



# STD11NM60ND, STF/11NM60ND STP11NM60ND, STU11NM60ND

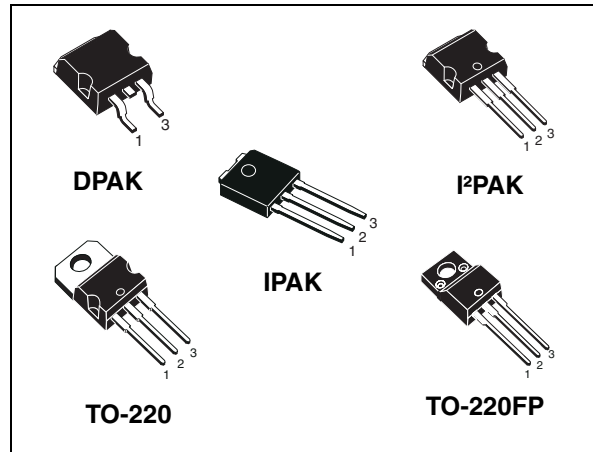
N-channel 600 V, 0.37  $\Omega$ , 10 A, FDmesh™ II Power MOSFET  
I<sup>2</sup>PAK, TO-220, TO-220FP, IPAK, DPAK

## Features

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



## 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.

Figure 1. Internal schematic diagram

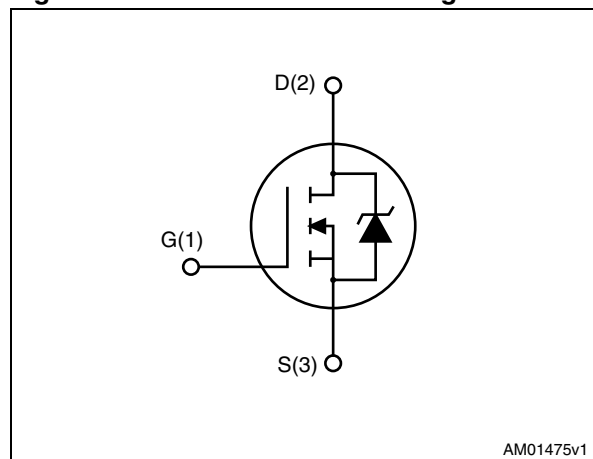


Table 1. Device summary

Order codes	Marking	Package	Packaging
STD11NM60ND	11NM60ND	DPAK	Tape and reel
STF11NM60ND		TO-220FP	Tube
STI11NM60ND		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	°C/W	
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5		100	62.5	°C/W	
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max		50			°C/W	
T <sub>l</sub>	Maximum lead temperature for soldering purposes	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  $T_j = 25\text{ °C}$ ,  $I_D = I_{AS}$ ,  $V_{DD} = 50\text{ V}$

## 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	600			V
dv/dt <sup>(1)</sup>	Drain-source voltage slope	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 10 A, V <sub>GS</sub> = 10 V	45			V/ns
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = max rating, V <sub>DS</sub> = max rating, @ 125 °C			1 100	μA μA
I <sub>GSS</sub>	Gate body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ±20 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	3	4	5	V
R <sub>DS(on)</sub>	Static drain-source on resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 5 A		0.37	0.45	Ω

1. Value measured at turn off under inductive load

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g <sub>fs</sub> <sup>(1)</sup>	Forward transconductance	V <sub>DS</sub> = 15 V, I <sub>D</sub> = 5 A	-	7.5	-	S
C <sub>iss</sub> C <sub>oss</sub> C <sub>rss</sub>	Input capacitance Output capacitance Reverse transfer capacitance	V <sub>DS</sub> = 50 V, f = 1 MHz, V <sub>GS</sub> = 0	-	850 44 5	-	pF pF pF
C <sub>oss eq.</sub> <sup>(2)</sup>	Equivalent output capacitance	V <sub>GS</sub> = 0, V <sub>DS</sub> = 0V to 480 V	-	130	-	pF
R <sub>g</sub>	Gate input resistance	f = 1 MHz Gate DC Bias = 0 Test signal level = 20 mV open drain	-	3.7	-	Ω
Q <sub>g</sub> Q <sub>gs</sub> Q <sub>gd</sub>	Total gate charge Gate-source charge Gate-drain charge	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 10 A V <sub>GS</sub> = 10 V (see <a href="#">Figure 19</a> )	-	30 4 16	-	nC nC nC

1. Pulsed: pulse duration = 300μs, duty cycle 1.5%

2. C<sub>oss eq.</sub> 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
$t_{d(on)}$	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

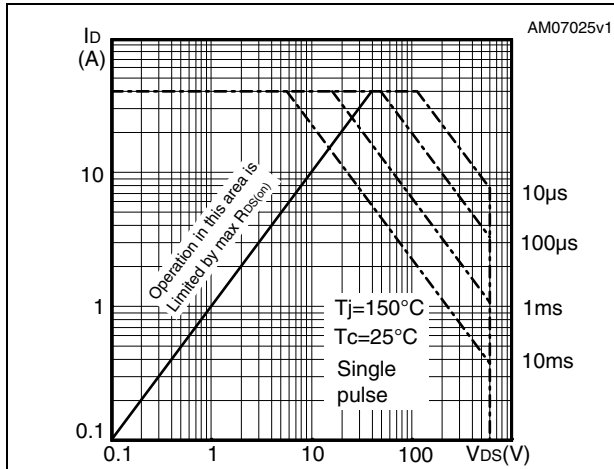
**Table 8. Source drain diode**

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

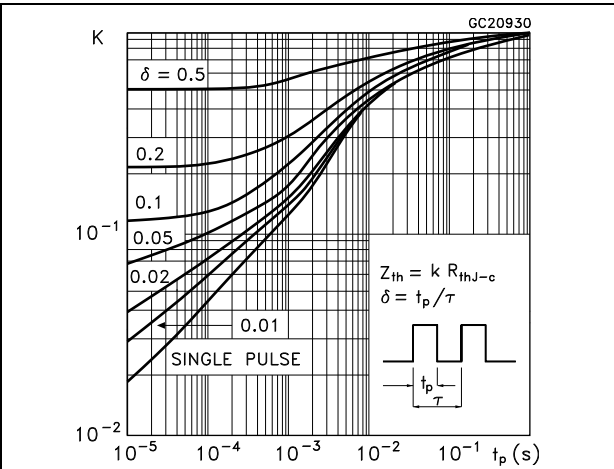
1. Pulse width limited by safe operating area
2. Pulsed: pulse duration = 300 $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

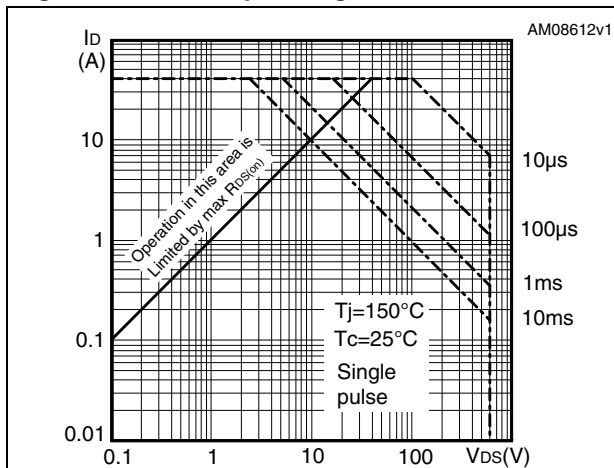
**Figure 2. Safe operating area for TO-220, I<sup>2</sup>PAK**



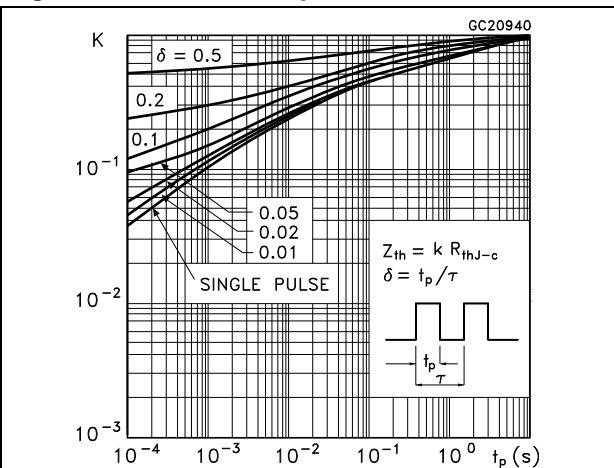
**Figure 3. Thermal impedance for TO-220, I<sup>2</sup>PAK**



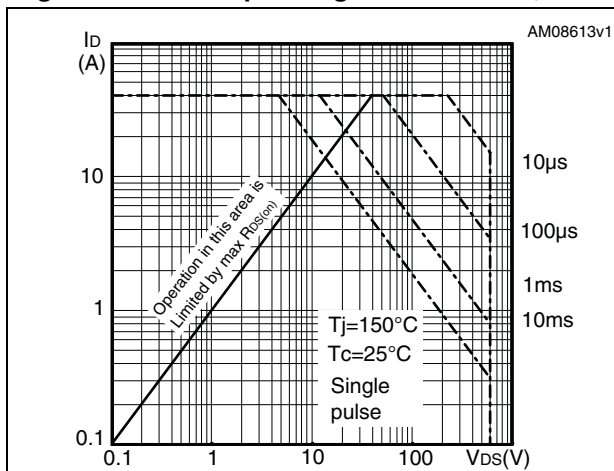
**Figure 4. Safe operating area for TO-220FP**



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



**Figure 6. Safe operating area for DPAK, IPAK**



**Figure 7. Thermal impedance for DPAK, IPAK**

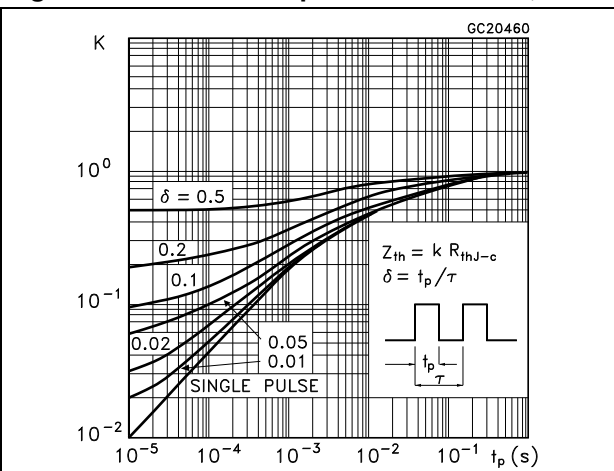


Figure 8. Output characteristics

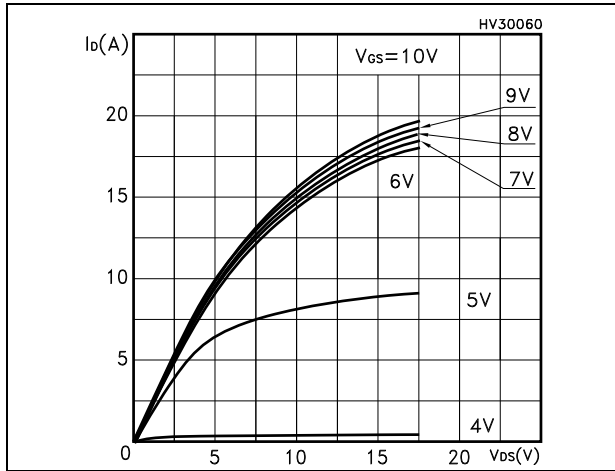


Figure 9. Transfer characteristics

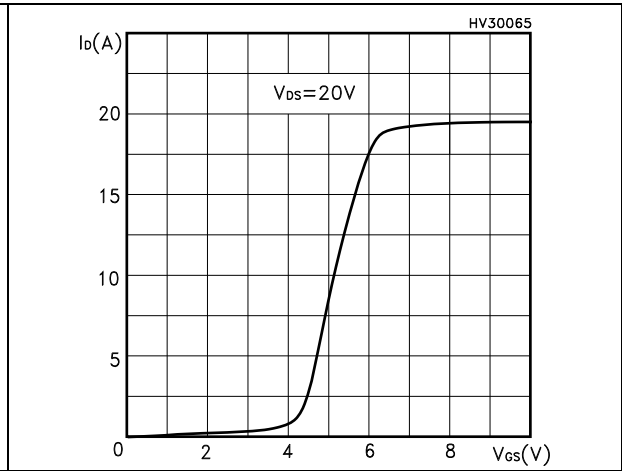


Figure 10. Transconductance

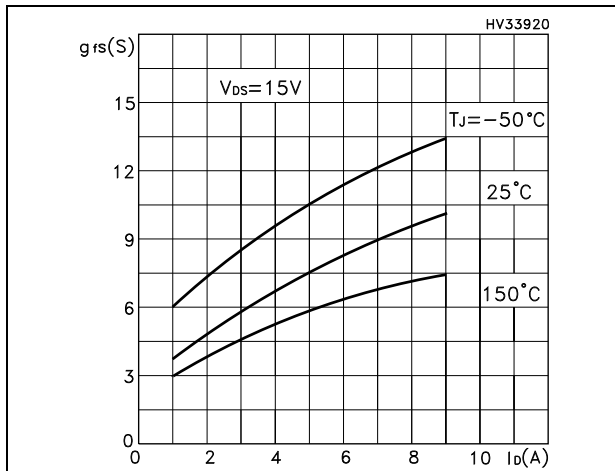


Figure 11. Static drain-source on resistance

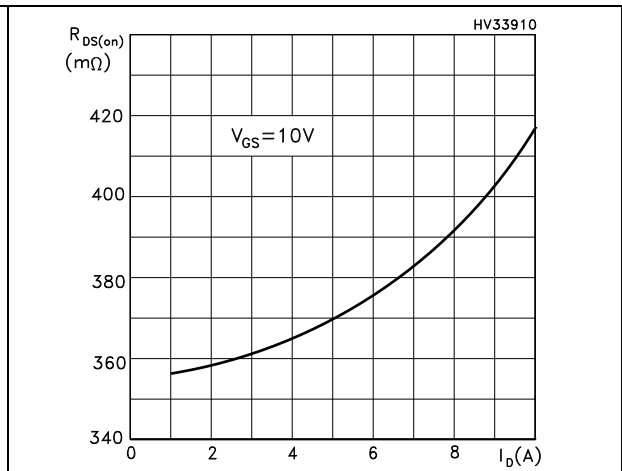


Figure 12. Gate charge vs gate-source voltage Figure 13. Capacitance variations

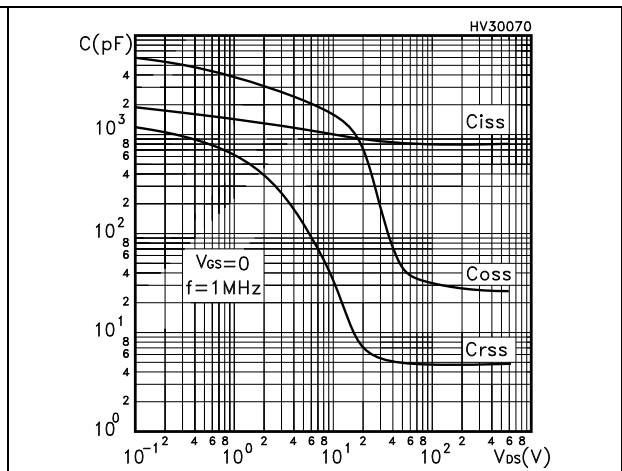
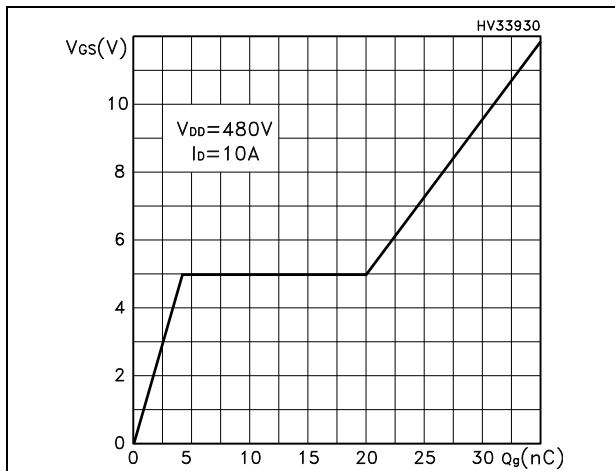




Figure 14. Normalized gate threshold voltage vs temperature

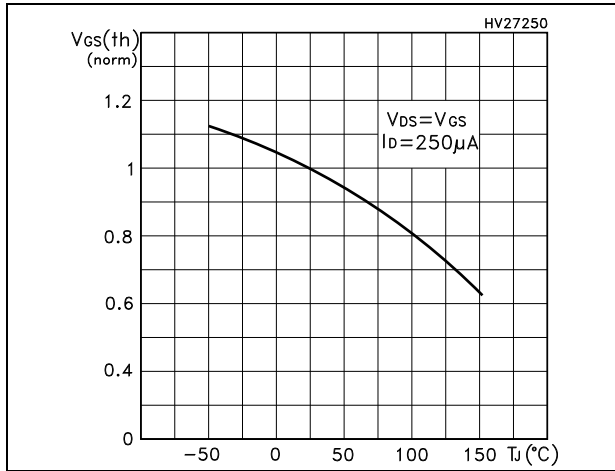


Figure 15. Normalized on resistance vs temperature

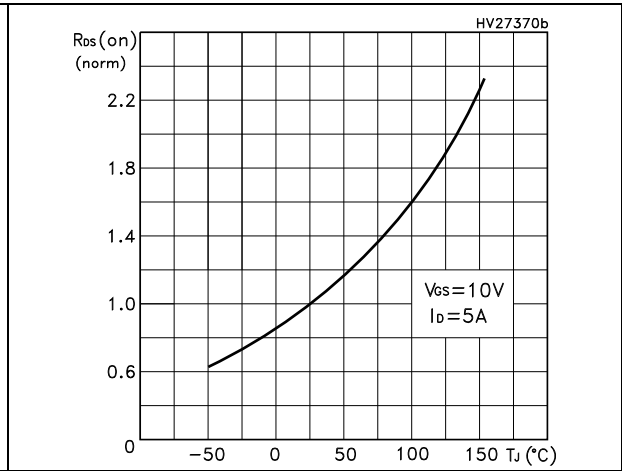


Figure 16. Source-drain diode forward characteristics

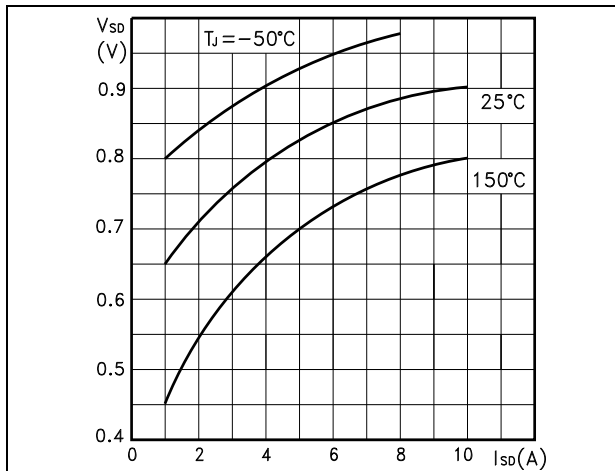
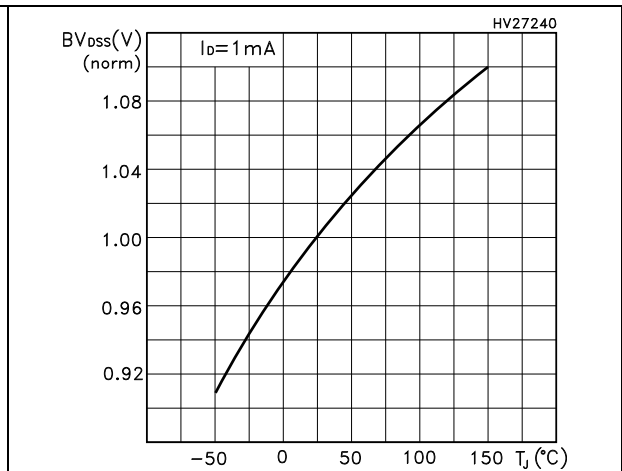
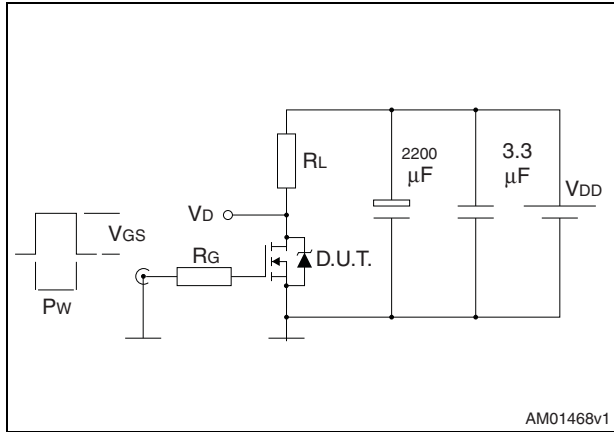


Figure 17. Normalized BV<sub>DSS</sub> vs temperature

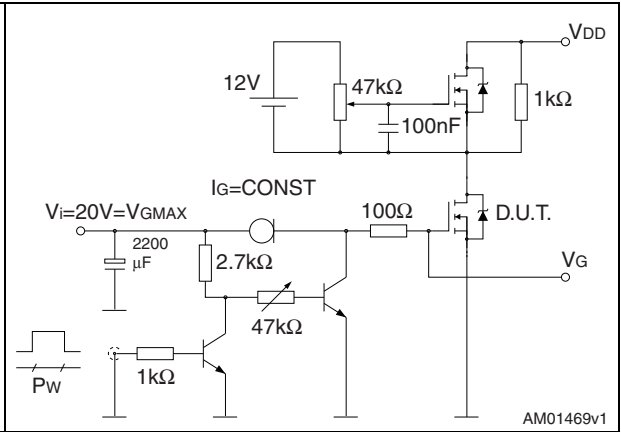


### 3 Test circuits

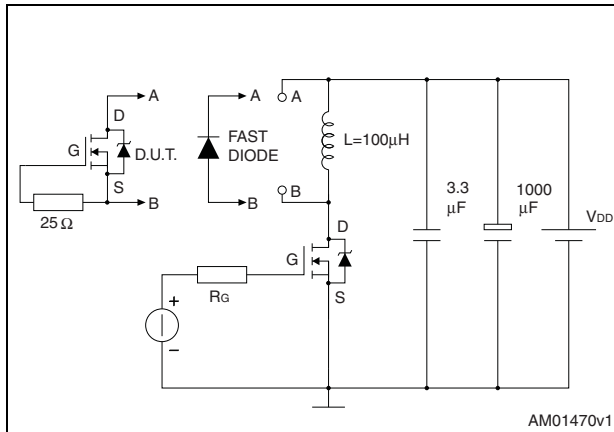
**Figure 18. Switching times test circuit for resistive load**



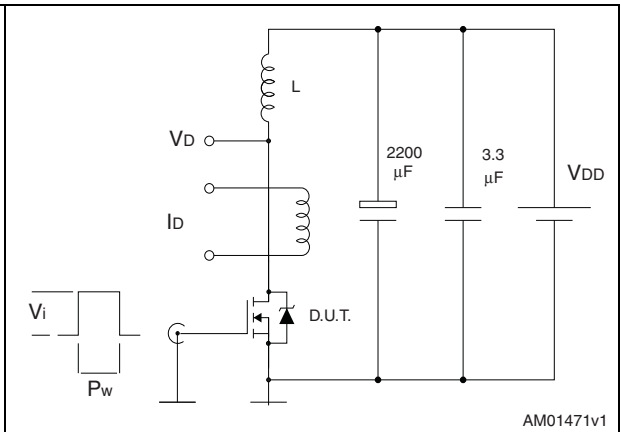
**Figure 19. Gate charge test circuit**



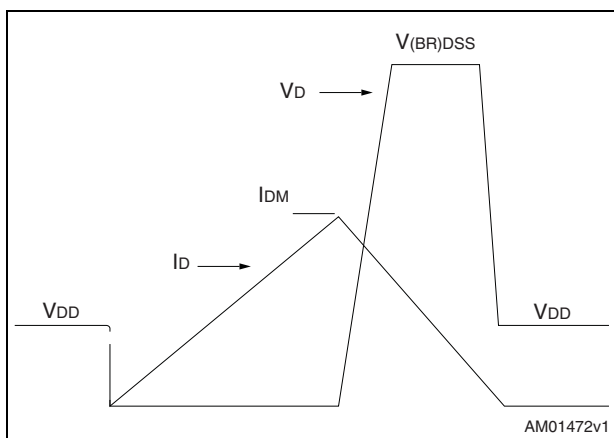
**Figure 20. Test circuit for inductive load switching and diode recovery times**



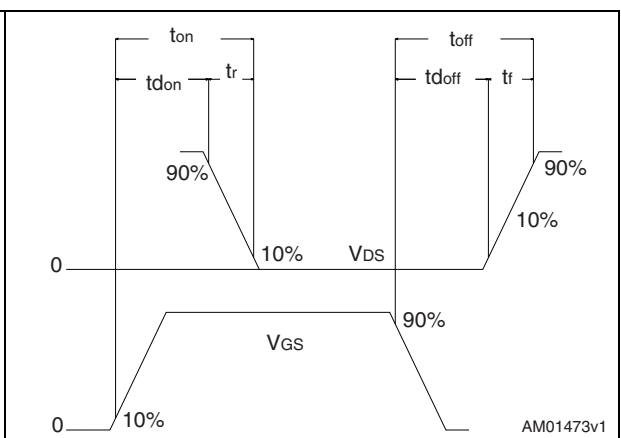
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**



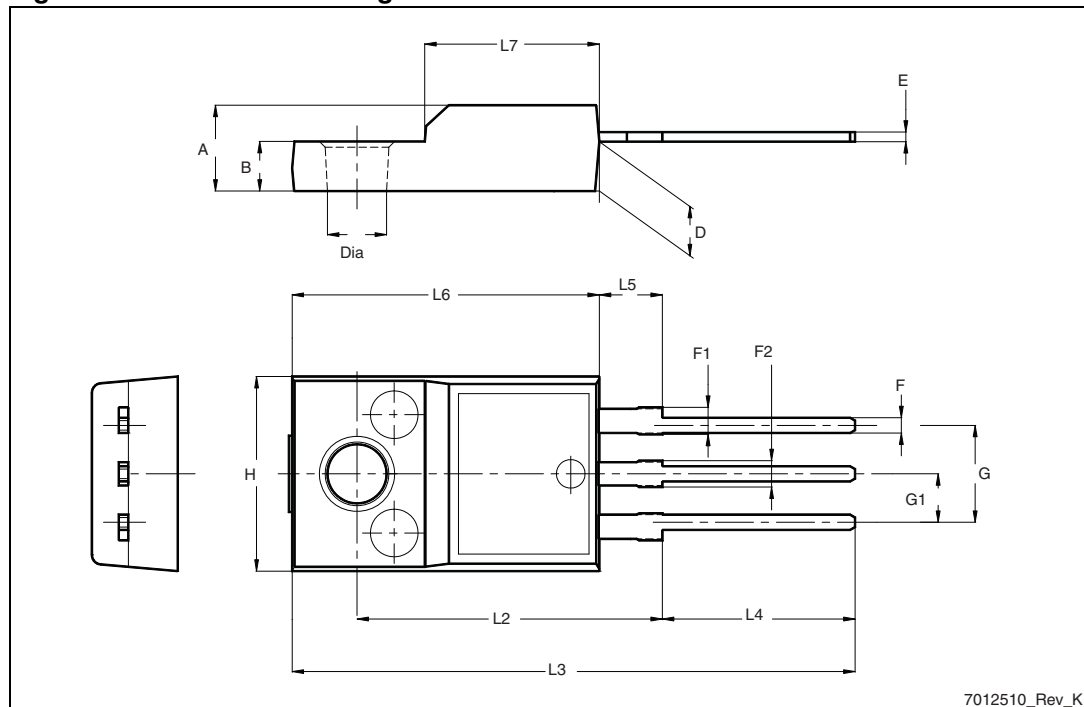
## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<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. 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

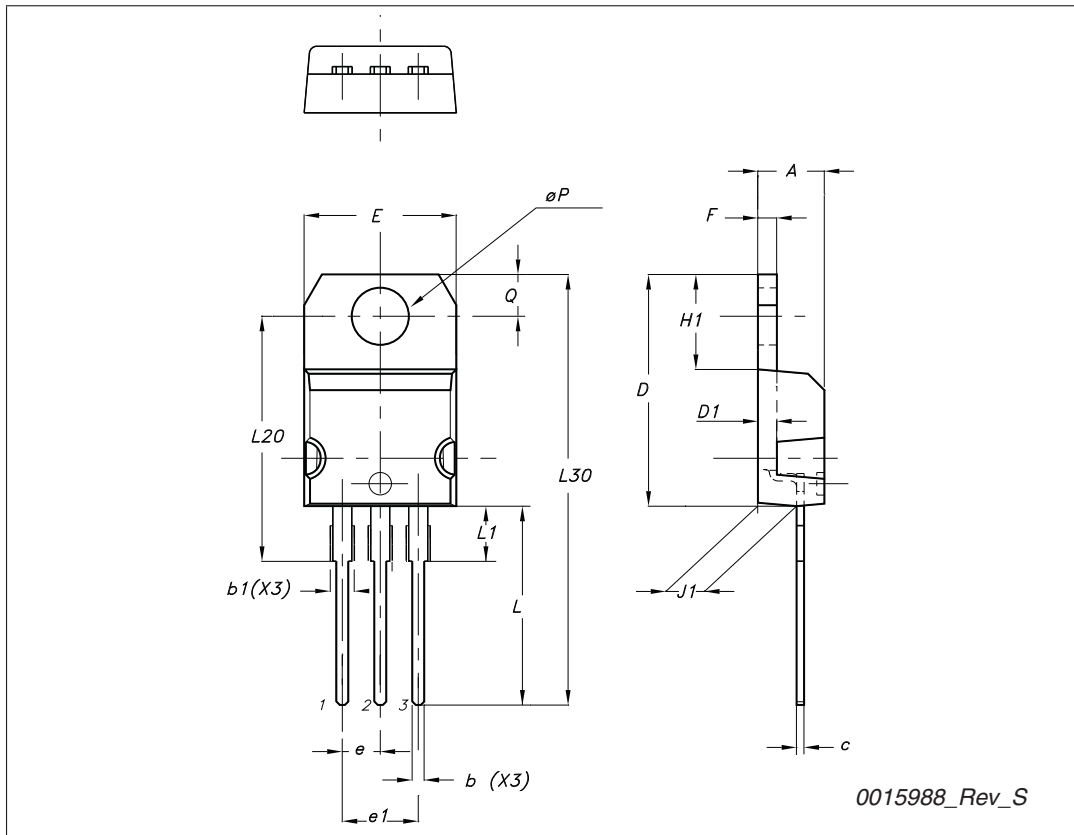
Figure 24. TO-220FP drawing



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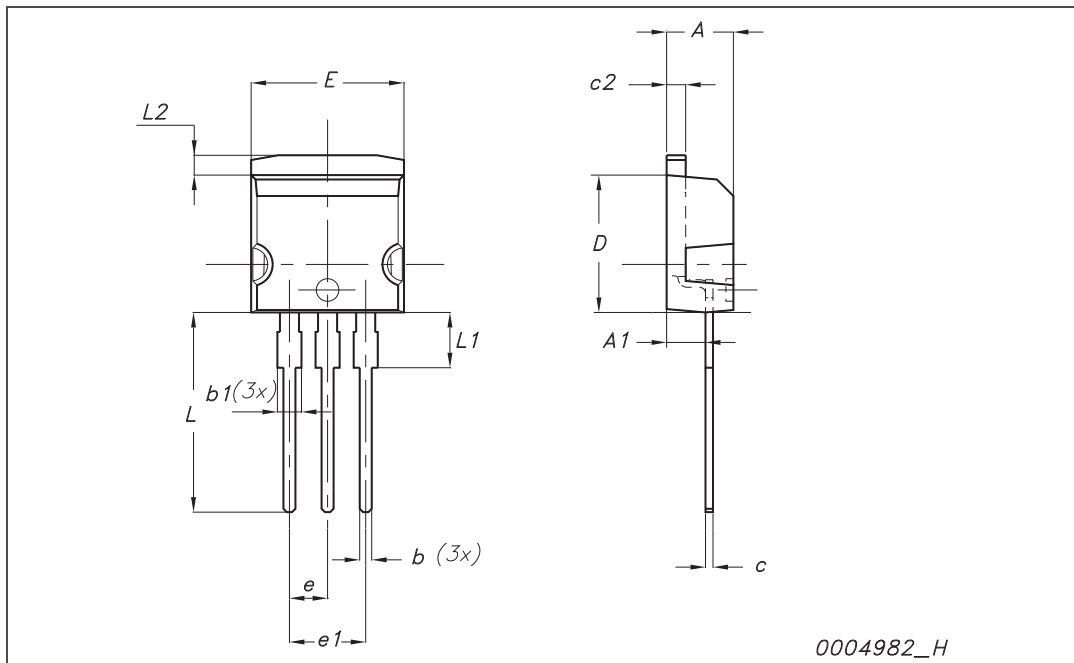
**TO-220 type A mechanical data**

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	
∅P	3.75		3.85
Q	2.65		2.95



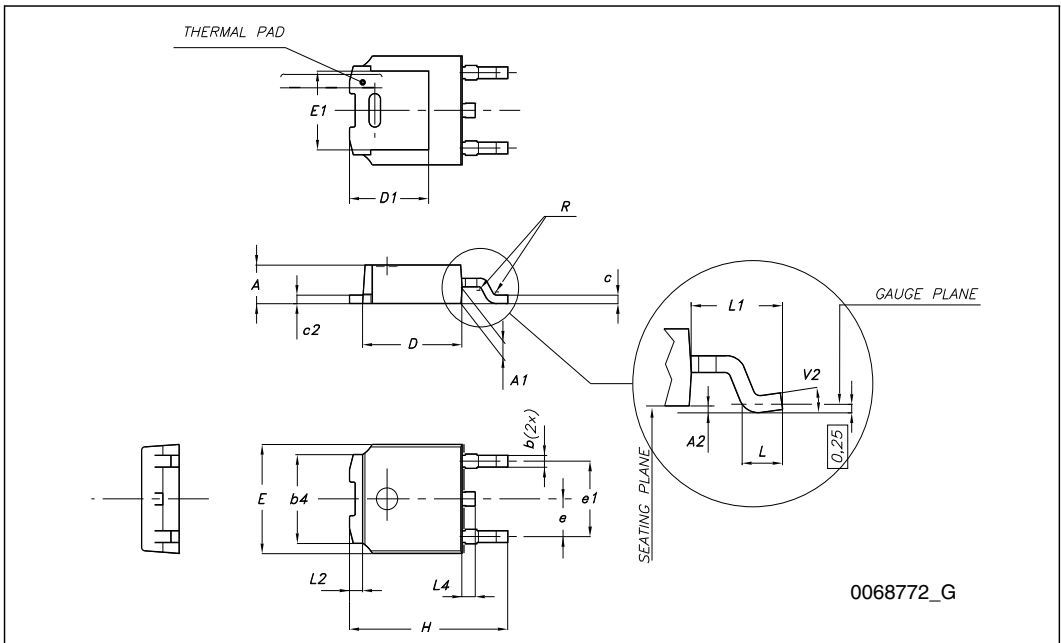
I<sup>2</sup>PAK (TO-262) mechanical data

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



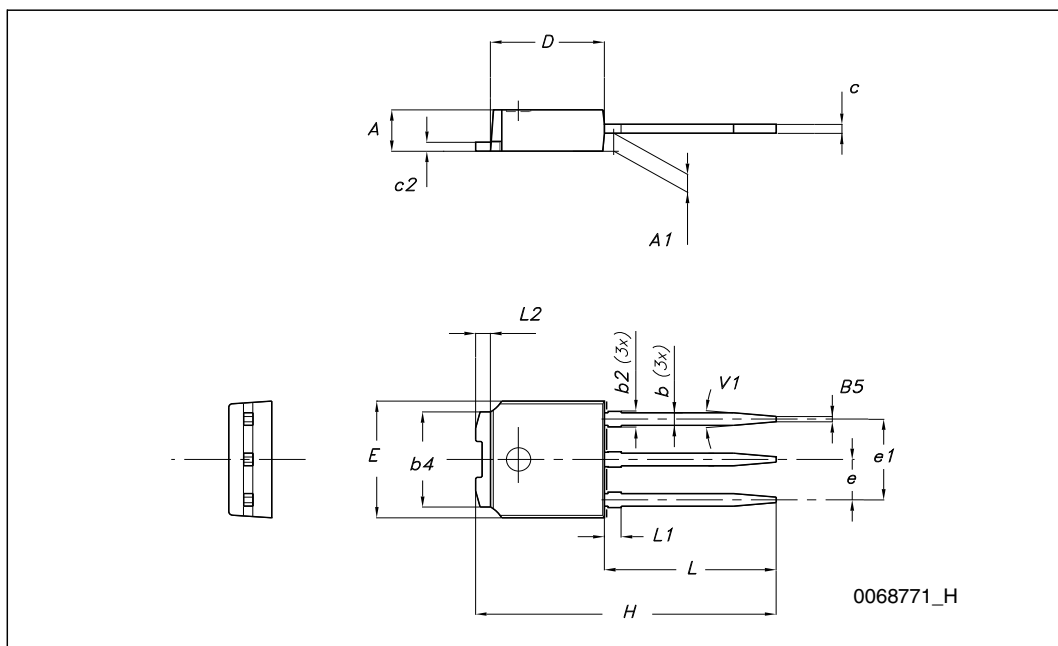
**TO-252 (DPAK) mechanical data**

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**

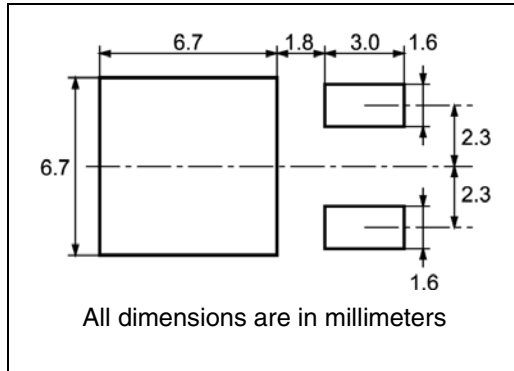
DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
(L1)	0.80		1.20
L2		0.80	
V1		10°	





# 5 Packaging mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

G measured at hub

### REEL MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	16.4	18.4	0.645	0.724
N	50		1.968	
T		22.4		0.881

BASE QTY	BULK QTY
2500	2500

### TAPE MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	6.8	7	0.267	0.275
B0	10.4	10.6	0.409	0.417
B1		12.1		0.476
D	1.5	1.6	0.059	0.063
D1	1.5		0.059	
E	1.65	1.85	0.065	0.073
F	7.4	7.6	0.291	0.299
K0	2.55	2.75	0.100	0.108
P0	3.9	4.1	0.153	0.161
P1	7.9	8.1	0.311	0.319
P2	1.9	2.1	0.075	0.082
R	40		1.574	
W	15.7	16.3	0.618	0.641

TOP COVER TAPE

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

FEED DIRECTION

Bending radius R min.

For machine ref. only including draft and radii concentric around B0

## 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, I<sup>2</sup>PAK</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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