



# STD6N95K5, STF6N95K5, STP6N95K5, STW6N95K5, STU6N95K5

N-channel 950 V, 1  $\Omega$  typ., 9 A Zener-protected SuperMESH™ 5 Power MOSFET in DPAK, TO-220FP, TO-220, TO-247 and IPAK

Datasheet — production data

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>	P <sub>W</sub>
STD6N95K5	950 V	< 1.25 $\Omega$	9 A	90 W
STF6N95K5			9 A	25 W
STP6N95K5			9 A	90 W
STW6N95K5			9 A	90 W
STU6N95K5			9 A	90 W

- DPAK 950 V worldwide best R<sub>DS(on)</sub>
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using SuperMESH™ 5 technology. This revolutionary, avalanche-rugged, high voltage Power MOSFET technology is based on an innovative proprietary vertical structure. The result is a drastic reduction in on-resistance and ultra low gate charge for applications which require superior power density and high efficiency.

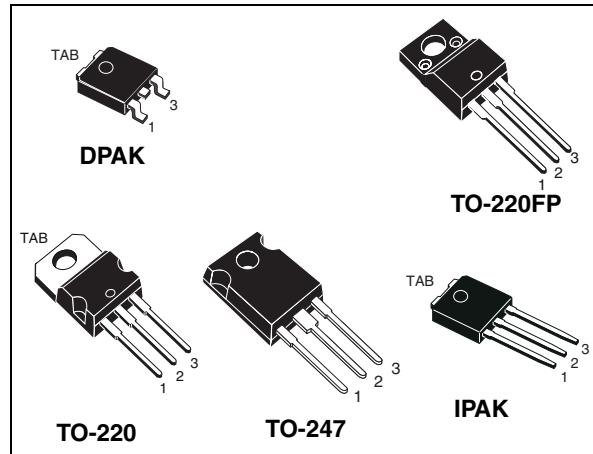


Figure 1. Internal schematic diagram



Table 1. Device summary

Order codes	Marking	Package	Packaging
STD6N95K5	6N95K5	DPAK	Tape and reel
STF6N95K5		TO-220FP	Tube
STP6N95K5		TO-220	
STW6N95K5		TO-247	
STU6N95K5		IPAK	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220, DPAK TO-247, IPAK	TO-220FP	
V <sub>GS</sub>	Gate- source voltage	± 30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	9	9 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	6	6 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	36	36 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	90	25	W
I <sub>AR</sub> <sup>(3)</sup>	Max current during repetitive or single pulse avalanche	3		A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> =I <sub>AS</sub> , V <sub>DD</sub> = 50 V)	90		mJ
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> =25 °C)		2500	V
dv/dt <sup>(4)</sup>	Peak diode recovery voltage slope	4.5		V/ns
T <sub>J</sub> T <sub>stg</sub>	Operating junction temperature Storage temperature	- 55 to 150		°C

- Limited by package.
- Pulse width limited by safe operating area.
- Pulse width limited by T<sub>Jmax</sub>.
- I<sub>SD</sub> ≤ 9 A, di/dt ≤ 100 A/μs, V<sub>Peak</sub> ≤ V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		TO-220 IPAK	DPAK	TO-247	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.39		5	°C/W	
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5		50	62.5	°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max		50			°C/W

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

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	950			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 950\text{ V}$ $V_{DS} = 950\text{ V}$ , $T_c = 125\text{ °C}$			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	$V_{DS} = V_{GS}$ , $I_D = 100\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 3\text{ A}$		1	1.25	$\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$C_{iss}$	Input capacitance			450		pF	
$C_{oss}$	Output capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	30	-	pF	
$C_{rss}$	Reverse transfer capacitance			1.6			pF
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{GS} = 0$ , $V_{DS} = 0\text{ to }760\text{ V}$	-	45	-	pF	
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related			19			pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	7	-	$\Omega$	
$Q_g$	Total gate charge	$V_{DD} = 760\text{ V}$ , $I_D = 6\text{ A}$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 20</a> )	-	13	-	nC	
$Q_{gs}$	Gate-source charge			3			nC
$Q_{gd}$	Gate-drain charge			7			nC

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

**Table 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 475\text{ V}$ , $I_D = 3\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 22</a> )		12		ns
$t_r$	Rise time		-	12	-	ns
$t_{d(off)}$	Turn-off delay time				33	ns
$t_f$	Fall time				21	ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		9	A
$I_{SDM}$	Source-drain current (pulsed)				36	A
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD} = 6\text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 6\text{ A}$ , $V_{DD} = 60\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$ , (see <a href="#">Figure 21</a> )	-	372		ns
$Q_{rr}$	Reverse recovery charge				4	$\mu\text{C}$
$I_{RRM}$	Reverse recovery current				22	A
$t_{rr}$	Reverse recovery time	$I_{SD} = 6\text{ A}$ , $V_{DD} = 60\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 21</a> )	-	522		ns
$Q_{rr}$	Reverse recovery charge				5	$\mu\text{C}$
$I_{RRM}$	Reverse recovery current				20	A

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

**Table 8. Gate-source Zener diode**

Symbol	Parameter	Test conditions	Min	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{gs} \pm 1\text{ mA}$ , $I_D = 0$	30	-		V

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220FP

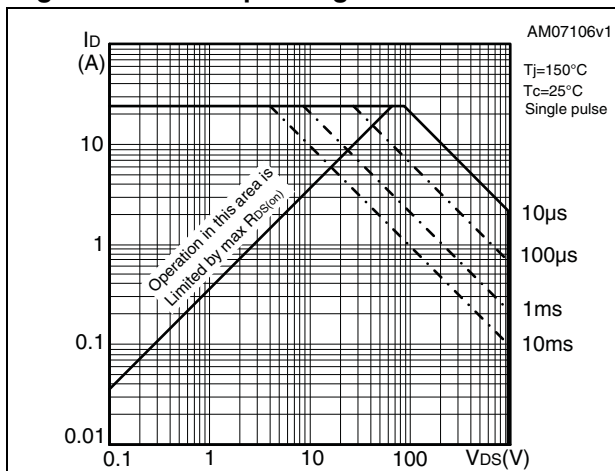


Figure 3. Thermal impedance for TO-220FP

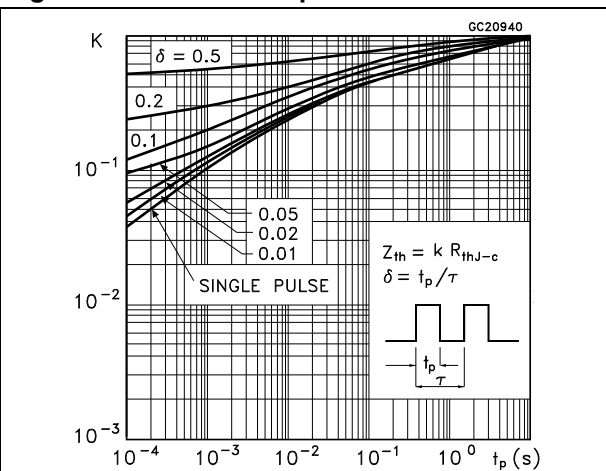


Figure 4. Safe operating area for TO-220 and TO-247

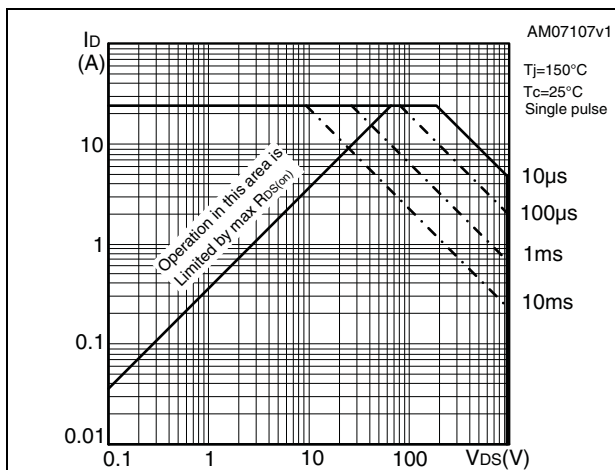


Figure 5. Thermal impedance for TO-220 and TO-247

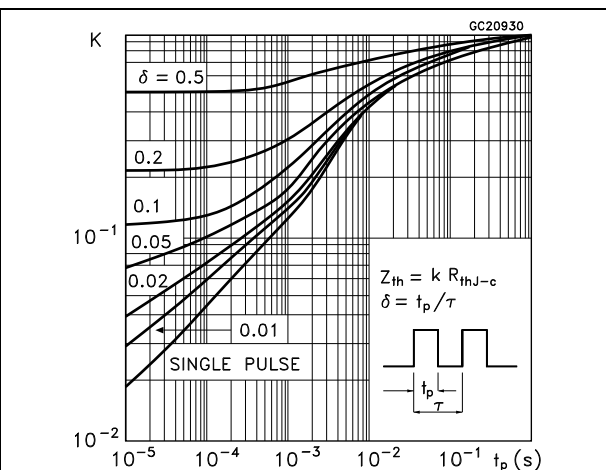


Figure 6. Safe operating area for DPAK and IPAQ

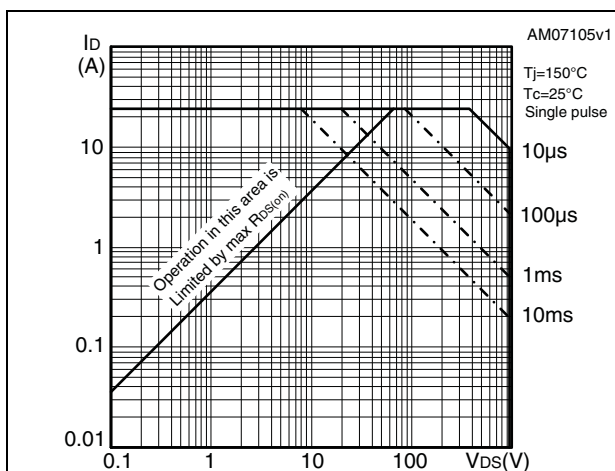


Figure 7. Thermal impedance for DPAK and IPAQ

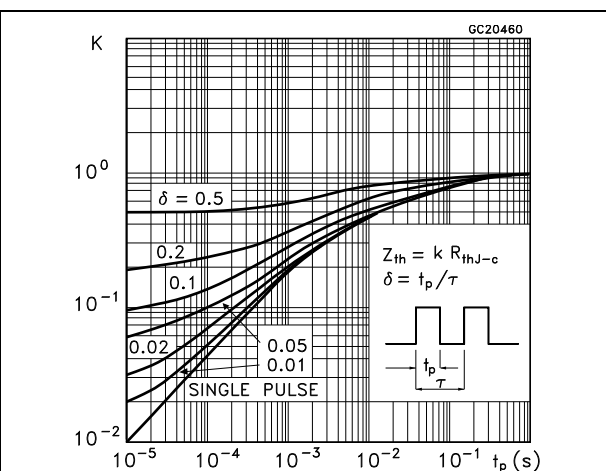


Figure 8. Output characteristics

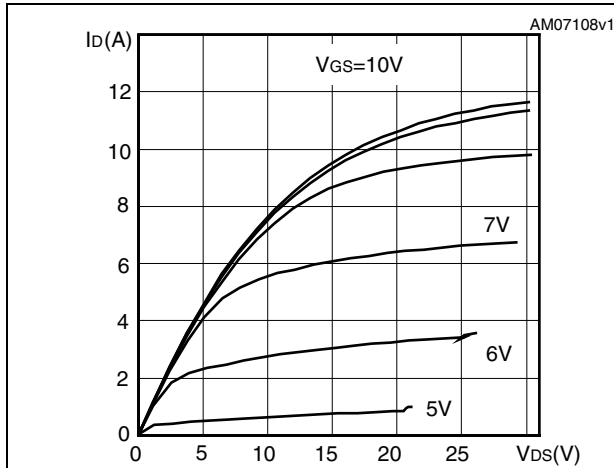


Figure 9. Transfer characteristics

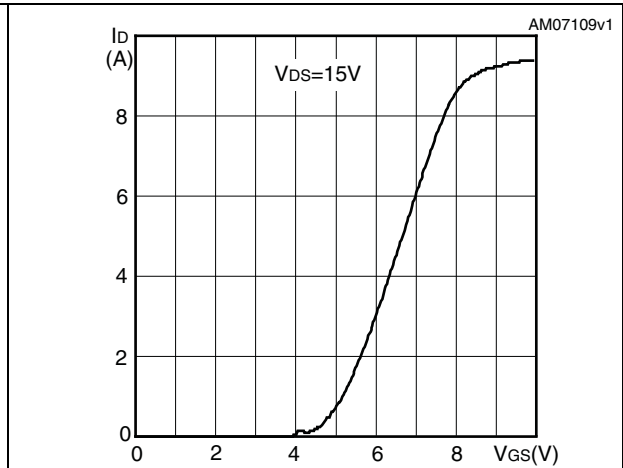


Figure 10. Gate charge vs gate-source voltage

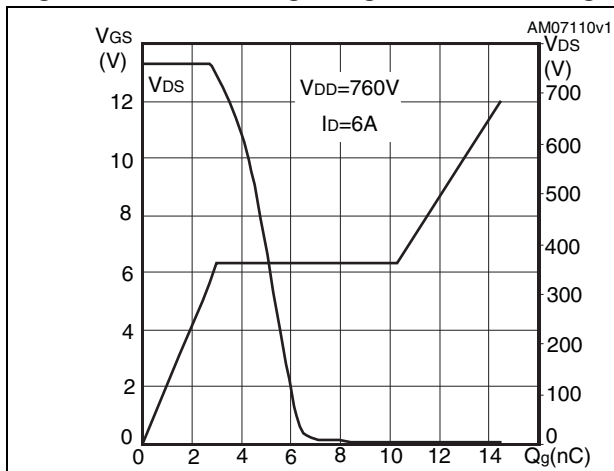


Figure 11. Static drain-source on-resistance

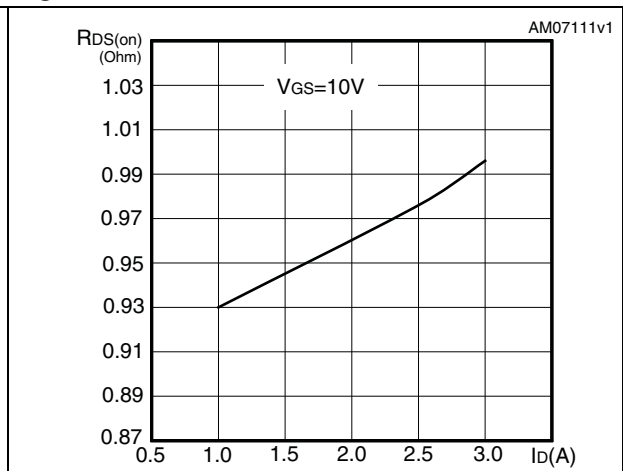


Figure 12. Capacitance variations

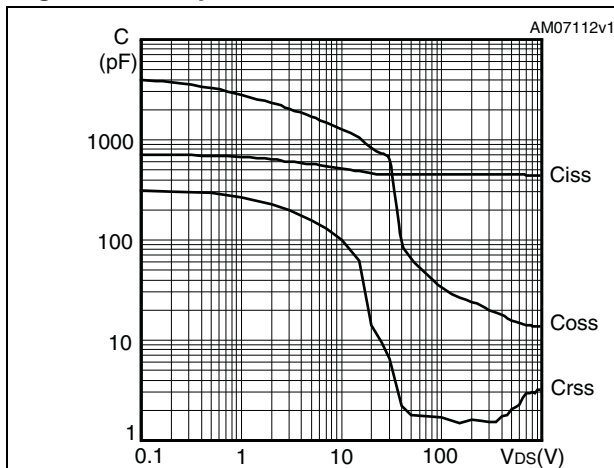


Figure 13. Output capacitance stored energy

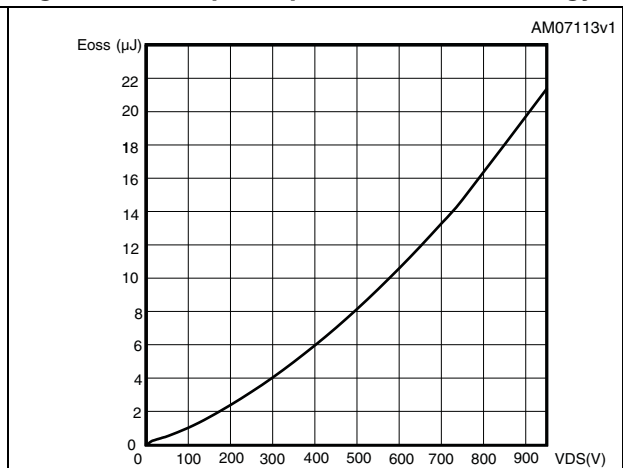


Figure 14. Normalized gate threshold voltage vs temperature

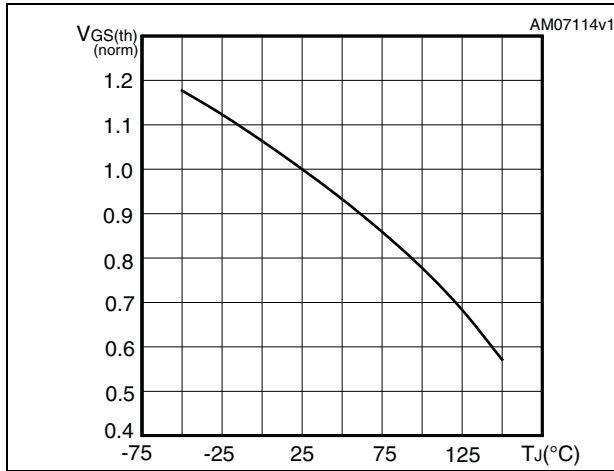


Figure 15. Normalized on-resistance vs temperature

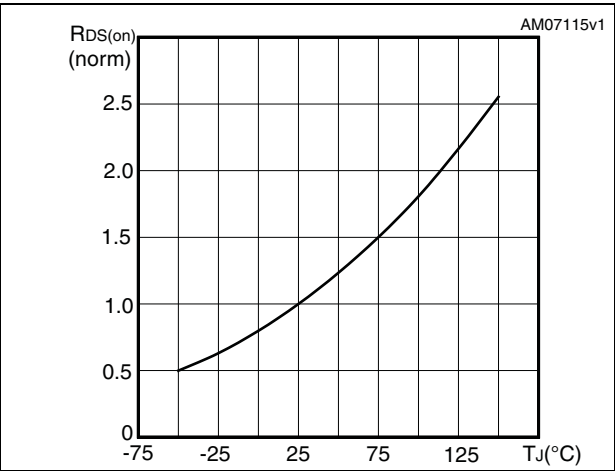


Figure 16. Source-drain diode forward characteristics

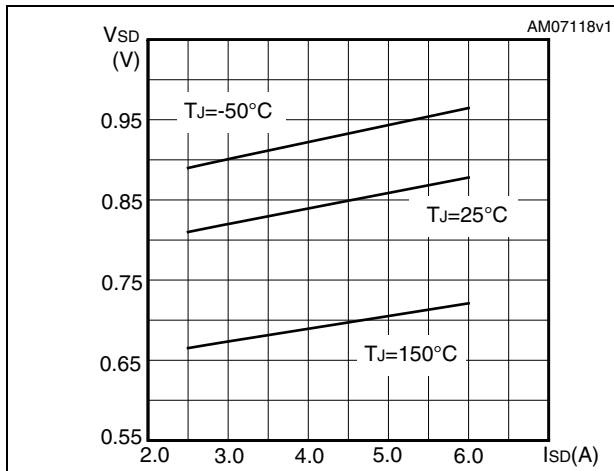


Figure 17. Normalized BV<sub>DSS</sub> vs temperature

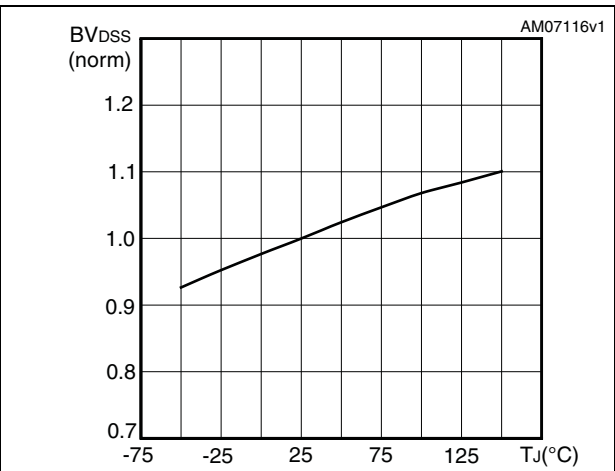
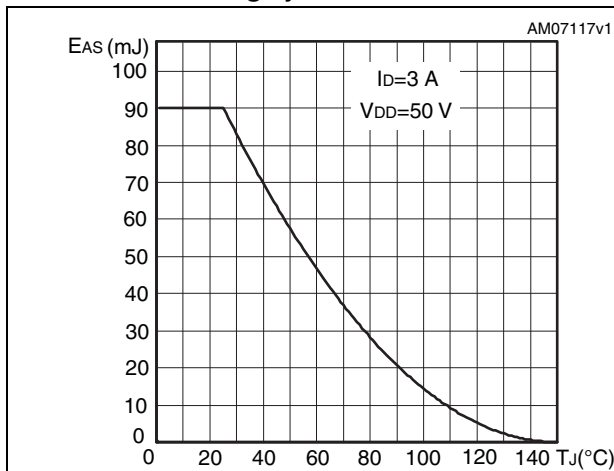


Figure 18. Maximum avalanche energy vs starting Tj



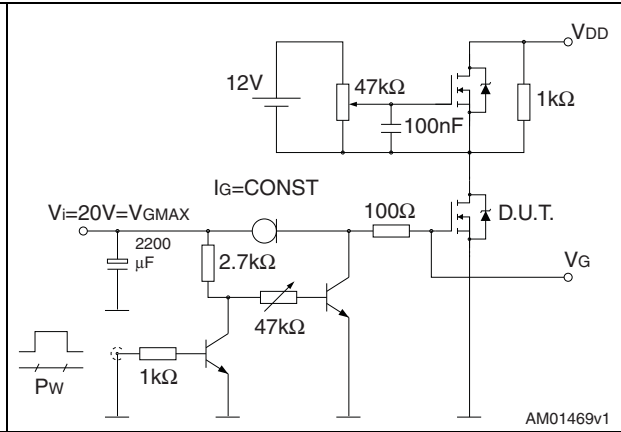


### 3 Test circuits

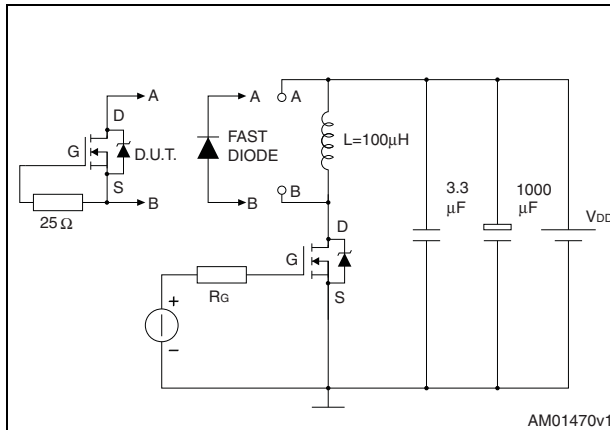
**Figure 19. Switching times test circuit for resistive load**



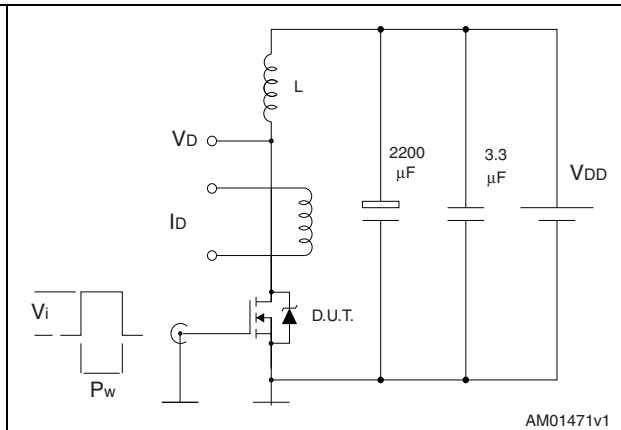
**Figure 20. Gate charge test circuit**



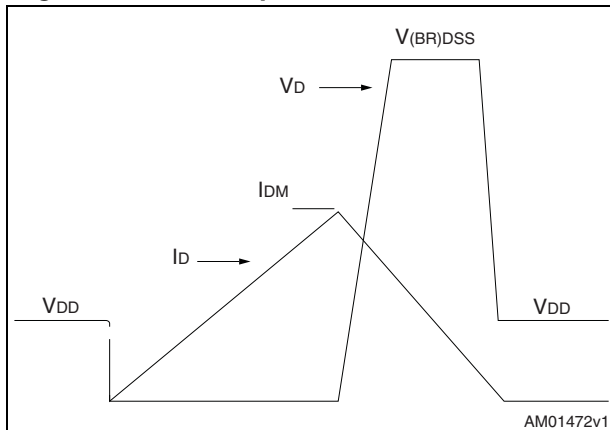
**Figure 21. Test circuit for inductive load switching and diode recovery times**



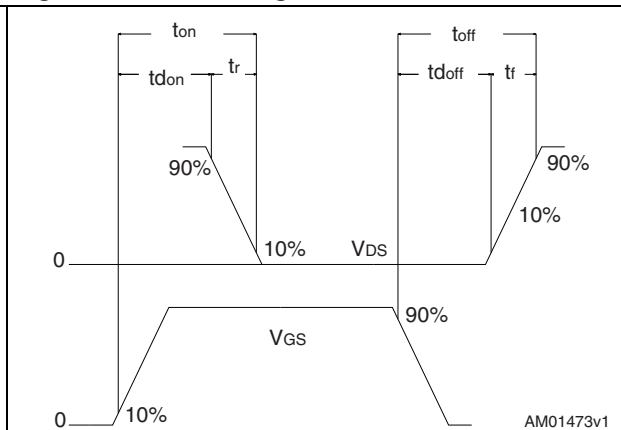
**Figure 22. Unclamped inductive load test circuit**



**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<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<sup>®</sup> is an ST trademark.

**Table 9. 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		
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0°		8°

Figure 25. DPAK (TO-252) drawing

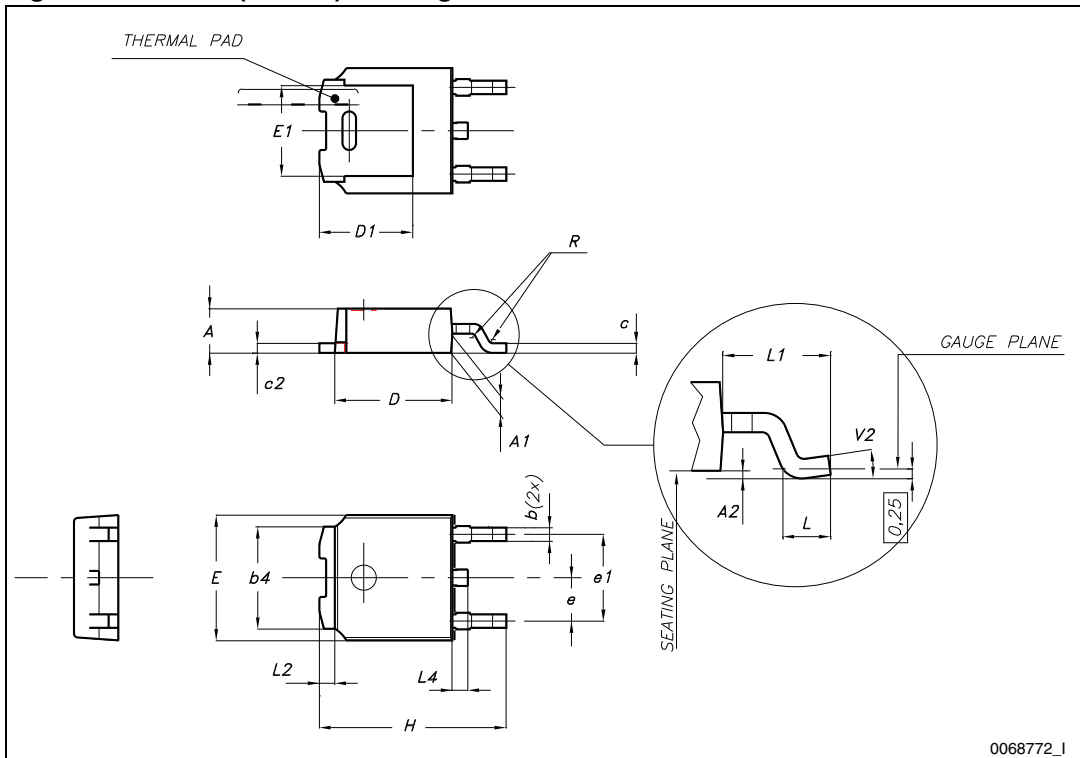
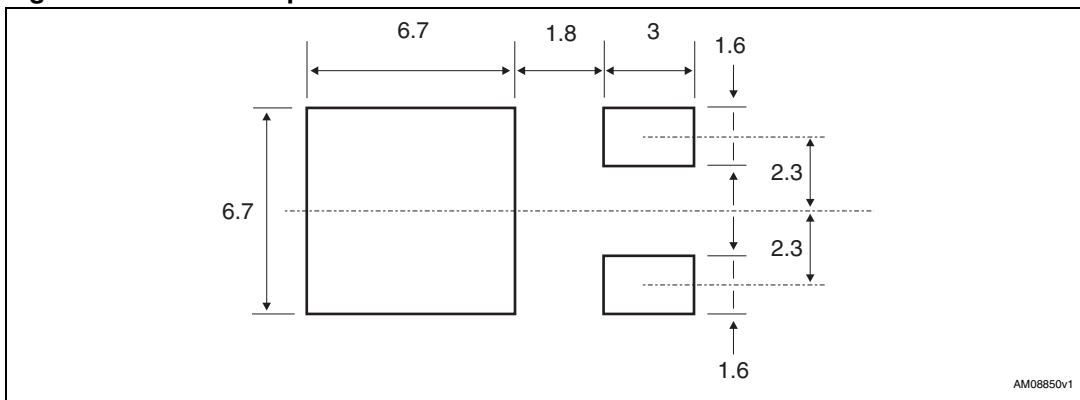


Figure 26. DPAK footprint<sup>(a)</sup>



a. All dimensions are in millimeters

Table 10. 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

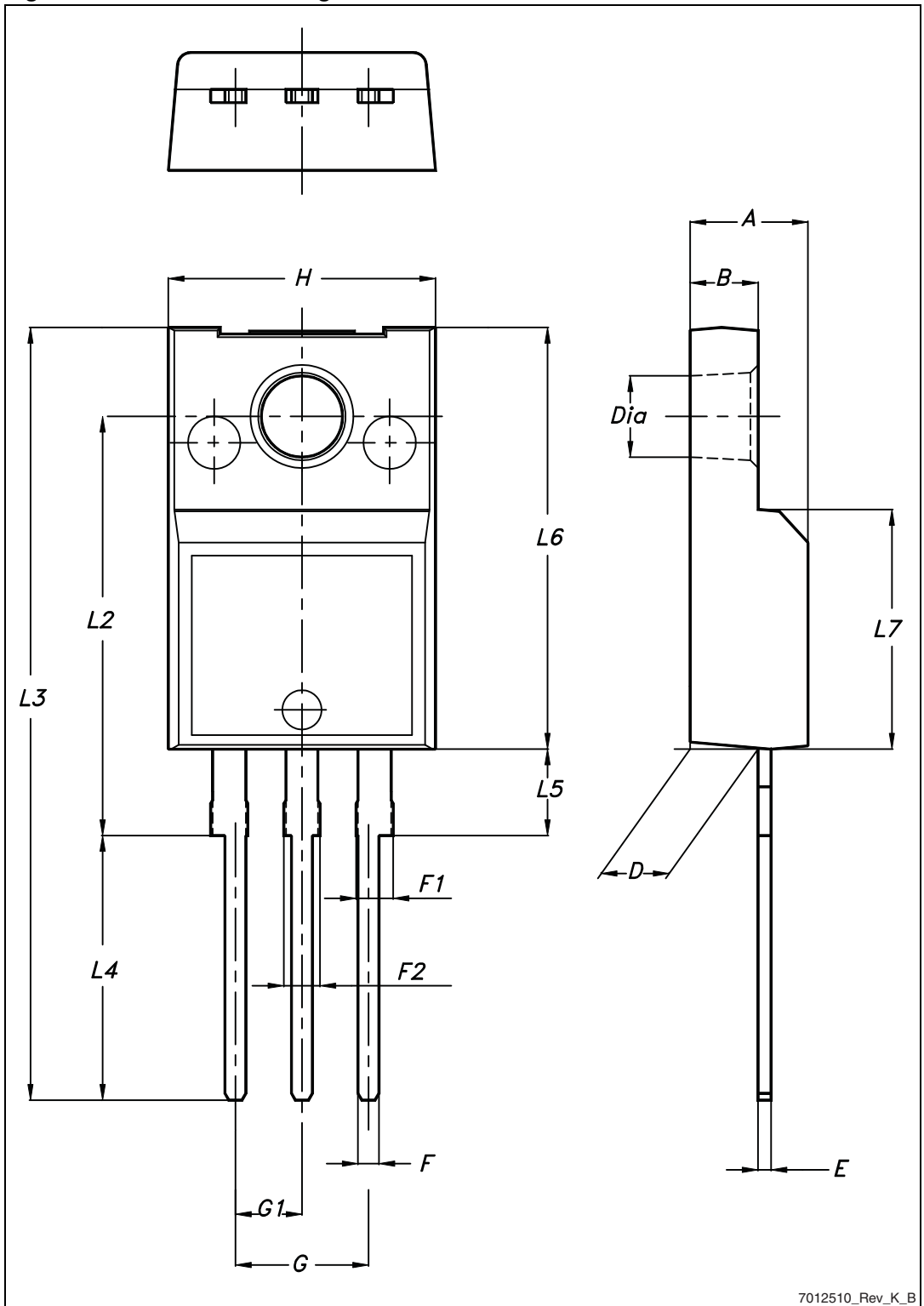
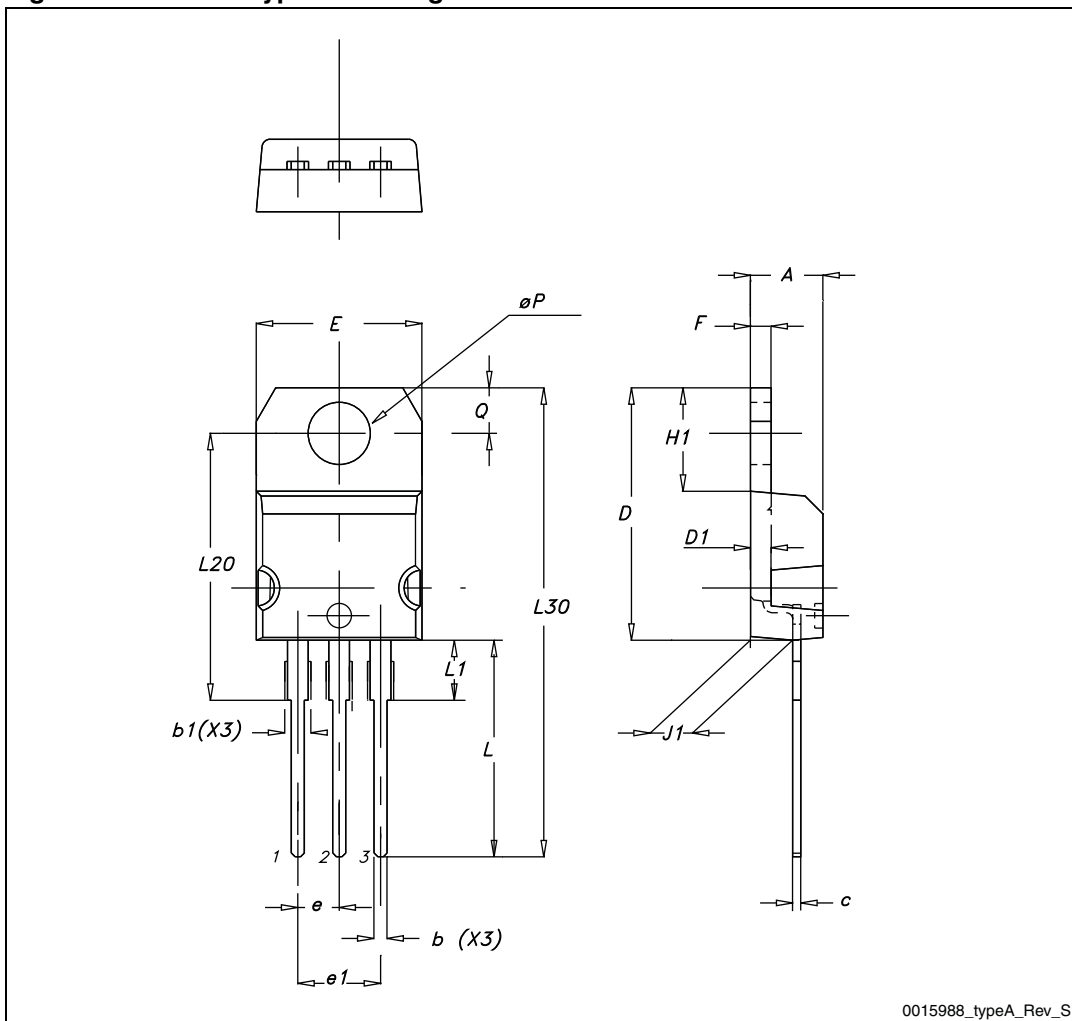


Table 11. TO-220 type A mechanical data

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 28. TO-220 type A drawing



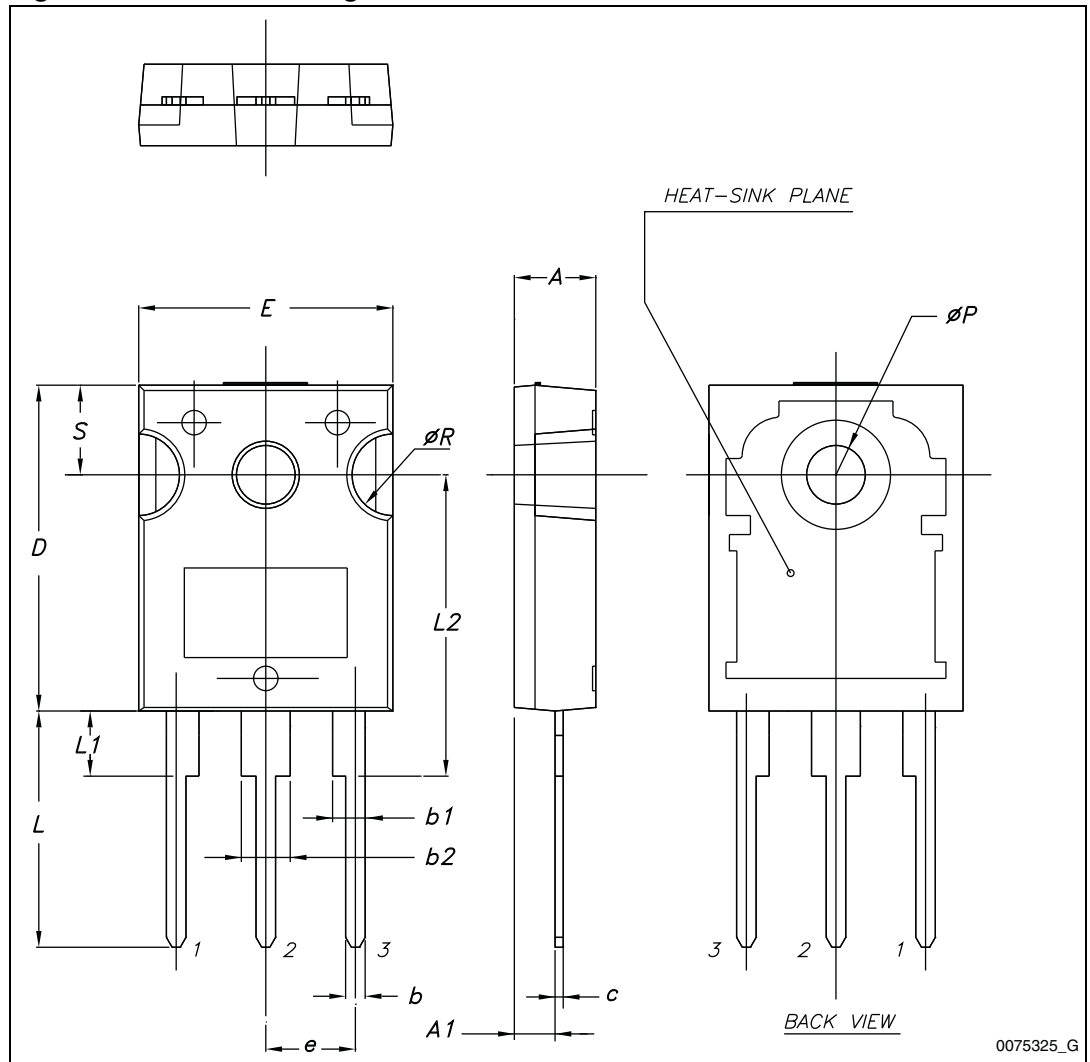
0015988\_typeA\_Rev\_S

Table 12. TO-247 mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e	5.30	5.45	5.60
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S	5.30	5.50	5.70



Figure 29. TO-247 drawing

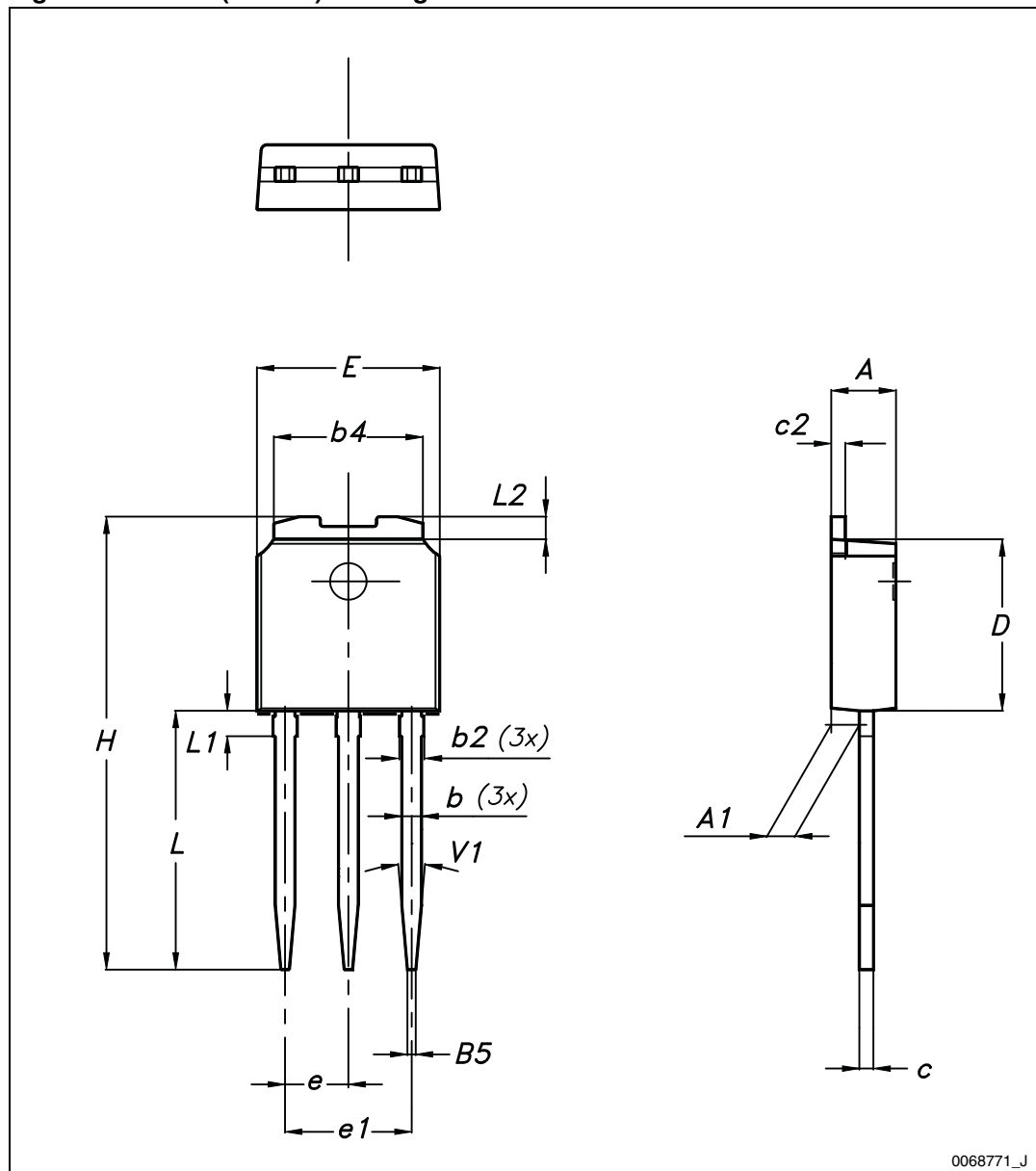


0075325\_G

Table 13. 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		0.30	
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 30. IPAK (TO-251) drawing



0068771\_J

## 5 Packaging mechanical data

Table 14. 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 31. Tape for DPAK (TO-252)

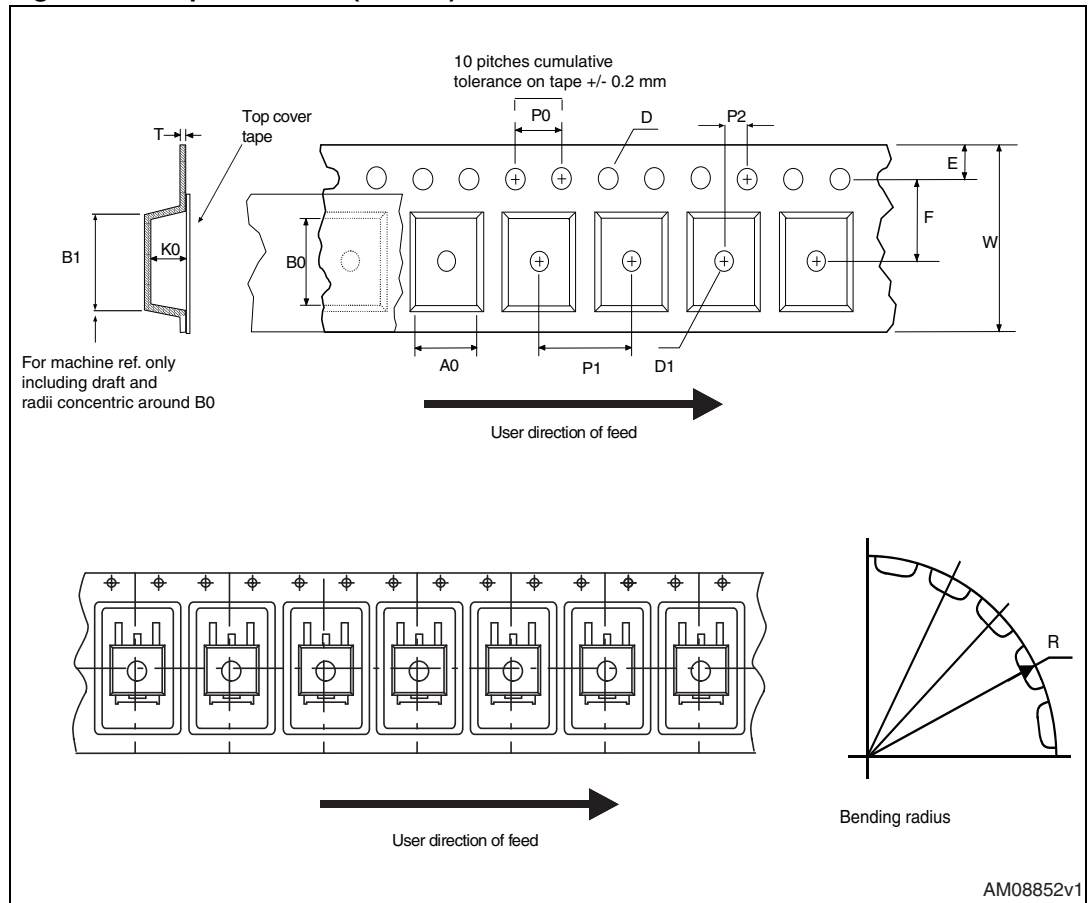
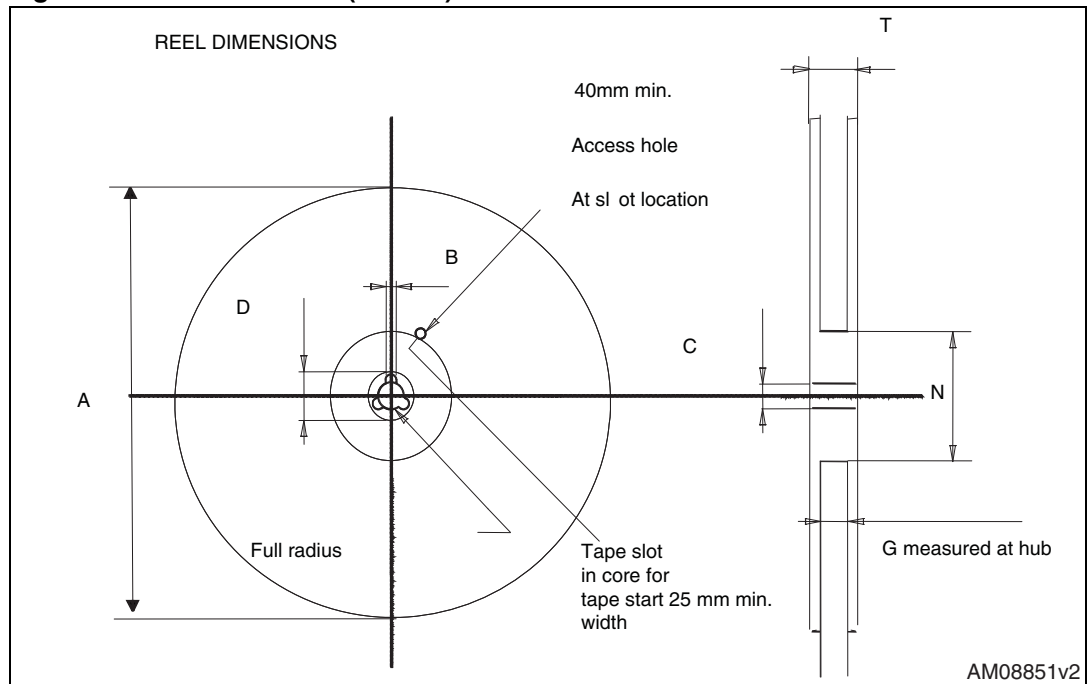


Figure 32. Reel for DPAK (TO-252)



## 6 Revision history

**Table 15. Document revision history**

Date	Revision	Changes
12-Jan-2010	1	First release.
01-Jul-2010	2	Document status promoted from preliminary data to datasheet.
31-Aug-2012	3	Inserted new device in IPAK. Updated <a href="#">Table 1: Device summary</a> , <a href="#">Table 2: Absolute maximum ratings</a> , and <a href="#">Table 3: Thermal data</a> . Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packaging mechanical data</a> . Minor text changes in the cover page.

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