



# STD11NM60ND, STF/I11NM60ND STP11NM60ND, STU11NM60ND

N-channel 600 V, 0.37  $\Omega$ , 10 A, FDmesh™ II Power MOSFET  
I<sup>2</sup>PAK, TO-220, TO-220FP, IPAK, DPAK

## Features

Order codes	V <sub>DSS</sub> (@T <sub>jmax</sub> )	R <sub>DS(on)</sub> max	I <sub>D</sub>
STD11NM60ND			10 A
STF11NM60ND			10 A <sup>(1)</sup>
STI11NM60ND	650 V	< 0.45 $\Omega$	10 A
STP11NM60ND			10 A
STU11NM60ND			10 A

1. Limited only by maximum temperature allowed
- The worldwide best R<sub>DS(on)</sub>\* area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

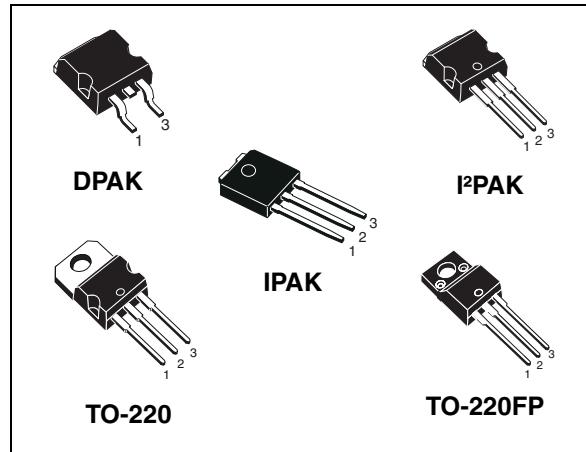
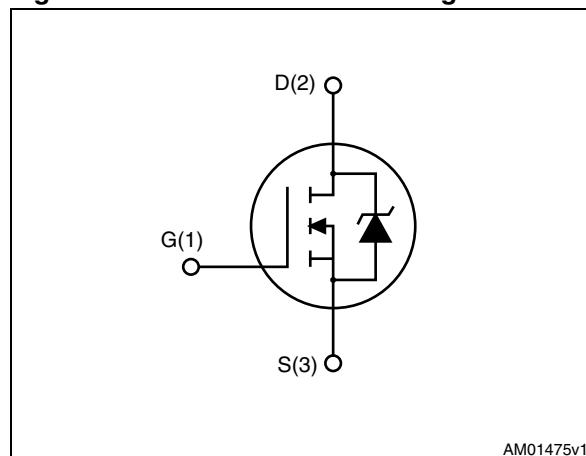


Figure 1. Internal schematic diagram



AM01475v1

## Application

Switching applications

## Description

The device is an N-channel FDmesh™ II Power MOSFET that belongs to the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout and associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

Table 1. Device summary

Order codes	Marking	Package	Packaging
STD11NM60ND		DPAK	Tape and reel
STF11NM60ND		TO-220FP	Tube
STI11NM60ND	11NM60ND	I <sup>2</sup> PAK	Tube
STP11NM60ND		TO-220	Tube
STU11NM60ND		IPAK	Tube

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		DPAK/I <sup>2</sup> PAK, TO-220/IPAK	TO-220FP	
V <sub>DS</sub>	Drain-source voltage (V <sub>GS</sub> =0)	600		V
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>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100°C	6.3	6.3 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	40	40 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25°C	90	25	W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	40		V/ns
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1s;T <sub>C</sub> =25°C)	2500		V
T <sub>stg</sub>	Storage temperature	-55 to 150		°C
T <sub>j</sub>	Max. operating junction temperature	150		°C

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 10 A, di/dt ≤ 400 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>, peak V<sub>DS</sub> ≤ V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value					Unit
		TO-220	I <sup>2</sup> PAK	DPAK	IPAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.38			5	5	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5		100	62.5	62.5	°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max		50				°C/W
T <sub>I</sub>	Maximum lead temperature for soldering purposes	300			300	300	°C

1. 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>	3.5	A
$E_{AS}$	Single pulse avalanche energy <sup>(2)</sup>	200	mJ

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

## 2 Electrical characteristics

( $T_{CASE} = 25^\circ\text{C}$  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
$dv/dt^{(1)}$	Drain-source voltage slope	$V_{DD} = 480 \text{ V}, I_D = 10 \text{ A}, V_{GS} = 10 \text{ V}$		45		V/ns
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{max rating}, V_{DS} = \text{max rating, } @ 125^\circ\text{C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20 \text{ V}$			100	nA
$V_{GS(\text{th})}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$	3	4	5	V
$R_{DS(\text{on})}$	Static drain-source on resistance	$V_{GS} = 10 \text{ V}, I_D = 5 \text{ A}$		0.37	0.45	$\Omega$

1. Value measured at turn off under inductive load

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15 \text{ V}, I_D = 5 \text{ A}$	-	7.5	-	S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 50 \text{ V}, f = 1 \text{ MHz}, V_{GS} = 0$	-	850 44 5	-	pF pF pF
$C_{oss \text{ eq.}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0 \text{ V to } 480 \text{ V}$	-	130	-	pF
$R_g$	Gate input resistance	$f = 1 \text{ MHz Gate DC Bias=0}$ Test signal level=20 mV open drain	-	3.7	-	$\Omega$
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 480 \text{ V}, I_D = 10 \text{ A}$ $V_{GS} = 10 \text{ V}$ (see <a href="#">Figure 19</a> )	-	30 4 16	-	nC nC nC

1. Pulsed: pulse duration = 300 $\mu\text{s}$ , duty cycle 1.5%

2.  $C_{oss \text{ eq.}}$  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	$V_{DD} = 300 \text{ V}, I_D = 5 \text{ A}, R_G = 4.7 \Omega, V_{GS} = 10 \text{ V}$ (see <a href="#">Figure 18</a> )	-	16		ns
$t_r$	Rise time			7		ns
$t_{d(off)}$	Turn-off delay time			50	-	ns
$t_f$	Fall time			9		ns

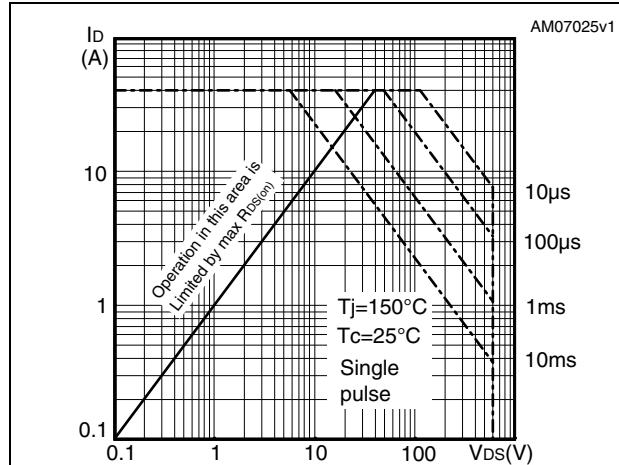
**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$I_{SD}$ $I_{SDM}^{(1)}$	Source-drain current		-		10	A
	Source-drain current (pulsed)				40	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 10 \text{ A}, V_{GS}=0$	-		1.3	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time	$I_{SD} = 10 \text{ A}, dI/dt = 100 \text{ A}/\mu\text{s}, V_{DD} = 100 \text{ V}$ (see <a href="#">Figure 20</a> )	-	130		ns
	Reverse recovery charge			0.69		$\mu\text{C}$
	Reverse recovery current			11		A
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time	$V_{DD} = 100 \text{ V}$ $dI/dt = 100 \text{ A}/\mu\text{s}, I_{SD} = 10 \text{ A}$ $T_j = 150^\circ\text{C}$ (see <a href="#">Figure 20</a> )	-	200		ns
	Reverse recovery charge			1.2		$\mu\text{C}$
	Reverse recovery current			12		A

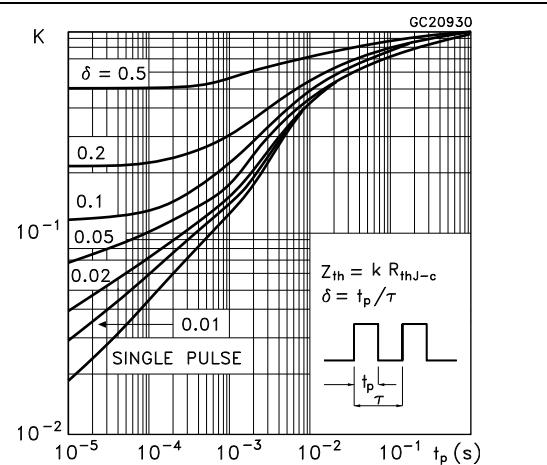
1. Pulse width limited by safe operating area
2. Pulsed: pulse duration = 300 $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

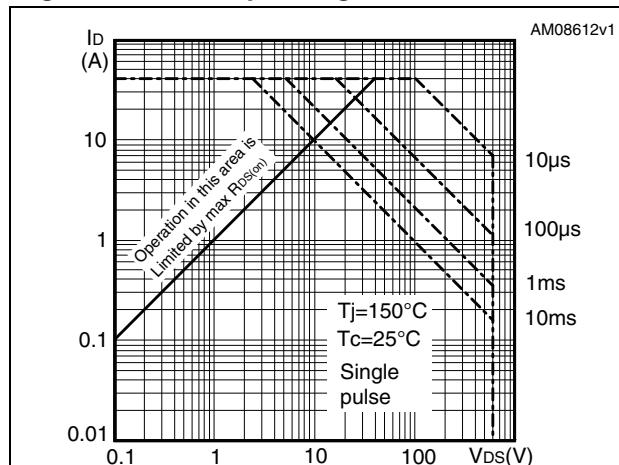
**Figure 2.** Safe operating area for TO-220, I<sup>2</sup>PAK



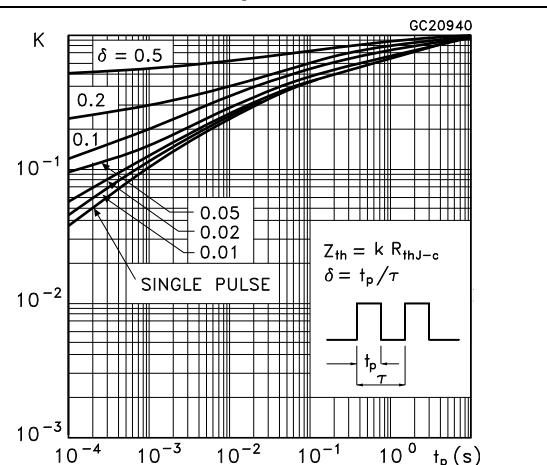
**Figure 3.** Thermal impedance for TO-220, I<sup>2</sup>PAK



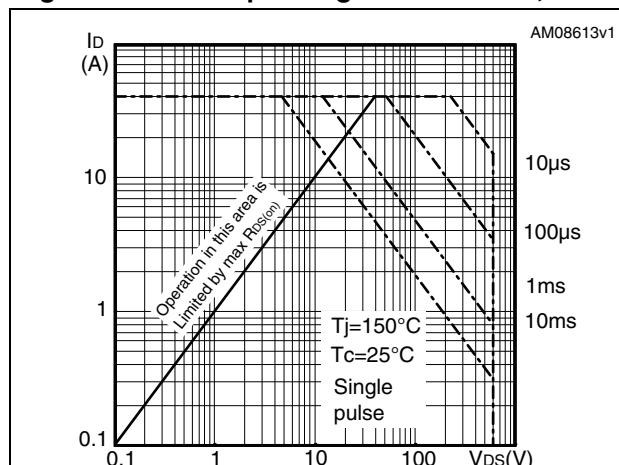
**Figure 4.** Safe operating area for TO-220FP



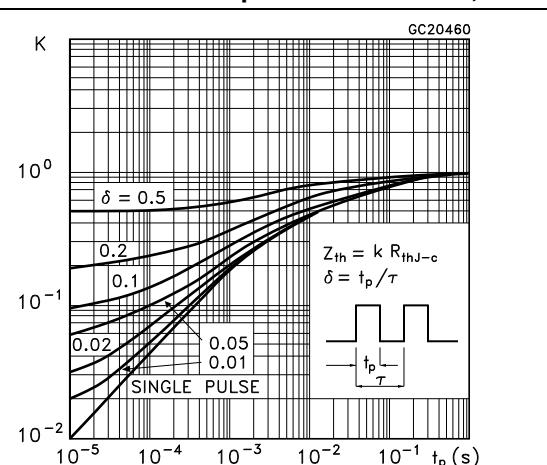
**Figure 5.** Thermal impedance for TO-220FP

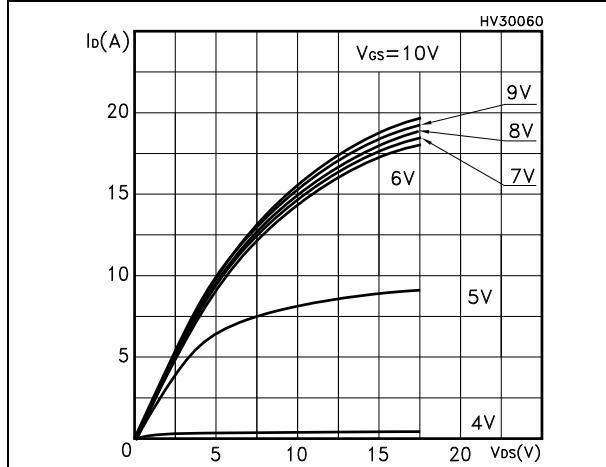
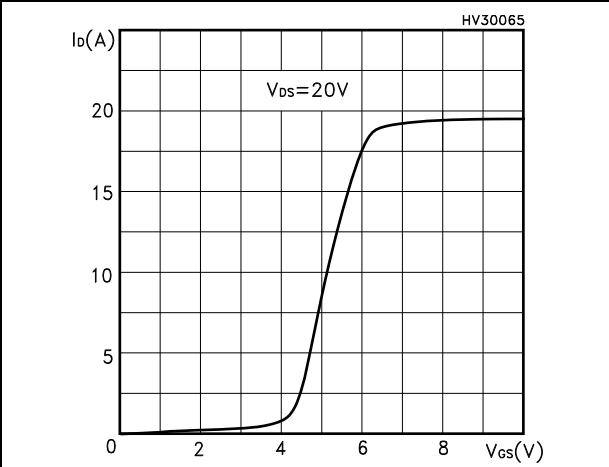
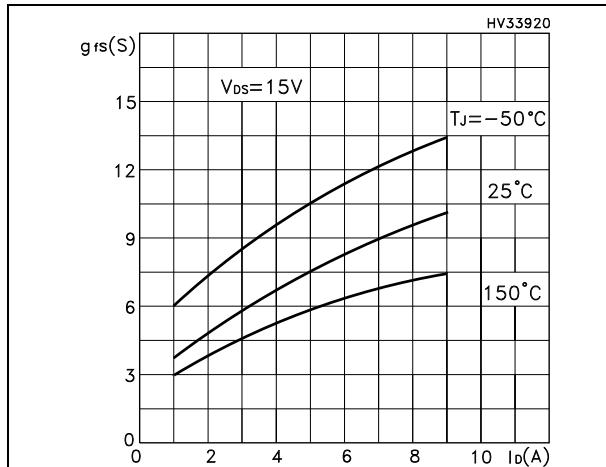
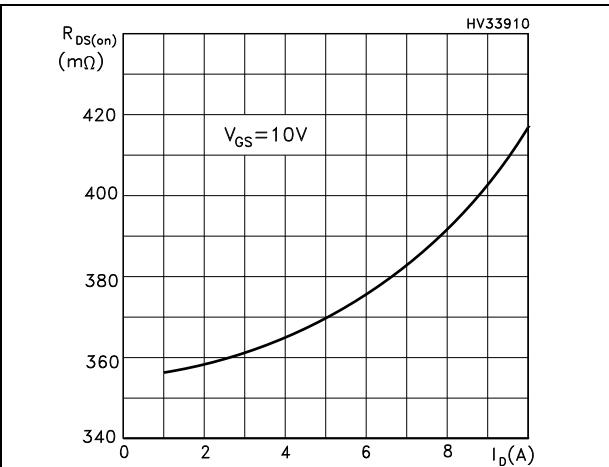
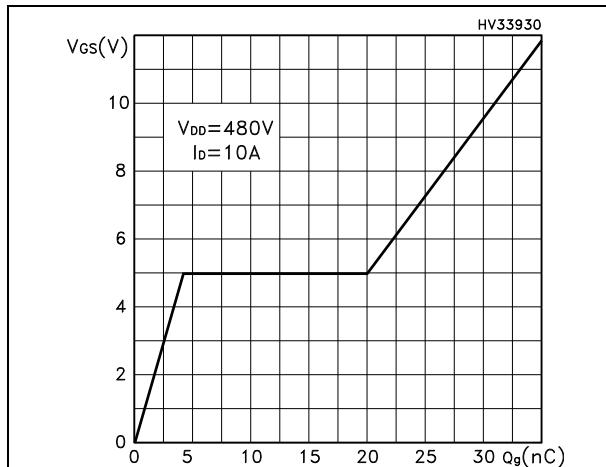
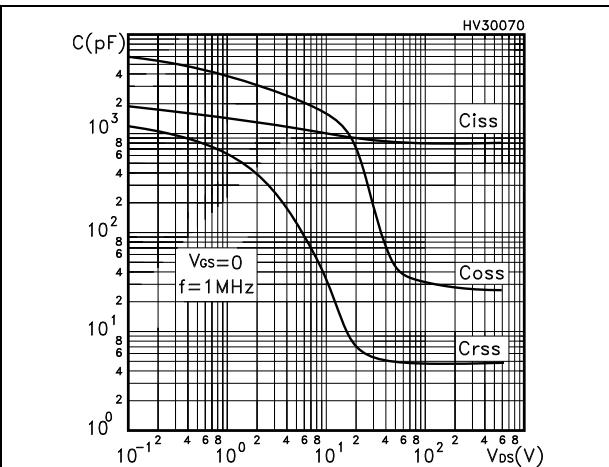


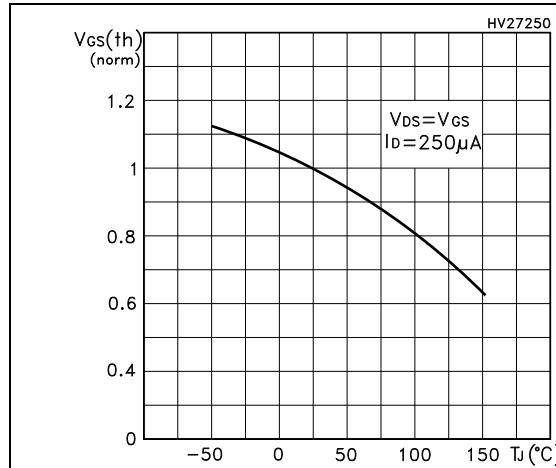
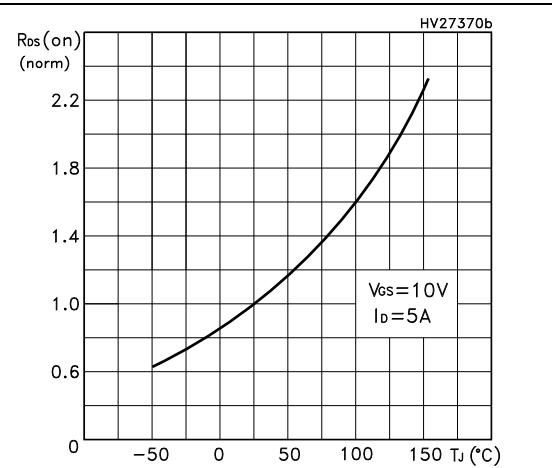
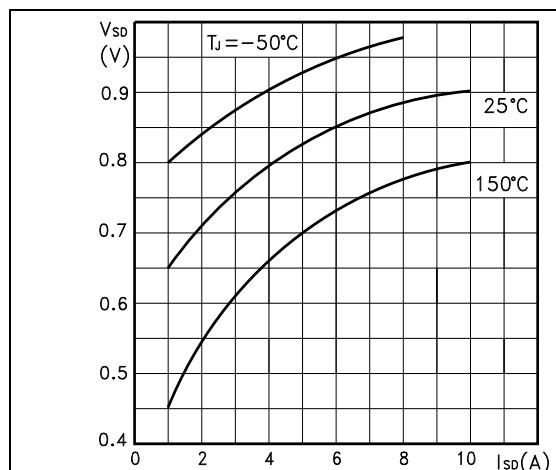
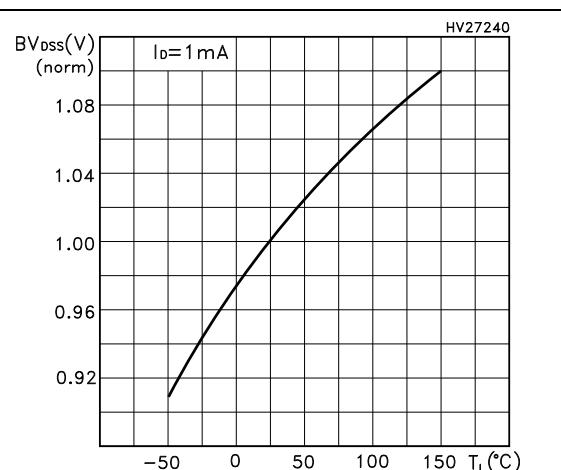
**Figure 6.** Safe operating area for DPAK, I<sup>2</sup>PAK



**Figure 7.** Thermal impedance for DPAK, I<sup>2</sup>PAK

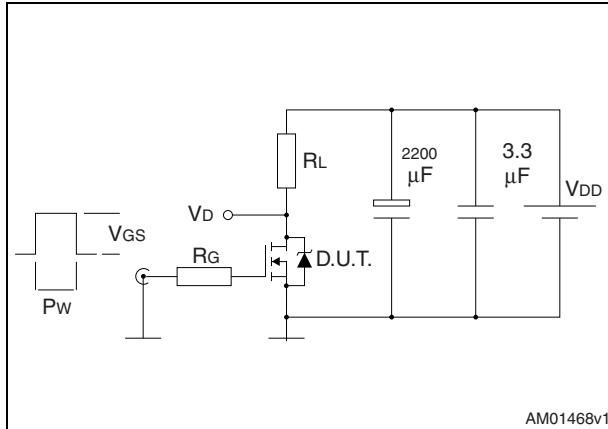


**Figure 8. Output characteristics****Figure 9. Transfer characteristics****Figure 10. Transconductance****Figure 11. Static drain-source on resistance****Figure 12. Gate charge vs gate-source voltage****Figure 13. Capacitance variations**

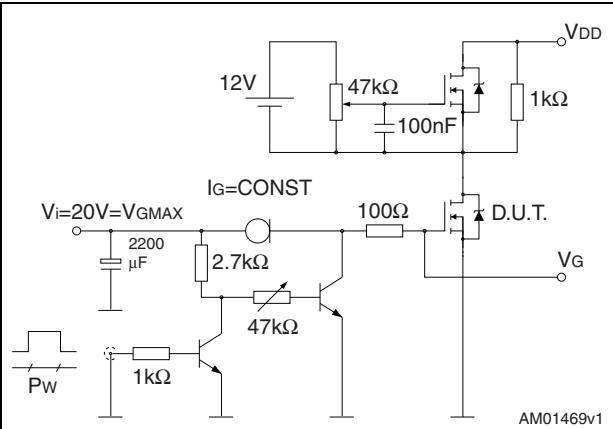
**Figure 14. Normalized gate threshold voltage vs temperature****Figure 15. Normalized on resistance vs temperature****Figure 16. Source-drain diode forward characteristics****Figure 17. Normalized BV<sub>DSS</sub> vs temperature**

### 3 Test circuits

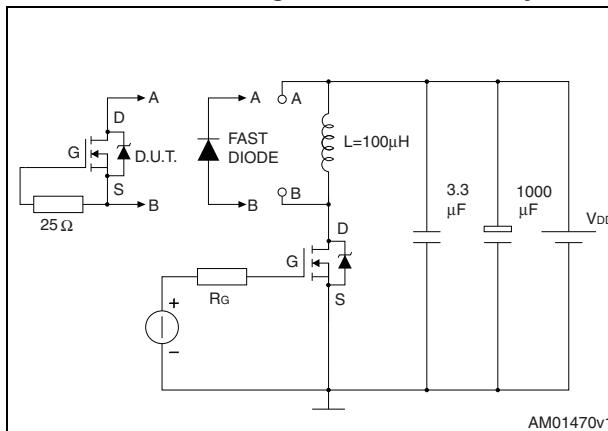
**Figure 18. Switching times test circuit for resistive load**



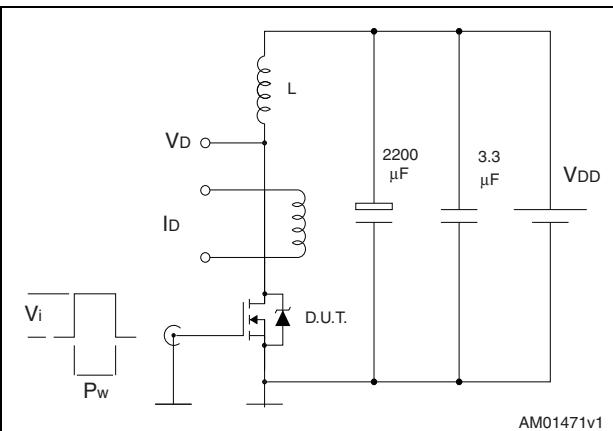
**Figure 19. Gate charge test circuit**



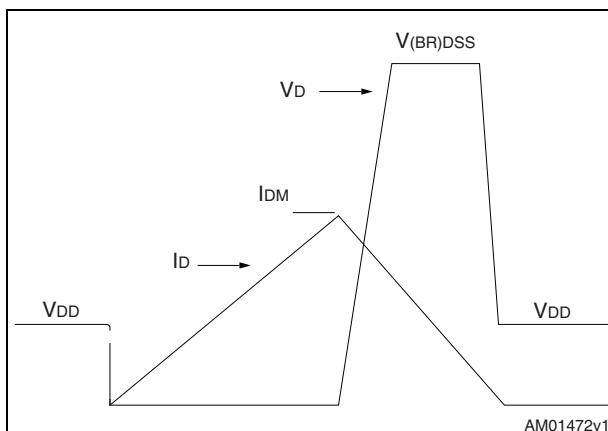
**Figure 20. Test circuit for inductive load switching and diode recovery times**



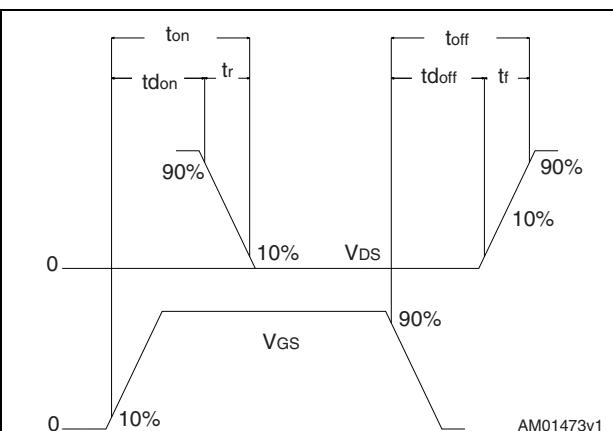
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**

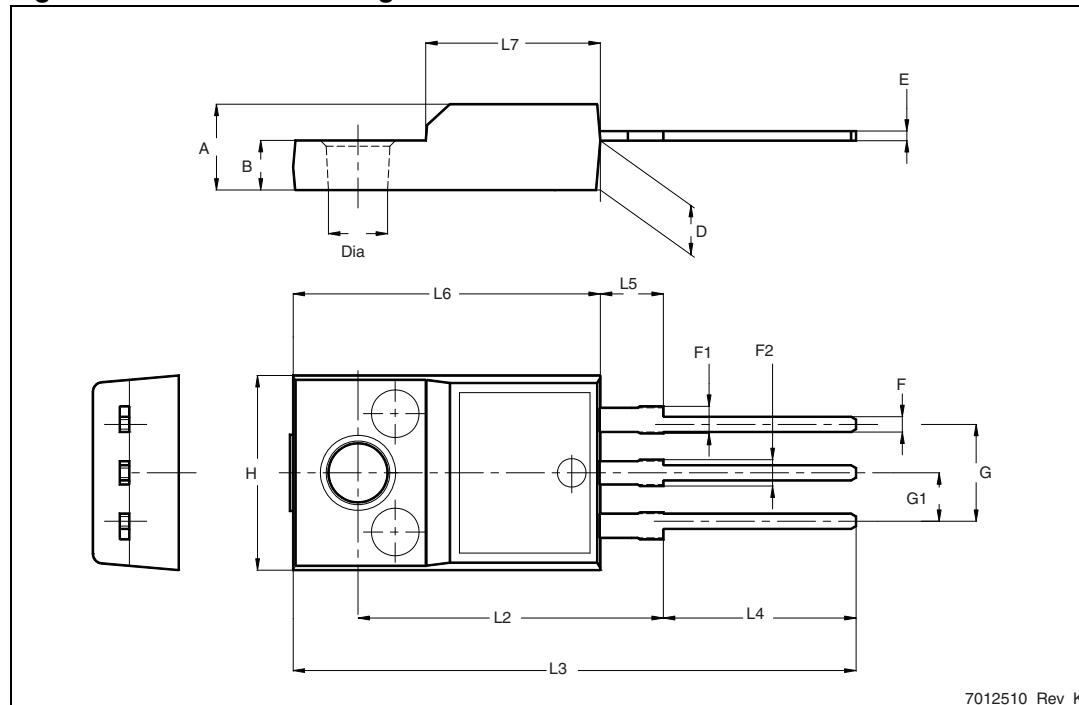


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

**Table 9.** TO-220FP mechanical data

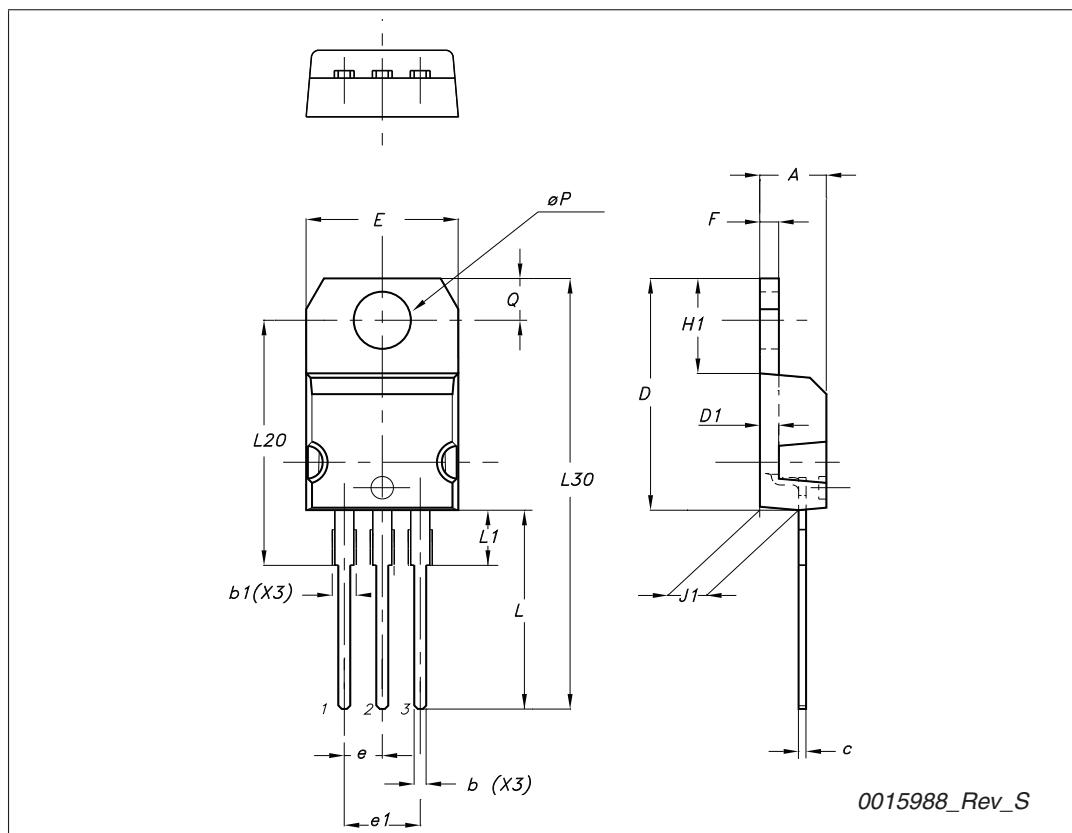
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

**Figure 24.** TO-220FP drawing

7012510\_Rev\_K

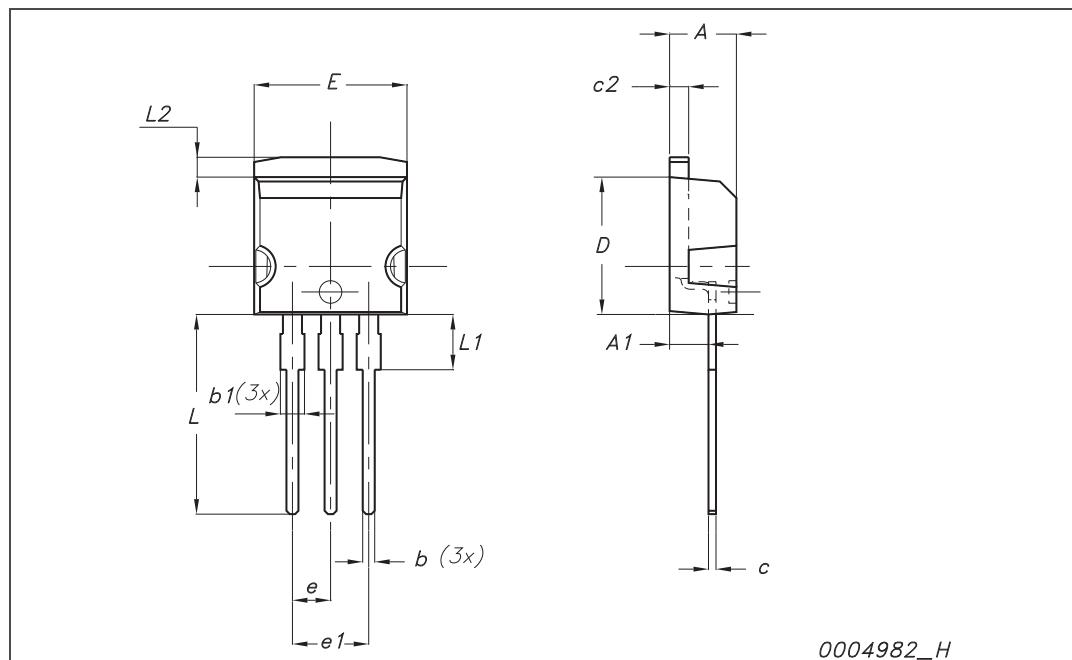
## TO-220 type A mechanical data

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	
$\emptyset P$	3.75		3.85
Q	2.65		2.95



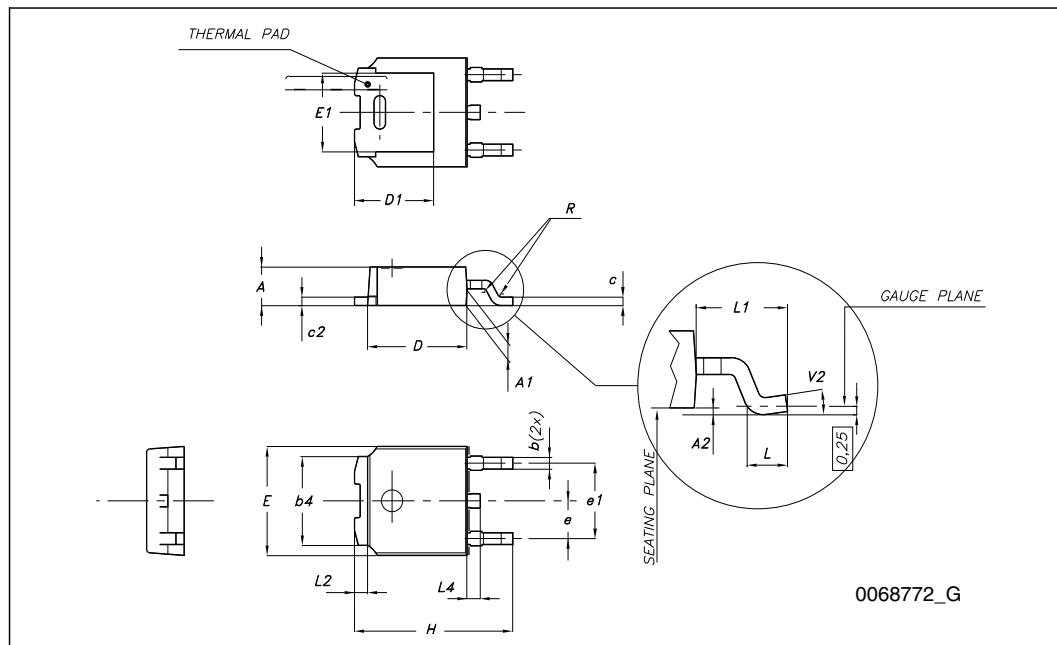
I<sup>2</sup>PAK (TO-262) mechanical data

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	4.40		4.60	0.173		0.181
A1	2.40		2.72	0.094		0.107
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
c2	1.23		1.32	0.048		0.052
D	8.95		9.35	0.352		0.368
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
E	10		10.40	0.393		0.410
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L2	1.27		1.40	0.050		0.055



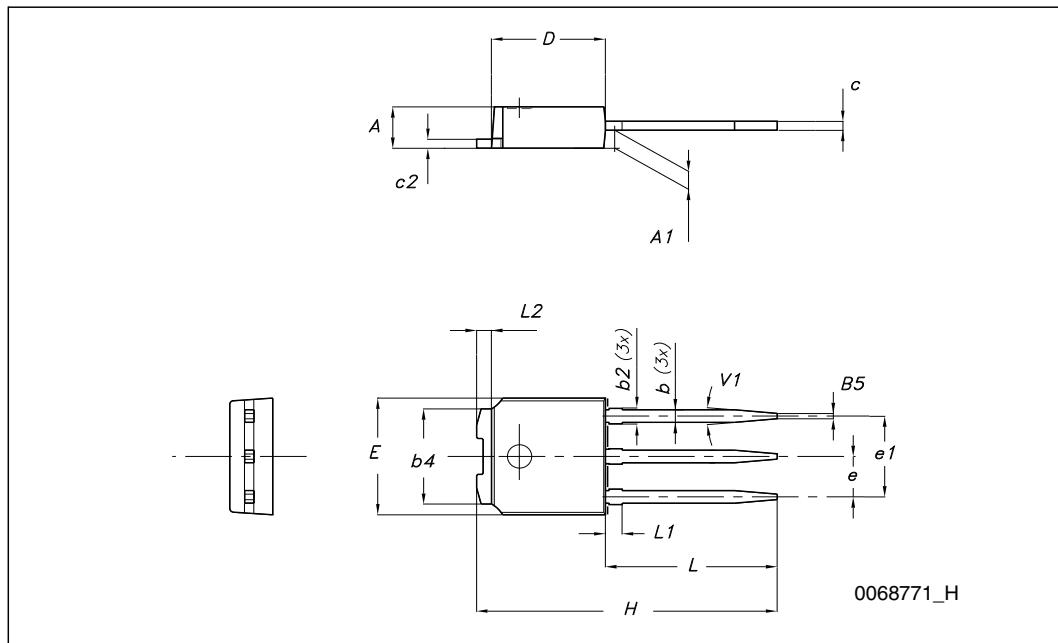
### TO-252 (DPAK) mechanical data

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		
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0 °		8 °



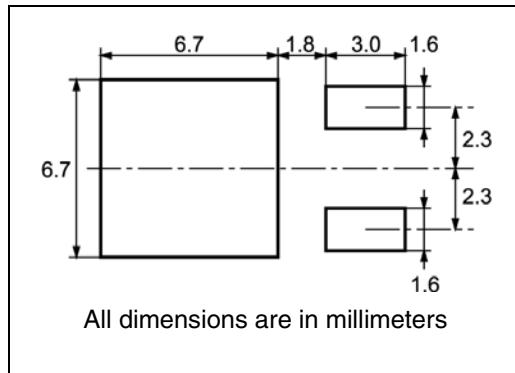
## TO-251 (IPAK) mechanical data

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
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	
V1		10 °	

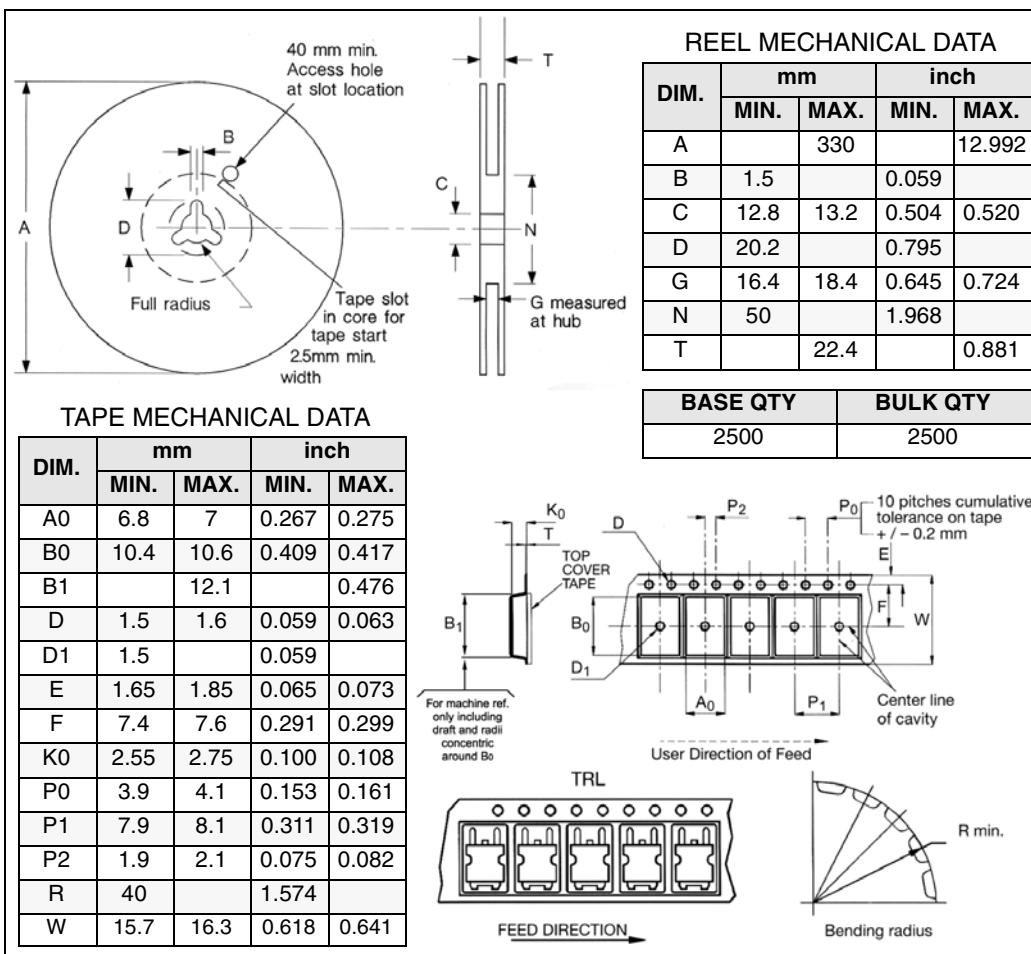


## 5 Packaging mechanical data

### DPAK FOOTPRINT



### TAPE AND REEL SHIPMENT



## 6 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
23-Apr-2008	1	First release
25-Oct-2010	2	<ul style="list-style-type: none"><li>– Corrected <i>Figure 2: Safe operating area for TO-220, IPAK</i></li><li>– Corrected <i>Figure 4: Safe operating area for TO-220FP</i></li><li>– Corrected <i>Figure 6: Safe operating area for DPAK, IPAK</i></li></ul>

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