



# STB11NM60FD - STB11NM60FD-1 STP11NM60FD - STP11NM60FD FP

N-channel 600V - 0.40Ω - 11A - TO-220/TO-220FP/D<sup>2</sup>PAK/I<sup>2</sup>PAK  
FDmesh™ Power MOSFET (with fast diode)

## General features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>
STB11NM60FD	600V	<0.45Ω	11A
STB11NM60FD-1	600V	<0.45Ω	11A
STP11NM60FD	600V	<0.45Ω	11A
STP11NM60FD FP	600V	<0.45Ω	11A

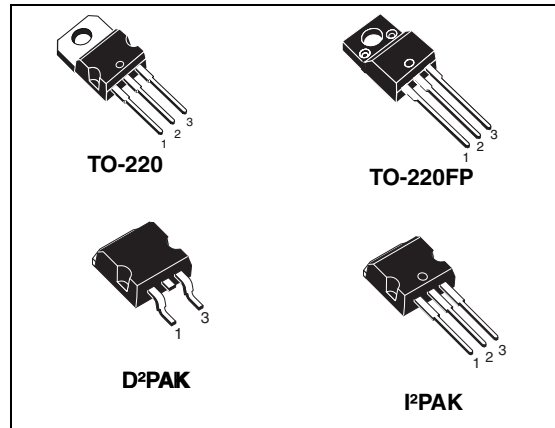
- 100% avalanche tested
- High dv/dt and avalanche capabilities
- Low input capacitance and gate charge
- Low gate input resistance
- Tight process control and high manufacturing yields

## Description

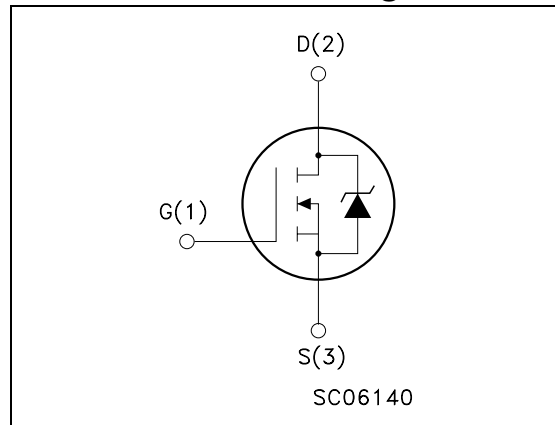
The FDmesh™ associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

## Applications

- Switching application



## Internal schematic diagram



## Order codes

Part number	Marking	Package	Packaging
STB11NM60FD	B11NM60FD	D <sup>2</sup> PAK	Tape & reel
STB11NM60FD-1	B11NM60FD	I <sup>2</sup> PAK	Tube
STP11NM60FD	P11NM60FD	TO-220	Tube
STP11NM60FD FP	P11NM60FD FP	TO-220FP	Tube

## Contents

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220/ D <sup>2</sup> PAK/I <sup>2</sup> PAK	TO-220FP	
V <sub>DS</sub>	Drain-source voltage (v <sub>gs</sub> = 0)	600		V
V <sub>DGR</sub>	Drain-gate voltage (R <sub>GS</sub> = 20 kΩ)	600		V
V <sub>GS</sub>	Gate- source voltage	±30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25°C	11	11 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100°C	7	7 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	44	44 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25°C	160	35	W
	Derating factor	0.88	0.28	W/°C
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	20		V/ns
V <sub>ISO</sub>	Insulation withstand voltage (dc)	--	2500	V
T <sub>stg</sub>	Storage temperature	-65 to 150		°C

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- I<sub>SD</sub> < 11A, di/dt < 400A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 2. Thermal resistance**

Symbol	Parameter	Value		Unit
		TO-220 D <sup>2</sup> PAK/I <sup>2</sup> PAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case Max	0.78	3.57	°C/W
R <sub>thj-a</sub>	Thermal resistance junction-ambient Max	62.5		°C/W
T <sub>I</sub>	Maximum lead temperature for soldering purpose	300		°C

**Table 3. Avalanche data**

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)	5.5	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>j</sub> = 25°C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 35V)	350	mJ

## 2 Electrical characteristics

( $T_{CASE}=25^{\circ}C$  unless otherwise specified)

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 250 \mu A, V_{GS} = 0$	600			V
$I_{DSS}$	Zero gate voltage Drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating}$ $V_{DS} = \text{Max rating}, T_C = 125^{\circ}C$			1 100	$\mu A$ $\mu A$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 30V$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250 \mu A$	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10V, I_D = 5.5A$		0.40	0.45	W

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} > I_{D(on)} \times R_{DS(on)max},$ $I_D = 5.5A$		5.2		S
$C_{iss}$	Input capacitance			900		pF
$C_{oss}$	Output capacitance	$V_{DS} = 25V, f = 1 \text{ MHz},$ $V_{GS} = 0$		350		pF
$C_{rss}$	Reverse transfer capacitance			35		pF
$C_{oss eq}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0V, V_{DS} = 0V \text{ to } 400V$		100		pF
$R_G$	Gate input resistance	$f = 1 \text{ MHz}$ Gate DC Bias = 0 test signal level = 20mV open drain		3		$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 400V, I_D = 11A,$		28	40	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10V$		7.8		nC
$Q_{gd}$	Gate-drain charge	(see Figure 15)		13		nC

1. Pulsed: Pulse duration = 300  $\mu s$ , duty cycle 1.5 %
2.  $C_{oss eq}$  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 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 250V, I_D = 5.5A$ $R_G = 4.7\Omega, V_{GS} = 10V$ (see Figure 14)		20		ns
$t_r$	Rise time			16		ns
$t_{r(Voff)}$	Off-voltage rise time	$V_{DD} = 400V, I_D = 11A,$ $R_G = 4.7\Omega, V_{GS} = 10V$ (see Figure 16)		10		ns
$t_f$	Fall time			15		ns
$t_c$	Cross-over time			24		ns

**Table 7. 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	$I_{SD} = 11A, V_{GS} = 0$			1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 11A, V_{DD} = 50V$ $di/dt = 100A/\mu s,$ (see Figure 19)		140		ns
$Q_{rr}$	Reverse recovery charge			680		nC
$I_{RRM}$	Reverse recovery current			A		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 11A, V_{DD} = 50V$ $di/dt = 100A/\mu s,$ $T_J = 150^\circ C$ (see Figure 19)		260		ns
$Q_{rr}$	Reverse recovery charge			1600		nC
$I_{RRM}$	Reverse recovery current			13		A

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

## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area

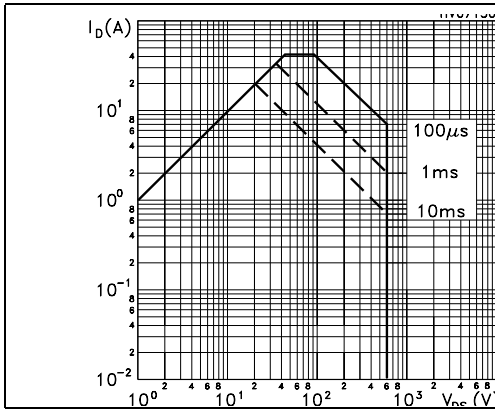


Figure 2. Thermal impedance

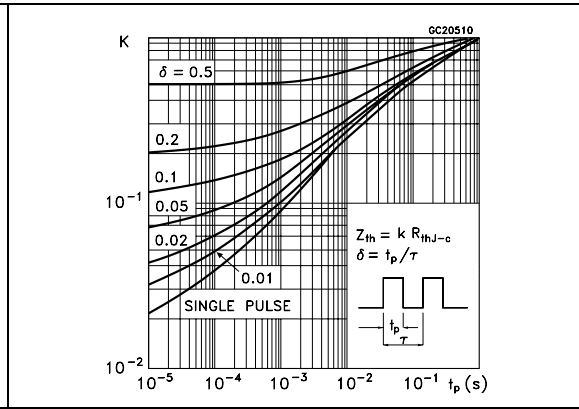


Figure 3. Safe operating area for TO-220FP

Figure 4. Thermal impedance for TO-220FP

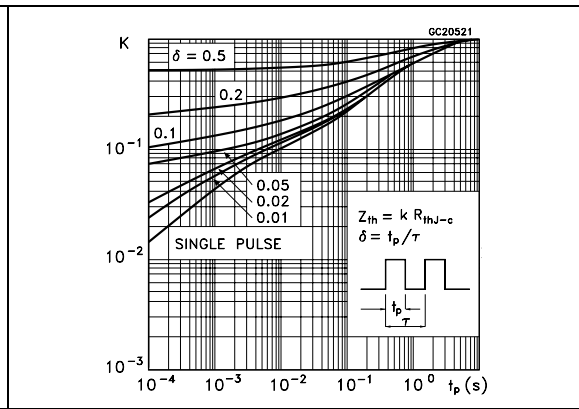
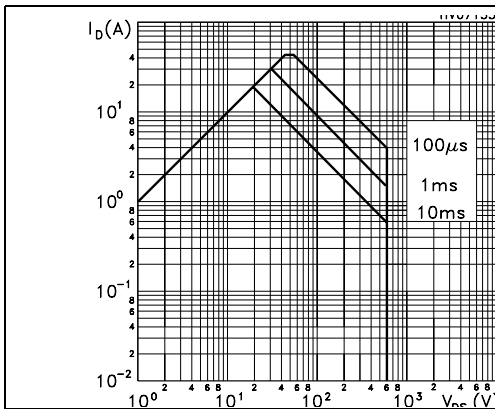


Figure 5. Output characteristics

Figure 6. Transfer characteristics

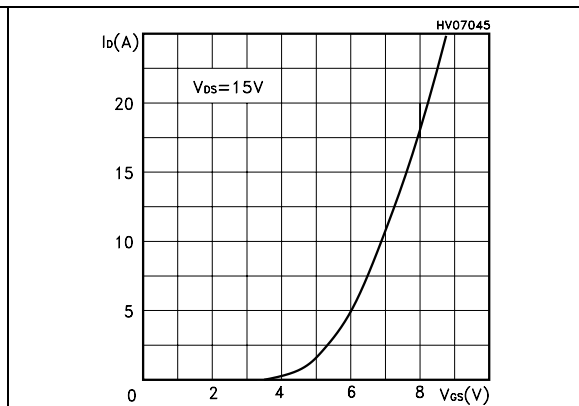
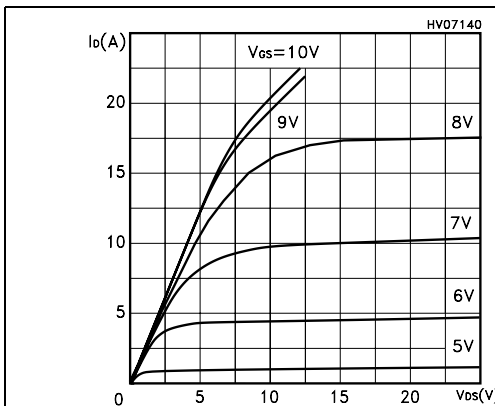


Figure 7. Transconductance

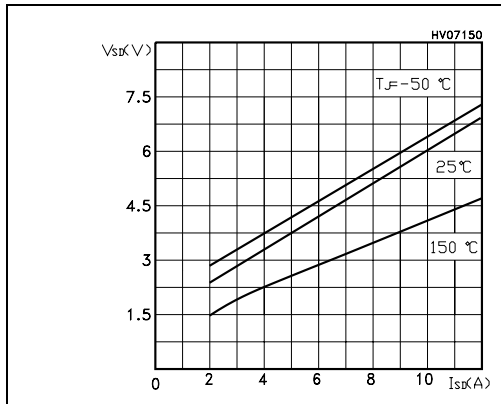


Figure 8. Static drain-source on resistance

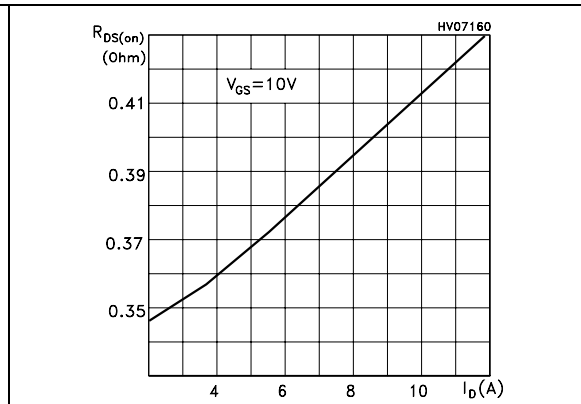


Figure 9. Gate charge vs gate-source voltage

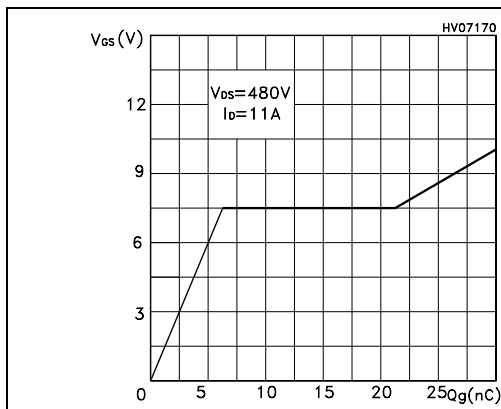


Figure 10. Capacitance variations

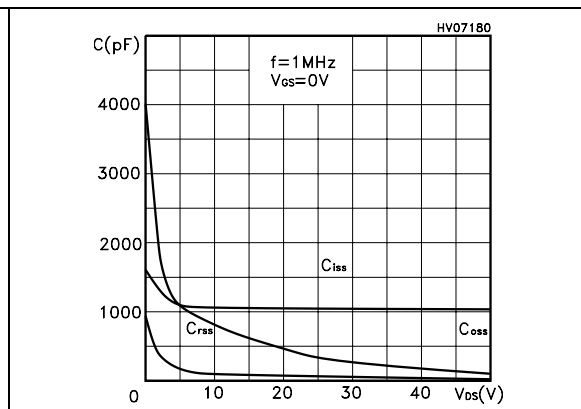


Figure 11. Normalized gate threshold voltage vs temperature

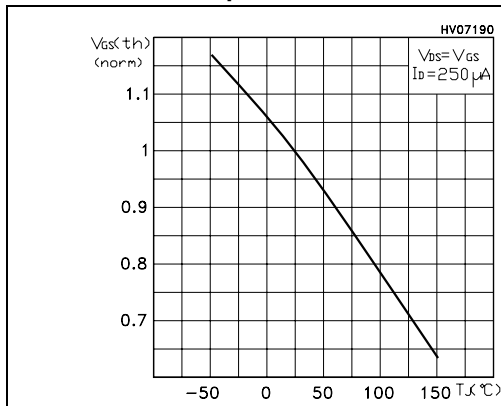


Figure 12. Normalized on resistance vs temperature

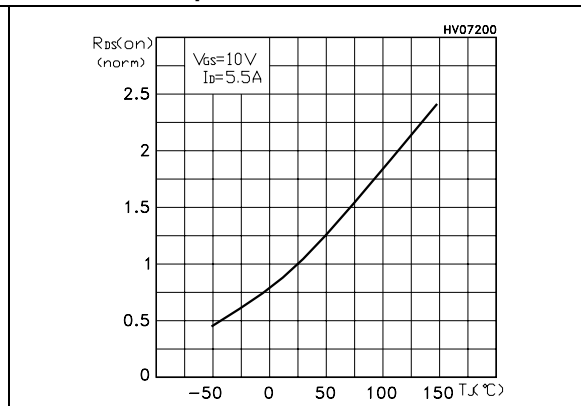
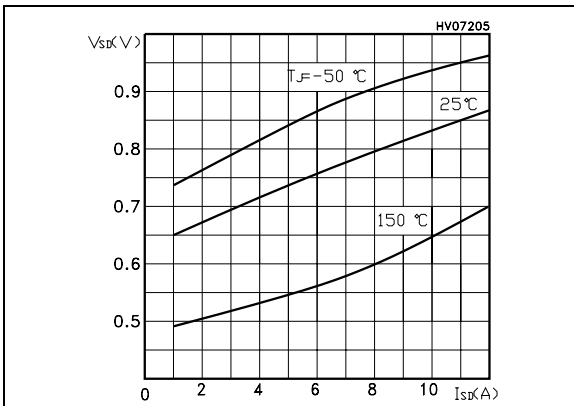


Figure 13. Source-drain diode forward characteristics





### 3 Test circuit

Figure 14. Switching times test circuit for resistive load

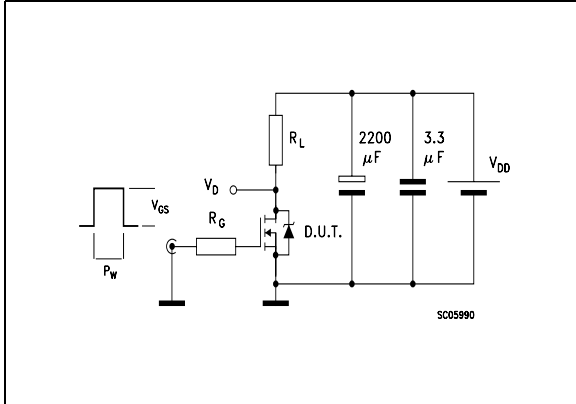


Figure 15. Gate charge test circuit

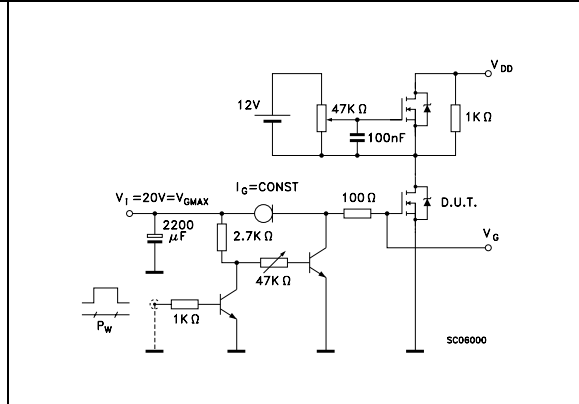


Figure 16. Test circuit for inductive load switching and diode recovery times

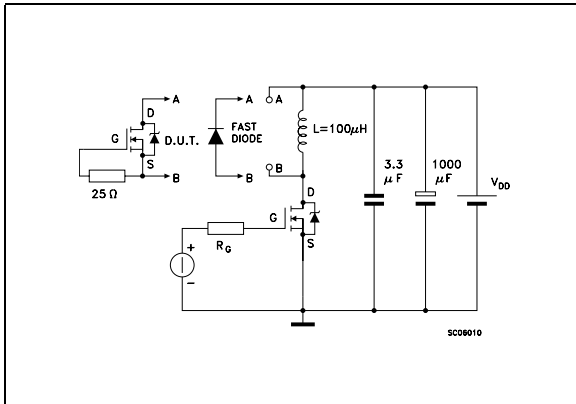


Figure 17. Unclamped Inductive load test circuit

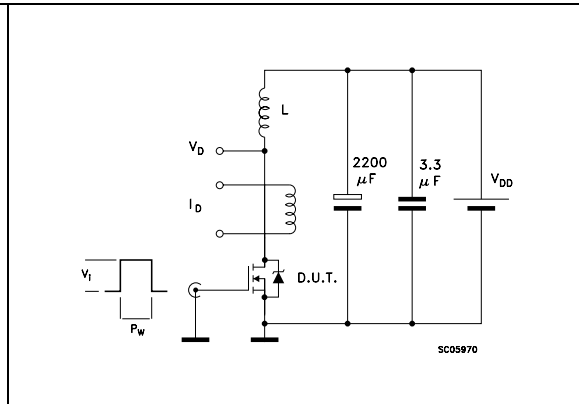


Figure 18. Unclamped inductive waveform

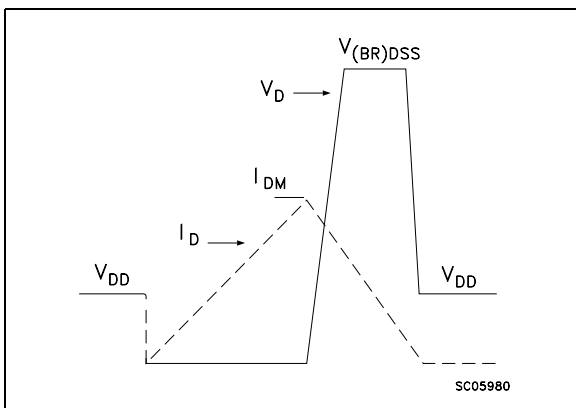
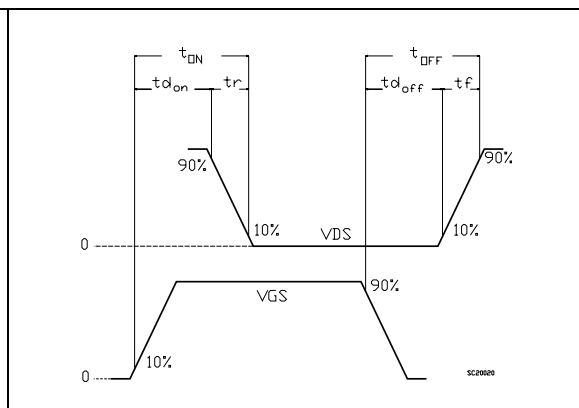


Figure 19. Switching time waveform

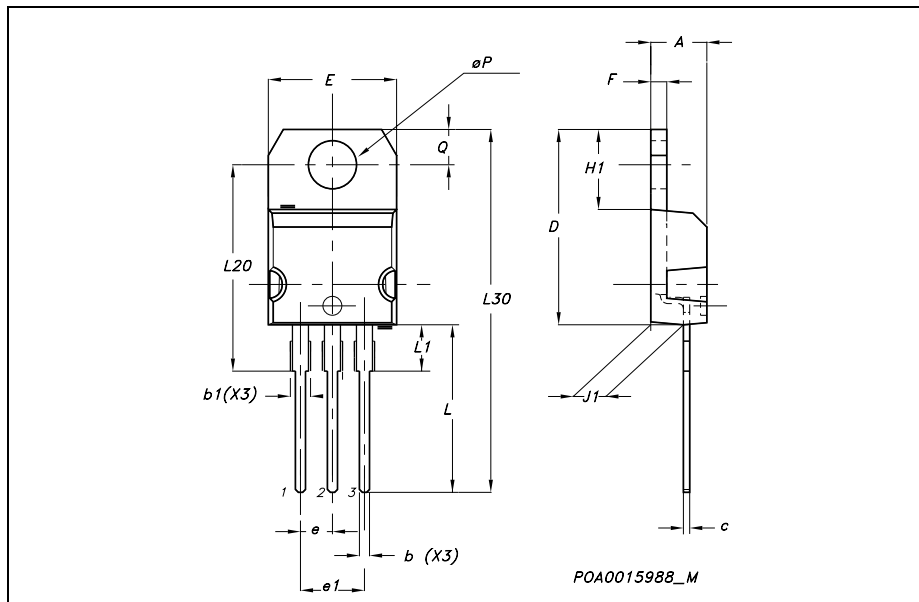


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at : [www.st.com](http://www.st.com)

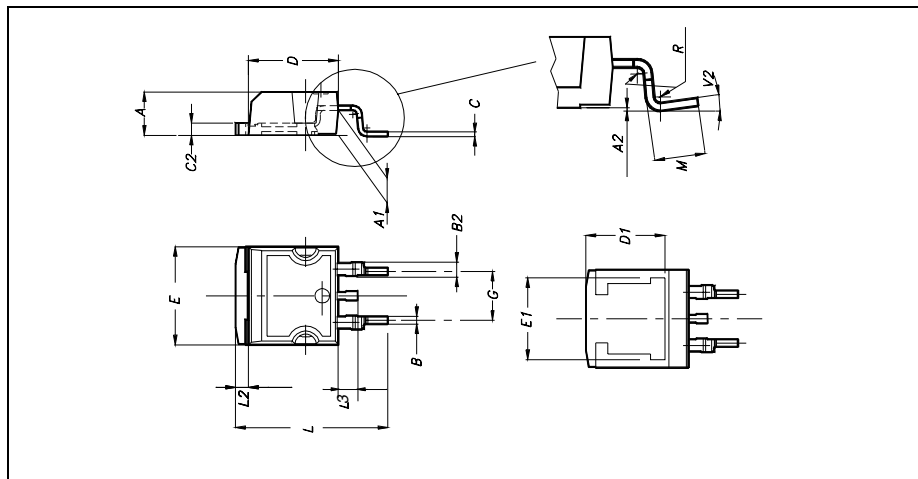
TO-220 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
øP	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



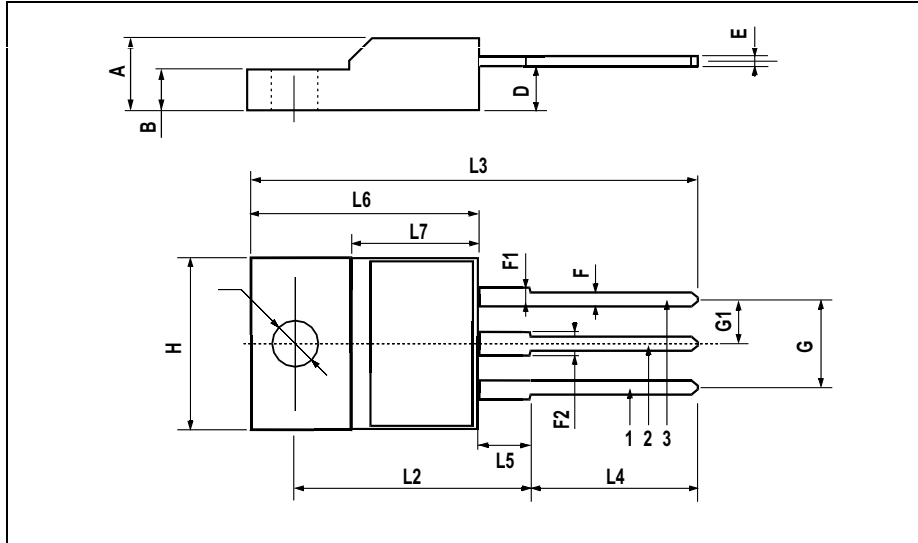
**D<sup>2</sup>PAK MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
A2	0.03		0.23	0.001		0.009
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1		8			0.315	
E	10		10.4	0.393		
E1		8.5			0.334	
G	4.88		5.28	0.192		0.208
L	15		15.85	0.590		0.625
L2	1.27		1.4	0.050		0.055
L3	1.4		1.75	0.055		0.068
M	2.4		3.2	0.094		0.126
R		0.4			0.015	
V2	0°		4°			



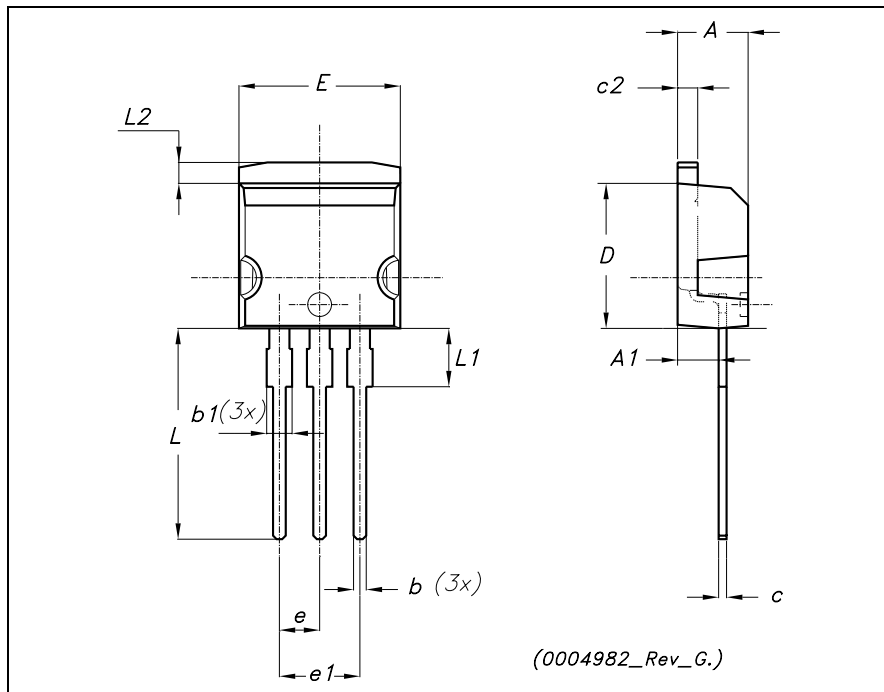
**TO-220FP MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.7	0.045		0.067
F2	1.15		1.7	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	.0385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
Ø	3		3.2	0.118		0.126



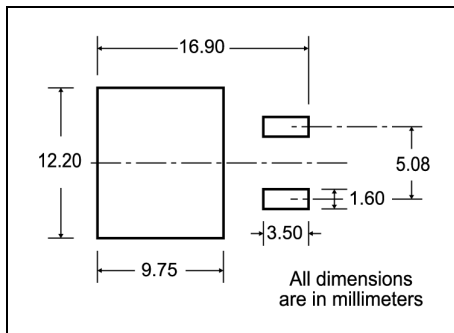
TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA

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



## 5 Packaging mechanical data

### D<sup>2</sup>PAK 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	24.4	26.4	0.960	1.039
N	100		3.937	
T		30.4		1.197

BASE QTY	BULK QTY
1000	1000

#### TAPE MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	10.5	10.7	0.413	0.421
B0	15.7	15.9	0.618	0.626
D	1.5	1.6	0.059	0.063
D1	1.59	1.61	0.062	0.063
E	1.65	1.85	0.065	0.073
F	11.4	11.6	0.449	0.456
K0	4.8	5.0	0.189	0.197
P0	3.9	4.1	0.153	0.161
P1	11.9	12.1	0.468	0.476
P2	1.9	2.1	0.075	0.082
R	50		1.574	
T	0.25	0.35	0.0098	0.0137
W	23.7	24.3	0.933	0.956

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

TRL

FEED DIRECTION

Bending radius R min.

\* on sales type

## 6 Revision history

Table 8. Revision history

Date	Revision	Changes
09-Sep-2004	6	Preliminary version
08-May-2006	7	D <sup>2</sup> PAK package inserted
22-May-2006	8	Updated values <a href="#">Table 5: Dynamic</a>
26-Jul-2006	9	New template, no content change



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