



# 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.

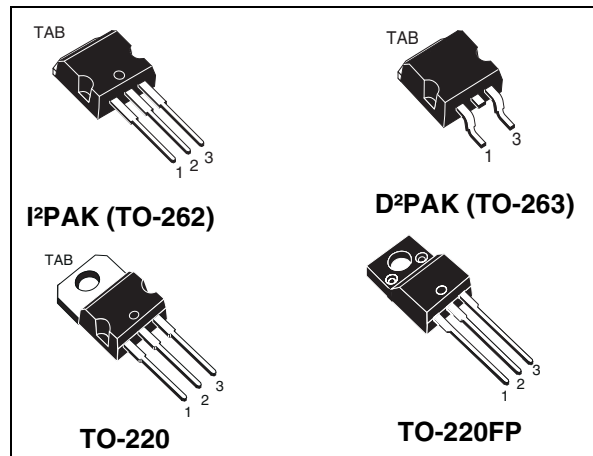


Figure 1. Internal schematic diagram

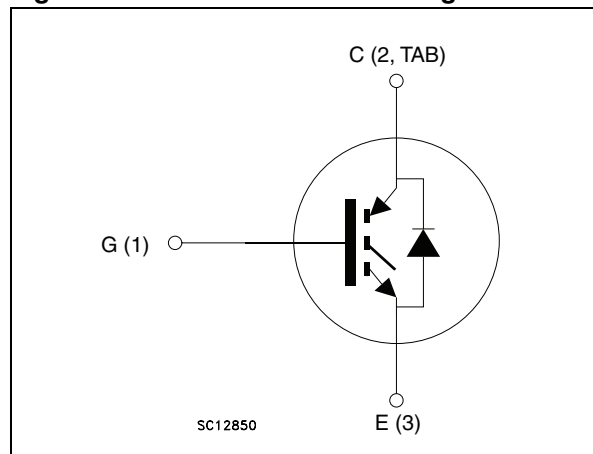


Table 1. Device summary

Order codes	Markings	Packages	Packaging
STGB7NC60HD-1	GB7NC60HD	I <sup>2</sup> PAK (TO-262)	Tube
STGB7NC60HDT4		D <sup>2</sup> PAK (TO-263)	Tape and reel
STGF7NC60HD	GF7NC60HD	TO-220FP	Tube
STGP7NC60HD	GP7NC60HD	TO-220	Tube

# Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>3</b>
<b>2</b>	<b>Electrical characteristics</b> .....	<b>4</b>
2.1	Electrical characteristics (curves) .....	6
2.2	Operating frequency .....	9
<b>3</b>	<b>Test circuits</b> .....	<b>10</b>
<b>4</b>	<b>Package mechanical data</b> .....	<b>11</b>
<b>5</b>	<b>Packaging mechanical data</b> .....	<b>19</b>
<b>6</b>	<b>Revision history</b> .....	<b>21</b>

# 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 ( $V_{GE} = 0$ )	$V_{CE} = 600 \text{ V}$ $V_{CE} = 600 \text{ V}, T_C = 125^{\circ}\text{C}$			10 1	$\mu\text{A}$ 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	$V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}$ $V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}, T_C = 125^{\circ}\text{C}$		1.85 1.7	2.5	V 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	$V_{CE} = 25 \text{ V}, f = 1 \text{ MHz},$ $V_{GE} = 0$		720		pF
$C_{oes}$	Output capacitance			81		pF
$C_{res}$	Reverse transfer capacitance			17		pF
$Q_g$	Total gate charge	$V_{CE} = 390 \text{ V}, I_C = 7 \text{ A},$ $V_{GE} = 15 \text{ V}$		35	48	nC
$Q_{ge}$	Gate-emitter charge			7		nC
$Q_{gc}$	Gate-collector charge			16		nC
$I_{CL}$	Turn-off SOA minimum current	$V_{clamp} = 480 \text{ V}, T_j = 150^{\circ}\text{C}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V}$	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	$V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V}$ (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	$V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V},$ $T_j = 125^{\circ}\text{C}$ (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	$V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$	-	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	$V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_j = 125\text{ }^\circ\text{C}$	-	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	$V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,	-	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	$V_{CC} = 390\text{ V}$ , $I_C = 7\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_j = 125\text{ }^\circ\text{C}$	-	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	$I_f = 3.5\text{ A}$ $I_f = 3.5\text{ A}$ , $T_j = 125\text{ }^\circ\text{C}$	-	1.3 1.1	1.9	V V
$t_{rr}$	Reverse recovery time	$I_f = 7\text{ A}$ , $V_R = 40\text{ V}$ , $di/dt = 100\text{ A}/\mu\text{s}$		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	$I_f = 7\text{ A}$ , $V_R = 40\text{ V}$ , $T_j = 125\text{ }^\circ\text{C}$ , $di/dt = 100\text{ A}/\mu\text{s}$		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

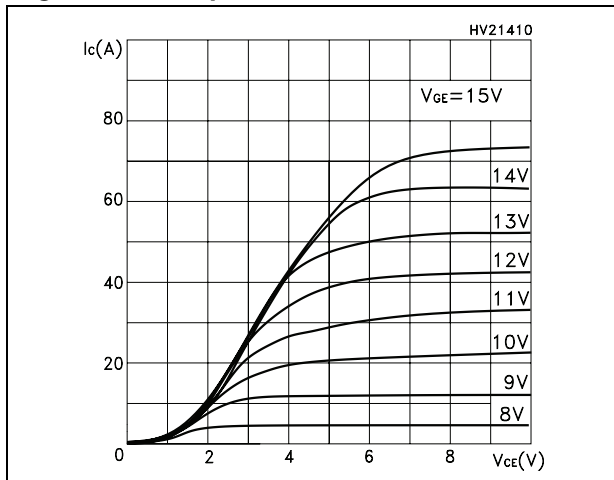


Figure 3. Transfer characteristics

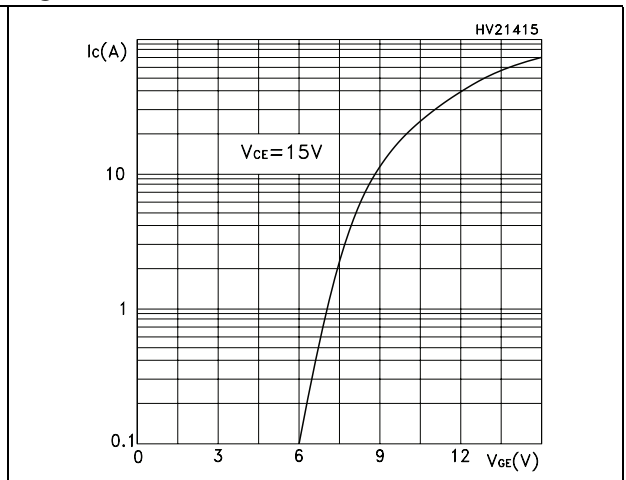


Figure 4. Transconductance

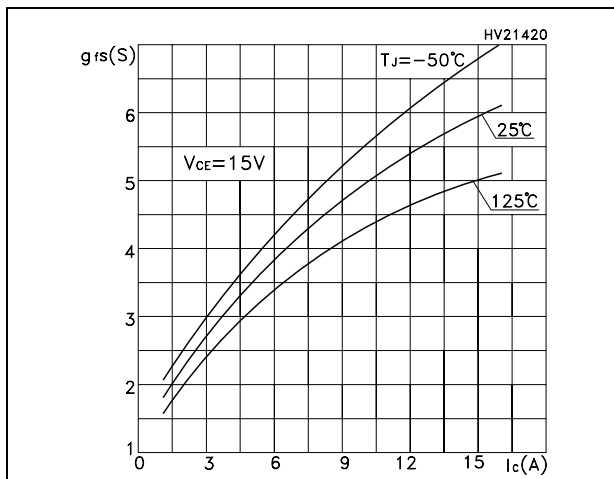


Figure 5. Collector-emitter on voltage vs. temperature

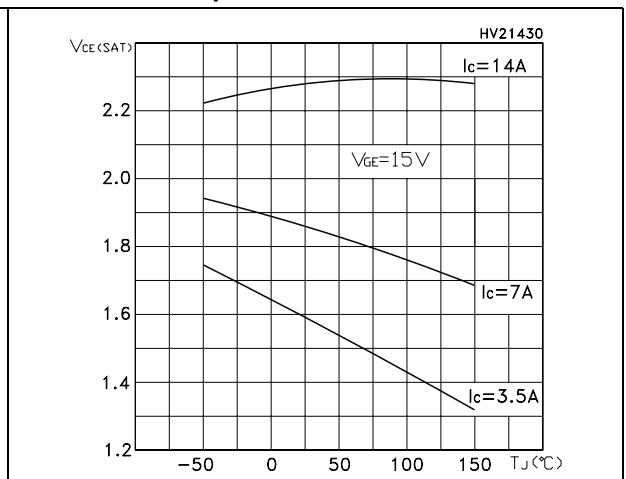


Figure 6. Collector-emitter on voltage vs. collector current

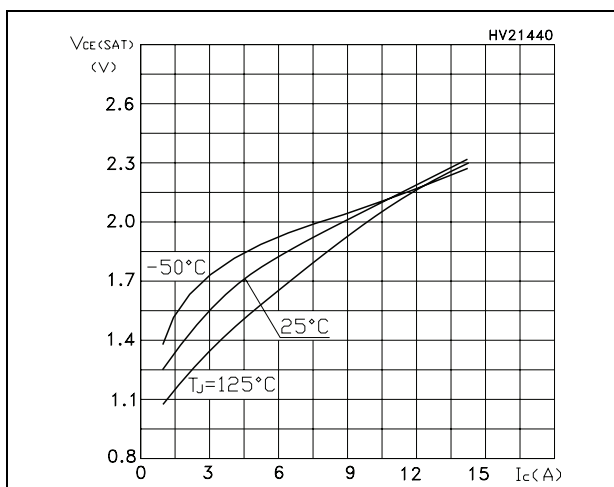
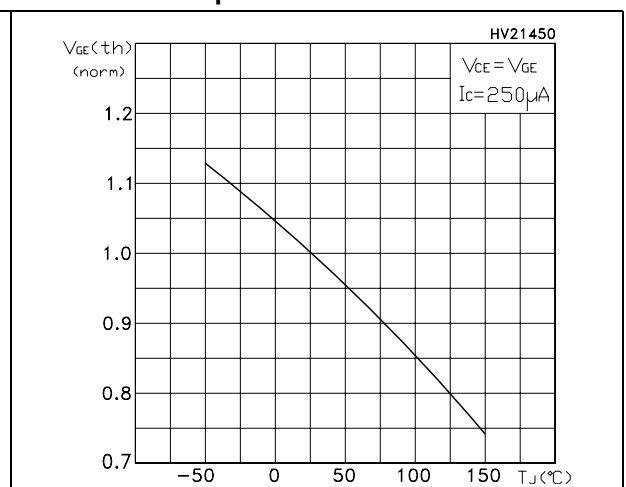
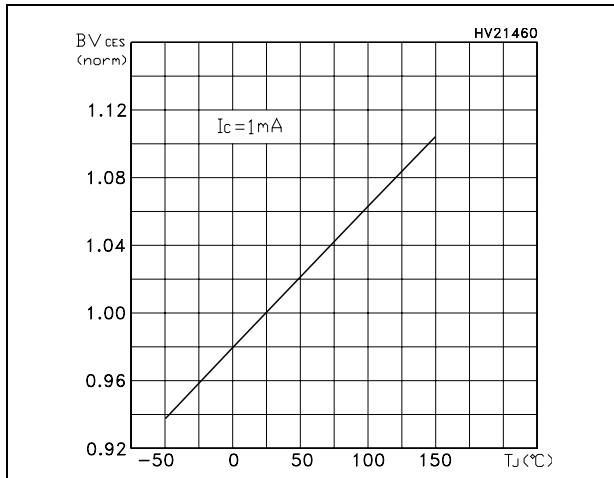


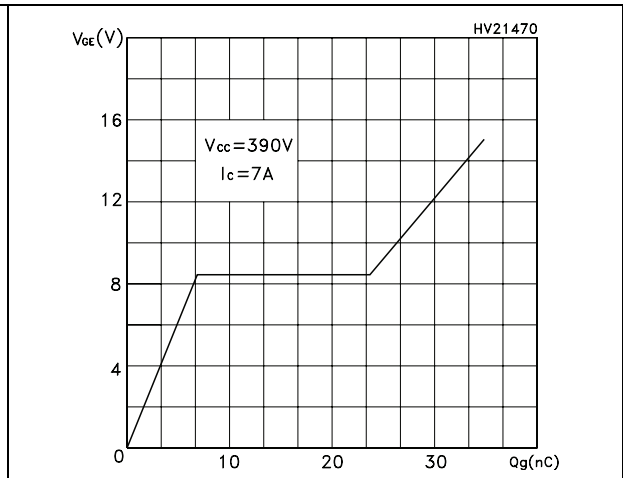
Figure 7. Normalized gate threshold vs. temperature



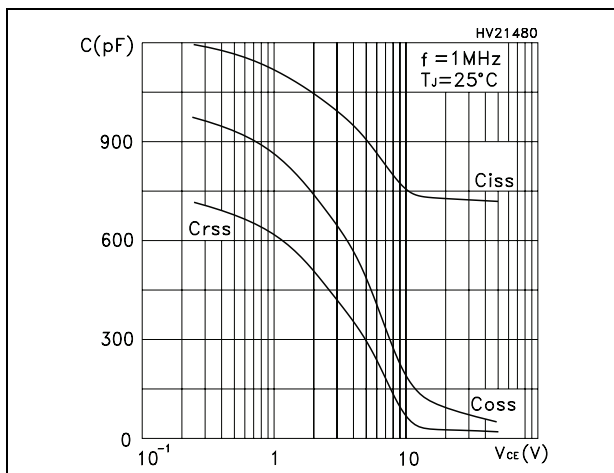
**Figure 8. Normalized breakdown voltage vs temperature**



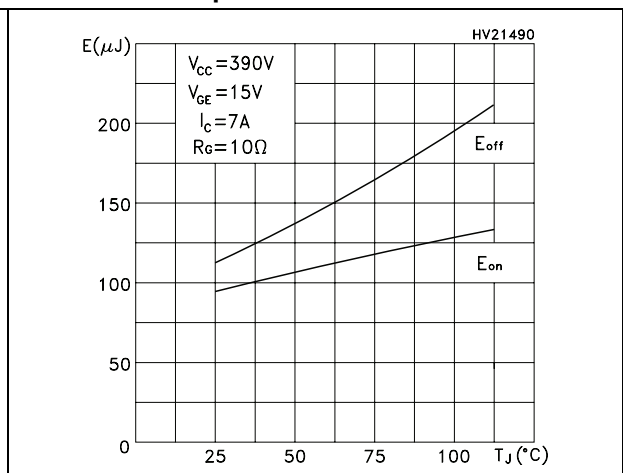
**Figure 9. Gate charge vs. gate-emitter voltage**



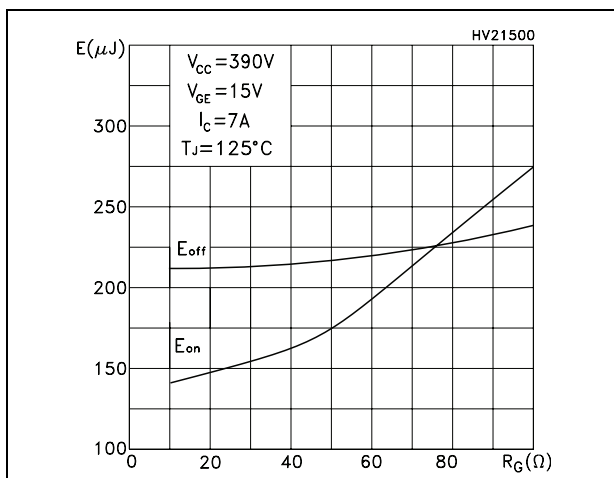
**Figure 10. Capacitance variations**



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



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



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

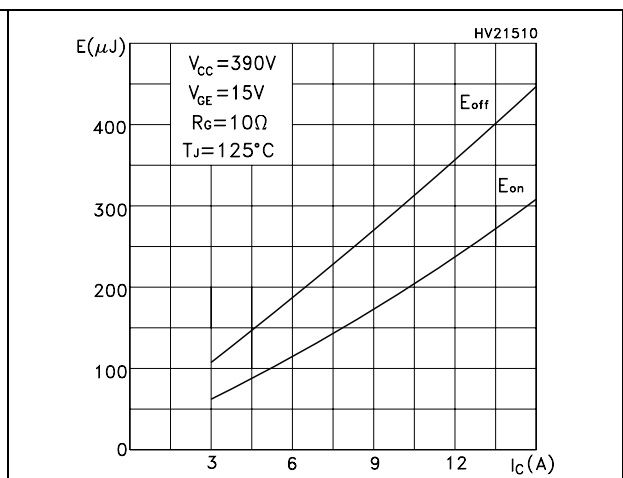


Figure 14. Emitter-collector diode characteristics

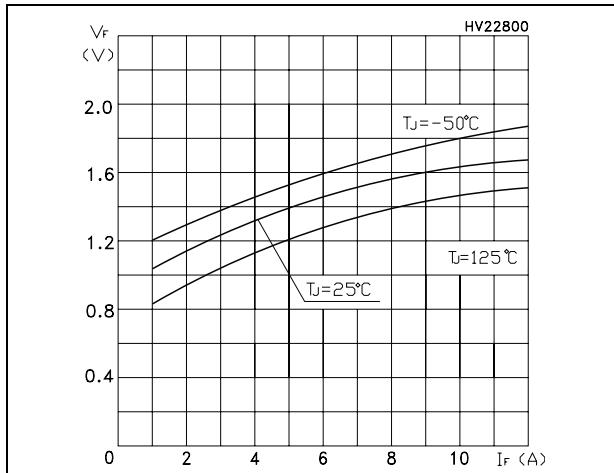


Figure 15. Turn-off SOA

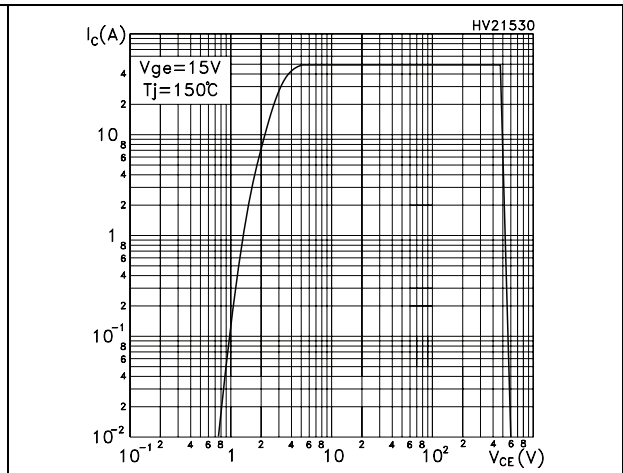


Figure 16. Thermal impedance for I<sup>2</sup>PAK, D<sup>2</sup>PAK and TO-220

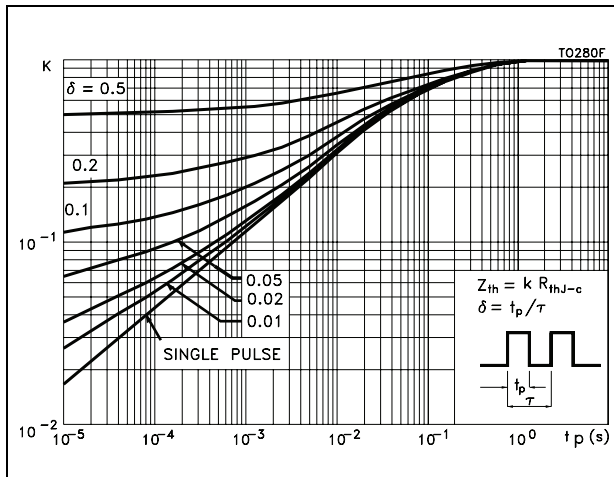
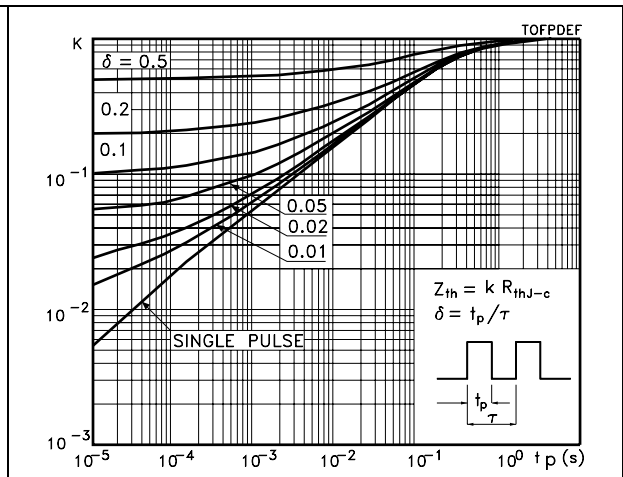


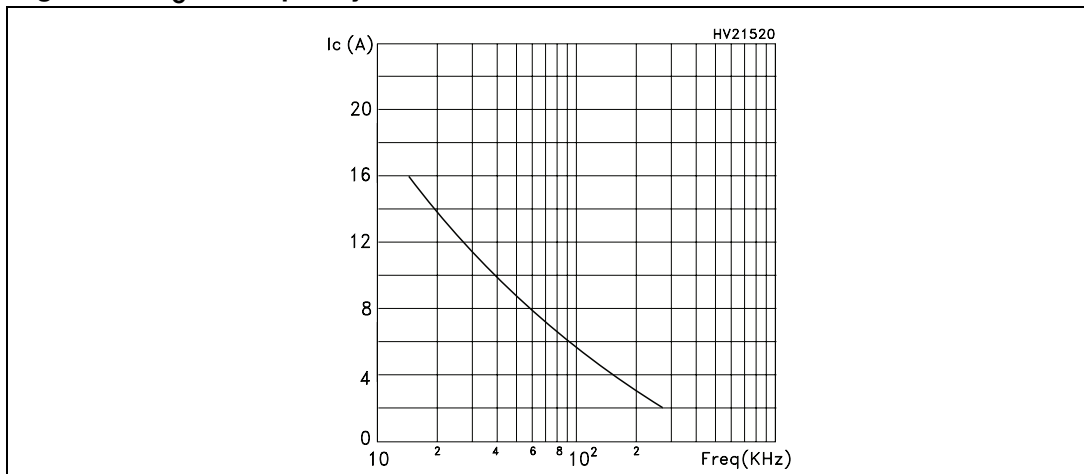
Figure 17. Thermal impedance for TO-220FP





## 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

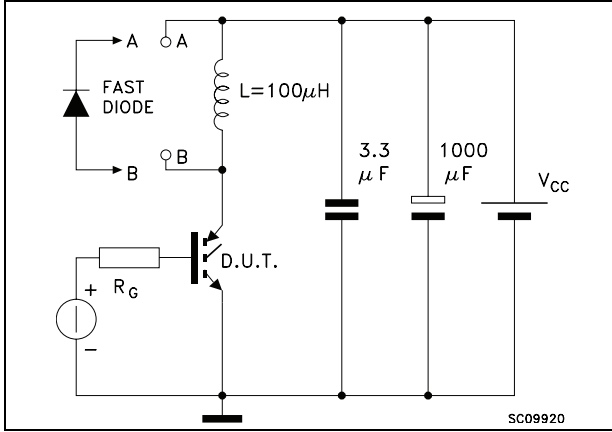


Figure 20. Gate charge test circuit

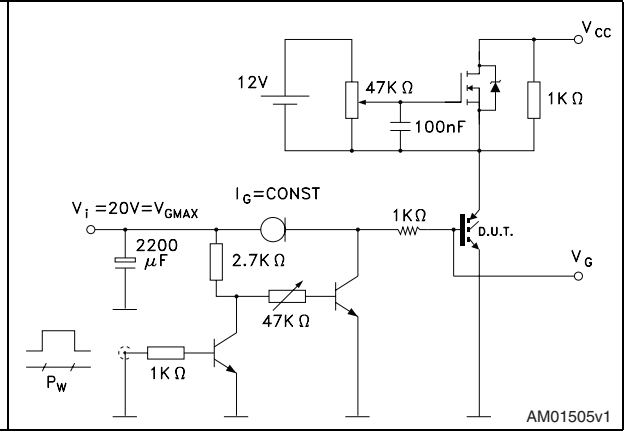


Figure 21. Switching waveform

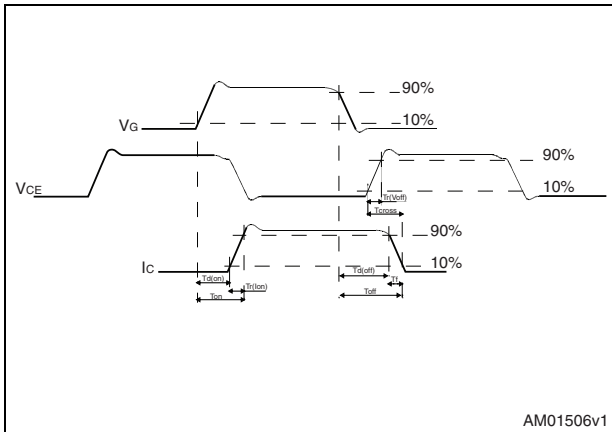
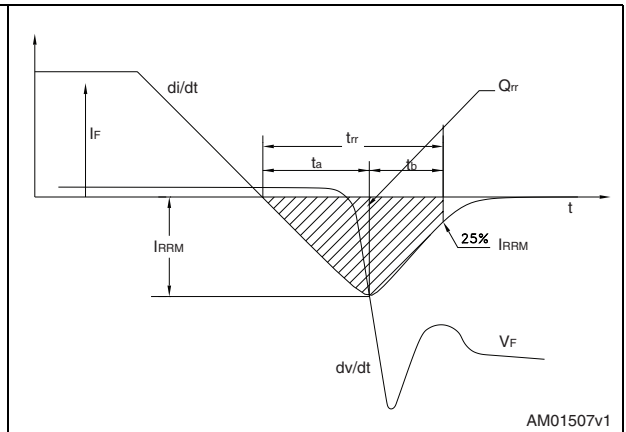


Figure 22. Diode recovery time waveform



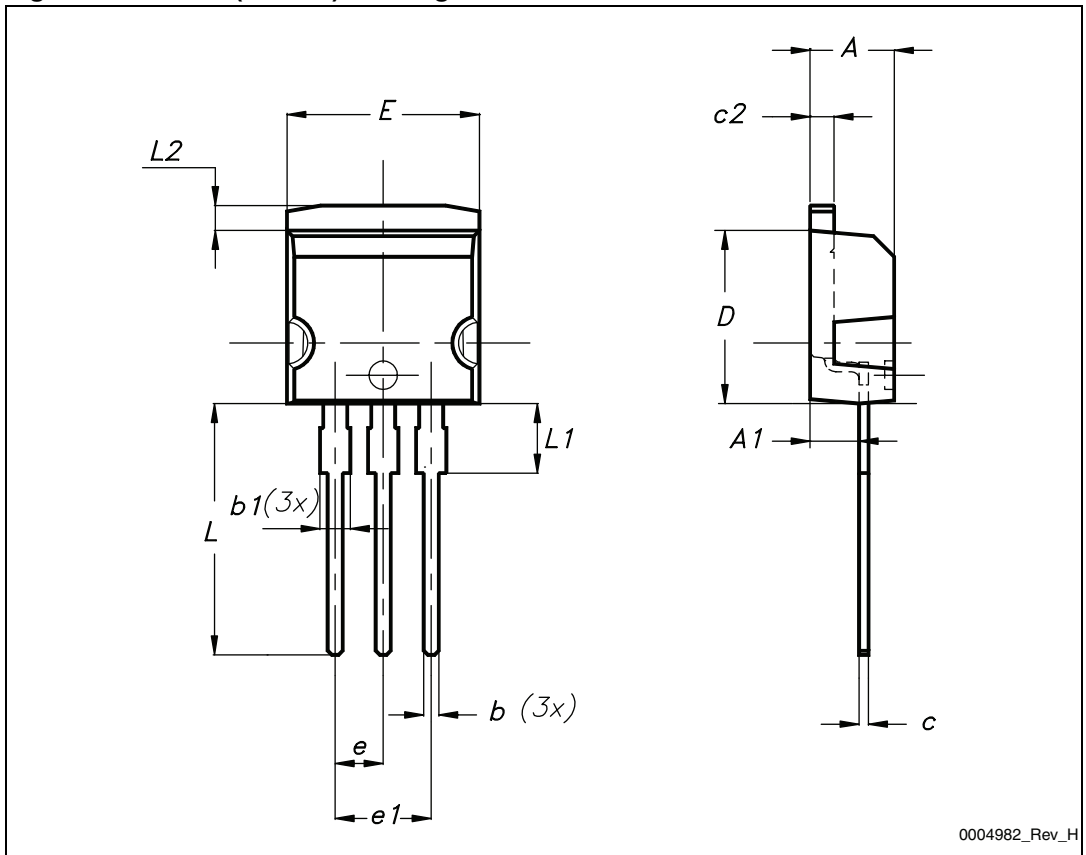
## 4 Package mechanical data

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



0004982\_Rev\_H

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

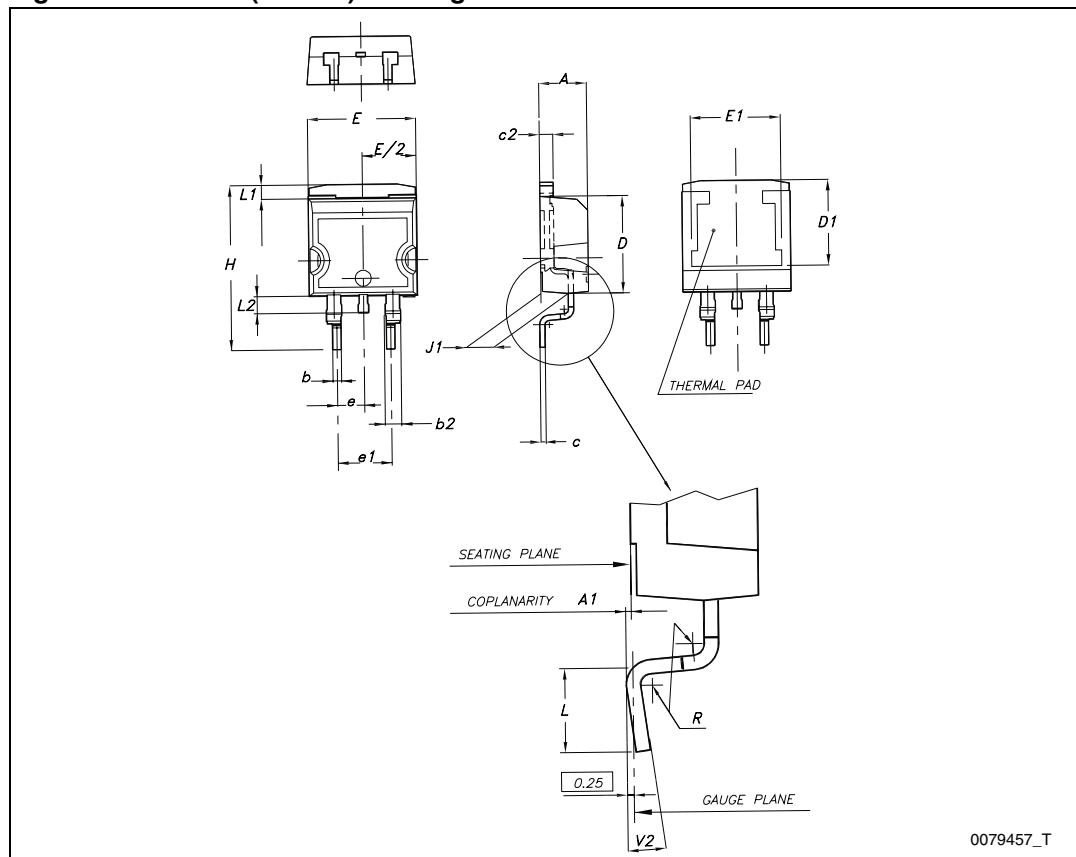
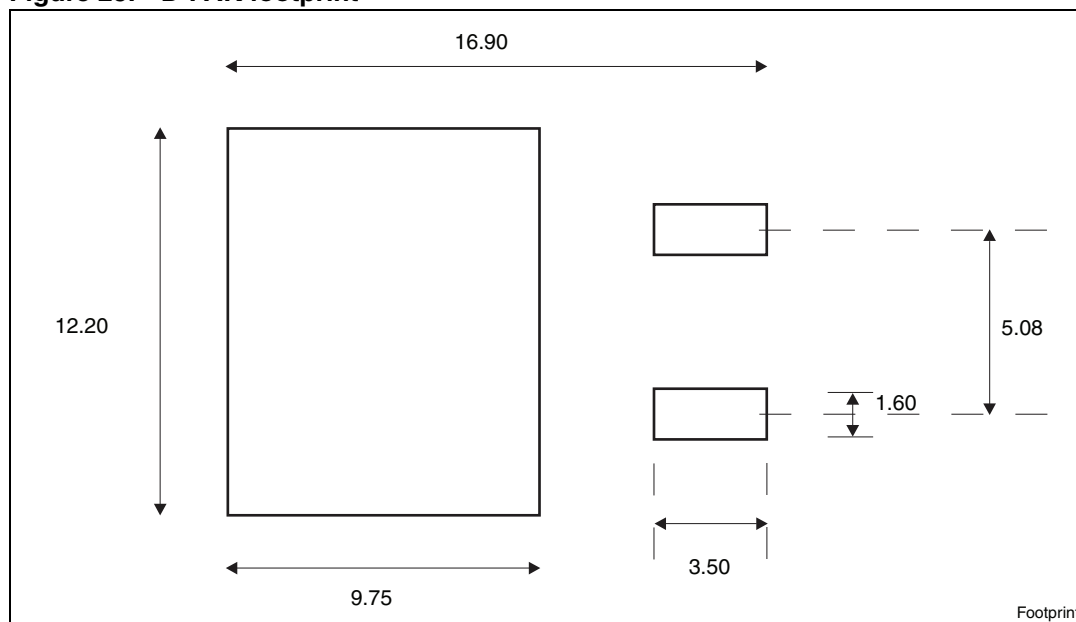


Figure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>

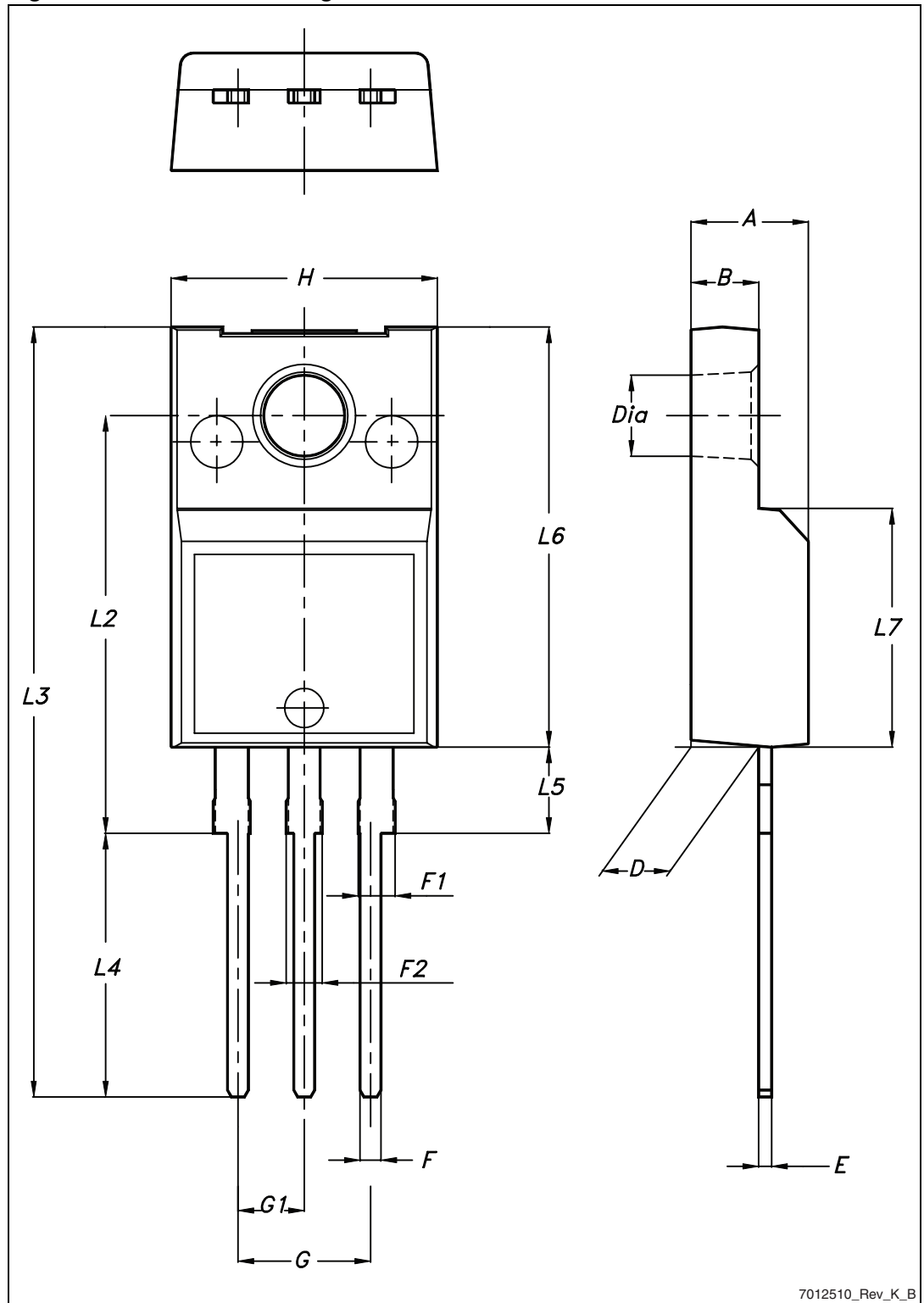


a. All dimensions are in millimeters

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



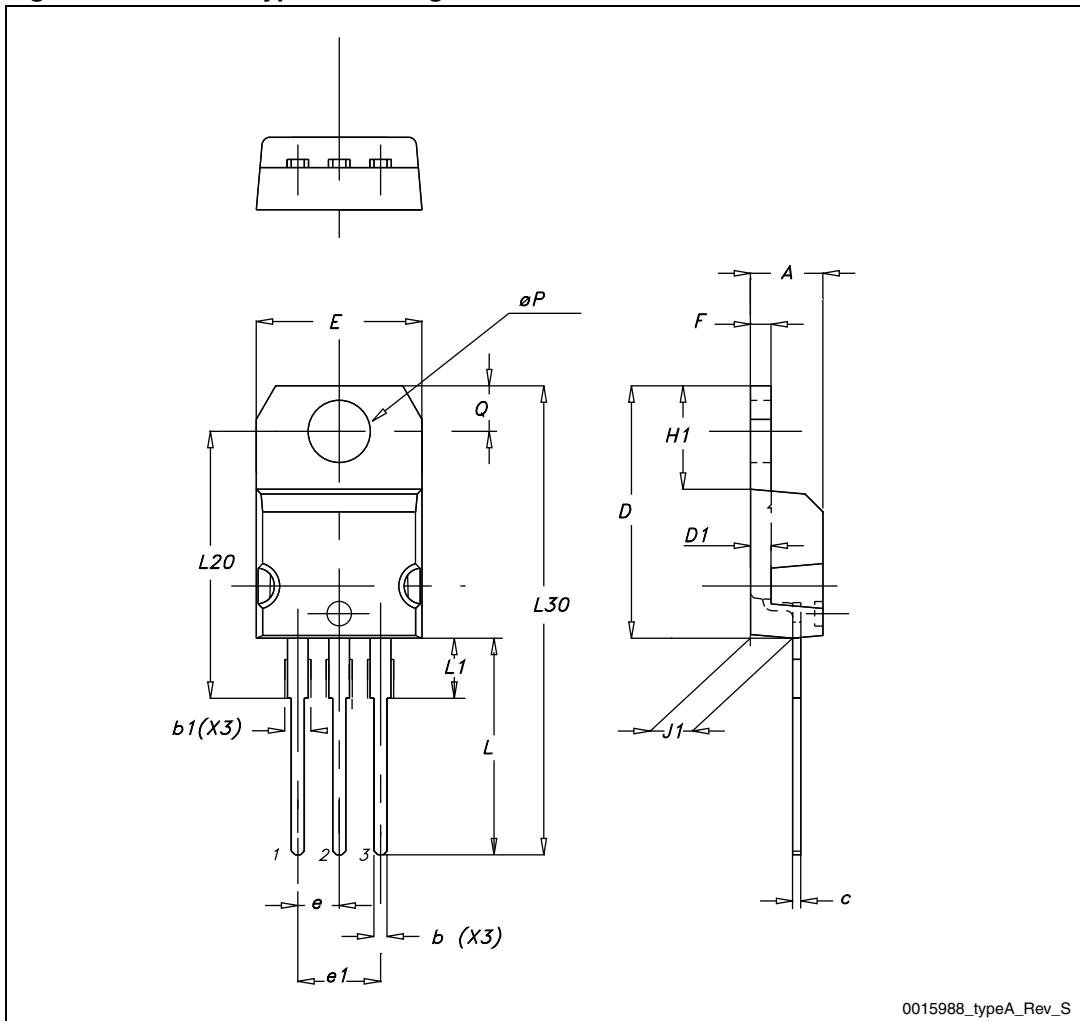
7012510\_Rev\_K\_B



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	
∅P	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

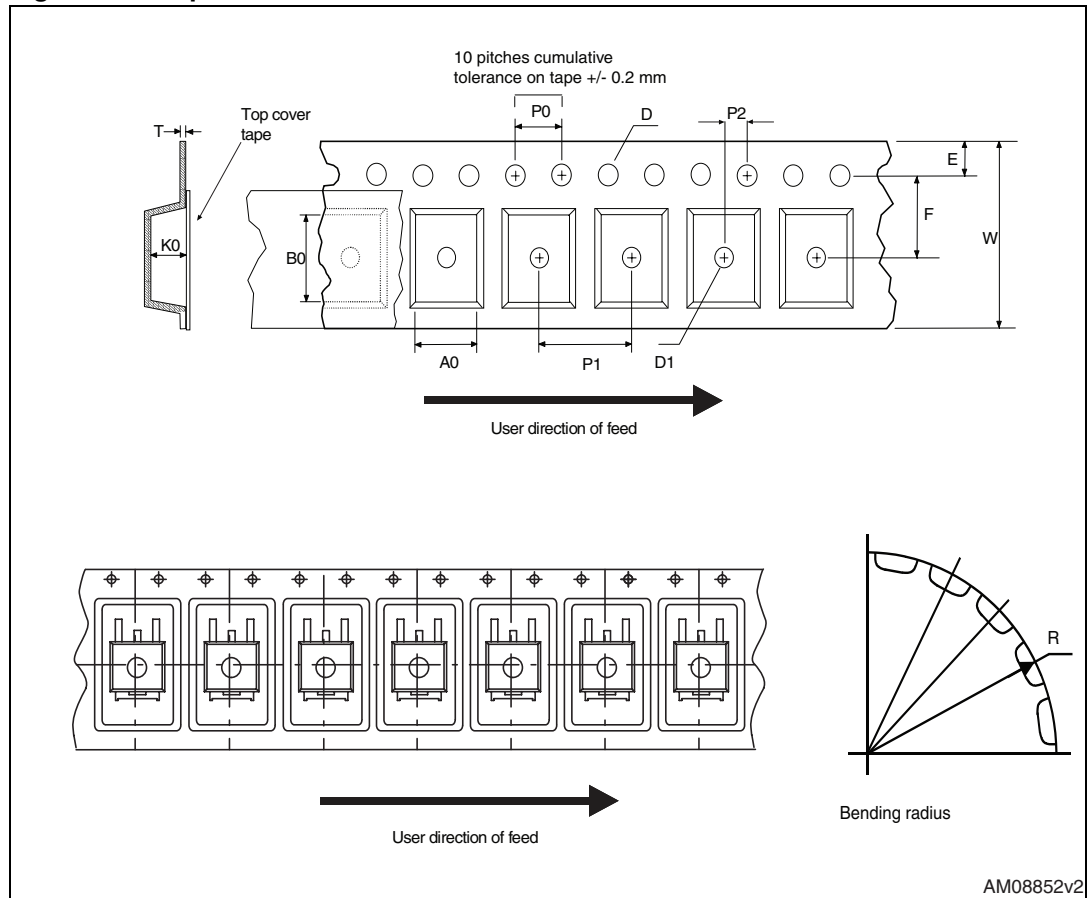
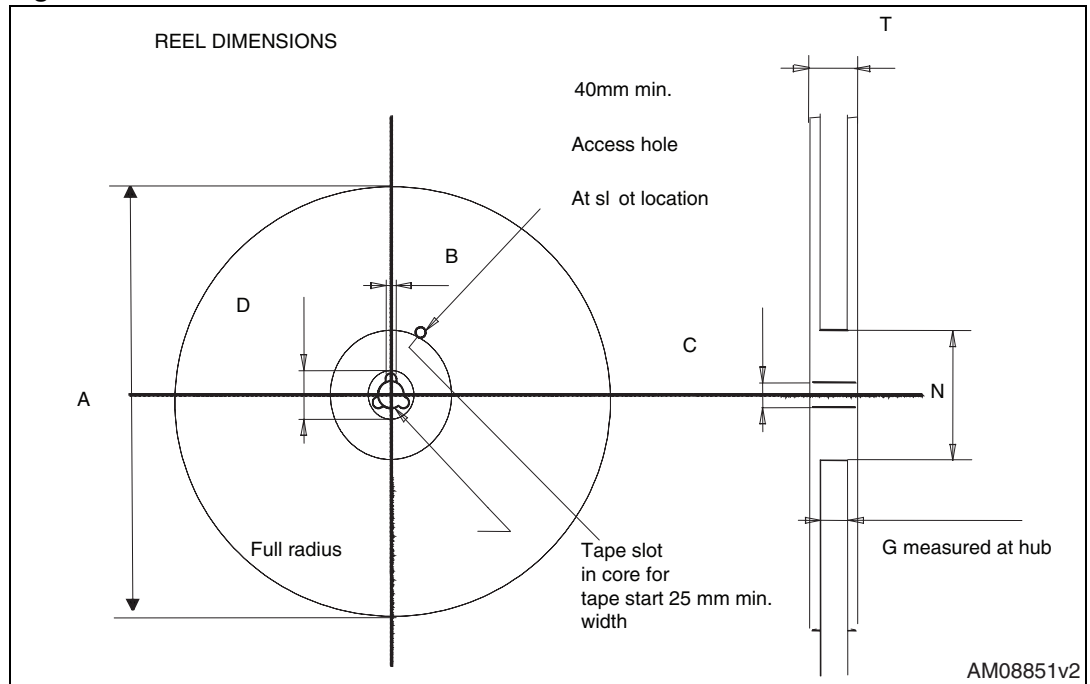


Figure 29. Reel



## 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. Minor text changes.

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