



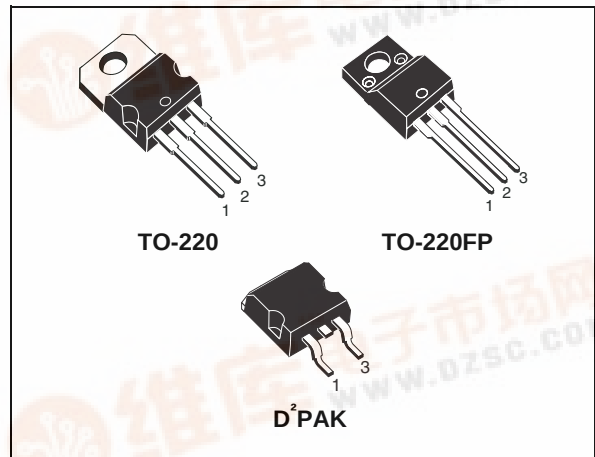
# STGB6NC60HD STGF6NC60HD - STGP6NC60HD

N-channel 600V - 7A - D<sup>2</sup>PAK / TO-220 / TO-220FP  
Very fast PowerMESH™ IGBT

## General features

| Type        | V <sub>CES</sub> | V <sub>CE(sat)</sub> <sup>max</sup><br>@25°C | I <sub>C</sub><br>@100°C |
|-------------|------------------|----------------------------------------------|--------------------------|
| STGB6NC60HD | 600V             | <2.5V                                        | 7A                       |
| STGP6NC60HD | 600V             | <2.5V                                        | 7A                       |
| STGF6NC60HD | 600V             | <2.5V                                        | 3A                       |

- Low on voltage drop (V<sub>cesat</sub>)
- Low C<sub>RES</sub> / C<sub>IES</sub> ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode
- High frequency operation



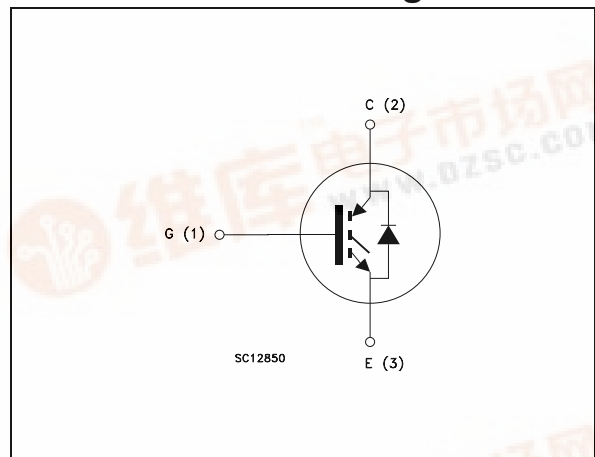
## Description

Using the latest high voltage technology based on a patented strip layout, STMicroelectronics has designed an advaced family of IGBTs, the PowerMESH™ IGBTs, with outstanding performances. The suffix "H" identifies a family optimized for high frequency application in order to achieve very high switching performances (reduced t<sub>fall</sub>) mantaining a low voltage drop.

## Applications

- High frequency inverters
- SMPS and PFC in both hard switch and resonant topologies
- Motor drivers

## Internal schematic diagram



## Order codes

| Part number   | Marking   | Package            | Packaging   |
|---------------|-----------|--------------------|-------------|
| STGB6NC60HDT4 | GB6NC60HD | D <sup>2</sup> PAK | Tape & reel |
| STGP6NC60HD   | GP6NC60HD | TO-220             | Tube        |
| STGF6NC60HD   | GF6NC60HD | TO-220FP           | Tube        |

Contents

1      **Electrical ratings** ..... 3

2      **Electrical characteristics** ..... 5

      2.1    Electrical characteristics (curves) ..... 7

3      **Test circuit** ..... 10

4      **Package mechanical data** ..... 11

5      **Packaging mechanical data** ..... 15

6      **Revision history** ..... 16

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol                         | Parameter                                                                    | Value                     |          | Unit |
|--------------------------------|------------------------------------------------------------------------------|---------------------------|----------|------|
|                                |                                                                              | D <sup>2</sup> PAK/TO-220 | TO-220FP |      |
| V <sub>CES</sub>               | Collector-emitter voltage (V <sub>GS</sub> = 0)                              | 600                       |          | V    |
| I <sub>C</sub> <sup>(1)</sup>  | Collector current (continuous) at T <sub>C</sub> = 25°C                      | 15                        | 6        | A    |
| I <sub>C</sub> <sup>(1)</sup>  | Collector current (continuous) at T <sub>C</sub> = 100°C                     | 7                         | 3        | A    |
| I <sub>CM</sub> <sup>(2)</sup> | Collector current (pulsed)                                                   | 21                        |          | A    |
| V <sub>GE</sub>                | Gate-emitter voltage                                                         | ±20                       |          | V    |
| I <sub>F</sub>                 | Diode RMS forward current at T <sub>C</sub> =25°C                            | 10                        |          | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25°C                                   | 56                        | 20       | W    |
| V <sub>ISO</sub>               | Insulation withstand voltage A.C.(t=1sec;T <sub>C</sub> =25°C)               | --                        | 2500     |      |
| T <sub>stg</sub>               | Storage temperature                                                          | – 55 to 150               |          | °C   |
| T <sub>j</sub>                 | Operating junction temperature                                               |                           |          |      |
| T <sub>l</sub>                 | Maximum lead temperature for soldering purpose (for 10sec. 1.6 mm from case) | 300                       |          | °C   |

1. Calculated according to the iterative formula::

$$I_C(T_C) = \frac{T_{JMAX} - T_C}{R_{THJ-C} \times V_{CESAT(MAX)}(T_C, I_C)}$$

2. Pulse width limited by max junction temperature

**Table 2. Thermal resistance**

| Symbol                | Parameter                               |                    | Value | Unit |
|-----------------------|-----------------------------------------|--------------------|-------|------|
| R <sub>thj-case</sub> | Thermal resistance junction-case max    | TO-220             | 2     | °C/W |
|                       |                                         | D <sup>2</sup> PAK | 2     | °C/W |
|                       |                                         | TO-220FP           | 5     | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max |                    | 62.5  | °C/W |

## 2 Electrical characteristics

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

**Table 3. Static**

| Symbol        | Parameter                                        | Test conditions                                                                                                         | Min. | Typ.       | Max.      | Unit                |
|---------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|------------|-----------|---------------------|
| $V_{BR(CES)}$ | Collector-emitter breakdown voltage              | $I_C = 1\text{mA}$ , $V_{GE} = 0$                                                                                       | 600  |            |           | V                   |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage             | $V_{GE} = 15\text{V}$ , $I_C = 3\text{A}$<br>$V_{GE} = 15\text{V}$ , $I_C = 3\text{A}$ , $T_C = 125^{\circ}\text{C}$    |      | 1.9<br>1.7 | 2.5       | 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<br>( $V_{GE} = 0$ )    | $V_{CE} = \text{Max rating}$ , $T_C = 25^{\circ}\text{C}$<br>$V_{CE} = \text{Max rating}$ , $T_C = 125^{\circ}\text{C}$ |      |            | 10<br>1   | $\mu\text{A}$<br>mA |
| $I_{GES}$     | Gate-emitter leakage current<br>( $V_{CE} = 0$ ) | $V_{GE} = \pm 20\text{V}$ , $V_{CE} = 0$                                                                                |      |            | $\pm 100$ | nA                  |
| $g_{fs}$      | Forward transconductance                         | $V_{CE} = 15\text{V}$ , $I_C = 3\text{A}$                                                                               |      | 3          |           | S                   |

**Table 4. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                                       | Min. | Typ.               | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------|--------------------|------|----------------|
| $C_{ies}$<br>$C_{oes}$<br>$C_{res}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{CE} = 25\text{V}$ , $f = 1\text{MHz}$ ,<br>$V_{GE} = 0$                                           |      | 205<br>32<br>5.5   |      | pF<br>pF<br>pF |
| $Q_g$<br>$Q_{ge}$<br>$Q_{gc}$       | Total gate charge<br>Gate-emitter charge<br>Gate-collector charge       | $V_{CE} = 390\text{V}$ , $I_C = 3\text{A}$ ,<br>$V_{GE} = 15\text{V}$ ,<br>(see Figure 18)            |      | 13.6<br>3.4<br>5.1 |      | nC<br>nC<br>nC |
| $I_{CL}$                            | Turn-off SOA minimum current                                            | $V_{clamp} = 390\text{V}$ , $T_j = 150^{\circ}\text{C}$ ,<br>$R_G = 10\Omega$ , $V_{GE} = 15\text{V}$ |      | 19                 |      | A              |

**Table 5. Switching on/off (inductive load)**

| Symbol         | Parameter             | Test conditions                     | Min. | Typ. | Max. | Unit       |
|----------------|-----------------------|-------------------------------------|------|------|------|------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390V, I_C = 3A$           |      | 12   |      | ns         |
| $t_r$          | Current rise time     | $R_G = 10\Omega, V_{GE} = 15V,$     |      | 5    |      | ns         |
| $(di/dt)_{on}$ | Turn-on current slope | $T_J = 25^\circ C$ (see Figure 19)  |      | 612  |      | A/ $\mu s$ |
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390V, I_C = 3A$           |      | 13   |      | ns         |
| $t_r$          | Current rise time     | $R_G = 10\Omega, V_{GE} = 15V,$     |      | 4.3  |      | ns         |
| $(di/dt)_{on}$ | Turn-on current slope | $T_J = 125^\circ C$ (see Figure 19) |      | 560  |      | A/ $\mu s$ |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390V, I_C = 3A,$          |      | 40   |      | ns         |
| $t_{d(off)}$   | Turn-off delay time   | $R_{GE} = 10\Omega, V_{GE} = 15V,$  |      | 76   |      | ns         |
| $t_f$          | Current fall time     | $T_J = 25^\circ C$ (see Figure 19)  |      | 100  |      | ns         |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390V, I_C = 3A,$          |      | 60   |      | ns         |
| $t_{d(off)}$   | Turn-off delay time   | $R_{GE} = 10\Omega, V_{GE} = 15V,$  |      | 98   |      | ns         |
| $t_f$          | Current fall time     | $T_J = 125^\circ C$ (see Figure 19) |      | 124  |      | ns         |

**Table 6. Switching energy (inductive load)**

| Symbol          | Parameter                 | Test conditions                     | Min. | Typ. | Max. | Unit    |
|-----------------|---------------------------|-------------------------------------|------|------|------|---------|
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 390V, I_C = 3A$           |      | 20   |      | $\mu J$ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\Omega, V_{GE} = 15V,$     |      | 68   |      | $\mu J$ |
| $E_{ts}$        | Total switching losses    | $T_J = 25^\circ C$ (see Figure 19)  |      | 88   |      | $\mu J$ |
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 390V, I_C = 3A$           |      | 37   |      | $\mu J$ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\Omega, V_{GE} = 15V,$     |      | 93   |      | $\mu J$ |
| $E_{ts}$        | Total switching losses    | $T_J = 125^\circ C$ (see Figure 19) |      | 130  |      | $\mu J$ |

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in figure 17. 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)
2. Turn-off losses include also the tail of the collector current

**Table 7. Collector-emitter diode**

| Symbol                            | Parameter                                                                    | Test conditions                                                                      | Min. | Typ.             | Max. | Unit          |
|-----------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------|------------------|------|---------------|
| $V_f$                             | Forward on-voltage                                                           | $I_f = 1.5A$<br>$I_f = 1.5A, T_j = 125^\circ C$                                      |      | 1.6<br>1.3       | 2.1  | V<br>V        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{rrm}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_f = 3A, V_R = 40V,$<br>$T_j = 25^\circ C, di/dt = 100 A/\mu s$<br>(see Figure 20) |      | 21<br>14<br>1.36 |      | ns<br>nC<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{rrm}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_f = 3A, V_R = 40V,$<br>$T_j = 125^\circ C, di/dt = 100A/\mu s$<br>(see Figure 20) |      | 34<br>32<br>1.88 |      | ns<br>nC<br>A |

2.1 Electrical characteristics (curves)

Figure 1. Output characteristics

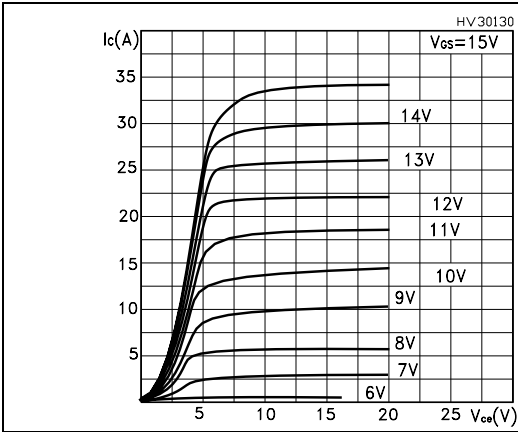


Figure 2. Transfer characteristics

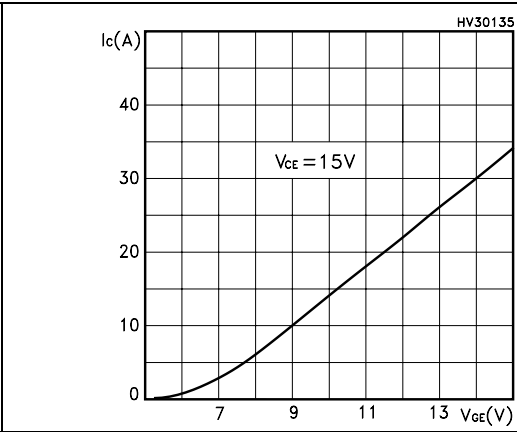


Figure 3. Transconductance

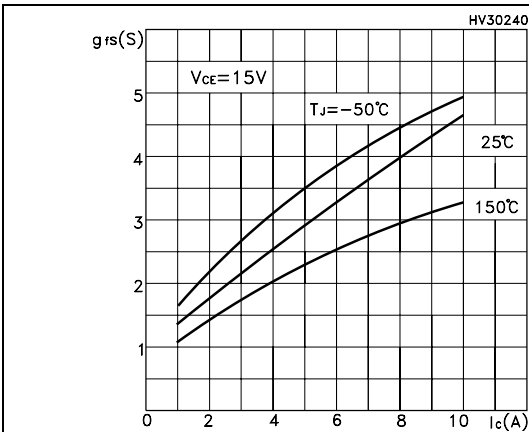


Figure 4. Collector-emitter on voltage vs temperature

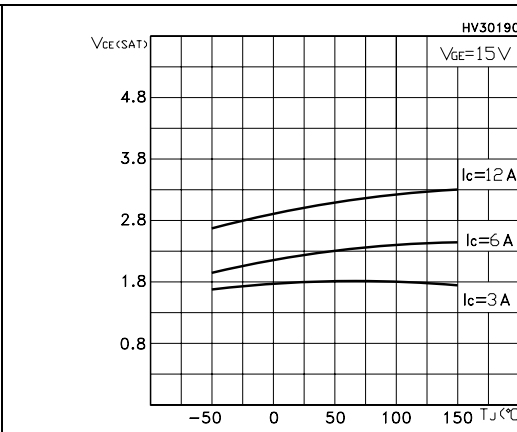


Figure 5. Gate charge vs gate-source voltage

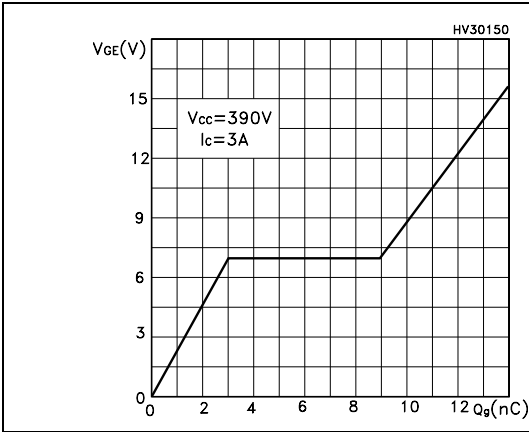


Figure 6. Capacitance variations

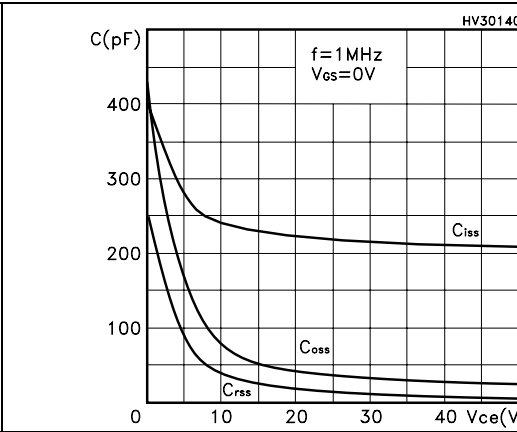


Figure 7. Normalized gate threshold voltage vs temperature

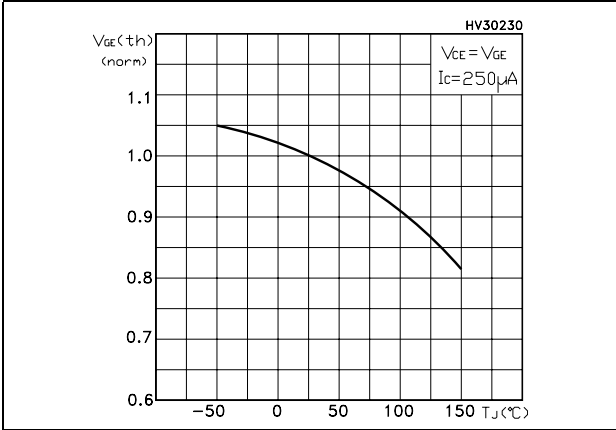


Figure 8. Collector-emitter on voltage vs collector current

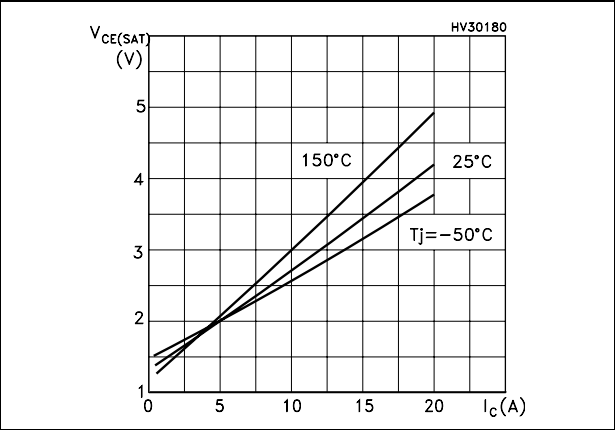


Figure 9. Normalized breakdown voltage vs temperature

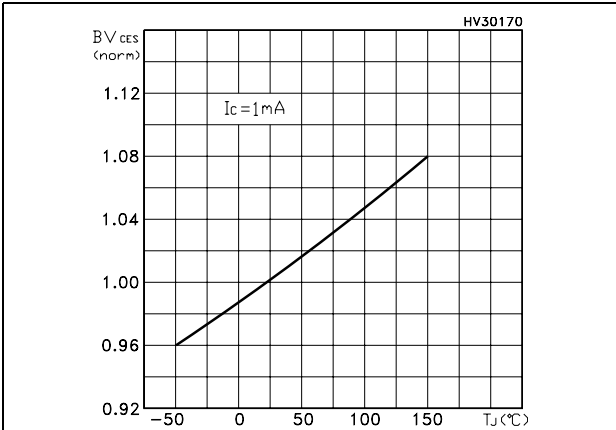


Figure 10. Switching losses vs temperature

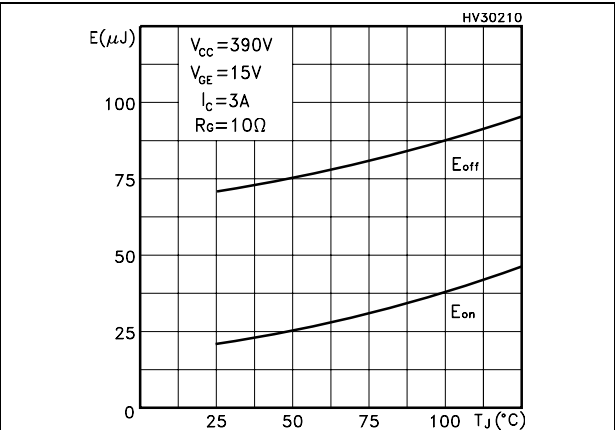


Figure 11. Switching losses vs gate resistance

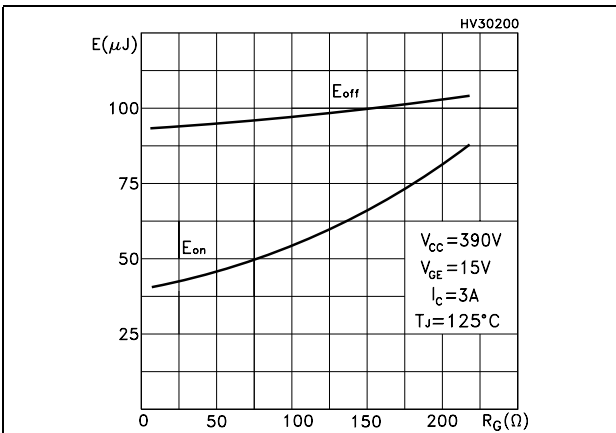


Figure 12. Switching losses vs collector current

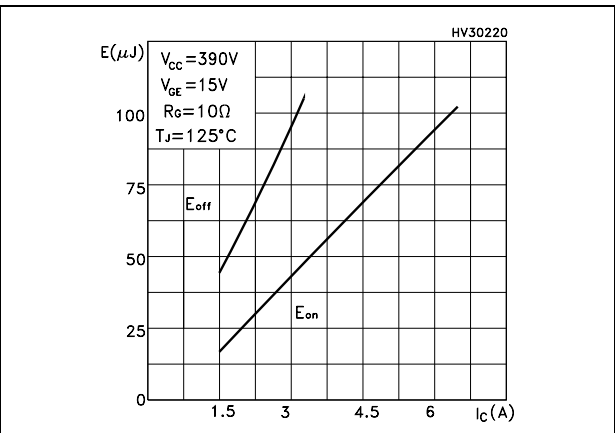


Figure 13. Thermal impedance for TO-220 / D<sup>2</sup>PAK

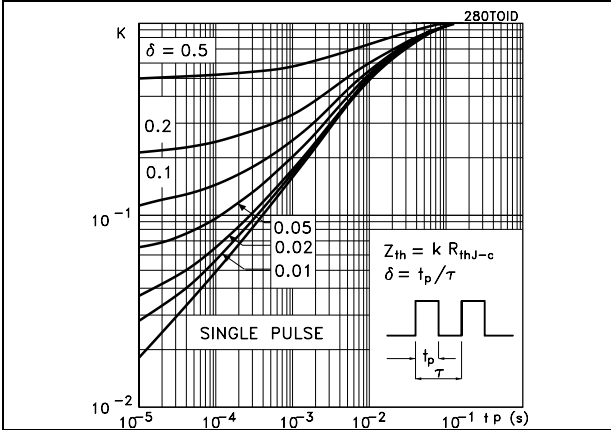


Figure 14. Turn-off SOA

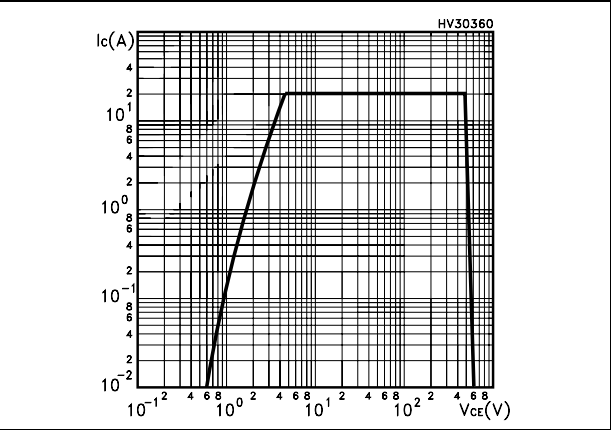


Figure 15. Thermal impedance for TO-220FP

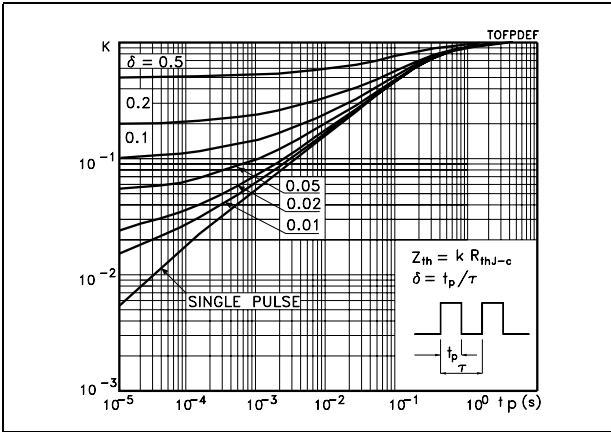
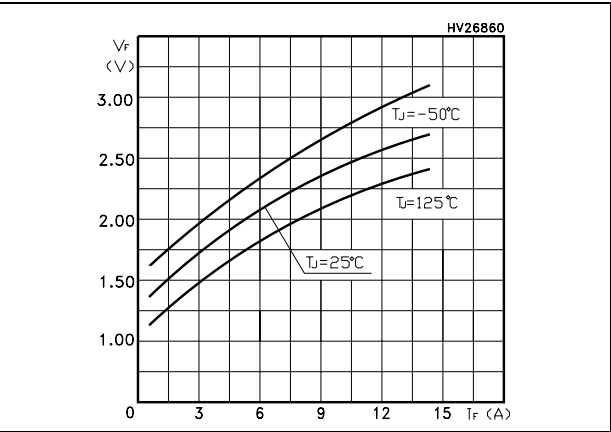


Figure 16. Emitter-collector diode characteristics



### 3 Test circuit

Figure 17. Test circuit for inductive load switching

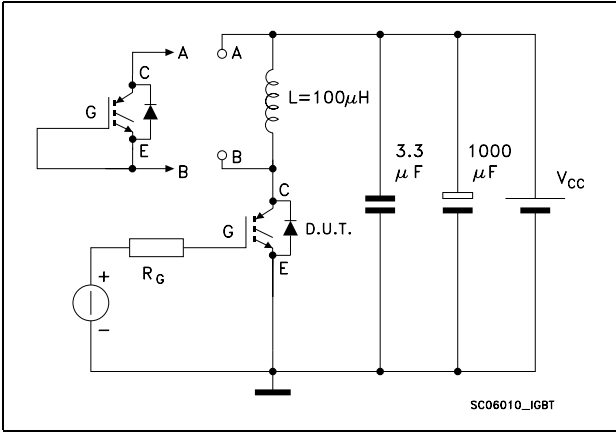


Figure 18. Gate charge test circuit

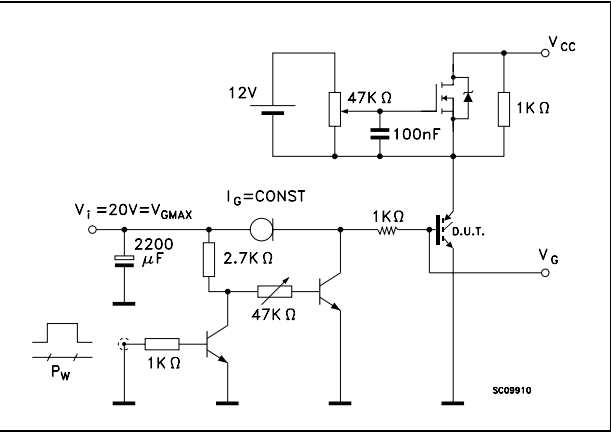


Figure 19. Switching waveform

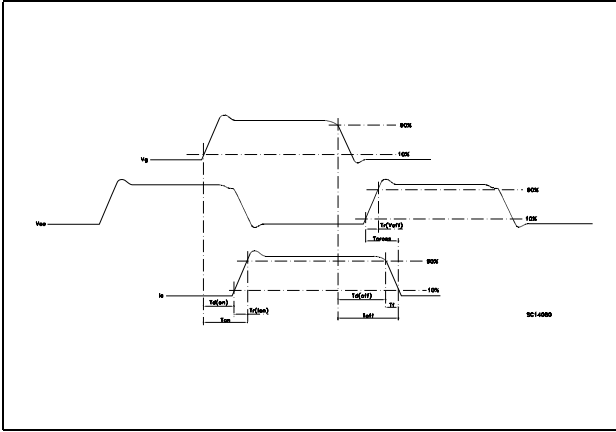
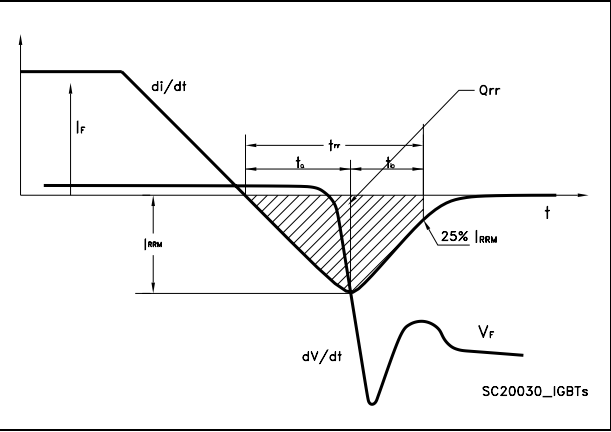


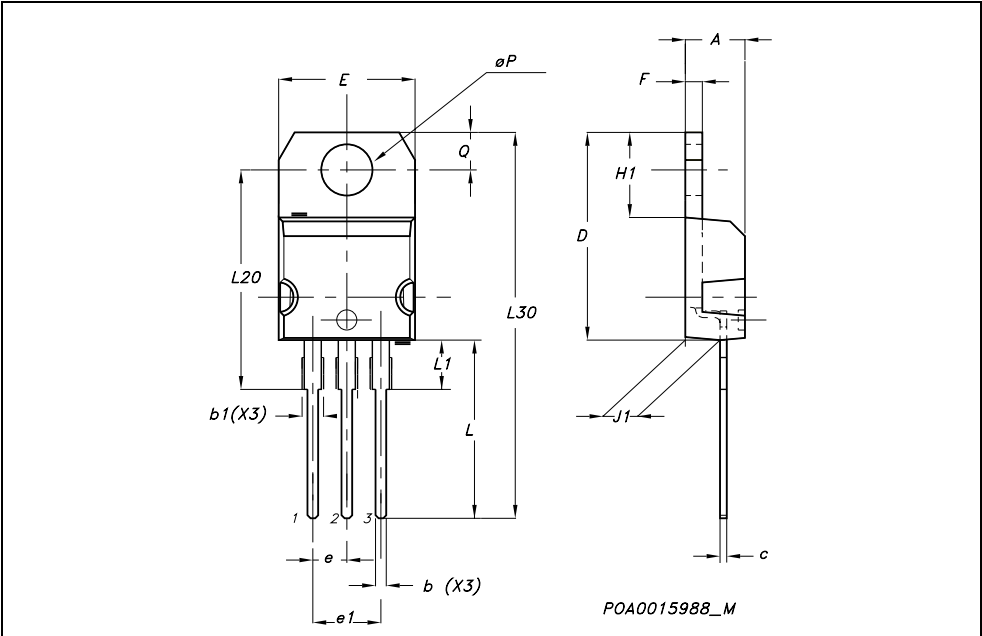
Figure 20. Diode recovery time waveform



## 4 Package mechanical data

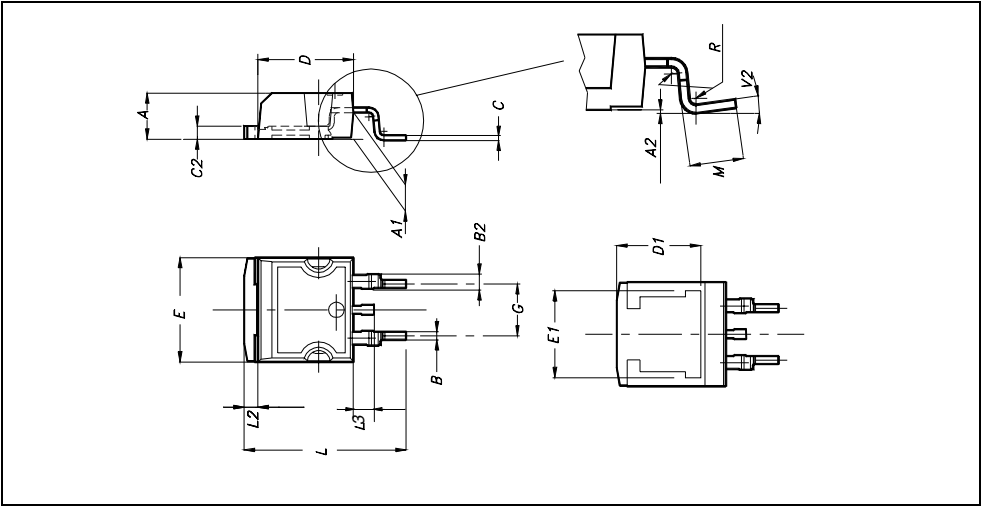
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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-220 MECHANICAL DATA |       |       |       |       |       |       |
|------------------------|-------|-------|-------|-------|-------|-------|
| DIM.                   | mm.   |       |       | inch  |       |       |
|                        | MIN.  | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A                      | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b                      | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1                     | 1.15  |       | 1.70  | 0.045 |       | 0.066 |
| c                      | 0.49  |       | 0.70  | 0.019 |       | 0.027 |
| D                      | 15.25 |       | 15.75 | 0.60  |       | 0.620 |
| E                      | 10    |       | 10.40 | 0.393 |       | 0.409 |
| e                      | 2.40  |       | 2.70  | 0.094 |       | 0.106 |
| e1                     | 4.95  |       | 5.15  | 0.194 |       | 0.202 |
| F                      | 1.23  |       | 1.32  | 0.048 |       | 0.052 |
| H1                     | 6.20  |       | 6.60  | 0.244 |       | 0.256 |
| J1                     | 2.40  |       | 2.72  | 0.094 |       | 0.107 |
| L                      | 13    |       | 14    | 0.511 |       | 0.551 |
| L1                     | 3.50  |       | 3.93  | 0.137 |       | 0.154 |
| L20                    |       | 16.40 |       |       | 0.645 |       |
| L30                    |       | 28.90 |       |       | 1.137 |       |
| øP                     | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q                      | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



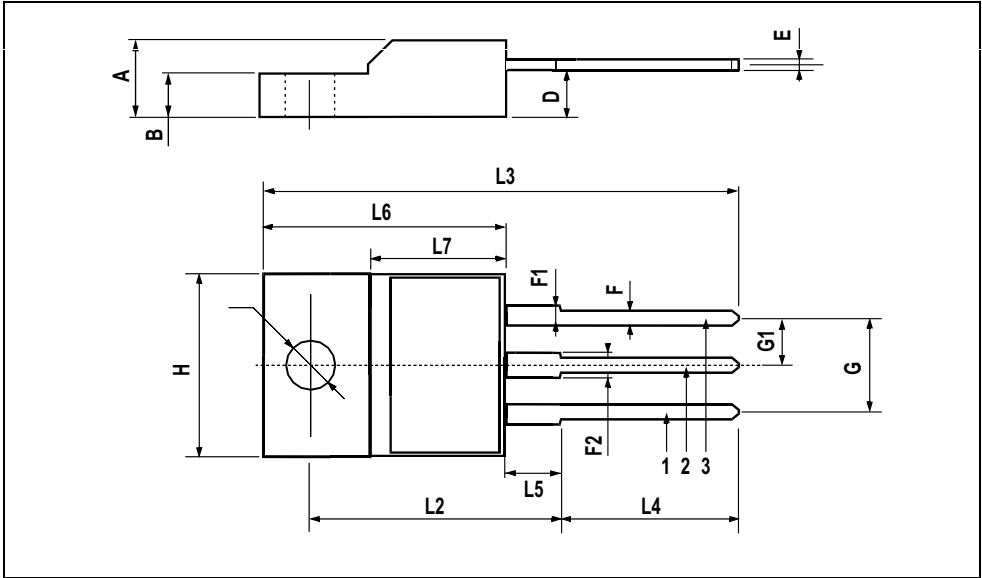
D<sup>2</sup>PAK MECHANICAL DATA

| DIM. | mm.  |     |       | inch  |       |       |
|------|------|-----|-------|-------|-------|-------|
|      | MIN. | TYP | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6   | 0.173 |       | 0.181 |
| A1   | 2.49 |     | 2.69  | 0.098 |       | 0.106 |
| A2   | 0.03 |     | 0.23  | 0.001 |       | 0.009 |
| B    | 0.7  |     | 0.93  | 0.027 |       | 0.036 |
| B2   | 1.14 |     | 1.7   | 0.044 |       | 0.067 |
| C    | 0.45 |     | 0.6   | 0.017 |       | 0.023 |
| C2   | 1.23 |     | 1.36  | 0.048 |       | 0.053 |
| D    | 8.95 |     | 9.35  | 0.352 |       | 0.368 |
| D1   |      | 8   |       |       | 0.315 |       |
| E    | 10   |     | 10.4  | 0.393 |       |       |
| E1   |      | 8.5 |       |       | 0.334 |       |
| G    | 4.88 |     | 5.28  | 0.192 |       | 0.208 |
| L    | 15   |     | 15.85 | 0.590 |       | 0.625 |
| L2   | 1.27 |     | 1.4   | 0.050 |       | 0.055 |
| L3   | 1.4  |     | 1.75  | 0.055 |       | 0.068 |
| M    | 2.4  |     | 3.2   | 0.094 |       | 0.126 |
| R    |      | 0.4 |       |       | 0.015 |       |
| V2   | 0°   |     | 4°    |       |       |       |

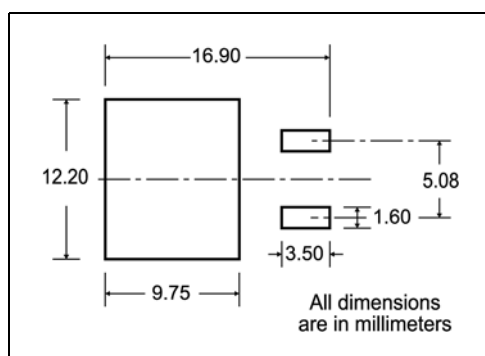


TO-220FP MECHANICAL DATA

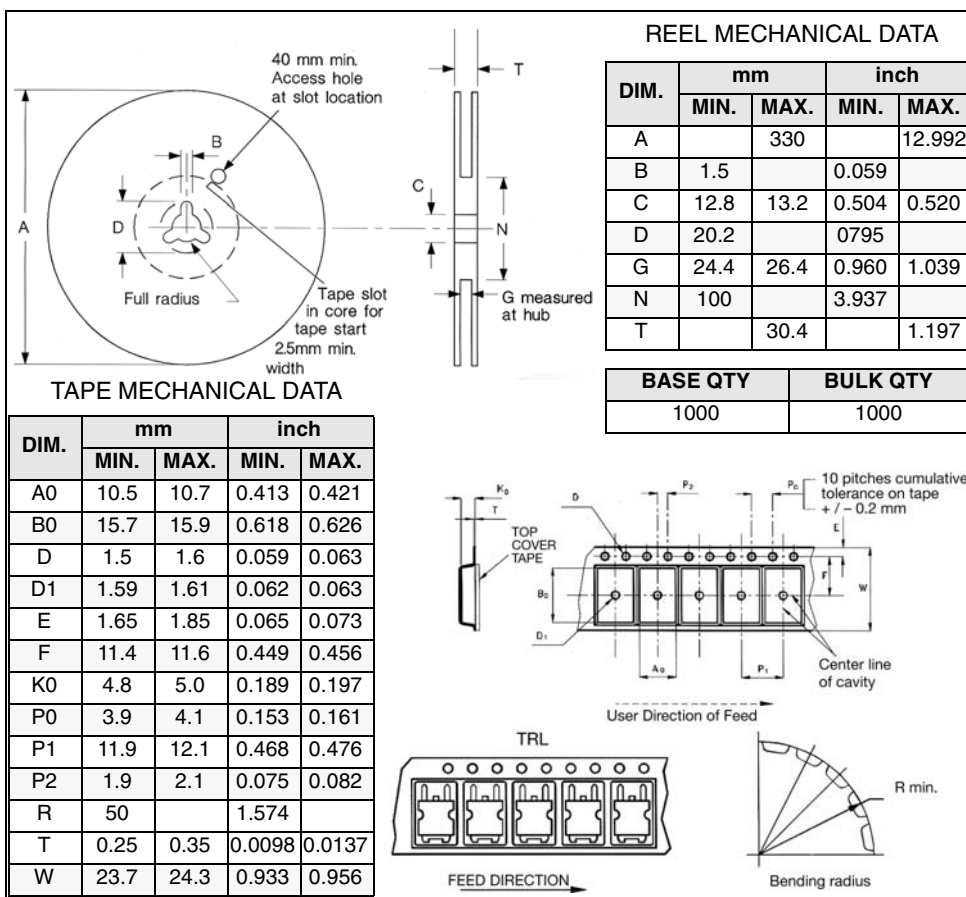
| DIM. | mm.  |     |      | inch  |       |       |
|------|------|-----|------|-------|-------|-------|
|      | MIN. | TYP | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6  | 0.173 |       | 0.181 |
| B    | 2.5  |     | 2.7  | 0.098 |       | 0.106 |
| D    | 2.5  |     | 2.75 | 0.098 |       | 0.108 |
| E    | 0.45 |     | 0.7  | 0.017 |       | 0.027 |
| F    | 0.75 |     | 1    | 0.030 |       | 0.039 |
| F1   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| F2   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| G    | 4.95 |     | 5.2  | 0.195 |       | 0.204 |
| G1   | 2.4  |     | 2.7  | 0.094 |       | 0.106 |
| H    | 10   |     | 10.4 | 0.393 |       | 0.409 |
| L2   |      | 16  |      |       | 0.630 |       |
| L3   | 28.6 |     | 30.6 | 1.126 |       | 1.204 |
| L4   | 9.8  |     | 10.6 | .0385 |       | 0.417 |
| L5   | 2.9  |     | 3.6  | 0.114 |       | 0.141 |
| L6   | 15.9 |     | 16.4 | 0.626 |       | 0.645 |
| L7   | 9    |     | 9.3  | 0.354 |       | 0.366 |
| Ø    | 3    |     | 3.2  | 0.118 |       | 0.126 |



## D<sup>2</sup>PAK FOOTPRINT



## REEL MECHANICAL DATA



\* on sales type

## 6 Revision history

**Table 8.** Revision history

| Date        | Revision | Changes                     |
|-------------|----------|-----------------------------|
| 28-Nov-2005 | 1        | First Release               |
| 07-Mar-2006 | 2        | Complete version            |
| 31-Jul-2006 | 3        | Modified <i>Figure 10</i> . |

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2006 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)