

Contents

1      **Electrical ratings** ..... 3

2      **Electrical characteristics** ..... 4

      2.1    Electrical characteristics (curves) ..... 6

3      **Test circuits** ..... 10

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

5      **Package mechanical data** ..... 20

6      **Revision history** ..... 22



# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		TO-220FP I <sup>2</sup> PAKFP	H <sup>2</sup> PAK-2	TO-220	
$V_{DS}$	Drain-source voltage	100			V
$V_{GS}$	Gate-source voltage	$\pm 20$			V
$I_D^{(1)}$	Drain current (continuous) at $T_C = 25^\circ\text{C}$	46	120		A
$I_D^{(1)}$	Drain current (continuous) at $T_C = 100^\circ\text{C}$	29	78		A
$I_{DM}^{(2)}$	Drain current (pulsed)	184	450		A
$P_{TOT}$	Total dissipation at $T_C = 25^\circ\text{C}$	35	250		W
$dv/dt$	Peak diode recovery voltage slope	22			V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1$ s; $T_C = 25^\circ\text{C}$ )	2500			V
$E_{AS}^{(3)}$	Single pulse avalanche energy	125			mJ
$T_j$ $T_{stg}$	Operating junction temperature storage temperature	- 55 to 175			$^\circ\text{C}$

1. Current limited by package.
2. Pulse width limited by safe operating area.
3. Starting  $T_j = 25^\circ\text{C}$ ,  $I_D = 50$  A,  $V_{DD} = 50$  V for TO-220 and H<sup>2</sup>PAK-2; Starting  $T_j = 25^\circ\text{C}$ ,  $I_D = 29$  A,  $V_{DD} = 60$  V for I<sup>2</sup>PAKFP and TO-220FP.

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220FP I <sup>2</sup> PAKFP	H <sup>2</sup> PAK-2	TO-220	
Rthj-case	Thermal resistance junction-case	4.3	0.6	0.6	$^\circ\text{C/W}$
Rthj-a	Thermal resistance junction-ambient	62.5		62.5	$^\circ\text{C/W}$
Rthj-pcb <sup>(1)</sup>	Thermal resistance junction-pcb		35		$^\circ\text{C/W}$

1. When mounted on FR-4 board, on 1inch<sup>2</sup>, 2oz Cu.

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0, I_D = 250\text{ }\mu\text{A}$	100	-		V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0, V_{DS} = 100\text{ V}$ $T_C = 25^{\circ}\text{C}$ $T_C = 125^{\circ}\text{C}$		-	10 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current	$V_{DS} = 0, V_{GS} = \pm 20\text{ V}$		-	$\pm 200$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	2	-	4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}, I_D = 23\text{ A}$ TO-220FP and I <sup>2</sup> PAKFP		8	9.6	m $\Omega$
		$V_{GS} = 10\text{ V}, I_D = 60\text{ A}$ H <sup>2</sup> PAK TO-220		7.8 8	9.3 9.6	

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{GS} = 0, V_{DS} = 25\text{ V},$ $f = 1\text{ MHz}$	-	3305	-	pF
$C_{oss}$	Output capacitance			373		pF
$C_{rss}$	Reverse transfer capacitance			23		pF
$Q_g$	Total gate charge	$V_{DD} = 50\text{ V}, I_D = 120\text{ A},$	-	57	-	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10\text{ V}$		22		nC
$Q_{gd}$	Gate-drain charge	(see <a href="#">Figure 20</a> )		17		nC

**Table 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 50\text{ V}, I_D = 60\text{ A}$ $R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$ (see <a href="#">Figure 19</a> , <a href="#">Figure 24</a> )	-	17	-	ns
$t_r$	Rise time			38		ns
$t_{d(off)}$	Turn-off delay time			52		ns
$t_f$	Fall time			7.2		ns

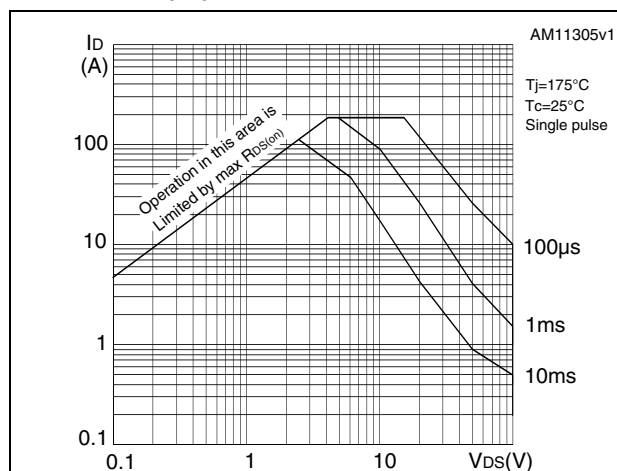
**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM}^{(1)}$	Source-drain current Source-drain current (pulsed)	For TO-220FP and I <sup>2</sup> PAKFP	-		46 184	A A
$I_{SD}$ $I_{SDM}^{(2)}$	Source-drain current Source-drain current (pulsed)	For TO-220, H <sup>2</sup> PAK-2	-		120 450	A A
$V_{SD}^{(3)}$	Forward on voltage	$I_{SD}=120\text{ A}$ , $V_{GS}=0$ ; for TO-220, H <sup>2</sup> PAK-2 $I_{SD}=46\text{ A}$ , $V_{GS}=0$ ; for TO-220FP and I <sup>2</sup> PAKFP	-		1.5	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_{SD}=120\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD}=80\text{ V}$ , $T_j=150\text{ }^{\circ}\text{C}$ (see <a href="#">Figure 21</a> )	-	68 182 5.4		ns nC A

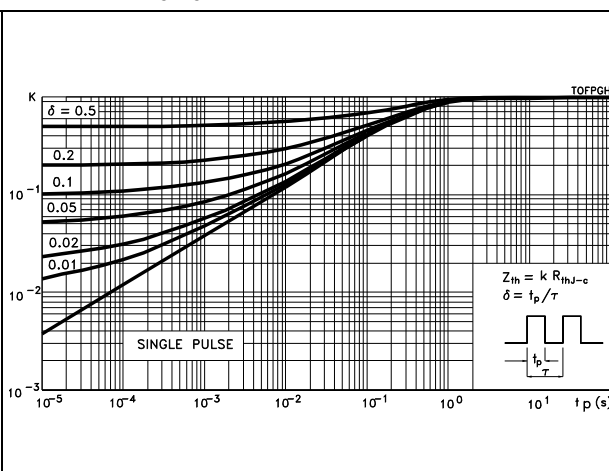
1. Pulse width limited by safe operating area
2. Pulse width limited by safe operating area
3. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

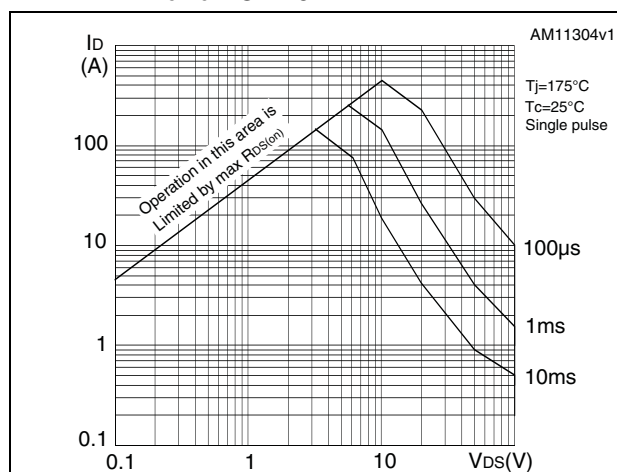
**Figure 2. Safe operating area for TO-220FP and I<sup>2</sup>PAKFP**



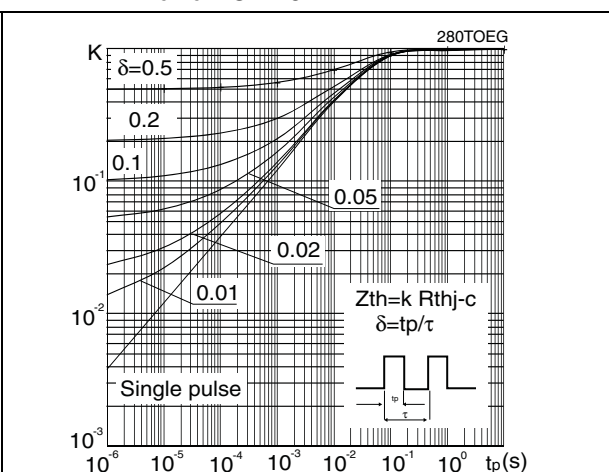
**Figure 3. Thermal impedance for TO-220FP and I<sup>2</sup>PAKFP**



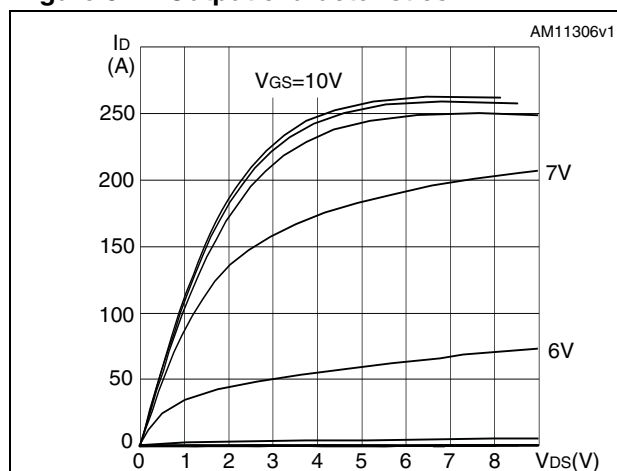
**Figure 4. Safe operating area for H<sup>2</sup>PAK-2 and TO-220**



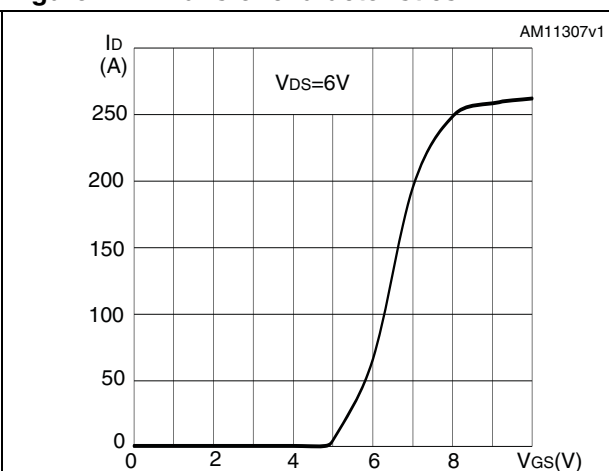
**Figure 5. Thermal impedance for H<sup>2</sup>PAK-2 and TO-220**



**Figure 6. Output characteristics**



**Figure 7. Transfer characteristics**



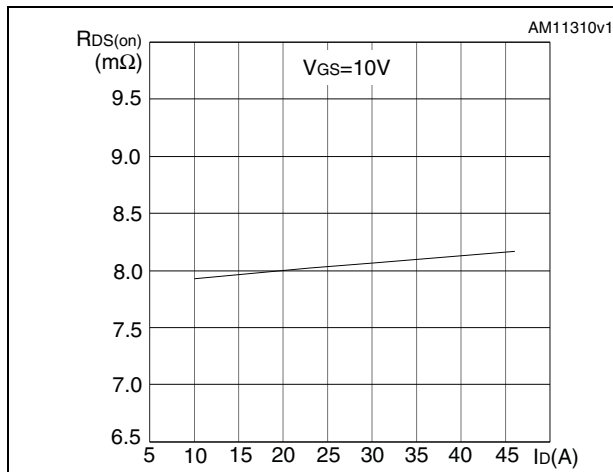
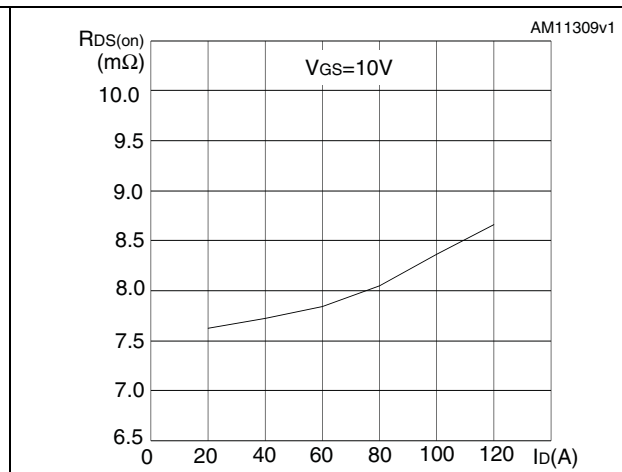
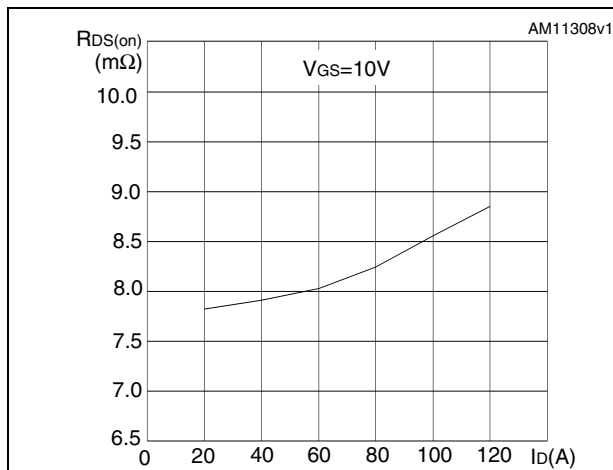
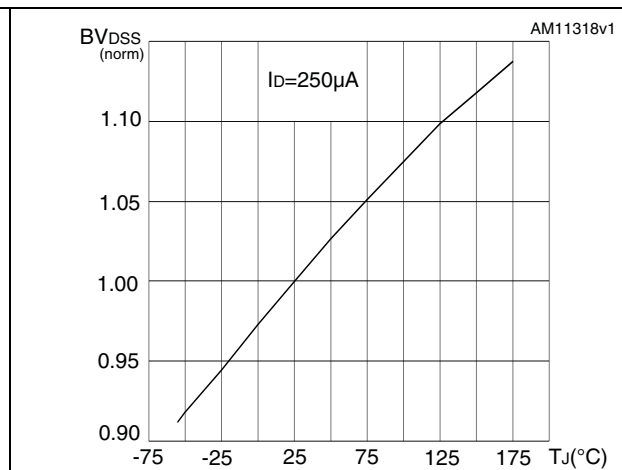
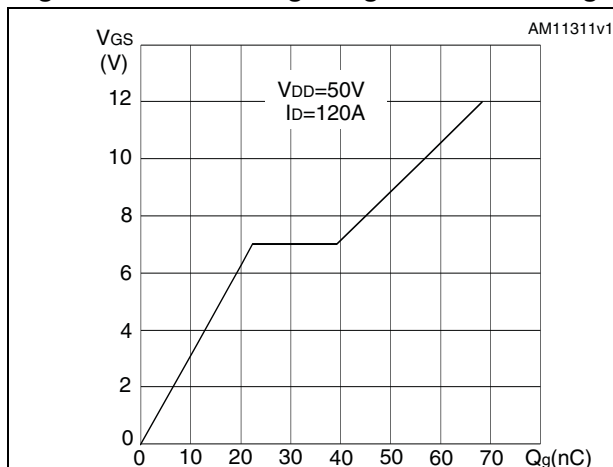
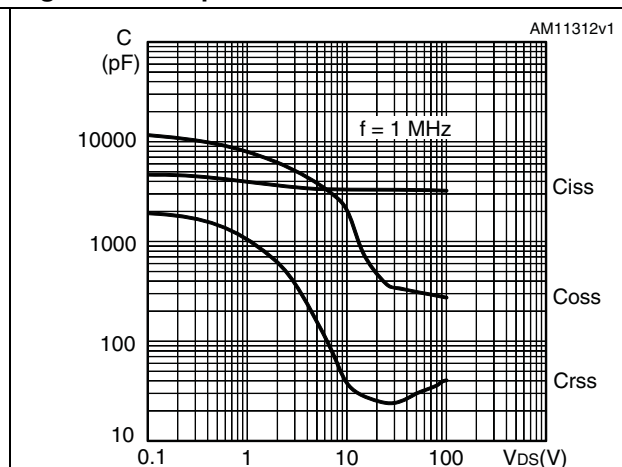
**Figure 8. Static drain-source on-resistance for TO-220FP and I<sup>2</sup>PAKFP****Figure 9. Static drain-source on-resistance for H<sup>2</sup>PAK-2****Figure 10. Static drain-source on-resistance for TO-220****Figure 11. Normalized  $B_{VDSS}$  vs temperature****Figure 12. Gate charge vs gate-source voltage****Figure 13. Capacitance variations**

Figure 14. Normalized gate threshold voltage vs temperature

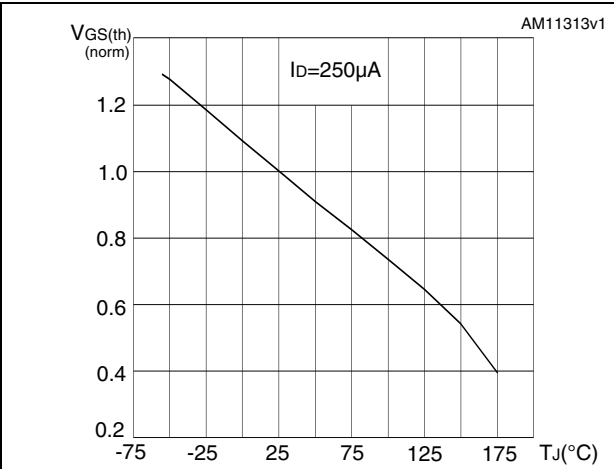


Figure 15. Normalized on-resistance vs temperature for TO-220FP and I<sup>2</sup>PAKFP

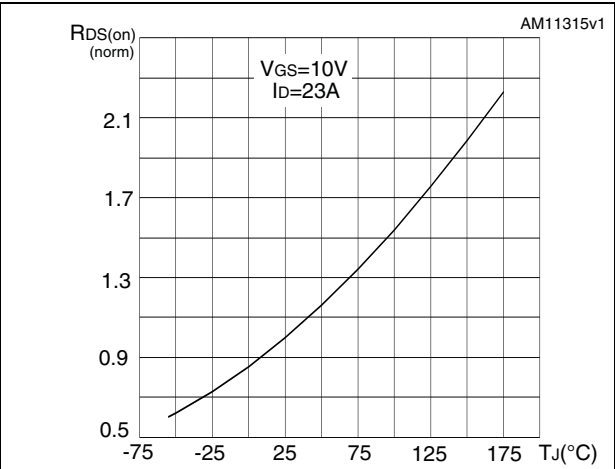


Figure 16. Normalized on resistance vs temperature for H<sup>2</sup>PAK-2 and TO-220

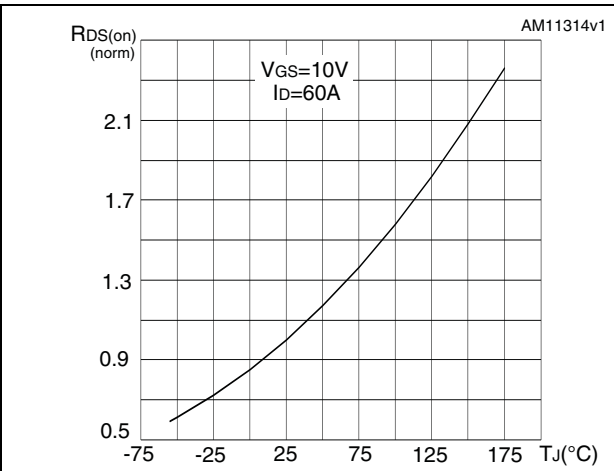
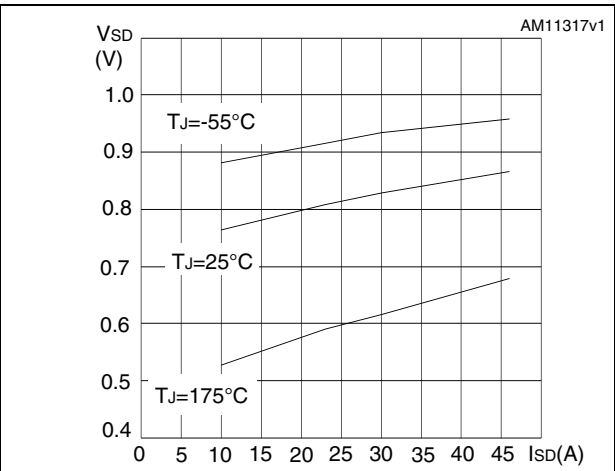
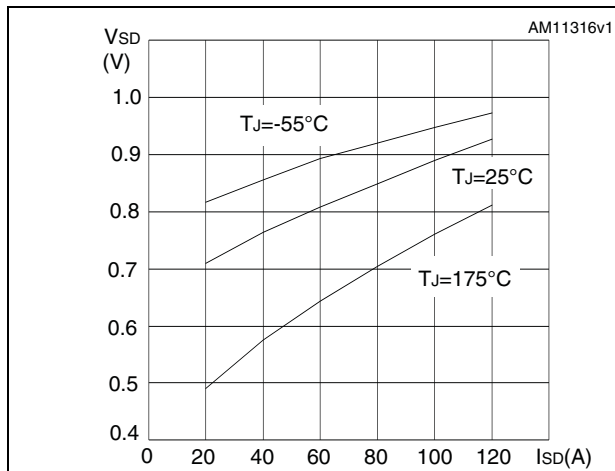


Figure 17. Source-drain diode forward characteristics for TO-220FP and I<sup>2</sup>PAKFP



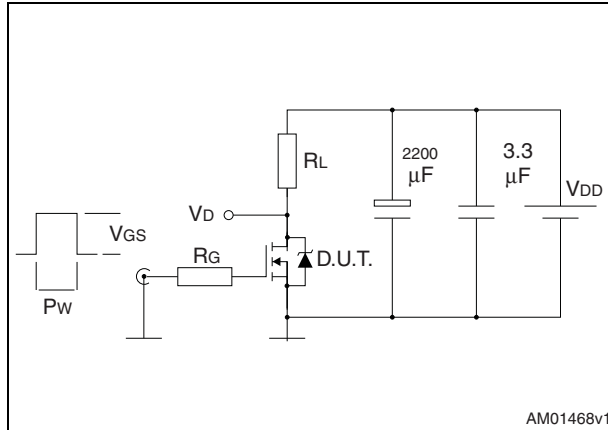
**Figure 18. Source-drain diode forward characteristics for H<sup>2</sup>PAK-2 and TO-220**



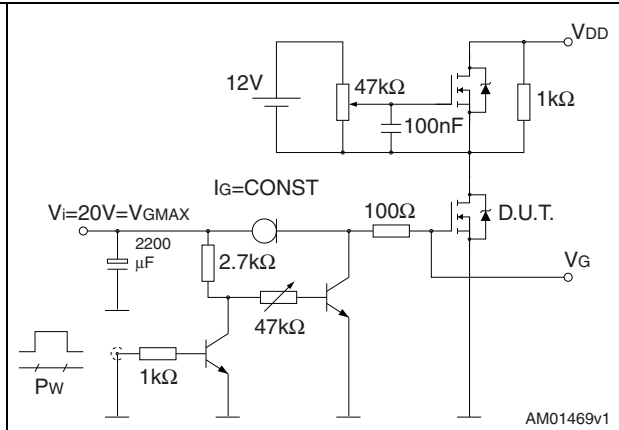


### 3 Test circuits

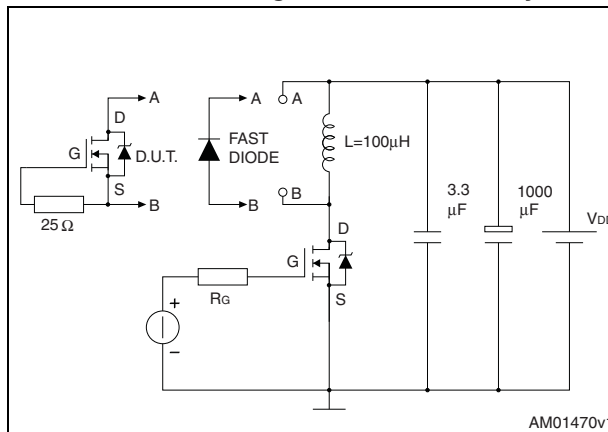
**Figure 19. Switching times test circuit for resistive load**



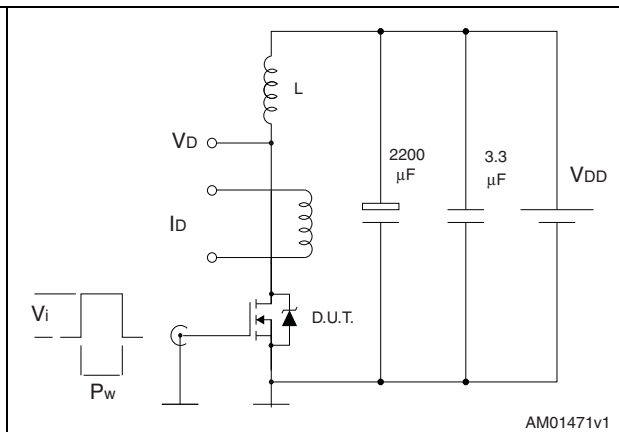
**Figure 20. Gate charge test circuit**



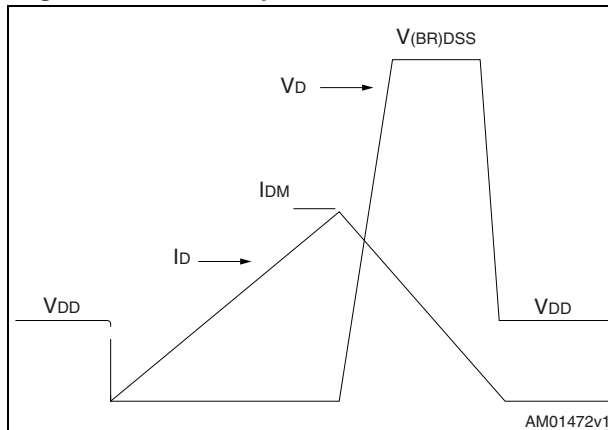
**Figure 21. Test circuit for inductive load switching and diode recovery times**



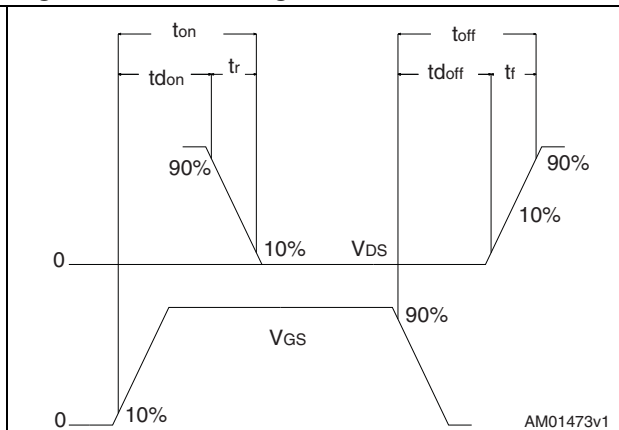
**Figure 22. Unclamped inductive load test circuit**



**Figure 23. Unclamped inductive waveform**



**Figure 24. Switching 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 8. 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 25. TO-220FP drawing

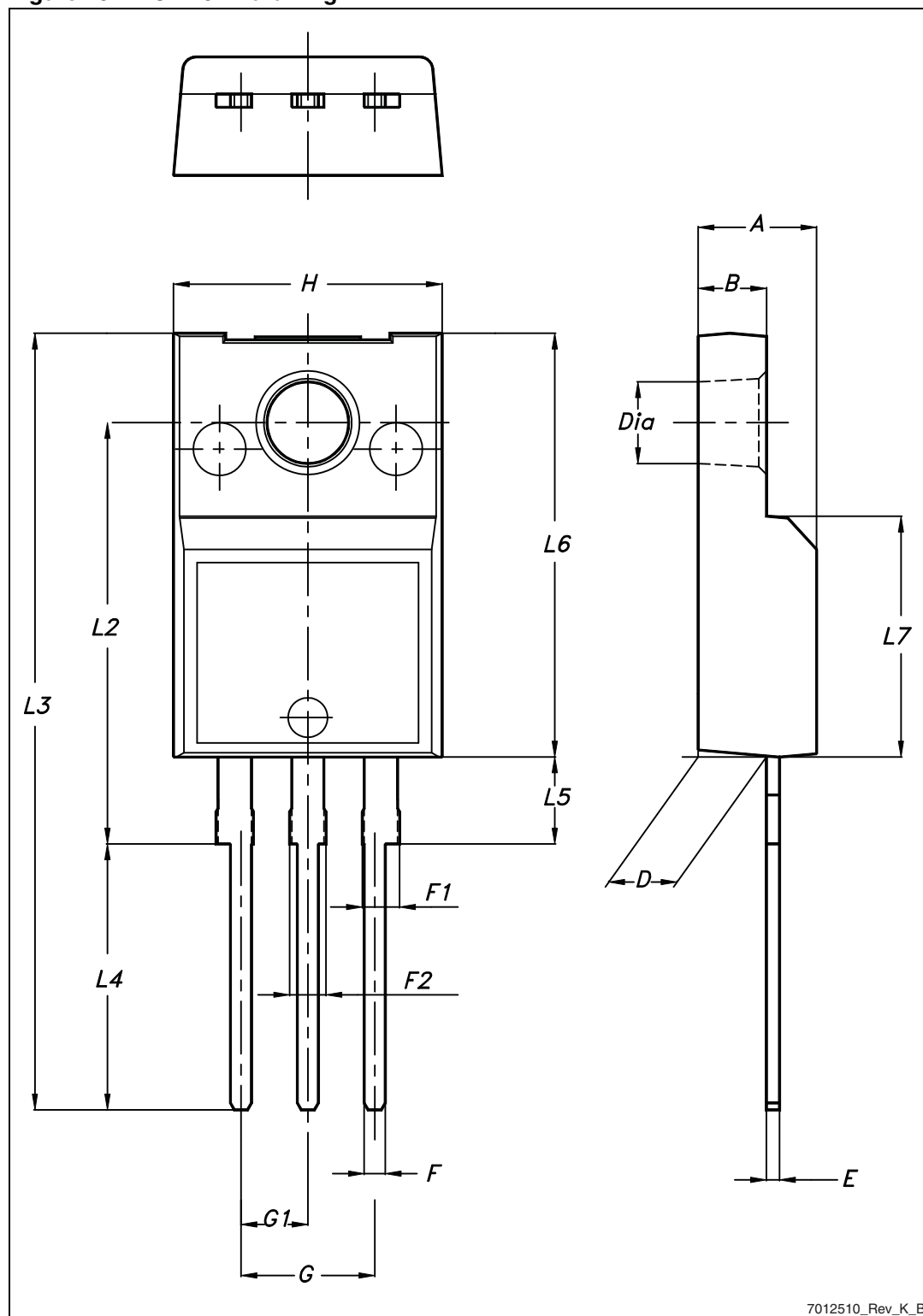


Table 9. I<sup>2</sup>PAKFP (TO-281) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40	-	4.60
B	2.50		2.70
D	2.50		2.75
D1	0.65		0.85
E	0.45		0.70
F	0.75		1.00
F1			1.20
G	4.95		5.20
H	10.00		10.40
L1	21.00		23.00
L2	13.20		14.10
L3	10.55		10.85
L4	2.70		3.20
L5	0.85		1.25
L6	7.30		7.50

Figure 26. I<sup>2</sup>PAKFP (TO-281) drawing

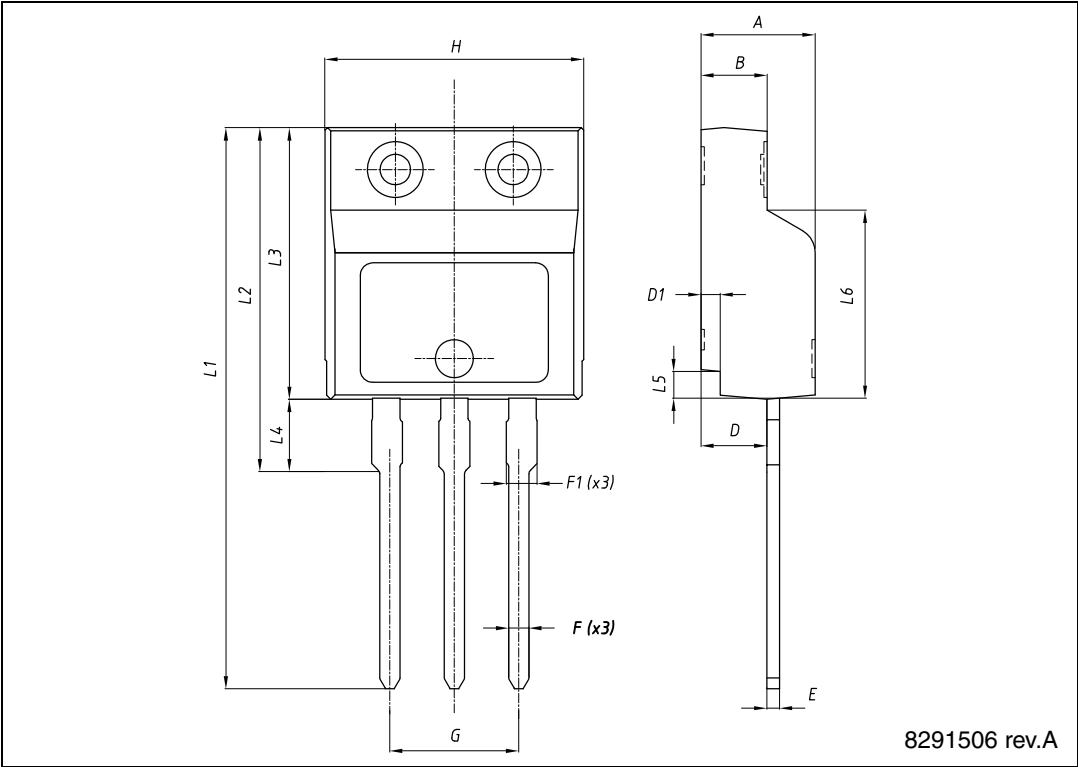


Table 10. H<sup>2</sup>PAK-2 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.30	-	4.80
A1	0.03		0.20
C	1.17		1.37
e	4.98		5.18
E	0.50		0.90
F	0.78		0.85
H	10.00		10.40
H1	7.40		7.80
L	15.30		15.80
L1	1.27		1.40
L2	4.93		5.23
L3	6.85		7.25
L4	1.5		1.7
M	2.6		2.9
R	0.20		0.60
V	0°		8°

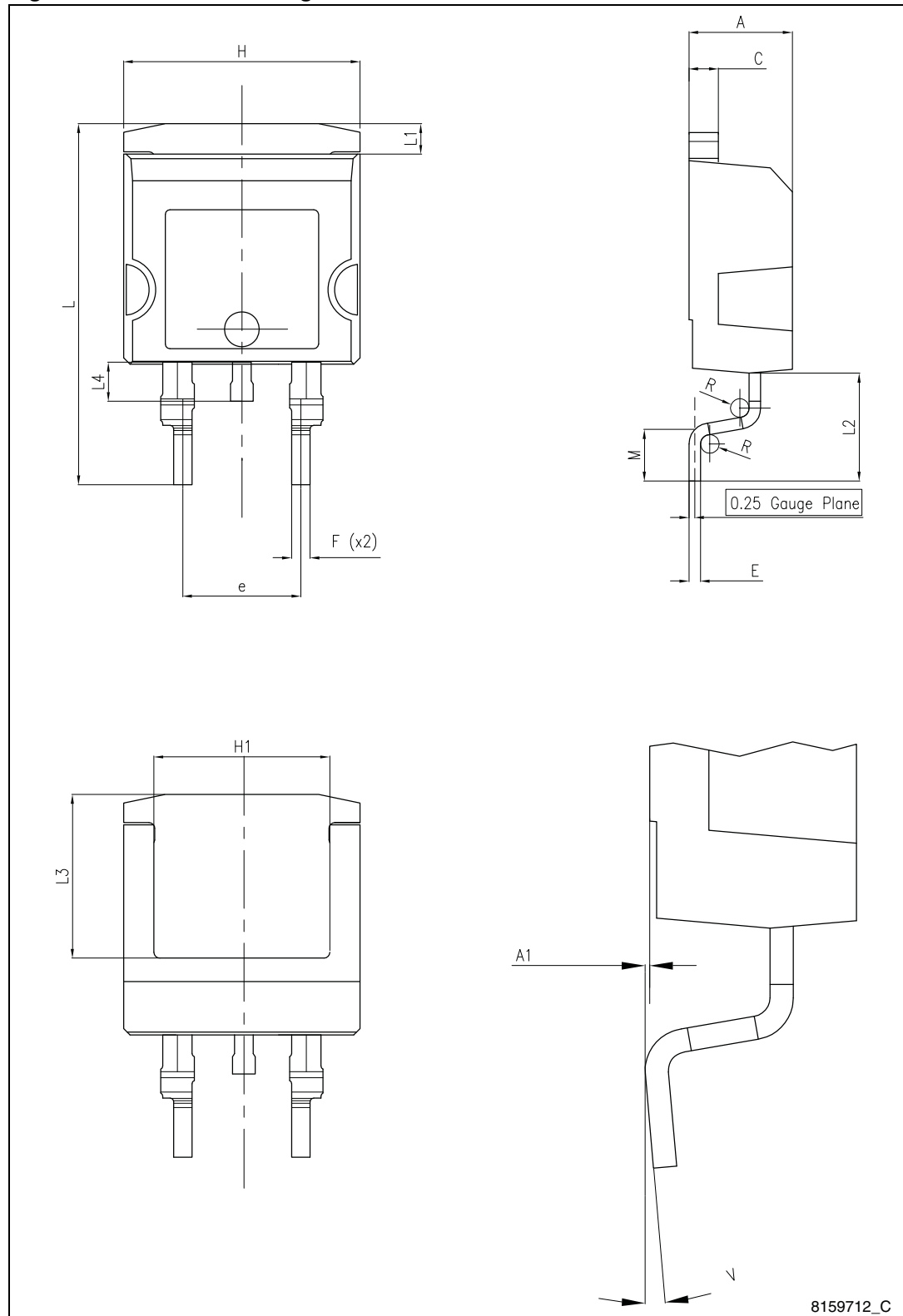
Figure 27. H<sup>2</sup>PAK-2 drawing

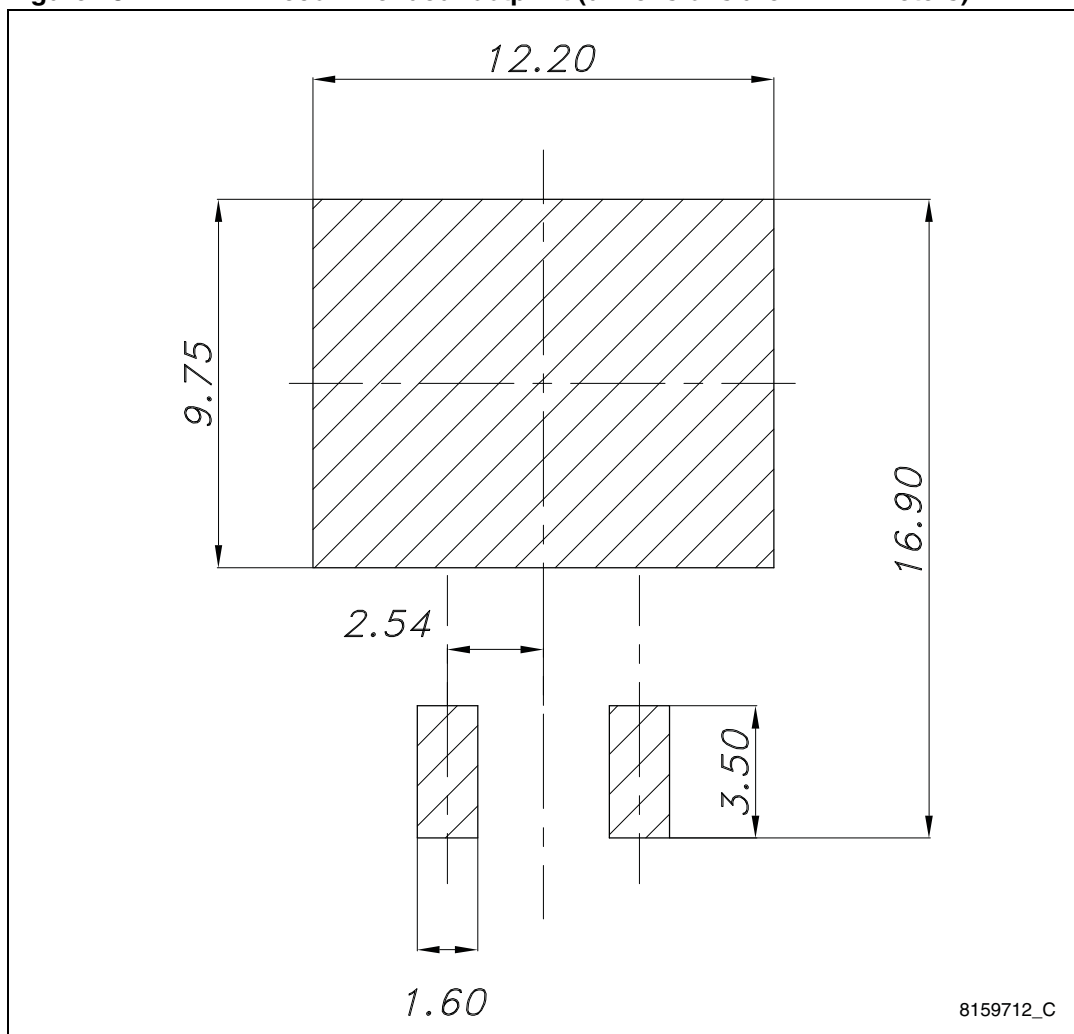
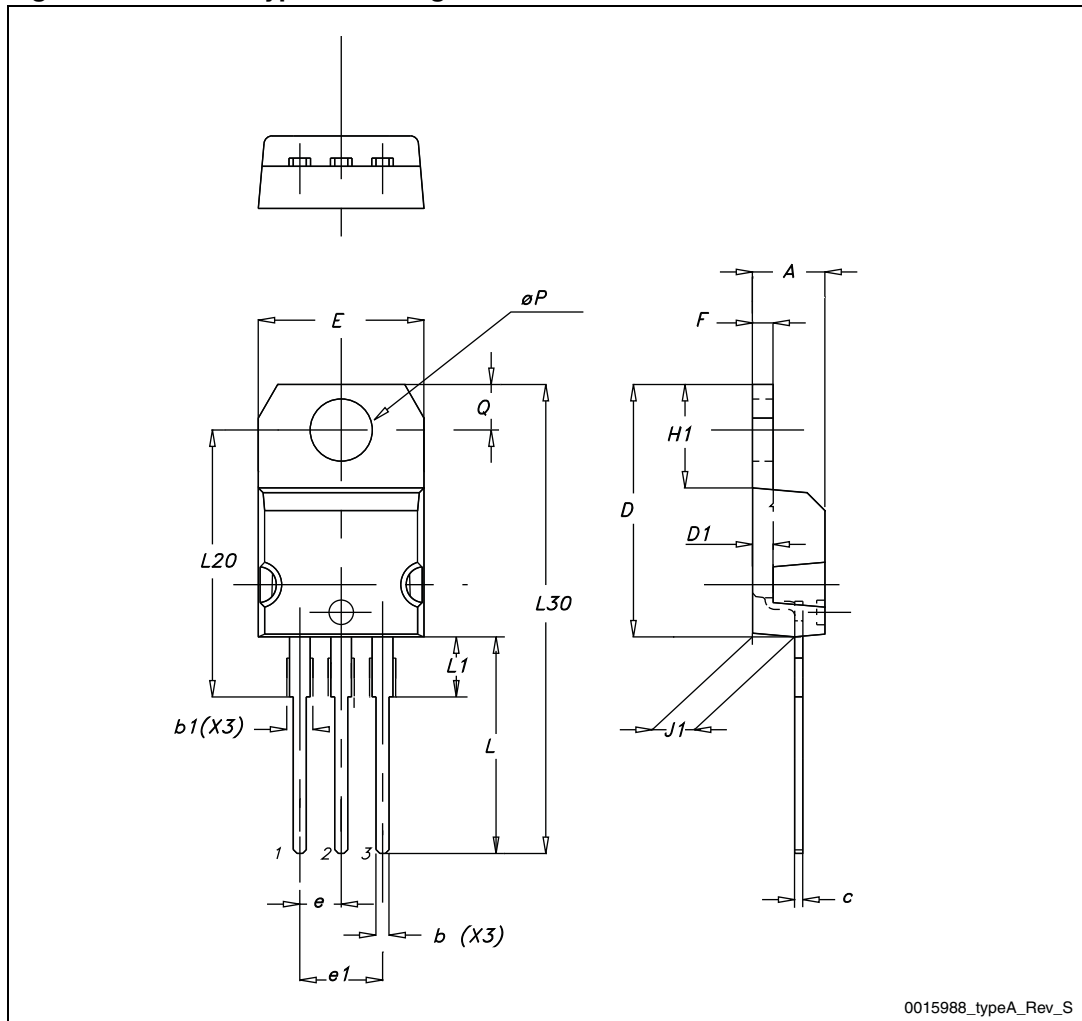
Figure 28. H<sup>2</sup>PAK-2 recommended footprint (dimensions are in millimeters)



Table 11. 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 29. TO-220 type A drawing



## 5 Package mechanical data

Table 12. H<sup>2</sup>PAK-2 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 30. Tape

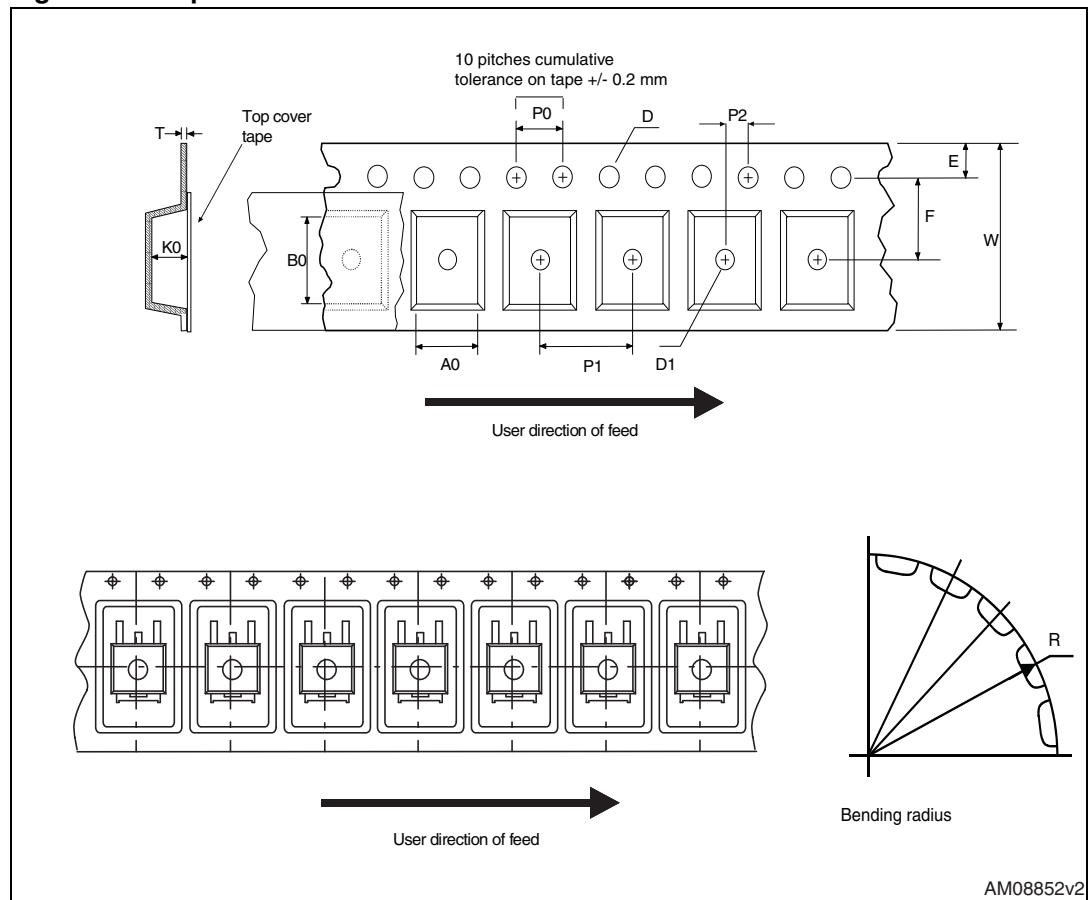
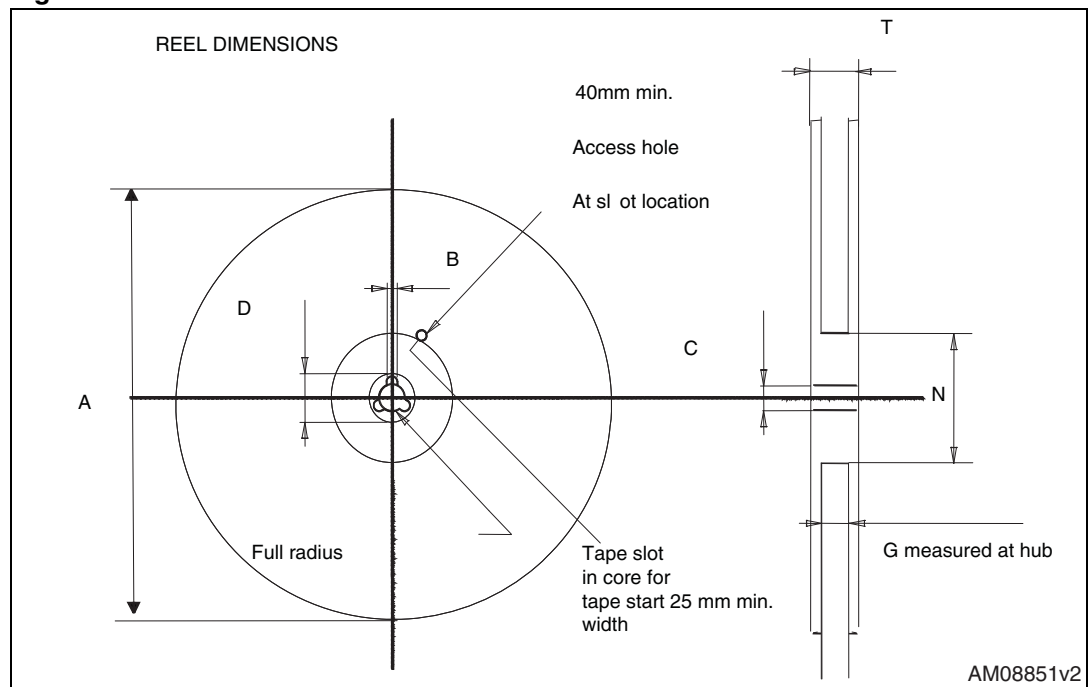


Figure 31. Reel



## 6 Revision history

**Table 13. Document revision history**

Date	Revision	Changes
24-Feb-2011	1	First version.
07-May-2012	2	Added <a href="#">Section 2.1: Electrical characteristics (curves)</a> . Minor text changes.
07-Nov-2012	3	Added new device in I <sup>2</sup> PAKFP and updated the document accordingly. Updated <a href="#">Section 4: Package mechanical data</a> .

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