



# STGW40N120KD STGWA40N120KD

40 A, 1200 V short circuit rugged IGBT with Ultrafast diode

## Features

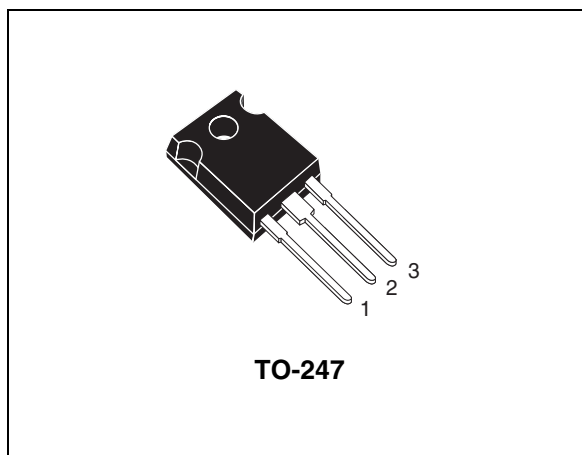
- Low on-losses
- High current capability
- Low gate charge
- Short circuit withstand time 10  $\mu$ s
- IGBT co-packaged with Ultrafast free-wheeling diode

## Applications

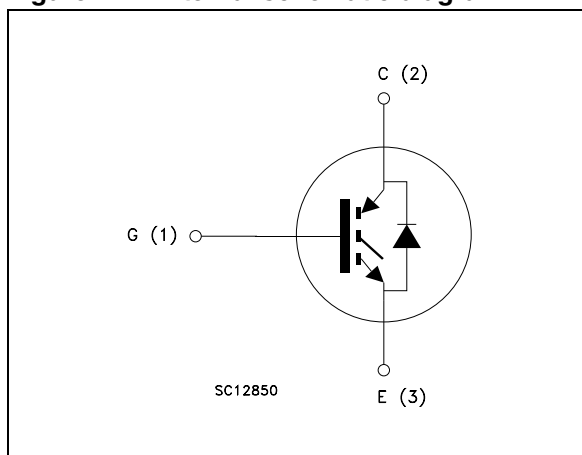
- Motor control

## Description

This high voltage and short-circuit rugged IGBT utilizes the advanced PowerMESH™ process resulting in an excellent trade-off between switching performance and low ON-state behavior.



**Figure 1. Internal schematic diagram**



**Table 1. Device summary**

| Order codes   | Markings    | Package           | Packaging |
|---------------|-------------|-------------------|-----------|
| STGW40N120KD  | GW40N120KD  | TO-247            | Tube      |
| STGWA40N120KD | GWA40N120KD | TO-247 long leads | Tube      |

Contents

1      **Electrical ratings** ..... 3

2      **Electrical characteristics** ..... 4

      2.1    Electrical characteristics (curves) ..... 6

3      **Test circuits** ..... 9

4      **Package mechanical data** ..... 10

5      **Revision history** ..... 14



# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                             | Value          | Unit               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0$ )                                                                                            | 1200           | V                  |
| $I_C^{(1)}$    | Continuous collector current at $T_C = 25\text{ °C}$                                                                                  | 80             | A                  |
| $I_C^{(1)}$    | Continuous collector current at $T_C = 100\text{ °C}$                                                                                 | 40             | A                  |
| $I_{CL}^{(2)}$ | Turn-off latching current                                                                                                             | 85             | A                  |
| $I_{CP}^{(3)}$ | Pulsed collector current                                                                                                              | 120            | A                  |
| $V_{GE}$       | Gate-emitter voltage                                                                                                                  | $\pm 25$       | V                  |
| $t_{SCW}$      | Short circuit withstand time, $V_{CE} = 0.5 V_{(BR)CES}$<br>$T_j = 125\text{ °C}$ , $R_G = 10\text{ }\Omega$ , $V_{GE} = 12\text{ V}$ | 10             | $\mu s$            |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ °C}$                                                                                             | 240            | W                  |
| $I_F$          | Diode RMS forward current at $T_C = 25\text{ °C}$                                                                                     | 30             | A                  |
| $I_{FSM}$      | Surge non repetitive forward current $t_p = 10\text{ ms}$<br>sinusoidal                                                               | 100            | A                  |
| $T_j$          | Operating junction temperature                                                                                                        | $-55$ to $125$ | $^{\circ}\text{C}$ |

1. Calculated according to the iterative formula:

$$I_C(T_C) = \frac{T_{j(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{j(max)}, I_C(T_C))}$$

2.  $V_{clamp} = 80\%$  of  $V_{CES}$ ,  $T_j = 125\text{ °C}$ ,  $R_G = 10\text{ }\Omega$ ,  $V_{GE} = 15\text{ V}$

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

**Table 3. Thermal data**

| Symbol         | Parameter                              | Value | Unit                 |
|----------------|----------------------------------------|-------|----------------------|
| $R_{thj-case}$ | Thermal resistance junction-case IGBT  | 0.42  | $^{\circ}\text{C/W}$ |
| $R_{thj-case}$ | Thermal resistance junction-case diode | 1.6   | $^{\circ}\text{C/W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient    | 50    | $^{\circ}\text{C/W}$ |

## 2 Electrical characteristics

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

**Table 4. Static**

| Symbol        | Parameter                                            | Test conditions                                                                                                                       | Min. | Typ.       | Max.      | Unit                |
|---------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------|------------|-----------|---------------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage ( $V_{GE} = 0$ ) | $I_C = 1\text{ mA}$                                                                                                                   | 1200 |            |           | V                   |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage                 | $V_{GE} = 15\text{ V}$ , $I_C = 30\text{ A}$<br>$V_{GE} = 15\text{ V}$ , $I_C = 30\text{ A}$ ,<br>$T_J = 125\text{ }^{\circ}\text{C}$ |      | 2.8<br>2.7 | 3.85      | V<br>V              |
| $V_{GE(th)}$  | Gate threshold voltage                               | $V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$                                                                                               | 4.5  |            | 6.5       | V                   |
| $I_{CES}$     | Collector cut-off current ( $V_{GE} = 0$ )           | $V_{CE} = 1200\text{ V}$<br>$V_{CE} = 1200\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$                                            |      |            | 500<br>10 | $\mu\text{A}$<br>mA |
| $I_{GES}$     | Gate-emitter leakage current ( $V_{CE} = 0$ )        | $V_{GE} = \pm 20\text{ V}$                                                                                                            |      |            | $\pm 100$ | nA                  |

**Table 5. Dynamic**

| Symbol    | Parameter                    | Test conditions                                                           | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|---------------------------------------------------------------------------|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0$                | -    | 2577 | -    | pF   |
| $C_{oes}$ | Output capacitance           |                                                                           |      | 196  |      | pF   |
| $C_{res}$ | Reverse transfer capacitance |                                                                           |      | 39.5 |      | pF   |
| $Q_g$     | Total gate charge            | $V_{CE} = 960\text{ V}$ ,<br>$I_C = 30\text{ A}$ , $V_{GE} = 15\text{ V}$ | -    | 126  | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |                                                                           |      | 22.2 |      | nC   |
| $Q_{gc}$  | Gate-collector charge        |                                                                           |      | 67   |      | nC   |

**Table 6. Switching on/off (inductive load)**

| Symbol         | Parameter             | Test conditions                                                                                                                                                              | Min. | Typ. | Max. | Unit             |
|----------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$<br>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ ,<br>(see <a href="#">Figure 16</a> )                                     | -    | 48   | -    | ns               |
| $t_r$          | Current rise time     |                                                                                                                                                                              |      | 40   |      | ns               |
| $(di/dt)_{on}$ | Turn-on current slope |                                                                                                                                                                              |      | 540  |      | A/ $\mu\text{s}$ |
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$<br>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 125\text{ }^{\circ}\text{C}$ (see <a href="#">Figure 16</a> ) | -    | 45   | -    | ns               |
| $t_r$          | Current rise time     |                                                                                                                                                                              |      | 38   |      | ns               |
| $(di/dt)_{on}$ | Turn-on current slope |                                                                                                                                                                              |      | 665  |      | A/ $\mu\text{s}$ |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$<br>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ ,<br>(see <a href="#">Figure 16</a> )                                     | -    | 84   | -    | ns               |
| $t_{d(off)}$   | Turn-off delay time   |                                                                                                                                                                              |      | 338  |      | ns               |
| $t_f$          | Current fall time     |                                                                                                                                                                              |      | 210  |      | ns               |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$<br>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 125\text{ }^{\circ}\text{C}$ (see <a href="#">Figure 16</a> ) | -    | 144  | -    | ns               |
| $t_{d(off)}$   | Turn-off delay time   |                                                                                                                                                                              |      | 420  |      | ns               |
| $t_f$          | Current fall time     |                                                                                                                                                                              |      | 360  |      | ns               |

**Table 7. Switching energy (inductive load)**

| Symbol          | Parameter                 | Test conditions                                                                                         | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------|---------------------------------------------------------------------------------------------------------|------|------|------|------|
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$                                                           |      | 3.7  |      | mJ   |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>(see <a href="#">Figure 16</a> )                       | -    | 5.7  | -    | mJ   |
| $E_{ts}$        | Total switching losses    |                                                                                                         |      | 9.4  |      | mJ   |
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 960\text{ V}$ , $I_C = 30\text{ A}$                                                           |      | 4.7  |      | mJ   |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_J = 125\text{ °C}$ (see <a href="#">Figure 16</a> ) | -    | 9.3  | -    | mJ   |
| $E_{ts}$        | Total switching losses    |                                                                                                         |      | 14   |      | mJ   |

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in [Figure 16](#). If the IGBT is offered in a package with a co-pack diode, the co-pack diode is used as external diode. IGBTs and diode are at the same temperature (25°C and 125°C)
2. Turn-off losses include also the tail of the collector current

**Table 8. Collector-emitter diode**

| Symbol    | Parameter                | Test conditions                                                                                              | Min. | Typ.       | Max. | Unit   |
|-----------|--------------------------|--------------------------------------------------------------------------------------------------------------|------|------------|------|--------|
| $V_F$     | Forward on-voltage       | $I_F = 20\text{ A}$<br>$I_F = 20\text{ A}$ , $T_J = 125\text{ °C}$                                           | -    | 1.9<br>1.7 | -    | V<br>V |
| $t_{rr}$  | Reverse recovery time    | $I_F = 20\text{ A}$ , $V_R = 45\text{ V}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$                            | -    | 84         | -    | ns     |
| $Q_{rr}$  | Reverse recovery charge  | (see <a href="#">Figure 19</a> )                                                                             |      | 235        | -    | nC     |
| $I_{rrm}$ | Reverse recovery current |                                                                                                              |      | 5.6        |      | A      |
| $t_{rr}$  | Reverse recovery time    | $I_F = 20\text{ A}$ , $V_R = 45\text{ V}$ ,<br>$T_J = 125\text{ °C}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ | -    | 152        | -    | ns     |
| $Q_{rr}$  | Reverse recovery charge  | (see <a href="#">Figure 19</a> )                                                                             |      | 722        | -    | nC     |
| $I_{rrm}$ | Reverse recovery current |                                                                                                              |      | 9          |      | A      |

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

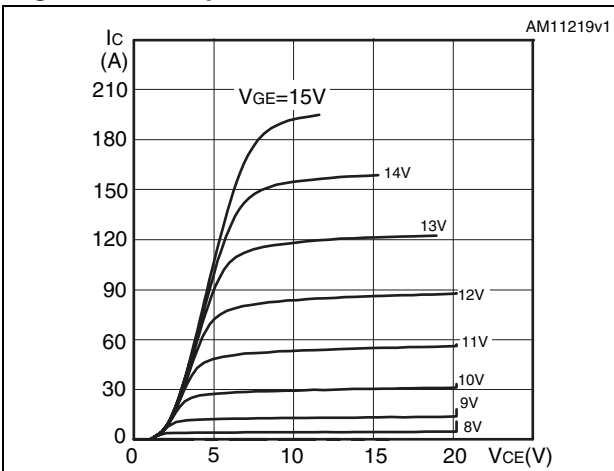


Figure 3. Transfer characteristics

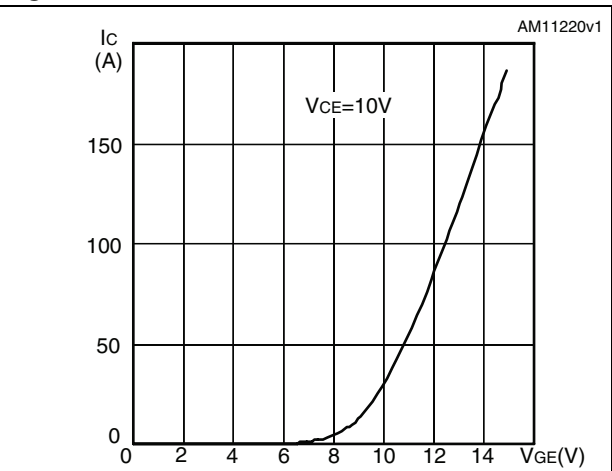


Figure 4. Collector-emitter on voltage vs. collector current

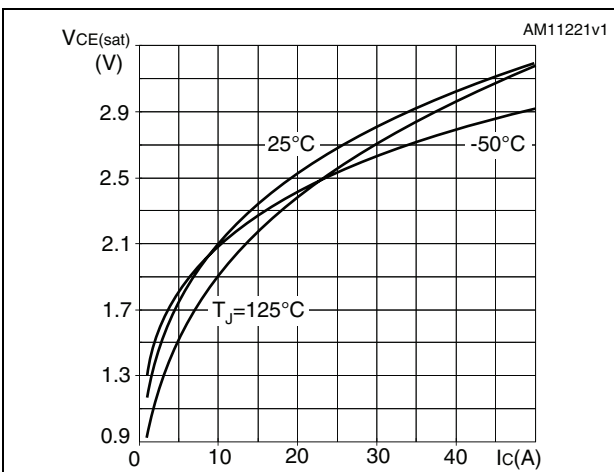


Figure 5. Collector-emitter on voltage vs. temperature

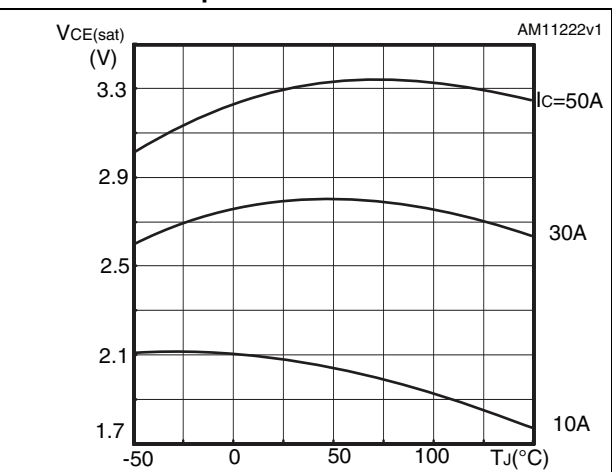


Figure 6. Gate charge vs. gate-source voltage

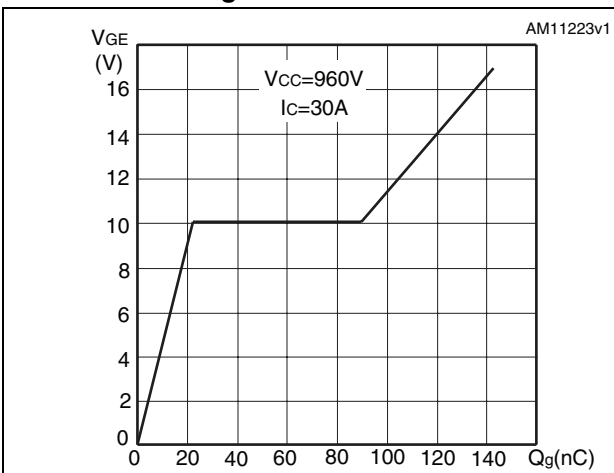


Figure 7. Capacitance variations

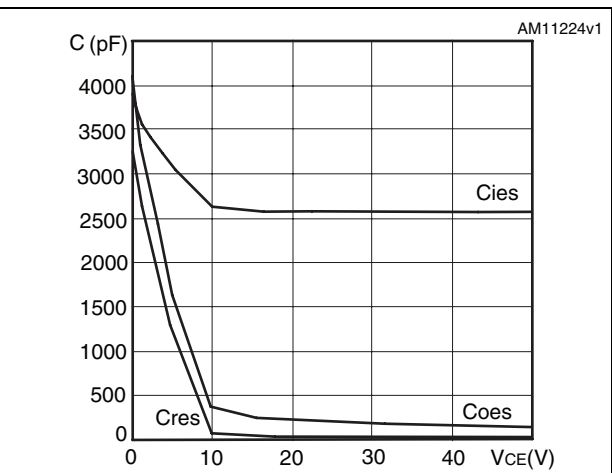


Figure 8. Normalized gate threshold voltage vs. temperature

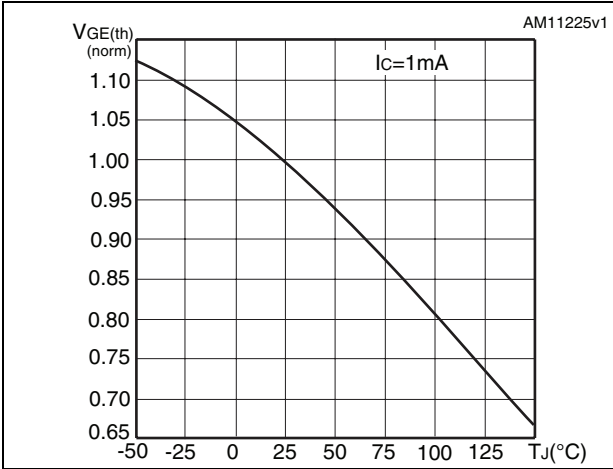


Figure 9. Normalized breakdown voltage vs. temperature

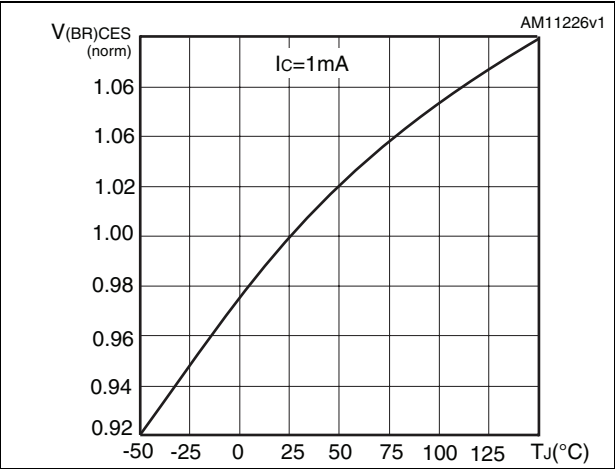


Figure 10. Switching losses vs. collector current

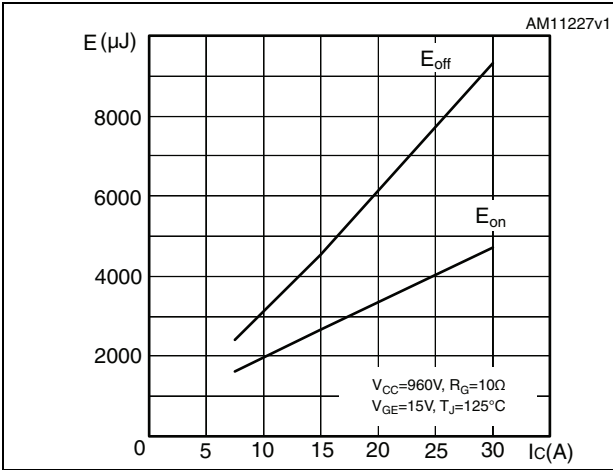


Figure 11. Switching losses vs. gate resistance

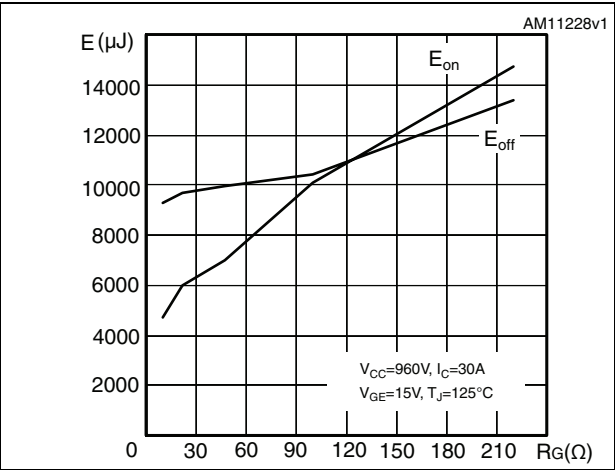


Figure 12. Switching losses vs. temperature

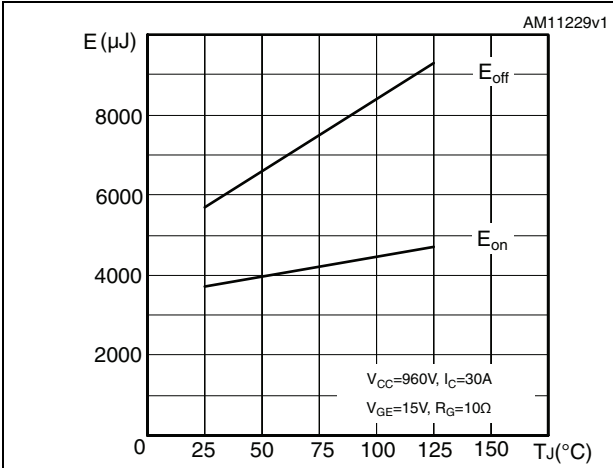


Figure 13. Thermal impedance

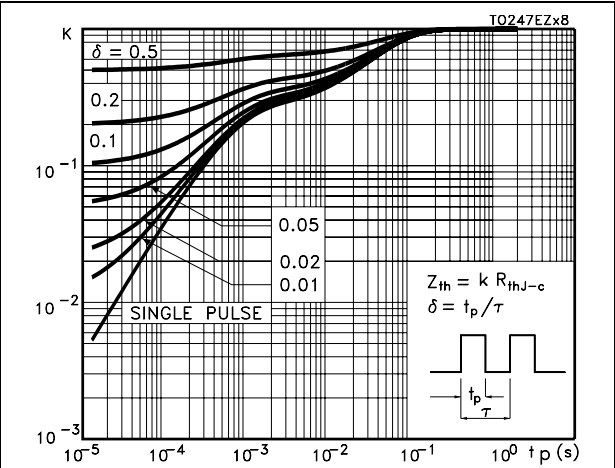


Figure 14. Turn-off SOA

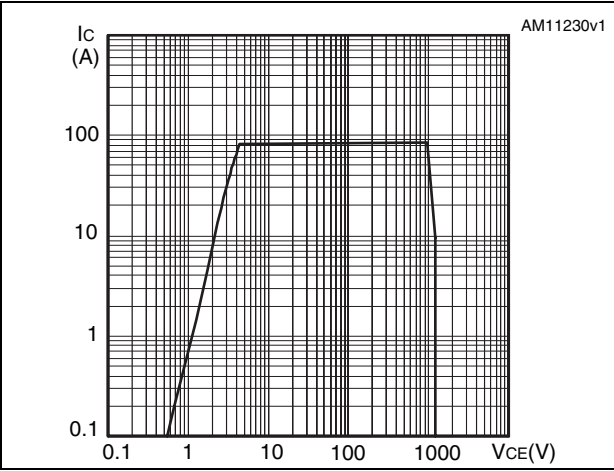
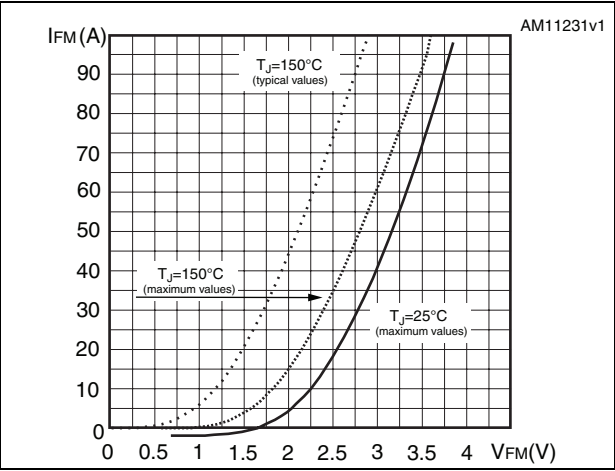


Figure 15. Forward voltage drop vs. forward current



3 Test circuits

Figure 16. Test circuit for inductive load switching

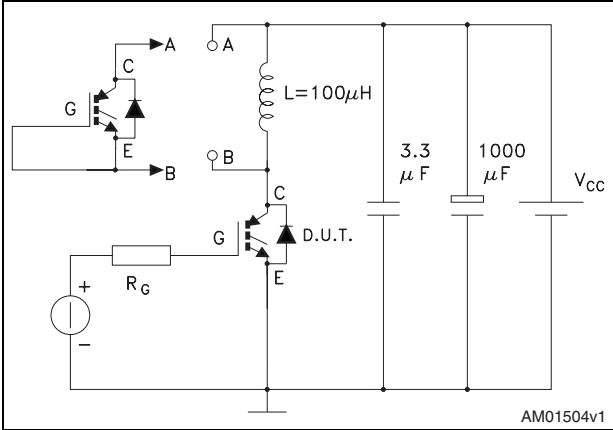


Figure 17. Gate charge test circuit

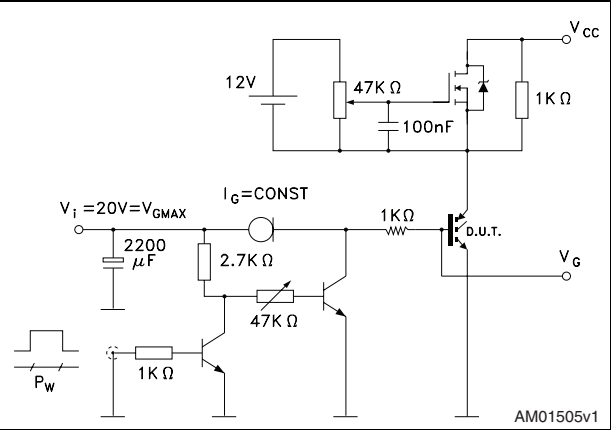


Figure 18. Switching waveform

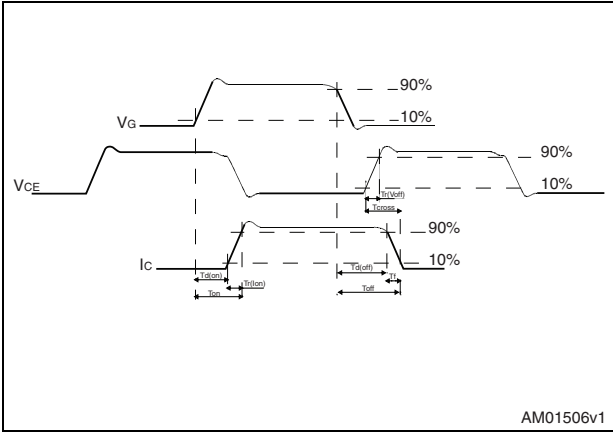
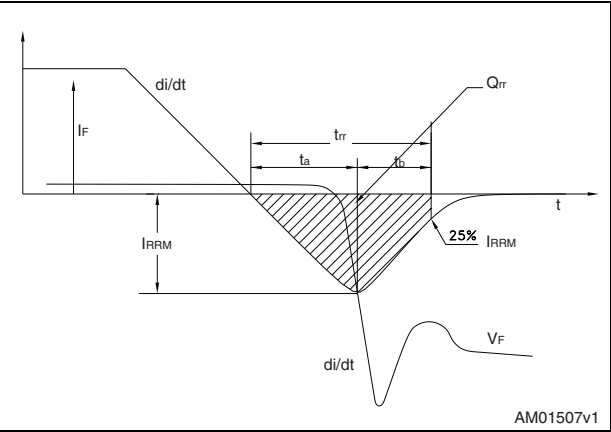


Figure 19. Diode recovery time waveform



## 4 Package mechanical data

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.

**Table 9. 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 20. TO-247 drawing dimensions

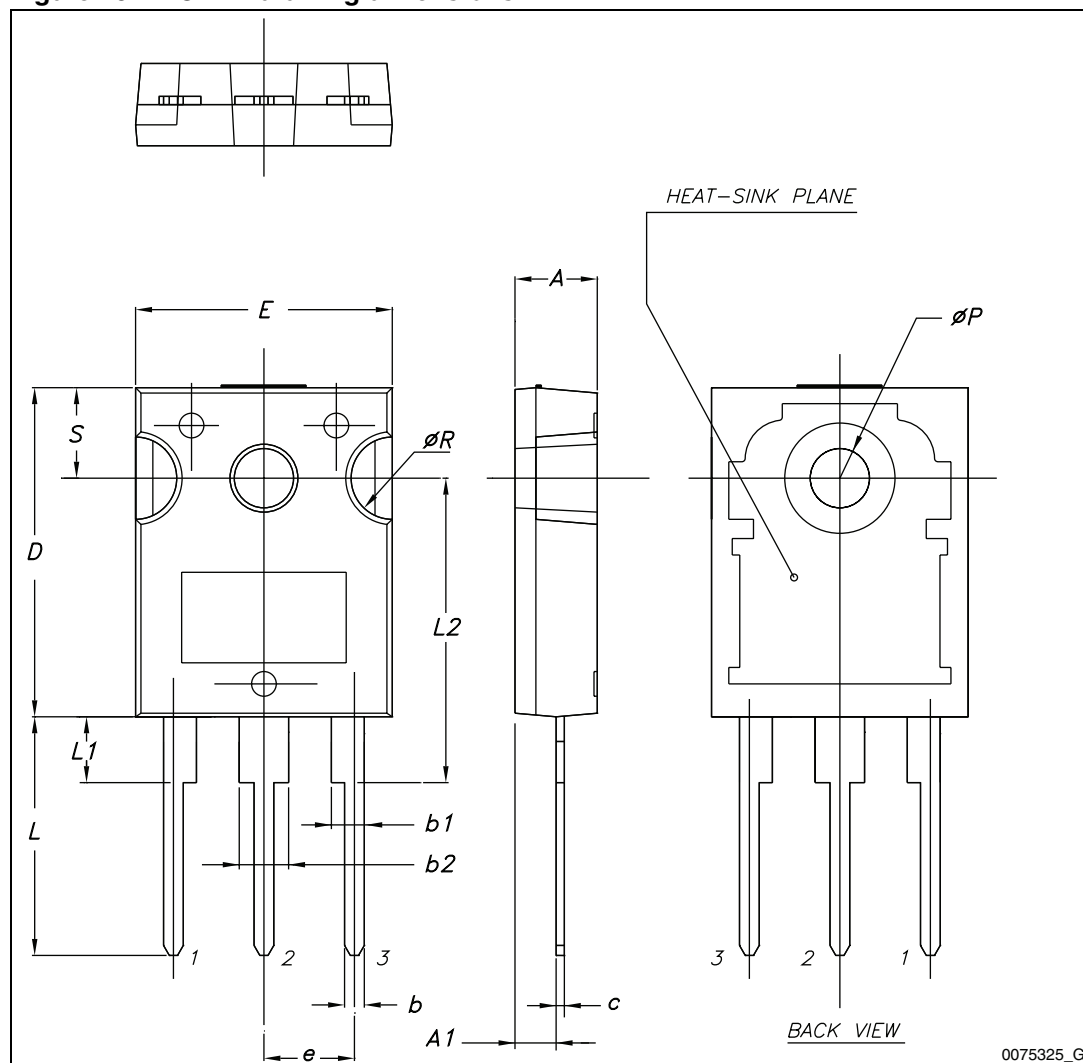
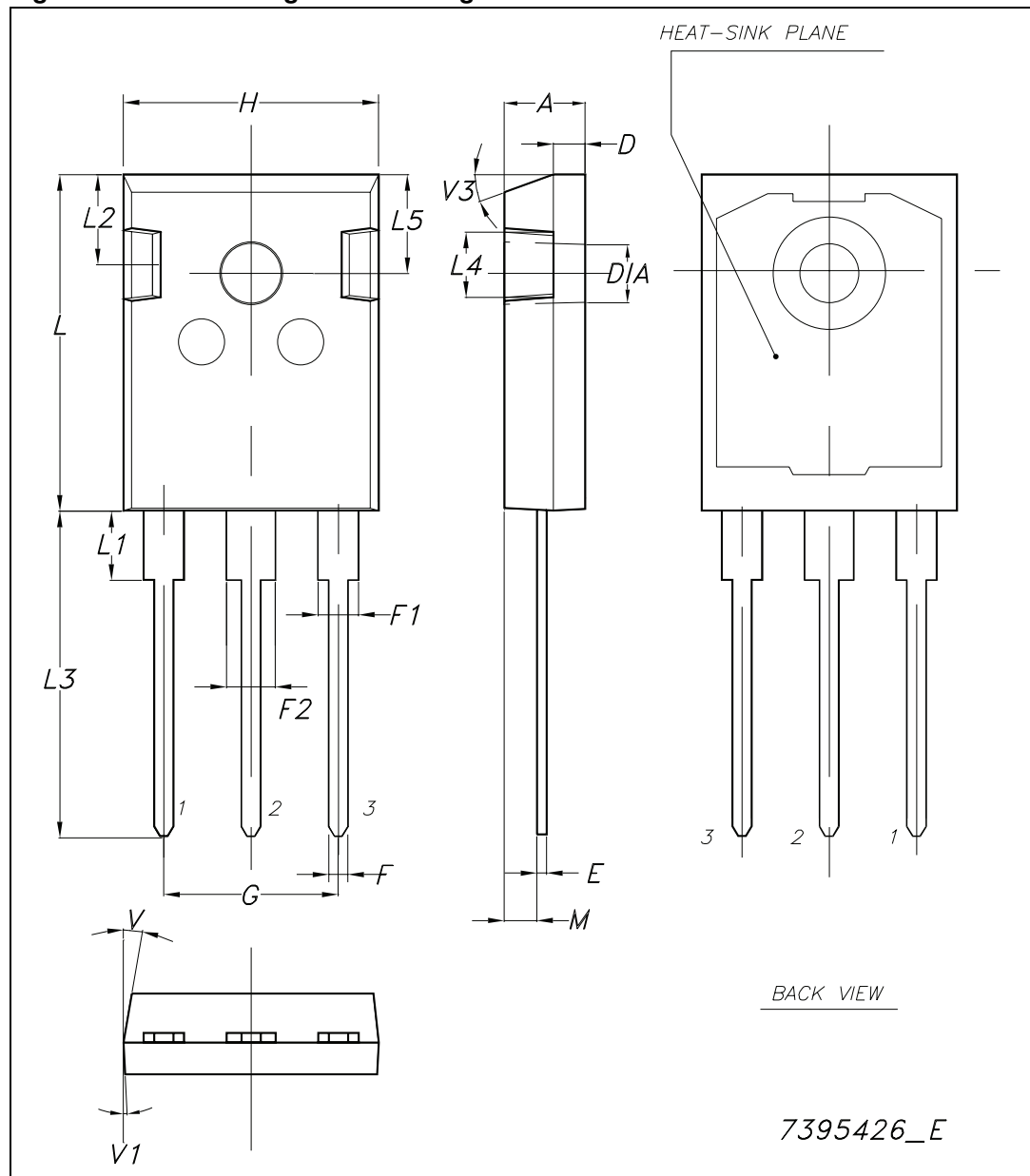


Table 10. TO-247 long leads mechanical data

| Dim. | mm        |      |       |
|------|-----------|------|-------|
|      | Min.      | Typ. | Max.  |
| A    | 4.90      |      | 5.15  |
| D    | 1.85      |      | 2.10  |
| E    | 0.55      |      | 0.67  |
| F    | 1.07      |      | 1.32  |
| F1   | 1.90      |      | 2.38  |
| F2   | 2.87      |      | 3.38  |
| G    | 10.90 BSC |      |       |
| H    | 15.77     |      | 16.02 |
| L    | 20.82     |      | 21.07 |
| L1   | 4.16      |      | 4.47  |
| L2   | 5.49      |      | 5.74  |
| L3   | 20.05     |      | 20.30 |
| L4   | 3.68      |      | 3.93  |
| L5   | 6.04      |      | 6.29  |
| M    | 2.27      |      | 2.52  |
| V    |           | 10°  |       |
| V1   |           | 3°   |       |
| V3   |           | 20°  |       |
| Dia. | 3.55      |      | 3.66  |

Figure 21. TO-247 long leads drawing



## 5 Revision history

**Table 11. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                     |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22-Jan-2009 | 1        | Initial release                                                                                                                                                                                                             |
| 29-Jun-2009 | 2        | Document status promoted from preliminary data to datasheet.                                                                                                                                                                |
| 09-Jul-2009 | 3        | Inserted dynamic values <a href="#">Table 5 on page 4</a> , <a href="#">Table 6 on page 4</a> and <a href="#">Table 7 on page 5</a> .                                                                                       |
| 11-Jan-2012 | 4        | Added order code STGWA40N120KD <a href="#">Table 1 on page 1</a> , <a href="#">Section 2.1 on page 6</a> , mechanical data TO-247 long leads <a href="#">Table 10 on page 12</a> and <a href="#">Figure 21 on page 13</a> . |
| 27-Feb-2012 | 5        | Modified: <a href="#">Description on page 1</a> .                                                                                                                                                                           |

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