



# life.augmented STD10NM60N, STF10NM60N, STI10NM60N, STP10NM60N, STU10NM60N

N-channel 600 V, 0.53  $\Omega$  typ., 10 A MDmesh™ II Power MOSFET  
in DPAK, TO-220FP, I<sup>2</sup>PAK, TO-220 and IPAK packages

Datasheet - production data

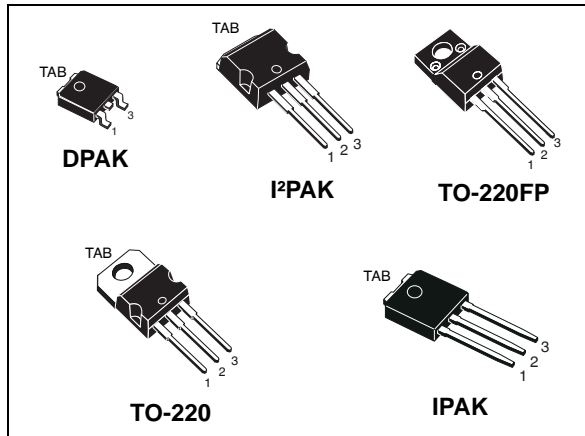
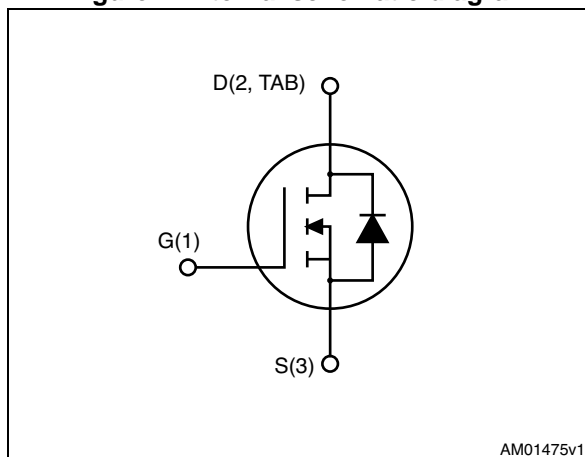


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DSS}$ @ $T_{Jmax}$	$R_{DS(on)}$ max.	$I_D$	$P_{TOT}$
STD10NM60N	650 V	< 0.55 $\Omega$	10 A	70 W
STF10NM60N				25 W
STI10NM60N				70 W
STP10NM60N				
STU10NM60N				

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STD10NM60N	10NM60N	DPAK	Tape and reel
STF10NM60N	10NM60N	TO-220FP	Tube
STI10NM60N	10NM60N	I <sup>2</sup> PAK	Tube
STP10NM60N	10NM60N	TO-220	Tube
STU10NM60N	10NM60N	IPAK	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value				Unit
		TO-220 I <sup>2</sup> PAK	TO-220FP	IPAK	DPAK	
V <sub>GS</sub>	Gate- source voltage	± 25				V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	10	10 <sup>(1)</sup>	10		A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	5	5 <sup>(1)</sup>	5		A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	32	32 <sup>(1)</sup>	32		A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	70	25	70		W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15				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> ≤ 10 A, di/dt ≤ 400 A/μs, V<sub>DS peak</sub> ≤ V<sub>(BR)DSS</sub>, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>.

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		TO-220 I <sup>2</sup> PAK	TO-220FP	IPAK	DPAK	
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.79	5	1.79		°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.50		100		°C/W
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb max				50	°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AS</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> Max)	4	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)	200	mJ

## 2 Electrical characteristics

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

**Table 5. 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 I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0, T <sub>C</sub> =150 °C	600	650		V
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 600 V V <sub>DS</sub> = 600 V, T <sub>C</sub> =125 °C			1 100	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 25 V			± 100	nA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	2	3	4	V
R <sub>DS(on)</sub>	Static drain-source on-resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4 A		0.53	0.55	Ω

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>DS</sub> = 50 V, f = 1 MHz, V <sub>GS</sub> = 0	-	540	-	pF
C <sub>oss</sub>	Output capacitance		-	44	-	pF
C <sub>rss</sub>	Reverse transfer capacitance		-	1.2	-	pF
C <sub>oss eq</sub> <sup>(1)</sup>	Equivalent capacitance time related	V <sub>DS</sub> = 0 to 480 V, V <sub>GS</sub> = 0	-	110	-	pF
R <sub>g</sub>	Gate input resistance	f=1 MHz open drain	-	6	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 8 A, V <sub>GS</sub> = 10 V (see Figure 17)	-	19	-	nC
Q <sub>gs</sub>	Gate-source charge		-	3	-	nC
Q <sub>gd</sub>	Gate-drain charge		-	10	-	nC

1. C<sub>oss eq</sub> 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>

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
t <sub>d(on)</sub>	Turn-on delay time	V <sub>DD</sub> = 300 V, I <sub>D</sub> = 4 A, R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V (see Figure 16)	-	10	-	ns
t <sub>r</sub>	Rise time		-	12	-	ns
t <sub>d(off)</sub>	Turn-off-delay time		-	32	-	ns
t <sub>f</sub>	Fall time		-	15	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$I_{SD}$	Source-drain current		-		8	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		32	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 8\text{ A}, V_{GS} = 0$	-		1.3	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 8\text{ A}, di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see Figure 18)	-	250		ns
$Q_{rr}$	Reverse recovery charge		-	2.12		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			17		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 8\text{ A}, di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}, T_J = 150\text{ }^\circ\text{C}$ (see Figure 18)	-	315		ns
$Q_{rr}$	Reverse recovery charge			2.6		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			16.5		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-220 and I<sup>2</sup>PAK

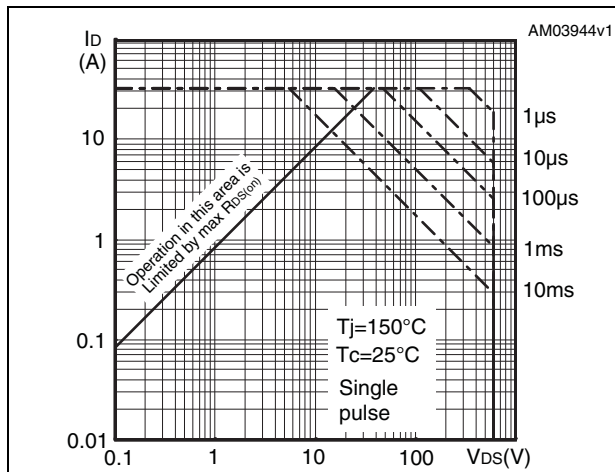


Figure 3. Thermal impedance for TO-220 and I<sup>2</sup>PAK

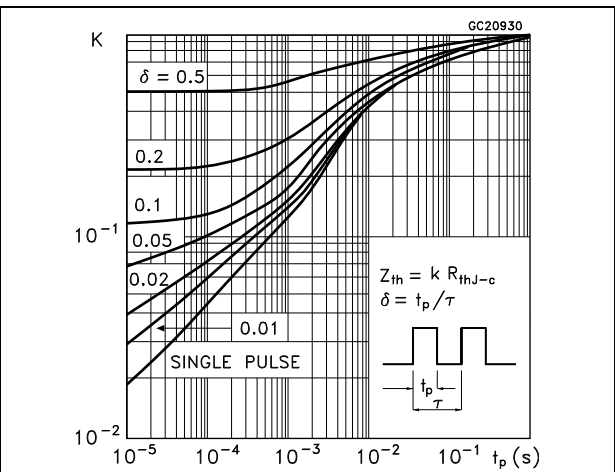


Figure 4. Safe operating area for TO-220FP

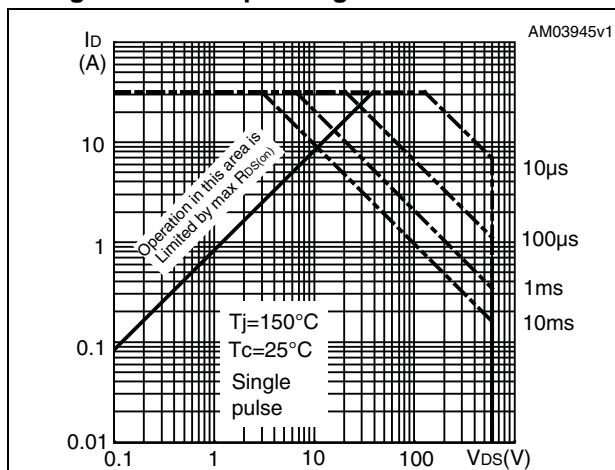


Figure 5. Thermal impedance for TO-220FP

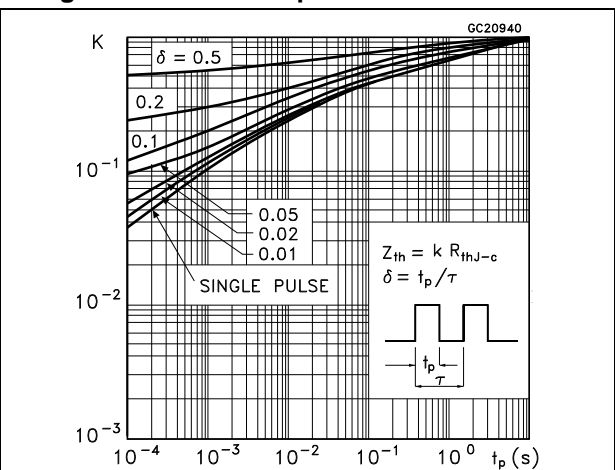


Figure 6. Safe operating area for DPAK, IPAK

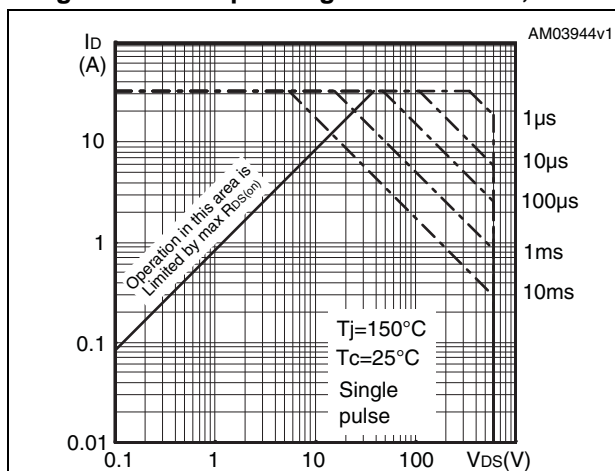


Figure 7. Thermal impedance for DPAK, IPAK

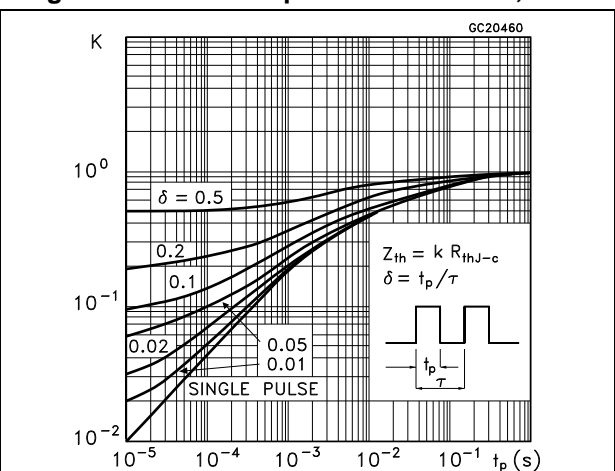


Figure 8. Output characteristics

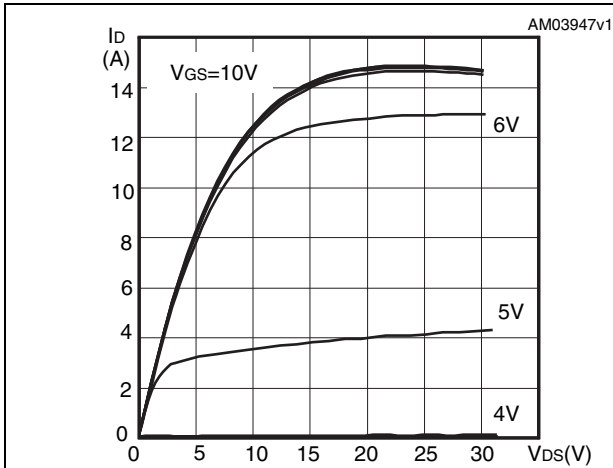


Figure 9. Transfer characteristics

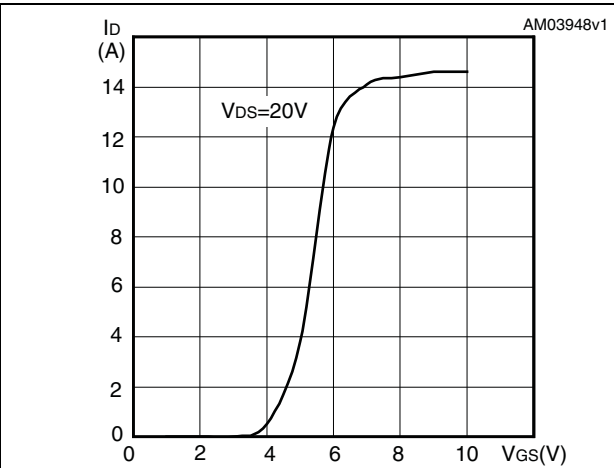


Figure 10. Normalized  $V_{DS}$  vs temperature

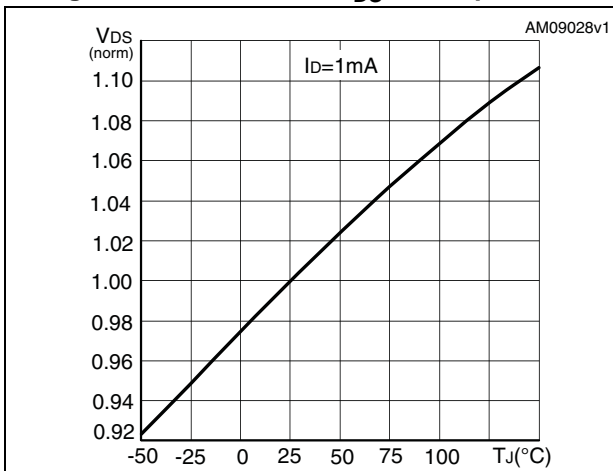


Figure 11. Static drain-source on-resistance

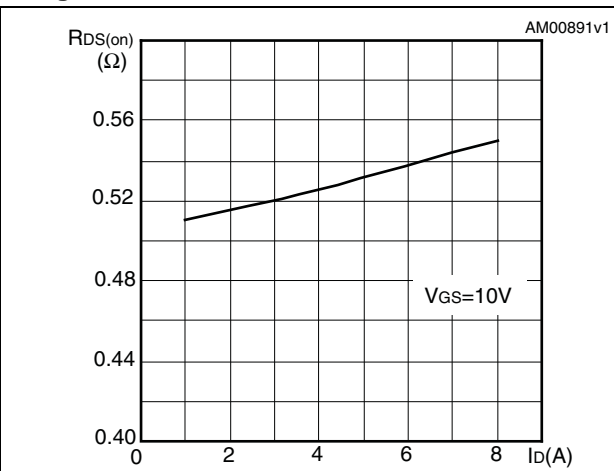


Figure 12. Gate charge vs gate-source voltage

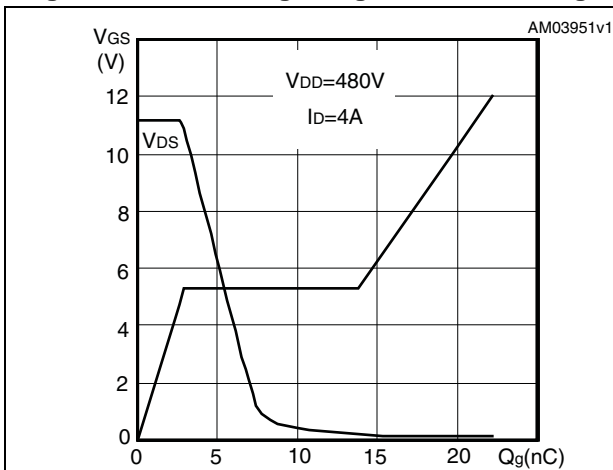


Figure 13. Capacitance variations

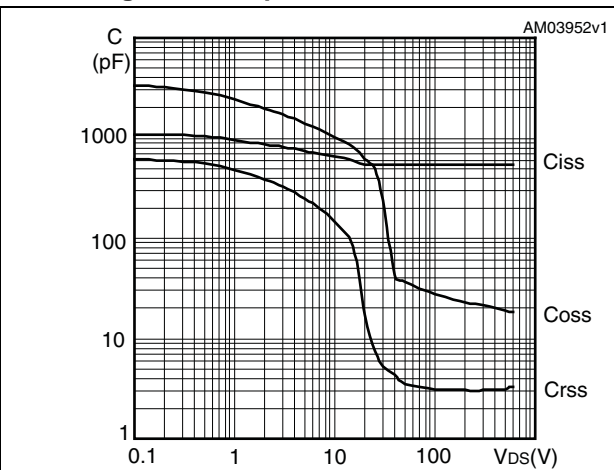


Figure 14. Normalized gate threshold voltage vs temperature

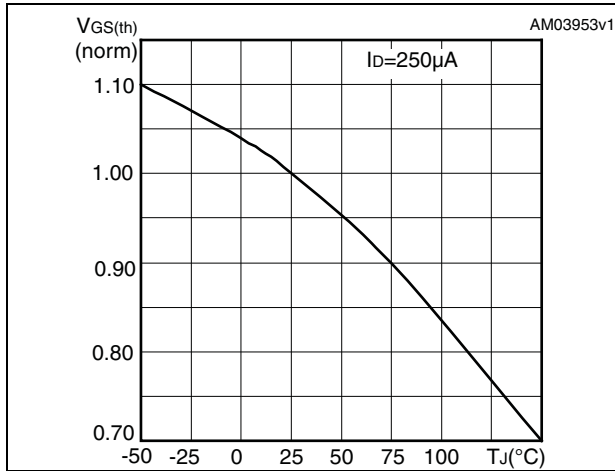
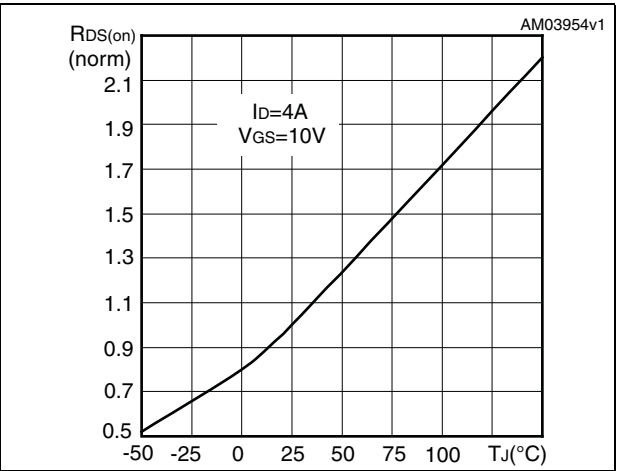


Figure 15. Normalized on-resistance vs temperature





### 3 Test circuits

Figure 16. Switching times test circuit for resistive load

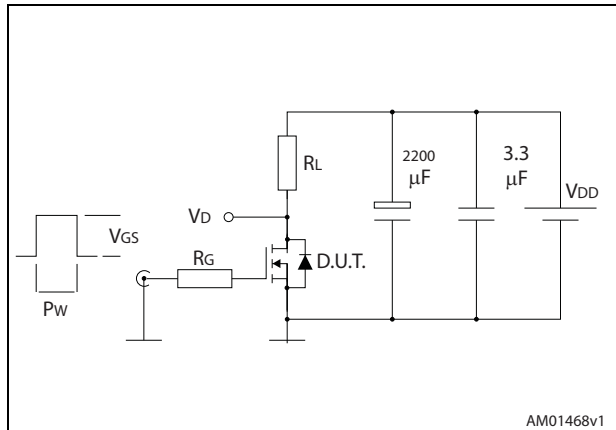


Figure 17. Gate charge test circuit

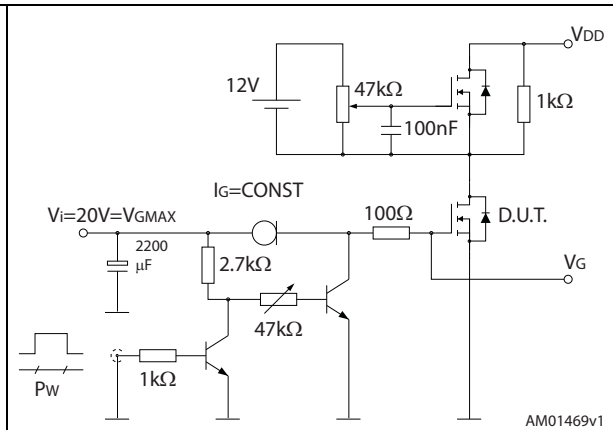


Figure 18. Test circuit for inductive load switching and diode recovery times

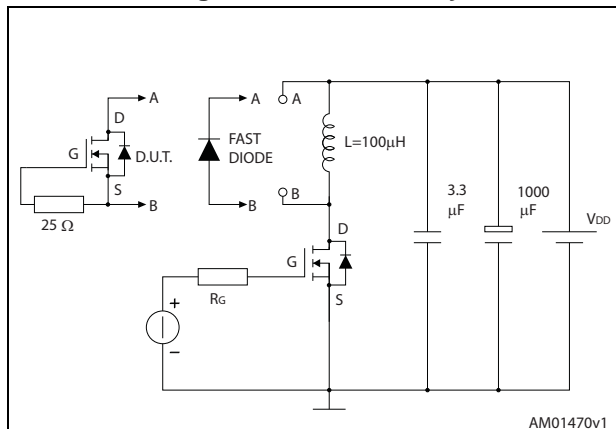


Figure 19. Unclamped inductive load test circuit

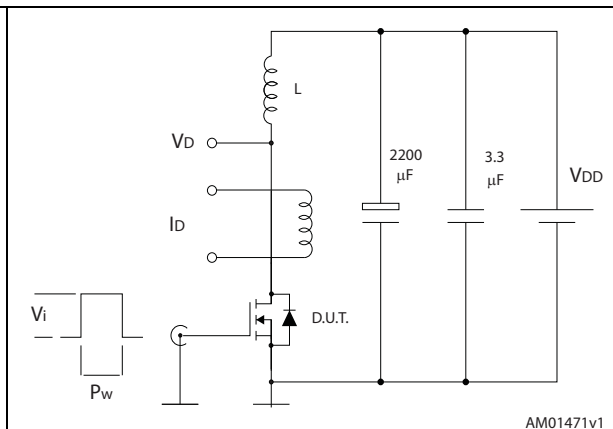


Figure 20. Unclamped inductive waveform

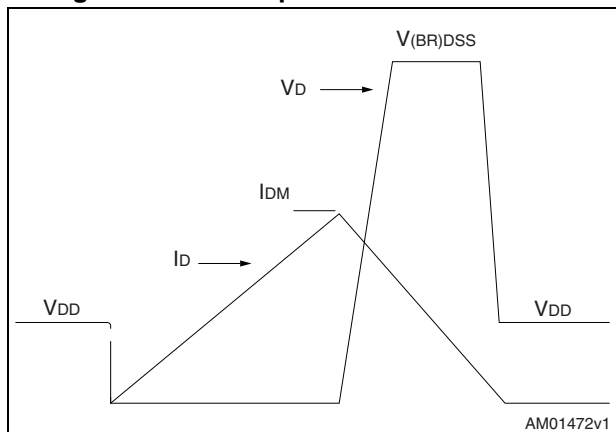
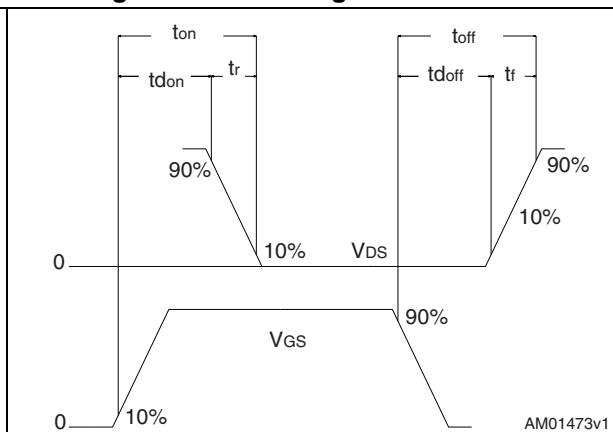


Figure 21. Switching time waveform



## 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 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°



Table 10. DPAK (TO-252) type E mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.18		2.39
A2			0.13
b	0.65		0.884
b4	4.95		5.46
c	0.46		0.61
c2	0.46		0.60
D	5.97		6.22
D1	5.21		
E	6.35		6.73
E1	4.32		
e		2.286	
e1		4.572	
H	9.94		10.34
L	1.50		1.78
L1		2.74	
L2	0.89		1.27
L4			1.02

Figure 23. DPAK (TO-252) type E drawing

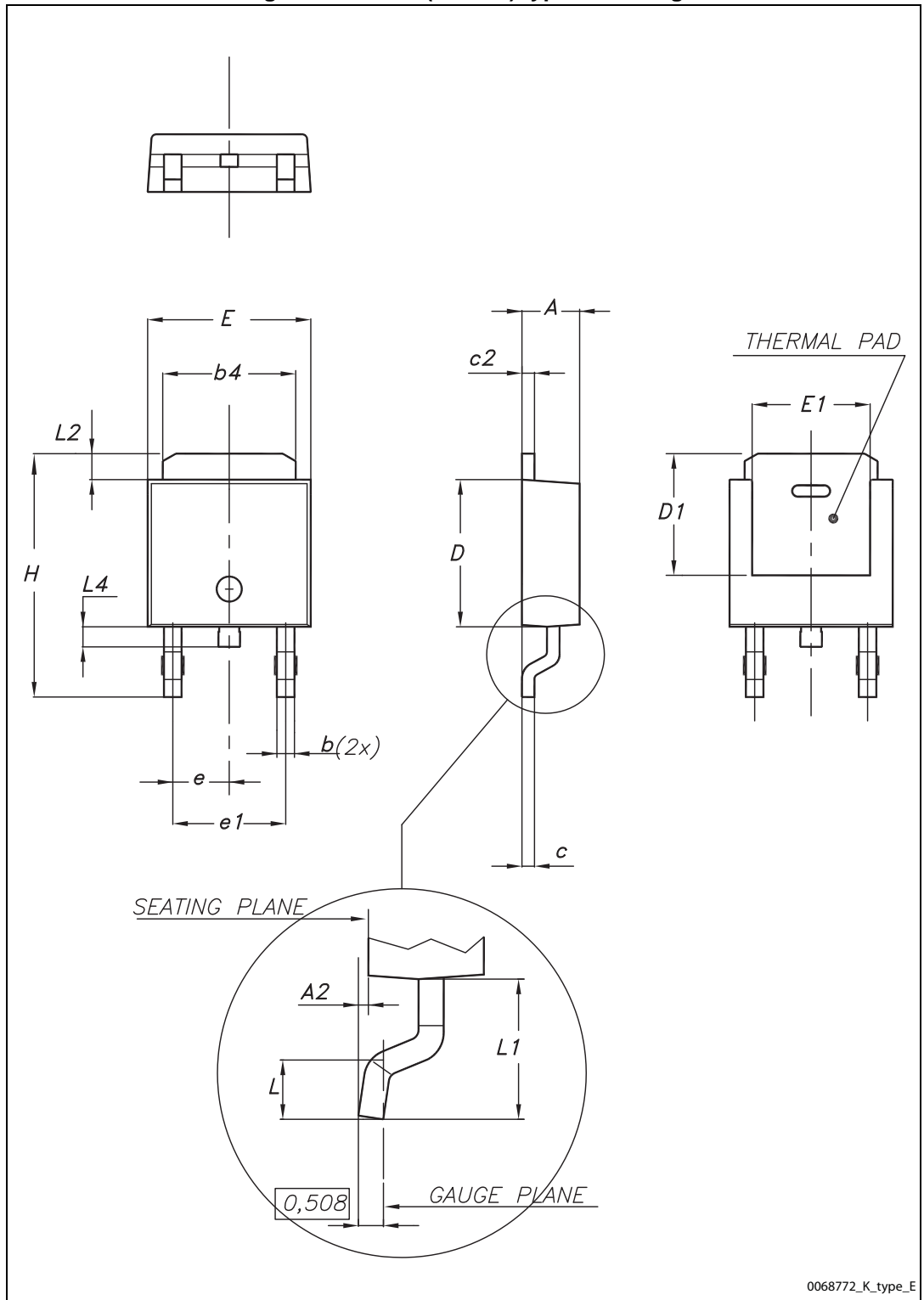
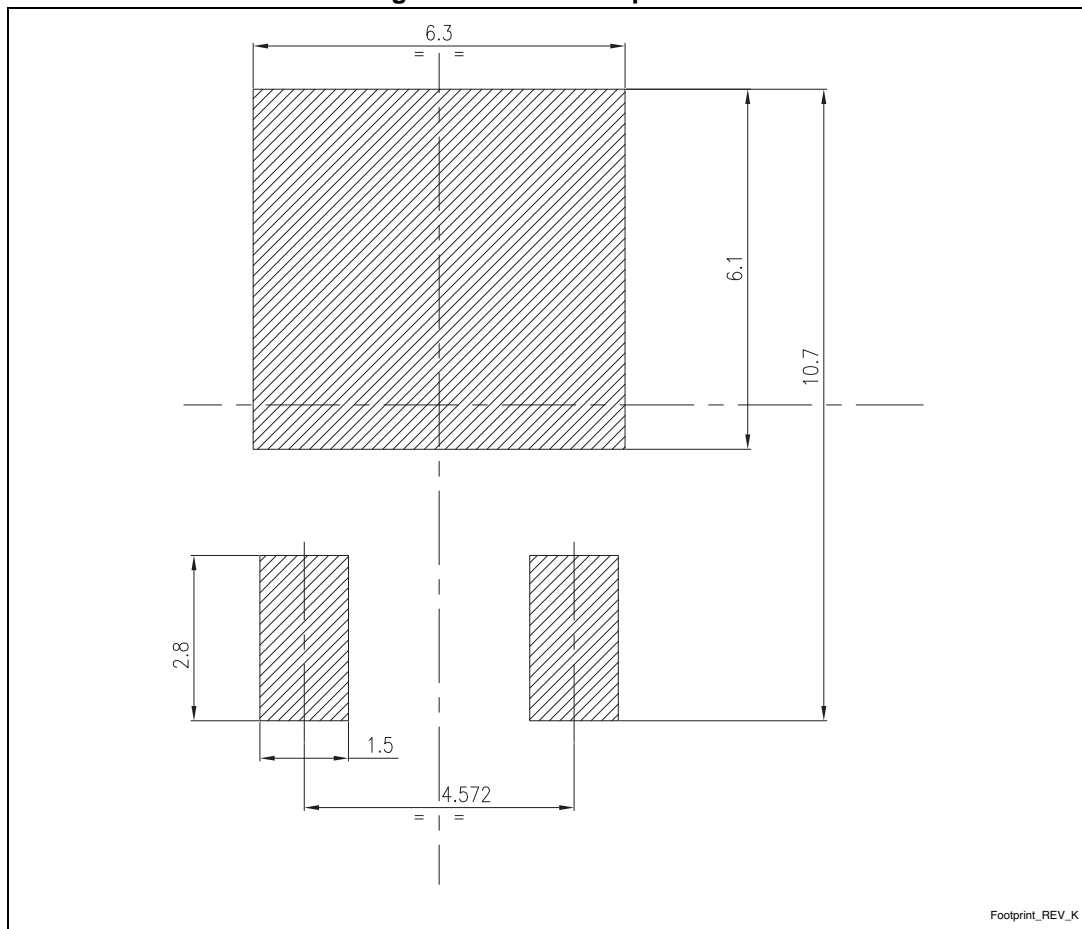


Figure 24. DPAK footprint (a)



Footprint\_REV\_K

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 25. TO-220FP drawing

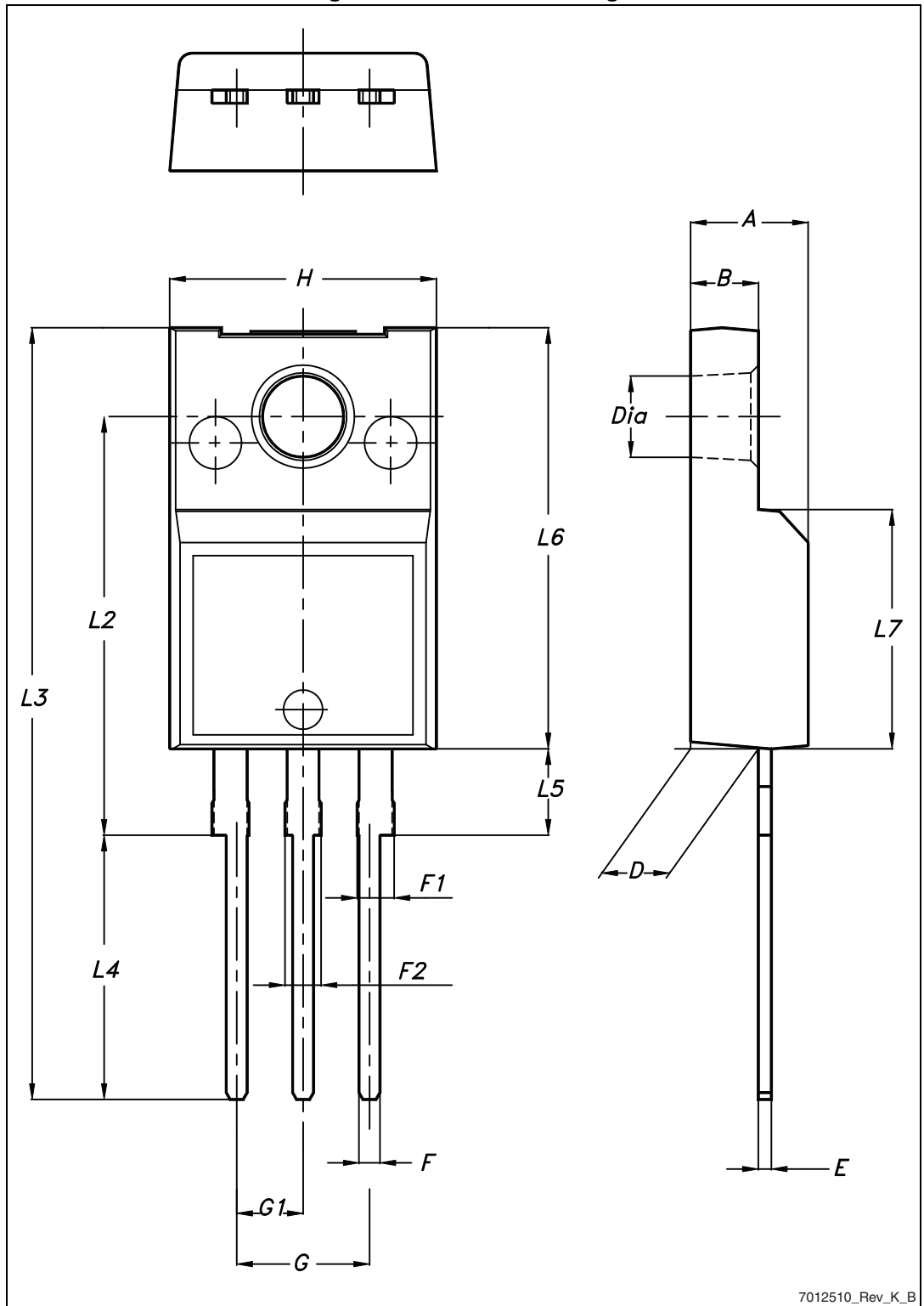


Table 12. I<sup>2</sup>PAK (TO-262) mechanical data

DIM.	mm.		
	min.	typ	max.
A	4.40		4.60
A1	2.40		2.72
b	0.61		0.88
b1	1.14		1.70
c	0.49		0.70
c2	1.23		1.32
D	8.95		9.35
e	2.40		2.70
e1	4.95		5.15
E	10		10.40
L	13		14
L1	3.50		3.93
L2	1.27		1.40

Figure 26. I<sup>2</sup>PAK (TO-262) drawing

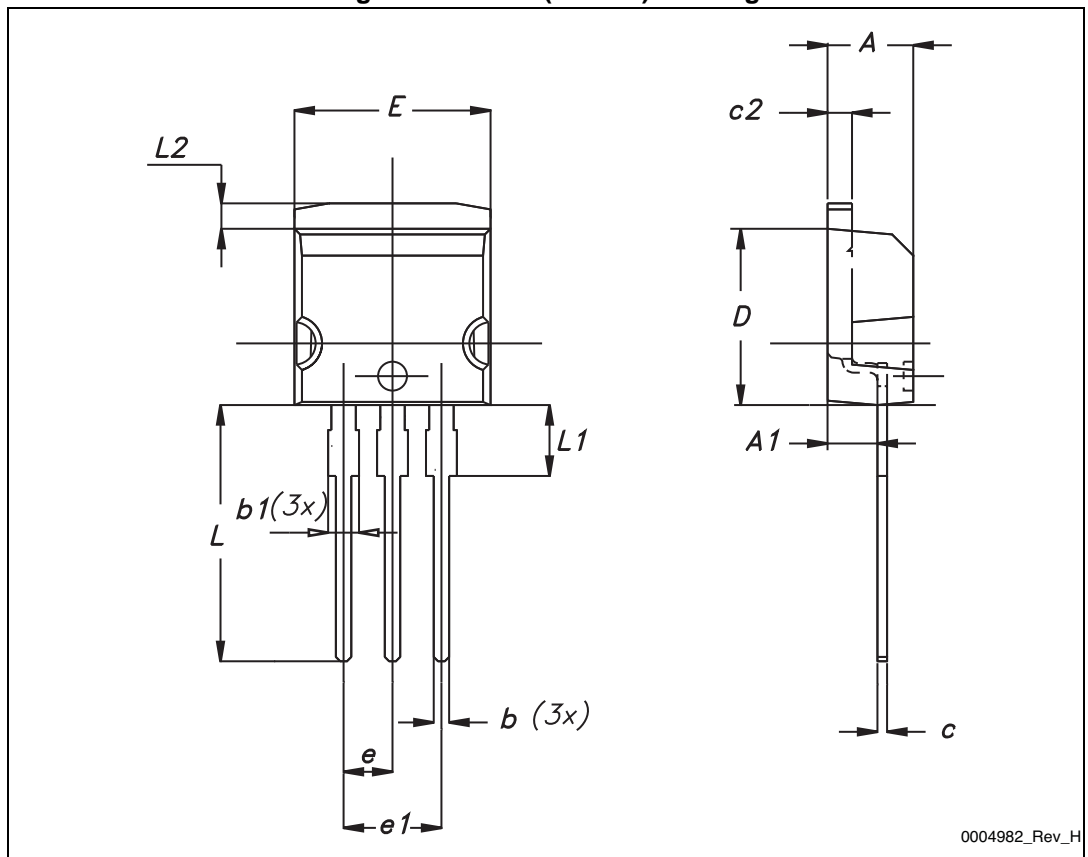


Table 13. TO-220 type A mechanical data

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

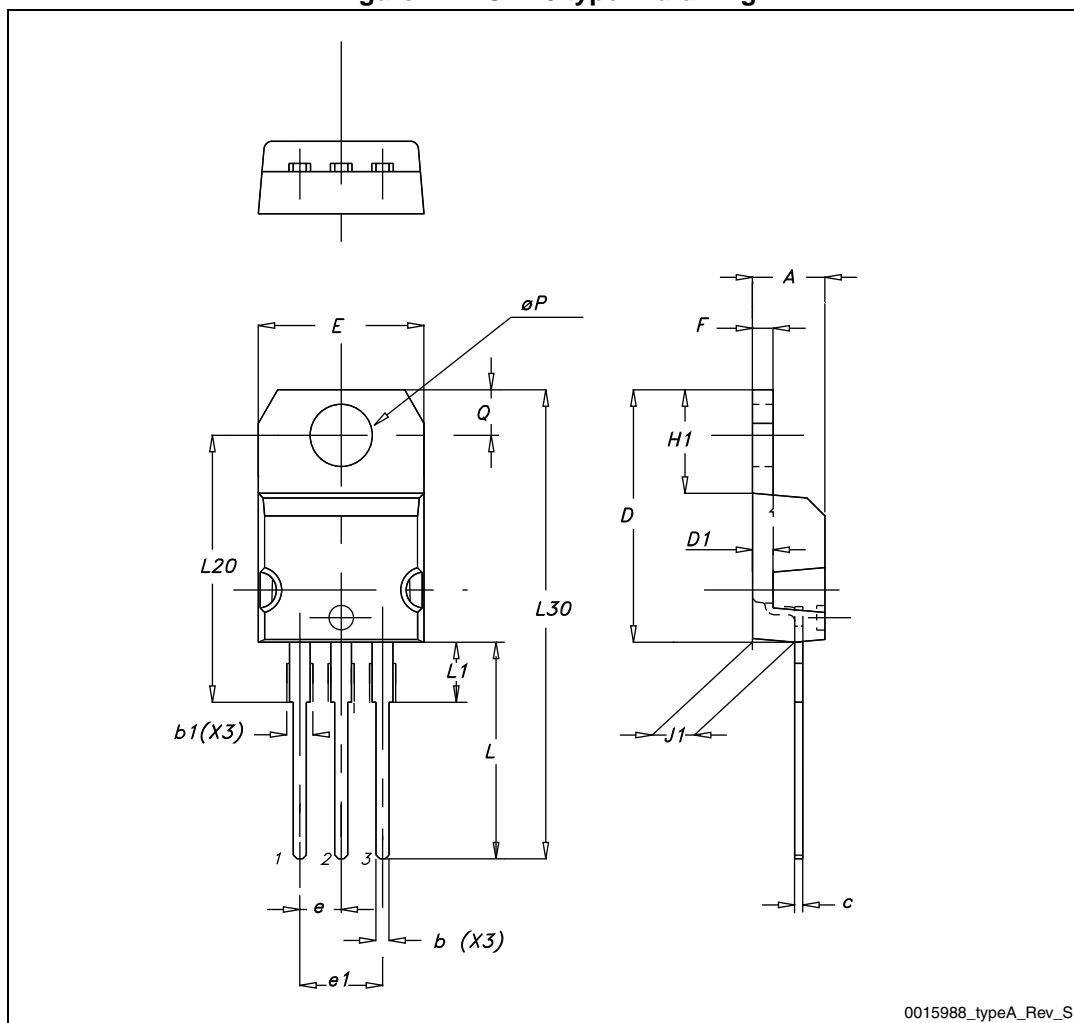
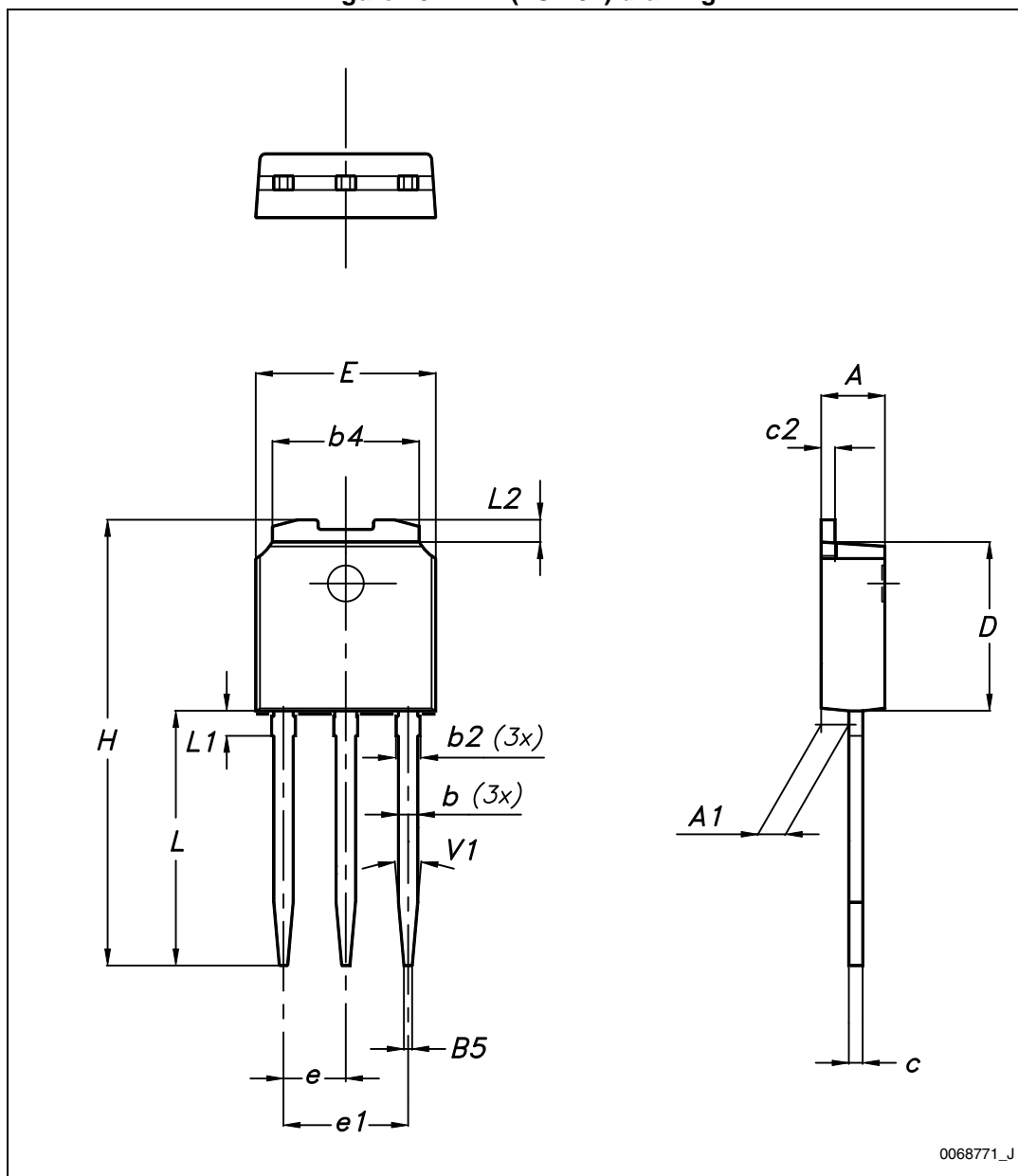


Table 14. IPAK (TO-251) mechanical data

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 28. IPAK (TO-251) drawing



## 5 Packaging mechanical data

Table 15. 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)

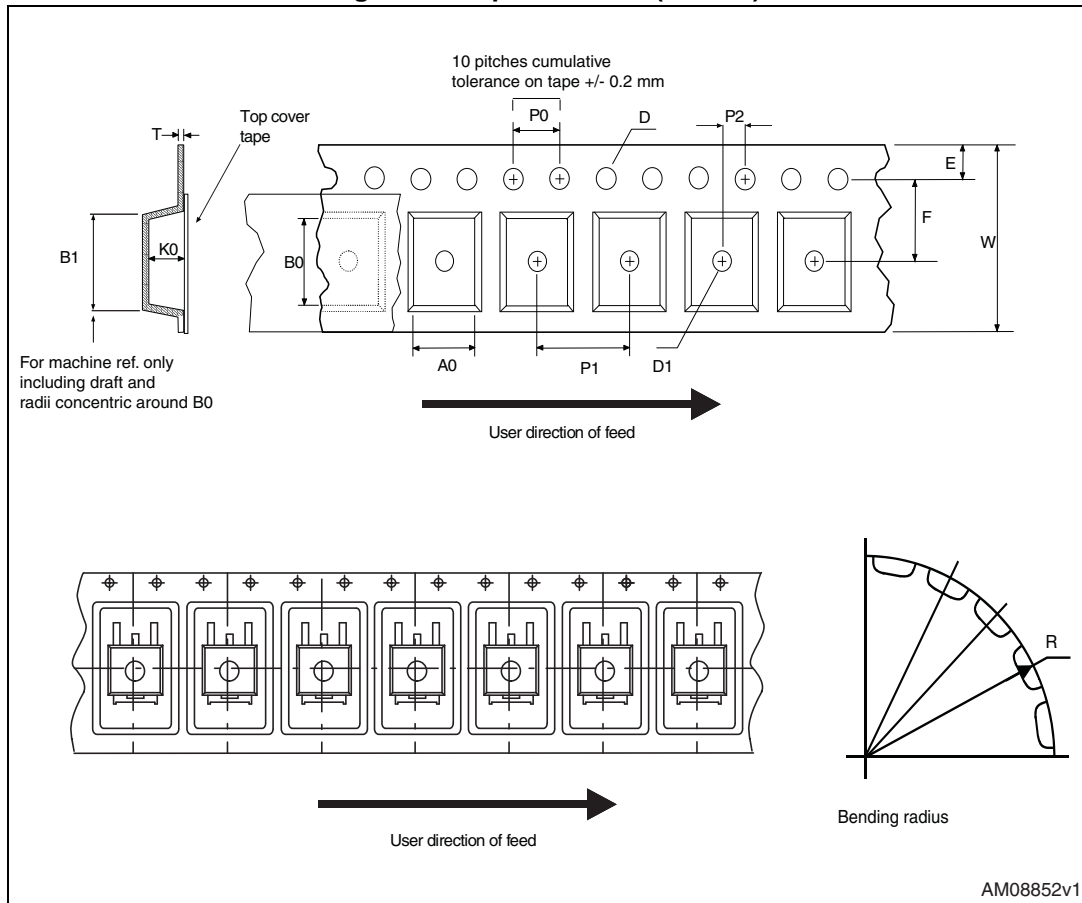
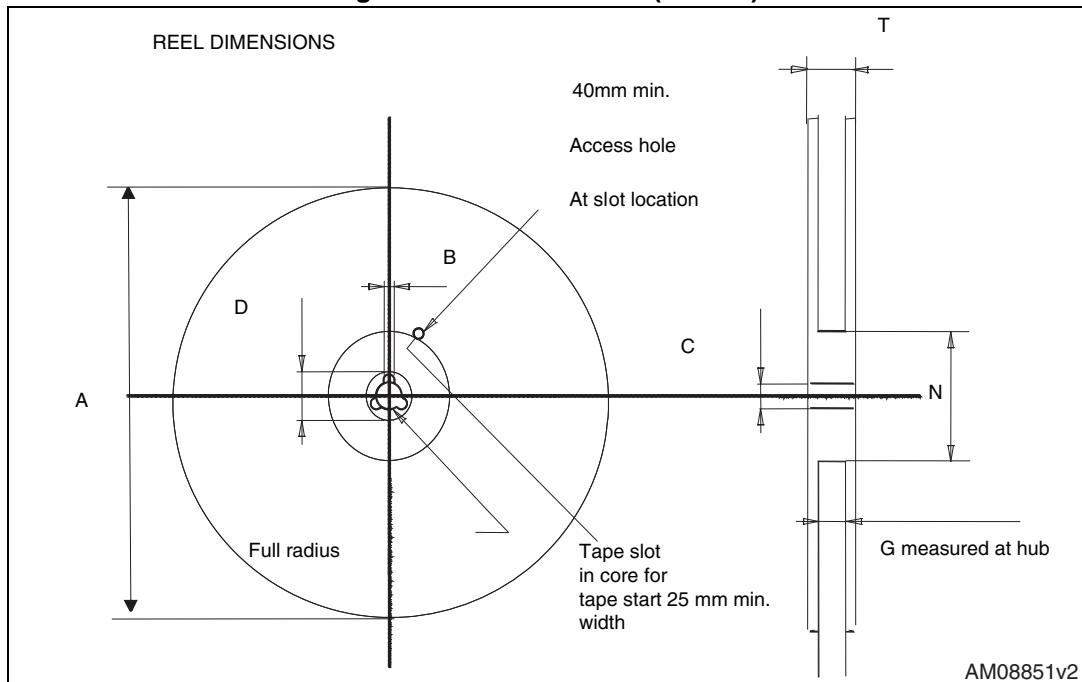


Figure 30. Reel for DPAK (TO-252)



## 6 Revision history

Table 16. Document revision history

Date	Revision	Changes
10-Jun-2009	1	First release
12-Jan-2010	2	<i>Figure 4: Safe operating area for TO-220FP</i> has been corrected
31-Mar-2010	3	<i>Features</i> have been corrected
17-Sep-2010	4	Content reworked to improve readability
24-Nov-2010	5	Corrected $I_D$ value
16-Nov-2012	6	Inserted new package and mechanical data: I <sup>2</sup> PAK
18-Jul-2013	7	Updated <i>Section 4: Package mechanical data</i> . Minor text changes.

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