



# STGB7NC60HD, STGF7NC60HD, STGP7NC60HD

N-channel 14 A, 600 V, very fast IGBT with Ultrafast diode

Datasheet – production data

## Features

- Low on-voltage drop ( $V_{CE(sat)}$ )
- Off losses include tail current
- Losses include diode recovery energy
- High frequency operation up to 70 kHz
- Very soft ultra fast recovery anti parallel diode

## Applications

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

## Description

These devices are very fast IGBT developed using advanced PowerMESH™ technology. This process guarantees an excellent trade-off between switching performance and low on-state behavior. These devices are well-suited for resonant or soft-switching applications.

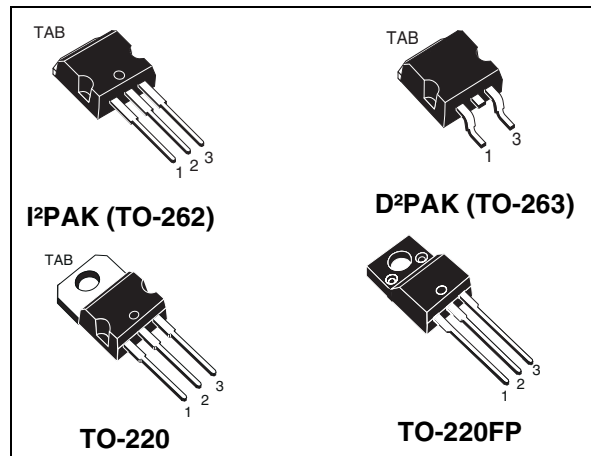


Figure 1. Internal schematic diagram

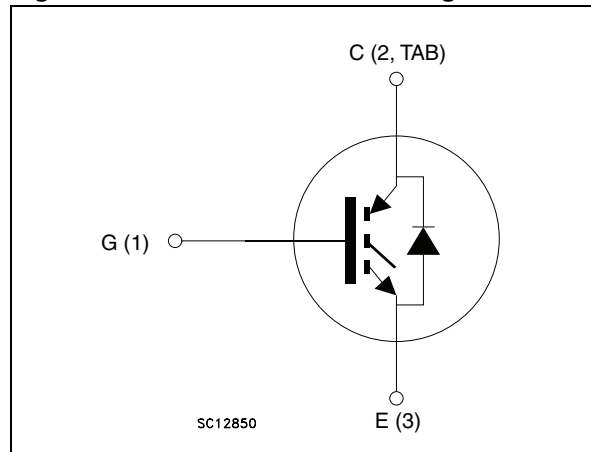


Table 1. Device summary

| Order codes   | Markings  | Packages       | Packaging     |
|---------------|-----------|----------------|---------------|
| STGB7NC60HD-1 | GB7NC60HD | I²PAK (TO-262) | Tube          |
| STGB7NC60HDT4 |           | D²PAK (TO-263) | Tape and reel |
| STGF7NC60HD   | GF7NC60HD | TO-220FP       | Tube          |
| STGP7NC60HD   | GP7NC60HD | TO-220         | Tube          |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                         | Parameter  | Value  |          | Unit |
|--------------------------------|--|--|----------|------|
|                                |  | I <sup>2</sup> PAK, D <sup>2</sup> PAK, TO-220 | TO-220FP |      |
| V <sub>CES</sub>               | Collector-emitter voltage (V <sub>GS</sub> = 0)                          | 600  |          | V    |
| V <sub>ECR</sub>               | Emitter-collector voltage  | 20   |          | V    |
| V <sub>GE</sub>                | Gate-emitter voltage   | ±20  |          | V    |
| I <sub>C</sub>                 | Collector current (continuous) at T <sub>C</sub> = 25 °C <sup>(1)</sup>  | 25   | 10       | A    |
| I <sub>C</sub>                 | Collector current (continuous) at T <sub>C</sub> = 100 °C <sup>(1)</sup> | 14   | 6        | A    |
| I <sub>CM</sub> <sup>(2)</sup> | Collector current (pulsed)   | 50   |          | A    |
| I <sub>F</sub>                 | Diode RMS forward current at T <sub>C</sub> = 25°C                       | 20   |          | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25°C                               | 80   | 25       | W    |
|                                | Derating factor  | 0.64   | 0.20     | W/°C |
| V <sub>ISO</sub>               | Insulation withstand voltage A.C. (t = 1 sec; T <sub>C</sub> = 25°C)     | --   | 2500     | V    |
| T <sub>stg</sub>               | Storage temperature  | - 55 to 150                                    |          | °C   |
| T <sub>j</sub>                 | 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 maximum junction temperature and turn-off within RBSOA.

**Table 3. Thermal data**

| Symbol            | Parameter                           | Value  |          | Unit |
|-------------------|-------------------------------------|--|----------|------|
|                   |                                     | I <sup>2</sup> PAK, D <sup>2</sup> PAK, TO-220 | TO-220FP |      |
| R <sub>thJC</sub> | Thermal resistance junction-case    | 1.56   | 5.0      | °C/W |
| R <sub>thJA</sub> | Thermal resistance junction-ambient | 62.5   |          | °C/W |

## 2 Electrical characteristics

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

**Table 4. Electrical characteristics**

| 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                   |
| $I_{CES}$     | Collector cut-off current ( $V_{GE} = 0$ )    | $V_{CE} = 600 \text{ V}$<br>$V_{CE} = 600 \text{ V}, T_C = 125^{\circ}\text{C}$                                     |      |             | 10<br>1   | $\mu\text{A}$<br>mA |
| $I_{GES}$     | Gate-emitter leakage current ( $V_{CE} = 0$ ) | $V_{GE} = \pm 20 \text{ V}$   |      |             | $\pm 100$ | nA                  |
| $V_{GE(th)}$  | Gate threshold voltage                        | $V_{CE} = V_{GE}, I_C = 250 \mu\text{A}$  | 3.75 |             | 5.75      | V                   |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage          | $V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}$<br>$V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}, T_C = 125^{\circ}\text{C}$ |      | 1.85<br>1.7 | 2.5       | V<br>V              |

**Table 5. Dynamic**

| Symbol         | Parameter                    | Test conditions  | Min. | Typ. | Max. | Unit |
|----------------|------------------------------|--|------|------|------|------|
| $g_{fs}^{(1)}$ | Forward transconductance     | $V_{CE} = 15 \text{ V}, I_C = 7 \text{ A}$   |      | 4.30 |      | S    |
| $C_{ies}$      | Input capacitance            | $V_{CE} = 25 \text{ V}, f = 1 \text{ MHz},$<br>$V_{GE} = 0$  |      | 720  |      | pF   |
| $C_{oes}$      | Output capacitance           |  |      | 81   |      | pF   |
| $C_{res}$      | Reverse transfer capacitance |  |      | 17   |      | pF   |
| $Q_g$          | Total gate charge            | $V_{CE} = 390 \text{ V}, I_C = 7 \text{ A},$<br>$V_{GE} = 15 \text{ V}$                            |      | 35   | 48   | nC   |
| $Q_{ge}$       | Gate-emitter charge          |  |      | 7    |      | nC   |
| $Q_{gc}$       | Gate-collector charge        |  |      | 16   |      | nC   |
| $I_{CL}$       | Turn-off SOA minimum current | $V_{clamp} = 480 \text{ V}, T_j = 150^{\circ}\text{C}$<br>$R_G = 10 \Omega, V_{GE} = 15 \text{ V}$ | 50   |      |      | A    |

1. Pulsed: Pulse duration= 300  $\mu\text{s}$ , duty cycle 1.5%

**Table 6. Switching on**

| Symbol         | Parameter             | Test conditions  | Min. | Typ. | Max. | Unit             |
|----------------|-----------------------|--|------|------|------|------------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$<br>$R_G = 10 \Omega, V_{GE} = 15 \text{ V}$<br>(see <a href="#">Figure 21</a> )                              |      | 18.5 |      | ns               |
| $t_r$          | Current rise time     |  |      | 8.5  |      | ns               |
| $(di/dt)_{on}$ | Turn-on current slope |  |      | 1060 |      | A/ $\mu\text{s}$ |
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$<br>$R_G = 10 \Omega, V_{GE} = 15 \text{ V},$<br>$T_j = 125^{\circ}\text{C}$ (see <a href="#">Figure 21</a> ) |      | 18.5 |      | ns               |
| $t_r$          | Current rise time     |  |      | 7    |      | ns               |
| $(di/dt)_{on}$ | Turn-on current slope |  |      | 1000 |      | A/ $\mu\text{s}$ |

**Table 7. Switching off**

| Symbol         | Parameter             | Test conditions  | Min. | Typ. | Max. | Unit |
|----------------|-----------------------|--|------|------|------|------|
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$                                      | -    | 27   | -    | ns   |
| $t_{d(off)}$   | Turn-off delay time   |  |      | 72   |      | ns   |
| $t_f$          | Current fall time     |  |      | 60   |      | ns   |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$<br>$T_j = 125\text{ }^\circ\text{C}$ | -    | 56   | -    | ns   |
| $t_{d(off)}$   | Turn-off delay time   |  |      | 116  |      | ns   |
| $t_f$          | Current fall time     |  |      | 105  |      | ns   |

**Table 8. Switching energy**

| Symbol          | Parameter                | Test conditions  | Min. | Typ. | Max. | Unit          |
|-----------------|--------------------------|--|------|------|------|---------------|
| $E_{on}^{(1)}$  | Turn-on switching losses | $V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,                                      | -    | 95   | 125  | $\mu\text{J}$ |
| $E_{off}^{(2)}$ | Turn-off switching loss  |  |      | 115  | 150  | $\mu\text{J}$ |
| $E_{ts}$        | Total switching loss     |  |      | 210  | 275  | $\mu\text{J}$ |
| $E_{on}^{(1)}$  | Turn-on switching losses | $V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_j = 125\text{ }^\circ\text{C}$ | -    | 140  |      | $\mu\text{J}$ |
| $E_{off}^{(2)}$ | Turn-off switching loss  |  |      | 215  |      | $\mu\text{J}$ |
| $E_{ts}$        | Total switching loss     |  |      | 355  |      | $\mu\text{J}$ |

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

**Table 9. Collector-emitter diode**

| Symbol    | Parameter                    | Test conditions  | Min. | Typ.       | Max. | Unit   |
|-----------|------------------------------|--|------|------------|------|--------|
| $V_f$     | Forward on-voltage           | $I_f = 3.5\text{ A}$<br>$I_f = 3.5\text{ A}$ , $T_j = 125\text{ }^\circ\text{C}$                                     | -    | 1.3<br>1.1 | 1.9  | V<br>V |
| $t_{rr}$  | Reverse recovery time        | $I_f = 7\text{ A}$ , $V_R = 40\text{ V}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$                                     |      | 37         |      | ns     |
| $t_a$     |                              |  |      | 22         |      | ns     |
| $Q_{rr}$  | Reverse recovery charge      |  |      | 40         |      | nC     |
| $I_{rrm}$ | Reverse recovery current     |  |      | 2.1        |      | A      |
| $S$       | Softness factor of the diode |  |      | 0.68       |      |        |
| $t_{rr}$  | Reverse recovery time        | $I_f = 7\text{ A}$ , $V_R = 40\text{ V}$ ,<br>$T_j = 125\text{ }^\circ\text{C}$ , $di/dt = 100\text{ A}/\mu\text{s}$ |      | 61         |      | ns     |
| $t_a$     |                              |  |      | 34         |      | ns     |
| $Q_{rr}$  | Reverse recovery charge      |  |      | 98         |      | nC     |
| $I_{rrm}$ | Reverse recovery current     |  |      | 3.2        |      | A      |
| $S$       | Softness factor of the diode |  | 0.79 |            |      |        |

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

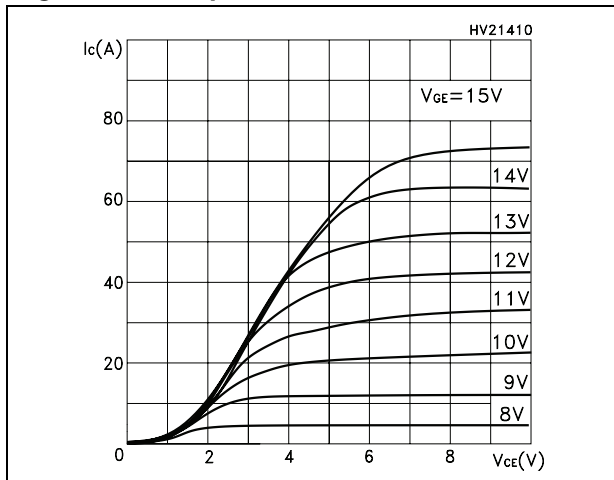


Figure 3. Transfer characteristics

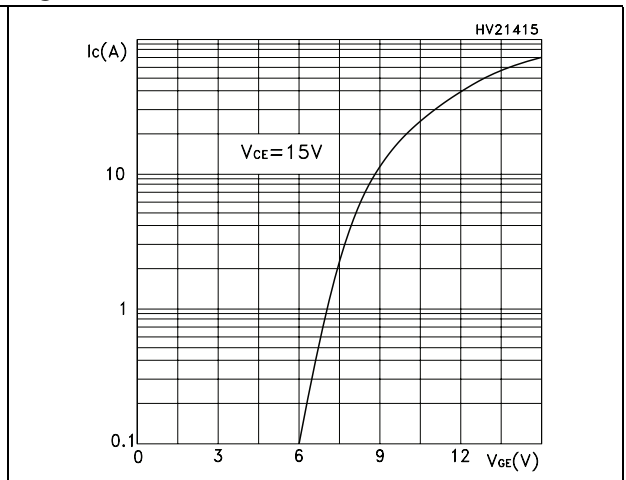


Figure 4. Transconductance

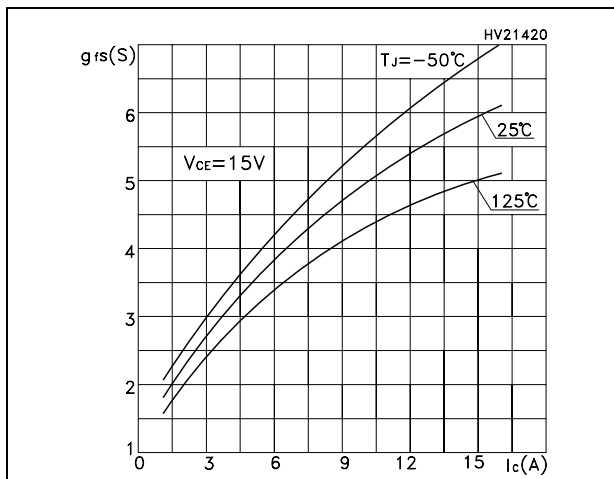


Figure 5. Collector-emitter on voltage vs. temperature

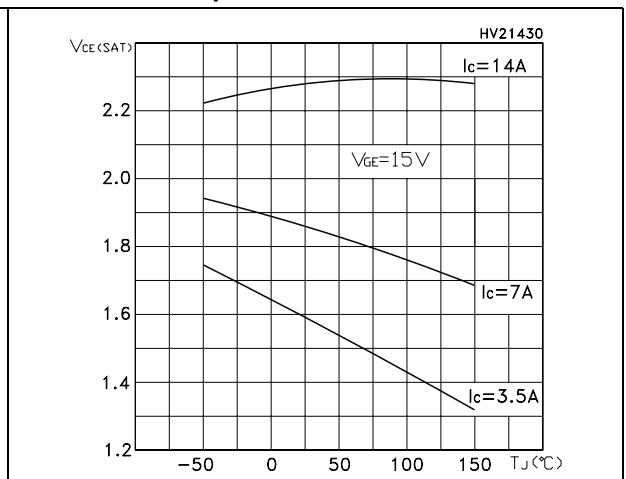


Figure 6. Collector-emitter on voltage vs. collector current

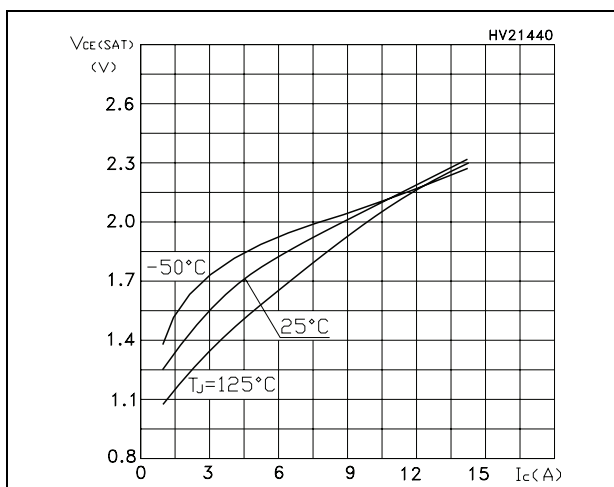
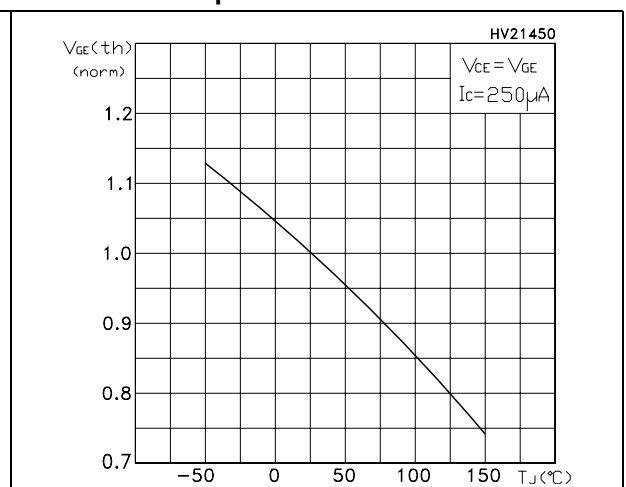
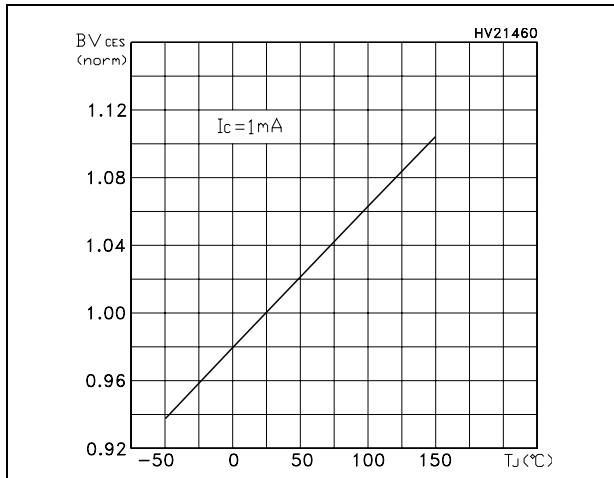


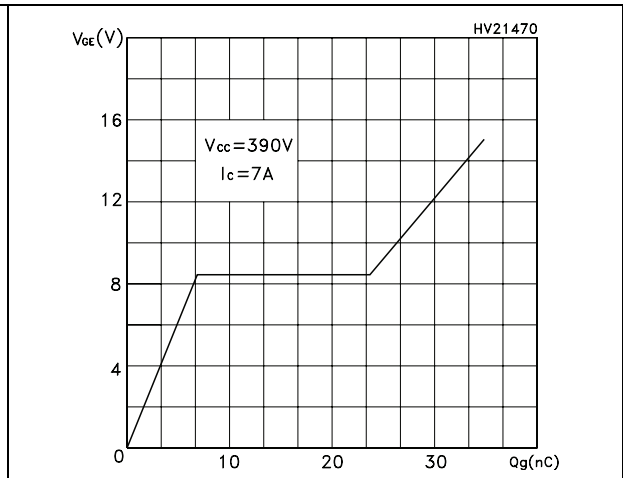
Figure 7. Normalized gate threshold vs. temperature



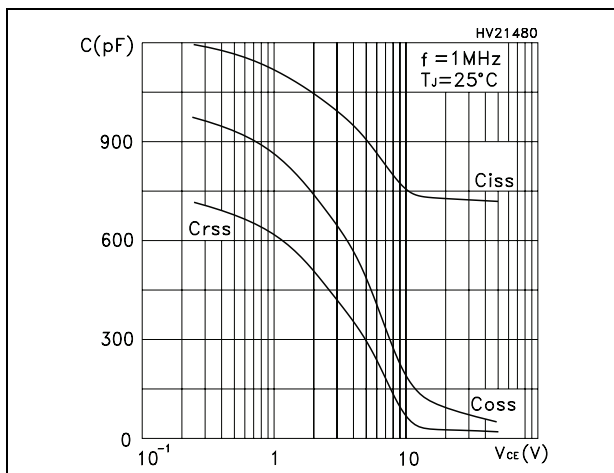
**Figure 8. Normalized breakdown voltage vs temperature**



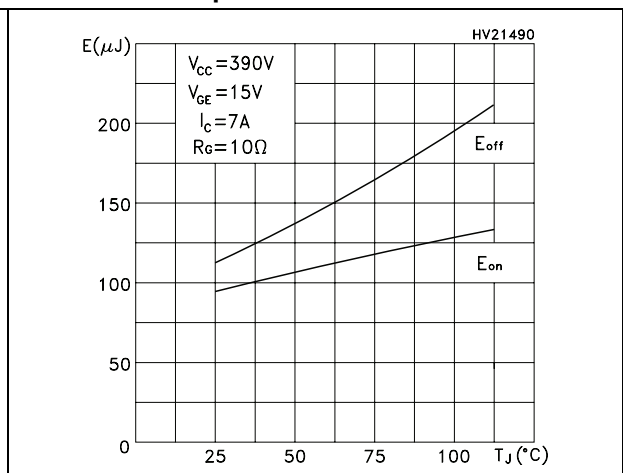
**Figure 9. Gate charge vs. gate-emitter voltage**



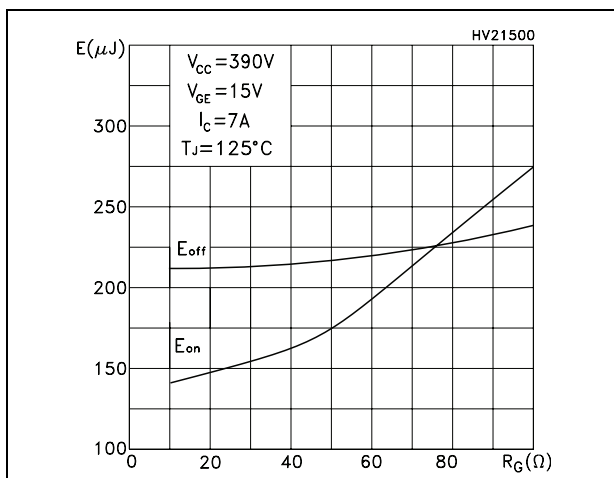
**Figure 10. Capacitance variations**



**Figure 11. Total switching losses vs. temperature**



**Figure 12. Total switching losses vs. gate resistance**



**Figure 13. Total switching losses vs collector current**

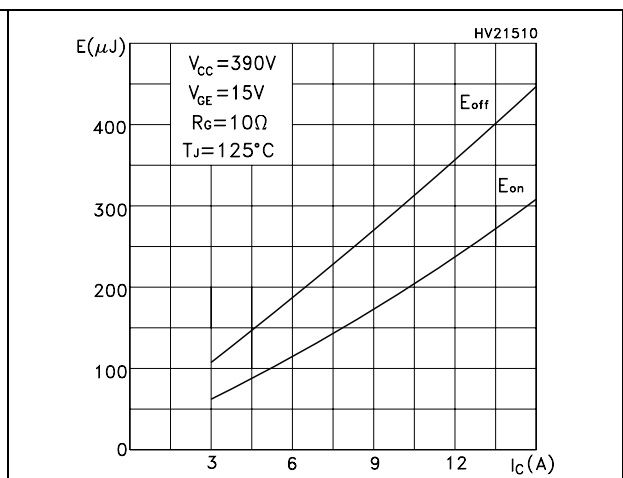


Figure 14. Emitter-collector diode characteristics

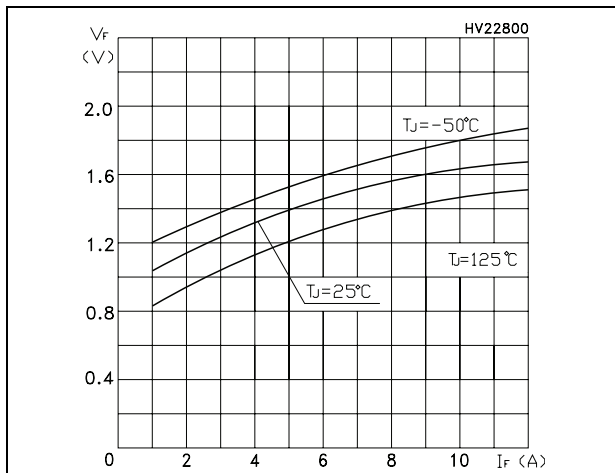


Figure 15. Turn-off SOA

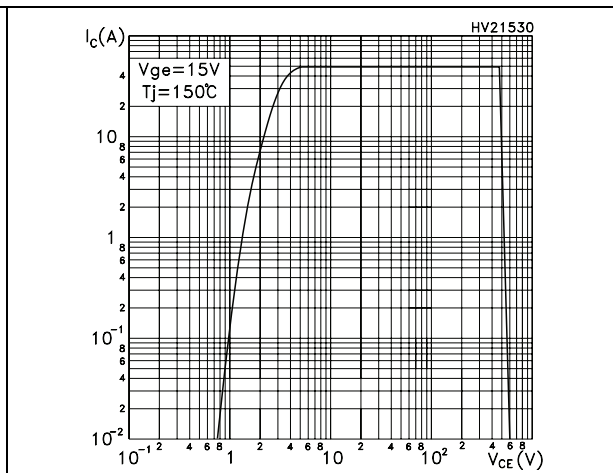


Figure 16. Thermal impedance for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

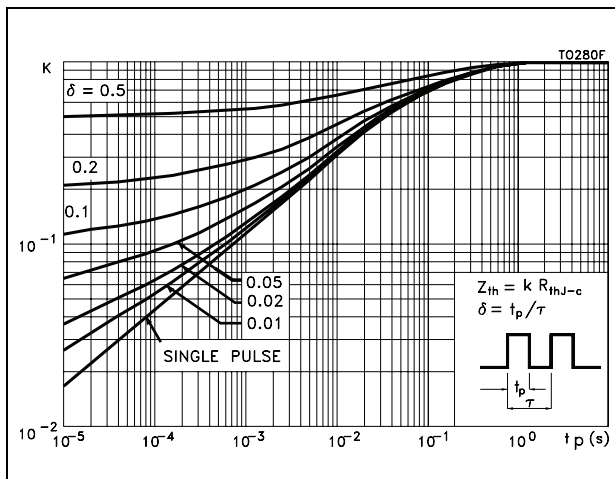
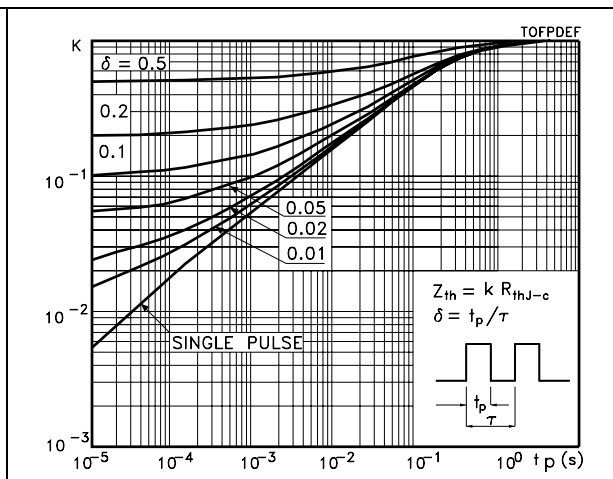


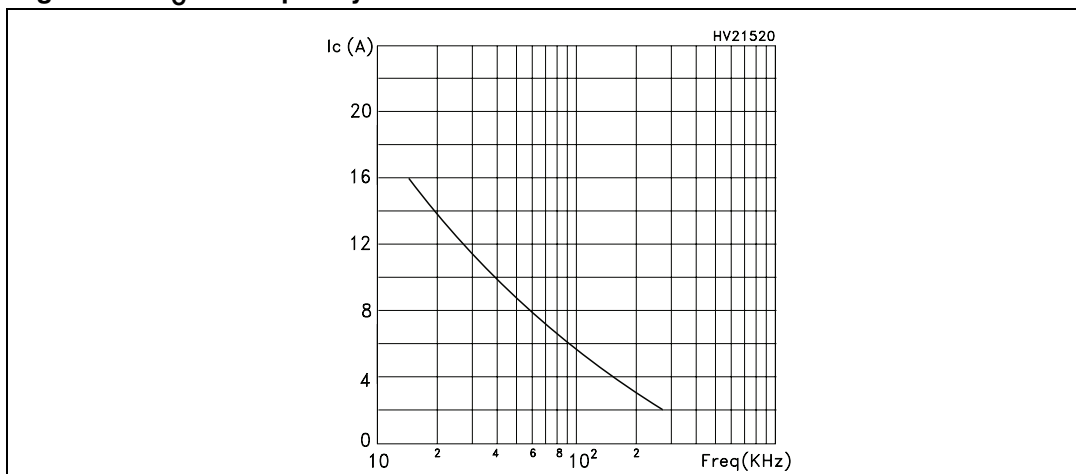
Figure 17. Thermal impedance for TO-220FP





## 2.2 Operating frequency

Figure 18.  $I_C$  vs. frequency



For a fast IGBT suitable for high frequency applications, the typical collector current vs. maximum operating frequency curve is reported. That frequency is defined as follows:

### Equation 1

$$f_{MAX} = (P_D - P_C) / (E_{ON} + E_{OFF})$$

The maximum power dissipation is limited by maximum junction to case thermal resistance:

### Equation 2

$$P_D = \Delta T / R_{THJ-C}$$

considering  $\Delta T = T_J - T_C = 125\text{ }^\circ\text{C} - 75\text{ }^\circ\text{C} = 50\text{ }^\circ\text{C}$

The conduction losses are:

### Equation 3

$$P_C = I_C * V_{CE(SAT)} * \delta$$

with 50% of duty cycle,  $V_{CE(sat)}$  typical value  $T_C = 125\text{ }^\circ\text{C}$ .

Power dissipation during ON & OFF commutations is due to the switching frequency:

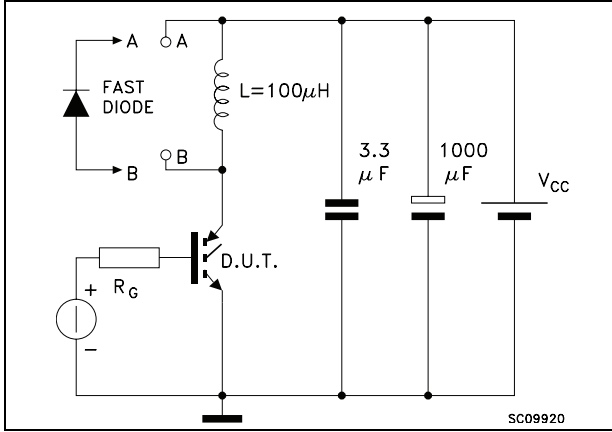
### Equation 4

$$P_{SW} = (E_{ON} + E_{OFF}) * \text{freq.}$$

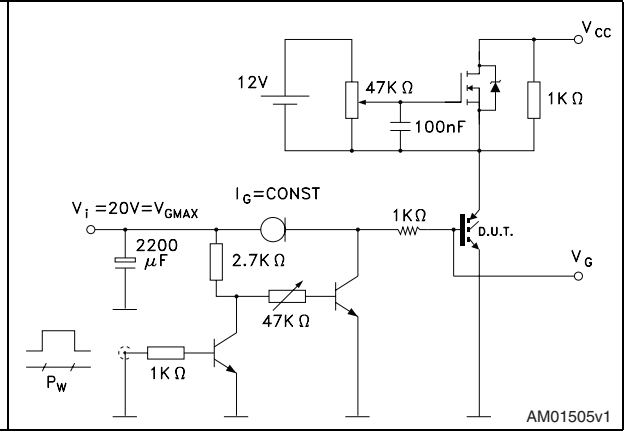
Typical values  $T_C = 125\text{ }^\circ\text{C}$  for switching losses are used (test conditions:  $V_{CE} = 390\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $R_G = 3.3\text{ }\Omega$ ). Furthermore, diode recovery energy is included in the  $E_{ON}$ , while the tail of the collector current is included in the  $E_{OFF}$  measurements.

### 3 Test circuits

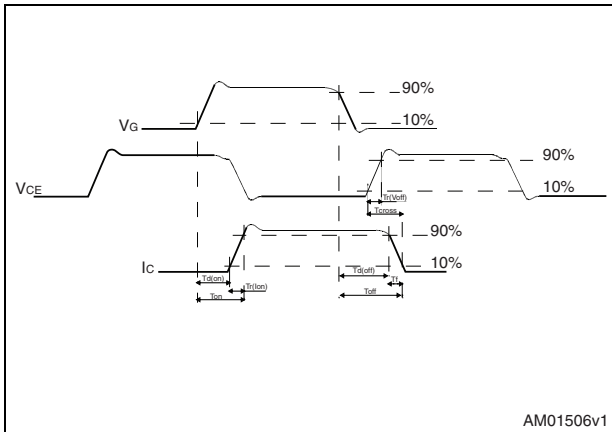
**Figure 19. Test circuit for inductive load switching**



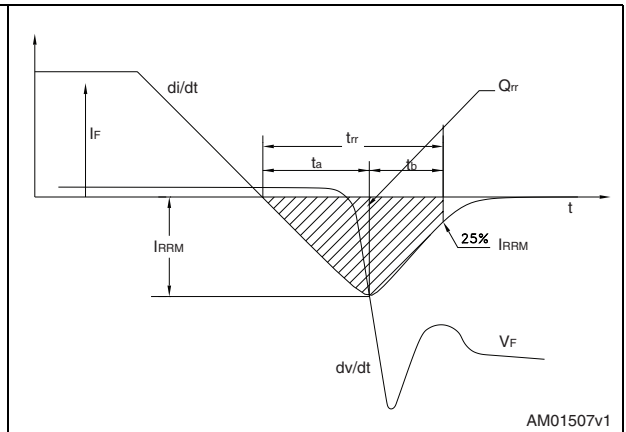
**Figure 20. Gate charge test circuit**



**Figure 21. Switching waveform**



**Figure 22. 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 10. I<sup>2</sup>PAK (TO-262) mechanical data**

| Dim. | mm.  |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 2.40 |      | 2.72  |
| b    | 0.61 |      | 0.88  |
| b1   | 1.14 |      | 1.70  |
| c    | 0.49 |      | 0.70  |
| c2   | 1.23 |      | 1.32  |
| D    | 8.95 |      | 9.35  |
| e    | 2.40 |      | 2.70  |
| e1   | 4.95 |      | 5.15  |
| E    | 10   |      | 10.40 |
| L    | 13   |      | 14    |
| L1   | 3.50 |      | 3.93  |
| L2   | 1.27 |      | 1.40  |

Figure 23. I<sup>2</sup>PAK (TO-262) drawing

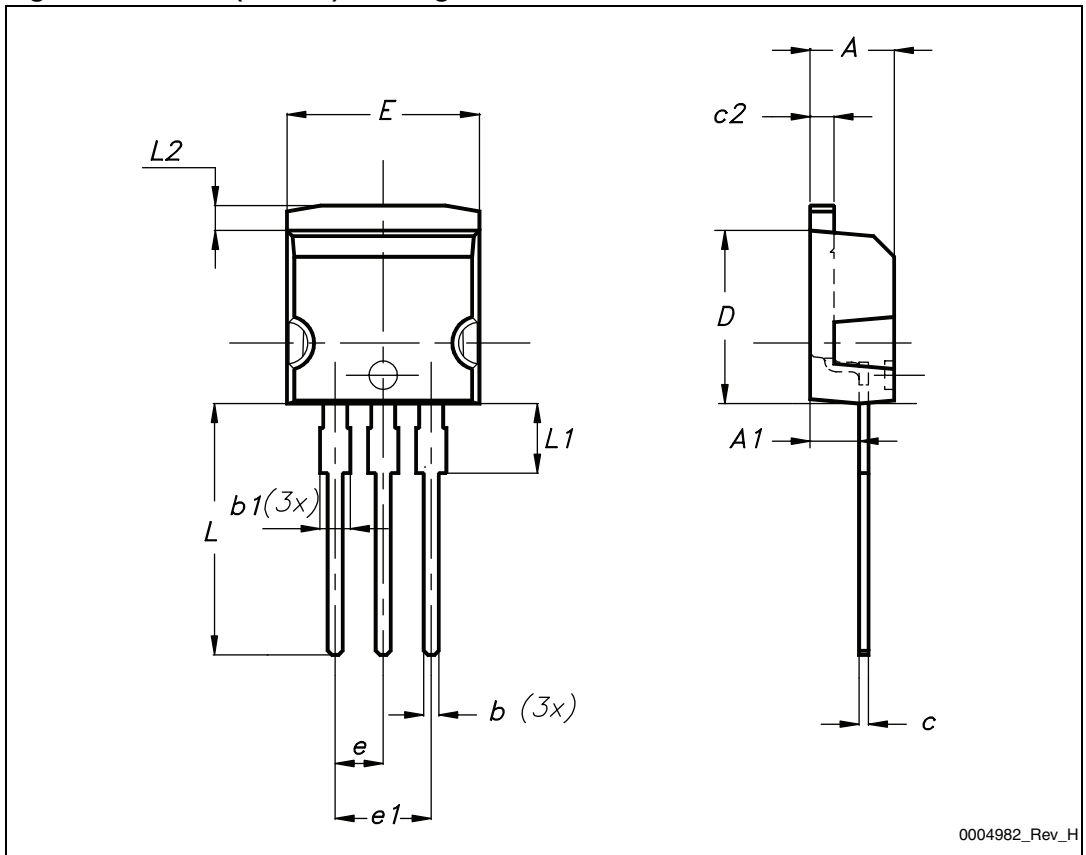


Table 11. D<sup>2</sup>PAK (TO-263) mechanical data

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 4.40 |      | 4.60  |
| A1   | 0.03 |      | 0.23  |
| b    | 0.70 |      | 0.93  |
| b2   | 1.14 |      | 1.70  |
| c    | 0.45 |      | 0.60  |
| c2   | 1.23 |      | 1.36  |
| D    | 8.95 |      | 9.35  |
| D1   | 7.50 |      |       |
| E    | 10   |      | 10.40 |
| E1   | 8.50 |      |       |
| e    |      | 2.54 |       |
| e1   | 4.88 |      | 5.28  |
| H    | 15   |      | 15.85 |
| J1   | 2.49 |      | 2.69  |
| L    | 2.29 |      | 2.79  |
| L1   | 1.27 |      | 1.40  |
| L2   | 1.30 |      | 1.75  |
| R    |      | 0.4  |       |
| V2   | 0°   |      | 8°    |

Figure 24. D<sup>2</sup>PAK (TO-263) drawing

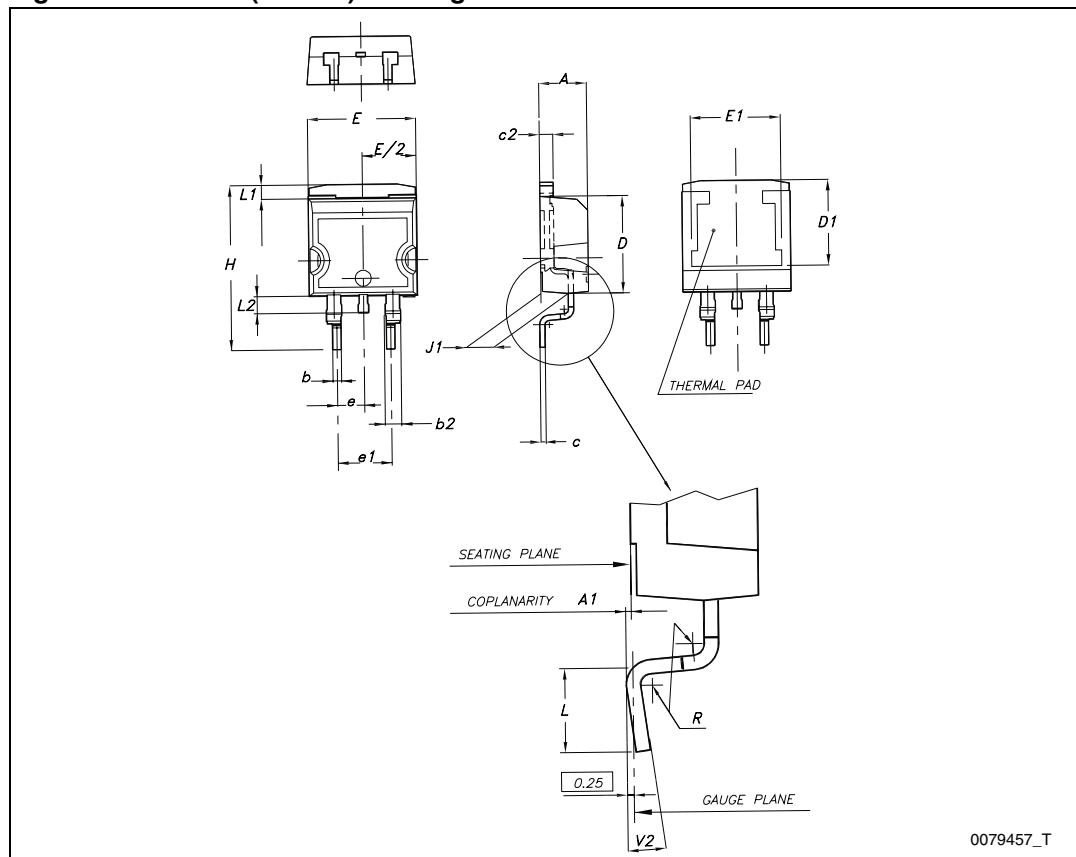
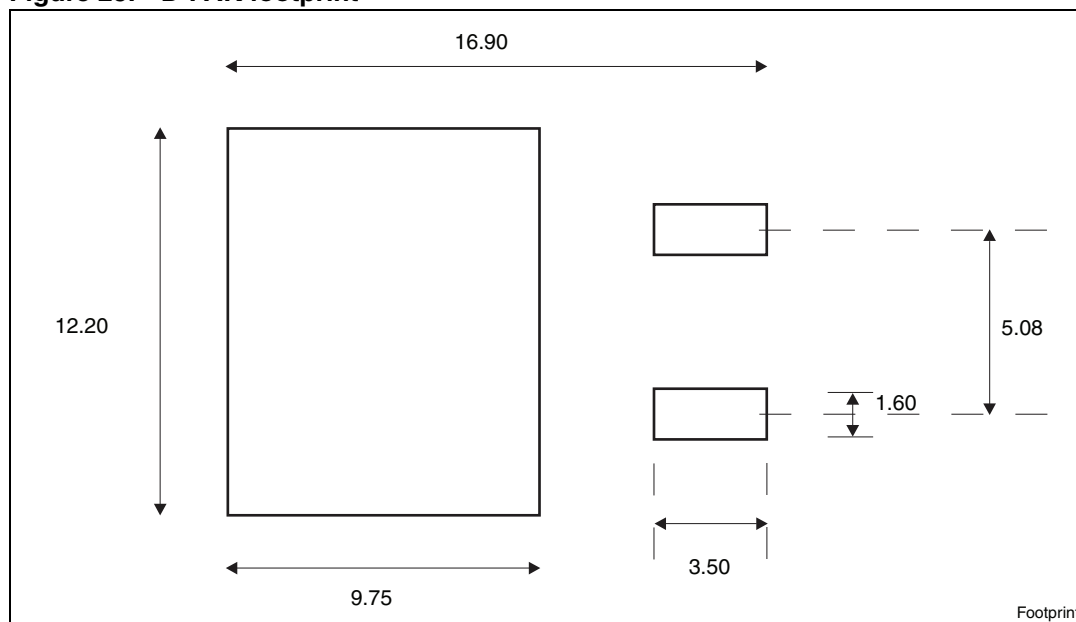


Figure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>

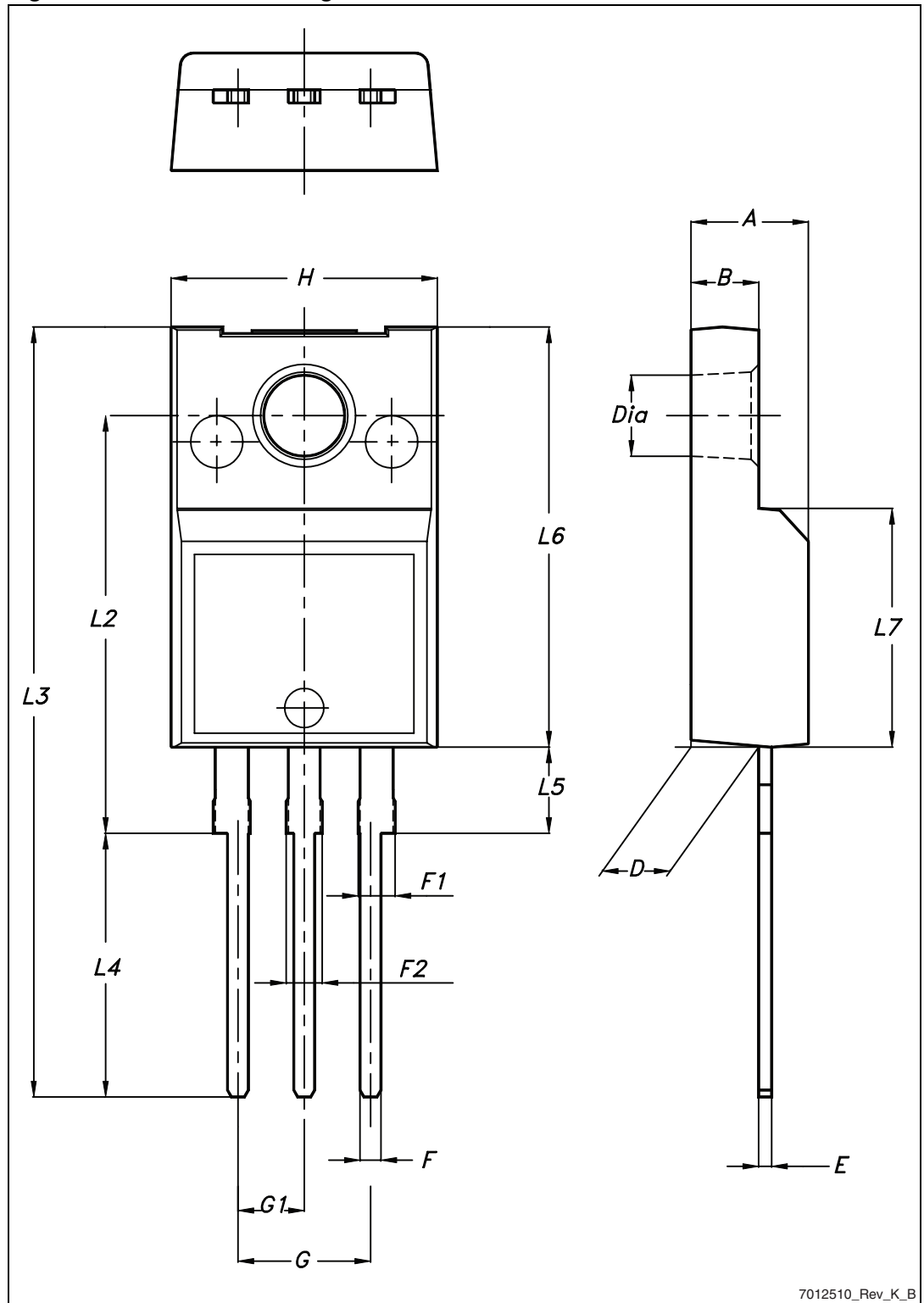


a. All dimensions are in millimeters

Table 12. TO-220FP mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |

Figure 26. TO-220FP drawing



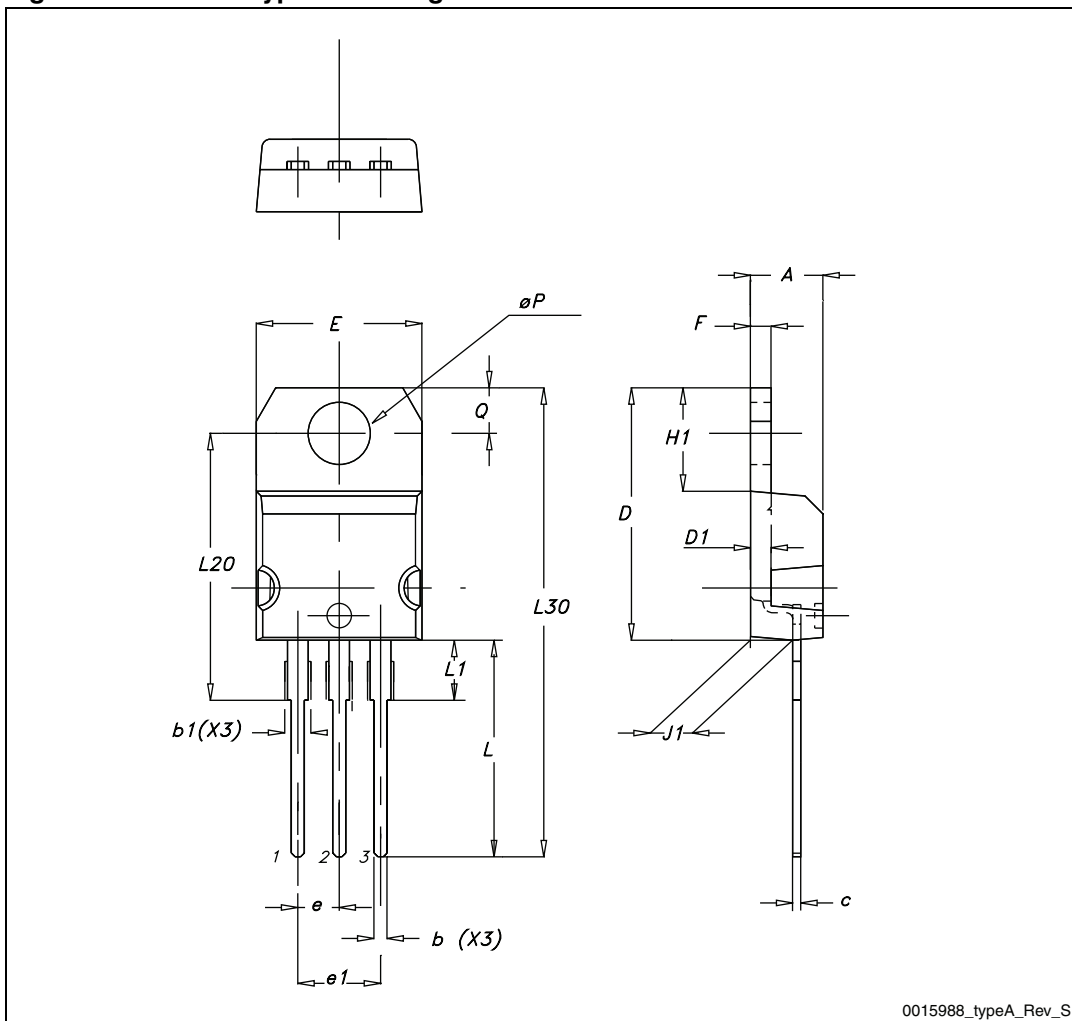
7012510\_Rev\_K\_B



Table 13. TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.70  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10    |       | 10.40 |
| e    | 2.40  |       | 2.70  |
| e1   | 4.95  |       | 5.15  |
| F    | 1.23  |       | 1.32  |
| H1   | 6.20  |       | 6.60  |
| J1   | 2.40  |       | 2.72  |
| L    | 13    |       | 14    |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| ØP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

Figure 27. TO-220 type A drawing

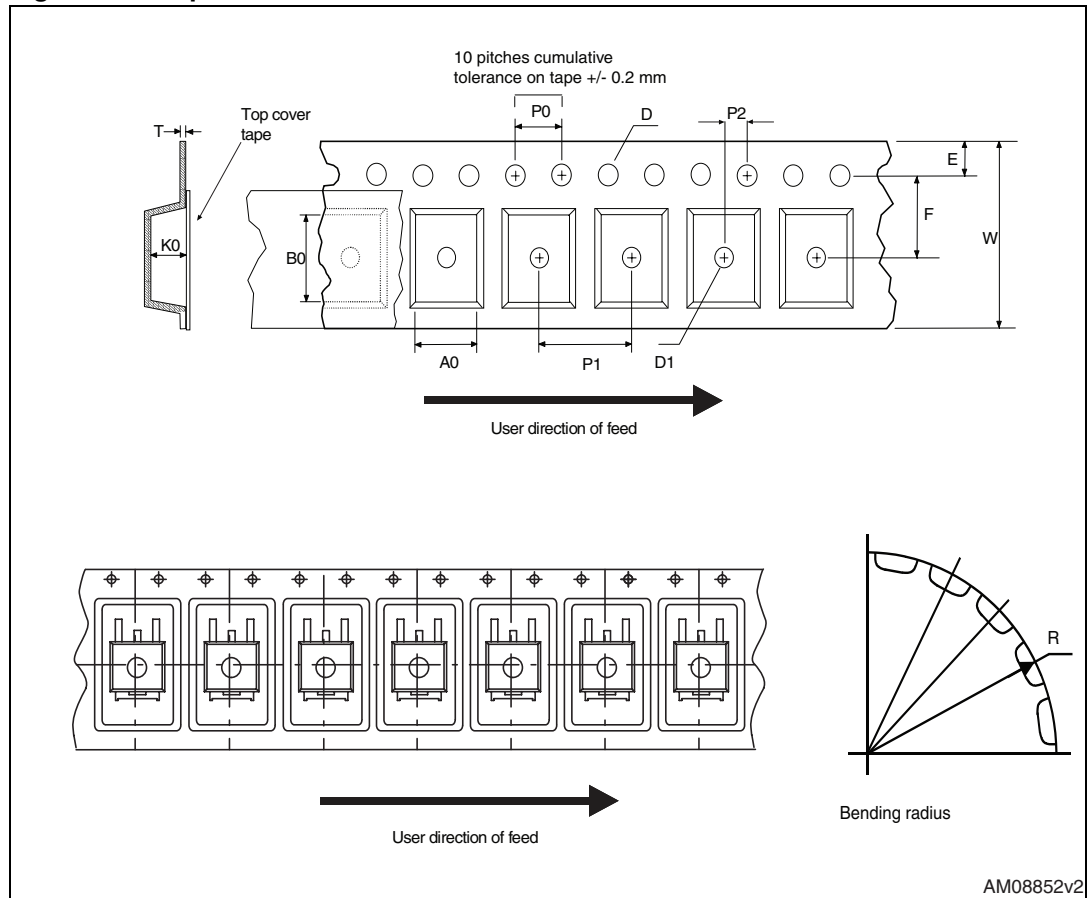


## 5 Packaging mechanical data

Table 14. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

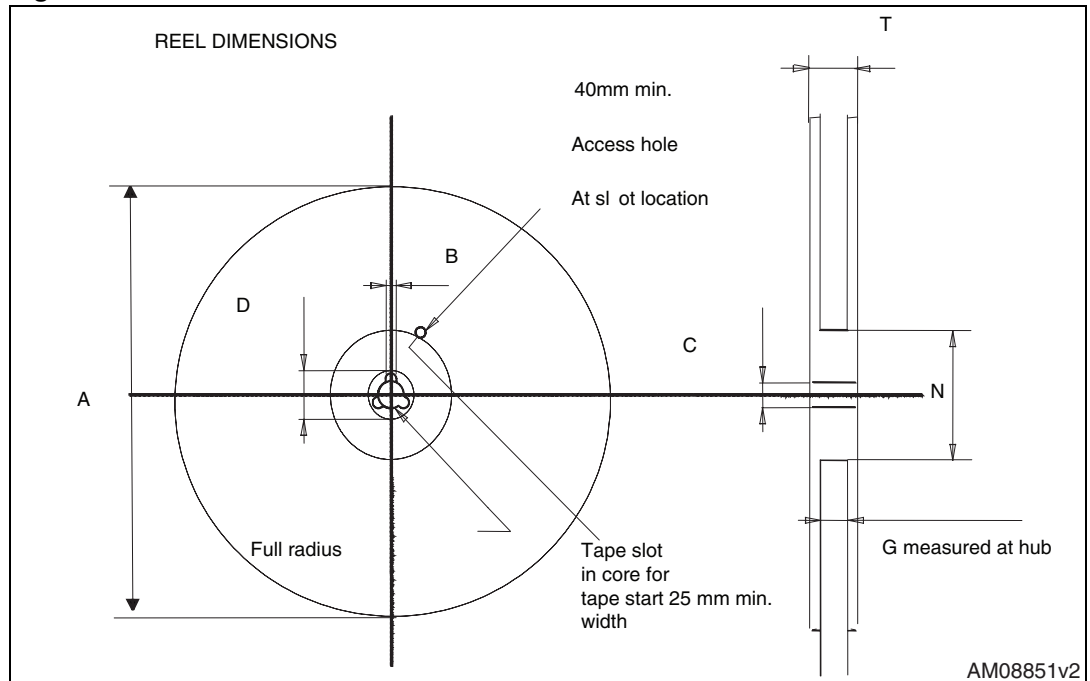
| Tape |      |      | Reel |          |      |
|------|------|------|------|----------|------|
| Dim. | mm   |      | Dim. | mm       |      |
|      | Min. | Max. |      | Min.     | Max. |
| A0   | 10.5 | 10.7 | A    |          | 330  |
| B0   | 15.7 | 15.9 | B    | 1.5      |      |
| D    | 1.5  | 1.6  | C    | 12.8     | 13.2 |
| D1   | 1.59 | 1.61 | D    | 20.2     |      |
| E    | 1.65 | 1.85 | G    | 24.4     | 26.4 |
| F    | 11.4 | 11.6 | N    | 100      |      |
| K0   | 4.8  | 5.0  | T    |          | 30.4 |
| P0   | 3.9  | 4.1  |      |          |      |
| P1   | 11.9 | 12.1 |      | Base qty | 1000 |
| P2   | 1.9  | 2.1  |      | Bulk qty | 1000 |
| R    | 50   |      |      |          |      |
| T    | 0.25 | 0.35 |      |          |      |
| W    | 23.7 | 24.3 |      |          |      |

Figure 28. Tape



AM08852v2

Figure 29. Reel



AM08851v2

## 6 Revision history

**Table 15. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 07-Jun-2004 | 4        | Stylesheet update. No content change.                        |
| 19-Aug-2004 | 5        | Complete version   |
| 17-Sep-2004 | 6        | <i>Figure 14</i> has been added                              |
| 09-Nov-2004 | 7        | Final datasheet  |
| 19-Jan-2005 | 8        | Datasheet updated  |
| 09-Jun-2005 | 9        | Modified title   |
| 27-Jun-2012 | 10       | Inserted commercial type STGB7NC60HD.<br>Minor text changes. |

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