

N-channel 950 V, 4.2  $\Omega$  typ., 2 A Zener-protected SuperMESH™ 5 Power MOSFETs in DPAK, TO-220FP, TO-220 and IPAK packages

Datasheet - production data

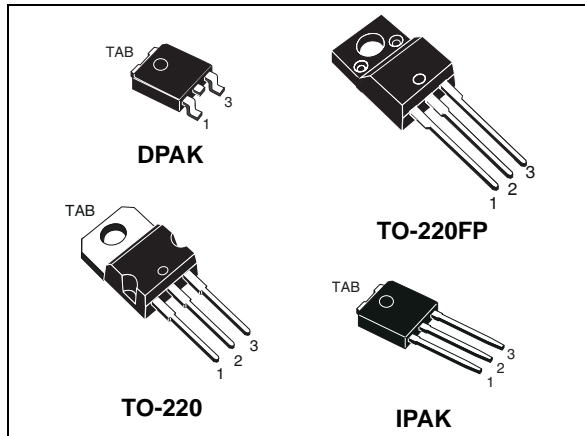
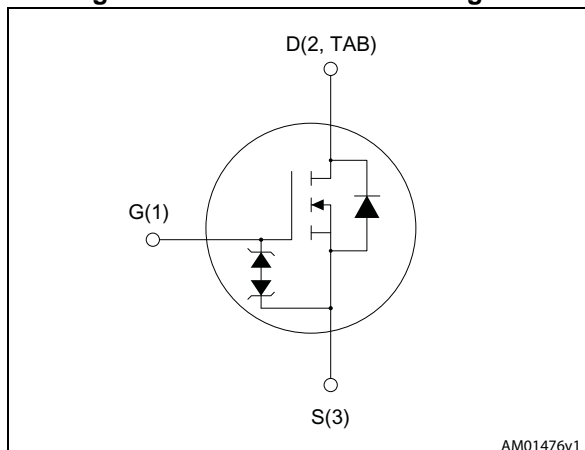


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DS}$	$R_{DS(on)}$ max	$I_D$	$P_{TOT}$
STD2N95K5	950 V	5 $\Omega$	2 A	45 W
STF2N95K5				20 W
STP2N95K5				45 W
STU2N95K5				45 W

- TO-220 worldwide best  $R_{DS(on)}$
- 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 codes	Marking	Package	Packaging
STD2N95K5	2N95K5	DPAK	Tape and reel
STF2N95K5		TO-220FP	Tube
STP2N95K5		TO-220	
STU2N95K5		IPAK	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220FP	DPAK, TO-220, IPAK	
V <sub>GS</sub>	Gate- source voltage	30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	2 <sup>(1)</sup>	2	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	1.3 <sup>(1)</sup>	1.3	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	8		A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	20	45	W
I <sub>AR</sub>	Max current during repetitive or single pulse avalanche	1		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)	50		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 <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
T <sub>J</sub> T <sub>stg</sub>	Operating junction temperature Storage temperature	- 55 to 150		°C

1. Limited by maximum junction temperature
2. Pulse width limited by safe operating area.
3. I<sub>SD</sub> ≤ 2 A, di/dt ≤ 100 A/μs, V<sub>Peak</sub> ≤ V<sub>(BR)DSS</sub>.
4. V<sub>SD</sub> ≤ 760 V

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220FP	DPAK, TO-220, IPAK	
R <sub>thj-case</sub>	Thermal resistance junction-case max	6.25	2.78	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.50		°C/W

## 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	950			V
I <sub>DSS</sub>	Zero gate voltage, V <sub>GS</sub> = 0 drain current	V <sub>DS</sub> = 950 V V <sub>DS</sub> = 950 V, T <sub>C</sub> =125 °C			1 50	μA μA
I <sub>GSS</sub>	Gate-body leakage current	V <sub>GS</sub> = ± 20 V; V <sub>DS</sub> =0			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 A		4.2	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	-	105	-	pF
C <sub>oss</sub>	Output capacitance		-	9	-	pF
C <sub>rss</sub>	Reverse transfer capacitance		-	0.5	-	pF
C <sub>o(tr)</sub> <sup>(1)</sup>	Equivalent capacitance time related	V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 760 V	-	16	-	pF
C <sub>o(er)</sub> <sup>(2)</sup>	Equivalent capacitance energy related		-	6	-	pF
R <sub>G</sub>	Intrinsic gate resistance	f = 1 MHz open drain	-	16	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 760 V, I <sub>D</sub> = 2 A V <sub>GS</sub> = 10 V (see <a href="#">Figure 19</a> )	-	10	-	nC
Q <sub>gs</sub>	Gate-source charge		-	1.5	-	nC
Q <sub>gd</sub>	Gate-drain charge		-	8	-	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	$V_{DD} = 475\text{ V}$ , $I_D = 1\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ <i>(see Figure 18)</i>	-	8.5	-	ns
$t_r$	Rise time		-	13.5	-	ns
$t_{d(off)}$	Turn-off-delay time		-	20.5	-	ns
$t_f$	Fall time		-	32.5	-	ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$I_{SD}$	Source-drain current		-		2	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		8	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 2\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ <i>(see Figure 20)</i>	-	300		ns
$Q_{rr}$	Reverse recovery charge		-	1.15		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	7.6		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 2\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ $T_J = 150\text{ }^\circ\text{C}$ <i>(see Figure 20)</i>	-	525		ns
$Q_{rr}$	Reverse recovery charge		-	1.90		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	7.2		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 been specifically designed to enhance not only the device’s ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for DPAK and IPAK

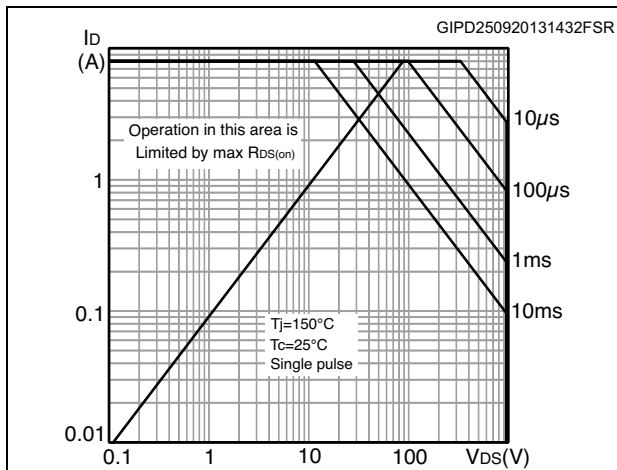


Figure 3. Thermal impedance for DPAK and IPAK

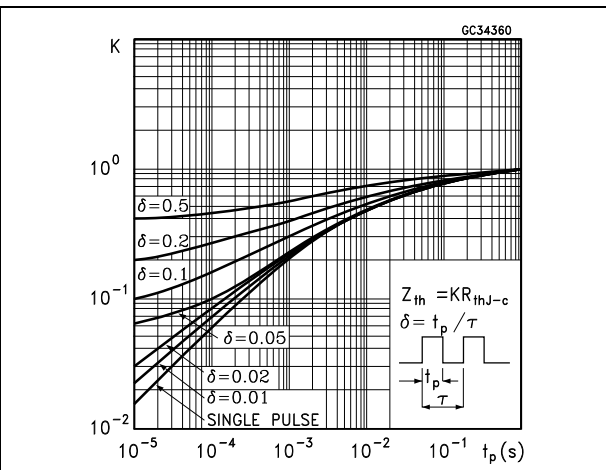


Figure 4. Safe operating area for TO-220FP

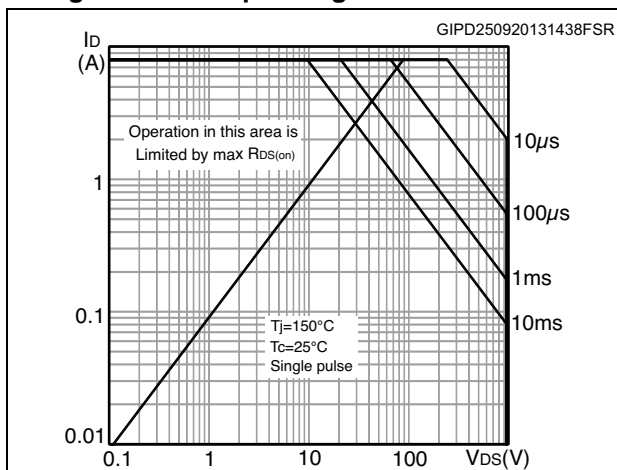


Figure 5. Thermal impedance for TO-220FP

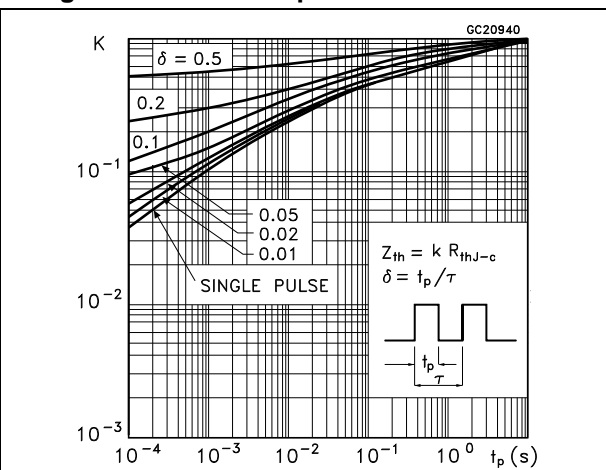


Figure 6. Safe operating area for TO-220

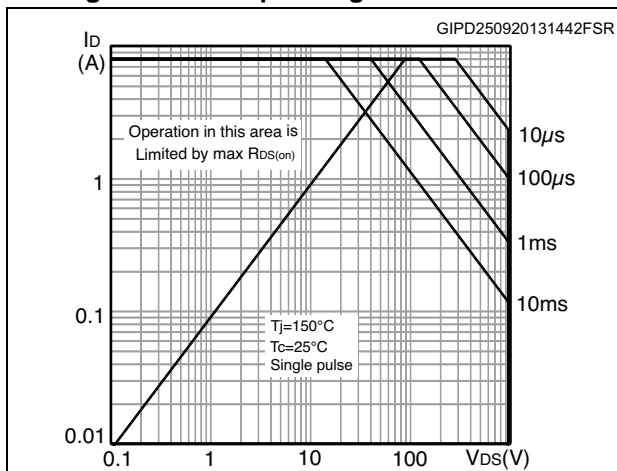


Figure 7. Thermal impedance for TO-220

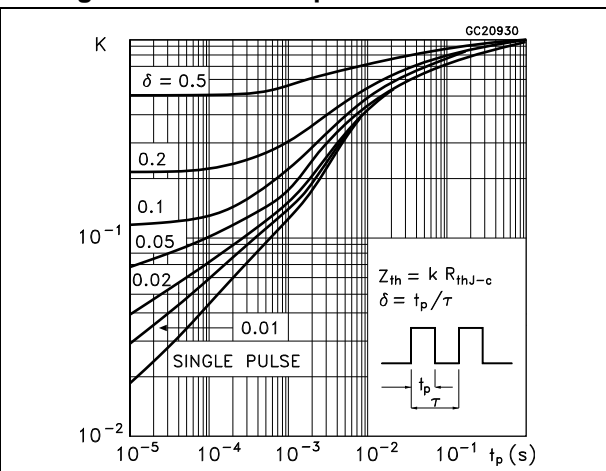


Figure 8. Output characteristics

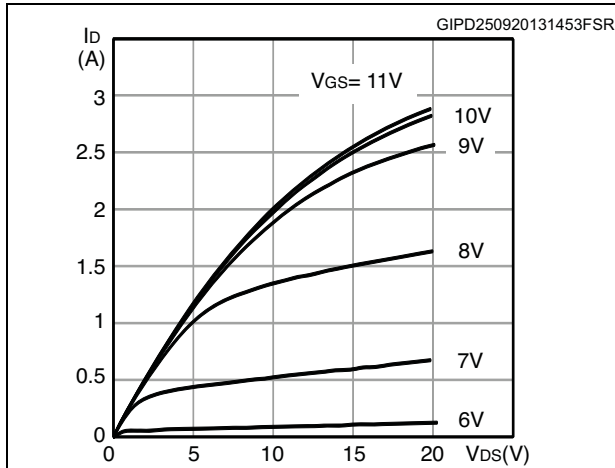


Figure 9. Transfer characteristics

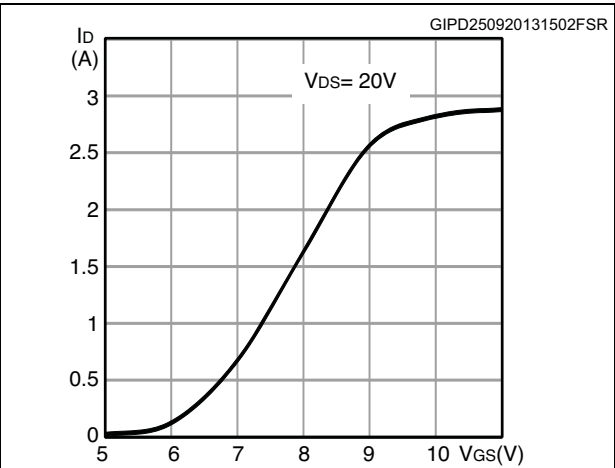


Figure 10. Gate charge vs gate-source voltage

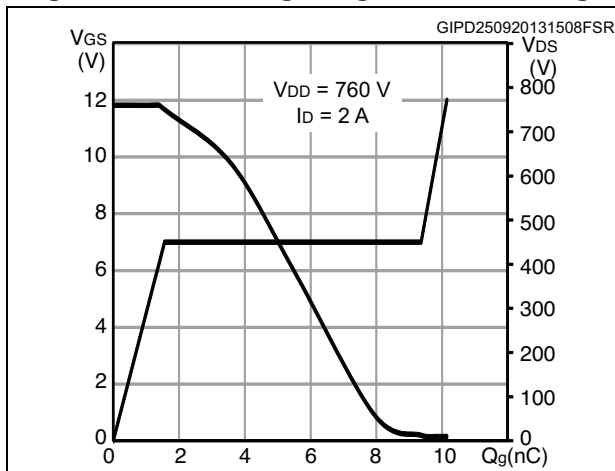


Figure 11. Static drain-source on-resistance

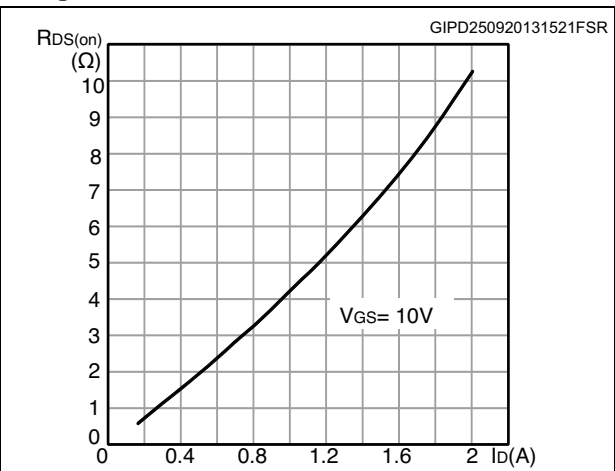


Figure 12. Capacitance variations

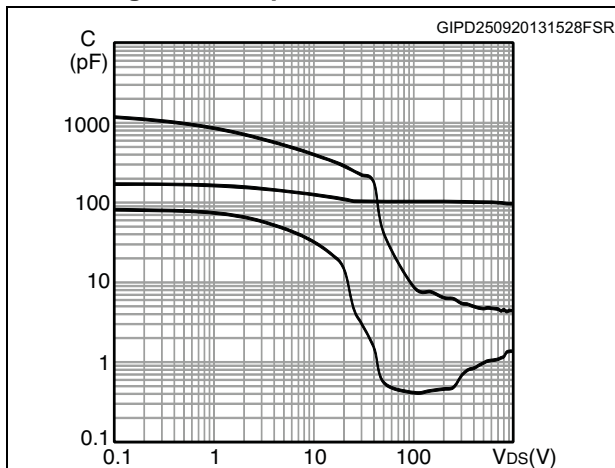


Figure 13. Output capacitance stored energy

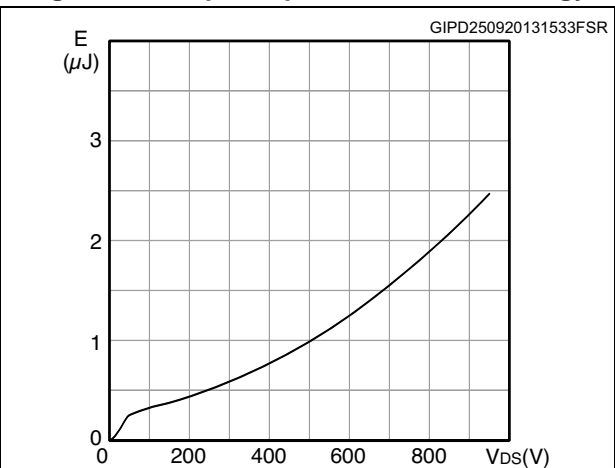


Figure 14. Normalized gate threshold voltage vs temperature

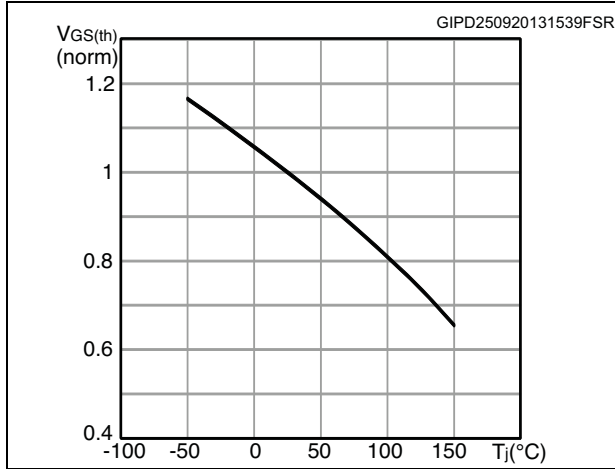


Figure 15. Normalized on-resistance vs temperature

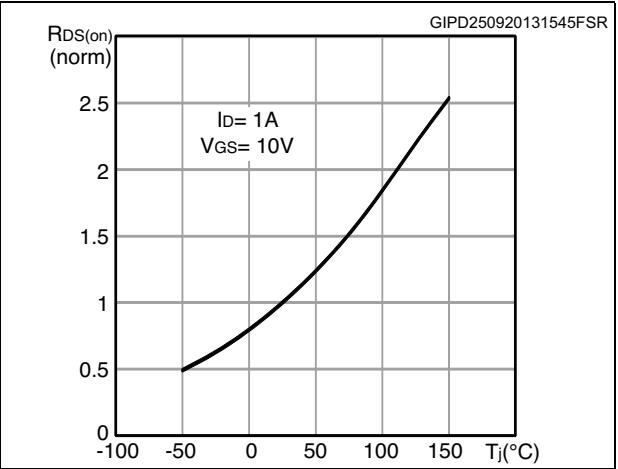


Figure 16. Source-drain diode forward characteristics

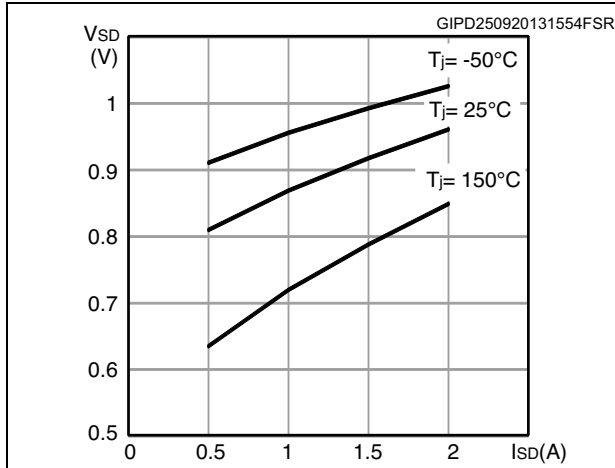
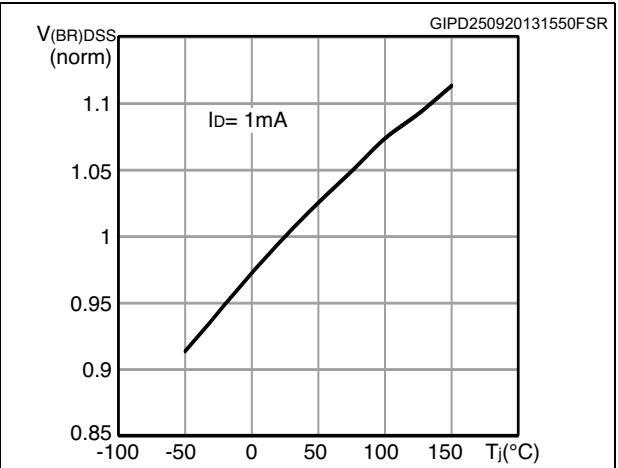


Figure 17. Normalized V<sub>(BR)DSS</sub> vs temperature





### 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



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

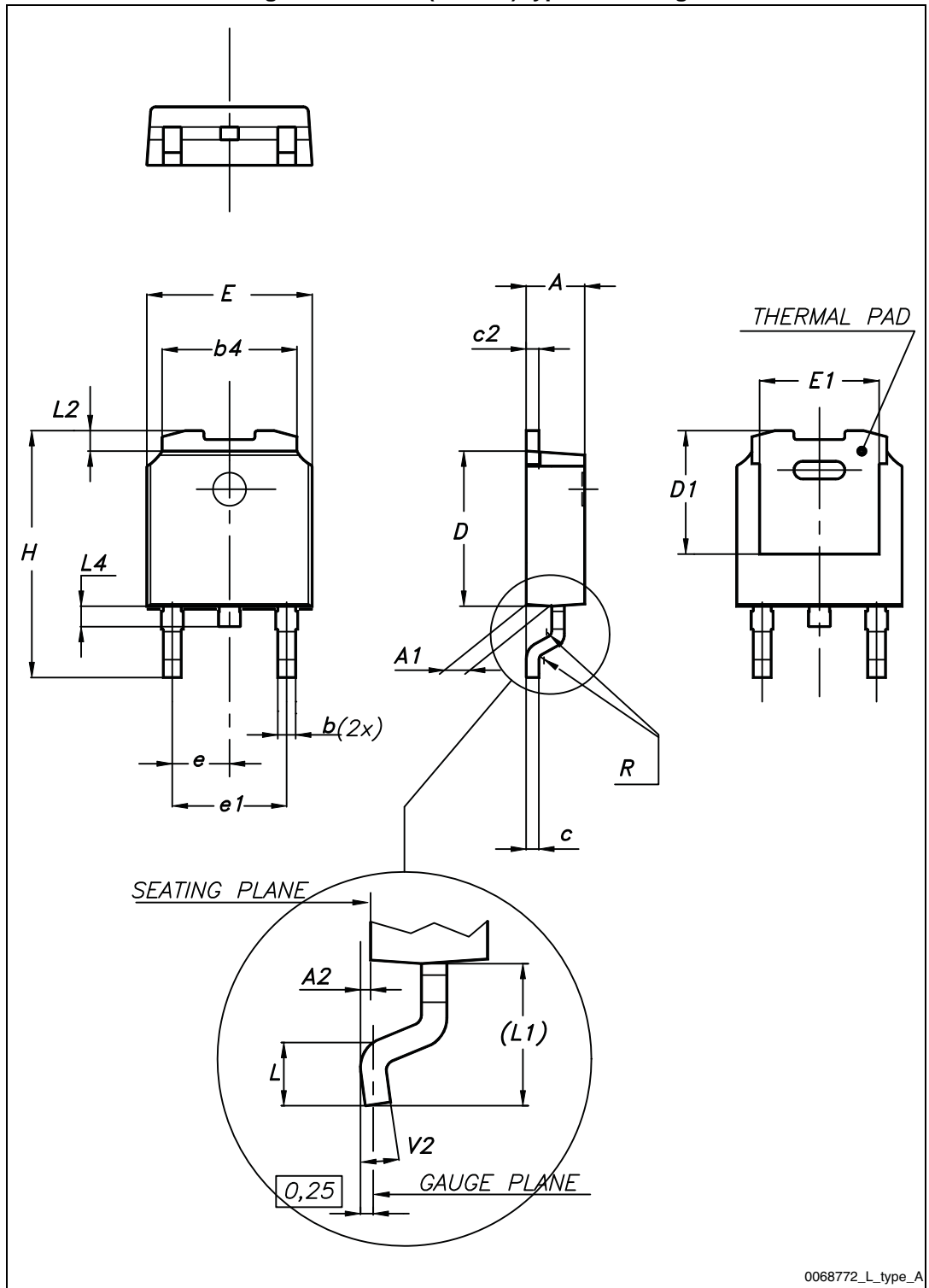
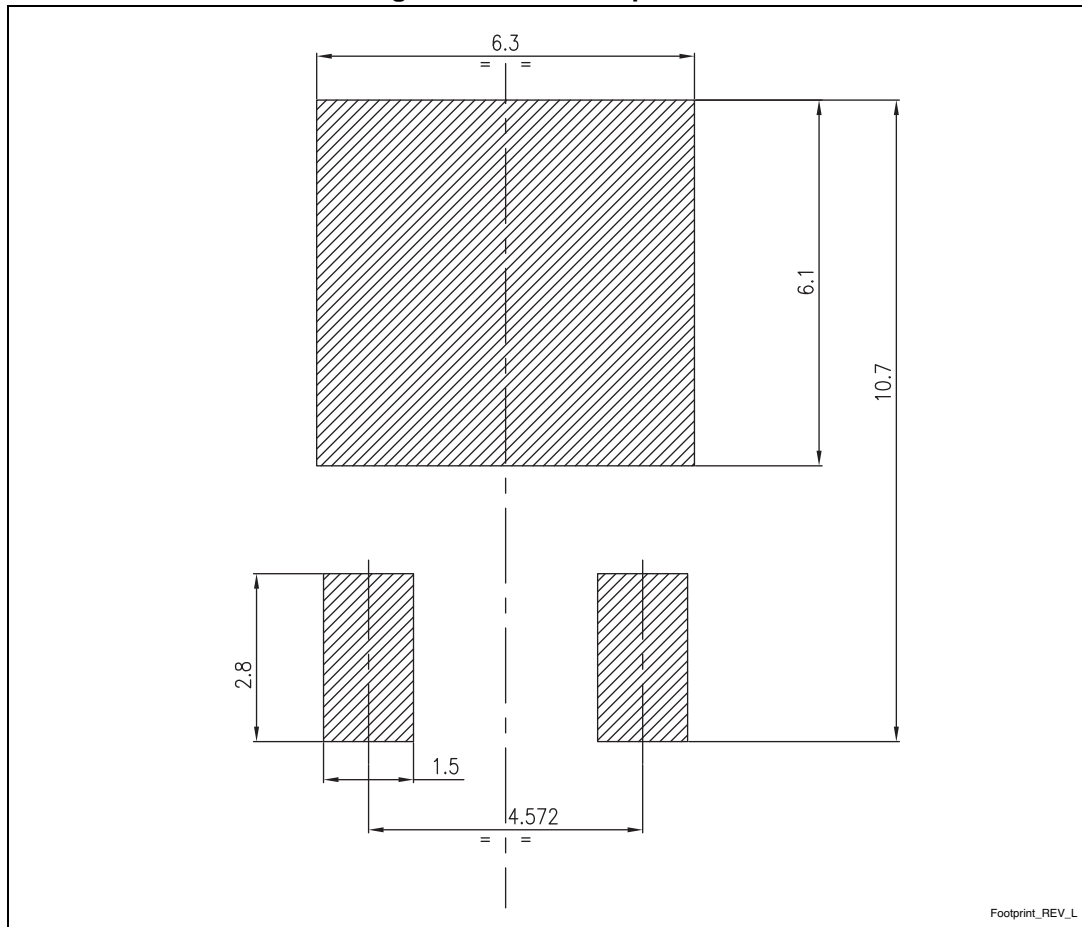


Figure 25. DPAK footprint (a)



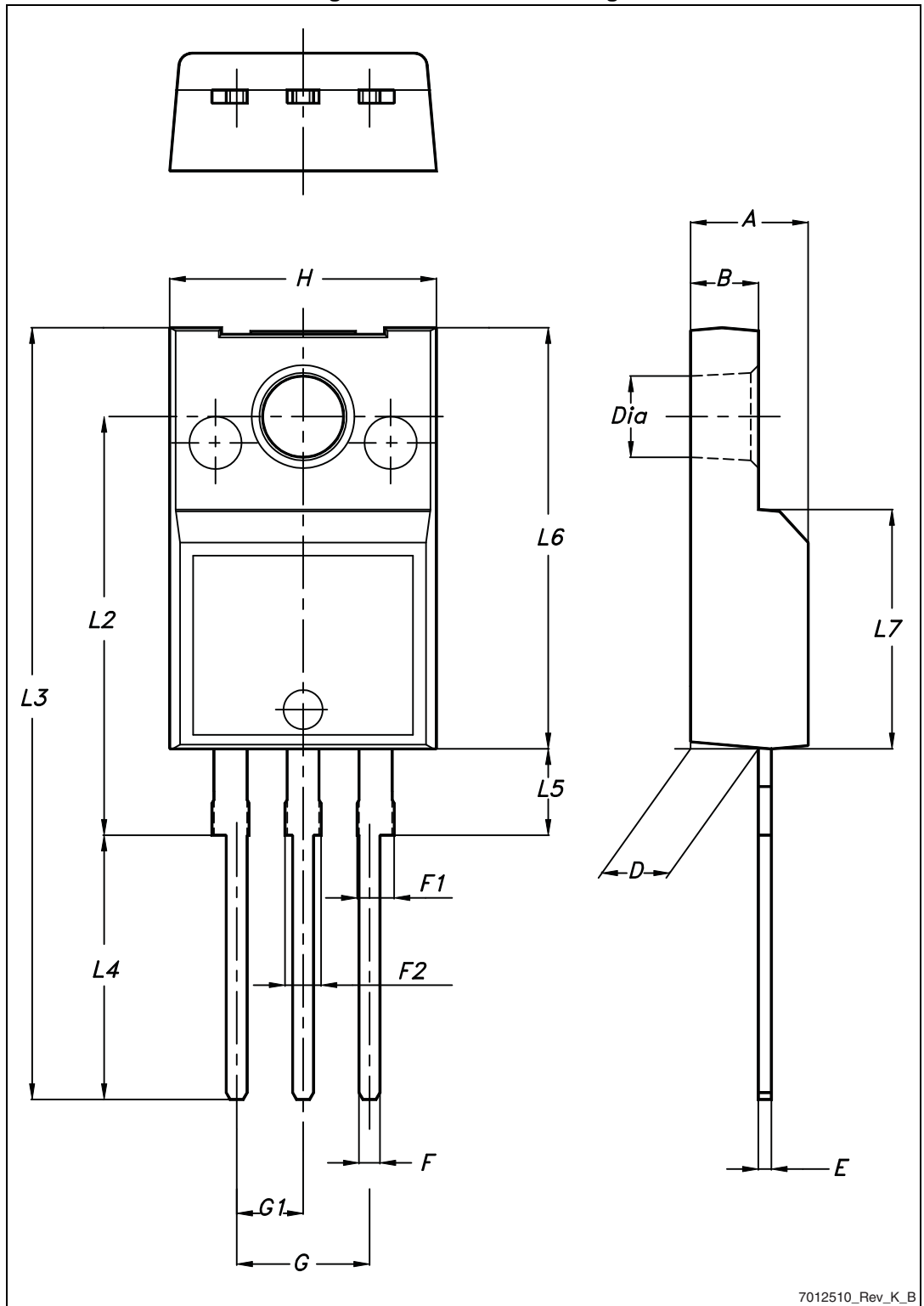
Footprint\_REV\_L

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



7012510\_Rev\_K\_B

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

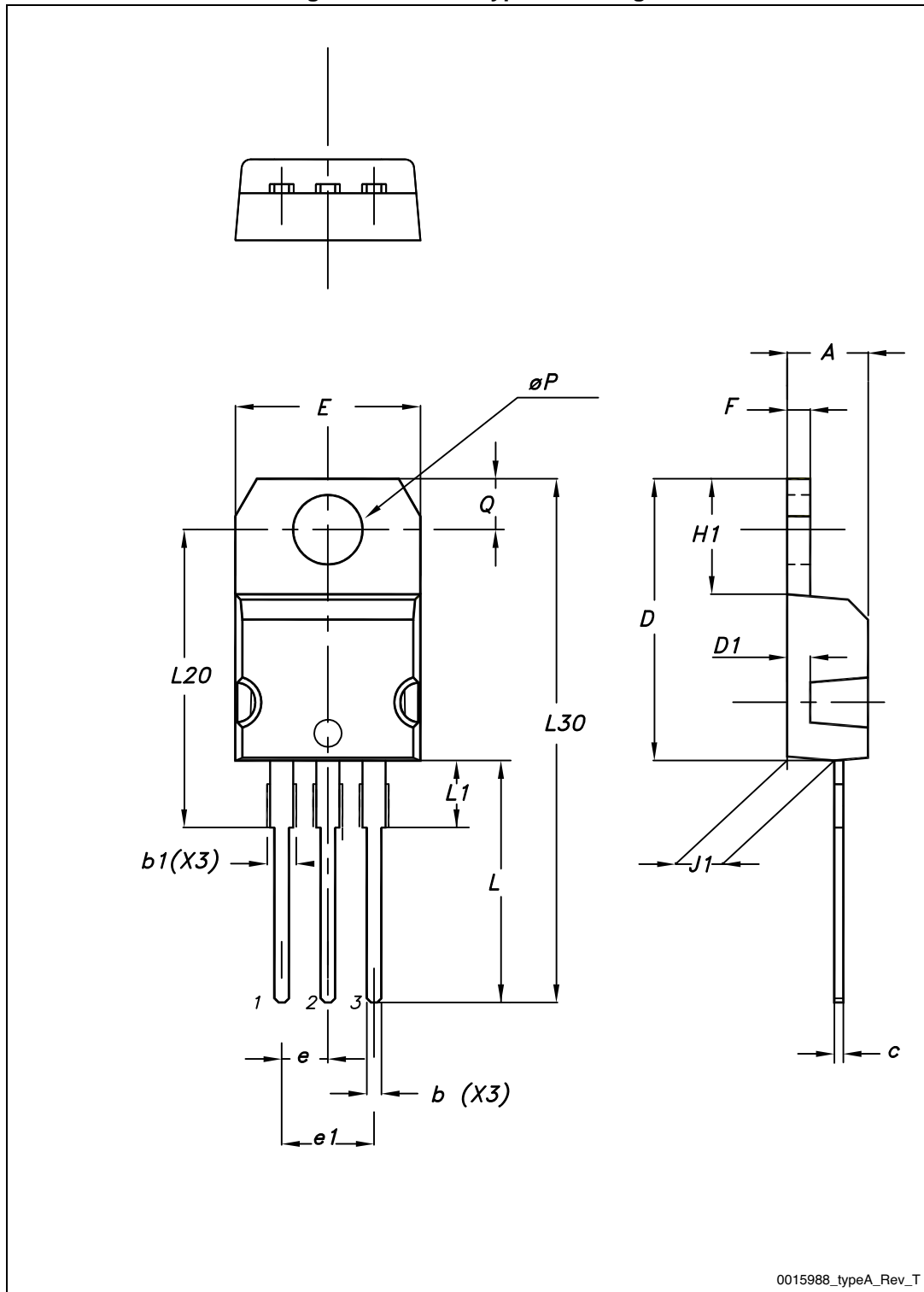
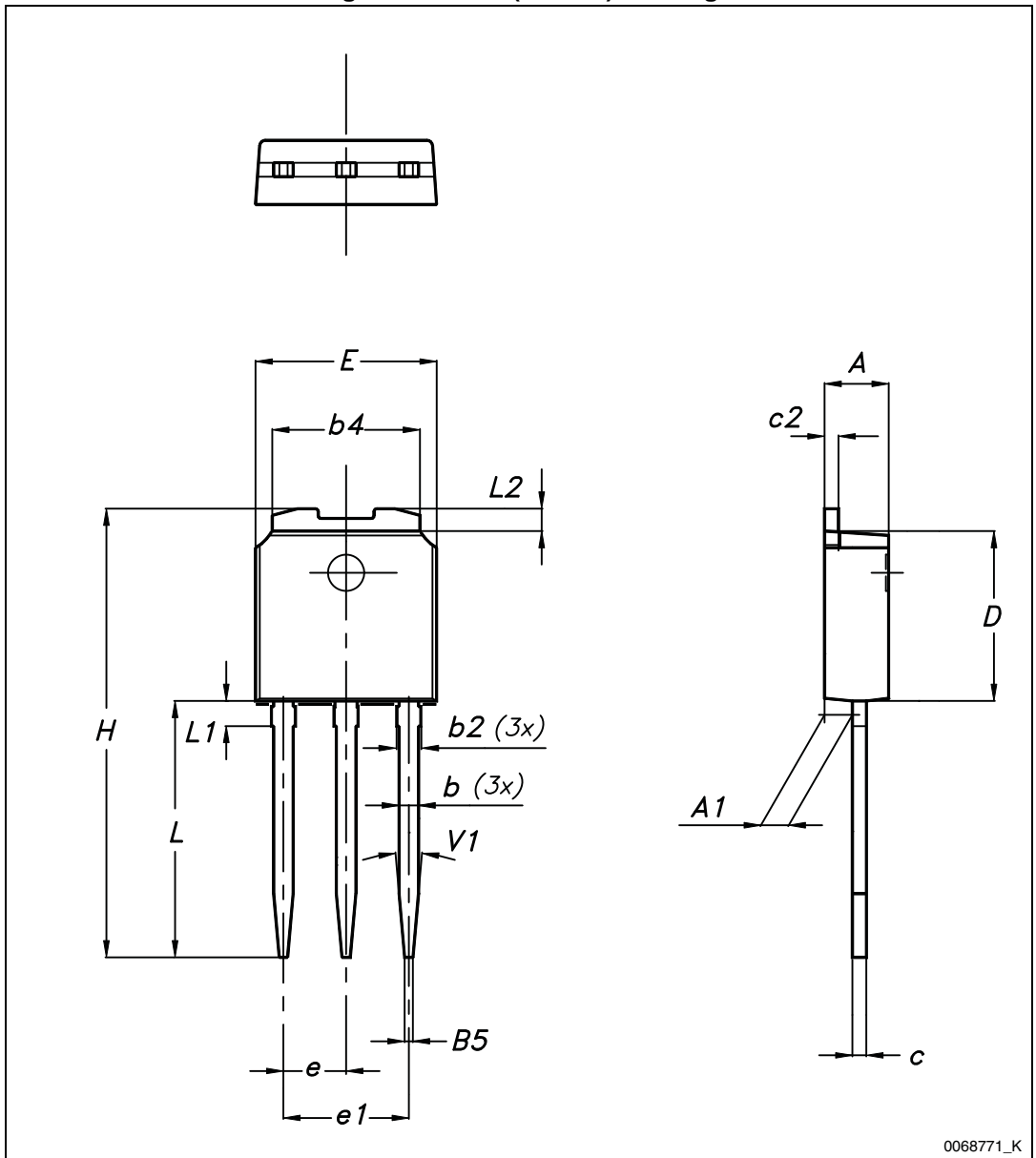


Table 12. IPAK (TO-251) mechanical data

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 28. IPAK (TO-251) drawing



0068771\_K

## 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)

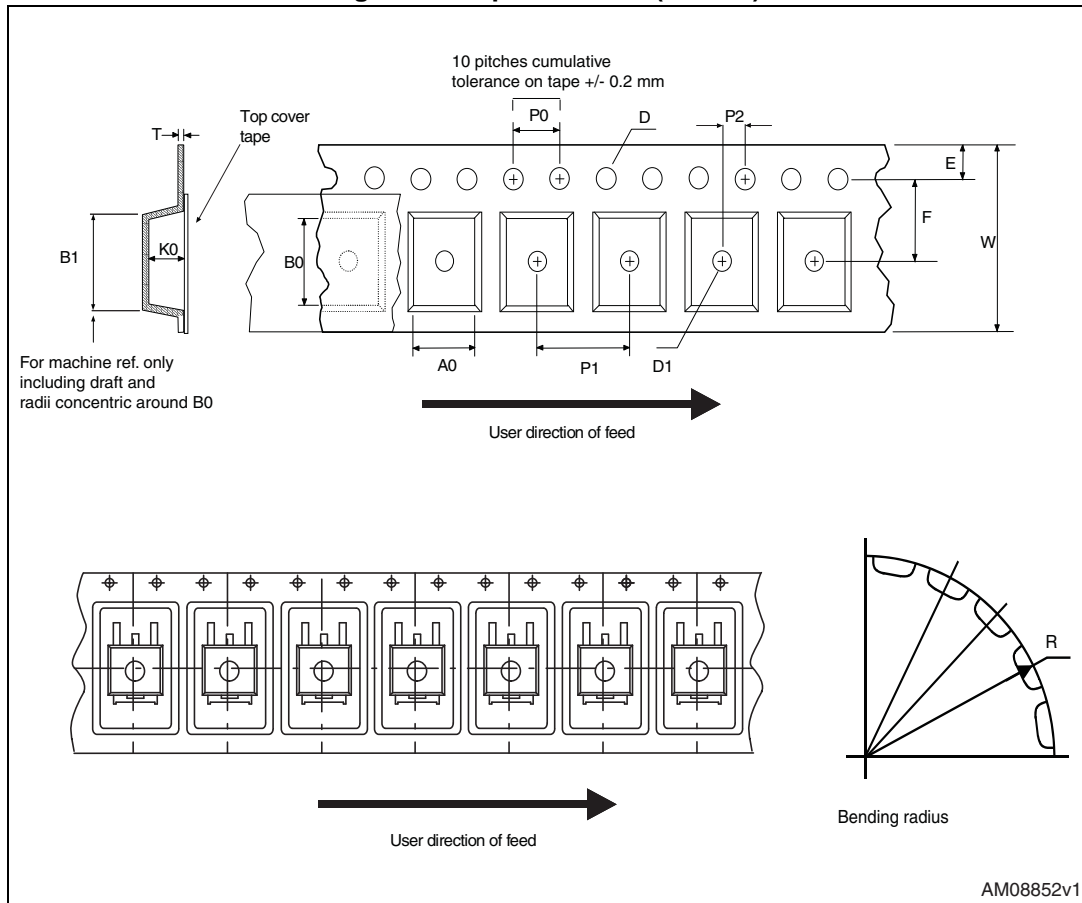
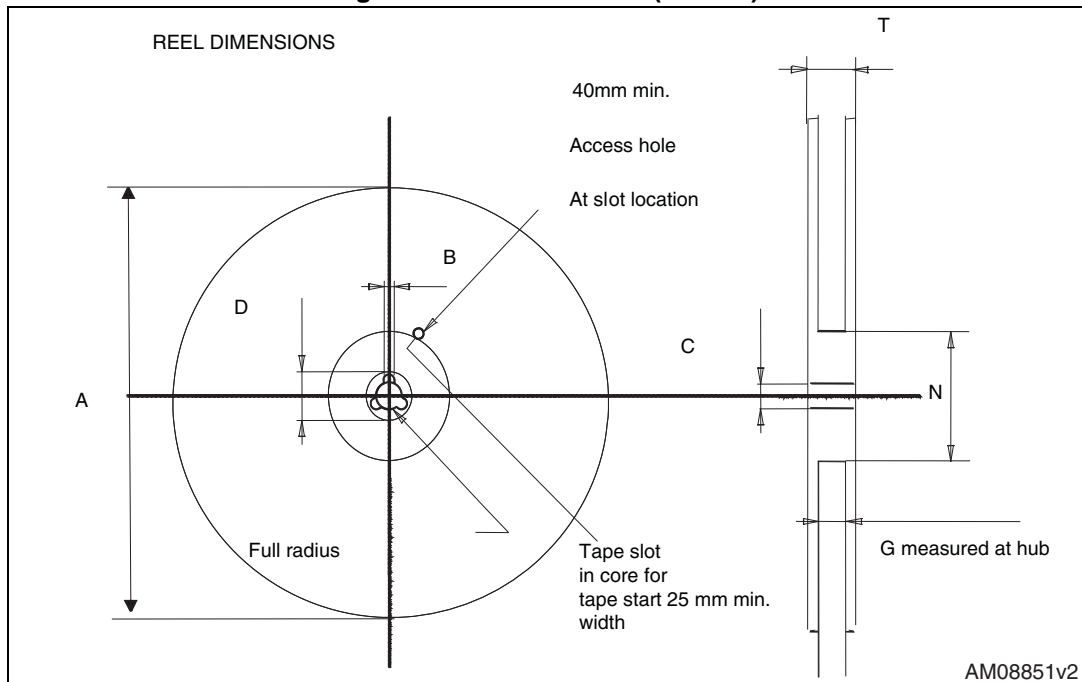


Figure 30. Reel for DPAK (TO-252)



## 6 Revision history

Table 14. Document revision history

Date	Revision	Changes
25-Sep-2013	1	First release.

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- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

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