



# STGB6NC60HD - STGB6NC60HD-1 STGF6NC60HD - STGP6NC60HD

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

## Features

| Type          | V <sub>CE</sub> | V <sub>CE(sat)</sub> max<br>@25°C | I <sub>C</sub><br>@100°C |
|---------------|-----------------|-----------------------------------|--------------------------|
| STGB6NC60HD   | 600V            | <2.5V                             | 7A                       |
| STGB6NC60HD-1 | 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

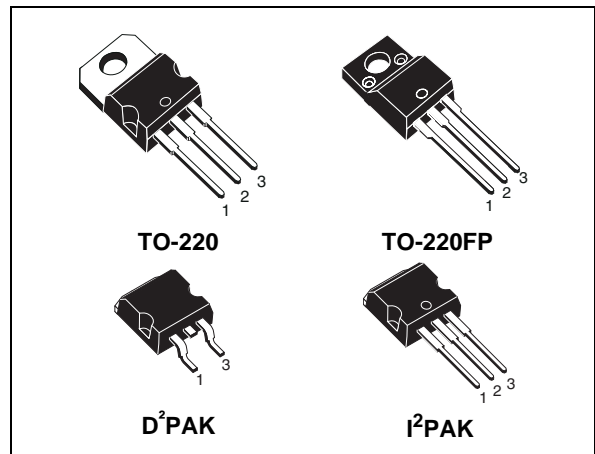
Using the latest high voltage technology based on a patented strip layout, STMicroelectronics has designed an advanced family of IGBTs, the PowerMESH™ IGBTs, with outstanding performances. The suffix “H” identifies a family optimized for high frequency application in order to achieve very high switching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

## Applications

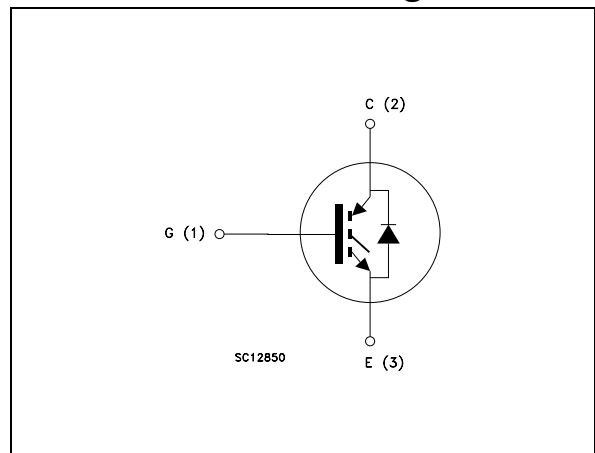
- High frequency inverters
- SMPS and PFC in both hard switch and resonant topologies
- Motor drivers

## Order codes

| Part number   | Marking   | Package            | Packaging   |
|---------------|-----------|--------------------|-------------|
| STGB6NC60HDT4 | GB6NC60HD | D <sup>2</sup> PAK | Tape & reel |
| STGB6NC60HD-1 | GB6NC60HD | I <sup>2</sup> PAK | Tube        |
| STGP6NC60HD   | GP6NC60HD | TO-220             | Tube        |
| STGF6NC60HD   | GF6NC60HD | TO-220FP           | Tube        |



## Internal schematic diagram



# Contents

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol                         | Parameter  | Value  |          | Unit |
|--------------------------------|--|--|----------|------|
|                                |  | D <sup>2</sup> PAK/I <sup>2</sup> PAK/<br>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;Tc=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<br>D <sup>2</sup> PAK<br>I <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                        | $V_{CE} = V_{GE}, I_C = 250\ \mu\text{A}$   | 3.75 |            | 5.75      | V                   |
| $I_{CES}$     | Collector cut-off current ( $V_{GE} = 0$ )    | $V_{CE} = \text{Max rating}, T_C = 25^{\circ}\text{C}$<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 ( $V_{CE} = 0$ ) | $V_{GE} = \pm 20\text{V}, V_{CE} = 0$   |      |            | $\pm 100$ | 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 |
|-----------|------------------------------|--|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{V}, f = 1\text{MHz},$<br>$V_{GE} = 0$  |      | 205  |      | pF   |
| $C_{oes}$ | Output capacitance           |  |      | 32   |      | pF   |
| $C_{res}$ | Reverse transfer capacitance |  |      | 5.5  |      | pF   |
| $Q_g$     | Total gate charge            | $V_{CE} = 390\text{V}, I_C = 3\text{A},$<br>$V_{GE} = 15\text{V},$<br><i>(see Figure 18)</i>     |      | 13.6 |      | nC   |
| $Q_{ge}$  | Gate-emitter charge          |  |      | 3.4  |      | nC   |
| $Q_{gc}$  | Gate-collector charge        |  |      | 5.1  |      | 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-pack diode, the co-pack 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       | $I_f = 1.5A$                            |      | 1.6  | 2.1  | V    |
|           |                          | $I_f = 1.5A, T_j = 125^\circ C$         |      | 1.3  |      | V    |
| $t_{rr}$  | Reverse recovery time    | $I_f = 3A, V_R = 40V,$                  |      | 21   |      | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $T_j = 25^\circ C, di/dt = 100 A/\mu s$ |      | 14   |      | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 20)                         |      | 1.36 |      | A    |
| $t_{rr}$  | Reverse recovery time    | $I_f = 3A, V_R = 40V,$                  |      | 34   |      | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $T_j = 125^\circ C, di/dt = 100A/\mu s$ |      | 32   |      | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 20)                         |      | 1.88 |      | A    |

## 2.1 Electrical characteristics (curves)

Figure 1. Output characteristics

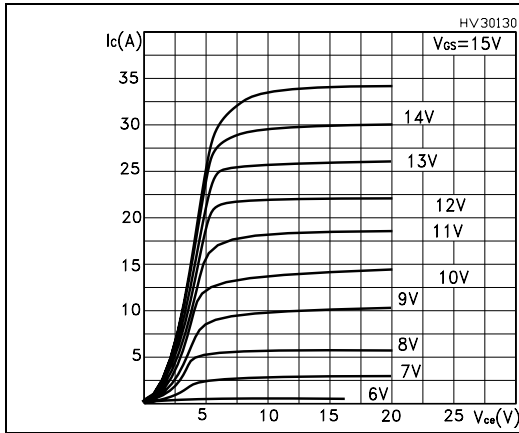


Figure 2. Transfer characteristics

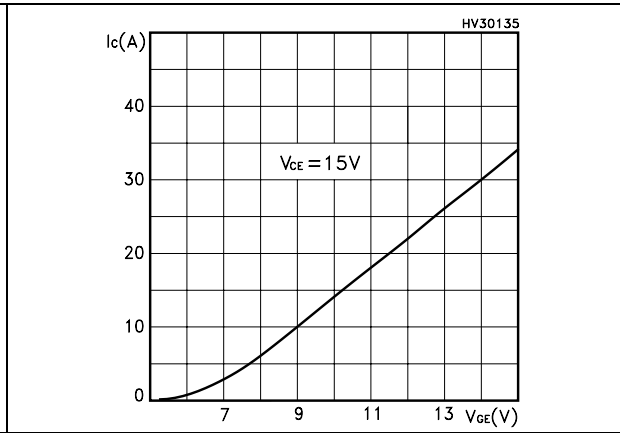


Figure 3. Transconductance

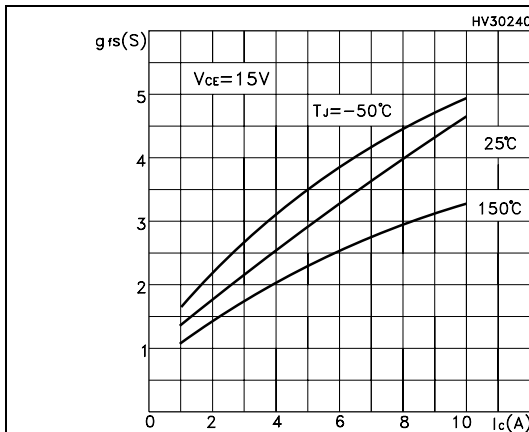


Figure 4. Collector-emitter on voltage vs temperature

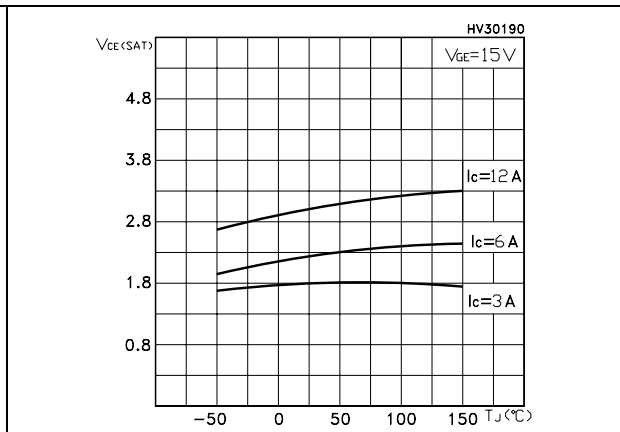


Figure 5. Gate charge vs gate-source voltage

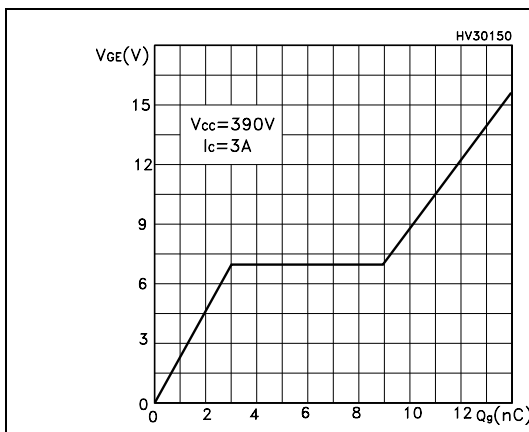


Figure 6. Capacitance variations

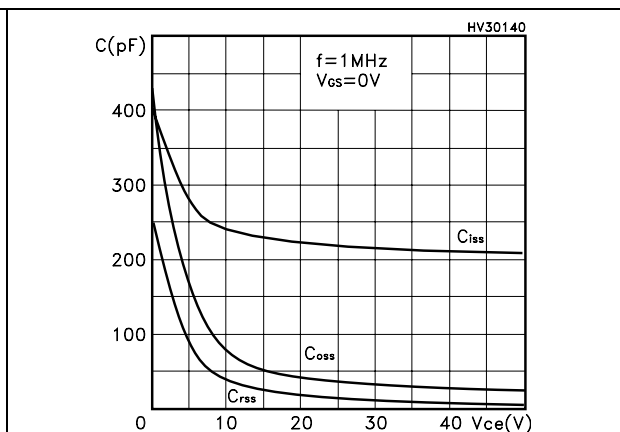


Figure 7. Normalized gate threshold voltage vs temperature

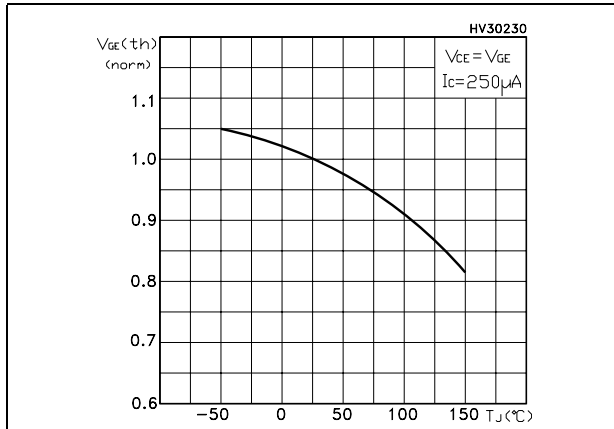


Figure 8. Collector-emitter on voltage vs collector current

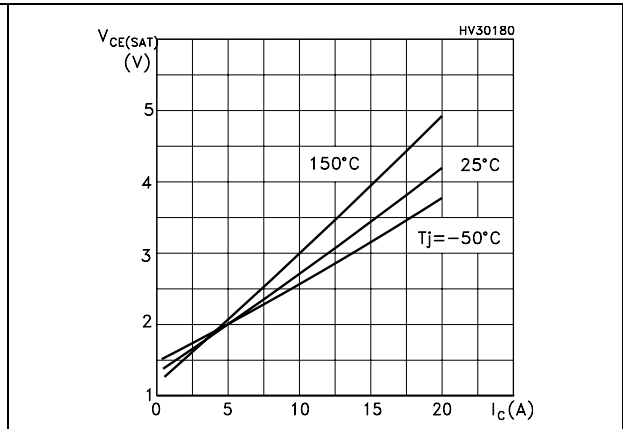


Figure 9. Normalized breakdown voltage vs temperature

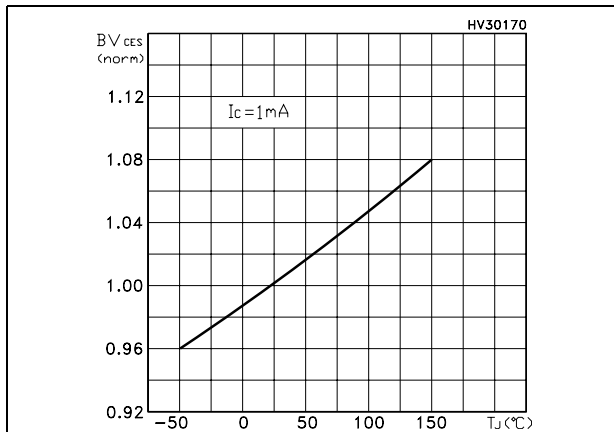


Figure 10. Switching losses vs temperature

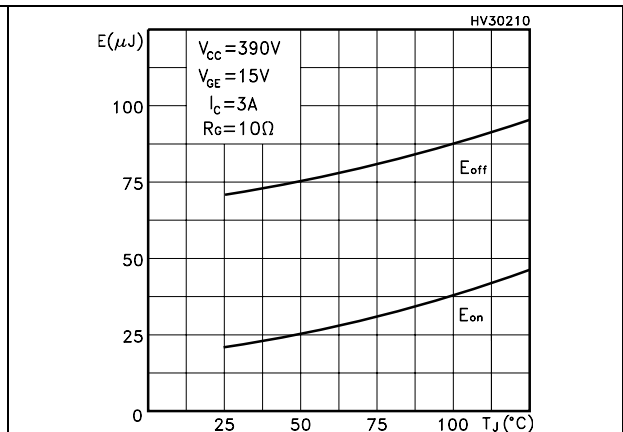


Figure 11. Switching losses vs gate resistance

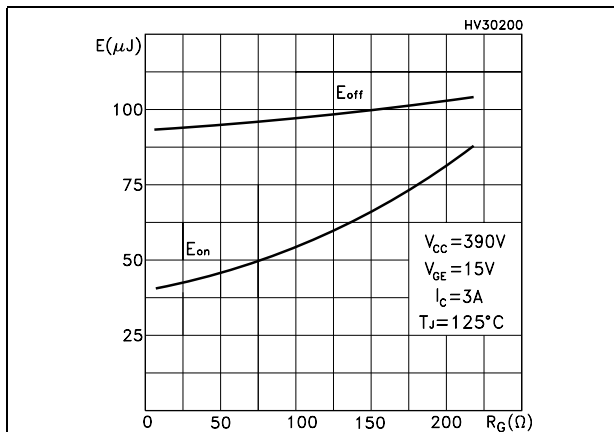


Figure 12. Switching losses vs collector current

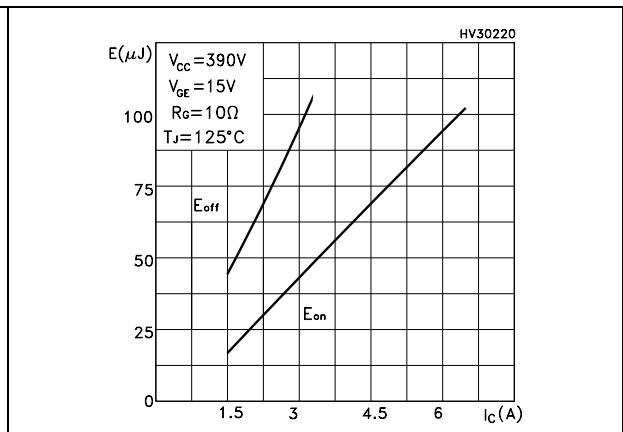




Figure 13. Thermal impedance for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

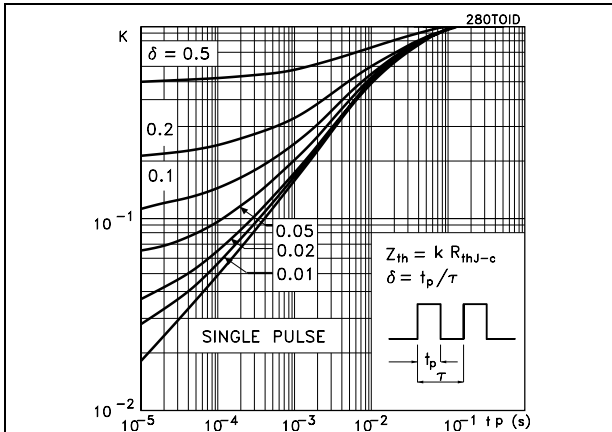


Figure 14. Turn-off SOA

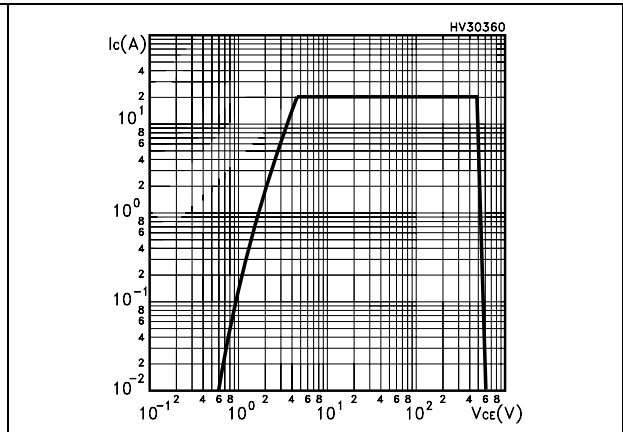


Figure 15. Thermal impedance for TO-220FP

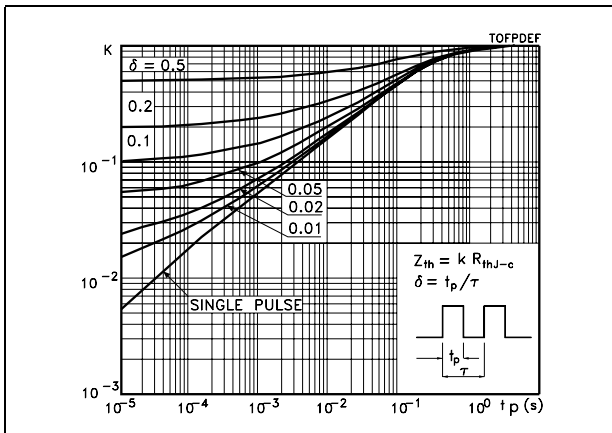
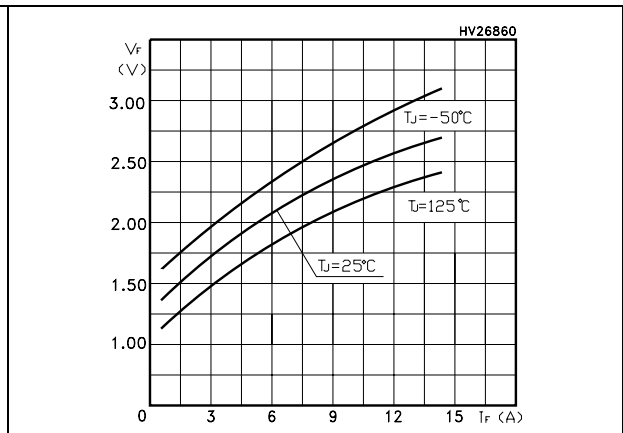


Figure 16. Emitter-collector diode characteristics



### 3 Test circuit

Figure 17. Test circuit for inductive load switching

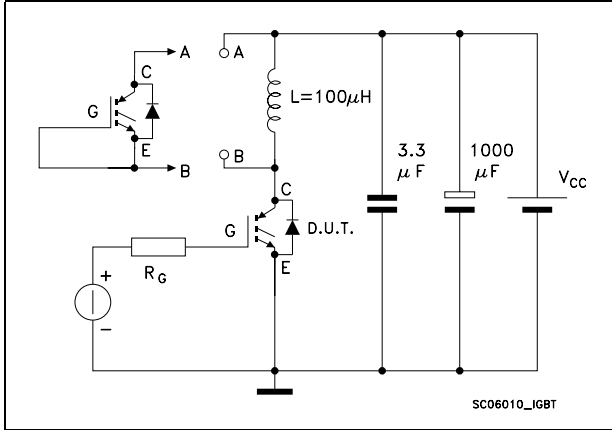


Figure 18. Gate charge test circuit

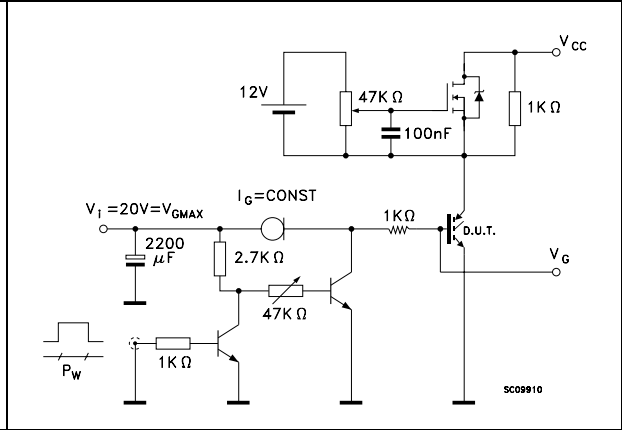


Figure 19. Switching waveform

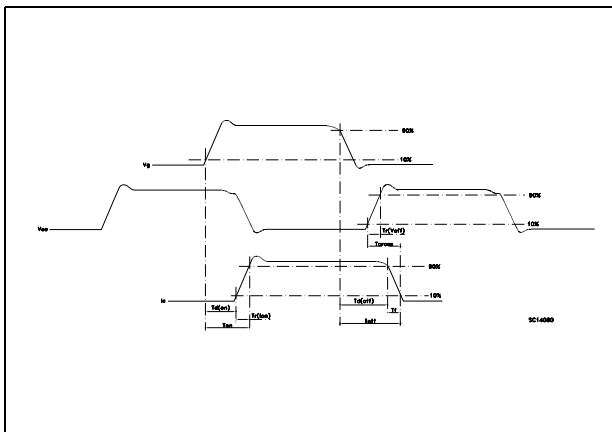
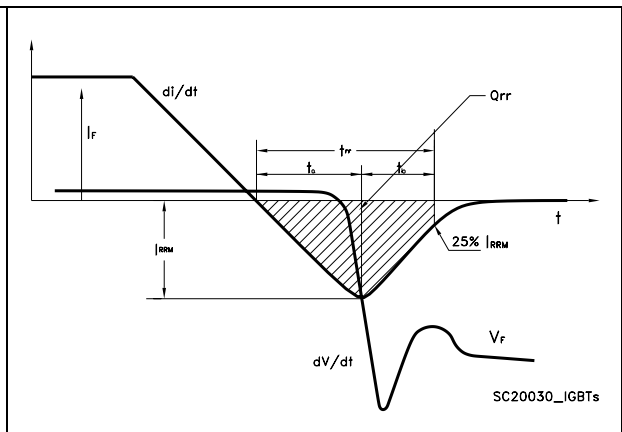


Figure 20. Diode recovery time waveform

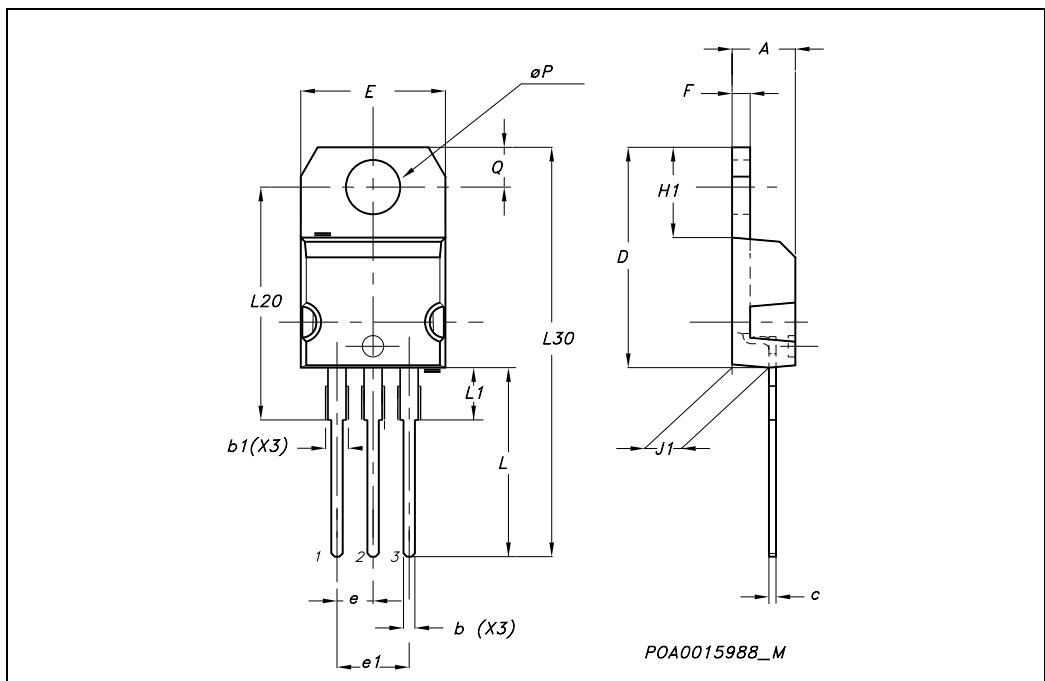


## 4 Package mechanical data

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)

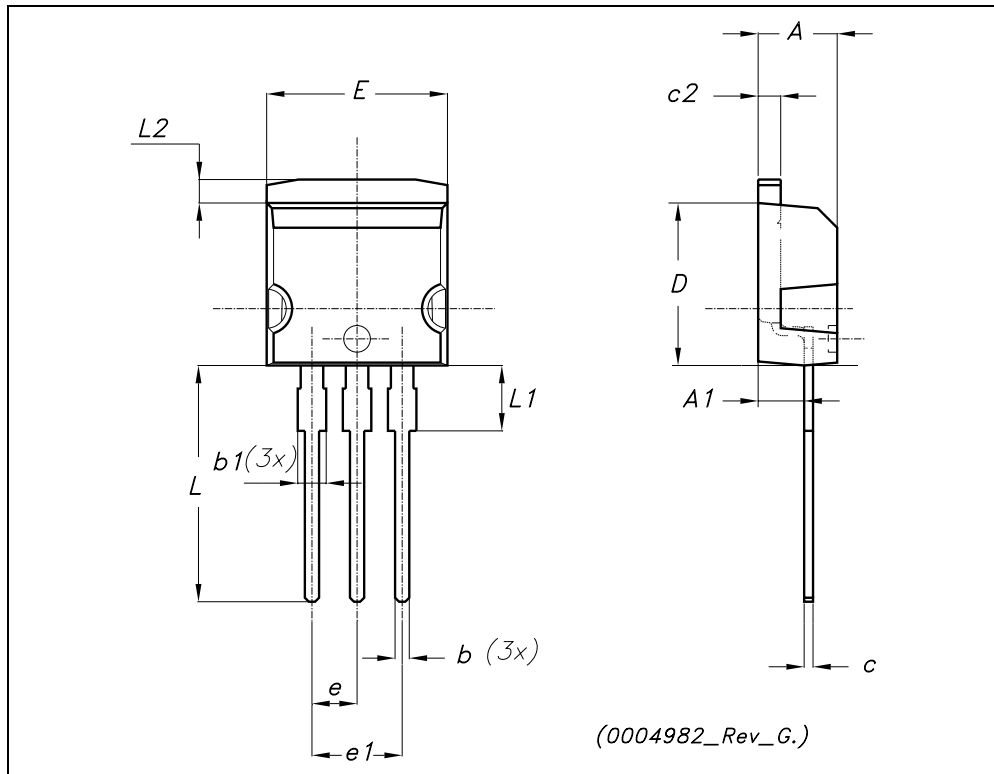
**TO-220 MECHANICAL DATA**

| 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 |



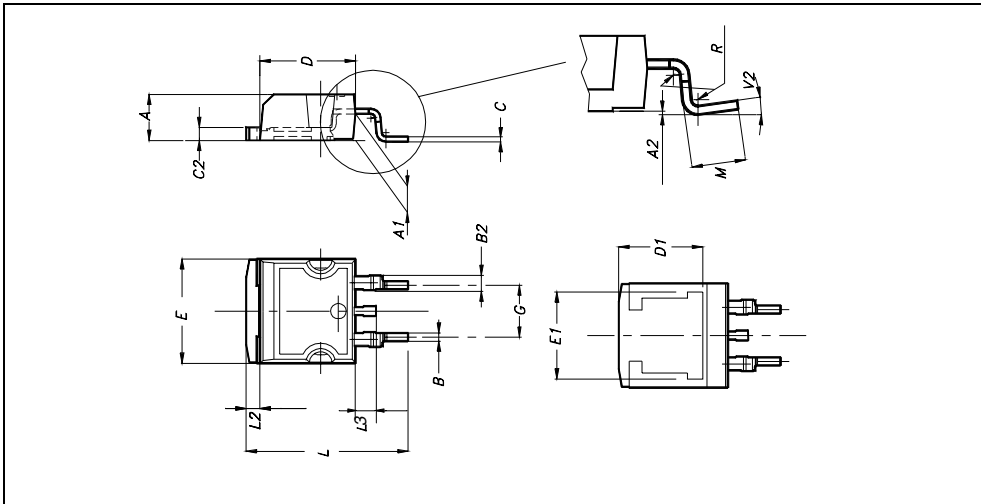
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

| DIM. | mm.  |      |       | inch  |      |       |
|------|------|------|-------|-------|------|-------|
|      | MIN. | TYP. | MAX.  | MIN.  | TYP. | MAX.  |
| A    | 4.40 |      | 4.60  | 0.173 |      | 0.181 |
| A1   | 2.40 |      | 2.72  | 0.094 |      | 0.107 |
| b    | 0.61 |      | 0.88  | 0.024 |      | 0.034 |
| b1   | 1.14 |      | 1.70  | 0.044 |      | 0.066 |
| c    | 0.49 |      | 0.70  | 0.019 |      | 0.027 |
| c2   | 1.23 |      | 1.32  | 0.048 |      | 0.052 |
| D    | 8.95 |      | 9.35  | 0.352 |      | 0.368 |
| e    | 2.40 |      | 2.70  | 0.094 |      | 0.106 |
| e1   | 4.95 |      | 5.15  | 0.194 |      | 0.202 |
| E    | 10   |      | 10.40 | 0.393 |      | 0.410 |
| L    | 13   |      | 14    | 0.511 |      | 0.551 |
| L1   | 3.50 |      | 3.93  | 0.137 |      | 0.154 |
| L2   | 1.27 |      | 1.40  | 0.050 |      | 0.055 |



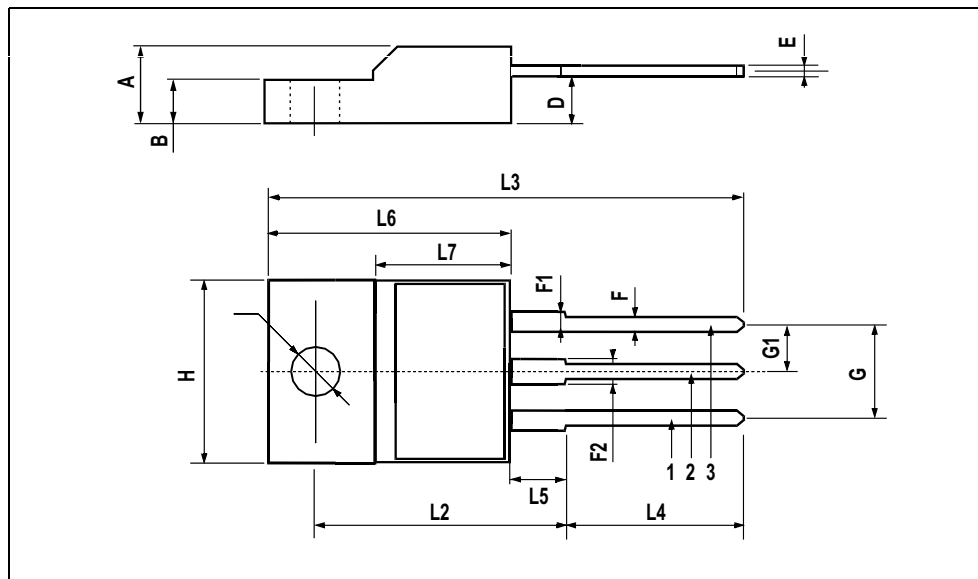
**D<sup>2</sup>PAK MECHANICAL DATA**

| 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 |



# 5 Packaging mechanical data

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



## TAPE AND REEL SHIPMENT

**TAPE MECHANICAL DATA**

| DIM. | mm   |      | inch   |        |
|------|------|------|--------|--------|
|      | MIN. | MAX. | MIN.   | MAX.   |
| A0   | 10.5 | 10.7 | 0.413  | 0.421  |
| B0   | 15.7 | 15.9 | 0.618  | 0.626  |
| D    | 1.5  | 1.6  | 0.059  | 0.063  |
| D1   | 1.59 | 1.61 | 0.062  | 0.063  |
| E    | 1.65 | 1.85 | 0.065  | 0.073  |
| F    | 11.4 | 11.6 | 0.449  | 0.456  |
| K0   | 4.8  | 5.0  | 0.189  | 0.197  |
| P0   | 3.9  | 4.1  | 0.153  | 0.161  |
| P1   | 11.9 | 12.1 | 0.468  | 0.476  |
| P2   | 1.9  | 2.1  | 0.075  | 0.082  |
| R    | 50   |      | 1.574  |        |
| T    | 0.25 | 0.35 | 0.0098 | 0.0137 |
| W    | 23.7 | 24.3 | 0.933  | 0.956  |

**REEL MECHANICAL DATA**

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 24.4 | 26.4 | 0.960 | 1.039  |
| N    | 100  |      | 3.937 |        |
| T    |      | 30.4 |       | 1.197  |

| BASE QTY | BULK QTY |
|----------|----------|
| 1000     | 1000     |

\* 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 <a href="#">Figure 10</a> . |
| 26-Apr-2007 | 4        | Inserted package I <sup>2</sup> PAK  |

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