



# 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.

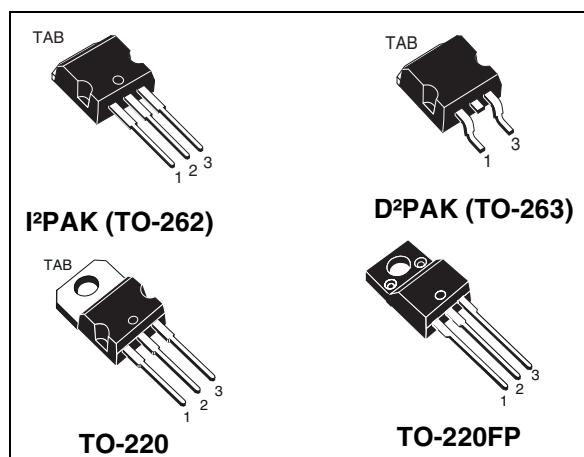


Figure 1. Internal schematic diagram

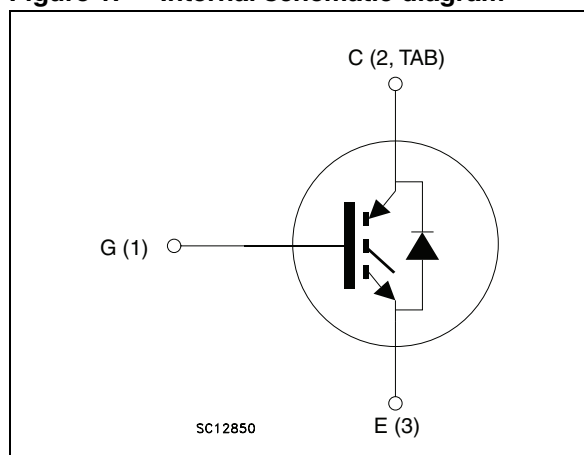


Table 1. Device summary

| 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          |

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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,<br>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;<br>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,<br>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                        | $V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$                                                                       | 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>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ | 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>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$<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>$R_G = 10\text{ }\Omega$ , $V_{GE} = 15\text{ V}$ ,<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 <sub>r</sub> (V <sub>off</sub> ) | Off voltage rise time | V <sub>CC</sub> = 390 V, I <sub>C</sub> = 7 A,<br>R <sub>G</sub> = 10 Ω , V <sub>GE</sub> = 15 V                            | -    | 27   | -    | ns   |
| t <sub>d</sub> (off)               | Turn-off delay time   |                                                                                                                             |      | 72   |      | ns   |
| t <sub>f</sub>                     | Current fall time     |                                                                                                                             |      | 60   |      | ns   |
| t <sub>r</sub> (V <sub>off</sub> ) | Off voltage rise time | V <sub>CC</sub> = 390 V, I <sub>C</sub> = 7 A,<br>R <sub>G</sub> = 10 Ω , V <sub>GE</sub> = 15 V<br>T <sub>j</sub> = 125 °C |      | 56   |      | ns   |
| t <sub>d</sub> (off)               | Turn-off delay time   |                                                                                                                             |      | 116  |      | ns   |
| t <sub>f</sub>                     | Current fall time     |                                                                                                                             |      | 105  |      | ns   |

**Table 8. Switching energy**

| Symbol                          | Parameter                | Test conditions                                                                                                           | Min. | Typ. | Max | Unit |
|---------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| E <sub>on</sub> <sup>(1)</sup>  | Turn-on switching losses | V <sub>CC</sub> = 390 V, I <sub>C</sub> = 7 A<br>R <sub>G</sub> = 10 Ω, V <sub>GE</sub> = 15 V,                           | -    | 95   | 125 | μJ   |
| E <sub>off</sub> <sup>(2)</sup> | Turn-off switching loss  |                                                                                                                           |      | 115  | 150 | μJ   |
| E <sub>ts</sub>                 | Total switching loss     |                                                                                                                           |      | 210  | 275 | μJ   |
| E <sub>on</sub> <sup>(1)</sup>  | Turn-on switching losses | V <sub>CC</sub> = 390 V, I <sub>C</sub> = 7 A<br>R <sub>G</sub> = 10 Ω, V <sub>GE</sub> = 15 V,<br>T <sub>j</sub> = 125°C |      | 140  |     | μJ   |
| E <sub>off</sub> <sup>(2)</sup> | Turn-off switching loss  |                                                                                                                           |      | 215  |     | μJ   |
| E <sub>ts</sub>                 | Total switching loss     |                                                                                                                           |      | 355  |     | μJ   |

1.  $E_{on}$  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 ( $25\text{ }^\circ\text{C}$  and  $125\text{ }^\circ\text{C}$ ).
2. 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 <sub>f</sub>                                                                | Forward on-voltage                                                                                               | If = 3.5 A<br>If = 3.5 A, T <sub>j</sub> = 125 °C                             | -    | 1.3<br>1.1                    | 1.9  | V<br>V              |
| t <sub>rr</sub><br>t <sub>a</sub><br>Q <sub>rr</sub><br>I <sub>rrm</sub><br>S | Reverse recovery time<br><br>Reverse recovery charge<br>Reverse recovery current<br>Softness factor of the diode | If = 7 A, V <sub>R</sub> = 40 V,<br>di/dt = 100 A/μs                          |      | 37<br>22<br>40<br>2.1<br>0.68 |      | ns<br>ns<br>nC<br>A |
| t <sub>rr</sub><br>t <sub>a</sub><br>Q <sub>rr</sub><br>I <sub>rrm</sub><br>S | Reverse recovery time<br><br>Reverse recovery charge<br>Reverse recovery current<br>Softness factor of the diode | If = 7 A, V <sub>R</sub> = 40 V,<br>T <sub>j</sub> = 125 °C, di/dt = 100 A/μs |      | 61<br>34<br>98<br>3.2<br>0.79 |      | ns<br>ns<br>nC<br>A |

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

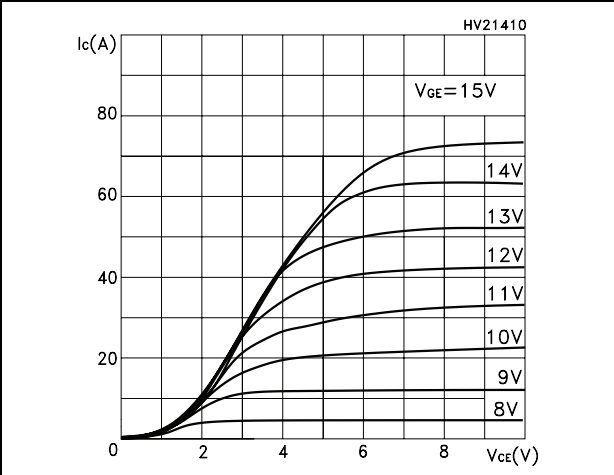


Figure 3. Transfer characteristics

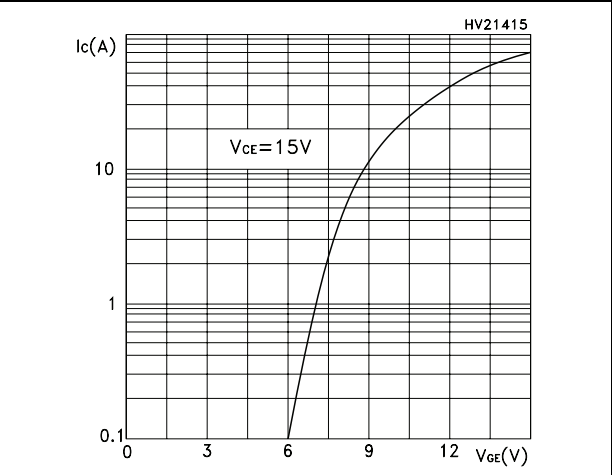


Figure 4. Transconductance

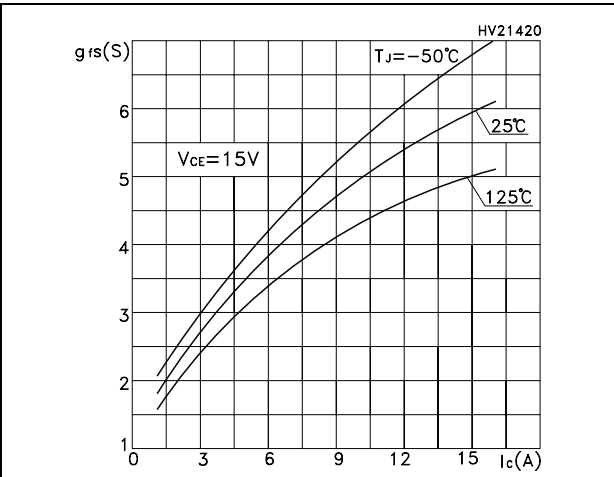


Figure 5. Collector-emitter on voltage vs. temperature

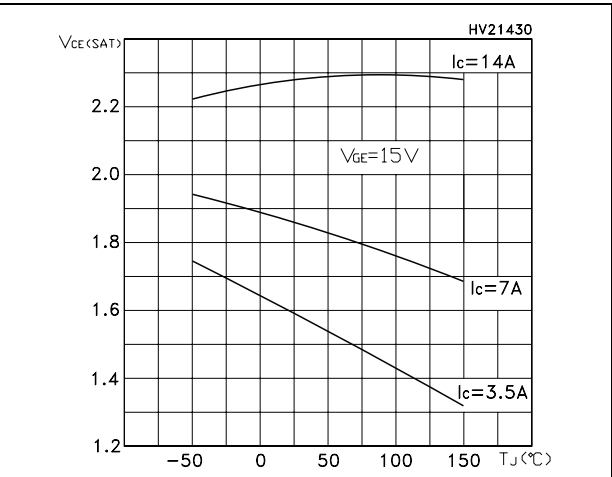


Figure 6. Collector-emitter on voltage vs. collector current

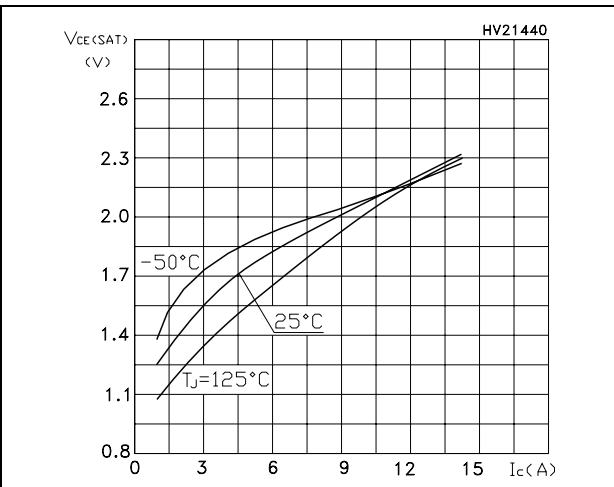


Figure 7. Normalized gate threshold vs. temperature

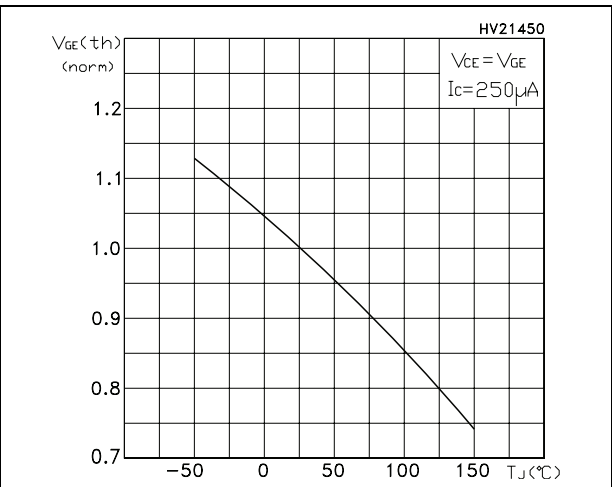


Figure 8. Normalized breakdown voltage vs temperature

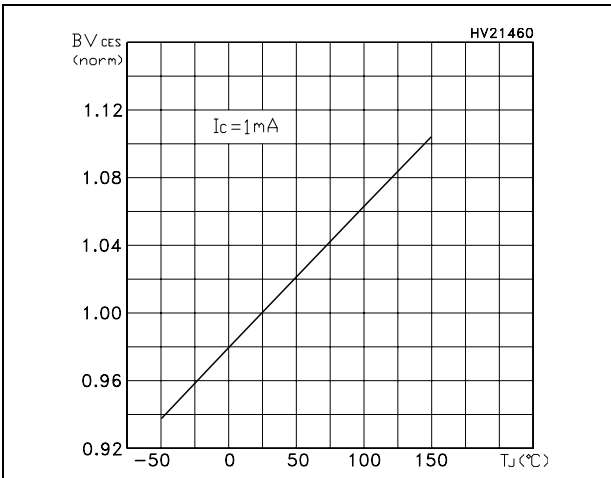


Figure 9. Gate charge vs. gate-emitter voltage

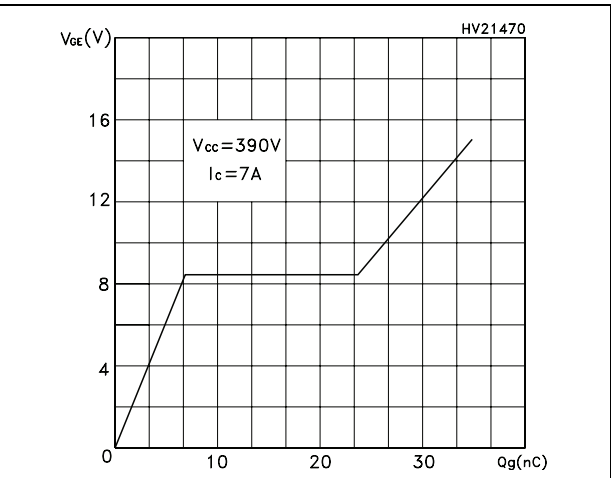


Figure 10. Capacitance variations

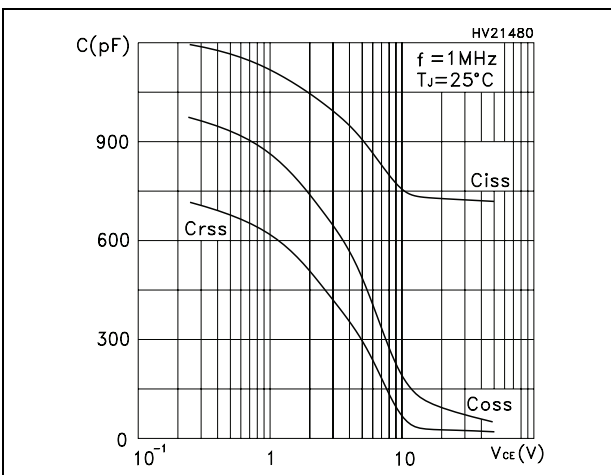


Figure 11. Total switching losses vs. temperature

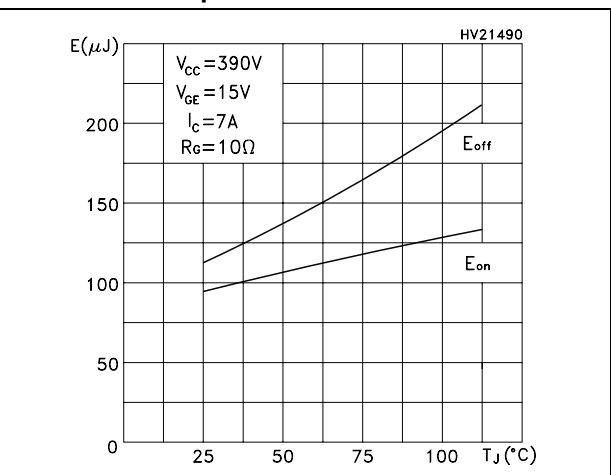


Figure 12. Total switching losses vs. gate resistance

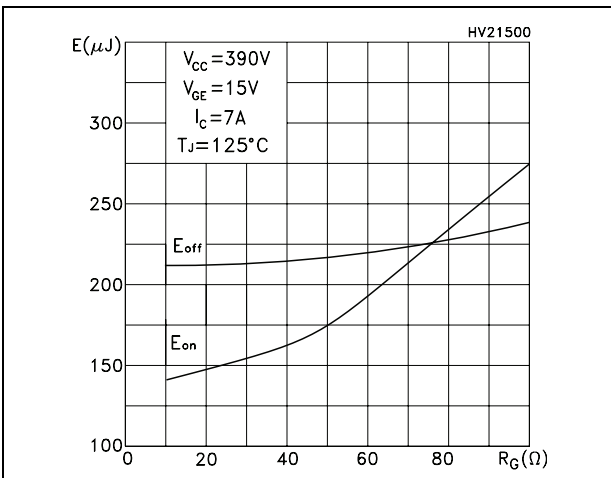


Figure 13. Total switching losses vs collector current

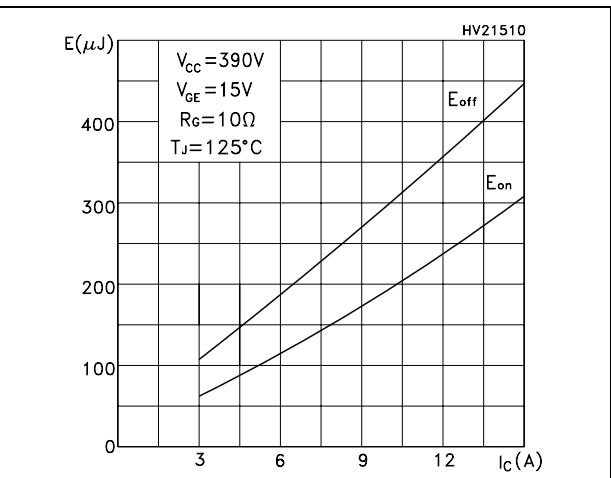


Figure 14. Emitter-collector diode characteristics

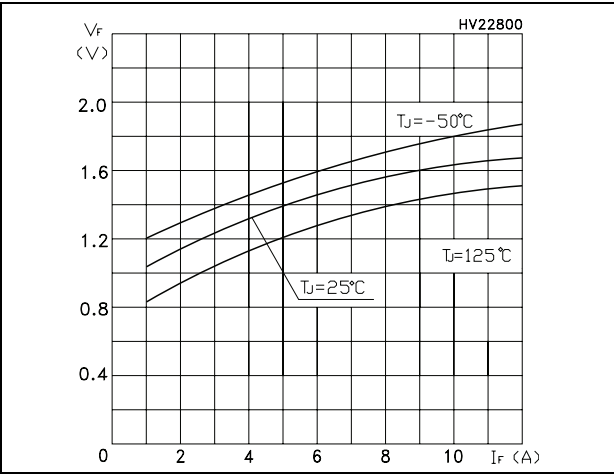


Figure 15. Turn-off SOA

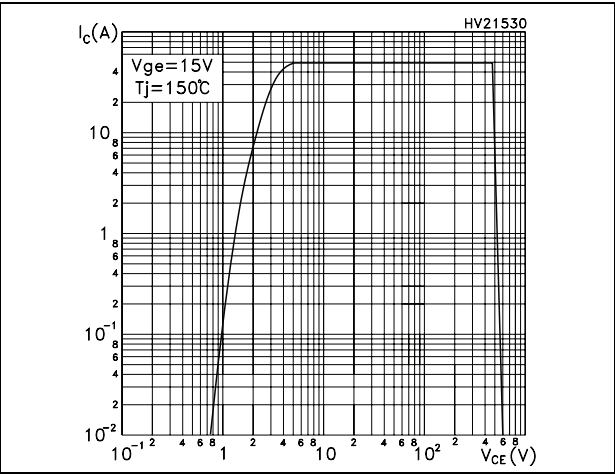


Figure 16. Thermal impedance for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

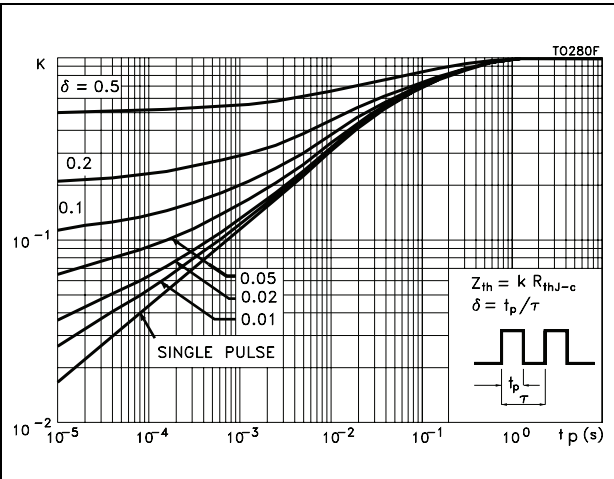
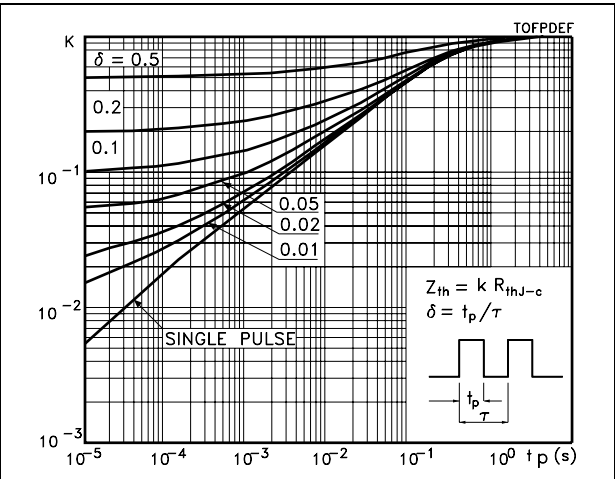
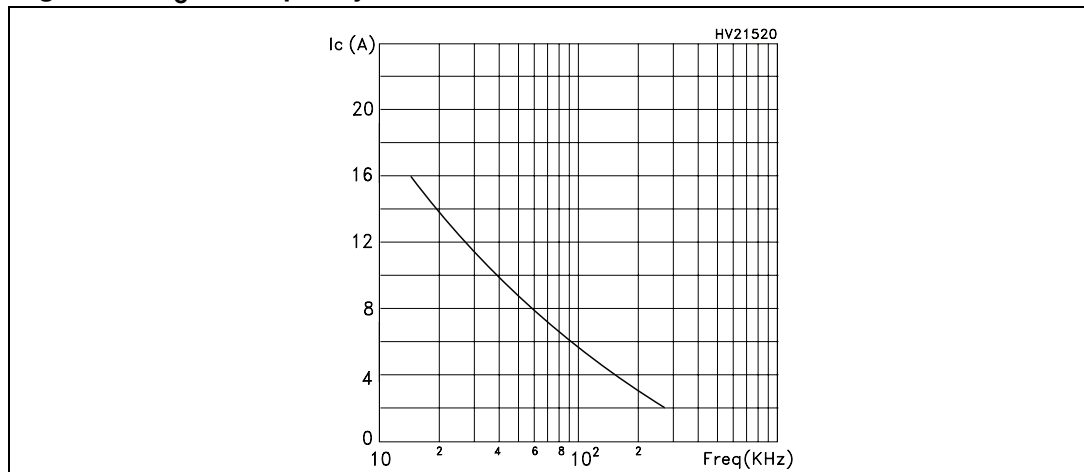


Figure 17. Thermal impedance for TO-220FP



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

The conduction losses are:

### Equation 3

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

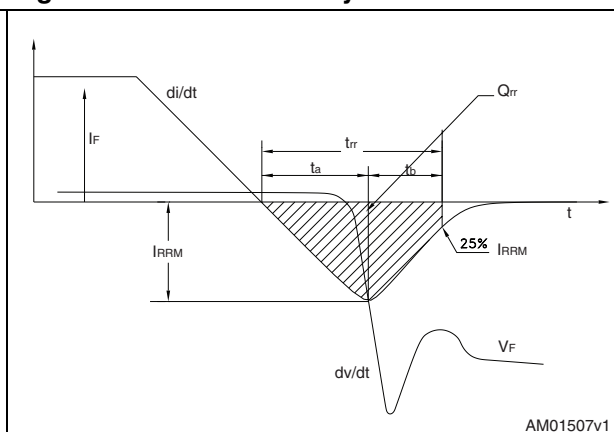
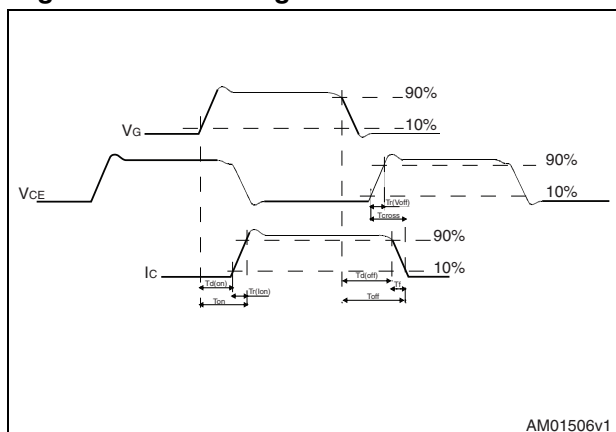
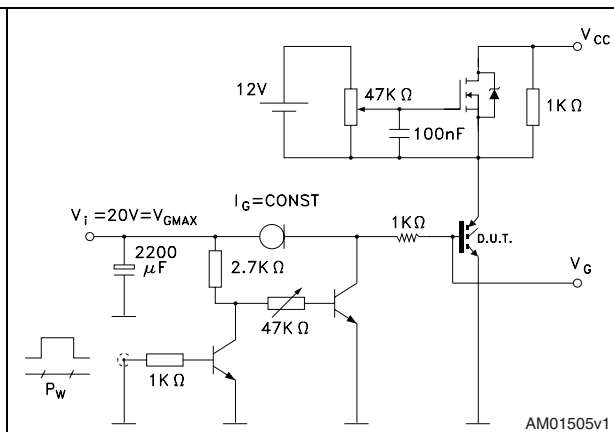
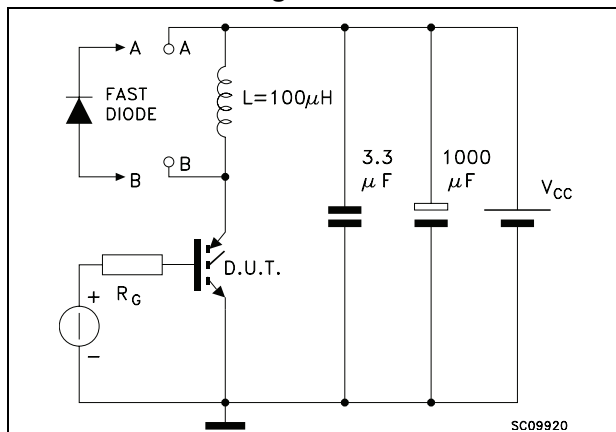
with 50% of duty cycle,  $V_{CE(sat)}$  typical value  $T_C = 125^\circ\text{C}$ .

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

### Equation 4

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

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



## 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  |

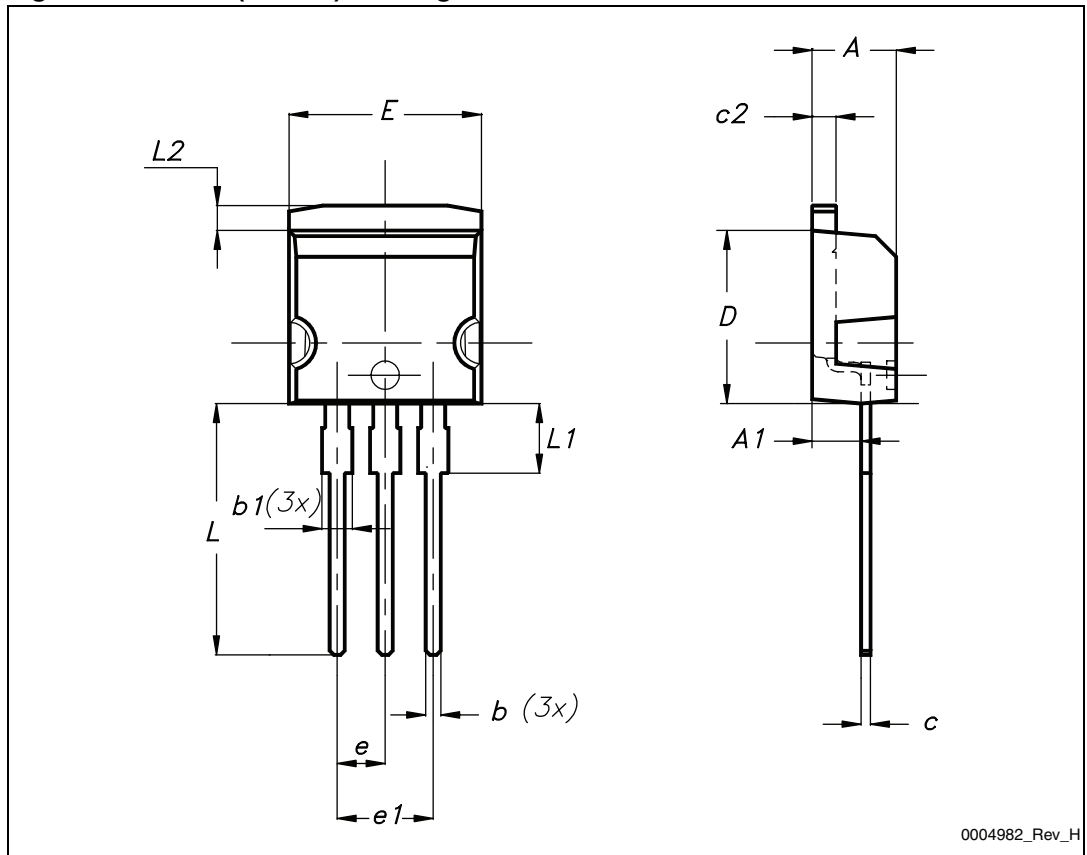
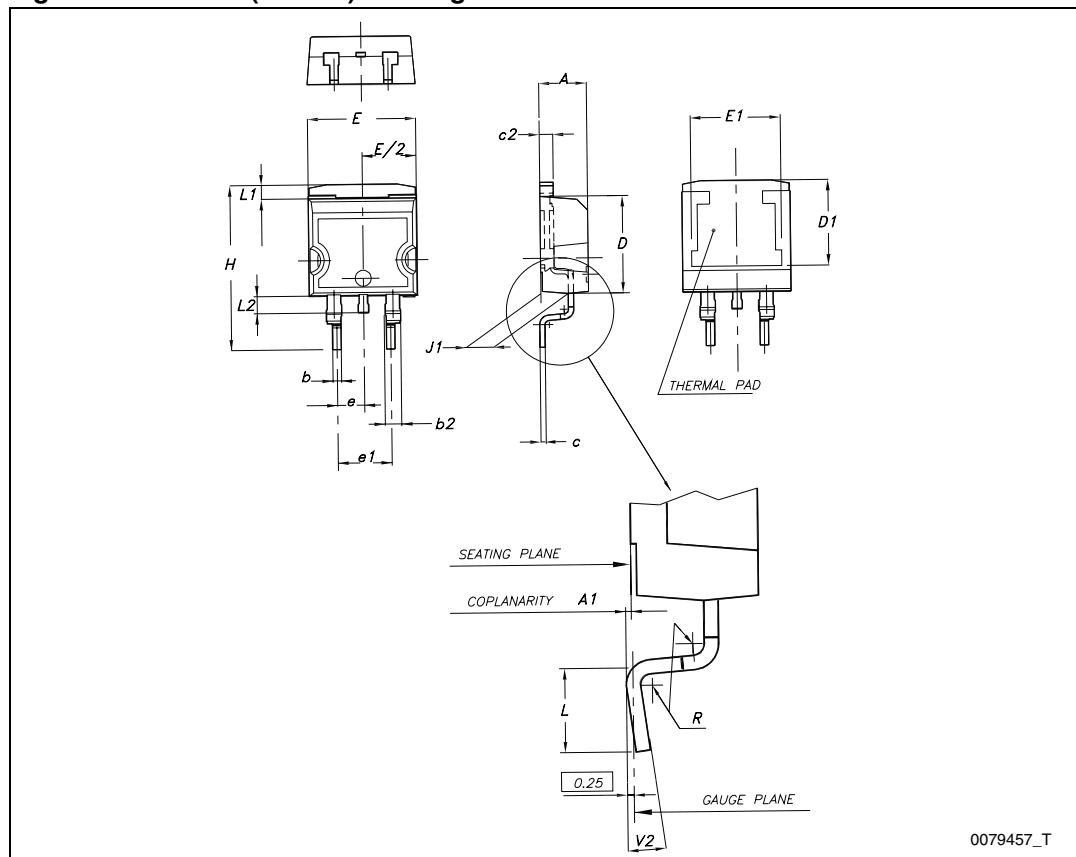
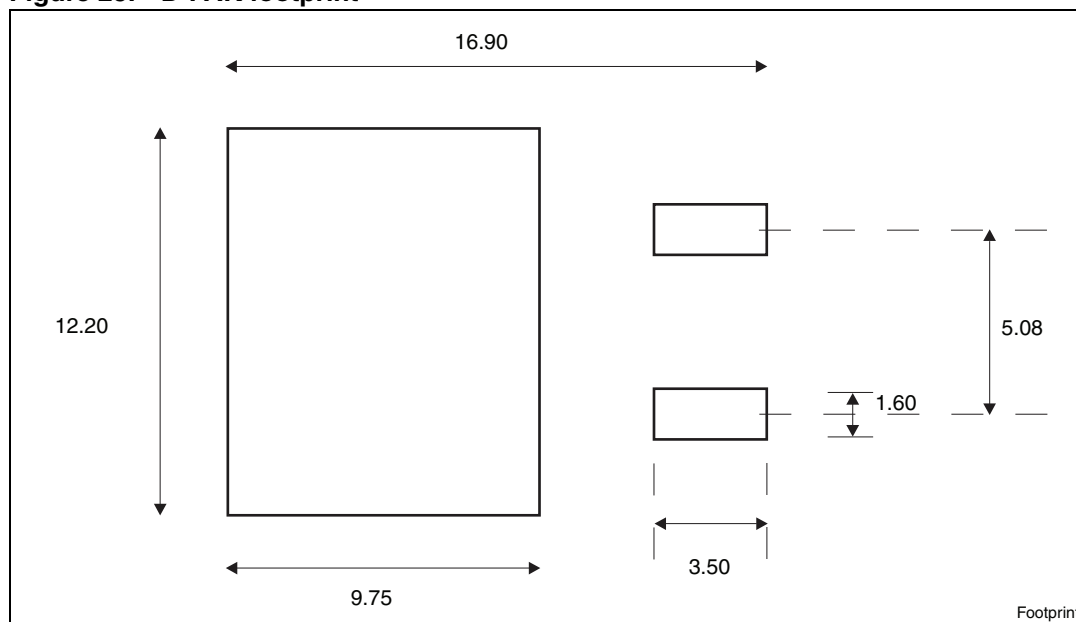
Figure 23. I<sup>2</sup>PAK (TO-262) drawing

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°    |

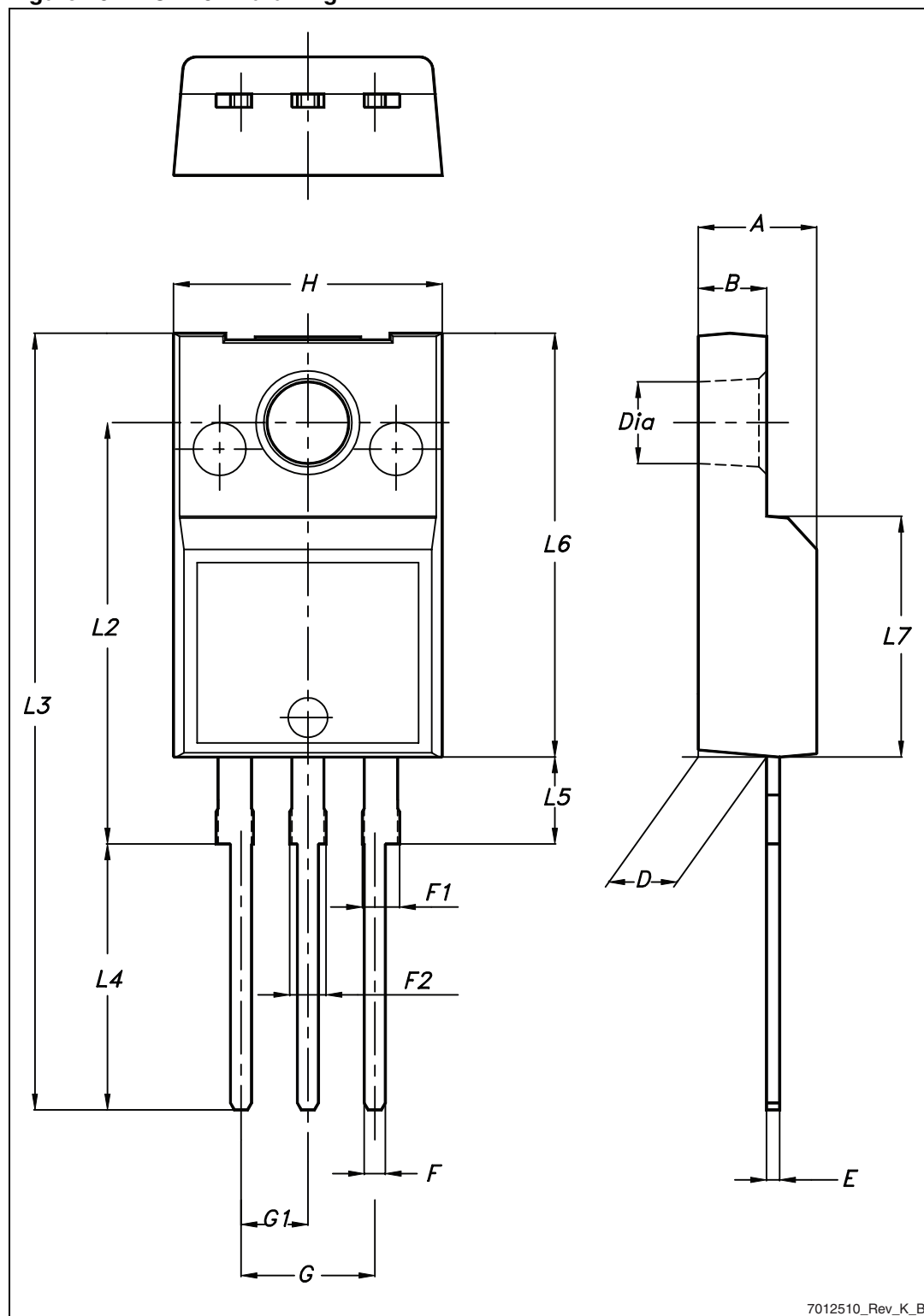
Figure 24. D<sup>2</sup>PAK (TO-263) drawingFigure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>

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

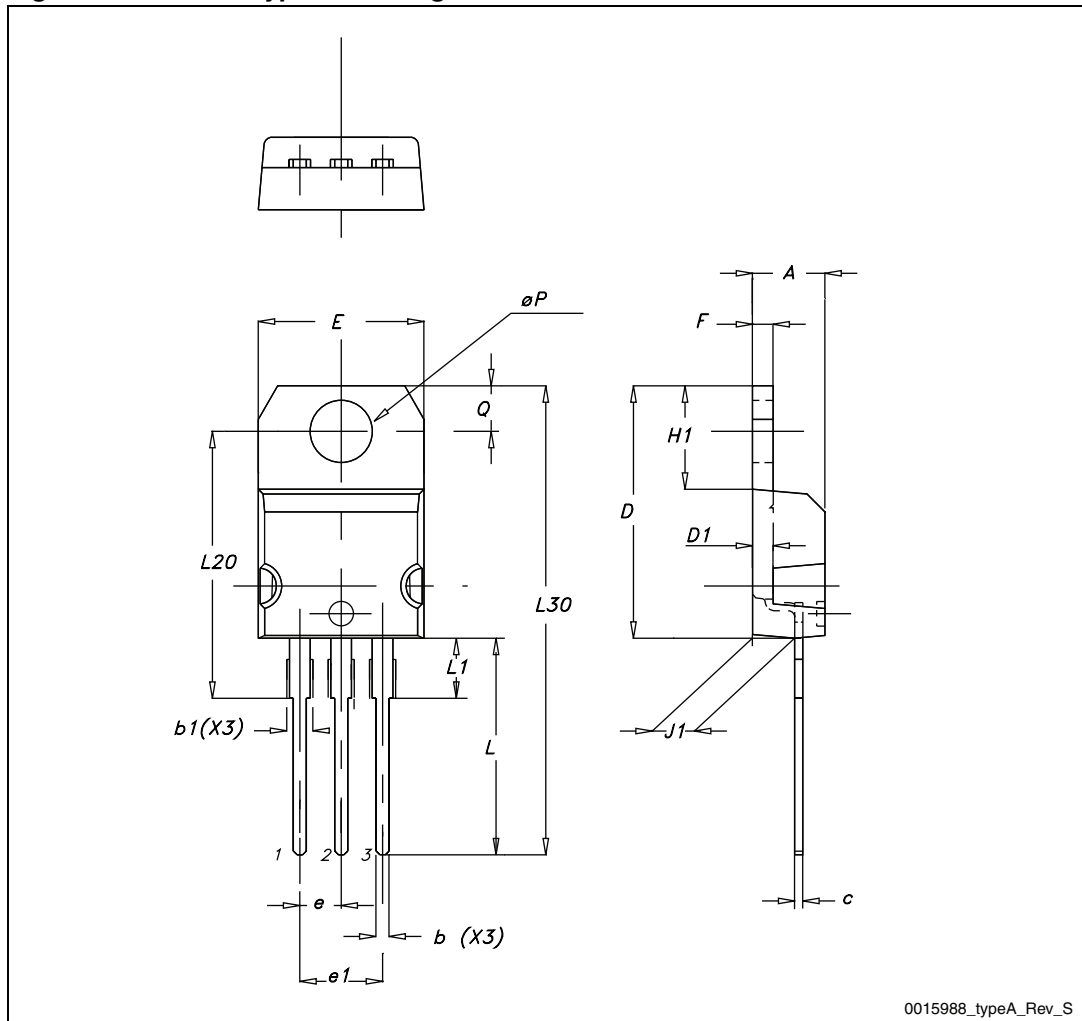


7012510\_Rev\_K\_B

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

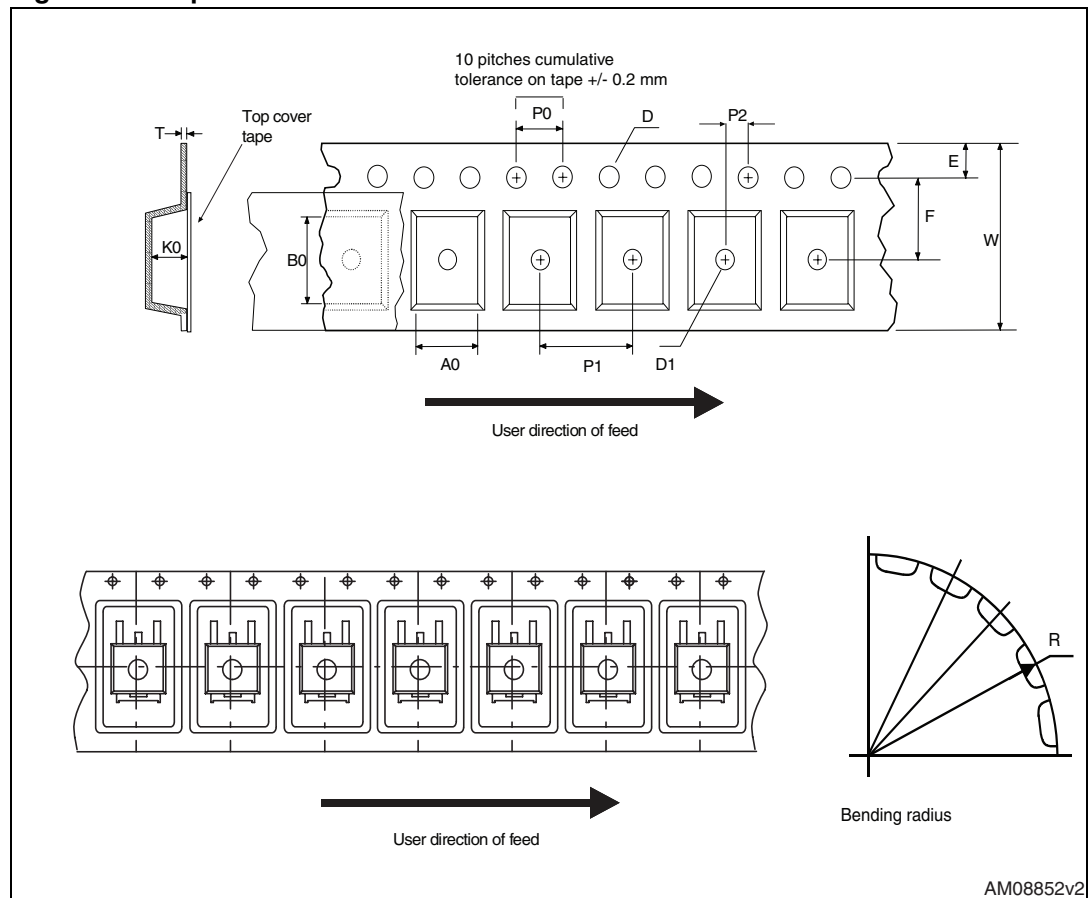
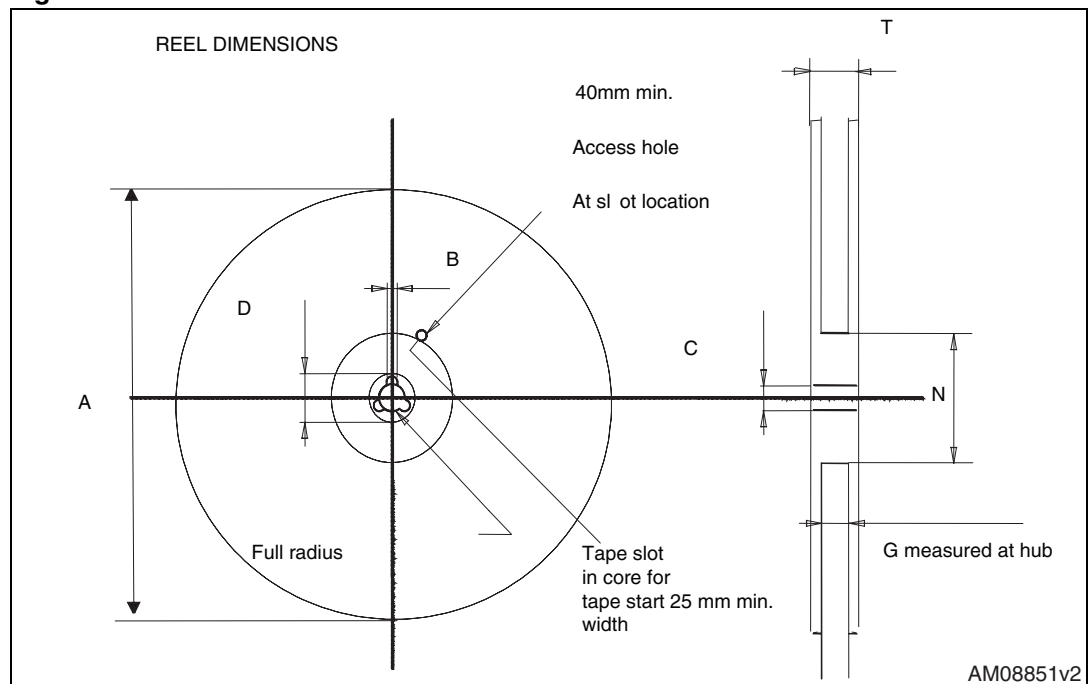


Figure 29. Reel



## 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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