistance

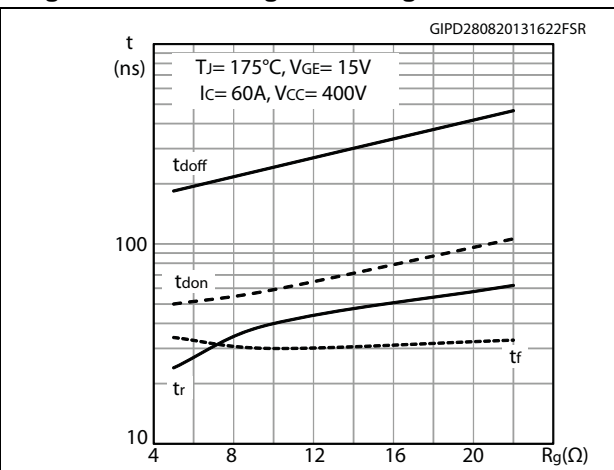




Figure 20. Reverse recovery current vs. diode current slope

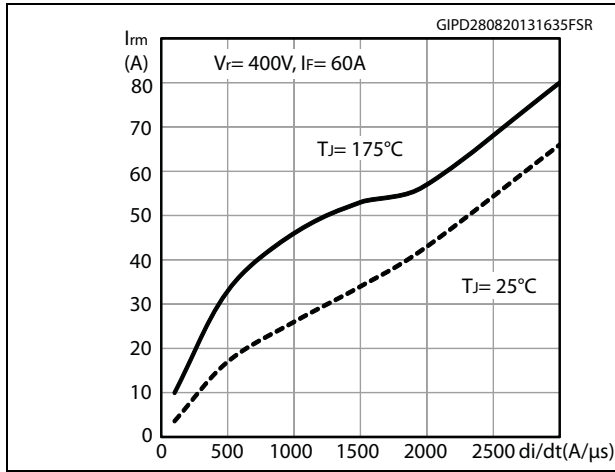


Figure 21. Reverse recovery time vs. diode current slope

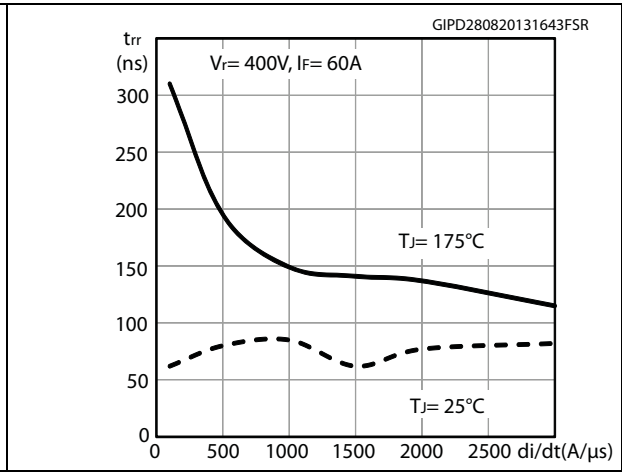


Figure 22. Reverse recovery charge vs. diode current slope

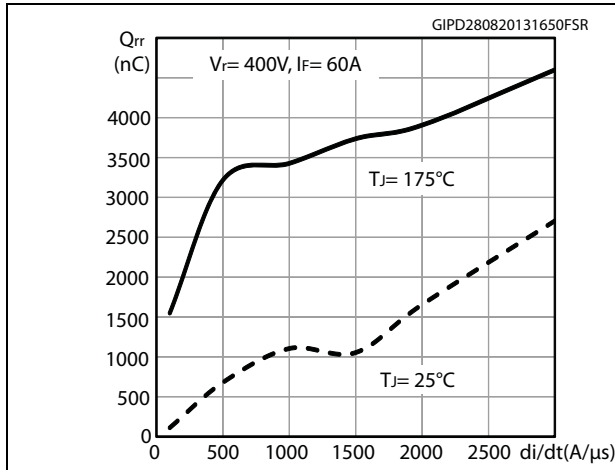


Figure 23. Reverse recovery energy vs. diode current slope

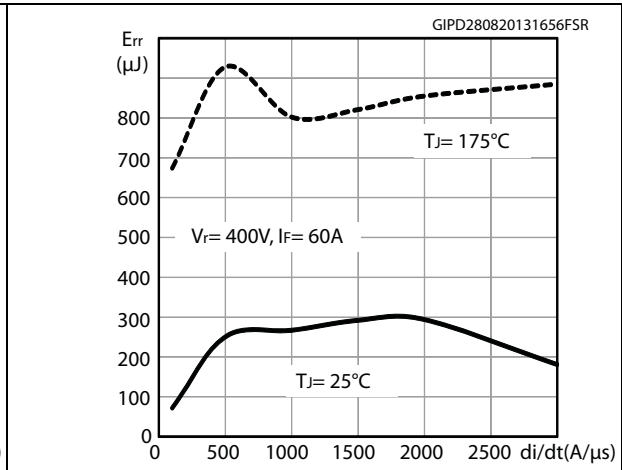


Figure 24. Capacitance variations

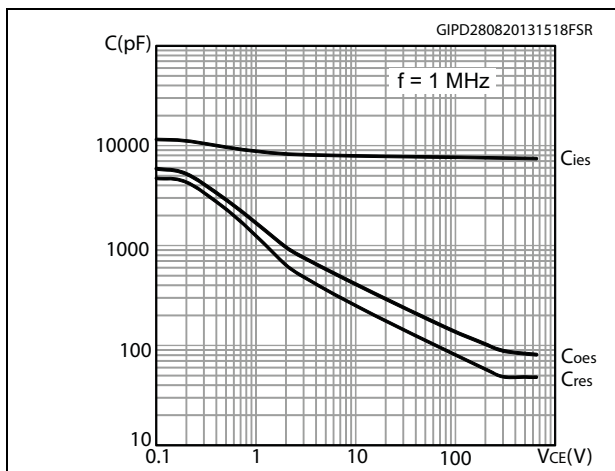


Figure 25. Collector current vs. switching frequency

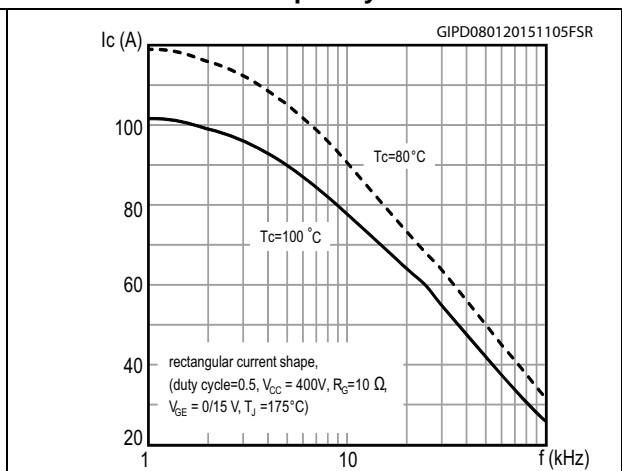


Figure 26. Thermal impedance for IGBT

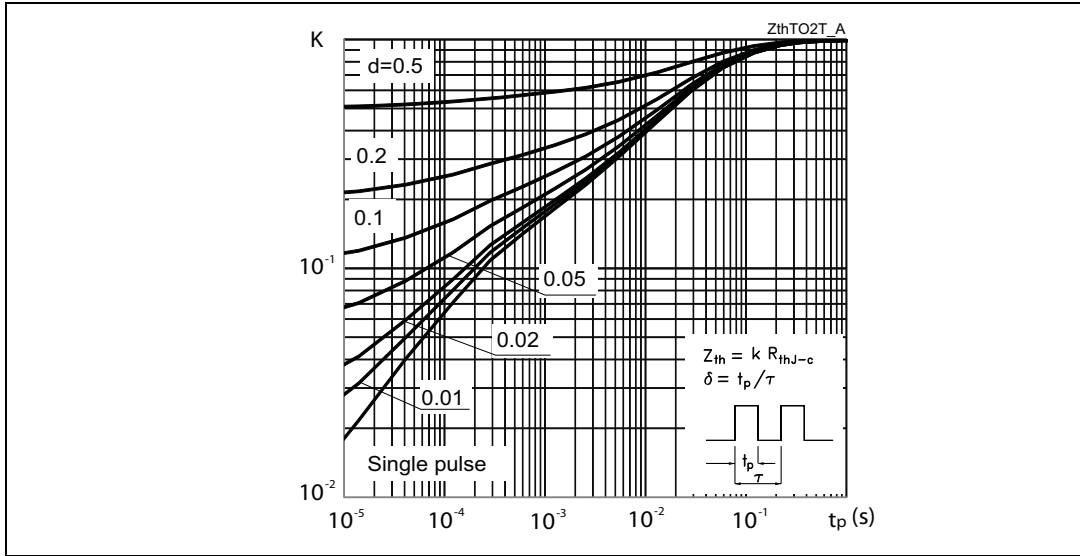
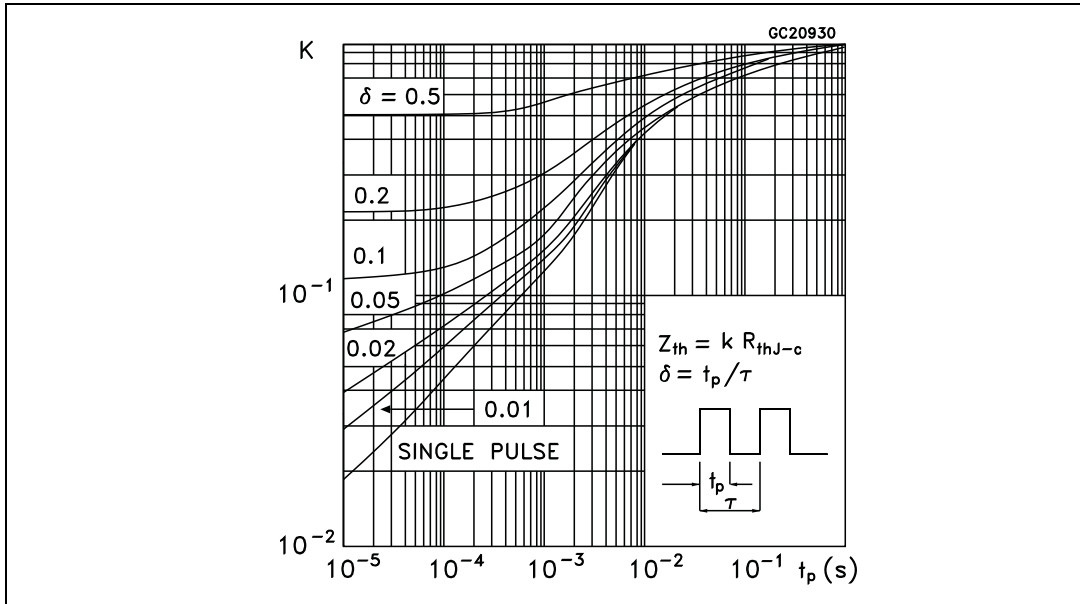
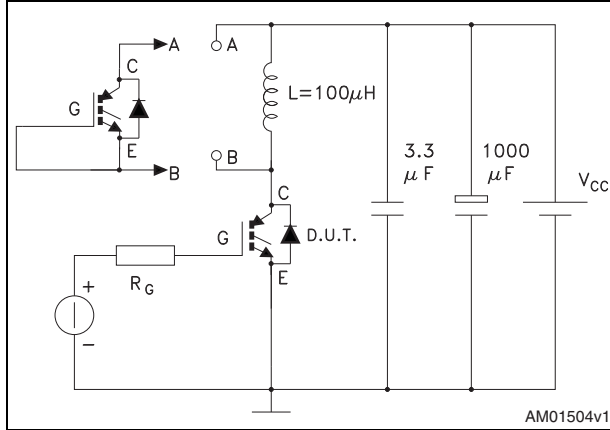


Figure 27. Thermal impedance for diode



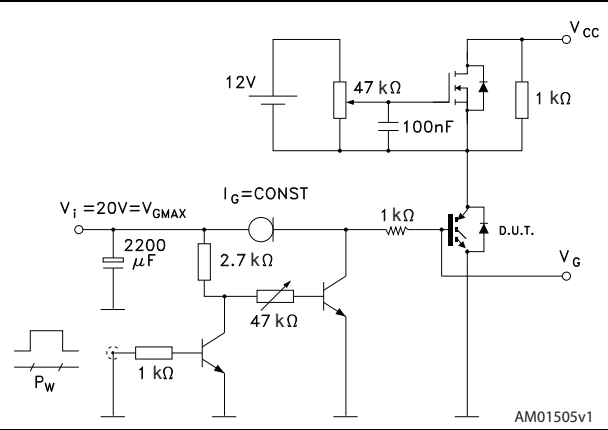
### 3 Test circuits

Figure 28. Test circuit for inductive load switching



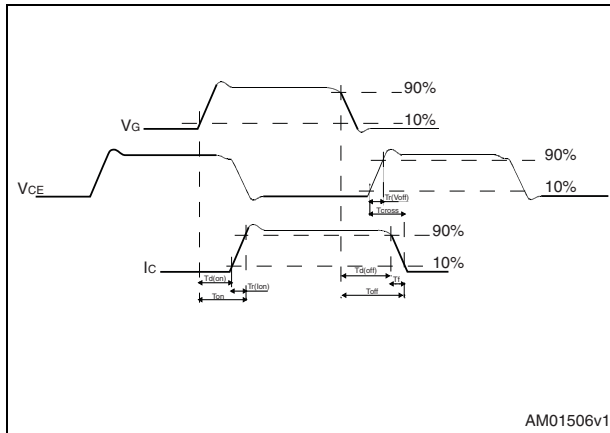
AM01504v1

Figure 29. Gate charge test circuit



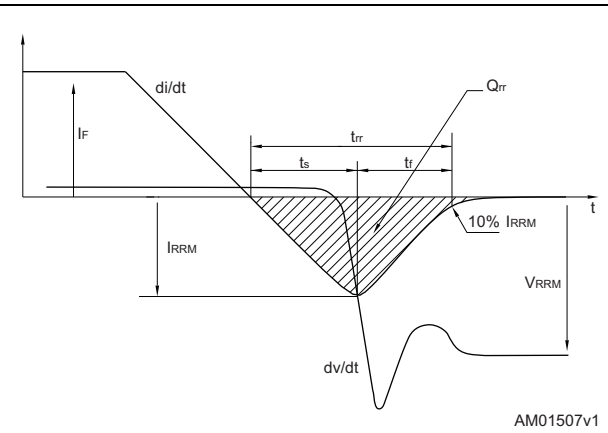
AM01505v1

Figure 30. Switching waveform



AM01506v1

Figure 31. Diode 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-247 package information

Figure 32. TO-247 package outline

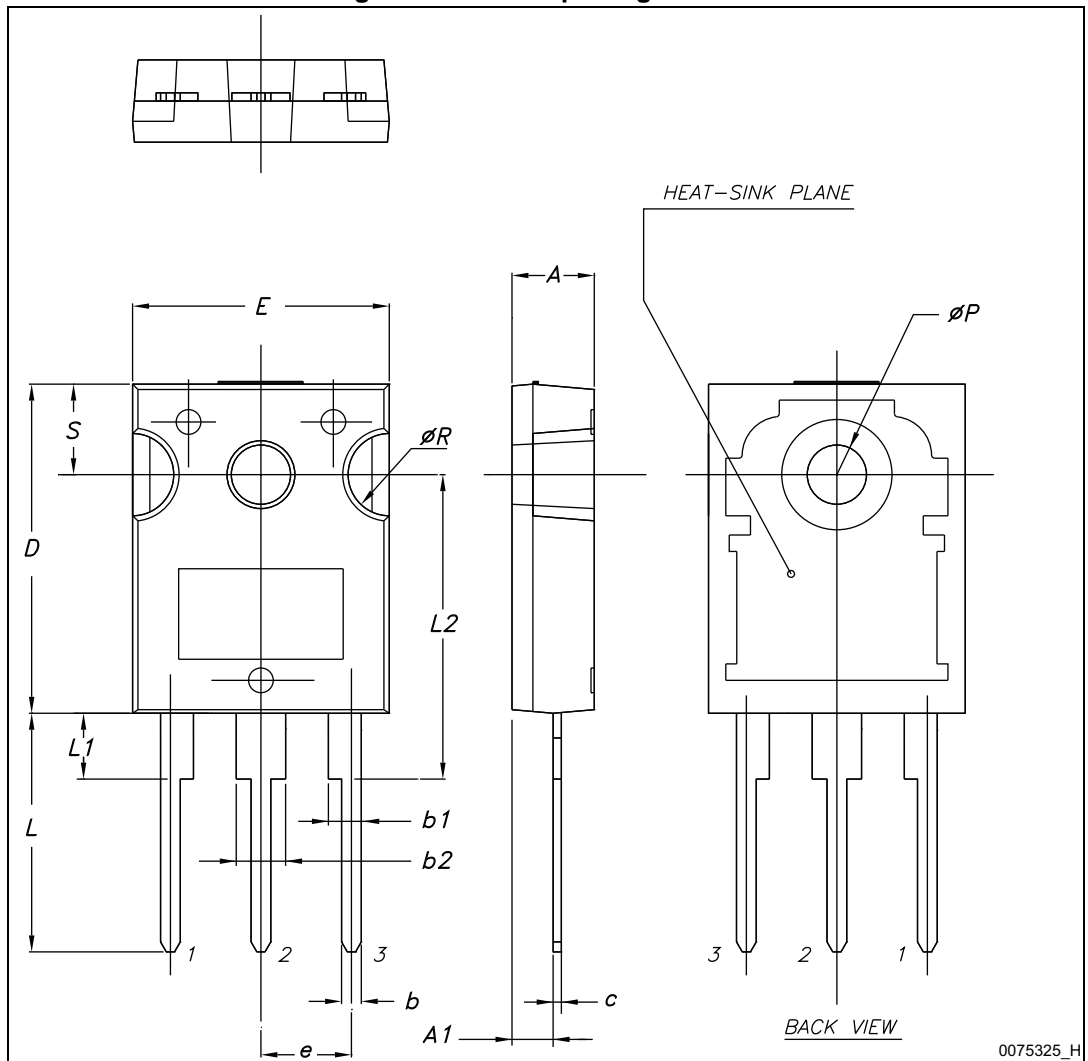


Table 8. TO-247 mechanical data

| 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  |

### 4.2 TO-247 long leads package information

Figure 33. TO-247 long leads package outline

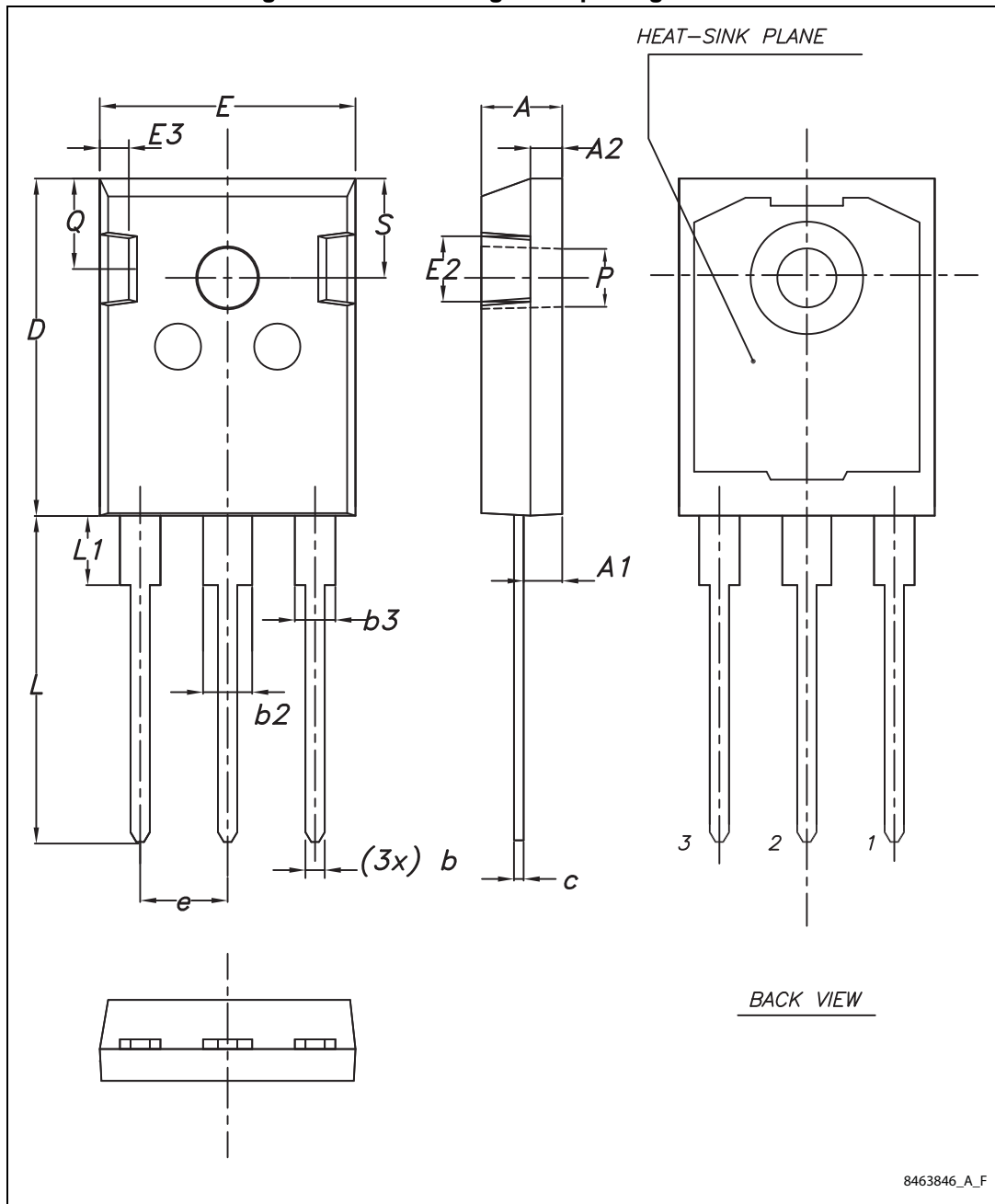


Table 9. TO-247 long leads mechanical data

| 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

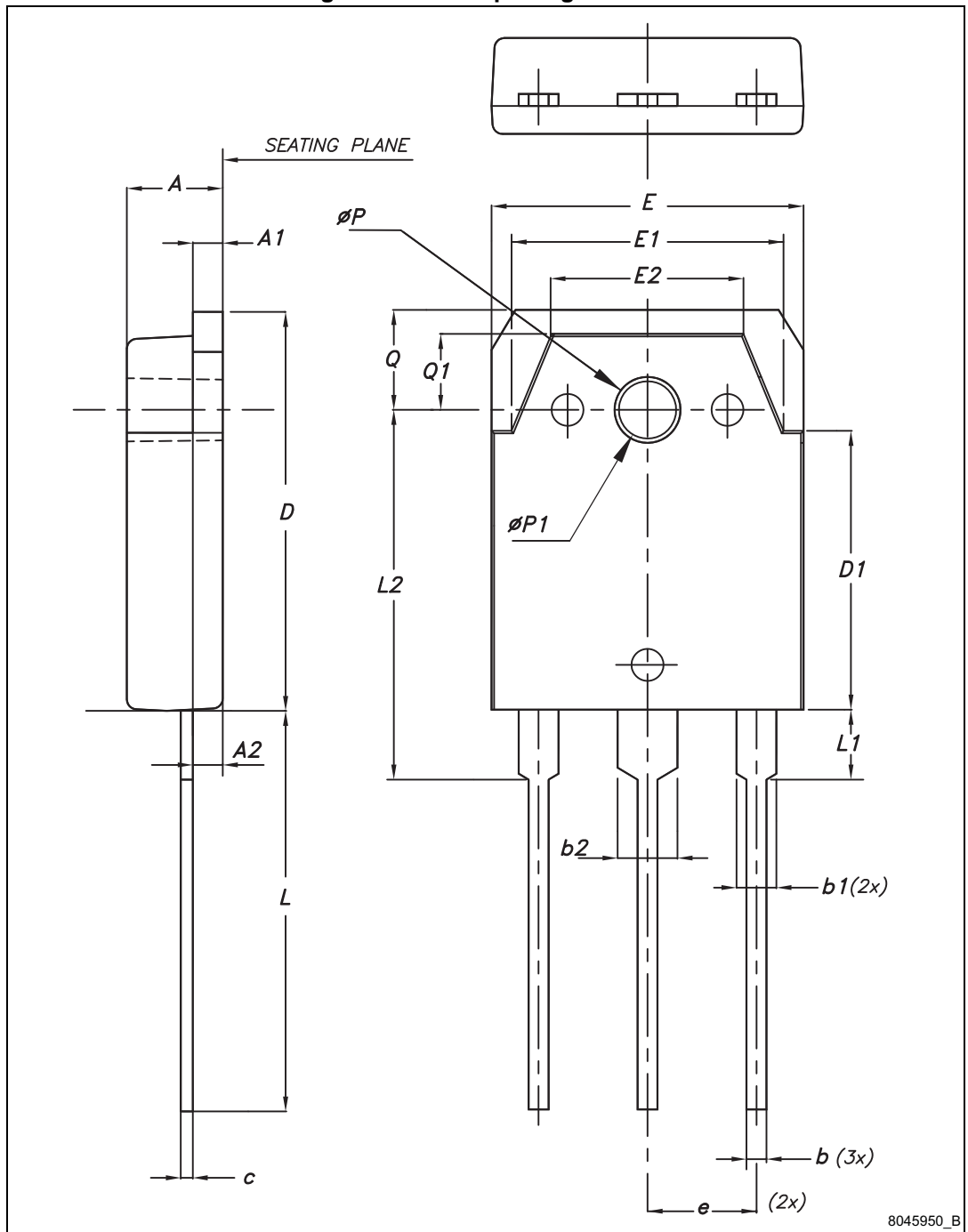




Table 10. TO-3P mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.60  | 4.80  | 5     |
| 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    | 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     | 5.20  |
| Q1   | 3.60  | 3.80  | 4     |

## 5 Revision history

Table 11. Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 12-Mar-2013 | 1        | Initial release.  |
| 30-Aug-2013 | 2        | Document status promoted from preliminary to production data.<br>Added <a href="#">Section 2.1: Electrical characteristics (curves)</a> .   |
| 31-Oct-2013 | 3        | Updated $V_{CE(sat)}$ in <a href="#">Table 4: Static characteristics</a> .  |
| 24-Feb-2014 | 4        | Updated title and description in cover page.  |
| 09-Jan-2015 | 5        | Updated features in cover page, <a href="#">Table 2: Absolute maximum ratings</a> , and <a href="#">Table 6: IGBT switching characteristics (inductive load)</a> .<br>Updated <a href="#">Figure 5: Collector current vs. case temperature</a> , <a href="#">Figure 6: Power dissipation vs. case temperature</a> , <a href="#">Figure 8: <math>V_{CE(sat)}</math> vs. collector current</a> , <a href="#">Figure 18: Switching times vs collector current</a> , <a href="#">Figure 19: Switching times vs gate resistance</a> and <a href="#">Figure 20: Reverse recovery current vs. diode current slope</a> .<br>Added <a href="#">Figure 25: Collector current vs. switching frequency</a> .<br>Updated <a href="#">Section 4: Package information</a> .<br>Minor text changes. |
| 23-Mar-2015 | 6        | Text edits throughout document.<br>In document, added new order code STGWA60H65DFB in TO-247 long leads package, with accompanying information and data.<br>In <a href="#">Section 2.1: Electrical characteristics (curves)</a> :<br>- updated <a href="#">Figure 2</a> , <a href="#">Figure 3</a> , <a href="#">Figure 4</a> , <a href="#">Figure 7</a> , <a href="#">Figure 9</a>   |
| 17-Apr-2015 | 7        | Text edits throughout document.<br>In <a href="#">Section 2: Electrical characteristics</a> :<br>- updated <a href="#">Table 4: Static characteristics</a><br>- updated <a href="#">Table 6: IGBT switching characteristics (inductive load)</a><br>In <a href="#">Section 2.1: Electrical characteristics (curves)</a> :<br>- updated <a href="#">Figure 3</a> and <a href="#">Figure 9</a>  |

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