

N-channel 800 V, 2.1  $\Omega$  typ., 3 A Zener-protected SuperMESH™ 5 Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK packages

Datasheet - production data

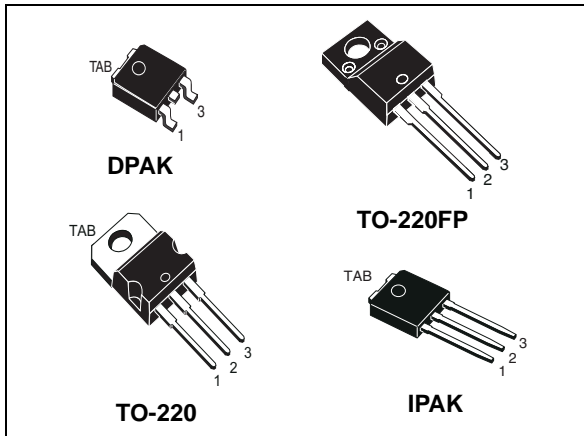
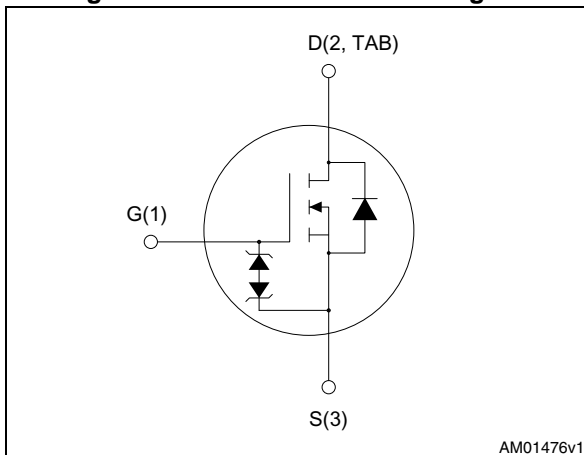


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DS}$	$R_{DS(on) max}$	$I_D$	$P_{TOT}$
STD4N80K5	800 V	2.5 $\Omega$	3 A	60 W
STF4N80K5				20 W
STP4N80K5				60 W
STU4N80K5				

- Outstanding  $R_{DS(on)}$  \* area
- Worldwide best FOM (figure of merit)
- Ultra low gate charge
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These N-channel Zener-protected Power MOSFETs are designed using ST's revolutionary avalanche-rugged very high voltage SuperMESH™ 5 technology, based on an innovative proprietary vertical structure. The result is a dramatic reduction in on-resistance, and ultra-low gate charge for applications which require superior power density and high efficiency.

Table 1. Device summary

Order code	Marking	Packages	Packaging
STD4N80K5	4N80K5	DPAK	Tape and reel
STF4N80K5		TO-220FP	Tube
STP4N80K5		TO-220	
STU4N80K5		IPAK	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		DPAK, IPAK	TO-220FP	TO-220	
$V_{DS}$	Drain-source voltage	800			
$V_{GS}$	Gate- source voltage	±30			V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	3 <sup>(1)</sup>			A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	1.7 <sup>(1)</sup>			A
$I_{DM}$ <sup>(2)</sup>	Drain current (pulsed)	12 <sup>(1)</sup>			A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	60	20	60	W
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ max)	1			A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	74.5			mJ
$dv/dt$ <sup>(3)</sup>	Peak diode recovery voltage slope	4.5			V/ns
$dv/dt$ <sup>(4)</sup>	MOSFET $dv/dt$ ruggedness	50			V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ , $T_C = 25\text{ °C}$ )		2500		V
$T_J$	Operating junction temperature	-55 to 150			°C
$T_{stg}$	Storage temperature				°C

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area
3.  $I_{SD} < 3\text{ A}$ ,  $di/dt < 100\text{ A}/\mu\text{s}$ , peak  $V_{DS(peak)} \leq V_{(BR)DSS}$
4.  $V_{DS} \leq 640\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		DPAK, IPAK	TO-220FP	TO-220	
$R_{thj-case}$	Thermal resistance junction-case max	2.08	6.25	2.08	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max		62.5		°C/W
$R_{thj-pcb}$ <sup>(1)</sup>	Thermal resistance junction-pcb max	50			°C/W

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

## 2 Electrical characteristics

(T<sub>case</sub> = 25 °C unless otherwise specified)

**Table 4. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0	800			V
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 800 V V <sub>DS</sub> = 800 V, T <sub>C</sub> = 125 °C			1 50	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 20 V			±10	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 100 μA	3	4	5	V
R <sub>DS(on)</sub>	Static drain-source on-resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 1.5 A		2.1	2.5	Ω

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>DS</sub> = 100 V, f = 1 MHz, V <sub>GS</sub> = 0	-	175	-	pF
C <sub>oss</sub>	Output capacitance		-	20	-	pF
C <sub>rss</sub>	Reverse transfer capacitance		-	1	-	pF
C <sub>o(tr)</sub> <sup>(1)</sup>	Equivalent capacitance time related	V <sub>DS</sub> = 0 to 640 V, V <sub>GS</sub> = 0	-	26	-	pF
C <sub>o(er)</sub> <sup>(2)</sup>	Equivalent capacitance energy related	V <sub>DS</sub> = 0 to 640 V, V <sub>GS</sub> = 0	-	11	-	pF
R <sub>g</sub>	Gate input resistance	f = 1 MHz, I <sub>D</sub> = 0	-	15	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 640 V, I <sub>D</sub> = 3 A, V <sub>GS</sub> = 10 V	-	10.5	-	nC
Q <sub>gs</sub>	Gate-source charge	(see Figure 19)	-	2	-	nC
Q <sub>gd</sub>	Gate-drain charge		-	7.5	-	nC

1. Time related is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>
2. Energy related is defined as a constant equivalent capacitance giving the same stored energy as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80% V<sub>DSS</sub>

**Table 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 400\text{ V}$ , $I_D = 1.5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 18)	-	16.5	-	ns
$t_r$	Rise time		-	15	-	ns
$t_{d(off)}$	Turn-off-delay time		-	36	-	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		-		3	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				12	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 3\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 3\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ $T_J = 25\text{ }^\circ\text{C}$ (see Figure 20)	-	242		ns
$Q_{rr}$	Reverse recovery charge		-	1.42		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	12		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 3\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ $T_J = 150\text{ }^\circ\text{C}$ (see Figure 20)	-	373		ns
$Q_{rr}$	Reverse recovery charge		-	1.98		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	10.5		A

1. Pulse width limited by safe operating area
2. 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 DPAK and IPAK

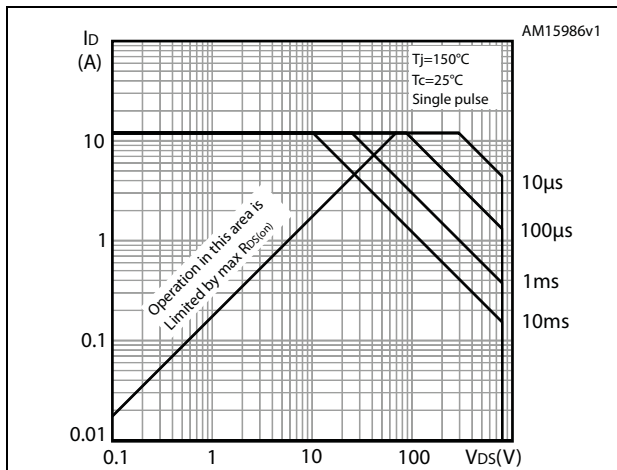


Figure 3. Thermal impedance for DPAK and IPAK

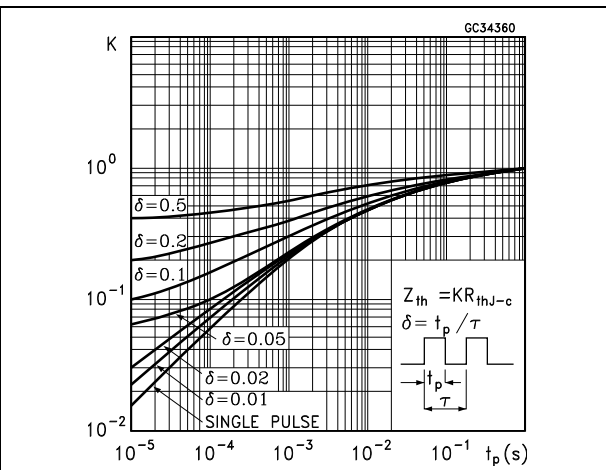


Figure 4. Safe operating area for TO-220FP

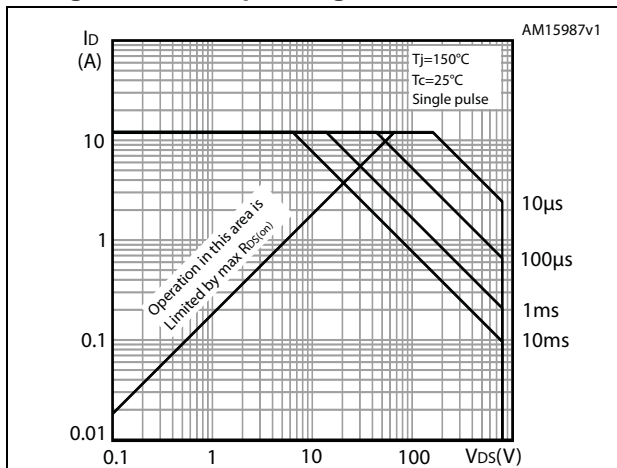


Figure 5. Thermal impedance for TO-220FP

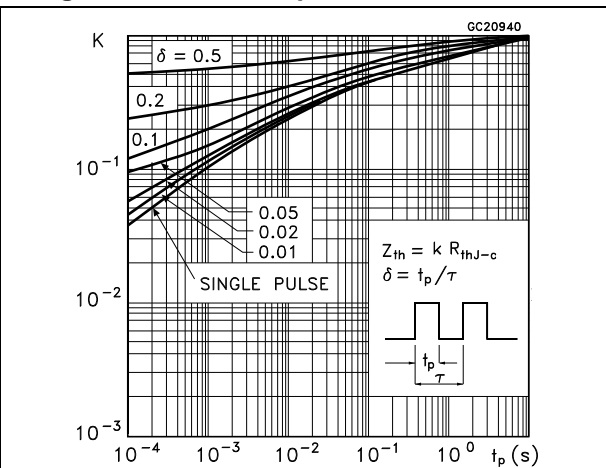


Figure 6. Safe operating area for TO-220

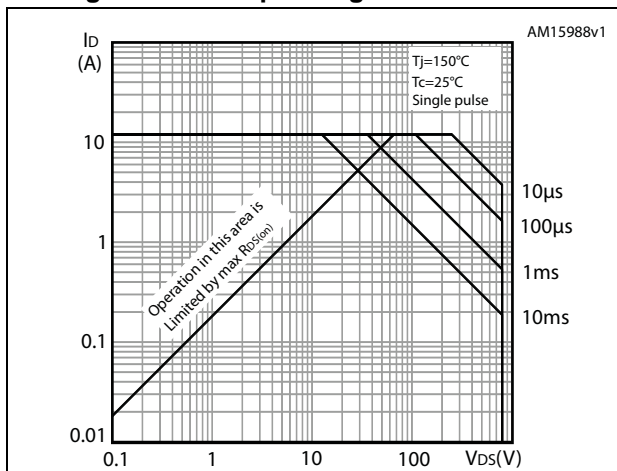


Figure 7. Thermal impedance for TO-220

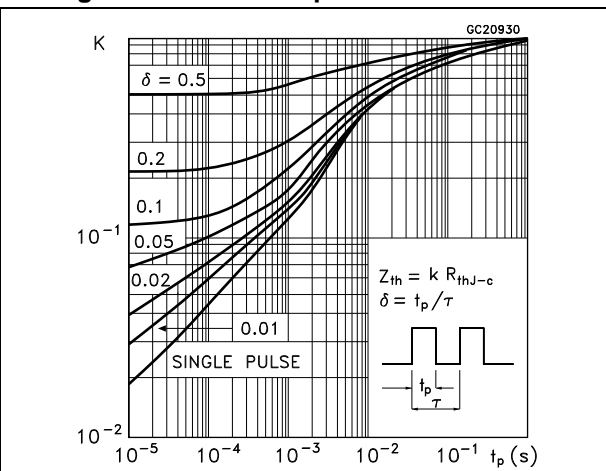


Figure 8. Output characteristics

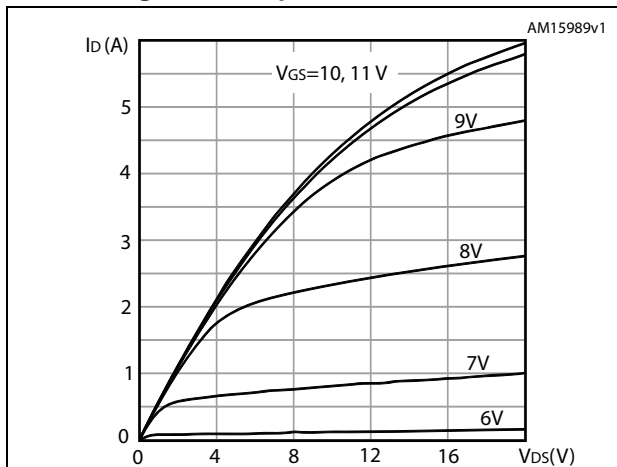


Figure 9. Transfer characteristics

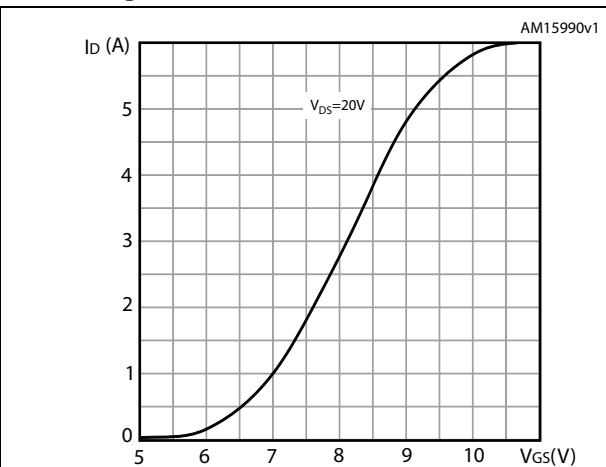


Figure 10. Gate charge vs gate-source voltage

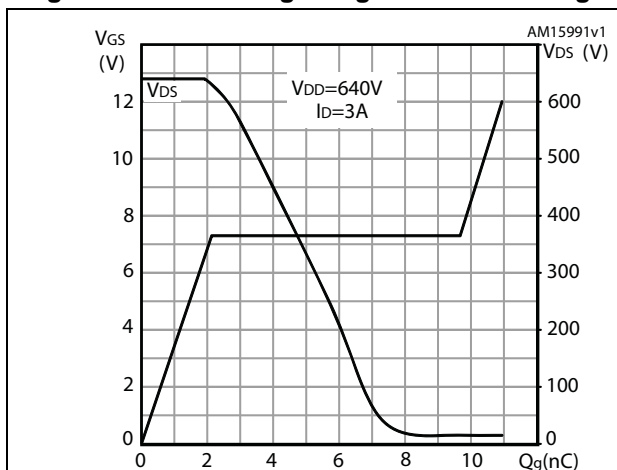


Figure 11. Static drain-source on-resistance

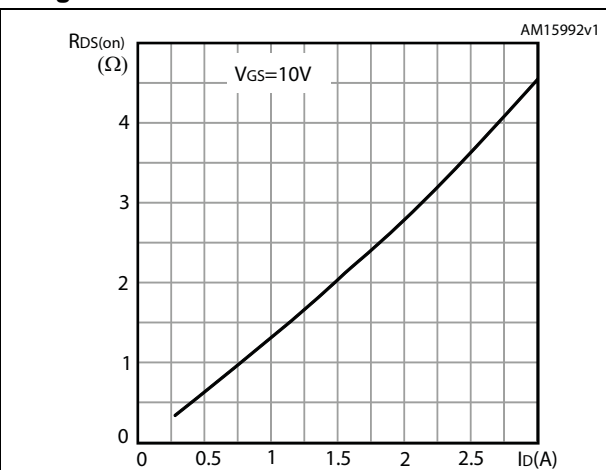


Figure 12. Capacitance variations

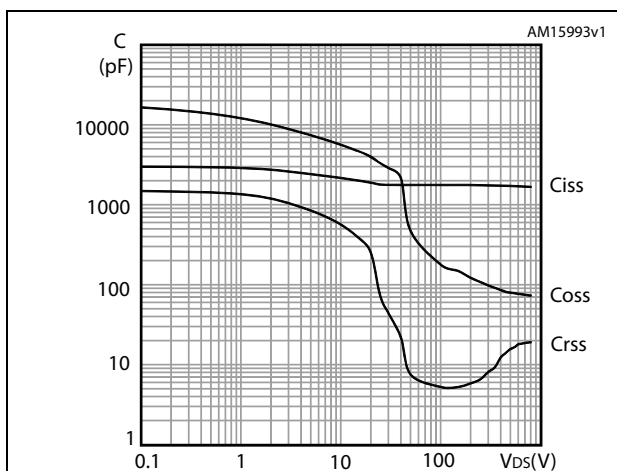


Figure 13. Normalized gate threshold voltage vs temperature

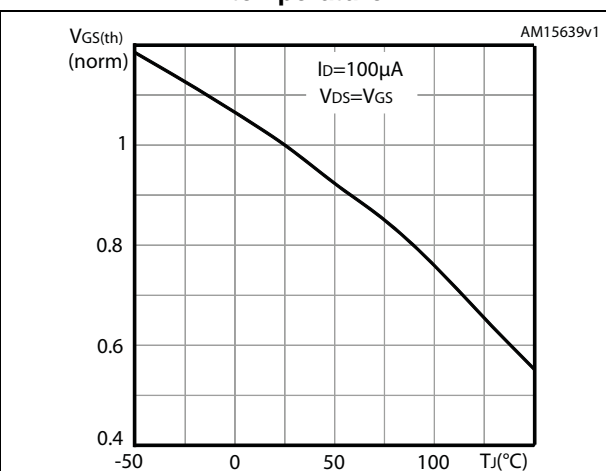


Figure 14. Normalized on-resistance vs temperature

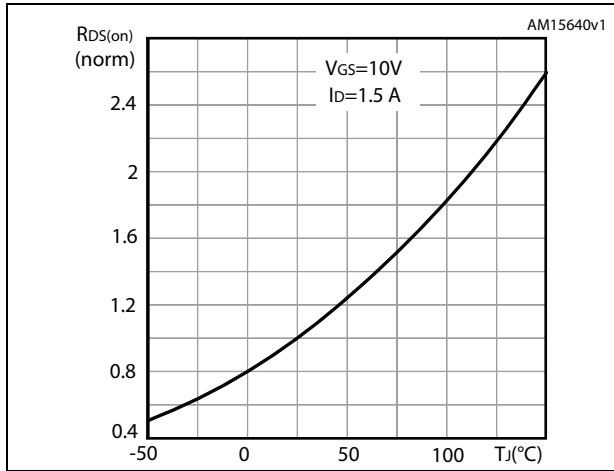


Figure 15. Source-drain diode forward characteristics

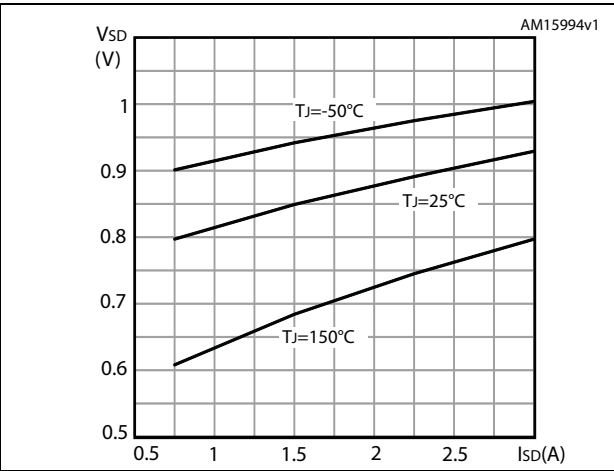


Figure 16. Normalized V<sub>DS</sub> vs temperature

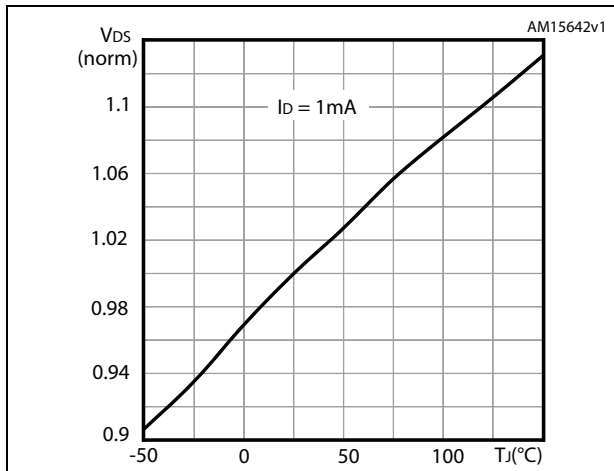
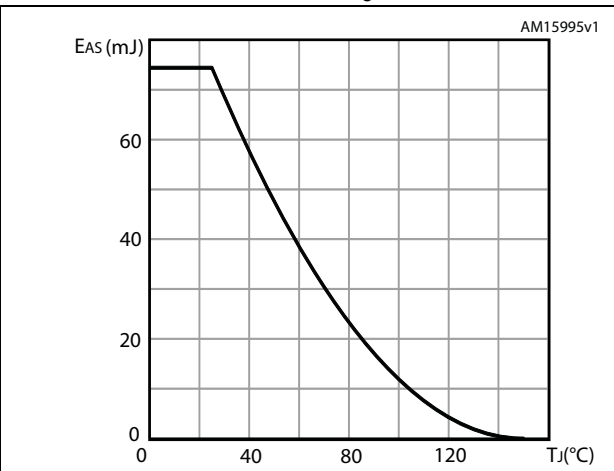


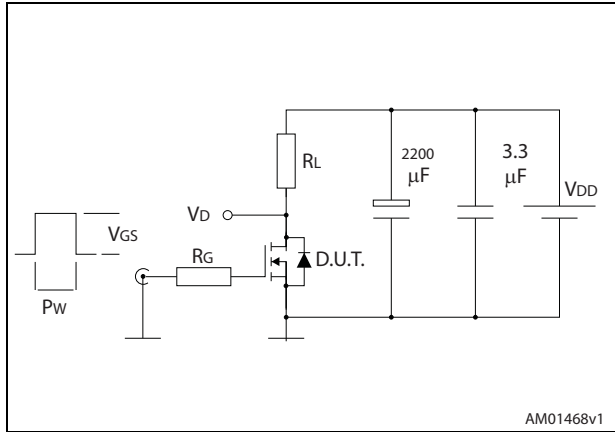
Figure 17. Maximum avalanche energy vs. starting T<sub>J</sub>





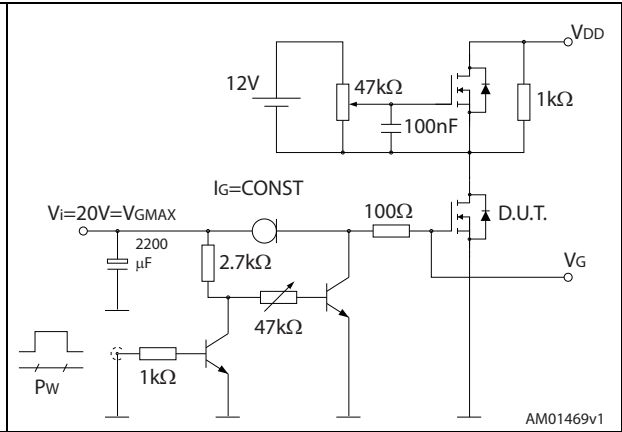
### 3 Test circuits

Figure 18. Switching times test circuit for resistive load



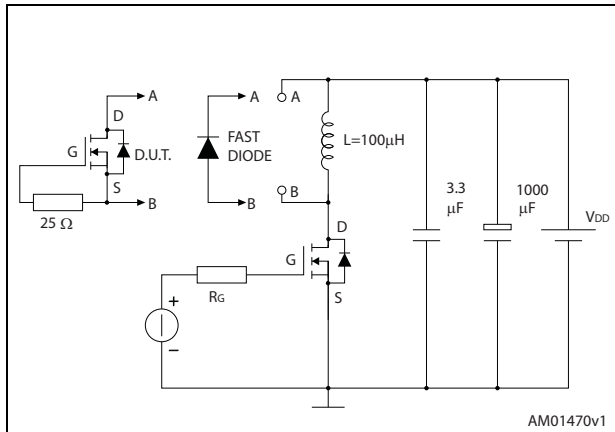
AM01468v1

Figure 19. Gate charge test circuit



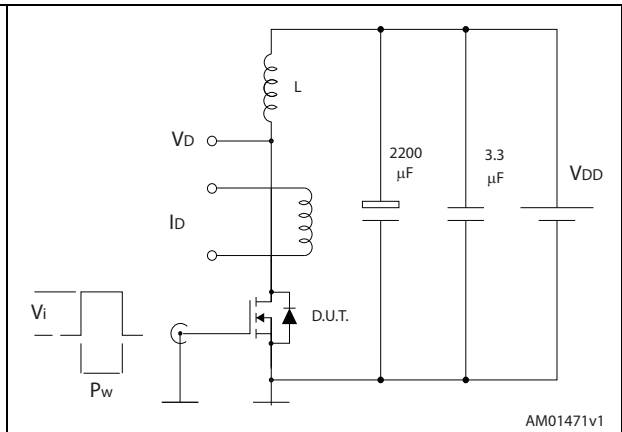
AM01469v1

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



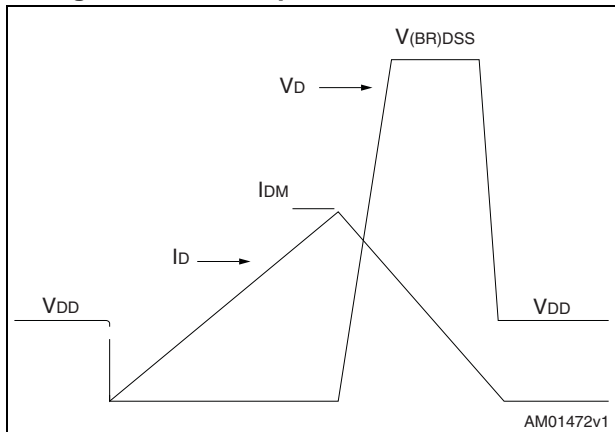
AM01470v1

Figure 21. Unclamped inductive load test circuit



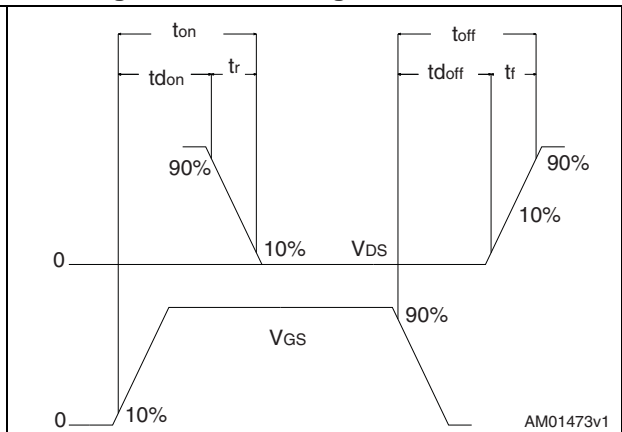
AM01471v1

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<sup>®</sup> is an ST trademark.

Table 9. DPAK (TO-252) type A 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	1.00		1.50
(L1)		2.80	
L2		0.80	
L4	0.60		1.00
R		0.20	
V2	0°		8°

Figure 24. DPAK (TO-252) type A drawing

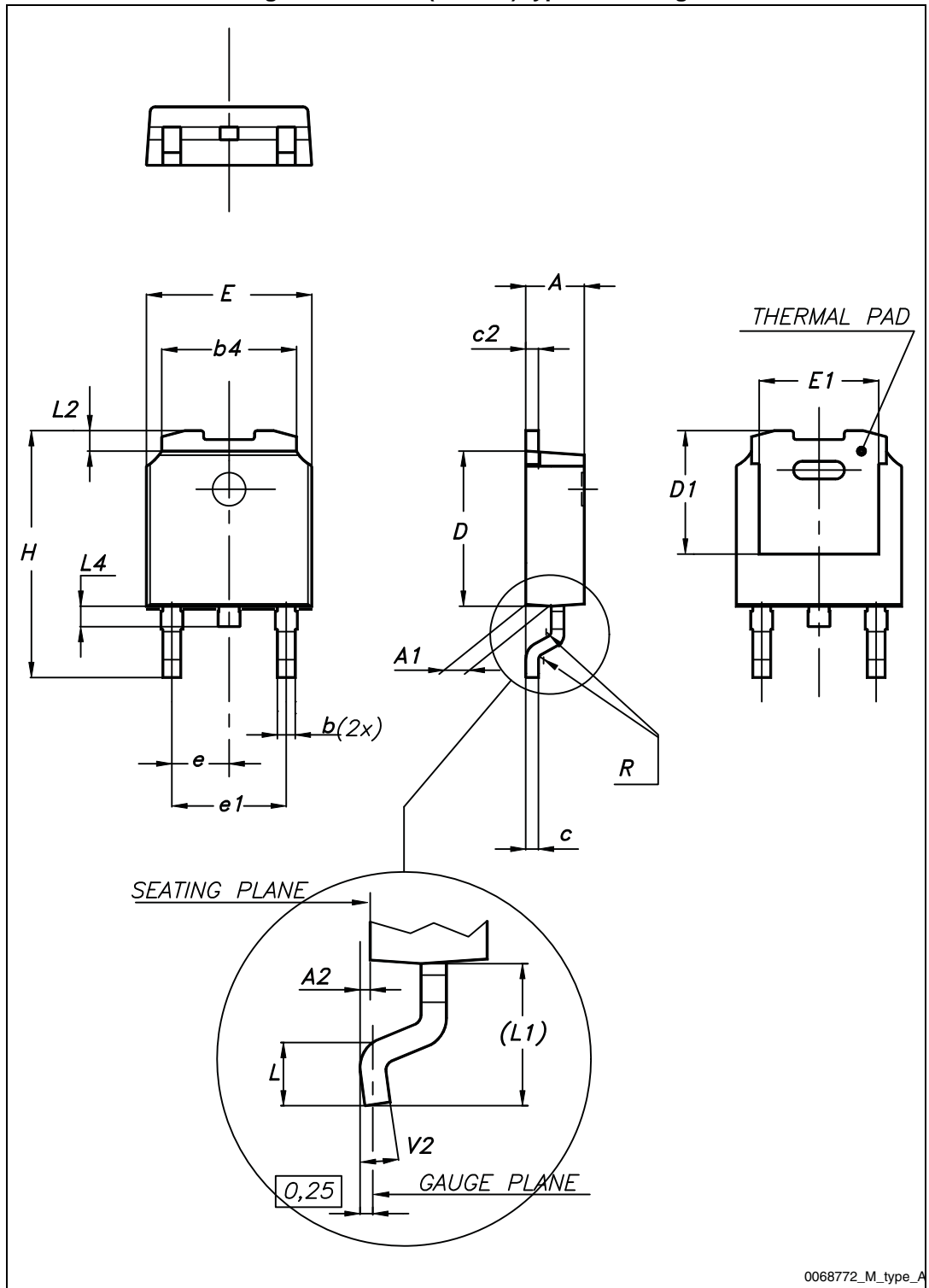
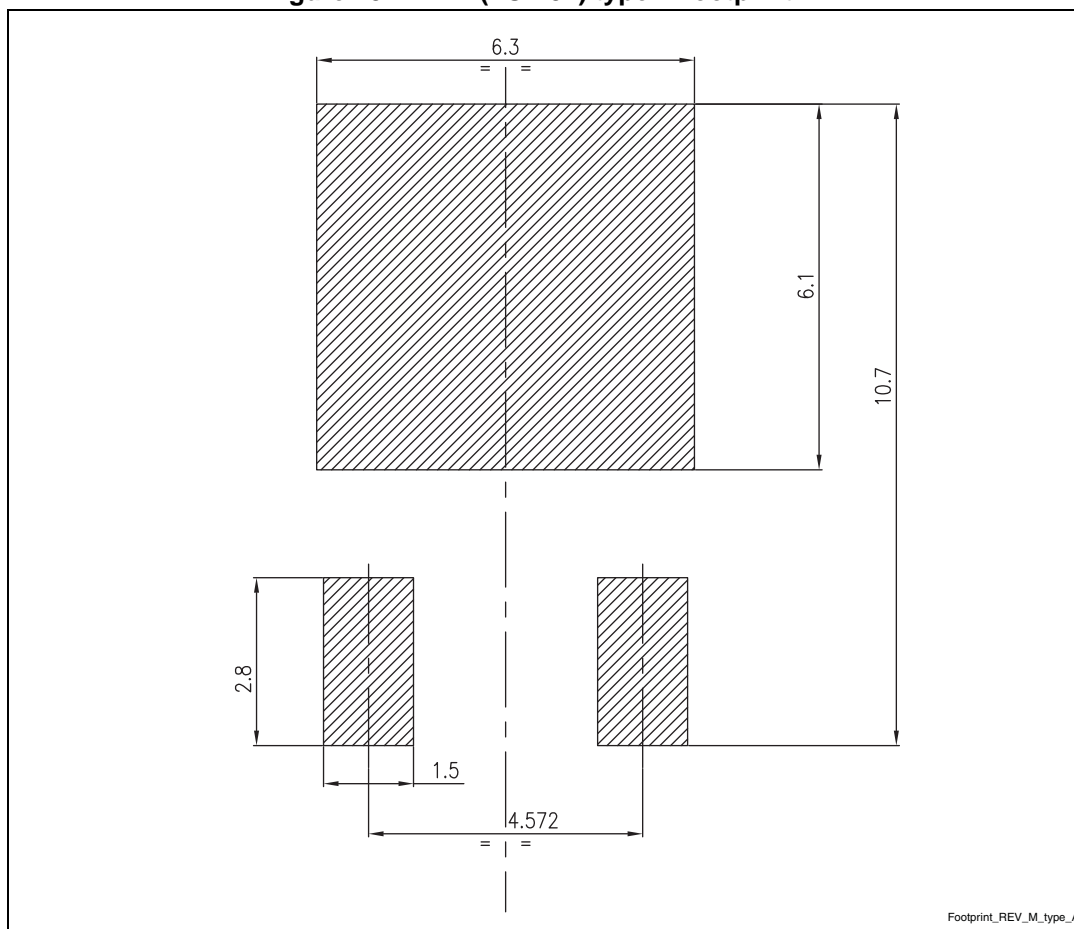


Figure 25. DPAK (TO-252) type A footprint (a)



Footprint\_REV\_M\_type\_A

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 26. TO-220FP drawing

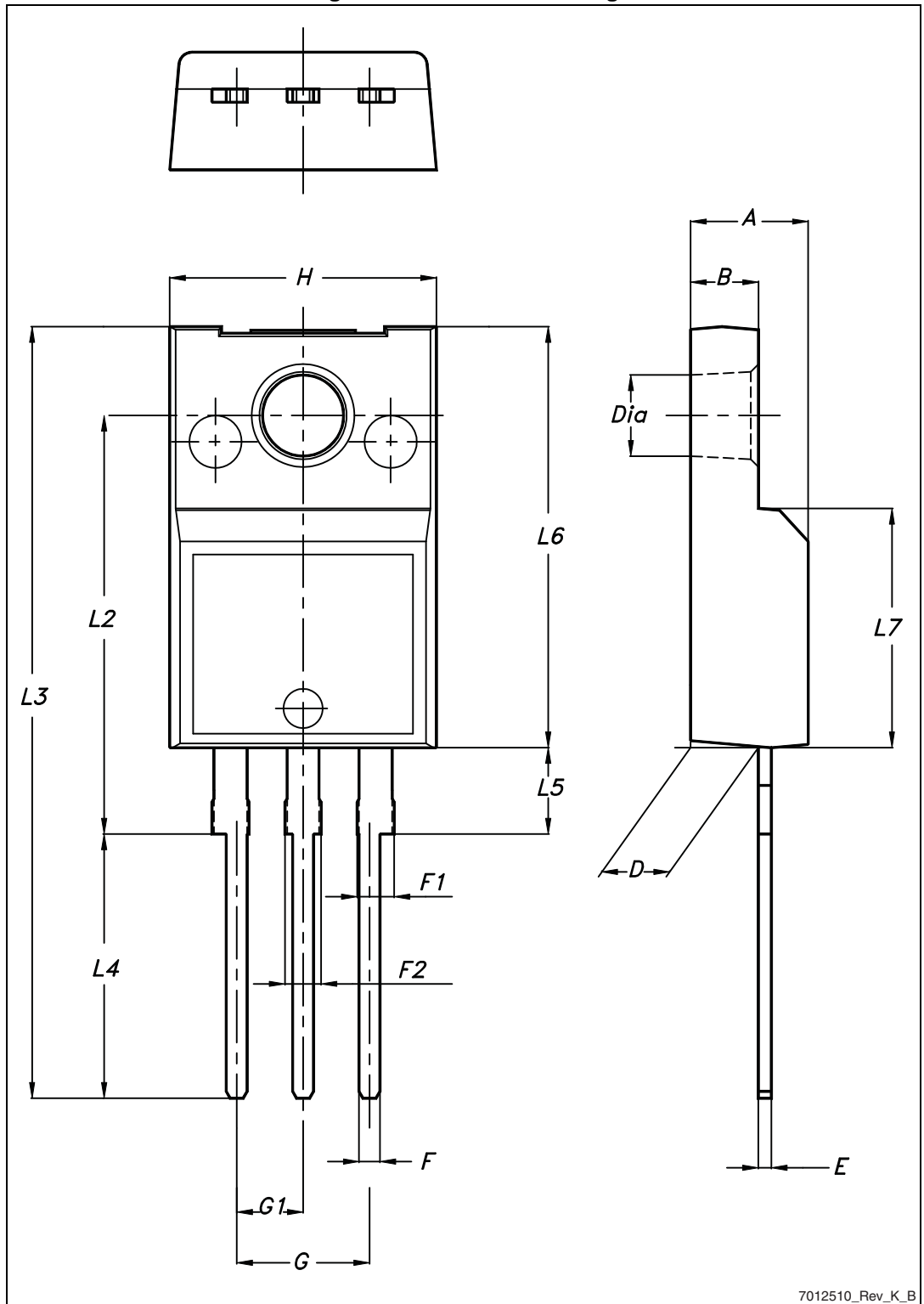
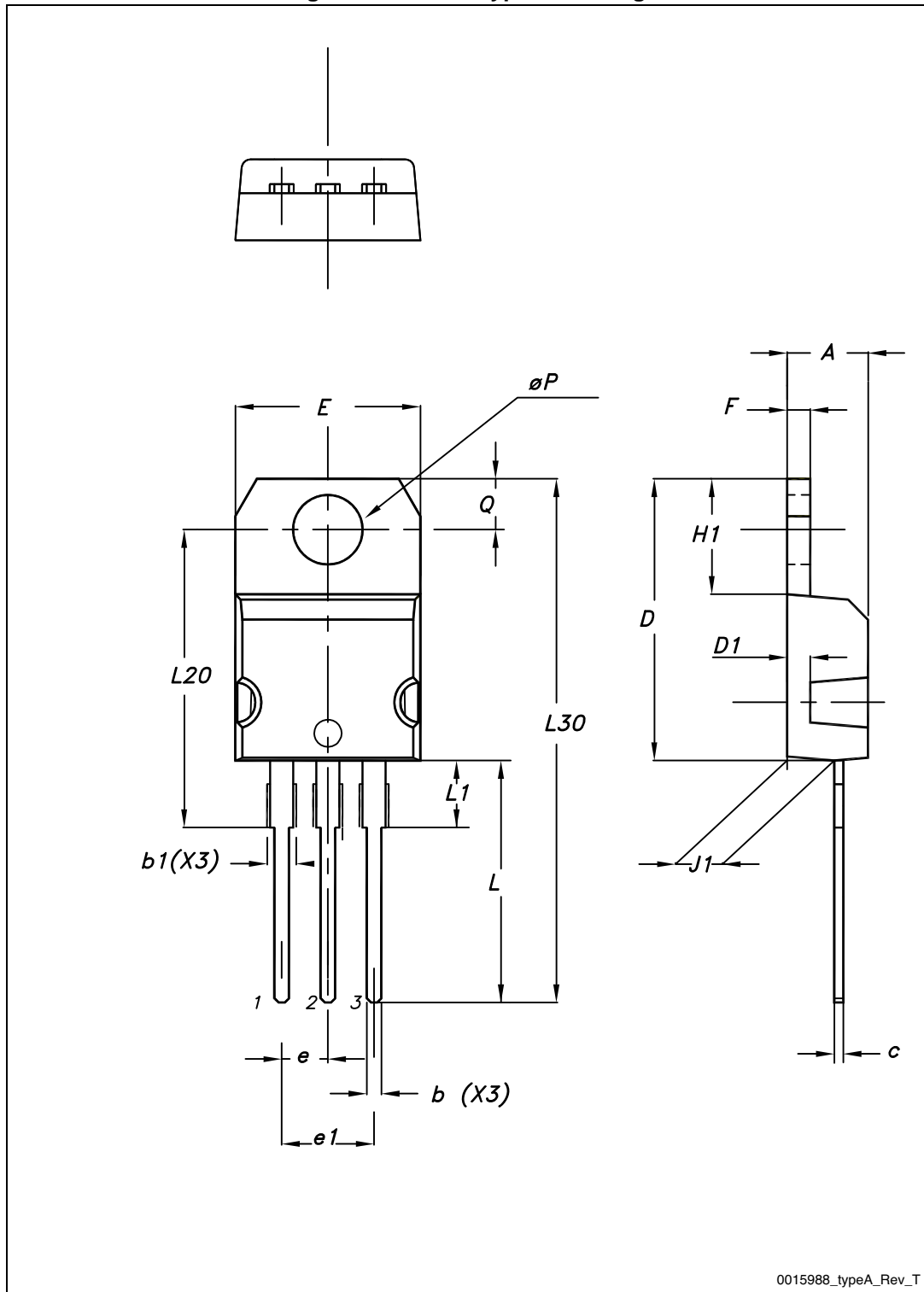


Table 11. TO-220 type A mechanical data

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 27. TO-220 type A drawing

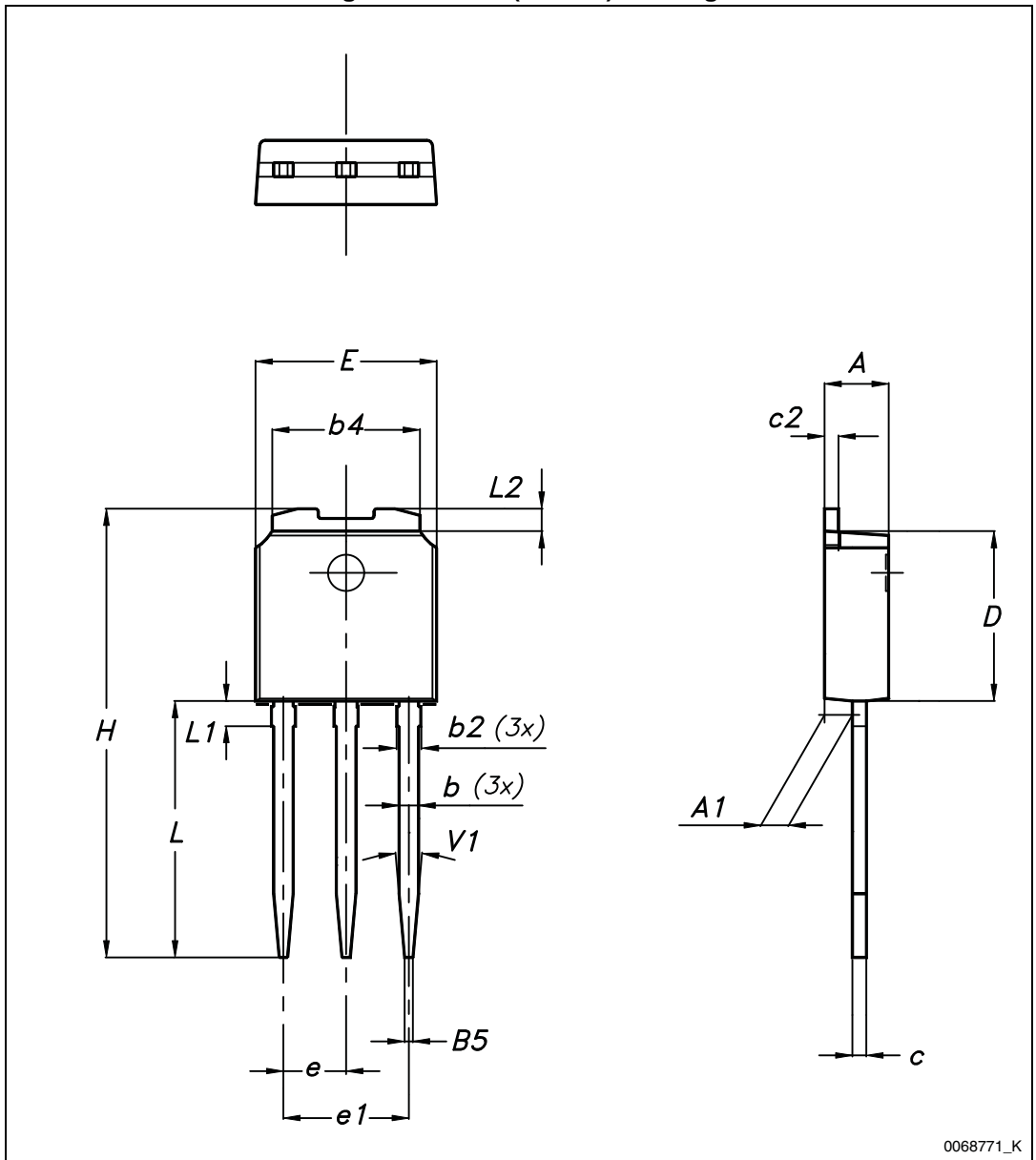


0015988\_typeA\_Rev\_T

Table 12. IPAK (TO-251) mechanical data

DIM	mm.		
	min.	typ.	max.
A	2.20		2.35
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		6.15
E	6.40		6.55
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 28. IPAK (TO-251) 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)

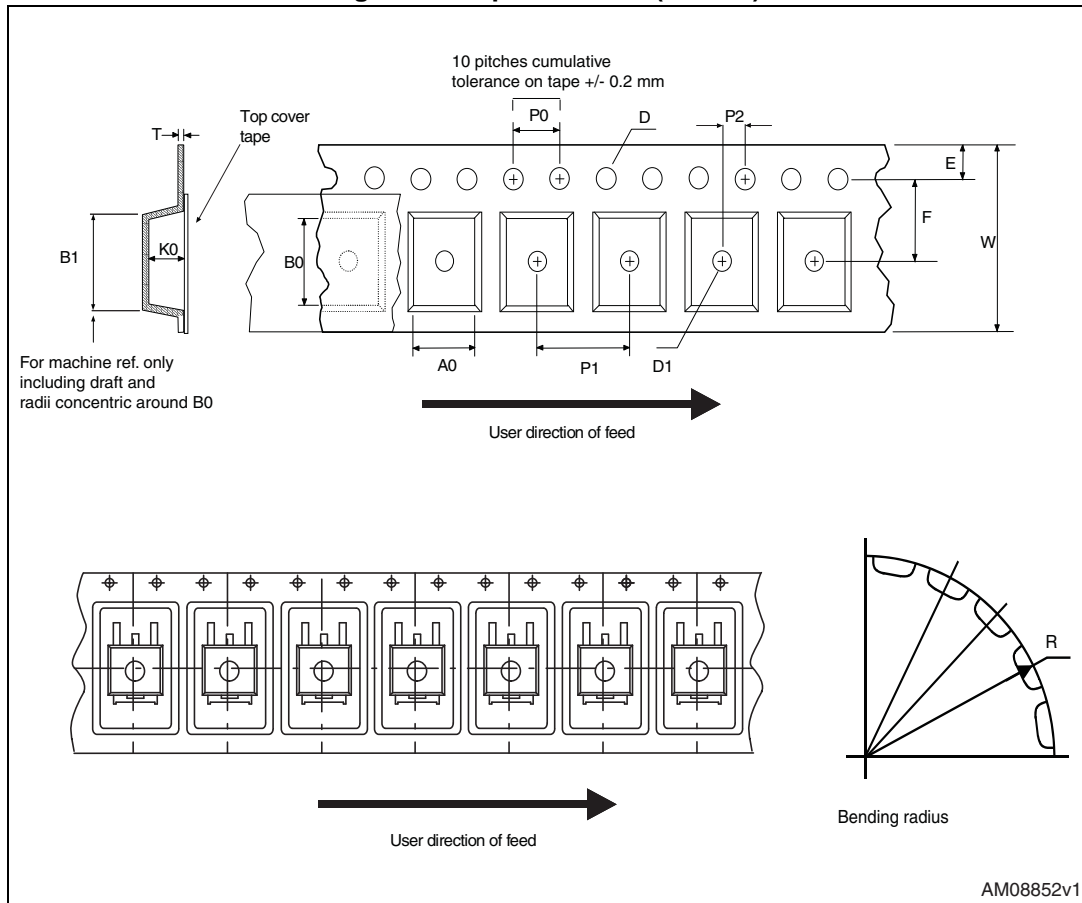
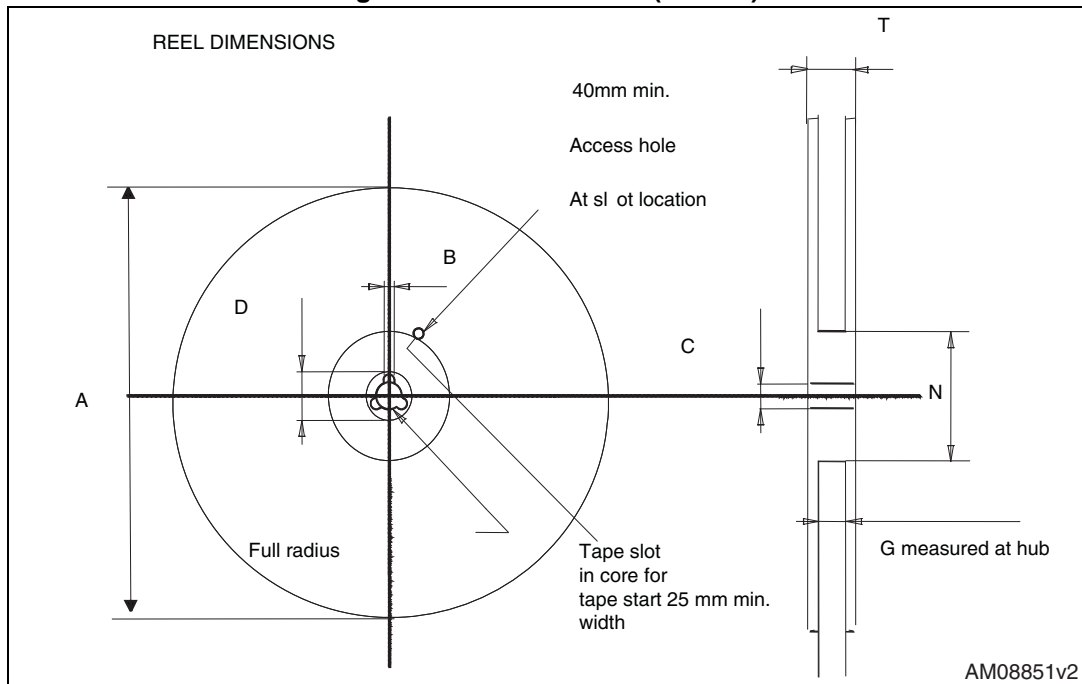


Figure 30. Reel for DPAK (TO-252)



## 6 Revision history

Table 14. Document revision history

Date	Revision	Changes
09-Aug-2013	1	First release
13-Dec-2013	2	<ul style="list-style-type: none"><li>– Added: IPAK package</li><li>– Added: <a href="#">Table 12</a> and <a href="#">Figure 28</a></li><li>– Minor text changes</li></ul>

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