

### Features

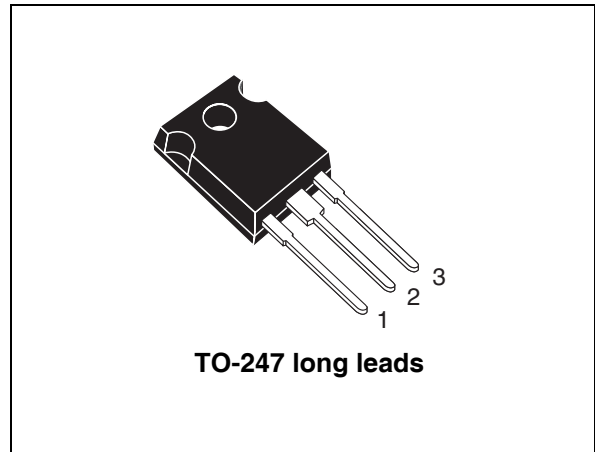
- High frequency operation
- Lower  $C_{RES} / C_{IES}$  ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode

### Applications

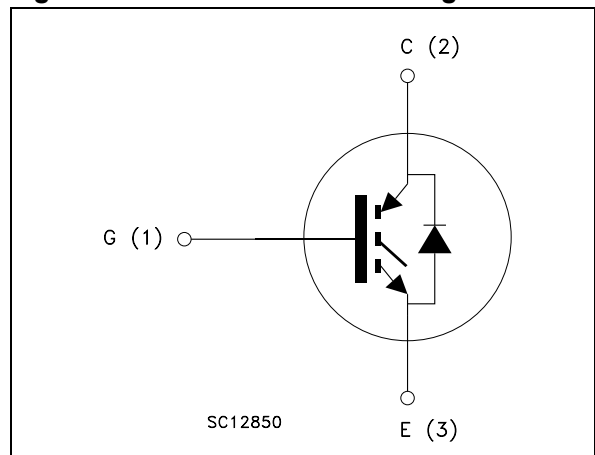
- High frequency motor controls, inverters, UPS
- HF, SMPS and PFC in both hard switch and resonant topologies

### Description

This IGBT utilizes the advanced Power MESH™ 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 code   | Marking    | Package           | Packaging |
|--------------|------------|-------------------|-----------|
| STGW35NC60WD | GW35NC60WD | TO-247 long leads | Tube      |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                     | Value       | Unit |
|----------------|---------------------------------------------------------------|-------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0$ )                    | 600         | V    |
| $I_C^{(1)}$    | Collector current (continuous) at 25 °C                       | 70          | A    |
| $I_C^{(1)}$    | Collector current (continuous) at 100 °C                      | 40          | A    |
| $I_{CP}^{(2)}$ | Collector current (pulsed)                                    | 150         | A    |
| $I_{CL}^{(3)}$ | Turn-off latching current                                     | 150         | A    |
| $V_{GE}$       | Gate-emitter voltage                                          | ± 20        | V    |
| $I_F$          | Diode RMS forward current at $T_C = 25$ °C                    | 30          | A    |
| $I_{FSM}$      | Surge not repetitive forward current $t_p = 10$ ms sinusoidal | 120         | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25$ °C                            | 260         | W    |
| $T_{stg}$      | Storage temperature                                           | – 55 to 150 | °C   |
| $T_j$          | Operating junction temperature                                |             |      |

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. Pulse width limited by max junction temperature

3.  $V_{CLAMP} = 80\%$  ( $V_{CES}$ ),  $V_{GE} = 15$  V,  $R_G = 10$  Ω,  $T_J = 150$  °C

**Table 3. Thermal resistance**

| Symbol         | Parameter                                   | Value | Unit |
|----------------|---------------------------------------------|-------|------|
| $R_{thj-case}$ | Thermal resistance junction-case IGBT max.  | 0.48  | °C/W |
|                | Thermal resistance junction-case diode max. | 1.5   | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max.    | 50    | °C/W |

## 2 Electrical characteristics

( $T_{CASE} = 25\text{ °C}$  unless otherwise specified)

**Table 4. Static electrical characteristics**

| Symbol        | Parameter                                            | Test conditions                                                                                                      | Min. | Typ.       | Max.      | Unit                |
|---------------|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------|------------|-----------|---------------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage ( $V_{GE} = 0$ ) | $I_C = 1\text{ mA}$                                                                                                  | 600  |            |           | V                   |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage                 | $V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$<br>$V_{GE} = 15\text{ V}$ , $I_C = 20\text{ A}$ , $T_C = 125\text{ °C}$ |      | 2.2<br>1.8 | 2.6       | V<br>V              |
| $V_{GE(th)}$  | Gate threshold voltage                               | $V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$                                                                   | 3.75 |            | 5.75      | V                   |
| $I_{CES}$     | Collector cut-off current ( $V_{GE} = 0$ )           | $V_{CE} = 600\text{ V}$<br>$V_{CE} = 600\text{ V}$ , $T_C = 125\text{ °C}$                                           |      |            | 250<br>1  | $\mu\text{A}$<br>mA |
| $I_{GES}$     | Gate-emitter leakage current ( $V_{CE} = 0$ )        | $V_{GE} = \pm 20\text{ V}$                                                                                           |      |            | $\pm 100$ | nA                  |
| $g_{fs}$      | Forward transconductance                             | $V_{CE} = 15\text{ V}$ , $I_C = 20\text{ A}$                                                                         |      | 15         |           | S                   |

**Table 5. Dynamic electrical characteristics**

| Symbol    | Parameter                    | Test conditions                                                                                | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|------------------------------------------------------------------------------------------------|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GE} = 0$                                  |      | 2080 |      | pF   |
| $C_{oes}$ | Output capacitance           |                                                                                                |      | 175  |      | pF   |
| $C_{res}$ | Reverse transfer capacitance |                                                                                                |      | 52   |      | pF   |
| $Q_g$     | Total gate charge            | $V_{CE} = 390\text{ V}$ , $I_C = 20\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ ,<br>(see Figure 18) |      | 102  | 140  | nC   |
| $Q_{ge}$  | Gate-emitter charge          |                                                                                                |      | 17.5 |      | nC   |
| $Q_{gc}$  | Gate-collector charge        |                                                                                                |      | 47   |      | nC   |

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

| Symbol         | Parameter             | Test conditions                                      | Min. | Typ. | Max. | Unit       |
|----------------|-----------------------|------------------------------------------------------|------|------|------|------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$        |      | 29.5 |      | ns         |
| $t_r$          | Current rise time     | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,        |      | 12   |      | ns         |
| $(di/dt)_{on}$ | Turn-on current slope | (see Figure 17)                                      |      | 1640 |      | A/ $\mu$ s |
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$        |      | 29   |      | ns         |
| $t_r$          | Current rise time     | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,        |      | 13.5 |      | ns         |
| $(di/dt)_{on}$ | Turn-on current slope | $T_C = 125\text{ }^\circ\text{C}$ (see Figure 17)    |      | 1600 |      | A/ $\mu$ s |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$ ,      |      | 19.5 |      | ns         |
| $t_{d(off)}$   | Turn-off delay time   | $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$       |      | 118  |      | ns         |
| $t_f$          | Current fall time     | (see Figure 17)                                      |      | 27   |      | ns         |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$ ,      |      | 46   |      | ns         |
| $t_{d(off)}$   | Turn-off delay time   | $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,     |      | 151  |      | ns         |
| $t_f$          | Current fall time     | $T_C = 125\text{ }^\circ\text{C}$<br>(see Figure 17) |      | 38   |      | ns         |

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

| Symbol         | Parameter                 | Test conditions                                   | Min. | Typ. | Max. | Unit    |
|----------------|---------------------------|---------------------------------------------------|------|------|------|---------|
| $E_{on}^{(1)}$ | Turn-on switching losses  | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$     |      | 305  |      | $\mu$ J |
| $E_{off}$      | Turn-off switching losses | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,     |      | 181  |      | $\mu$ J |
| $E_{ts}$       | Total switching losses    | (see Figure 19)                                   |      | 486  |      | $\mu$ J |
| $E_{on}^{(1)}$ | Turn-on switching losses  | $V_{CC} = 390\text{ V}$ , $I_C = 20\text{ A}$     |      | 455  |      | $\mu$ J |
| $E_{off}$      | Turn-off switching losses | $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,     |      | 355  |      | $\mu$ J |
| $E_{ts}$       | Total switching losses    | $T_C = 125\text{ }^\circ\text{C}$ (see Figure 19) |      | 810  |      | $\mu$ J |

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in Figure 19. If the IGBT is offered in a package with a co-pak diode, the co-pak diode is used as external diode. IGBTs & Diode are at the same temperature (25°C and 125°C).  $E_{on}$  include diode recovery energy.

Table 8. Collector-emitter diode

| Symbol    | Parameter                | Test conditions                                                                                                       | Min. | Typ.       | Max. | Unit   |
|-----------|--------------------------|-----------------------------------------------------------------------------------------------------------------------|------|------------|------|--------|
| $V_F$     | Forward on-voltage       | $I_F = 20\text{ A}$<br>$I_F = 20\text{ A}, T_C = 125\text{ °C}$                                                       |      | 2.6<br>1.6 |      | V<br>V |
| $t_{rr}$  | Reverse recovery time    | $I_F = 20\text{ A}, V_R = 50\text{ V},$<br>$di/dt = 100\text{ A/}\mu\text{s}$<br>(see Figure 20)                      |      | 40         |      | ns     |
| $Q_{rr}$  | Reverse recovery charge  |                                                                                                                       |      | 50         |      | nC     |
| $I_{rrm}$ | Reverse recovery current |                                                                                                                       |      | 2.5        |      | A      |
| $t_{rr}$  | Reverse recovery time    | $I_F = 20\text{ A}, V_R = 50\text{ V},$<br>$T_C = 125\text{ °C}, di/dt = 100\text{ A/}\mu\text{s}$<br>(see Figure 20) |      | 80         |      | ns     |
| $Q_{rr}$  | Reverse recovery charge  |                                                                                                                       |      | 180        |      | nC     |
| $I_{rrm}$ | Reverse recovery current |                                                                                                                       |      | 4.5        |      | A      |

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

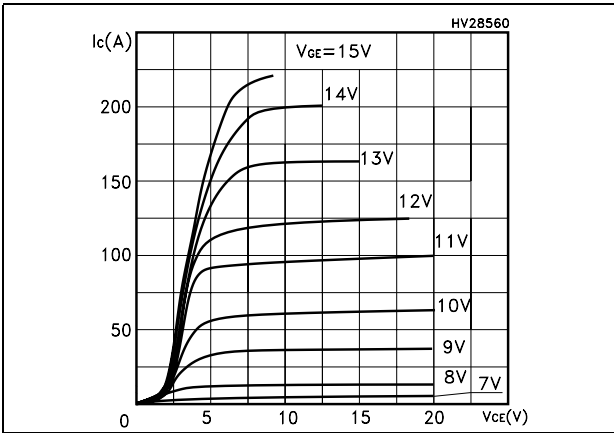


Figure 3. Transfer characteristics

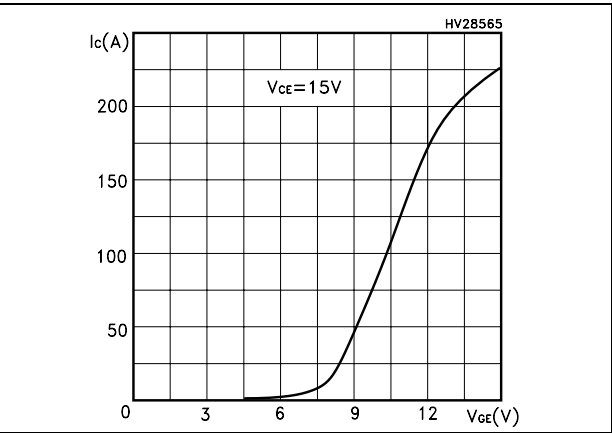


Figure 4. Transconductance

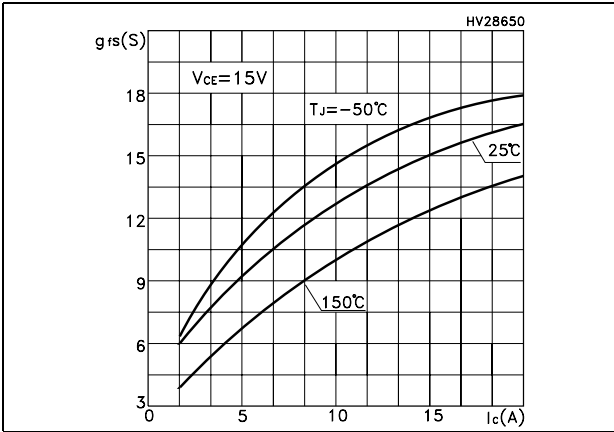


Figure 5. Collector-emitter on voltage vs temperature

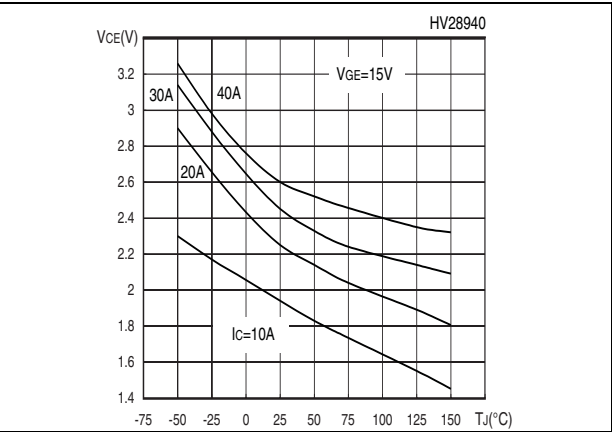


Figure 6. Gate charge vs gate-source voltage

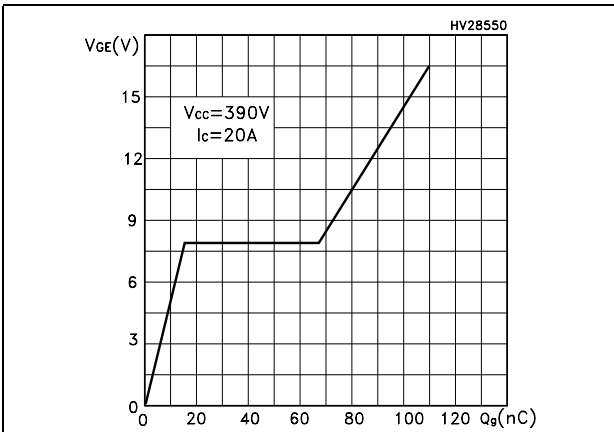


Figure 7. Capacitance variations

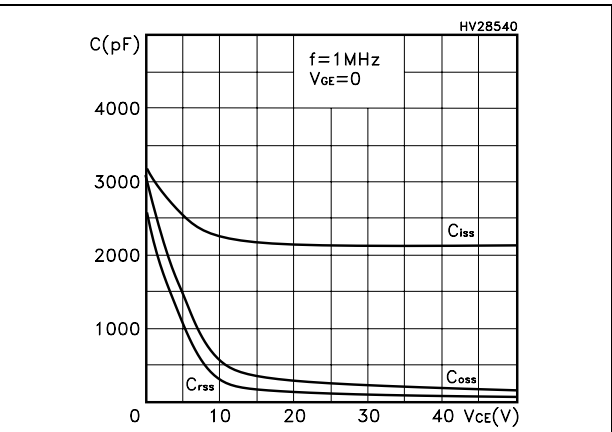


Figure 8. Normalized gate threshold voltage vs temperature

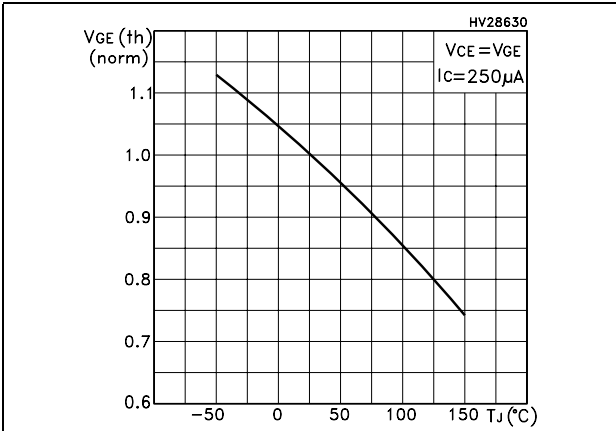


Figure 9. Collector-emitter on voltage vs collector current

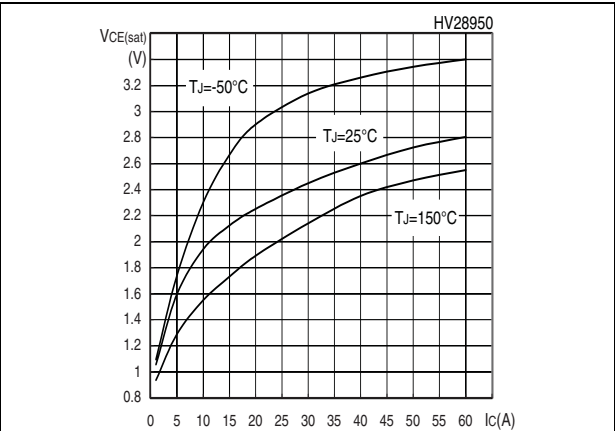


Figure 10. Normalized breakdown voltage vs temperature

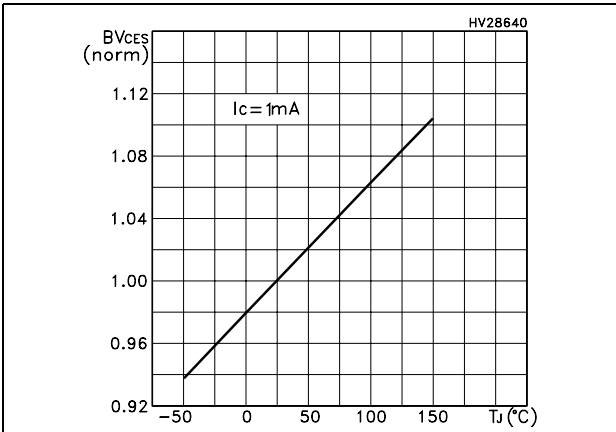


Figure 11. Switching losses vs temperature

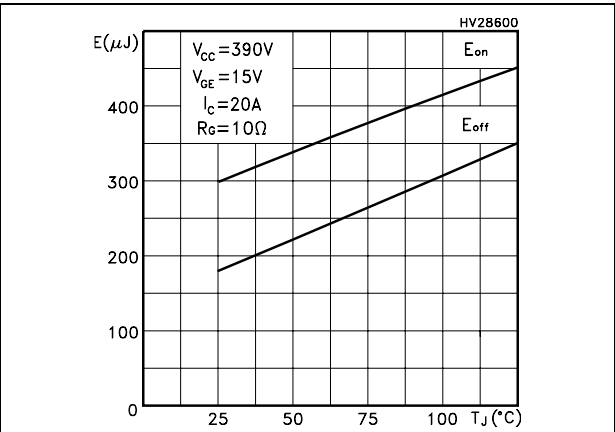


Figure 12. Switching losses vs gate resistance

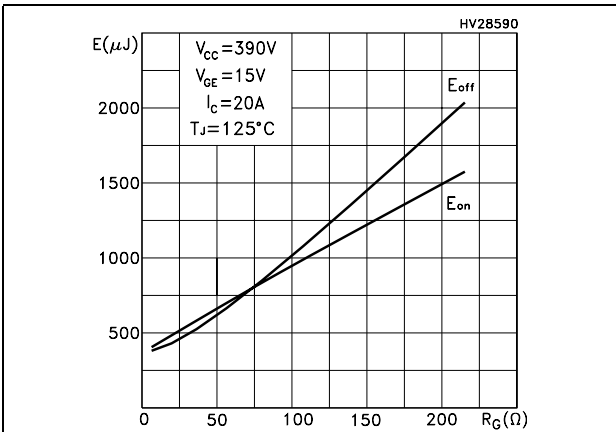


Figure 13. Switching losses vs collector current

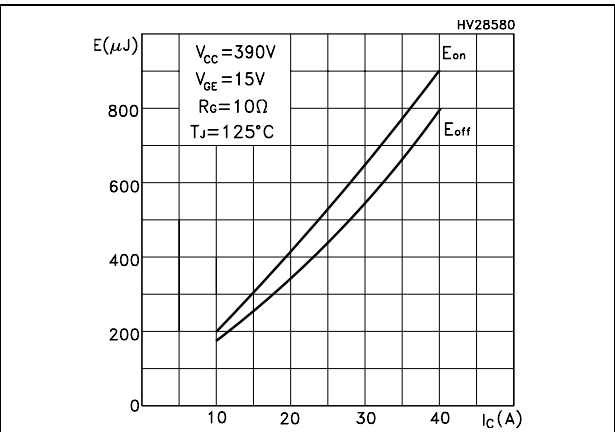




Figure 14. Thermal impedance

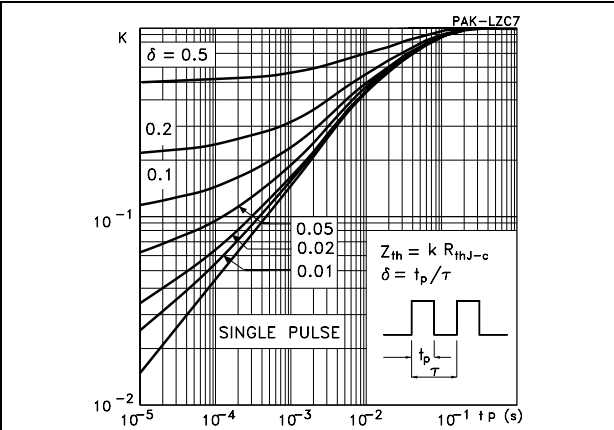


Figure 15. Turn-off SOA

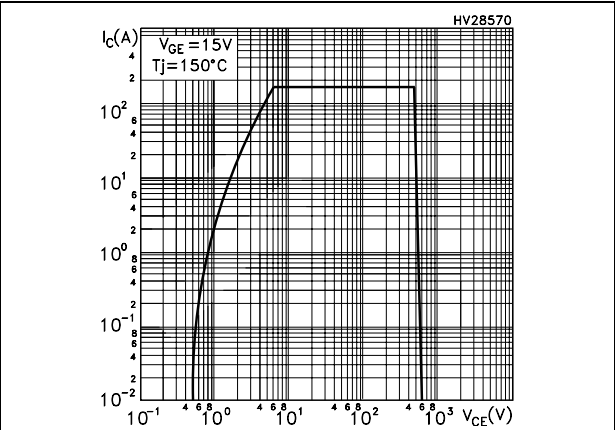
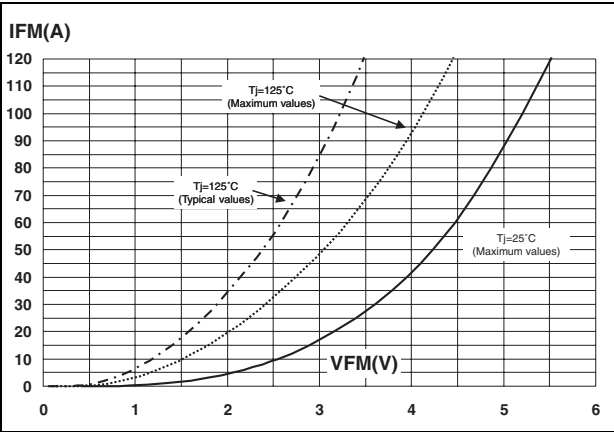


Figure 16. Emitter-collector diode characteristics



### 3 Test circuit

Figure 17. Test circuit for inductive load switching

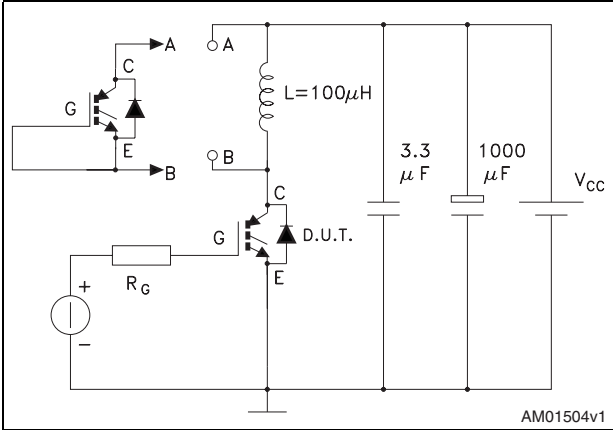


Figure 18. Gate charge test circuit

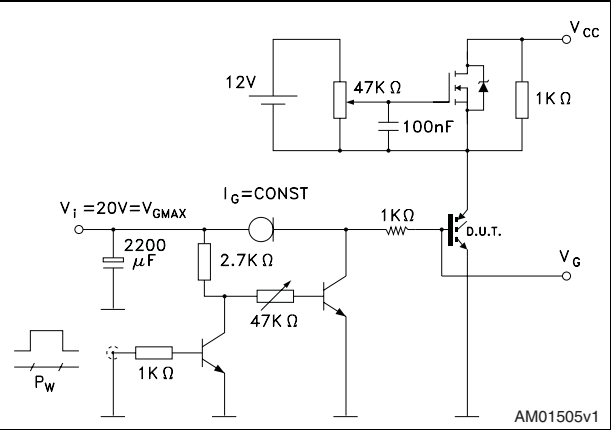


Figure 19. Switching waveform

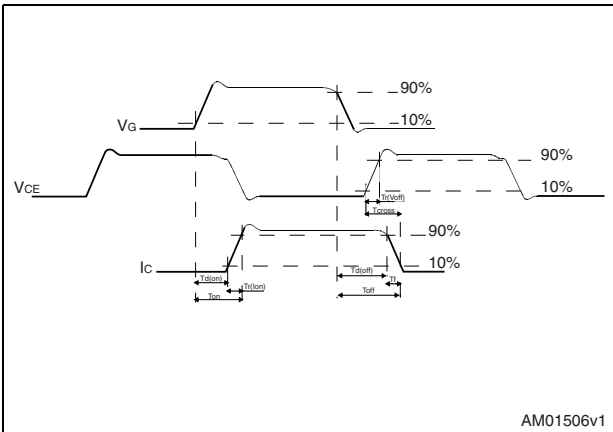
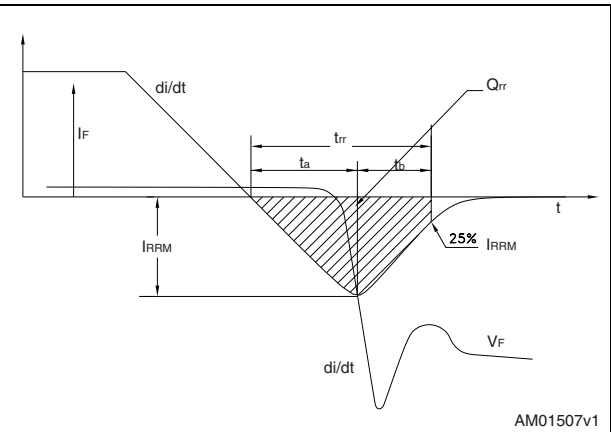


Figure 20. Diode recovery time waveform

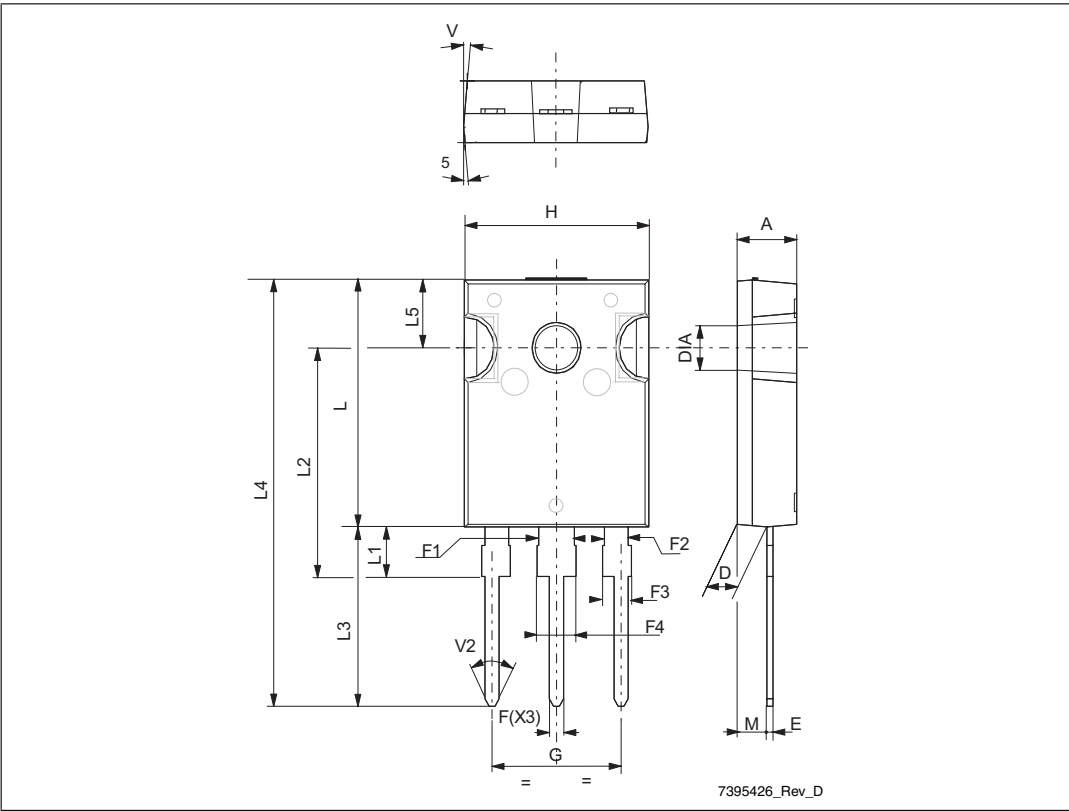


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

TO-247 long leads mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.85  |      | 5.16  |
| D    | 2.2   |      | 2.6   |
| E    | 0.4   |      | 0.8   |
| F    | 1     |      | 1.4   |
| F1   |       | 3    |       |
| F2   |       | 2    |       |
| F3   | 1.9   |      | 2.4   |
| F4   | 3     |      | 3.4   |
| G    |       | 10.9 |       |
| H    | 15.45 |      | 16.03 |
| L    | 19.85 |      | 21.09 |
| L1   | 3.7   |      | 4.3   |
| L2   | 18.3  |      | 19.13 |
| L3   | 14.2  |      | 20.3  |
| L4   | 34.05 |      | 41.38 |
| L5   | 5.35  |      | 6.3   |
| M    | 2     |      | 3     |
| V    |       | 5°   |       |
| V2   |       | 60°  |       |
| DIAM | 3.55  |      | 3.65  |



## 5 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                      |
|-------------|----------|--------------------------------------------------------------|
| 12-Jul-2007 | 1        | Initial release.                                             |
| 11-Nov-2008 | 2        | Document status promoted from preliminary data to datasheet. |

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