

P-channel 60 V, 0.13  $\Omega$  typ., 10 A STripFET™ VI DeepGATE™ Power MOSFET in DPAK, TO-220FP, TO-220 and IPAK packages

Datasheet – production data

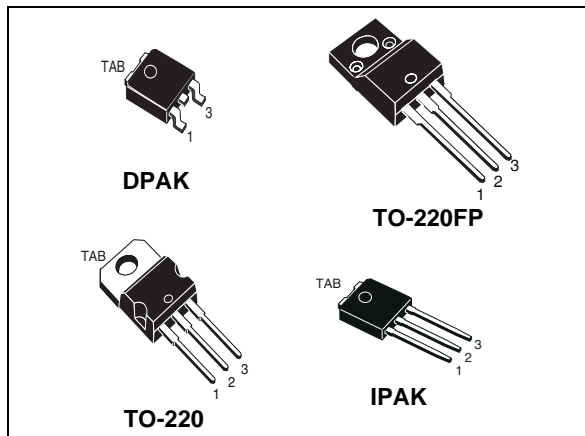
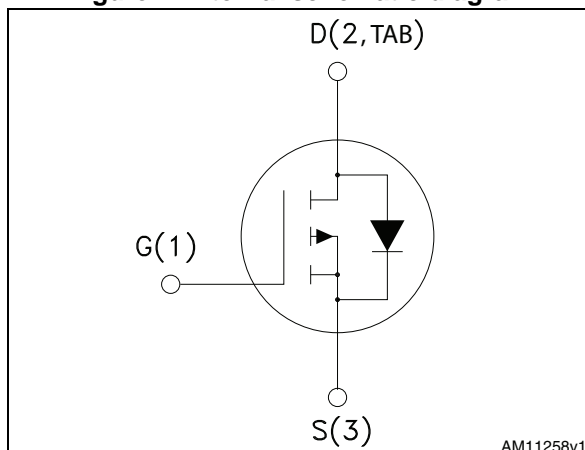


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DSS}$	$R_{DS(on) \max}$	$I_D$
STD10P6F6	60 V	0.16 $\Omega$	10 A
STF10P6F6			
STP10P6F6			
STU10P6F6			

- $R_{DS(on)} * Q_g$  industry benchmark
- Extremely low on-resistance  $R_{DS(on)}$
- High avalanche ruggedness
- Low gate drive power losses

## Applications

- Switching applications

## Description

These devices are P-channel Power MOSFETs developed using the 6<sup>th</sup> generation of STripFET™ DeepGATE™ technology, with a new gate structure. The resulting Power MOSFETs exhibits the lowest  $R_{DS(on)}$  in all packages.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STD10P6F6	10P6F6	DPAK	Tape and reel
STF10P6F6		TO-220FP	Tube
STP10P6F6		TO-220	
STU10P6F6		IPAK	

**Note:** For the P-channel Power MOSFET the actual polarity of the voltages and the current must be reversed.

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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	60			V
$V_{GS}$	Gate-source voltage	± 20			V
$I_D^{(1)}$	Drain current (continuous) at $T_C = 25\text{ °C}$	10			A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	7.2			A
$I_{DM}^{(2)}$	Drain current (pulsed)	40			A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	35	20	30	W
$E_{AS}$	Single pulse avalanche energy (starting $T_J=25\text{ °C}$ , $I_D=3\text{ A}$ , $V_{DD}=40\text{ V}$ )	80			mJ
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{ s}$ ; $T_C=25\text{ °C}$ )		2500		V
$V_{DG}$	Drain-gate voltage ( $V_{GS} = 0$ )	20			V
$T_{stg}$	Storage temperature	-55 to 175			°C
$T_j$	Max. operating junction temperature	175			°C

- 1. Limited by package
- 2. Pulse width limited by safe operating area

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		DPAK	IPAK	TO-220FP	TO-220	
$R_{thj-case}$	Thermal resistance junction-case max	4.29		7.5	5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max		100	62.5	62.5	°C/W
$R_{thj-pcb}$	Thermal resistance junction-pcb max <sup>(1)</sup>	50				°C/W

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

*Note: For the P-channel Power MOSFET the actual polarity of the voltages and the current must be reversed.*

## 2 Electrical characteristics

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown Voltage	$I_D = 250\ \mu\text{A}$ , $V_{GS} = 0$	60			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 60\text{ V}$			1	$\mu\text{A}$
		$V_{DS} = 60\text{ V}$ , $T_C = 125\text{ °C}$			10	$\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\ \mu\text{A}$	2		4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 5\text{ A}$		0.13	0.16	$\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 48\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	340	-	pF
$C_{oss}$	Output capacitance		-	40	-	pF
$C_{rss}$	Reverse transfer capacitance		-	20	-	pF
$Q_g$	Total gate charge	$V_{DD} = 30\text{ V}$ , $I_D = 10\text{ A}$	-	6.4	-	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10\text{ V}$	-	1.7	-	nC
$Q_{gd}$	Gate-drain charge	Figure 16	-	1.7	-	nC

Note: For the P-channel Power MOSFET the actual polarity of the voltages and the current must be reversed.

**Table 6. Switching on/off (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 48\text{ V}$ , $I_D = 5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ Figure 15	-	64	-	ns
$t_r$	Rise time		-	5.3	-	ns
$t_{d(off)}$	Turn-off delay time		-	14	-	ns
$t_f$	Fall time		-	3.7	-	ns

Table 7. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		10	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		40	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 5\text{ A}, V_{GS} = 0$	-		1.1	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 10\text{ A},$ $di/dt = 100\text{ A}/\mu\text{s},$ $V_{DD} = 48\text{ V}$ <i>Figure 17</i>	-	20		ns
$Q_{rr}$	Reverse recovery charge		-	17.8		nC
$I_{RRM}$	Reverse recovery current		-	1.8		A

1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

*Note:* For the P-channel Power MOSFET the actual polarity of the voltages and the current must be reversed.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for DPAK, TO-220 and IPAK

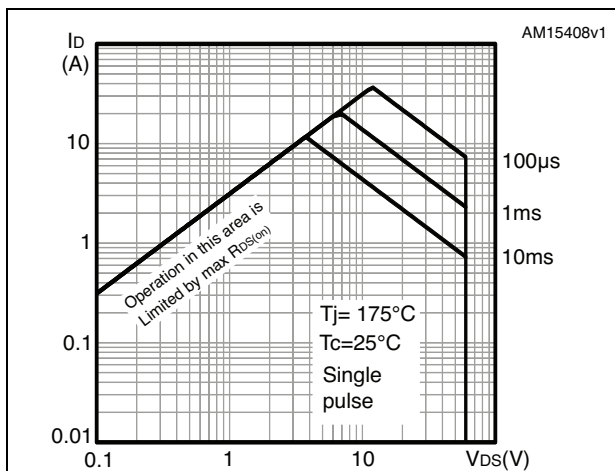


Figure 3. Thermal impedance DPAK, TO-220 and IPAK

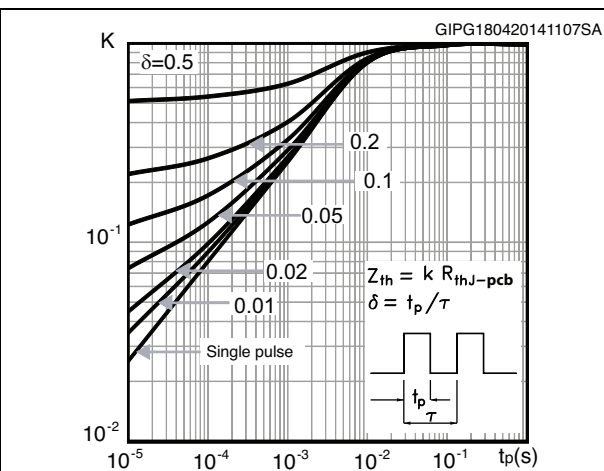


Figure 4. Safe operating area for TO-220FP

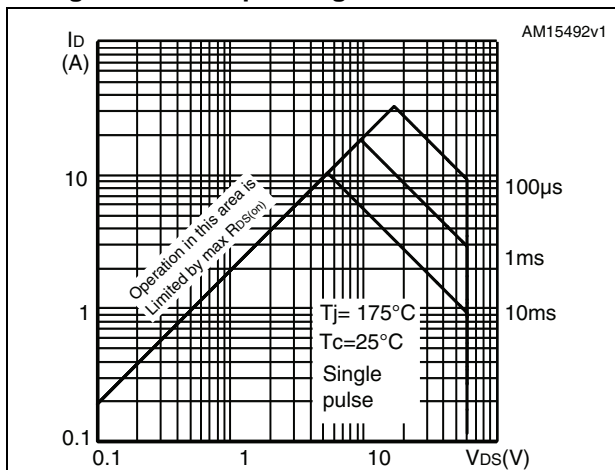


Figure 5. Thermal impedance for TO-220FP

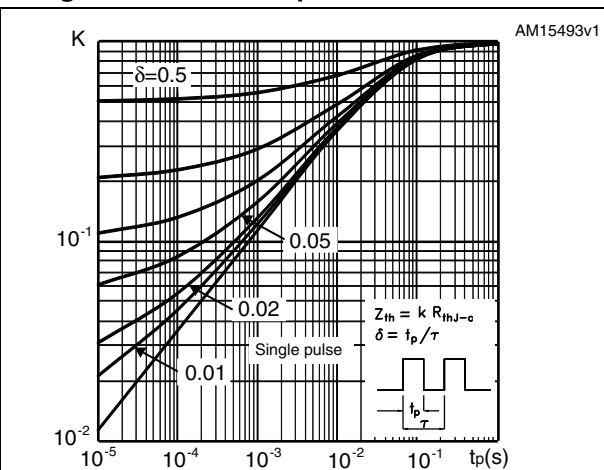


Figure 6. Output characteristics

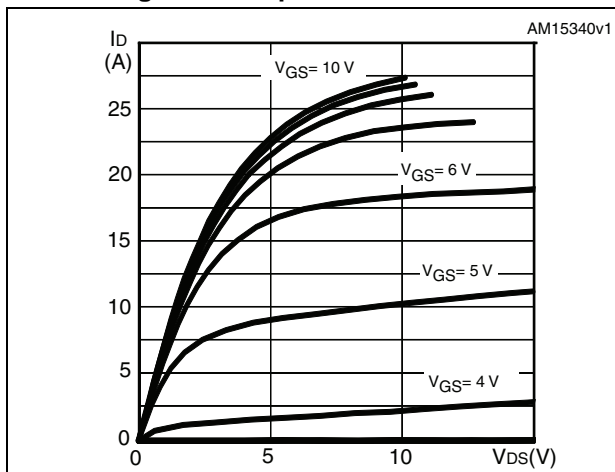


Figure 7. Transfer characteristics

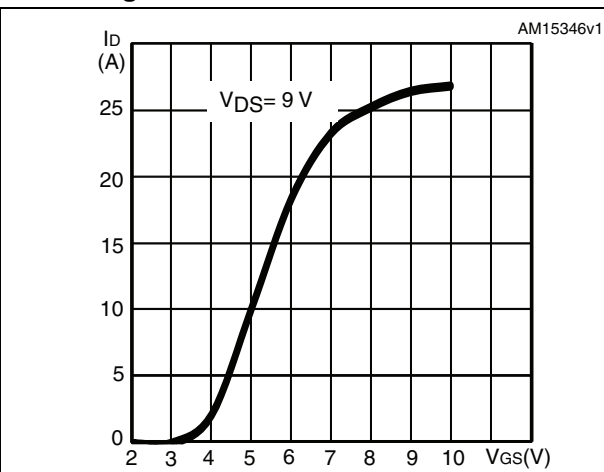


Figure 8. Gate charge vs gate-source voltage

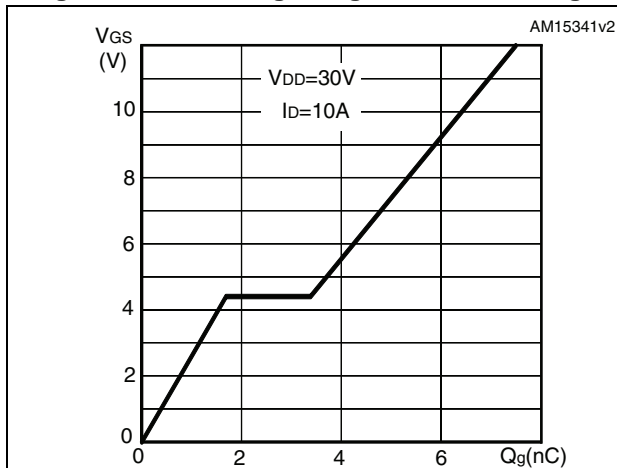


Figure 9. Static drain-source on-resistance

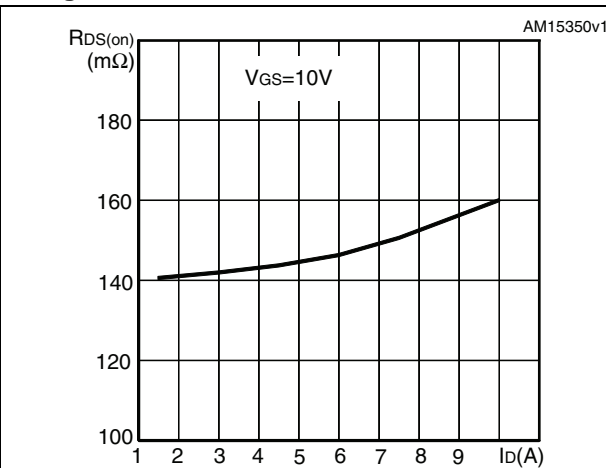


Figure 10. Capacitance variations

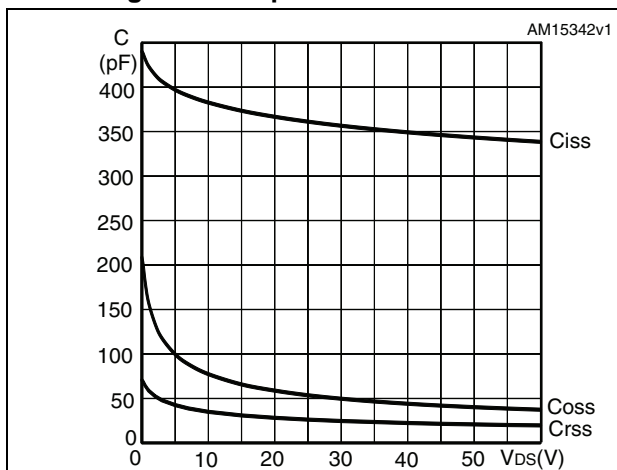


Figure 11. Normalized  $V_{(BR)DSS}$  vs temperature

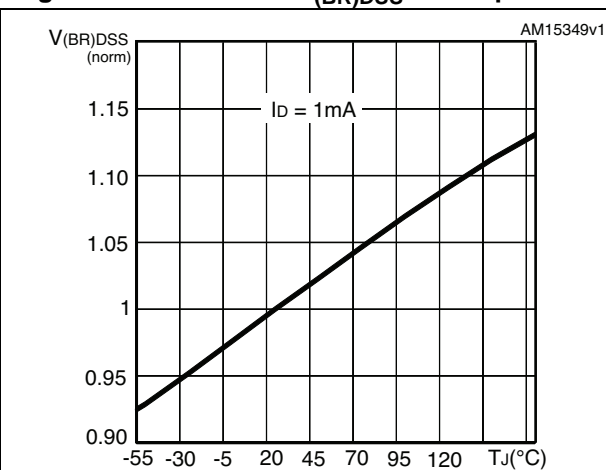


Figure 12. Normalized gate threshold voltage vs temperature

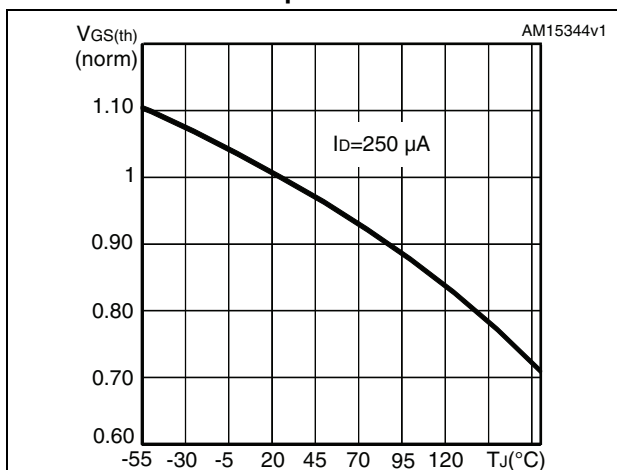


Figure 13. Normalized on-resistance vs temperature

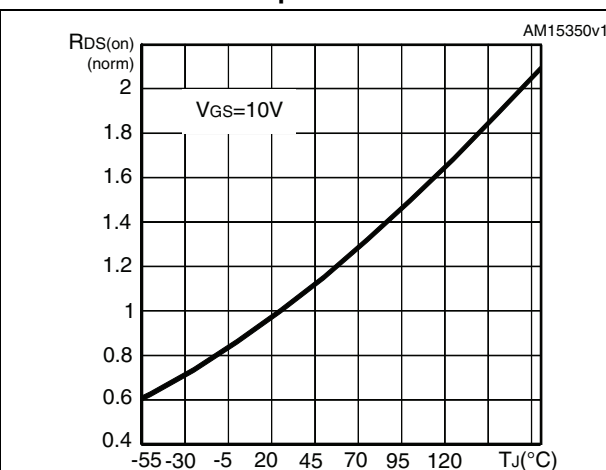
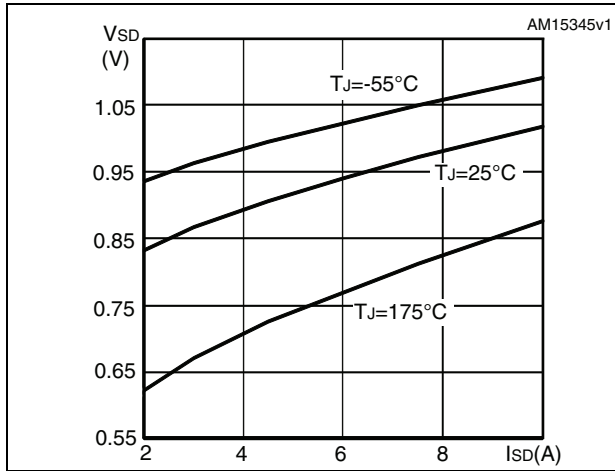


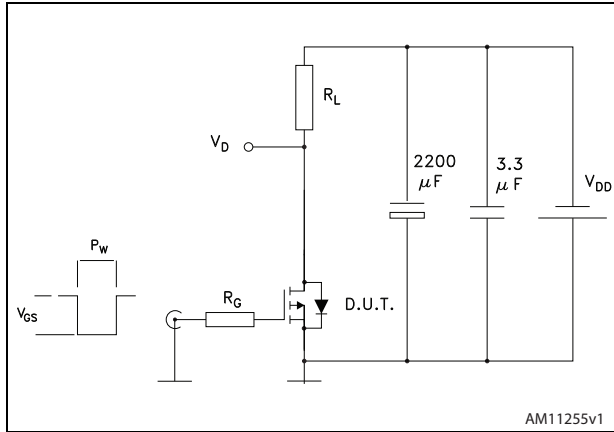
Figure 14. Source-drain diode forward characteristics



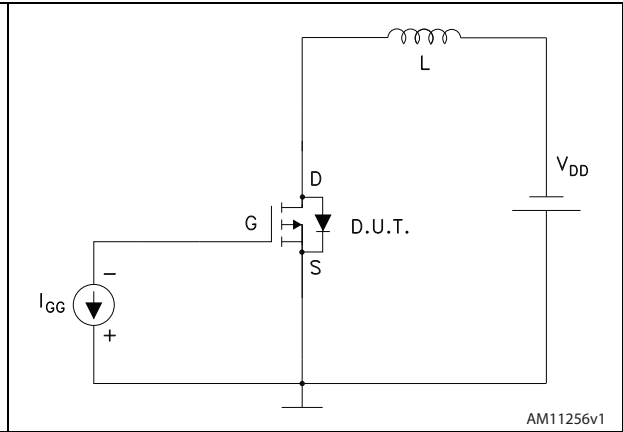


### 3 Test circuits

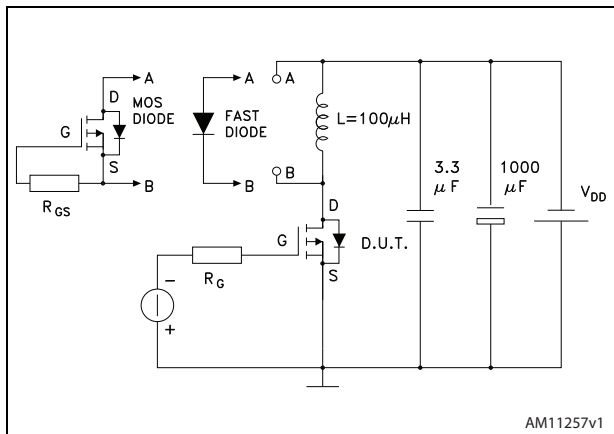
**Figure 15. Switching times test circuit for resistive load**



**Figure 16. Gate charge test circuit**



**Figure 17. Test circuit for diode recovery behaviour**



## 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.

4.1 DPAK, STD10P6F6

Figure 18. DPAK (TO-252) type A drawing

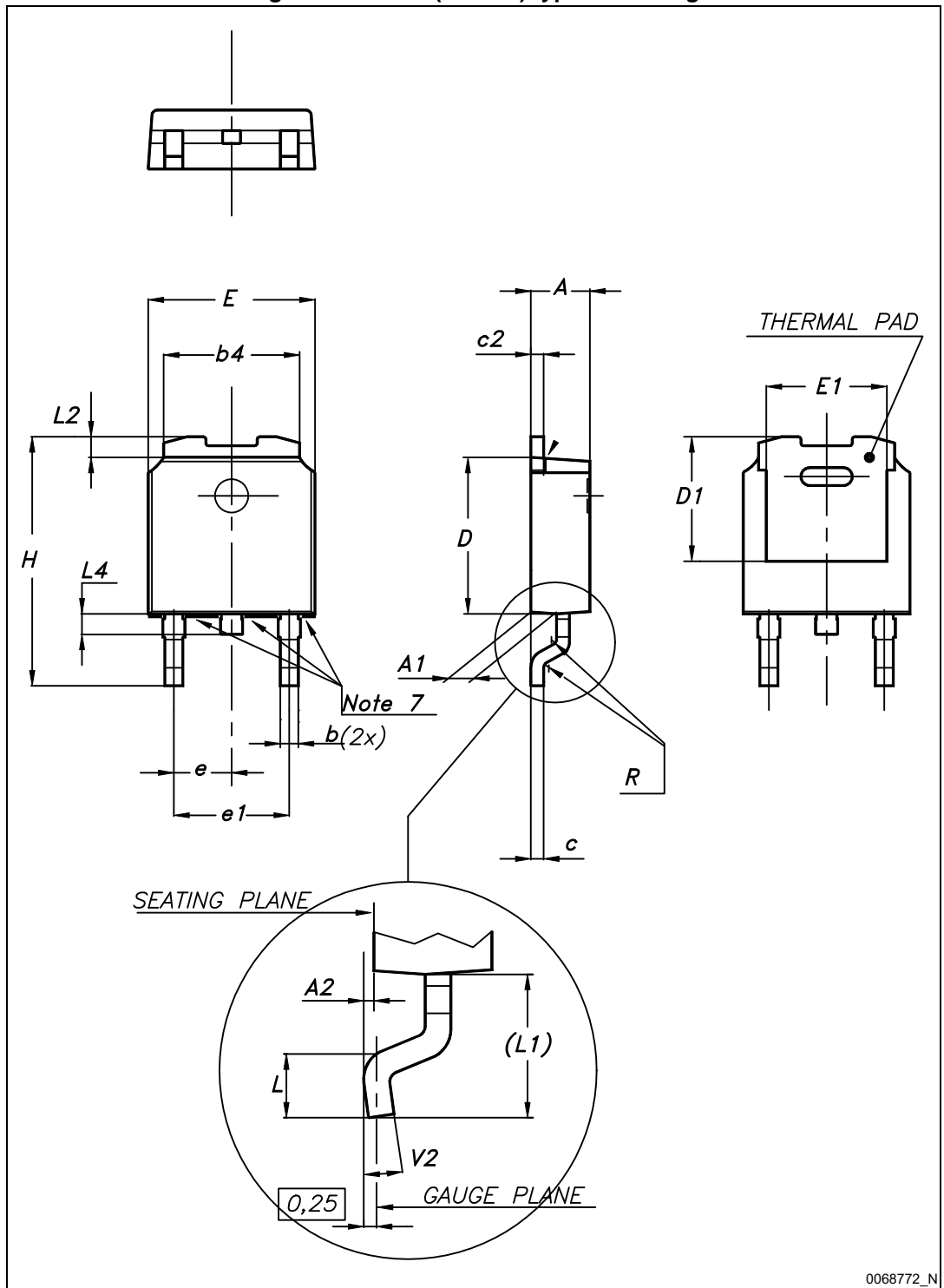
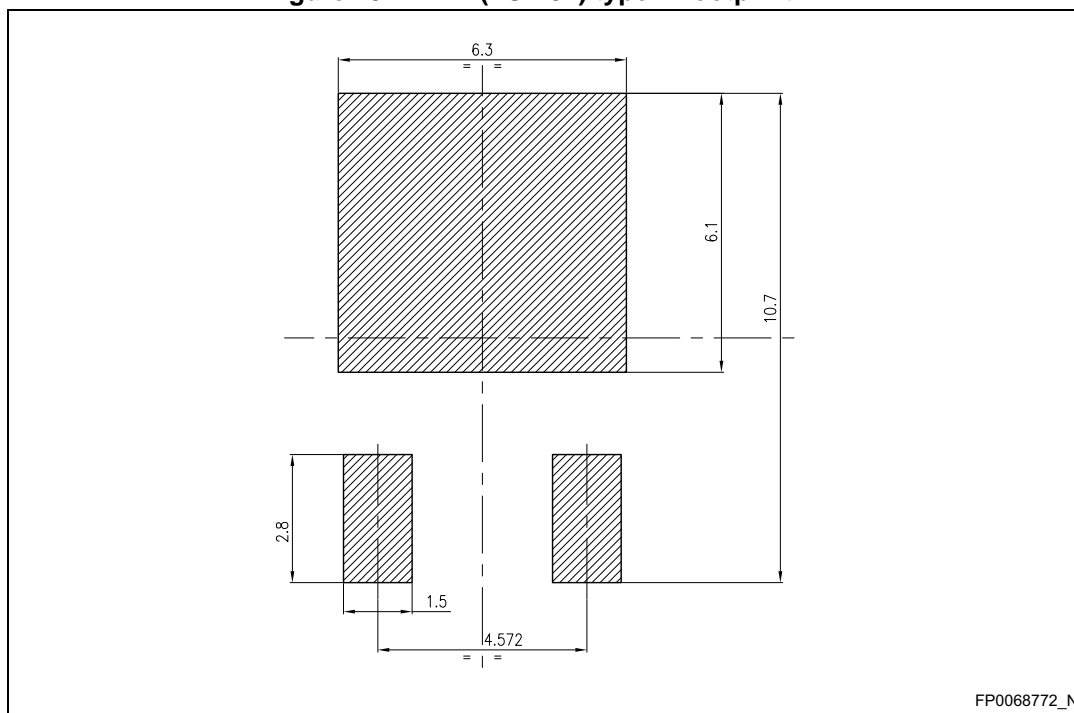


Table 8. DPAK (TO-252) type A mechanical data

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 19. DPAK (TO-252) type A footprint (a)

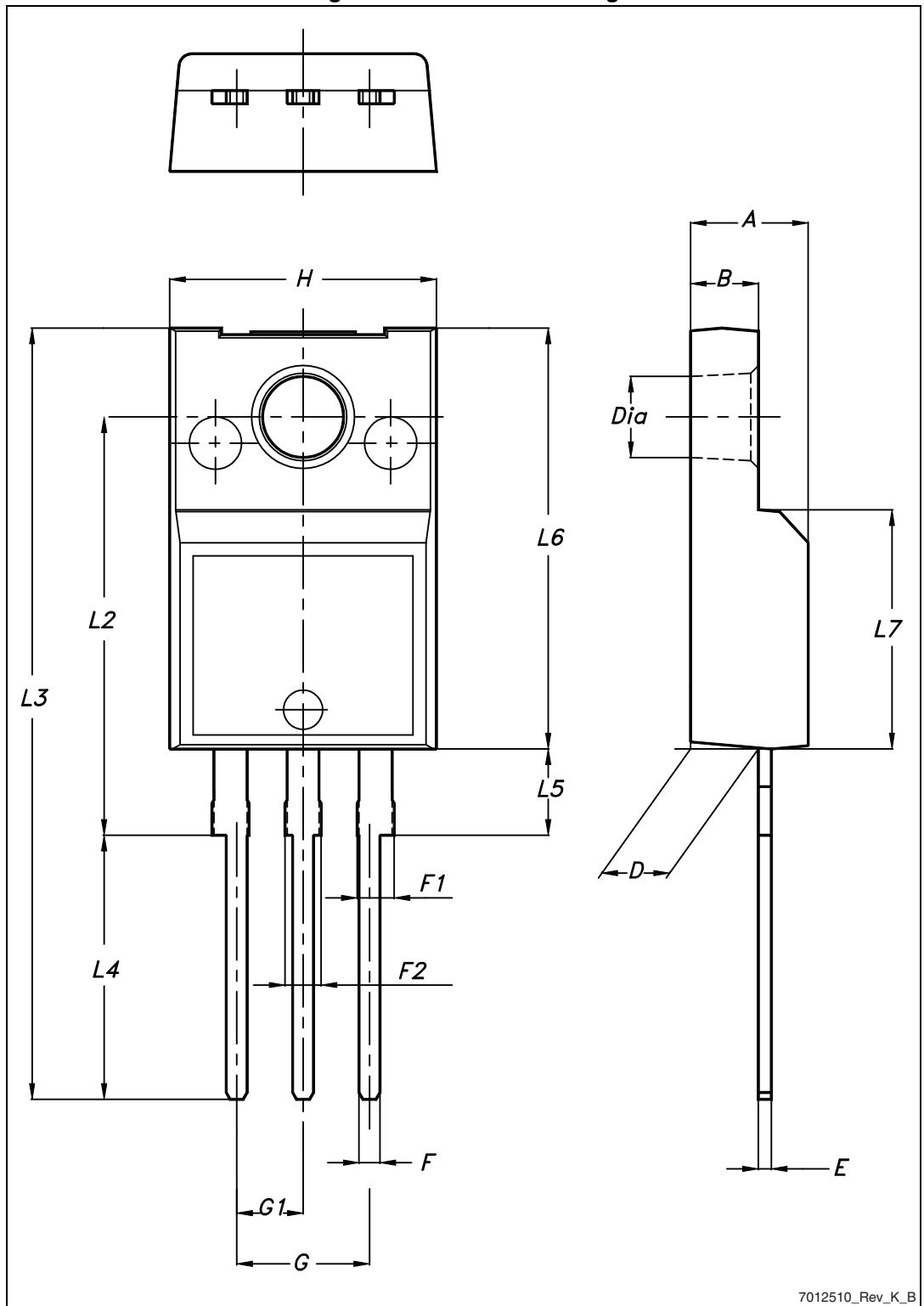


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a. All dimensions are in millimeters

### 4.2 TO-220FP, STF10P6F6

Figure 20. TO-220FP drawing



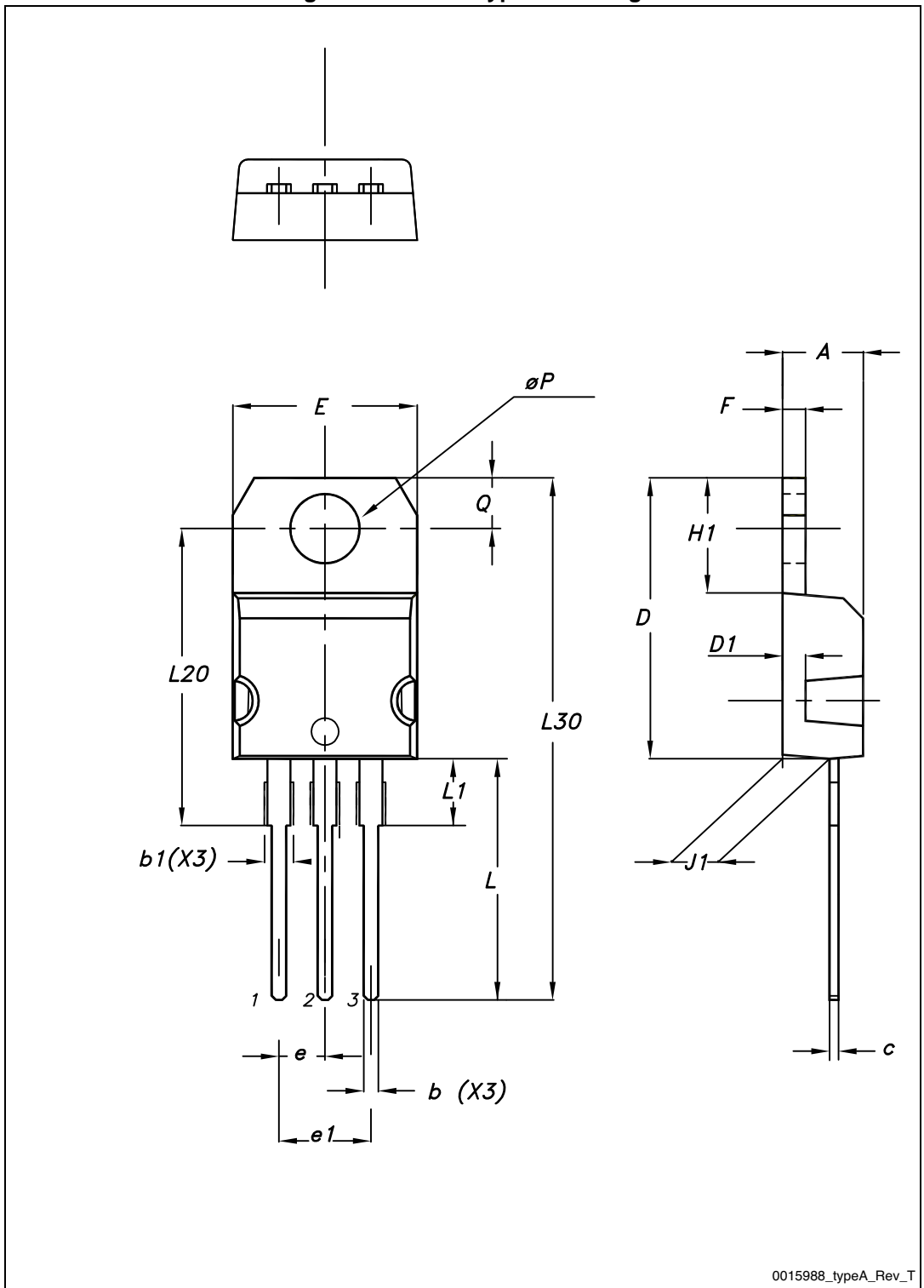
7012510\_Rev\_K\_B

Table 9. 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

### 4.3 TO-220, STP10P6F6

Figure 21. TO-220 type A drawing



0015988\_typeA\_Rev\_T



Table 10. 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

### 4.4 IPAK, STU10P6F6

Figure 22. IPAK (TO-251) drawing

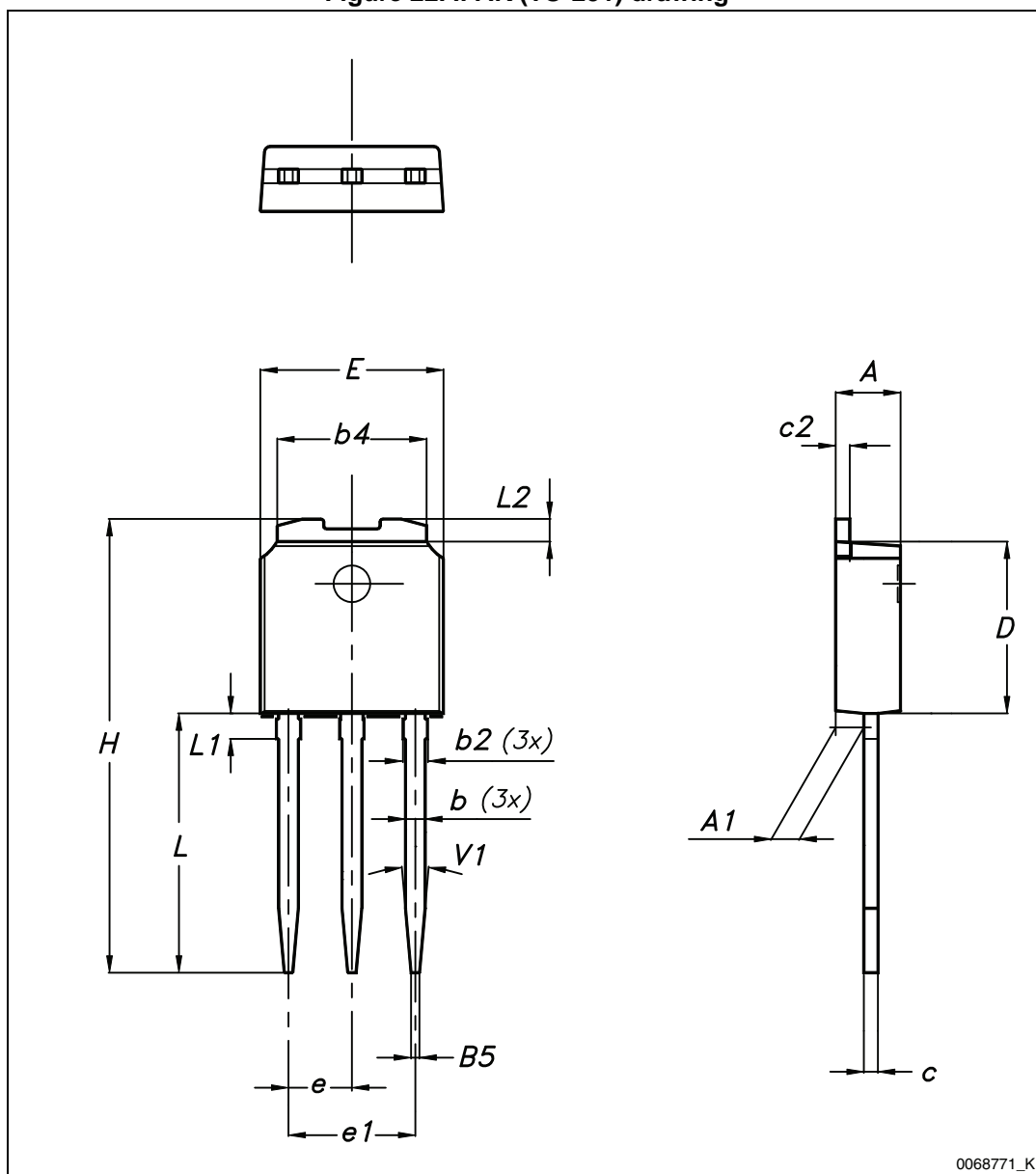


Table 11. IPAK (TO-251) mechanical data

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°	

# 5 Packaging mechanical data

Figure 23. Tape for DPAK (TO-252)

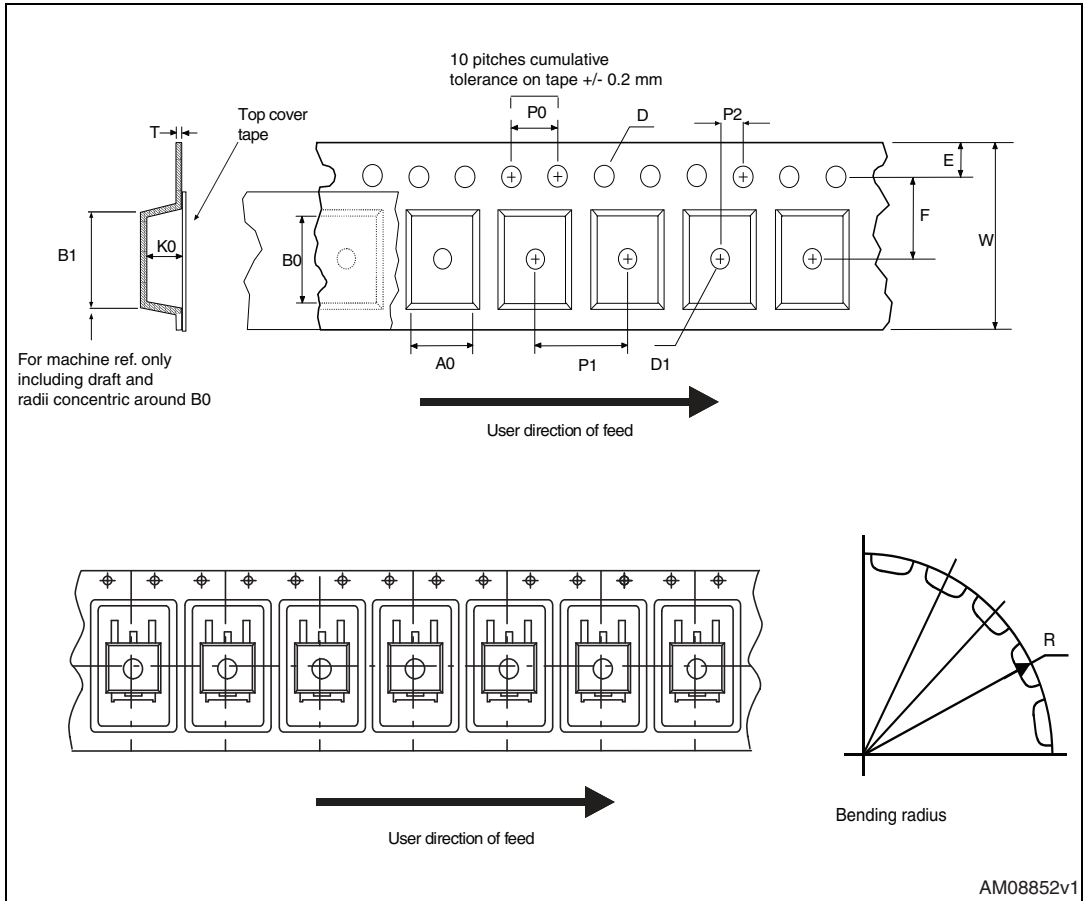


Figure 24. Reel for DPAK (TO-252)

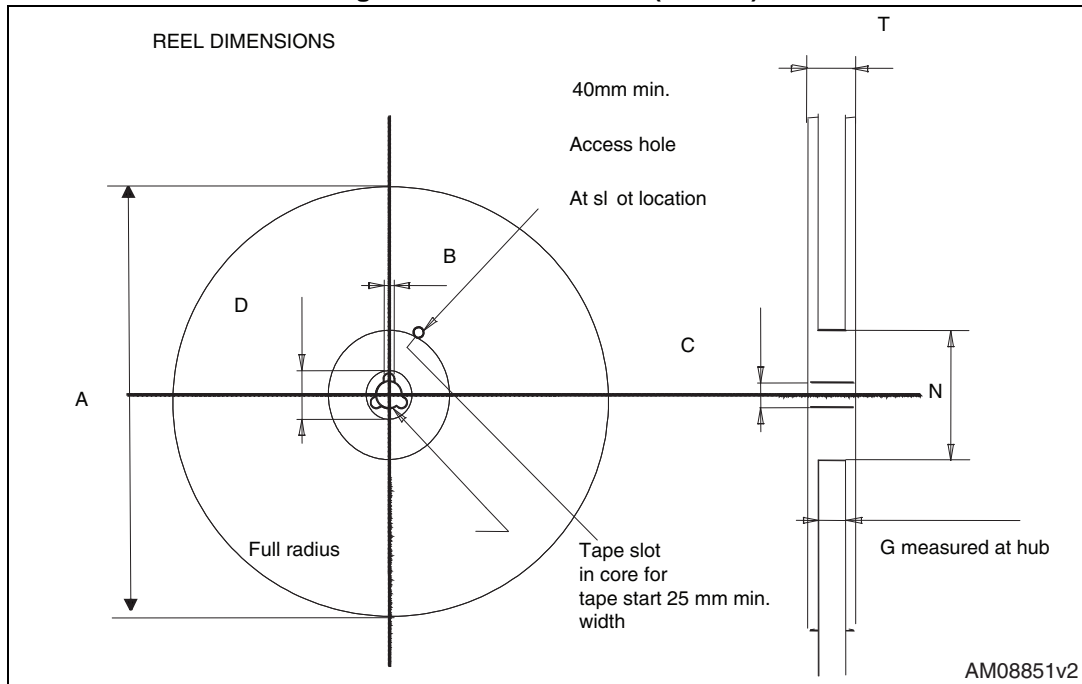


Table 12. DPAK (TO-252) tape and reel mechanical data

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			

## 6 Revision history

**Table 13. Document revision history**

Date	Revision	Changes
10-May-2012	1	First release.
20-Jun-2012	2	Updated title on the cover page. Updated all parameter values in <a href="#">Table 5</a> , <a href="#">Table 6</a> and <a href="#">Figure 1</a> .
17-May-2013	3	<ul style="list-style-type: none"> <li>– Added: TO-220FP and IPAK packages</li> <li>– Updated: <math>R_{DS(on)}</math> value in cover page, <math>R_{thj-case}</math> values, <a href="#">Table 5</a>, <a href="#">6</a> and <a href="#">7</a> typical values</li> <li>– Updated mechanical data only for DPAK in <a href="#">Section 4: Package mechanical data</a></li> </ul>
24-Apr-2014	4	<ul style="list-style-type: none"> <li>– Updated: <a href="#">Figure 2</a> and <a href="#">3</a></li> <li>– Updated: <a href="#">Section 4.1: DPAK, STD10P6F6</a> and <a href="#">Section 4.3: TO-220, STP10P6F6</a></li> <li>– Minor text changes</li> </ul>

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