



STD11NM60ND, STF11NM60ND STP11NM60ND, STU11NM60ND

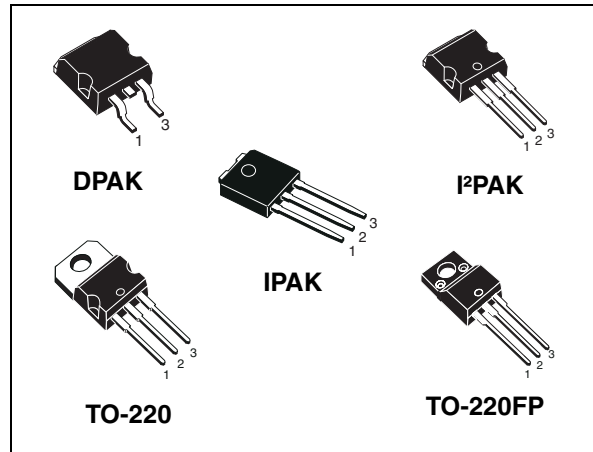
N-channel 600 V, 0.37 Ω , 10 A, FDmesh™ II Power MOSFET
I²PAK, TO-220, TO-220FP, IPAK, DPAK

Features

Order codes	V _{DSS} (@T _{Jmax})	R _{DS(on)} max	I _D
STD11NM60ND	650 V	< 0.45 Ω	10 A
STF11NM60ND			10 A ⁽¹⁾
STI11NM60ND			10 A
STP11NM60ND			10 A
STU11NM60ND			10 A

1. Limited only by maximum temperature allowed

- The worldwide best R_{DS(on)}* 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

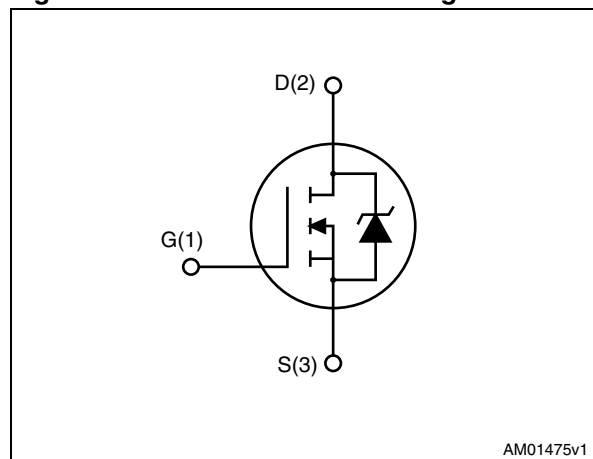
Description

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.

Table 1. Device summary

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

Figure 1. Internal schematic diagram



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1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		DPAK/I ² PAK, TO-220/IPAK	TO-220FP	
V_{DS}	Drain-source voltage ($V_{GS}=0$)	600		V
V_{GS}	Gate-source voltage	± 25		V
I_D	Drain current (continuous) at $T_C = 25^\circ\text{C}$	10	10 ⁽¹⁾	A
I_D	Drain current (continuous) at $T_C = 100^\circ\text{C}$	6.3	6.3 ⁽¹⁾	A
$I_{DM}^{(2)}$	Drain current (pulsed)	40	40 ⁽¹⁾	A
P_{TOT}	Total dissipation at $T_C = 25^\circ\text{C}$	90	25	W
$dv/dt^{(3)}$	Peak diode recovery voltage slope	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		$^\circ\text{C}$

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. $I_{SD} \leq 10\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$, $V_{DD} = 80\% V_{(BR)DSS}$, peak $V_{DS} \leq V_{(BR)DSS}$

Table 3. Thermal data

Symbol	Parameter	Value					Unit
		TO-220	I ² PAK	DPAK	IPAK	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	1.38				5	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-amb max	62.5			100	62.5	$^\circ\text{C}/\text{W}$
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb max			50			$^\circ\text{C}/\text{W}$
T_l	Maximum lead temperature for soldering purposes	300			300		$^\circ\text{C}$

1. When mounted on 1inch² FR-4 board, 2 oz Cu

Table 4. Avalanche characteristics

Symbol	Parameter	Max value	Unit
I_{AS}	Avalanche current, repetitive or not-repetitive ⁽¹⁾	3.5	A
E_{AS}	Single pulse avalanche energy ⁽²⁾	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

($T_{CASE} = 25\text{ }^{\circ}\text{C}$ 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 ($V_{GS} = 0$)	$V_{DS} = \text{max rating}$, $V_{DS} = \text{max rating}$, @ $125\text{ }^{\circ}\text{C}$			1 100	μA μA
I_{GSS}	Gate body leakage current ($V_{DS} = 0$)	$V_{GS} = \pm 20\text{ V}$			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	$V_{GS} = 10\text{ V}$, $I_D = 5\text{ A}$		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
$g_{fs}^{(1)}$	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	-	Ω
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 Figure 19)	-	30 4 16	-	nC nC nC

1. Pulsed: pulse duration = 300 μs , 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 Figure 18)	-	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 Figure 20)	-	130		ns
Q_{rr}	Reverse recovery charge			0.69		μC
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 Figure 20)	-	200		ns
Q_{rr}	Reverse recovery charge			1.2		μC
I_{RRM}	Reverse recovery current			12		A

1. Pulse width limited by safe operating area

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

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220, I²PAK

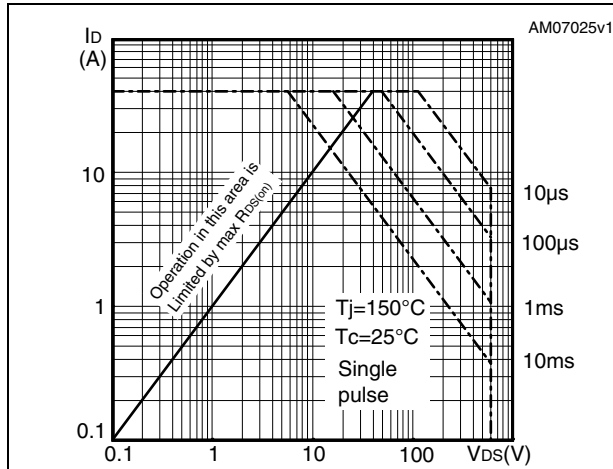


Figure 3. Thermal impedance for TO-220, I²PAK

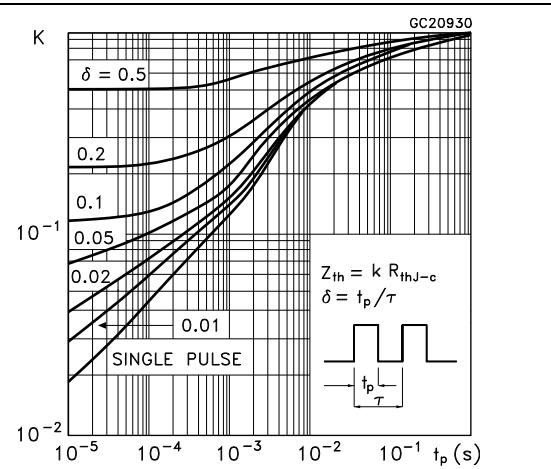


Figure 4. Safe operating area for TO-220FP

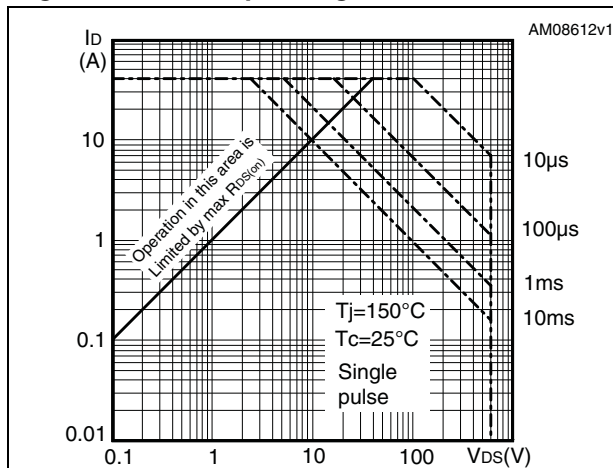


Figure 5. Thermal impedance for TO-220FP

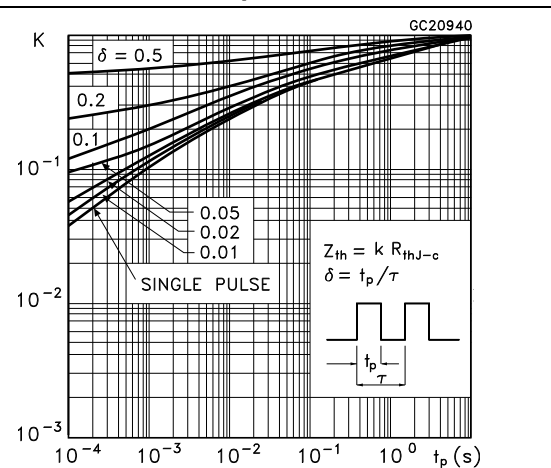


Figure 6. Safe operating area for DPAK, IPAK

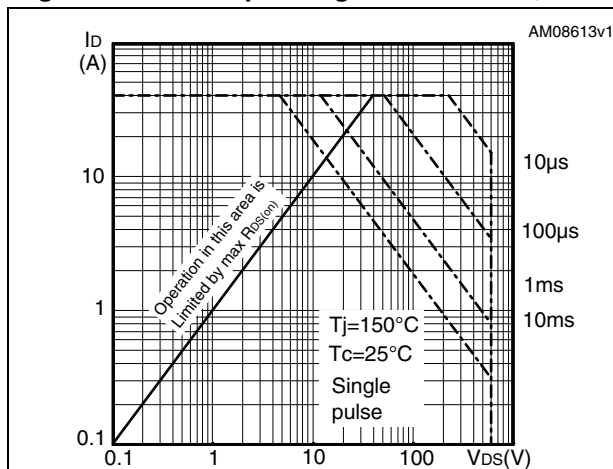


Figure 7. Thermal impedance for DPAK, IPAK

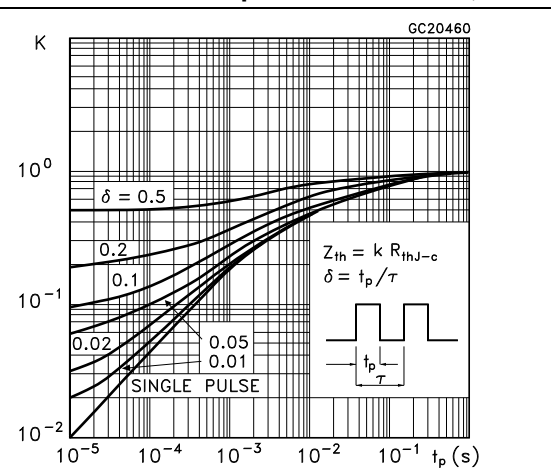


Figure 8. Output characteristics

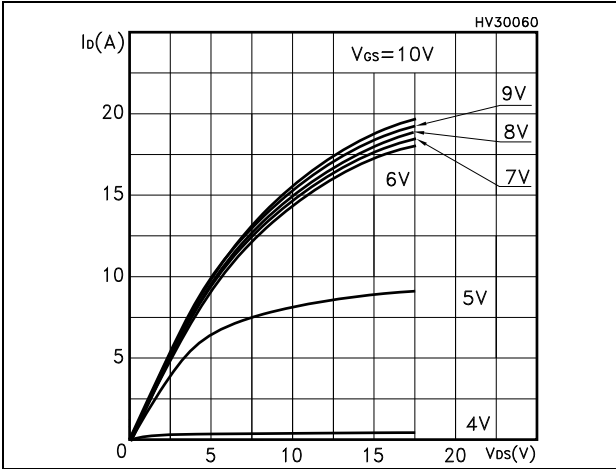


Figure 9. Transfer characteristics

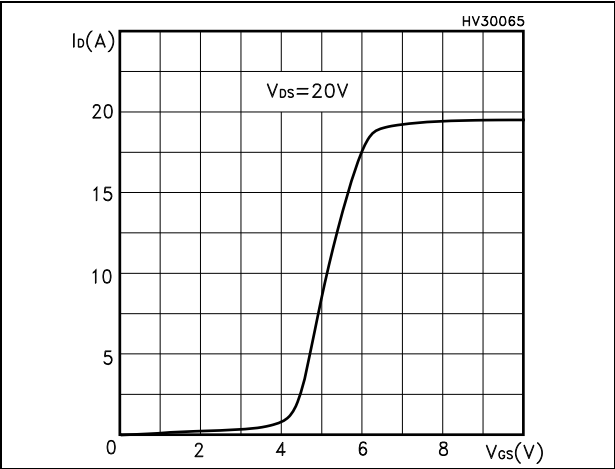


Figure 10. Transconductance

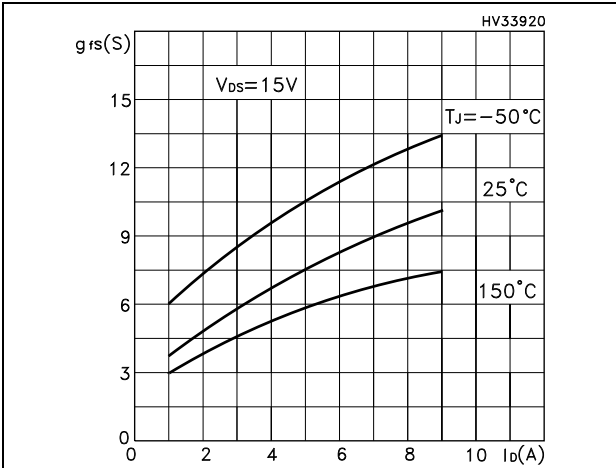


Figure 11. Static drain-source on resistance

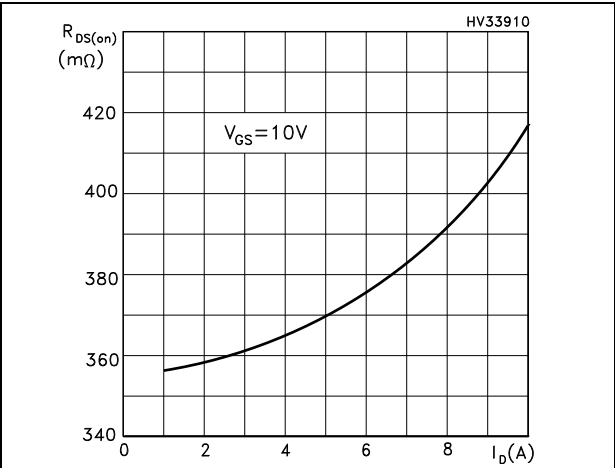


Figure 12. Gate charge vs gate-source voltage

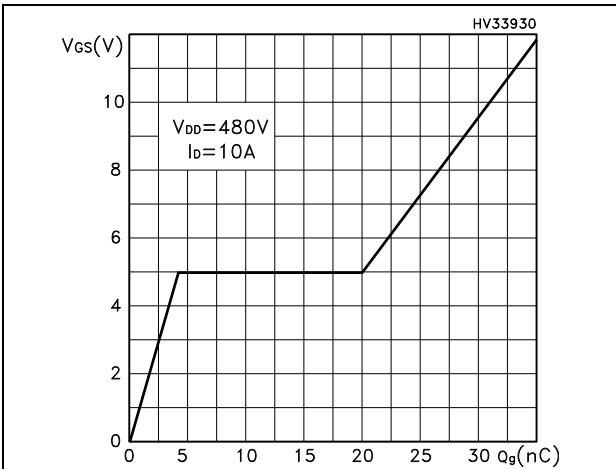


Figure 13. Capacitance variations

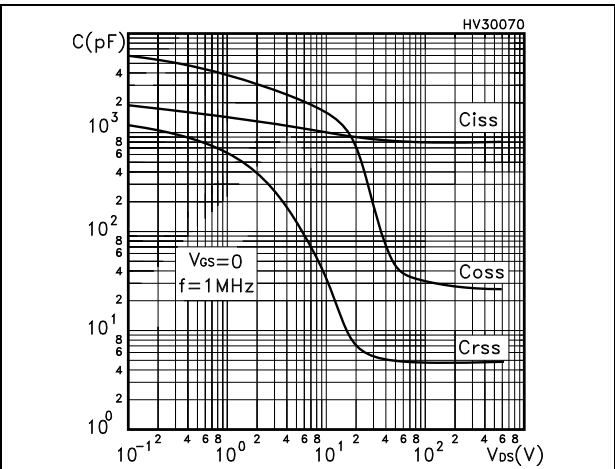


Figure 14. Normalized gate threshold voltage vs temperature

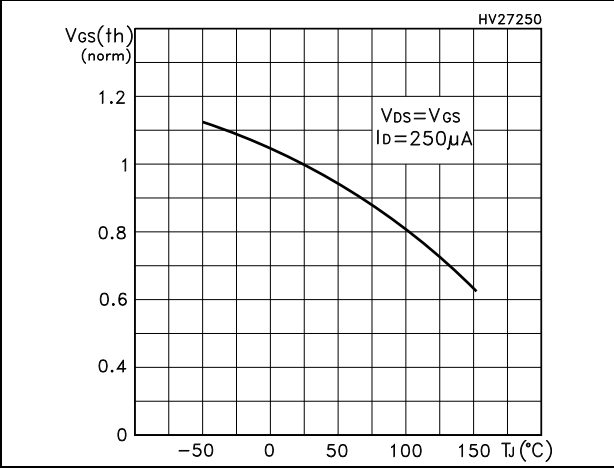


Figure 15. Normalized on resistance vs temperature

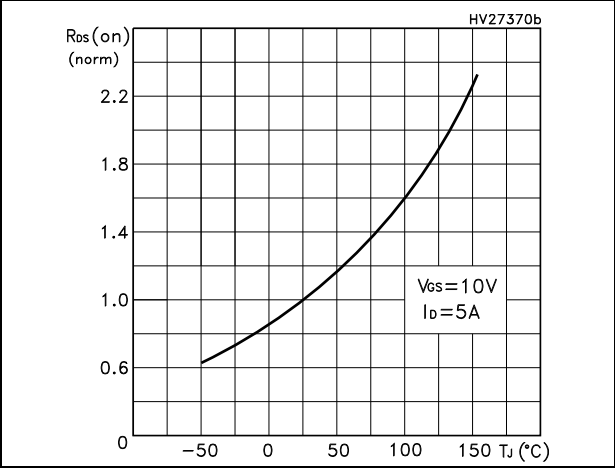


Figure 16. Source-drain diode forward characteristics

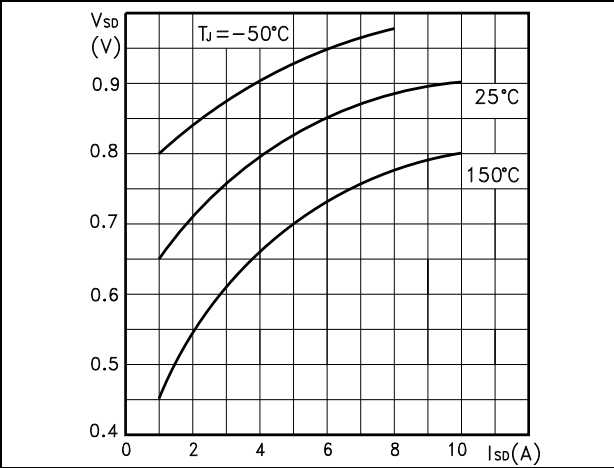
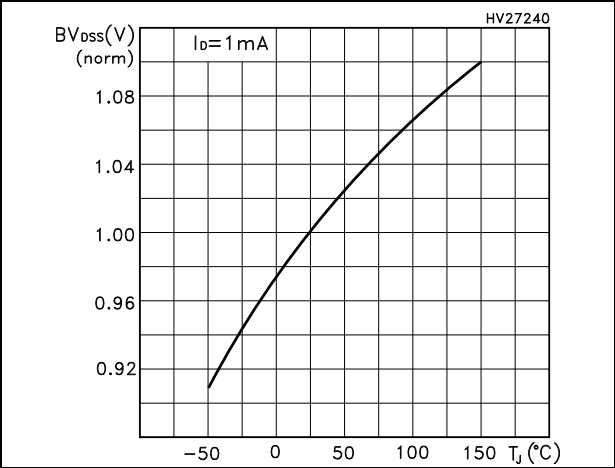


Figure 17. Normalized B_{VDSS} vs temperature



3 Test circuits

Figure 18. Switching times test circuit for resistive load

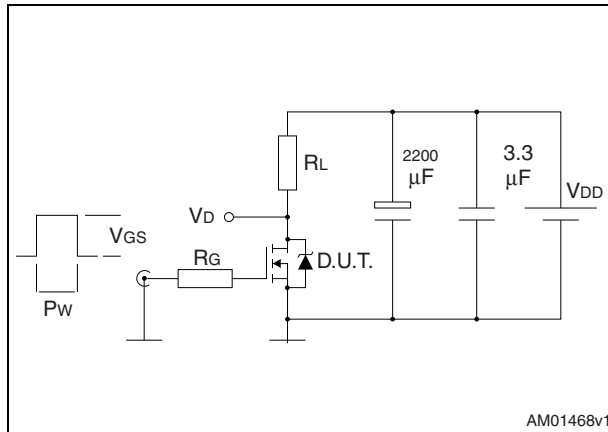


Figure 19. Gate charge test circuit

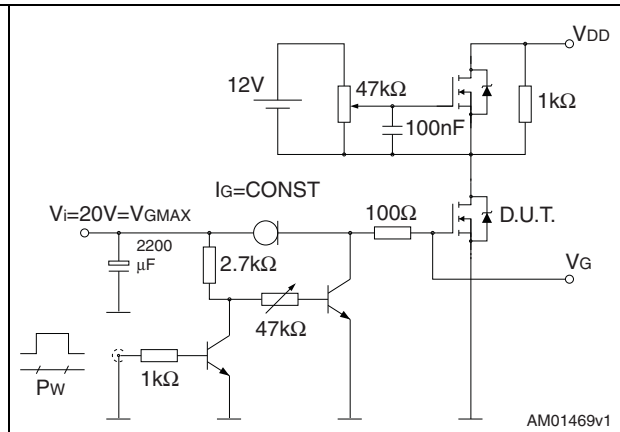


Figure 20. Test circuit for inductive load switching and diode recovery times

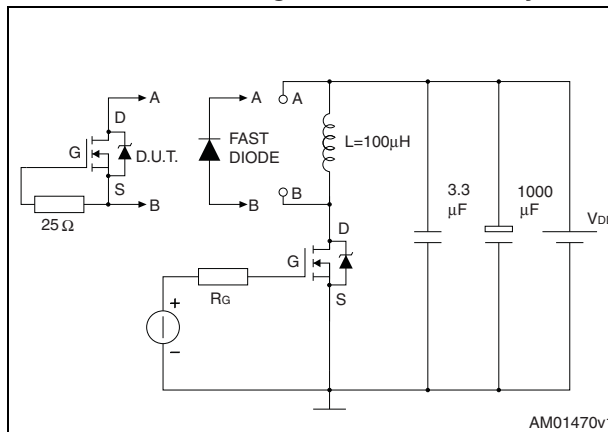


Figure 21. Unclamped inductive load test circuit

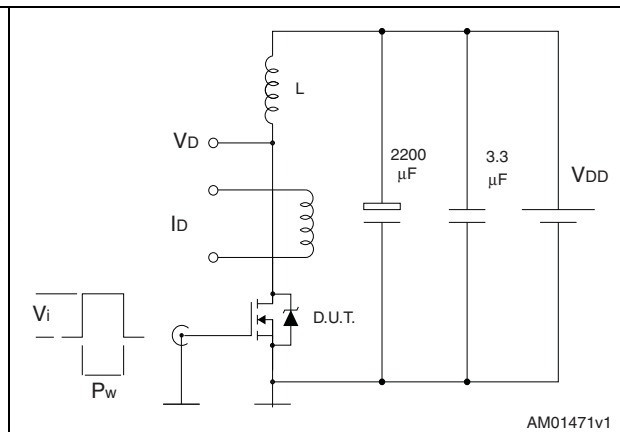


Figure 22. Unclamped inductive waveform

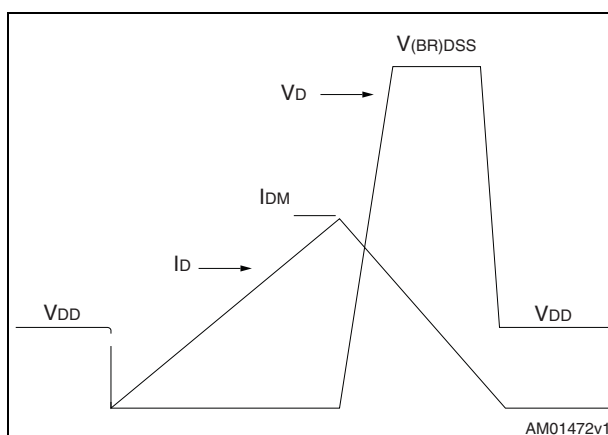
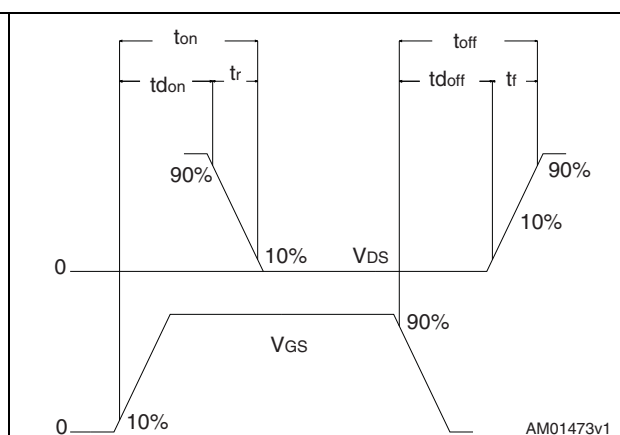


Figure 23. Switching time waveform



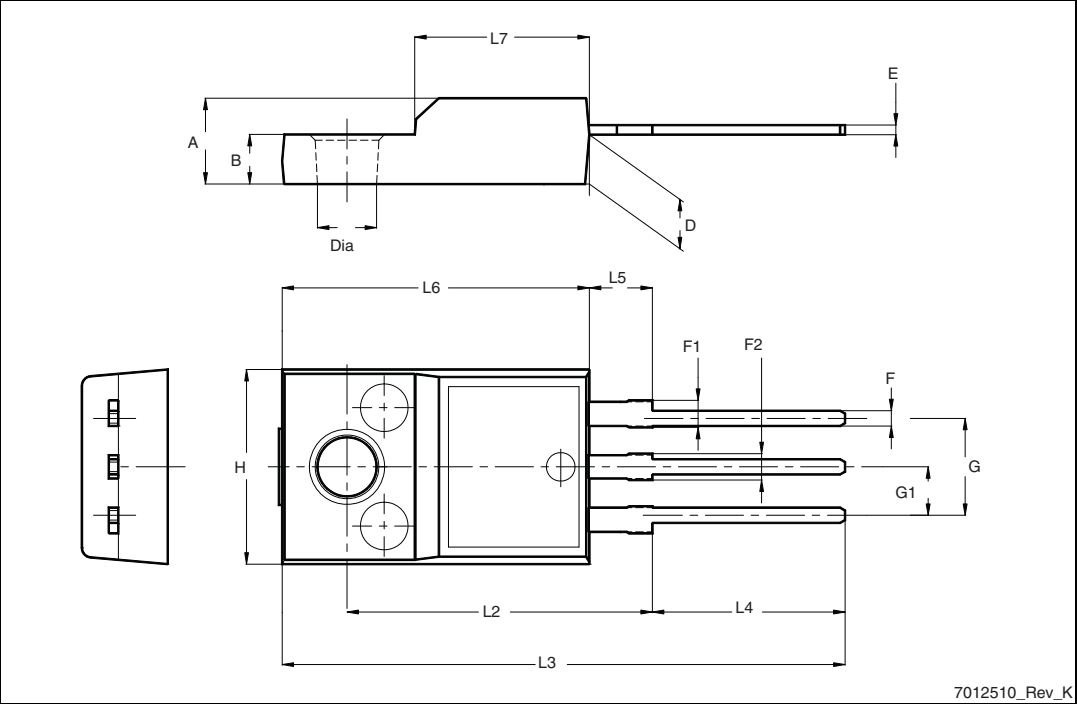
4 Package mechanical data

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. 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

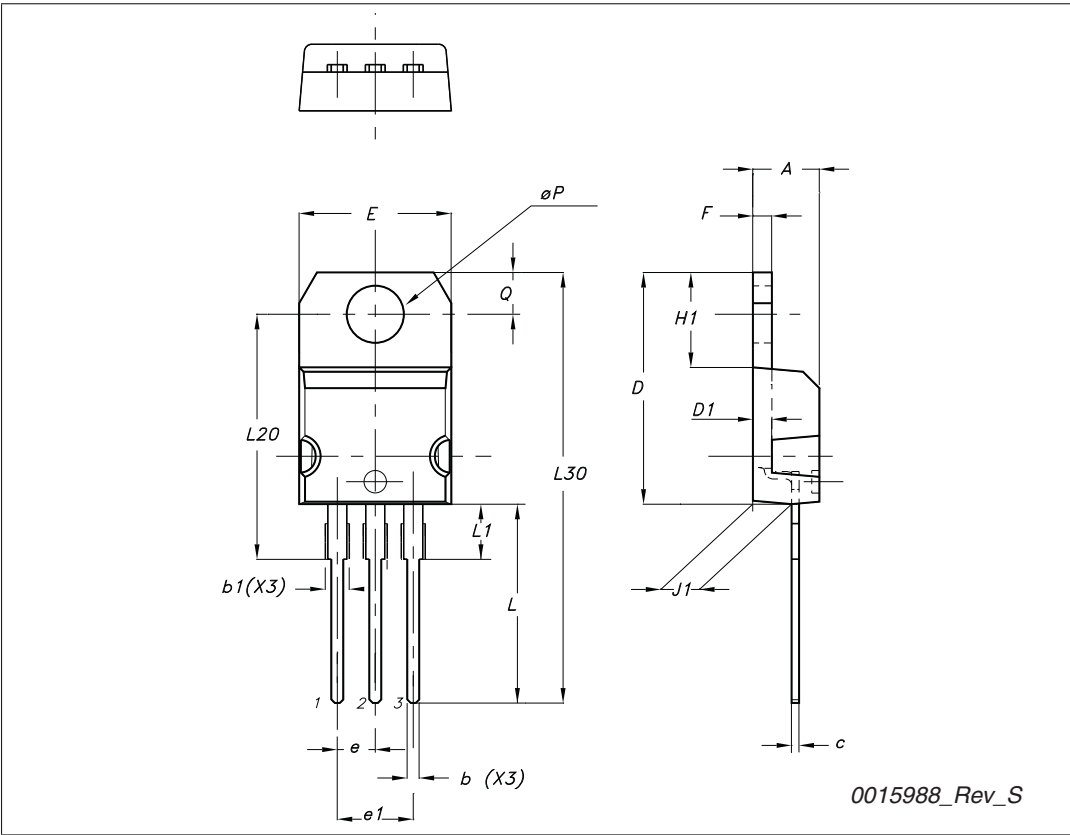
Figure 24. TO-220FP drawing



7012510_Rev_K

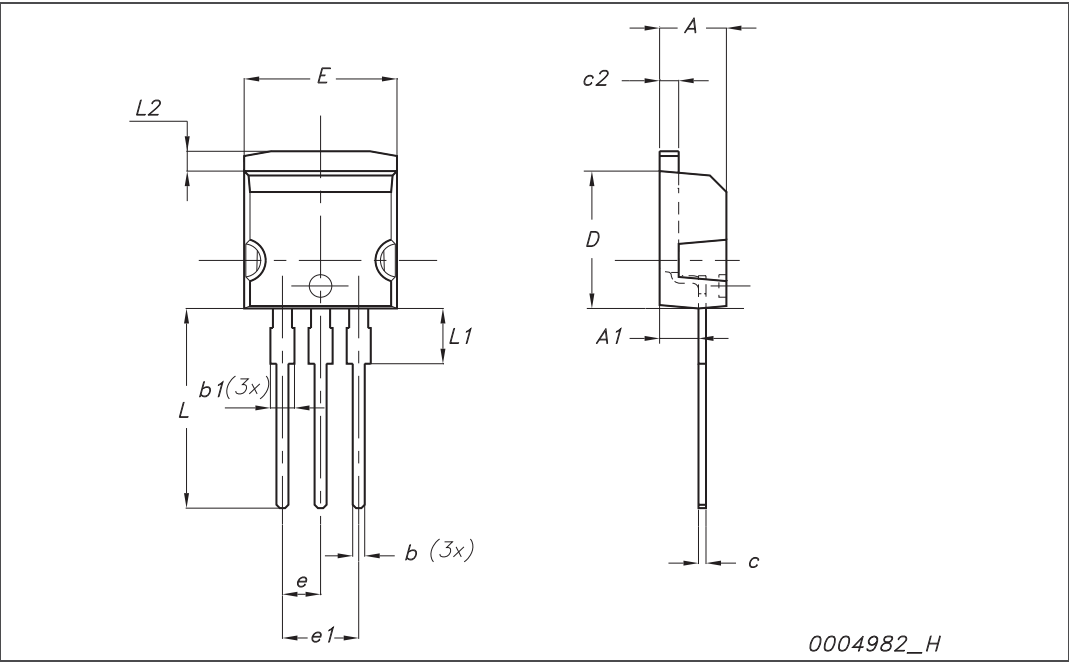
TO-220 type A mechanical data

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	
ØP	3.75		3.85
Q	2.65		2.95



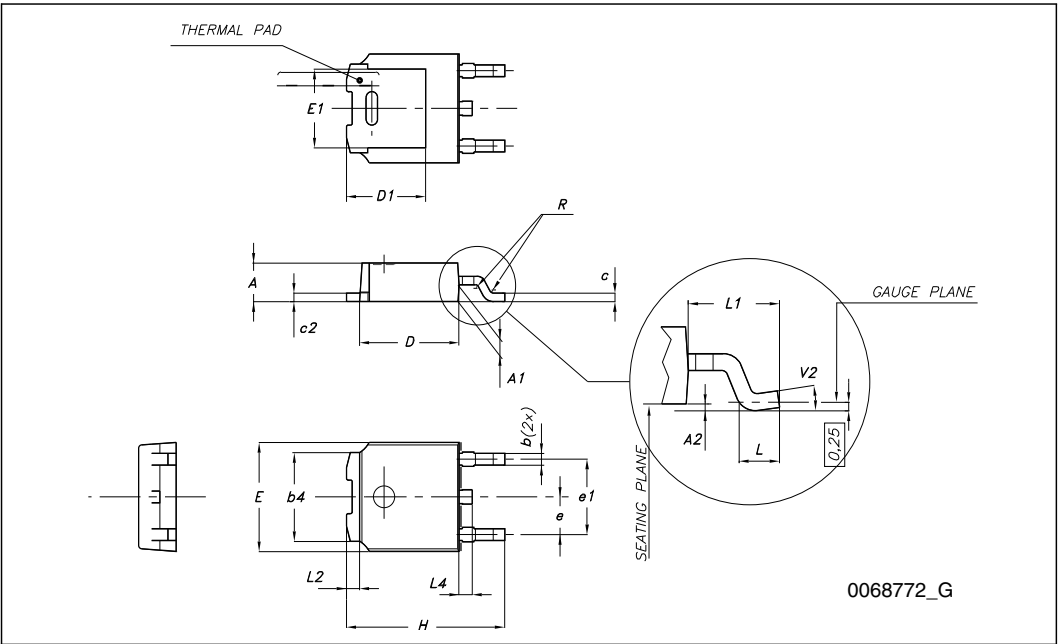
I²PAK (TO-262) mechanical data

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



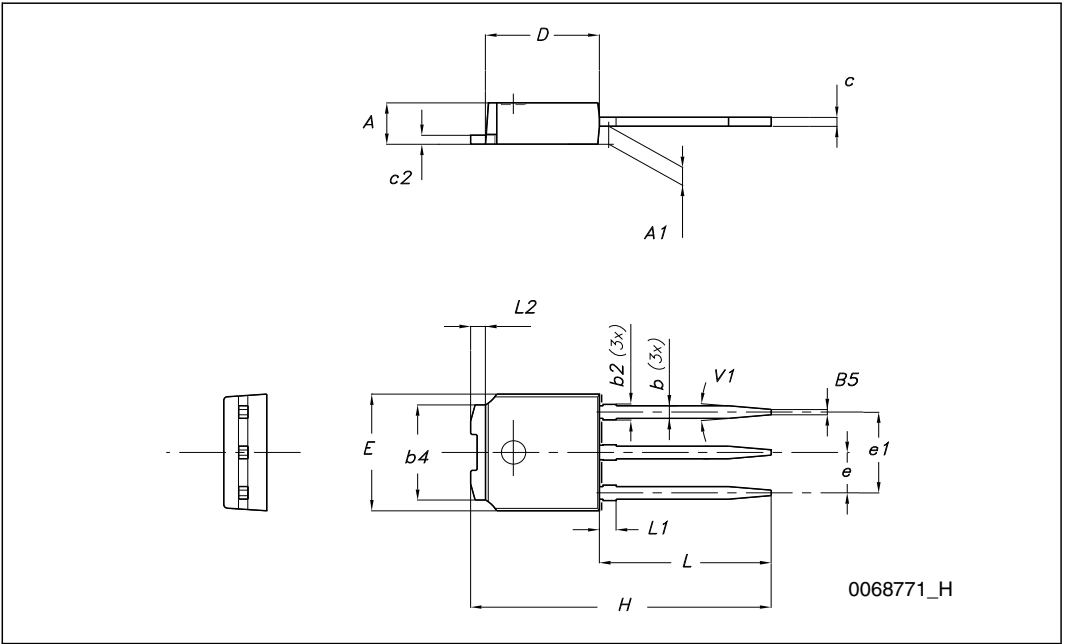
TO-252 (DPAK) mechanical data

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°



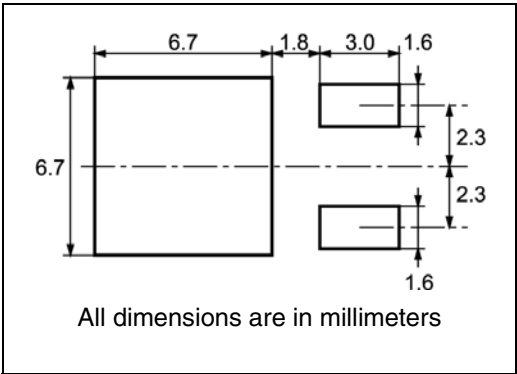
TO-251 (IPAK) mechanical data

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°	

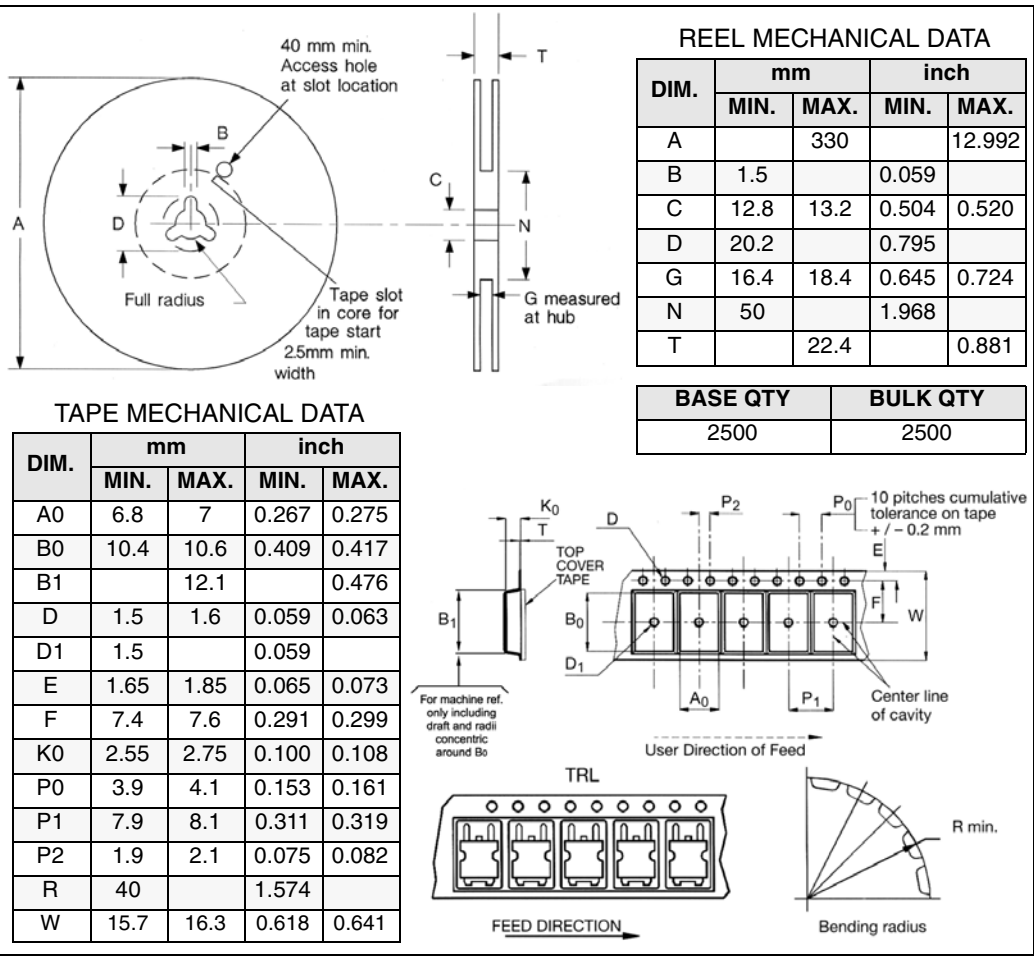


5 Packaging mechanical data

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	– Corrected Figure 2: Safe operating area for TO-220, I²PAK – Corrected Figure 4: Safe operating area for TO-220FP – Corrected Figure 6: Safe operating area for DPAK, IPAK

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