

# STD13NM60ND, STF13NM60ND, STP13NM60ND

N-channel 600 V, 0.32  $\Omega$  typ., 11 A, FDmesh™ II Power MOSFET (with fast diode) in DPAK, TO-220FP and TO-220 packages

Datasheet – production data

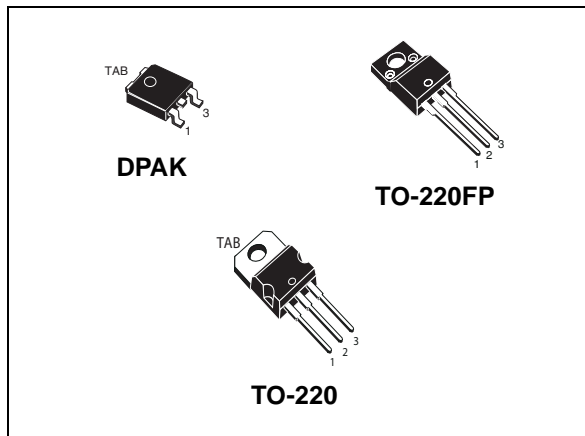
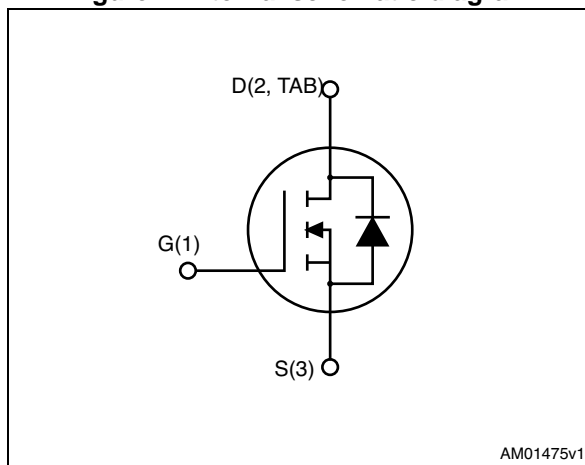


Figure 1. Internal schematic diagram



## Features

Order codes	$V_{DS} @ T_{Jmax}$	$R_{DS(on) max}$	$I_D$
STD13NM60ND	650 V	0.38 $\Omega$	11 A
STF13NM60ND			
STP13NM60ND			

- The worldwide best  $R_{DS(on)}$ \* area among fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

## Applications

- Switching applications

## Description

These FDmesh™ II Power MOSFETs with intrinsic fast-recovery body diode are produced using the second generation of MDmesh™ technology. Utilizing a new strip-layout vertical structure, these revolutionary devices feature extremely low on-resistance and superior switching performance. They are ideal for bridge topologies and ZVS phase-shift converters.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STD13NM60ND	13NM60ND	DPAK	Tape and reel
STF13NM60ND		TO-220FP	Tube
STP13NM60ND		TO-220	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		DPAK, TO-220	TO-220FP	
$V_{DS}$	Drain-source voltage	600		V
$V_{GS}$	Gate-source voltage	$\pm 25$		V
$I_D$	Drain current (continuous) at $T_C = 25^\circ\text{C}$	11	11 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100^\circ\text{C}$	6.93	6.93 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	44	44 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25^\circ\text{C}$	109	25	W
$dv/dt^{(3)}$	Peak diode recovery voltage slope	40		V/ns
$dv/dt^{(4)}$	MOSFET $dv/dt$ ruggedness	40		V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{s}; T_C=25^\circ\text{C}$ )		2500	V
$T_{stg}$	Storage temperature	-55 to 150		$^\circ\text{C}$
$T_j$	Max. operating junction temperature	150		$^\circ\text{C}$

- Limited by maximum junction temperature
- Pulse width limited by safe operating area
- $I_{SD} \leq 11\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ ,  $V_{DS(\text{peak})} \leq V_{(BR)DSS}$
- $V_{DS} \leq 480\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		DPAK	TO-220FP	TO-220	
$R_{thj-case}$	Thermal resistance junction-case max	1.15	5	1.15	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-amb max		62.5		$^\circ\text{C}/\text{W}$
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb max	50			$^\circ\text{C}/\text{W}$

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

**Table 4. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
$I_{AS}$	Avalanche current, repetitive or not-repetitive <sup>(1)</sup>	3	A
$E_{AS}$	Single pulse avalanche energy <sup>(2)</sup>	162	mJ

- Pulse width limited by  $T_j$  max
- starting  $T_j = 25^\circ\text{C}$ ,  $I_D = I_{AS}$ ,  $V_{DD} = 50\text{ V}$

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	600			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$ $V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}$ , $I_D = 5.5\text{ A}$		0.32	0.38	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	845	-	pF
$C_{oss}$	Output capacitance		-	47	-	pF
$C_{rss}$	Reverse transfer capacitance		-	2.5	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0$ , $V_{DS} = 0\text{ V to } 480\text{ V}$	-	121	-	pF
$R_g$	Gate input resistance	$f = 1\text{ MHz}$ Gate DC Bias = 0 Test signal level = 20 mV open drain	-	4.3	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 11\text{ A}$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18</a> )	-	24.5	-	nC
$Q_{gs}$	Gate-source charge		-	4.8	-	nC
$Q_{gd}$	Gate-drain charge		-	17	-	nC

1.  $C_{oss\text{ eq.}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 5.5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> )	-	46.5	-	ns
$t_r$	Rise time		-	10	-	ns
$t_{d(off)}$	Turn-off delay time		-	9.6	-	ns
$t_f$	Fall time		-	15.4	-	ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$I_{SD}$	Source-drain current		-		11	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		44	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 11\text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 100\text{ V}$ (see <a href="#">Figure 19</a> )	-	150		ns
$Q_{rr}$	Reverse recovery charge		-	755		nC
$I_{RRM}$	Reverse recovery current		-	12		A
$t_{rr}$	Reverse recovery time	$V_{DD} = 100\text{ V}$ $di/dt = 100\text{ A}/\mu\text{s}$ , $I_{SD} = 11\text{ A}$ $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 19</a> )	-	187		ns
$Q_{rr}$	Reverse recovery charge		-	1271		nC
$I_{RRM}$	Reverse recovery current		-	13.6		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 DPAK

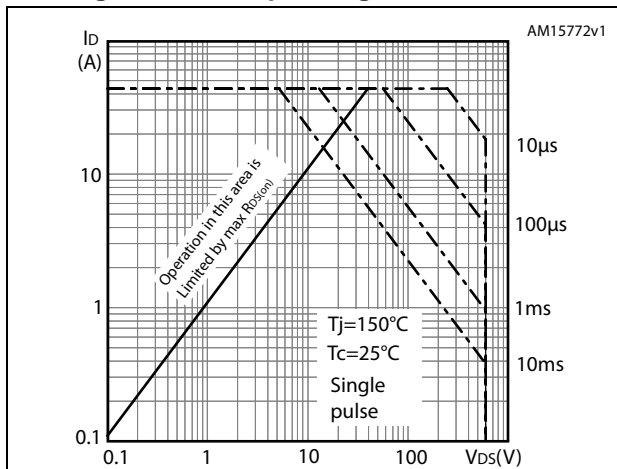


Figure 3. Thermal impedance for DPAK

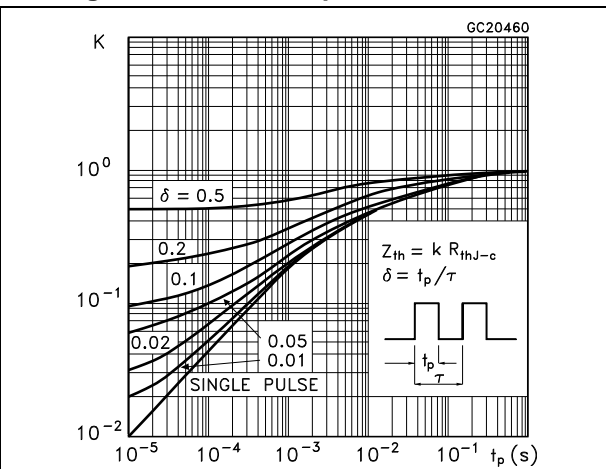


Figure 4. Safe operating area for TO-220FP

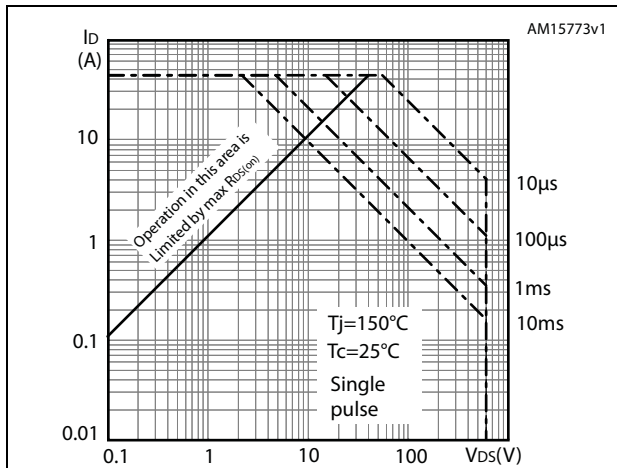


Figure 5. Thermal impedance for TO-220FP

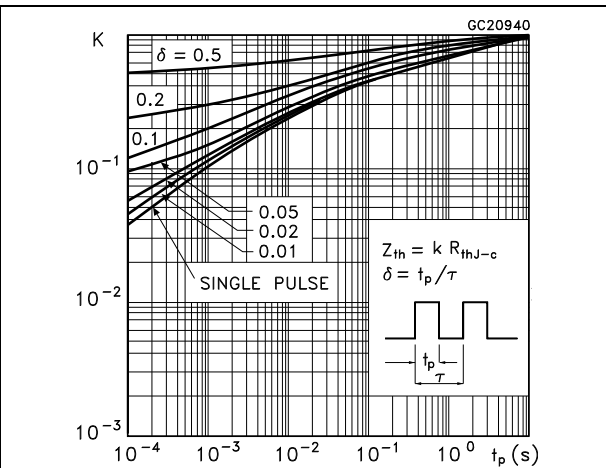


Figure 6. Safe operating area for TO-220

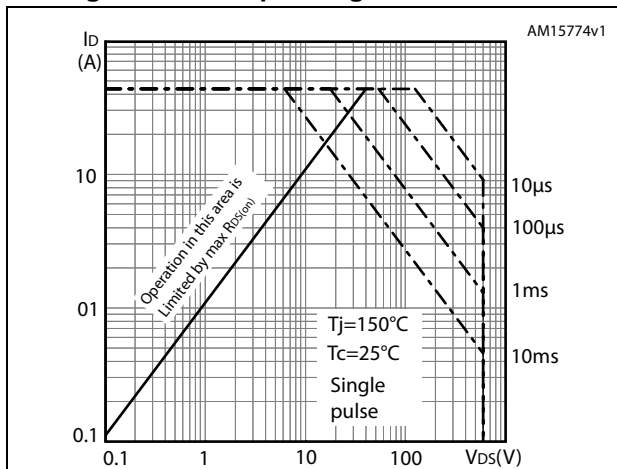


Figure 7. Thermal impedance for TO-220

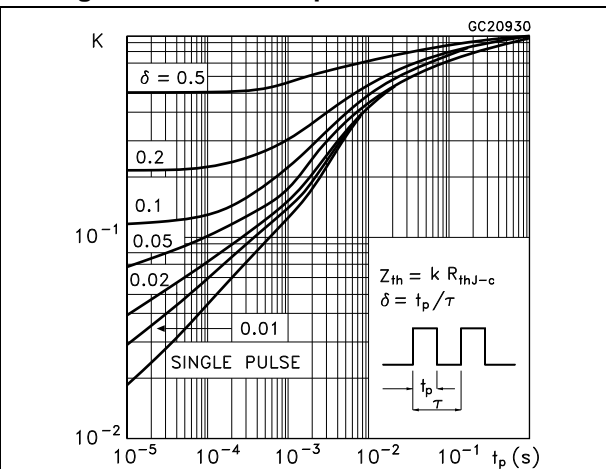


Figure 8. Output characteristics

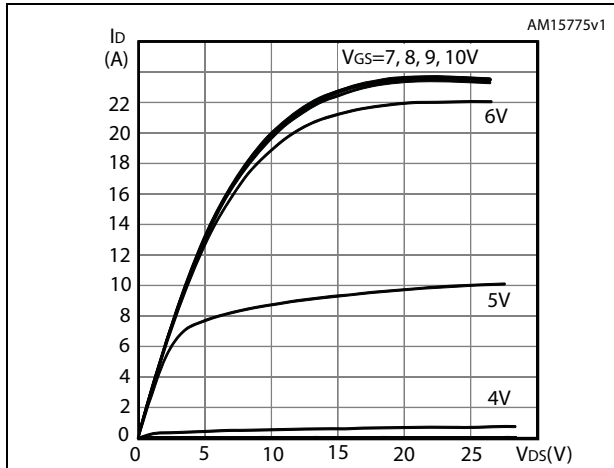


Figure 9. Transfer characteristics

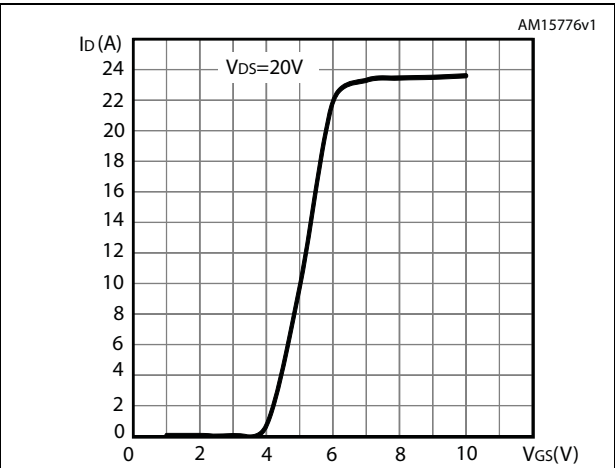


Figure 10. Gate charge vs gate-source voltage

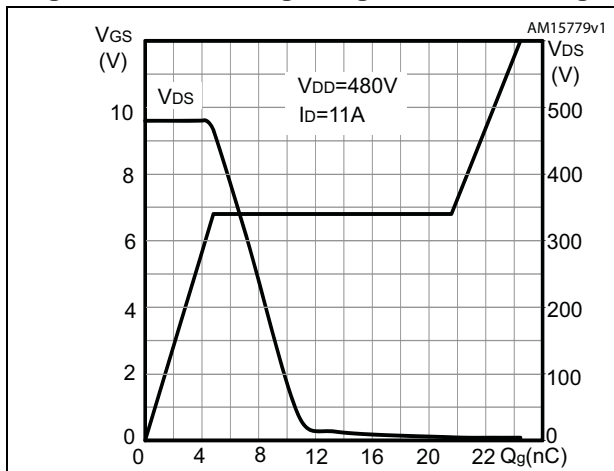


Figure 11. Static drain-source on-resistance

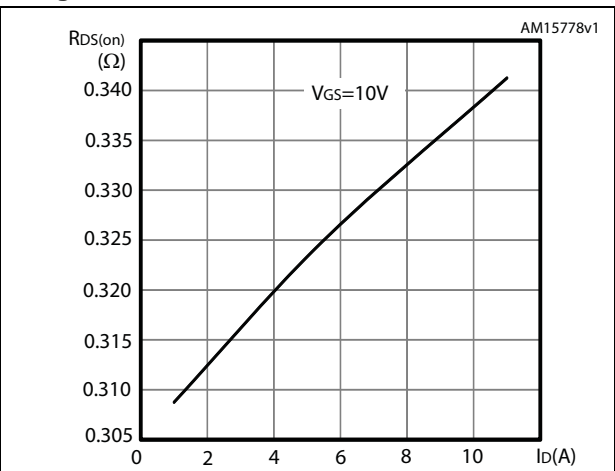


Figure 12. Capacitance variations

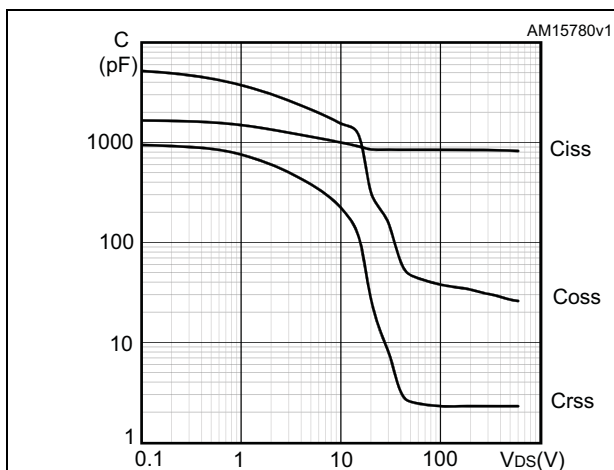


Figure 13. Normalized gate threshold voltage vs. temperature

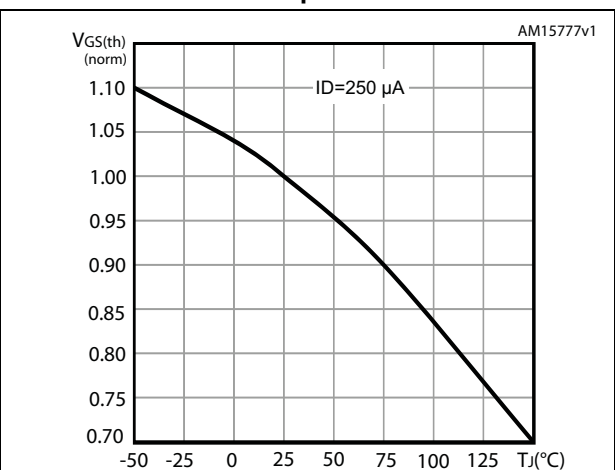


Figure 14. Normalized on-resistance vs temperature

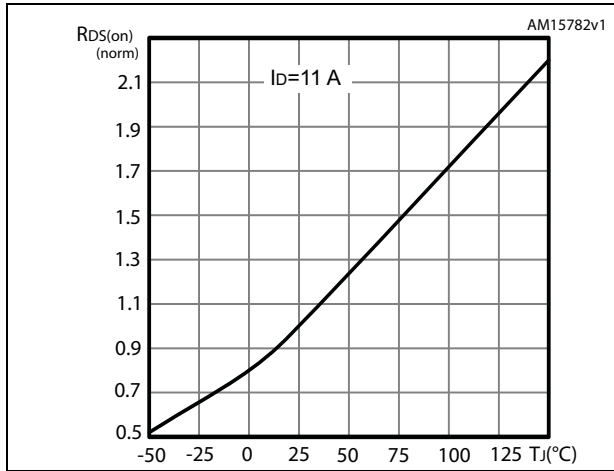


Figure 15. Source-drain diode forward characteristics

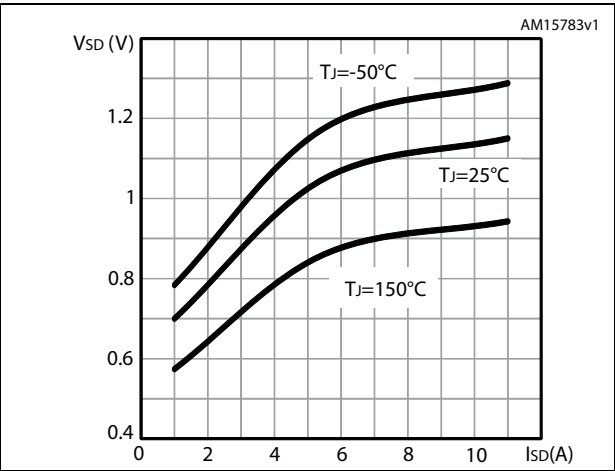
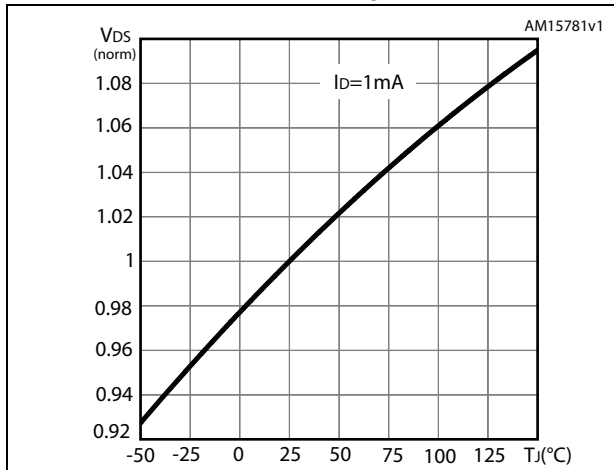


Figure 16. Normalized  $V_{DS}$  vs temperature



### 3 Test circuits

Figure 17. Switching times test circuit for resistive load

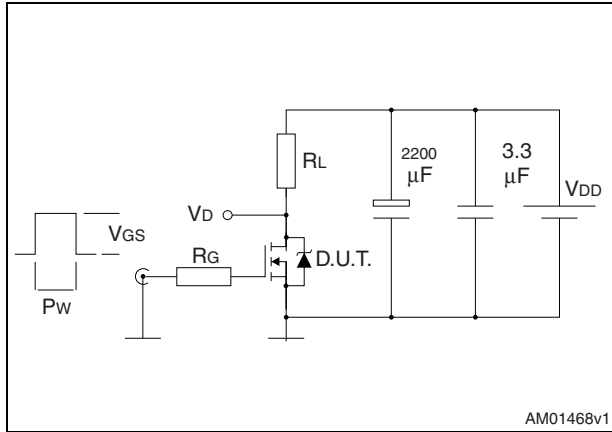


Figure 18. Gate charge test circuit

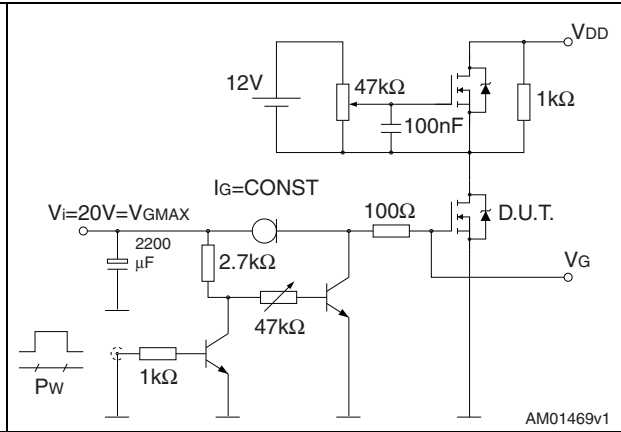


Figure 19. Test circuit for inductive load switching and diode recovery times

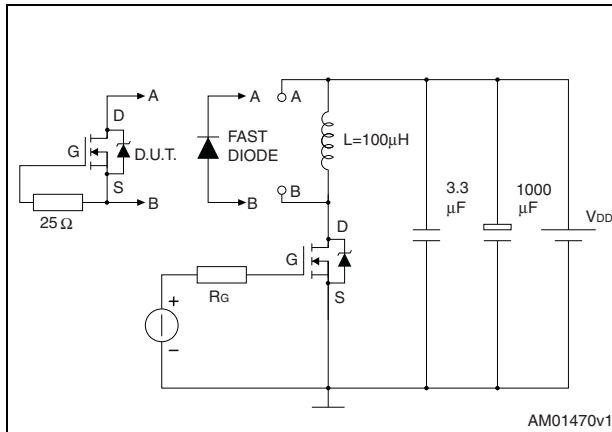


Figure 20. Unclamped inductive load test circuit

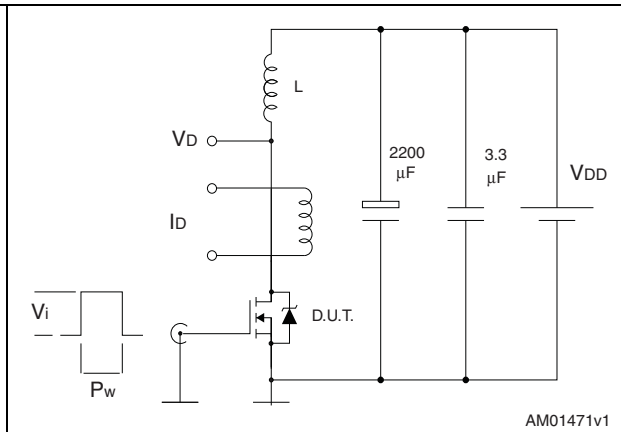


Figure 21. Unclamped inductive waveform

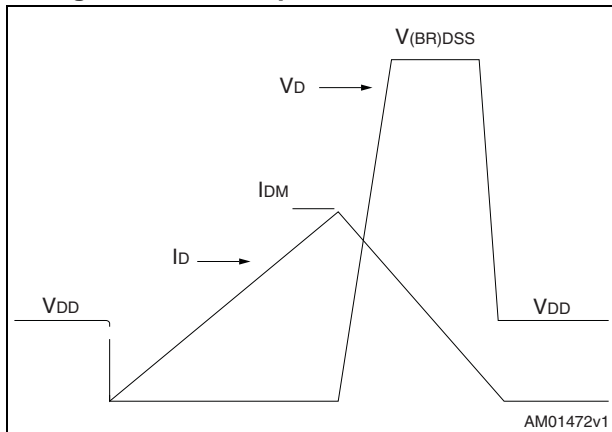
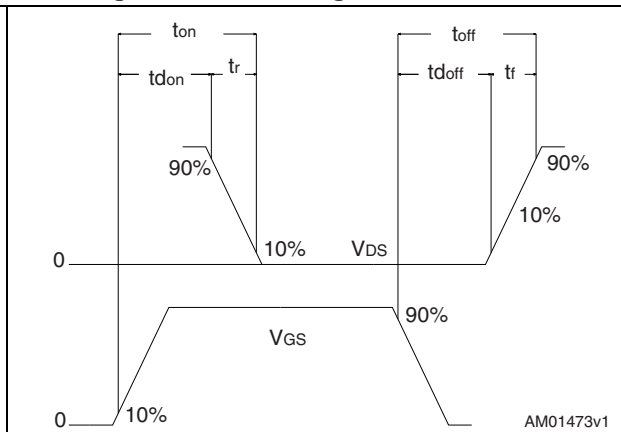


Figure 22. Switching time waveform



## 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	1.00		1.50
(L1)		2.80	
L2		0.80	
L4	0.60		1.00
R		0.20	
V2	0°		8°

Figure 23. DPAK (TO-252) drawing

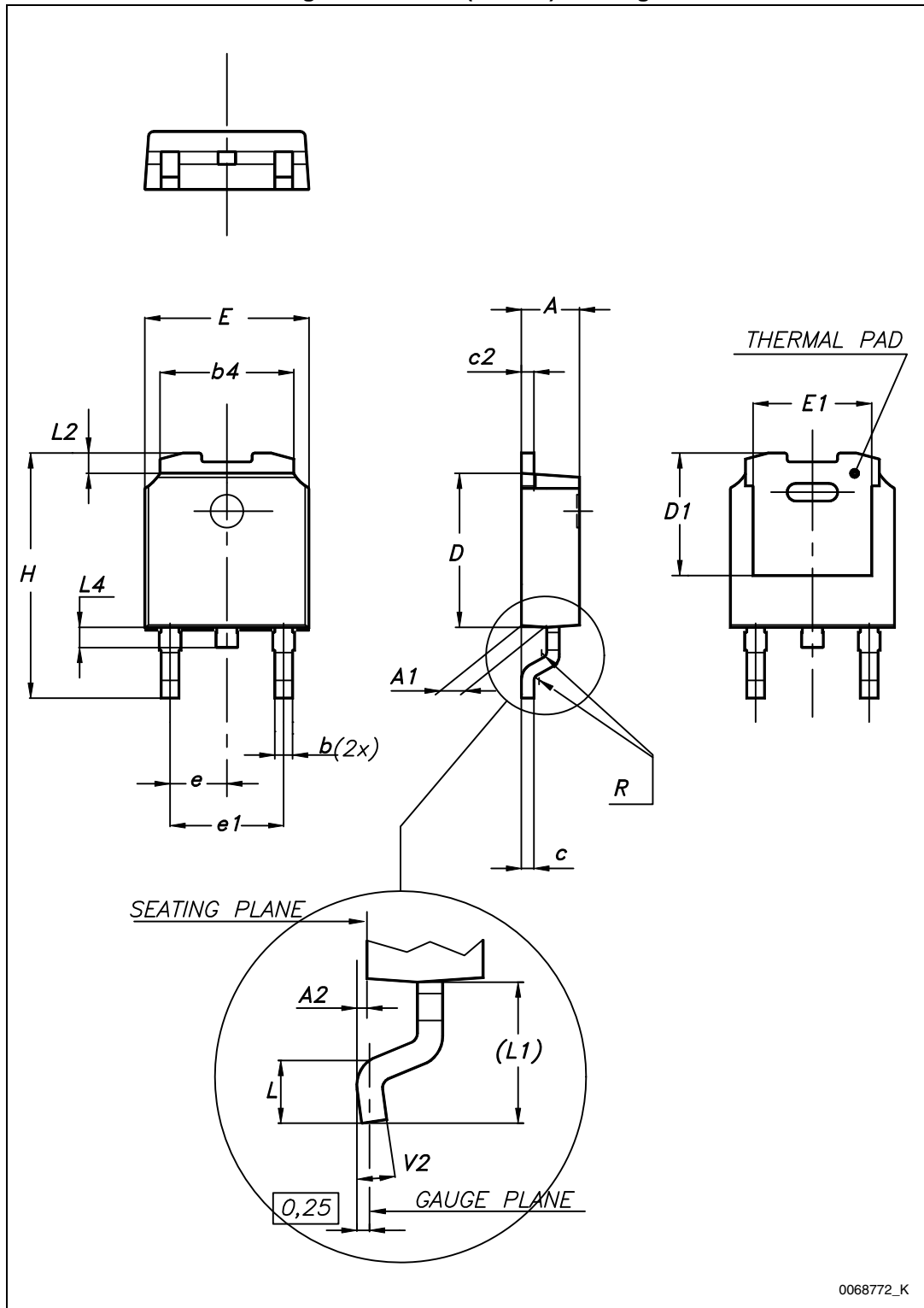
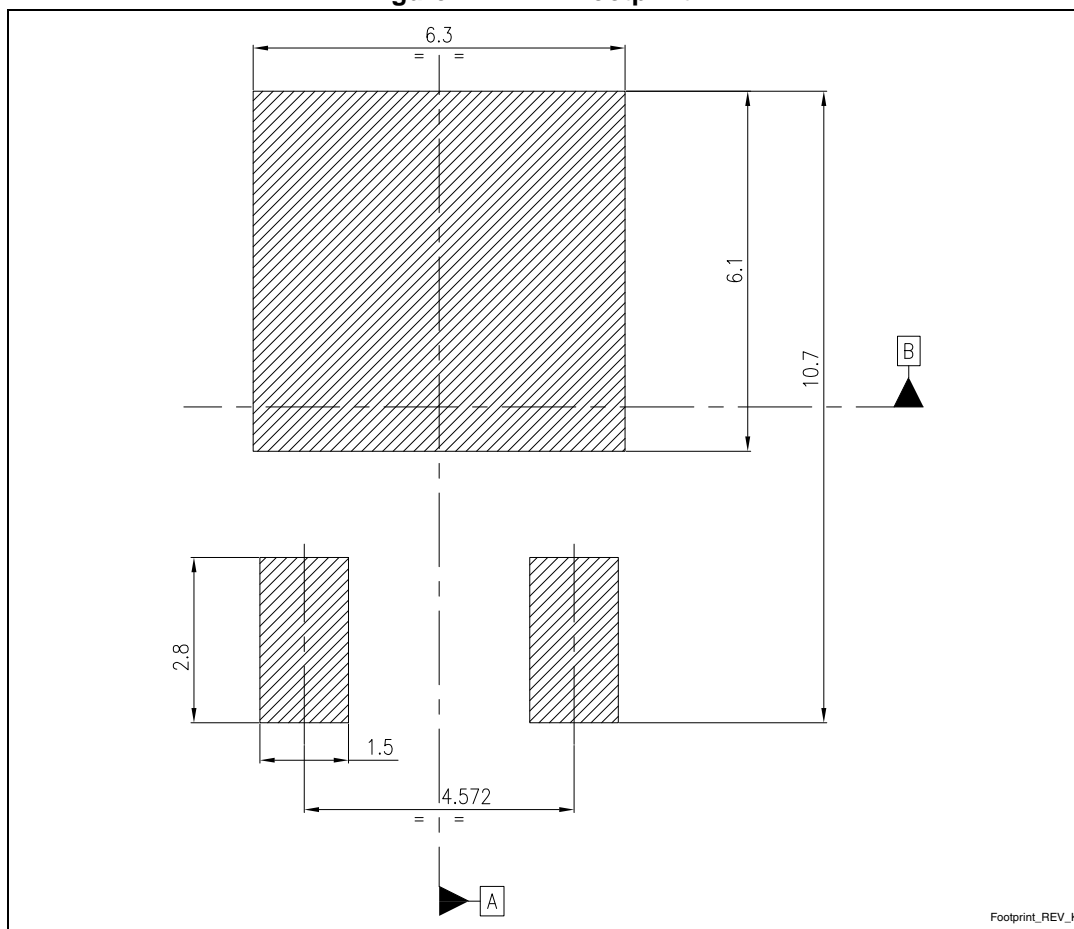


Figure 24. DPAK footprint (a)

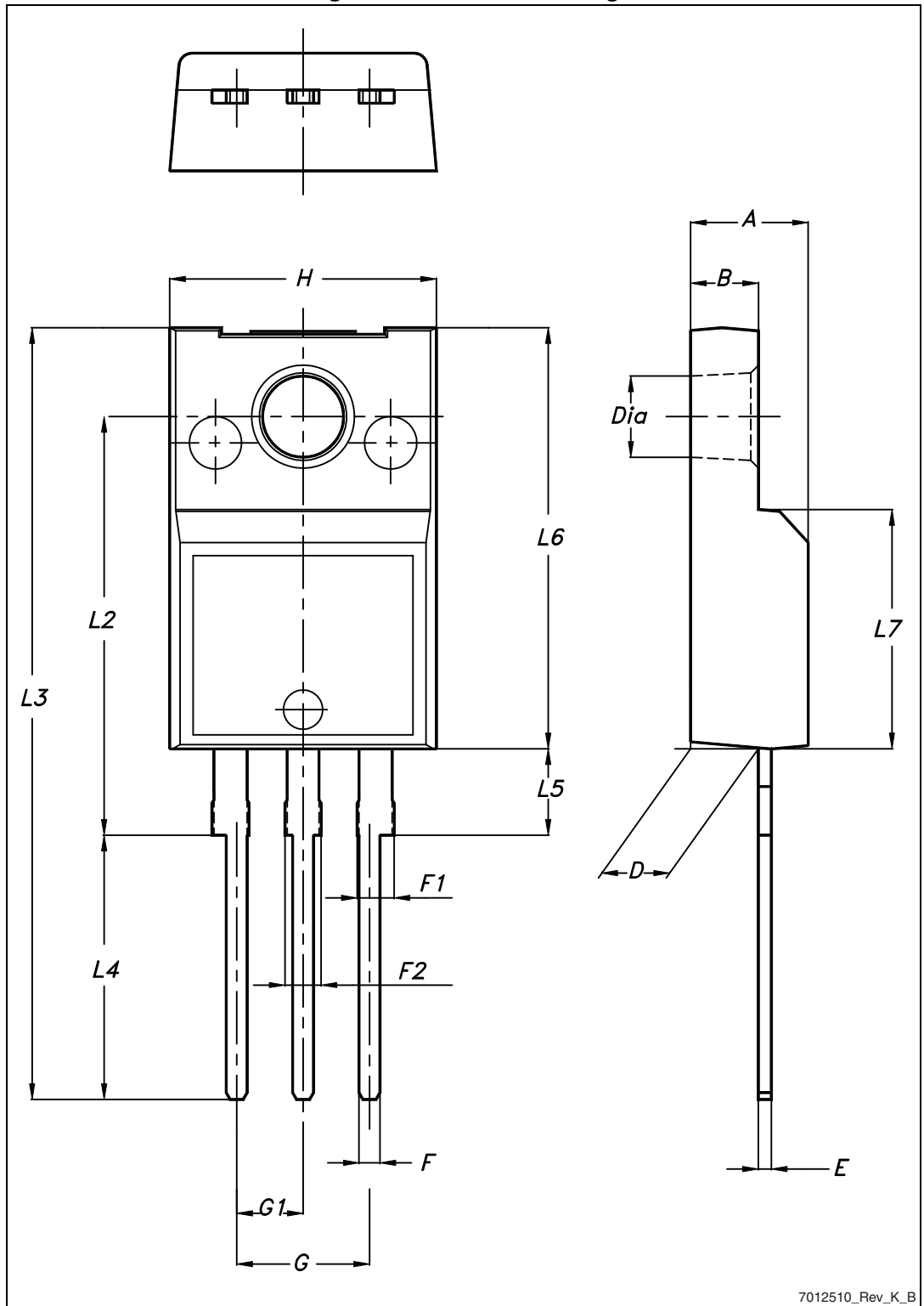


a. All dimensions are in millimeters

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 25. TO-220FP drawing

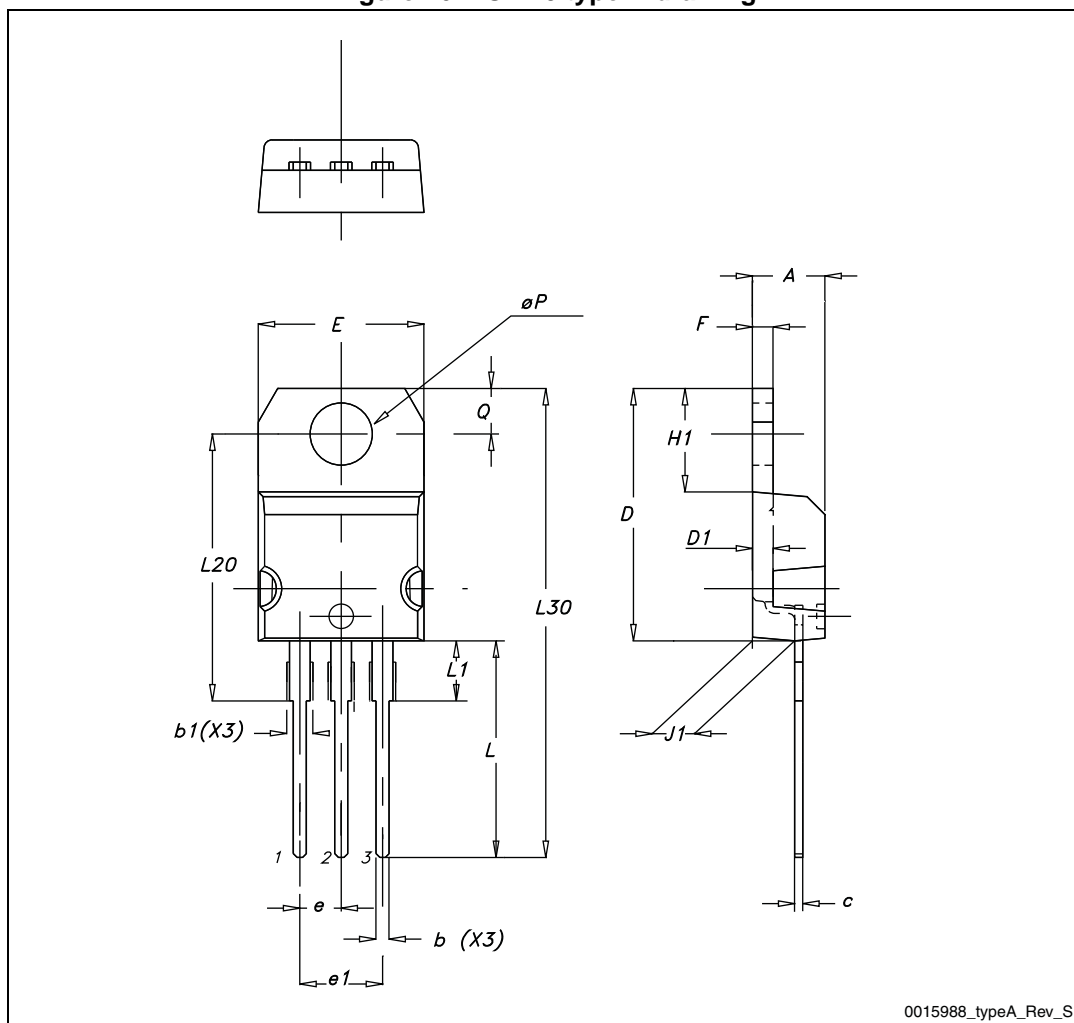


7012510\_Rev\_K\_B

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 26. TO-220 type A drawing



0015988\_typeA\_Rev\_S

## 5 Packaging mechanical data

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			

Figure 27. Tape for DPAK (TO-252)

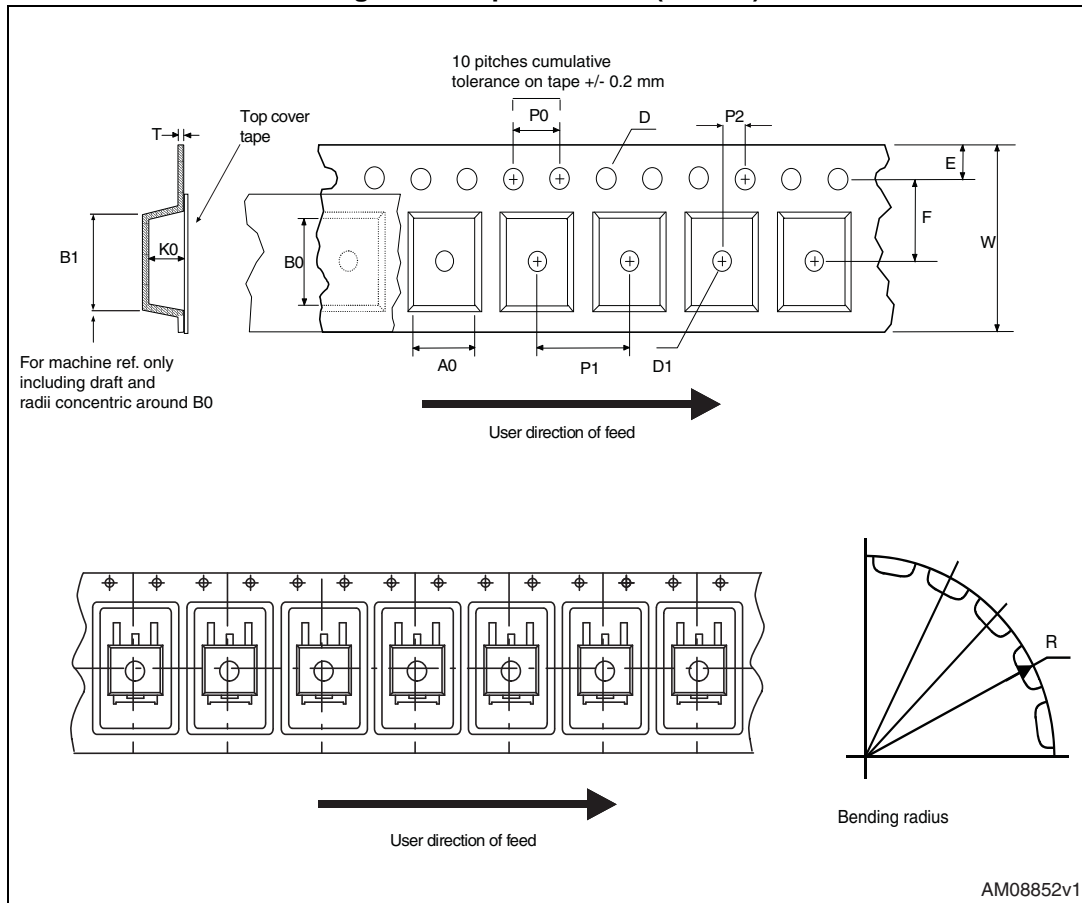
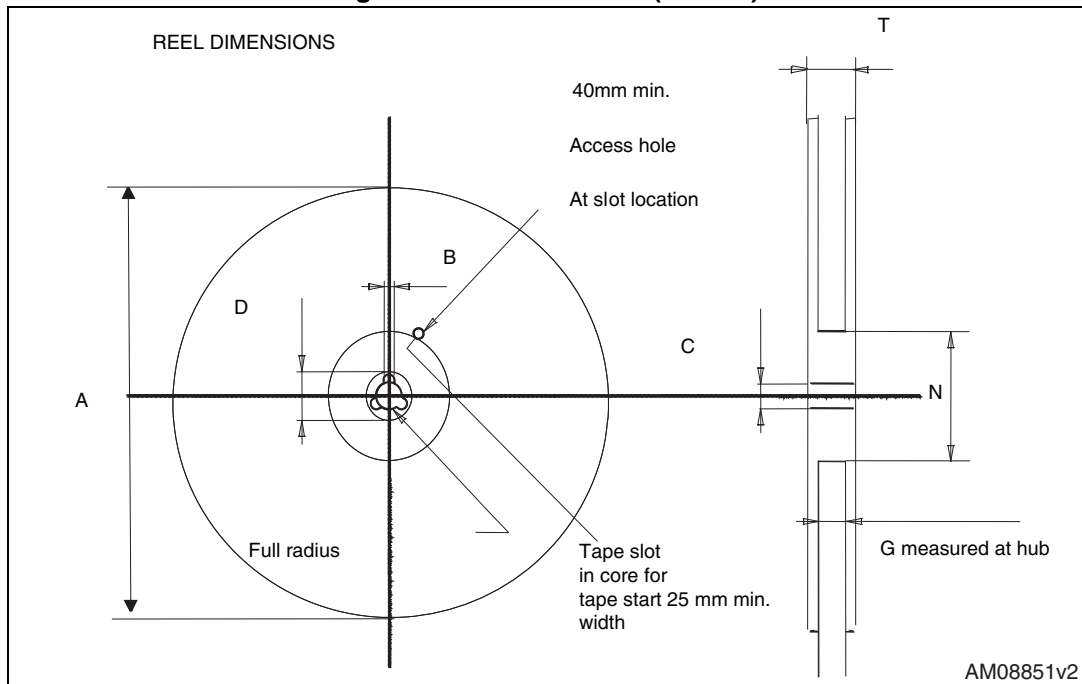


Figure 28. Reel for DPAK (TO-252)



## 6 Revision history

Table 13. Document revision history

Date	Revision	Changes
15-May-2013	1	First release.

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