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# STD2HNK60Z, STD2HNK60Z-1 STF2HNK60Z, STD2HNK60Z-AP

N-channel 600 V, 4.4  $\Omega$ , 2 A Zener-protected SuperMESH™  
Power MOSFET in TO-92-TO-220FP-DPAK-IPAK packages

Datasheet — production data

## Features

Order codes	V <sub>DSS</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>	P <sub>TOT</sub>
STD2HNK60Z	600 V	< 4.8 $\Omega$	2 A	45 W
STD2HNK60Z-1	600 V	< 4.8 $\Omega$	2 A	45 W
STF2HNK60Z	600 V	< 4.8 $\Omega$	2 A	20 W
STQ2HNK60ZR-AP	600 V	< 4.8 $\Omega$	0.5 A	3 W

- Gate charge minimized
- 100% avalanche tested
- Extremely high dv/dt capability
- ESD improved capability
- New high voltage benchmark

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

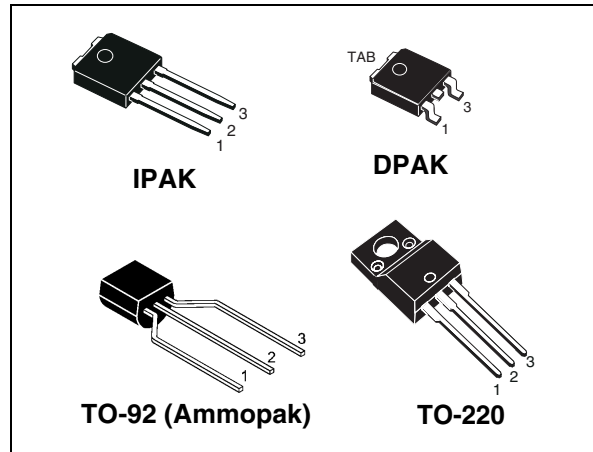


Figure 1. Internal schematic diagram

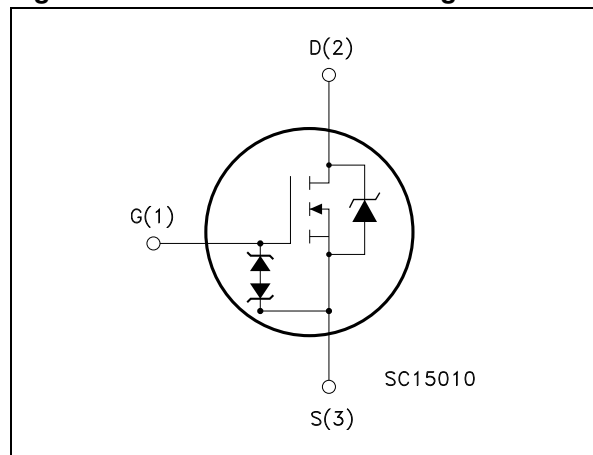


Table 1. Device summary

Order codes	Marking	Package	Packaging
STD2HNK60Z	D2HNK60Z	DPAK	Tape and reel
STD2HNK60Z-1	D2HNK60Z	IPAK	Tube
STF2HNK60Z	F2HNK60Z	TO-220FP	Tube
STQ2HNK60ZR-AP	Q2HNK60ZR	TO-92	Ammopak

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		IPAK,DPAK	TO-220FP	TO-92	
$V_{DS}$	Drain-source voltage	600			V
$V_{GS}$	Gate-source voltage	±30			V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	2.0	2.0	0.5	A
$I_D$	Drain current (continuous) at $T_C=100\text{ °C}$	1.26	1.26	0.32	A
$I_{DM}^{(1)}$	Drain current (pulsed)	8	8	2	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	45	20	3	W
	Derating factor	0.36	0.16	0.025	W/°C
$V_{ESD(G-S)}$	Gate source ESD (HBM-C=100 pF, R=1.5 kΩ)	2000			V
$V_{ISO}$	Insulation withstand voltage (DC)		2500		V
$dv/dt^{(2)}$	Peak diode recovery voltage slope	4.5			V/ns
$T_J$ $T_{stg}$	Operating junction temperature Storage temperature	- 55 to 150			°C
$T_I$	Maximum lead temperature for soldering purpose	300		260	°C

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 2\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\%V_{(BR)DSS}$ .

**Table 3. Thermal data**

Symbol	Parameter	IPAK/DPAK	TO-220FP	TO-92	Unit
$R_{thj-case}$	Thermal resistance junction-case max	2.77	6.25		°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	100	62.5	120	°C/W
$R_{thj-lead}$	Thermal resistance junction-lead max			40	°C/W

**Table 4. Avalanche data**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	2	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD} = 50\text{ mV}$ )	120	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	600			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$ , $V_{DS} = 600\text{ V}$ , $T_c = 125\text{ °C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 50\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 1\text{ A}$		4.4	4.8	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15\text{ V}$ , $I_D = 1\text{ A}$	-	1.5		S
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	280		pF
$C_{oss}$	Output capacitance			38		pF
$C_{rss}$	Reverse transfer capacitance			7		pF
$C_{oss\ eq}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0$ , $V_{DS} = 0$ to $480\text{ V}$	-	30		pF
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 2\text{ A}$	-	11	15	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10\text{ V}$		2.25		nC
$Q_{gd}$	Gate-drain charge	(see Figure 19)		6		nC

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

2.  $C_{oss\ eq}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$	Turn-on delay time Rise time	$V_{DD}=300\text{ V}$ , $I_D=1\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ <i>(see Figure 18)</i>	-	10 30	-	ns ns
$t_{d(off)}$ $t_f$	Turn-off delay time Fall time		-	23 50	-	ns ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM}^{(1)}$	Source-drain current Source-drain current (pulsed)		-		2 8	A A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 2\text{ A}$ , $V_{GS} = 0$	-		1.3	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_{SD}=2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD}=20\text{ V}$	-	178 445 5		ns nC A
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_{SD}=2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD}=20\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$	-	200 500 5		ns nC A

1. Pulse width limited by safe operating area

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

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-92

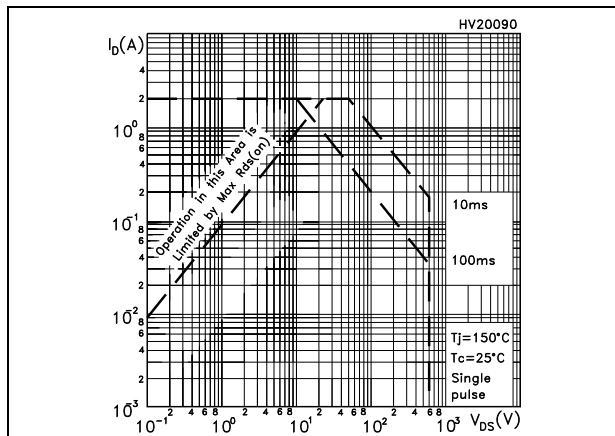


Figure 3. Thermal impedance for TO-92

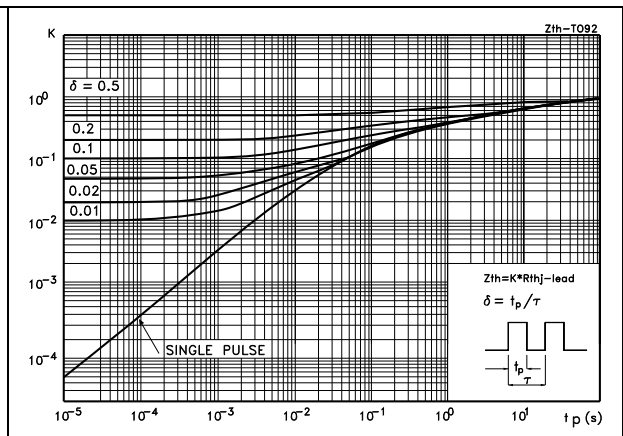


Figure 4. Safe operating area for TO-220FP

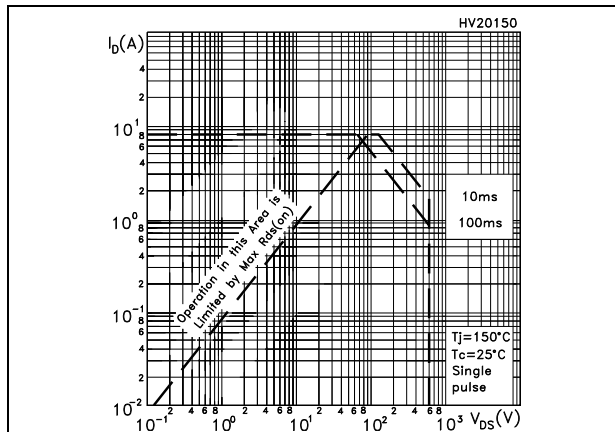


Figure 5. Thermal impedance for TO-220FP

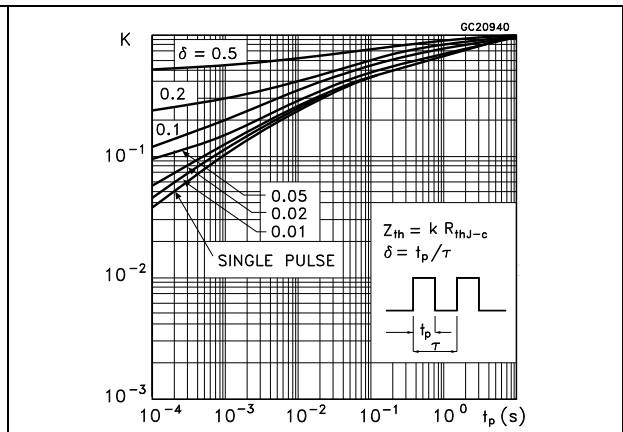


Figure 6. Safe operating area for IPAK/DPAK

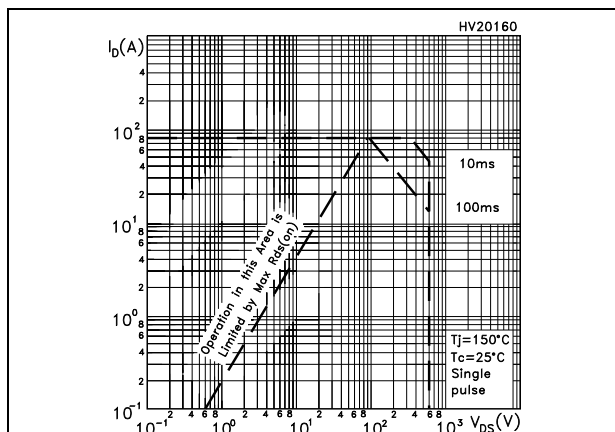


Figure 7. Thermal impedance for IPAK/DPAK

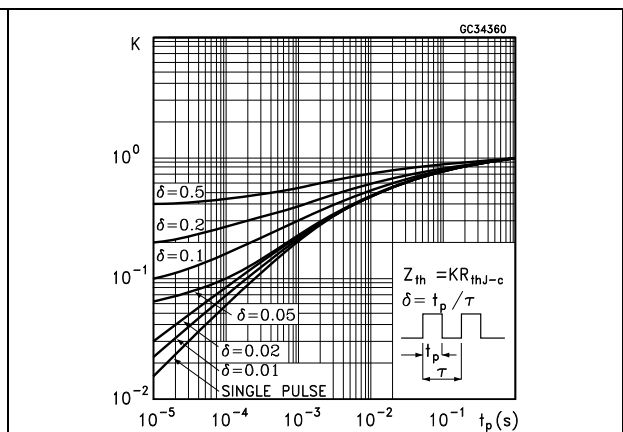


Figure 8. Output characteristics

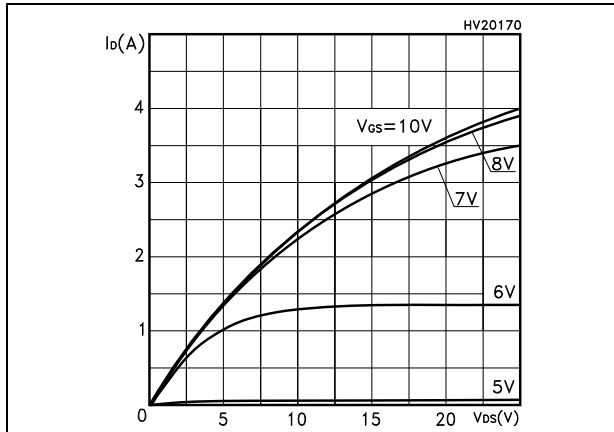


Figure 9. Transfer characteristics

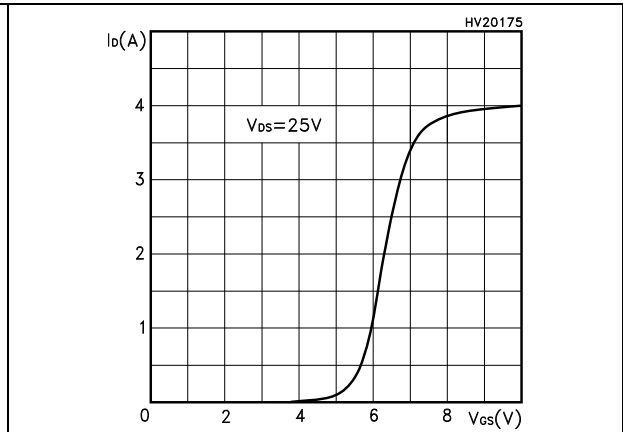


Figure 10. Normalized  $B_{VDSS}$  vs temperature

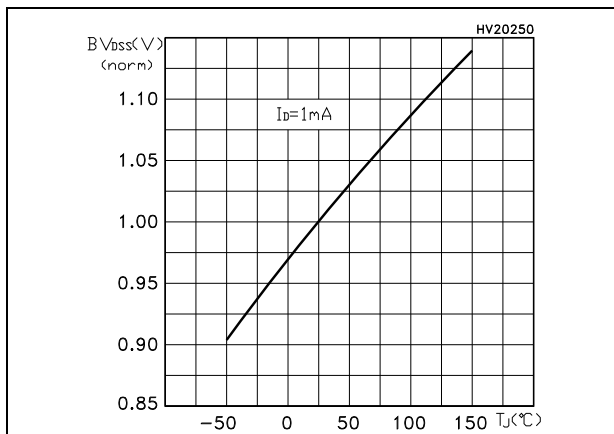


Figure 11. Static drain-source on-resistance

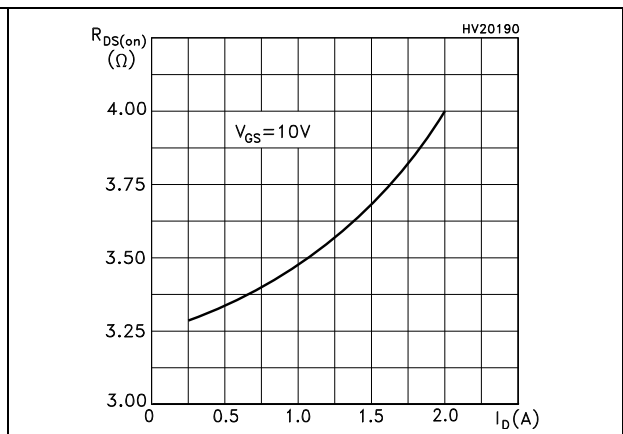


Figure 12. Gate charge vs gate-source voltage

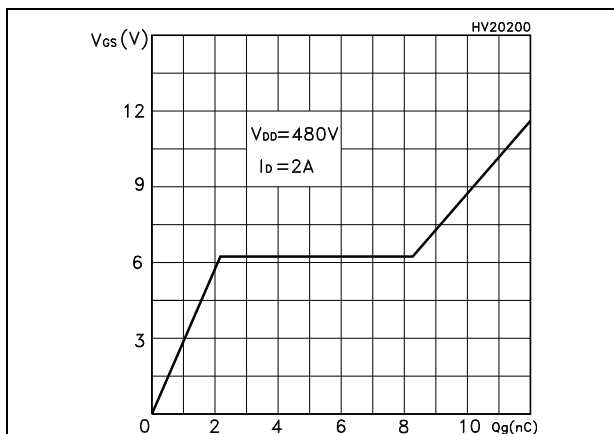


Figure 13. Capacitance variations

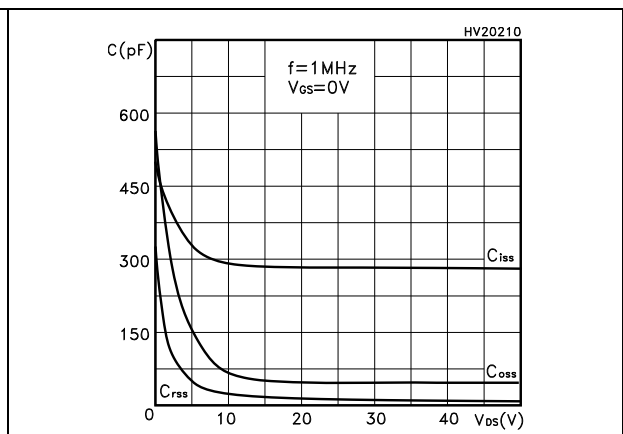




Figure 14. Normalized gate threshold voltage vs temperature

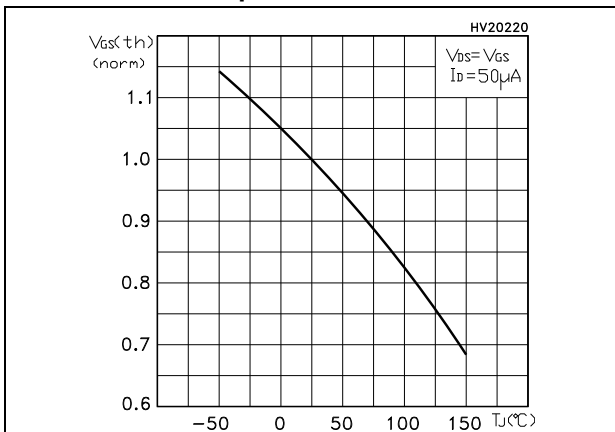


Figure 15. Normalized on-resistance vs temperature

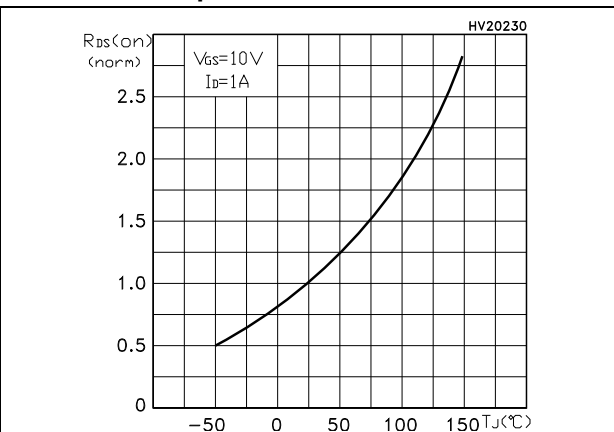


Figure 16. Source-drain diode forward characteristics

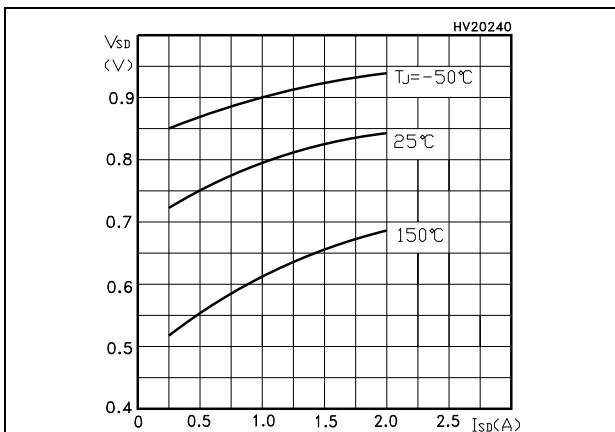
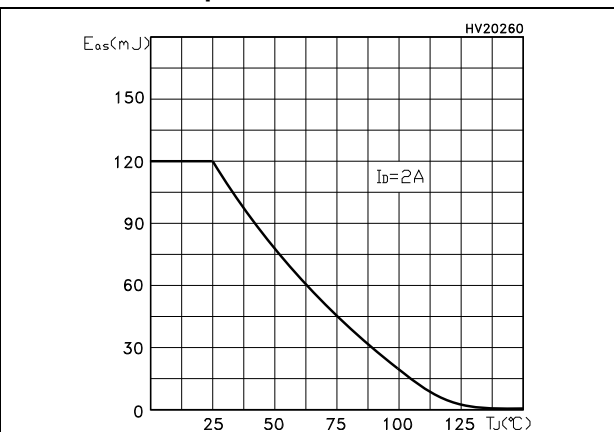
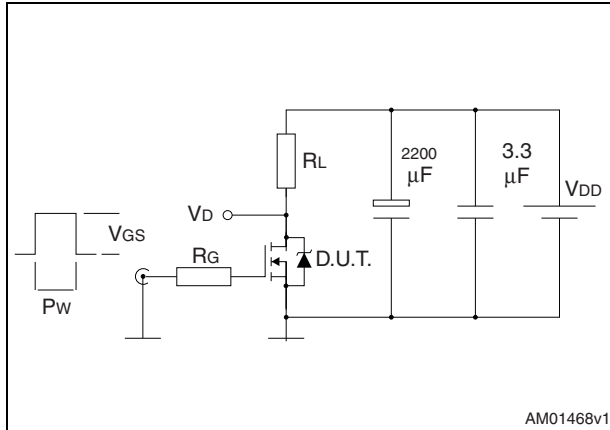


Figure 17. Maximum avalanche energy vs temperature



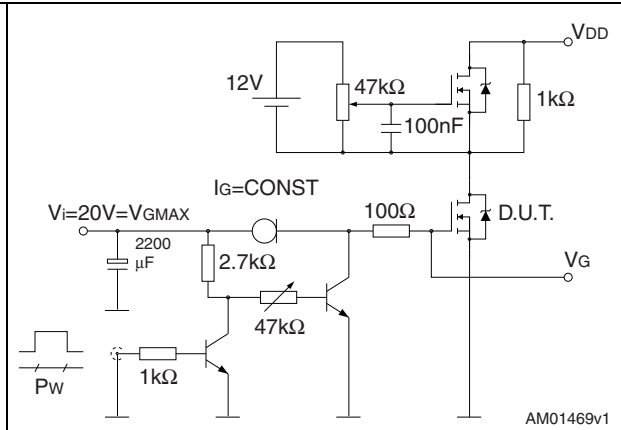
### 3 Test circuits

**Figure 18. Switching times test circuit for resistive load**



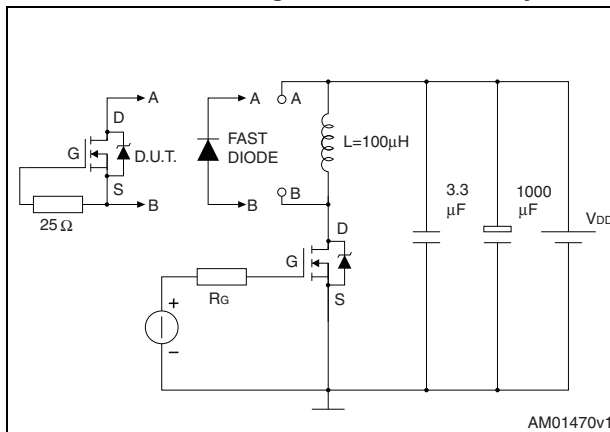
AM01468v1

**Figure 19. Gate charge test circuit**



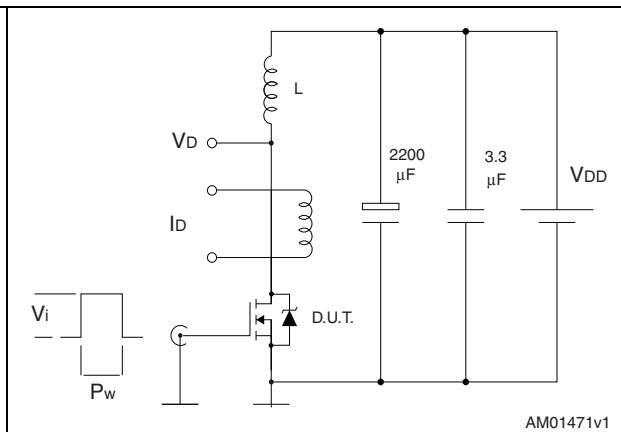
AM01469v1

**Figure 20. Test circuit for inductive load switching and diode recovery times**



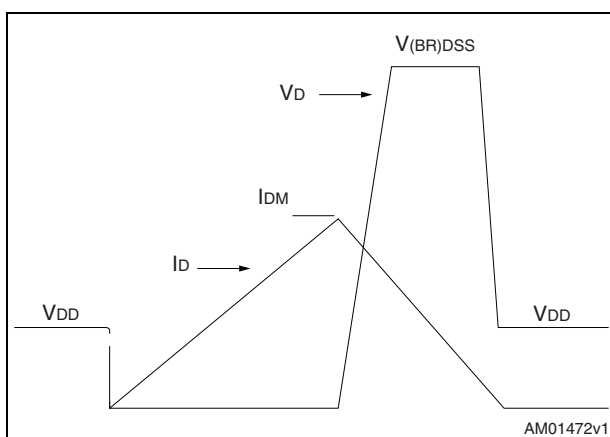
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**Figure 21. Unclamped inductive load test circuit**



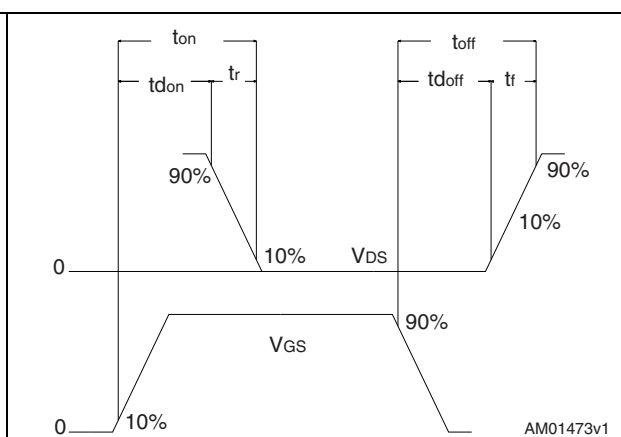
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**Figure 22. Unclamped inductive waveform**



AM01472v1

**Figure 23. Switching time waveform**



AM01473v1

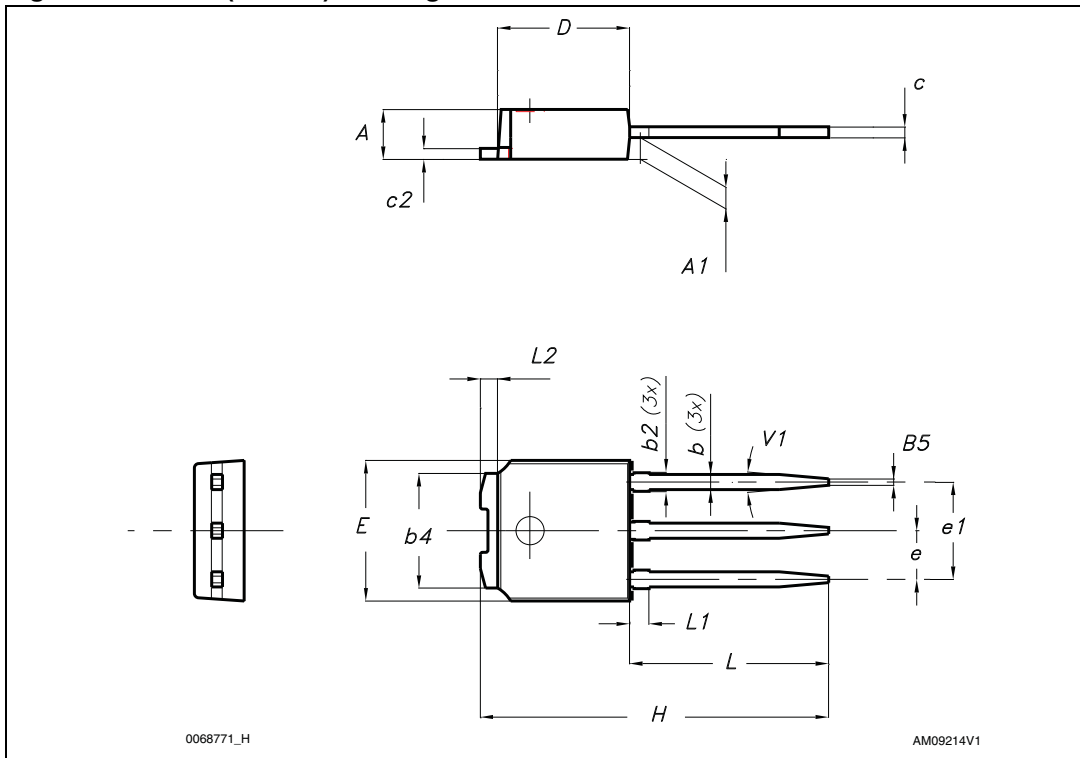
## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

Table 9. IPAK (TO-251) mechanical data

DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
B5		0.3	
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
L1	0.80		1.20
L2		0.80	1.00
V1		10 °	

Figure 24. IPAK (TO-251) drawing



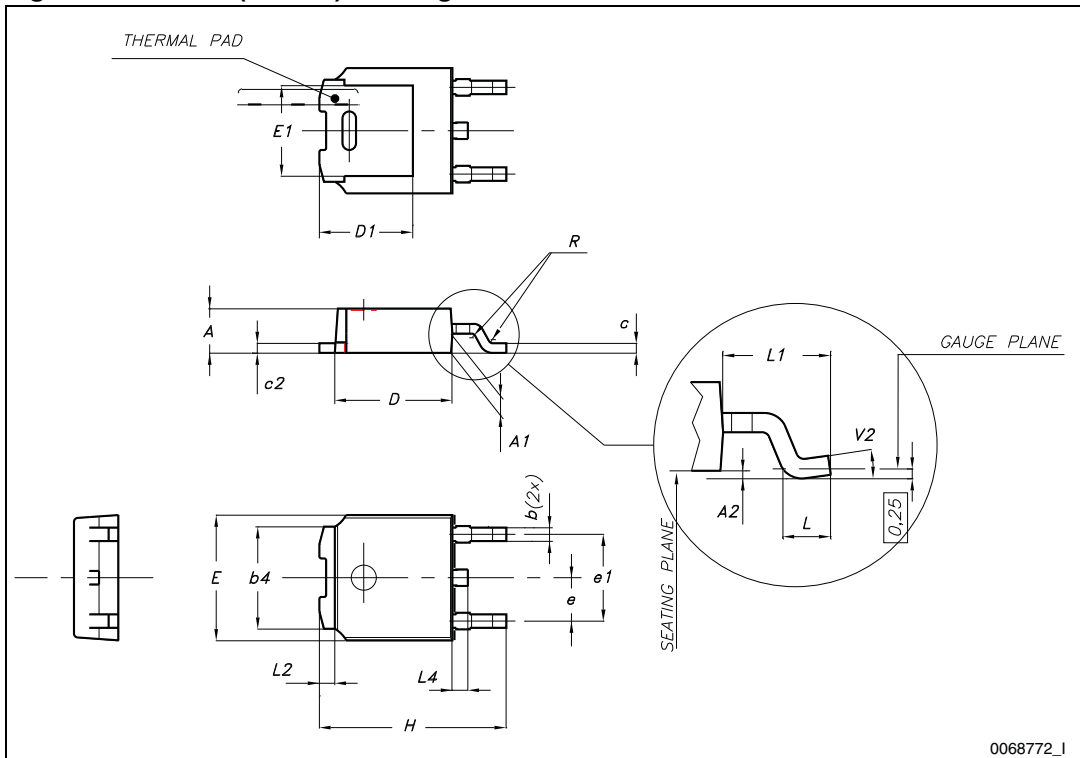
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AM09214V1

Table 10. DPAK (TO-252) mechanical data

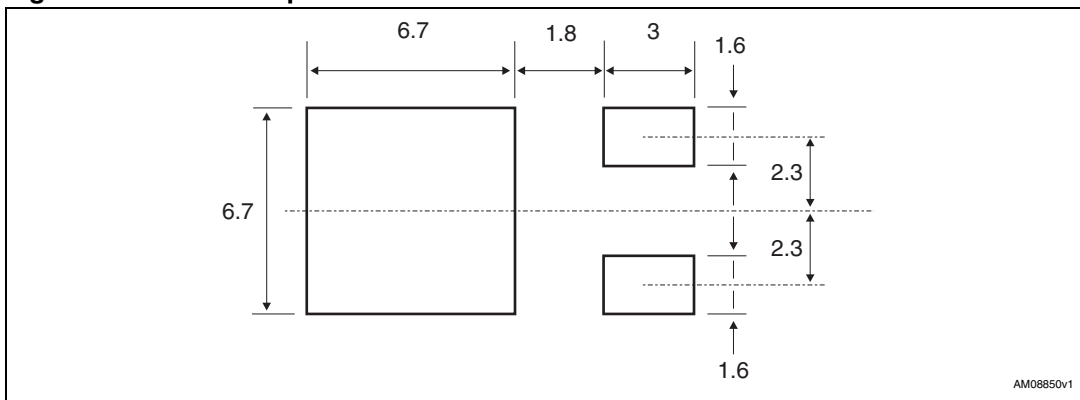
Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1		5.10	
E	6.40		6.60
E1		4.70	
e		2.28	
e1	4.40		4.60
H	9.35		10.10
L	1		1.50
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0°		8°

Figure 25. DPAK (TO-252) drawing



0068772\_I

Figure 26. DPAK footprint<sup>(a)</sup>



AM08850v1

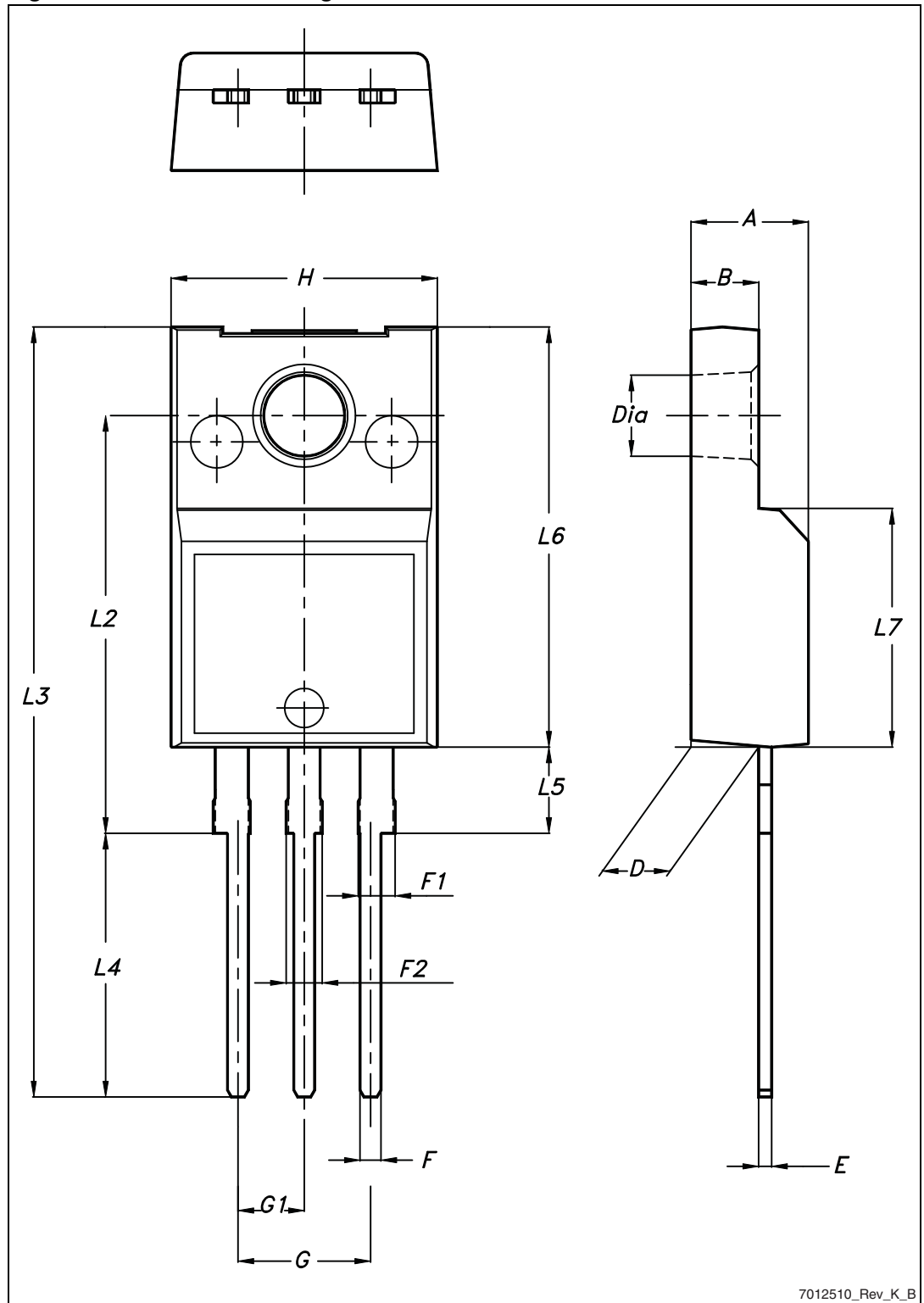
a. All dimensions are in millimeters

Table 11. 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 27. TO-220FP drawing

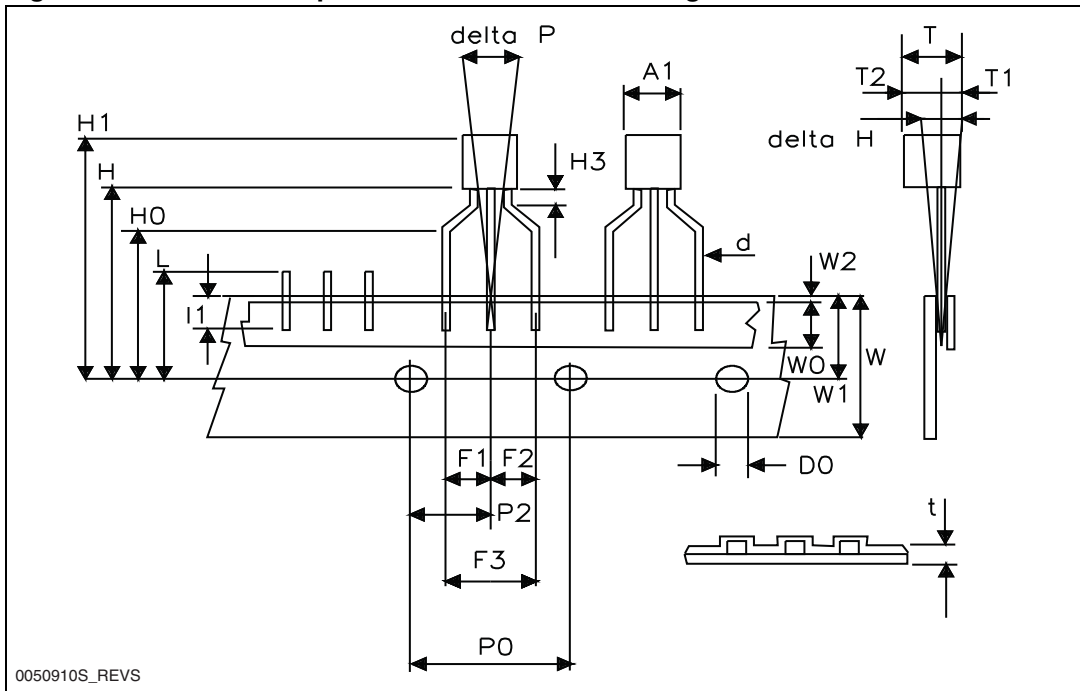


7012510\_Rev\_K\_B

Table 12. TO-92 ammopack mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A1			4.80
T			3.80
T1			1.60
T2			2.30
d			0.48
P0	12.50	12.70	12.90
P2	5.65	6.35	7.05
F1, F2	2.44	2.54	2.94
F3	4.98	5.08	5.48
delta H	-2.00		2.00
W	17.50	18.00	19.00
W0	5.70	6.00	6.30
W1	8.50	9.00	9.25
W2			0.50
H	18.50		20.50
H3	0.5	1	1.5
H0	15.50	16.00	16.50
H1			25.00
D0	3.80	4.00	4.20
t			0.90
L			11.00
l1	3.00		
delta P	-1.00		1.00

Figure 28. TO-92 ammopack mechanical data drawing



## 5 Packaging mechanical data

Table 13. DPAK (TO-252) tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	6.8	7	A		330
B0	10.4	10.6	B	1.5	
B1		12.1	C	12.8	13.2
D	1.5	1.6	D	20.2	
D1	1.5		G	16.4	18.4
E	1.65	1.85	N	50	
F	7.4	7.6	T		22.4
K0	2.55	2.75			
P0	3.9	4.1	Base qty.		2500
P1	7.9	8.1	Bulk qty.		2500
P2	1.9	2.1			
R	40				
T	0.25	0.35			
W	15.7	16.3			

Figure 29. Tape for DPAK (TO-252)

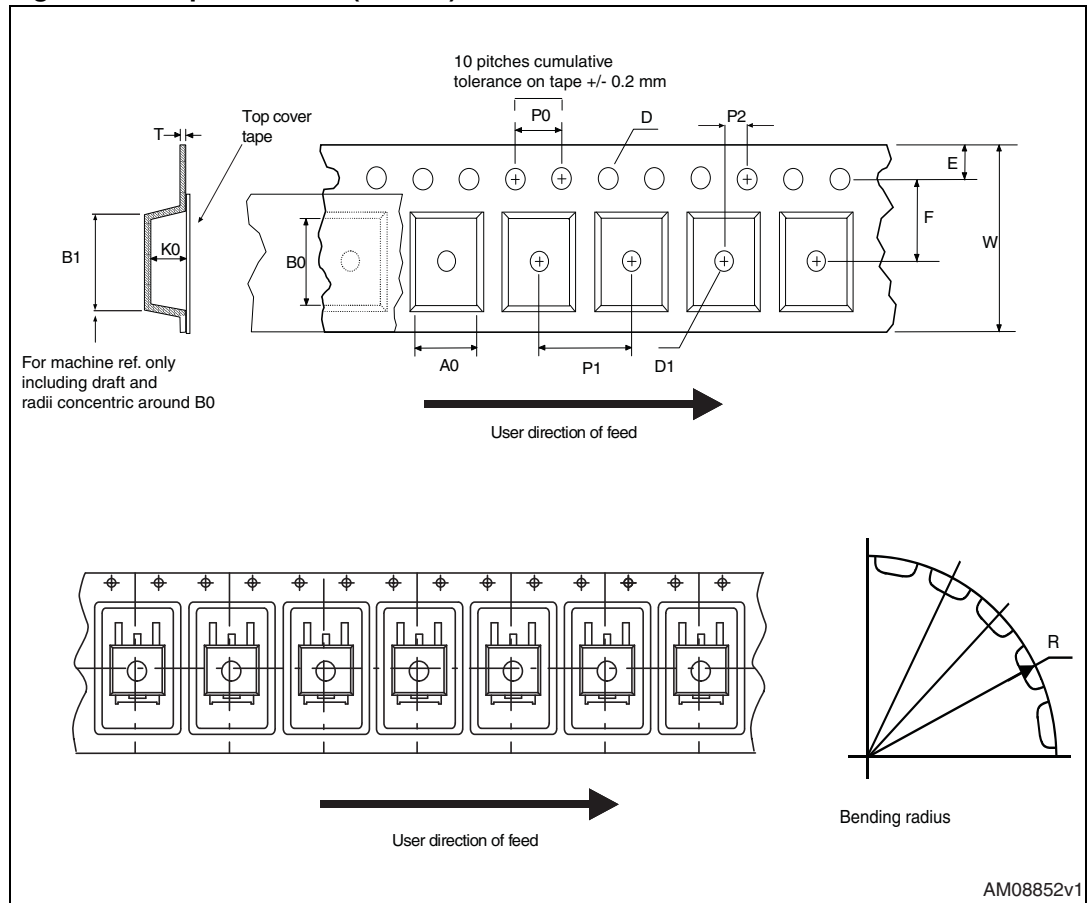
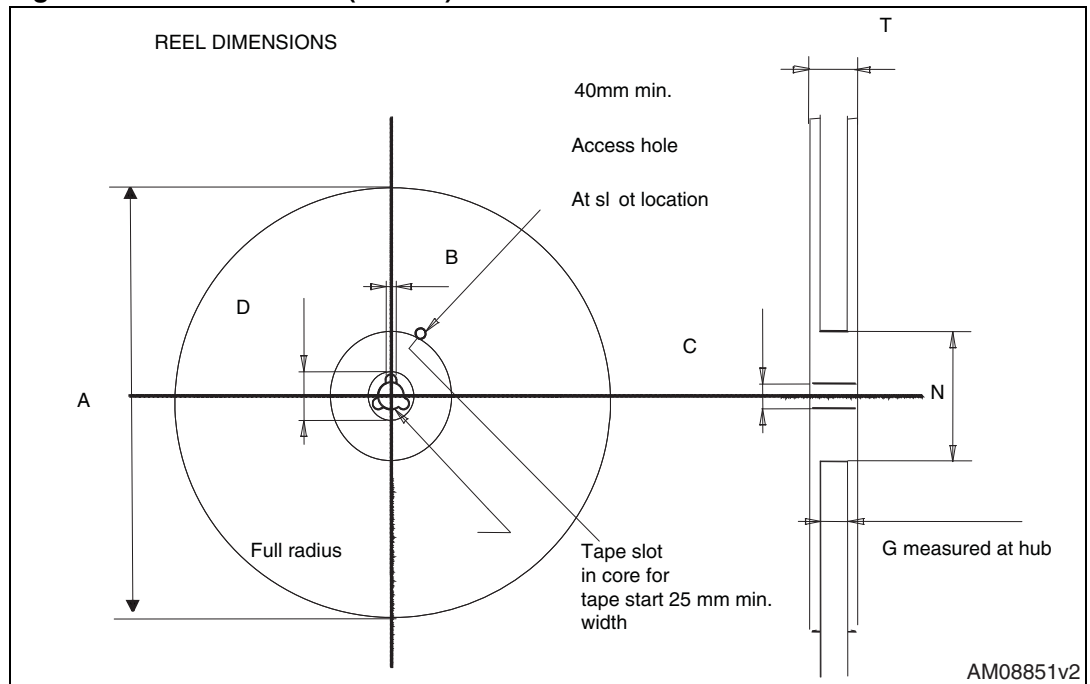


Figure 30. Reel for DPAK (TO-252)



## 6 Revision history

Table 14. Document revision history

Date	Revision	Changes
09-Mar-2004	1	First release
23-Mar-2004	2	Modified title
02-Apr-2005	3	Added new section: <i>Electrical characteristics (curves)</i>
06-Mar-2006	4	Inserted DPAK. The document has been reformatted
25-May-2012	5	Corrected unit in <i>Table 5: On/off states</i>

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