



# STB6NK60Z - STB6NK60Z-1 STP6NK60ZFP - STP6NK60Z

N-channel 600 V - 1  $\Omega$  - 6 A - TO-220/TO-220FP/D<sup>2</sup>PAK/I<sup>2</sup>PAK  
Zener-Protected SuperMESH™ Power MOSFET

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>	P <sub>W</sub>
STB6NK60Z	600 V	< 1.2 $\Omega$	6 A	110 W
STB6NK60Z-1	600 V	< 1.2 $\Omega$	6 A	110 W
STP6NK60ZFP	600 V	< 1.2 $\Omega$	6 A	30 W
STP6NK60Z	600 V	< 1.2 $\Omega$	6 A	110 W

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized

## Application

- Switching applications

## Description

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications.

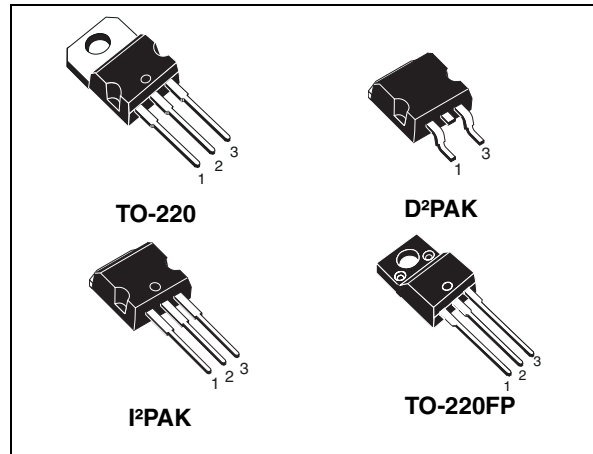


Figure 1. Internal schematic diagram

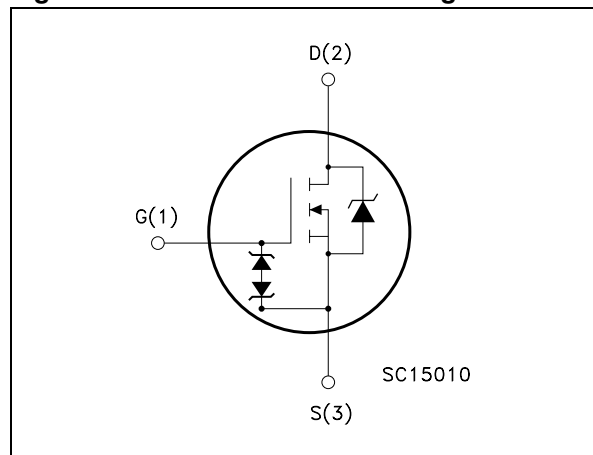


Table 1. Device summary

Order codes	Marking	Package	Packaging
STB6NK60Z	B6NK60Z	D <sup>2</sup> PAK	Tape & reel
STB6NK60Z-1	B6NK60Z	I <sup>2</sup> PAK	Tube
STP6NK60ZFP	P6NK60ZFP	TO-220FP	Tube
STP6NK60Z	P6NK60Z	TO-220	Tube

# Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>3</b>
<b>2</b>	<b>Electrical characteristics</b> .....	<b>4</b>
	2.1 Electrical characteristics (curves) .....	6
<b>3</b>	<b>Test circuit</b> .....	<b>9</b>
<b>4</b>	<b>Package mechanical data</b> .....	<b>10</b>
<b>5</b>	<b>Packing mechanical data</b> .....	<b>15</b>
<b>6</b>	<b>Revision history</b> .....	<b>16</b>

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220/D <sup>2</sup> /I <sup>2</sup> PAK	TO-220FP	
V <sub>DS</sub>	Drain-source voltage (V <sub>GS</sub> = 0)	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	6	6 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	3.8	3.8 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	24	24 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	110	30	W
	Derating factor	0.88	0.24	W/°C
V <sub>ESD(G-S)</sub>	G-S ESD (HBM C=100 pF, R=1.5 kΩ)	3500		V
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	4.5		V/ns
V <sub>ISO</sub>	Insulation withstand voltage (DC)	--	2500	V
T <sub>j</sub> T <sub>stg</sub>	Operating junction temperature Storage temperature	-55 to 150		°C

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 6 A, di/dt ≤ 200 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220/D <sup>2</sup> /I <sup>2</sup> PAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.14	4.2	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5		°C/W
T <sub>l</sub>	Maximum lead temperature for soldering purpose	300		°C

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> max)	6	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> = 50 V)	210	mJ

## 2 Electrical characteristics

( $T_{CASE}=25^{\circ}C$  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 ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating}$ $V_{DS} = \text{Max rating}, T_C = 125^{\circ}C$			1 50	$\mu A$ $\mu A$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20 \text{ V}$			$\pm 10$	$\mu A$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 100 \mu A$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10 \text{ V}, I_D = 3 \text{ A}$		1	1.2	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 8 \text{ V}, I_D = 3 \text{ A}$		5		S
$C_{iss}$	Input capacitance	$V_{DS} = 25 \text{ V}, f = 1 \text{ MHz},$ $V_{GS} = 0$		905		pF
$C_{oss}$	Output capacitance			115		pF
$C_{riss}$	Reverse transfer capacitance			25		pF
$C_{oss \text{ eq}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0 \text{ to } 480 \text{ V}$		56		pF
$Q_g$	Total gate charge	$V_{DD} = 480 \text{ V}, I_D = 6 \text{ A},$ $V_{GS} = 10 \text{ V}$ <i>(see Figure 18)</i>		33	46	nC
$Q_{gs}$	Gate-source charge			6		nC
$Q_{gd}$	Gate-drain charge			17		nC

1. Pulsed: pulse duration=300 $\mu s$ , 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	$V_{DD} = 300\text{ V}$ , $I_D = 3\text{ A}$ $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ <i>(see Figure 17)</i>		14		ns
$t_r$	Rise time			14		ns
$t_{d(off)}$	Turn-off delay time			47		ns
$t_f$	Fall time			19		ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ.	Max	Unit
$I_{SD}$	Source-drain current				6	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				24	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 6\text{ A}$ , $V_{GS} = 0$			1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 6\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 50\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ <i>(see Figure 19)</i>		445		ns
$Q_{rr}$	Reverse recovery charge			2.7		$\mu\text{C}$
$I_{RRM}$	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%

**Table 9. Gate-source zener diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$BV_{GSO}^{(1)}$	Gate-source breakdown voltage	Eggs $\pm$ 1 mA (open drain)	30			V

1. The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

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

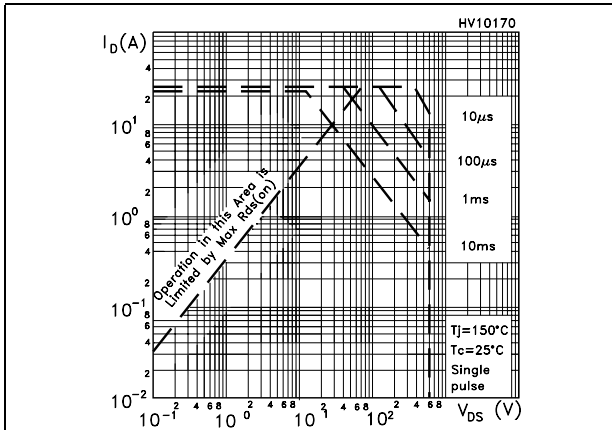


Figure 3. Thermal impedance for TO-220/ I<sup>2</sup>PAK/ D<sup>2</sup>PAK

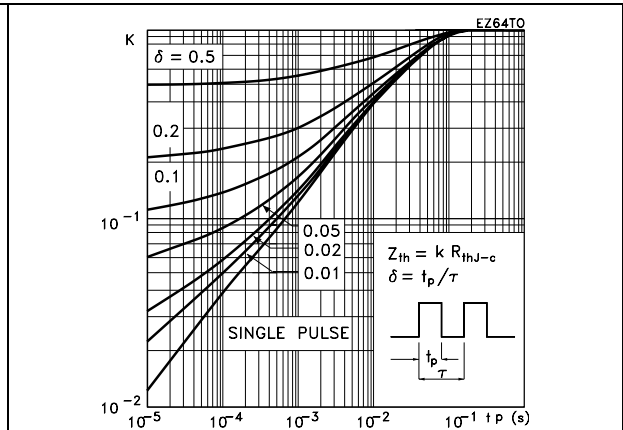


Figure 4. Safe operating area for TO-220FP

Figure 5. Thermal impedance for TO-220FP

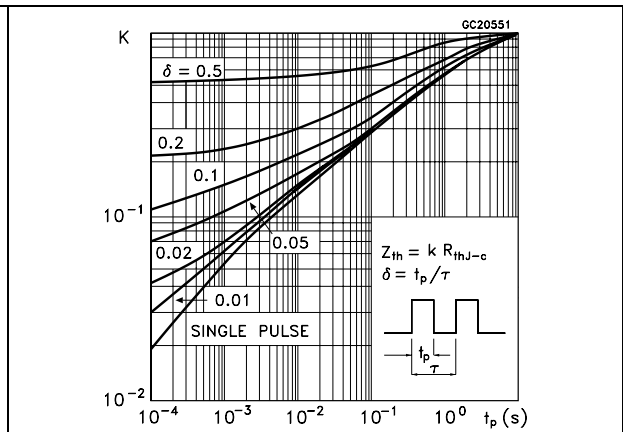
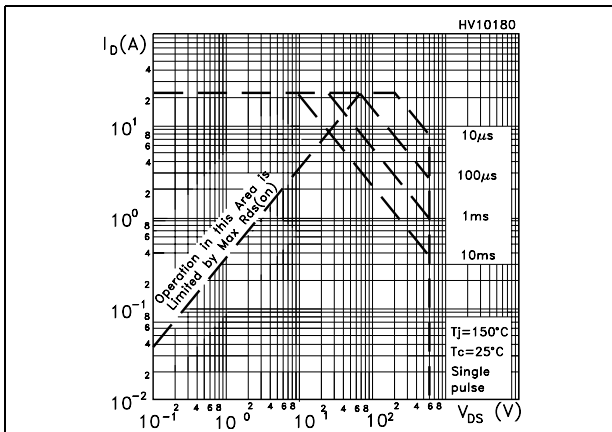


Figure 6. Output characteristics

Figure 7. Transfer characteristics

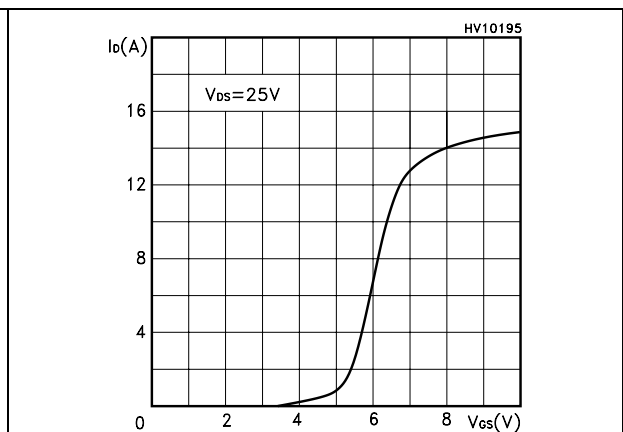
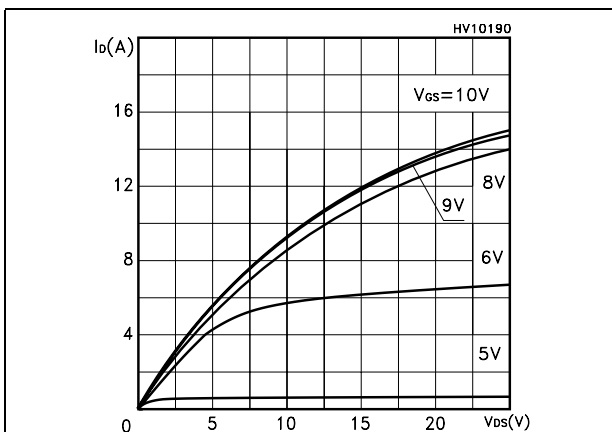


Figure 8. Transconductance

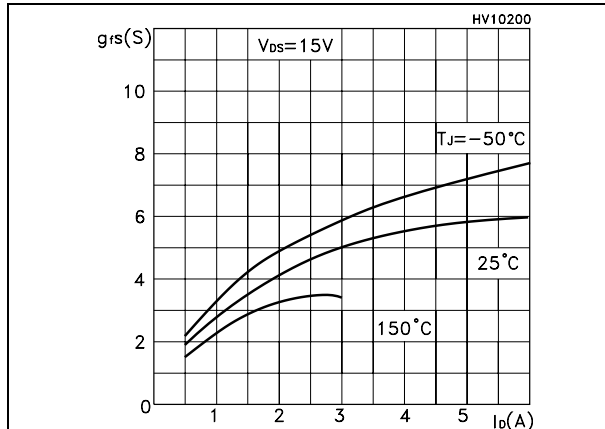


Figure 9. Static drain-source on resistance

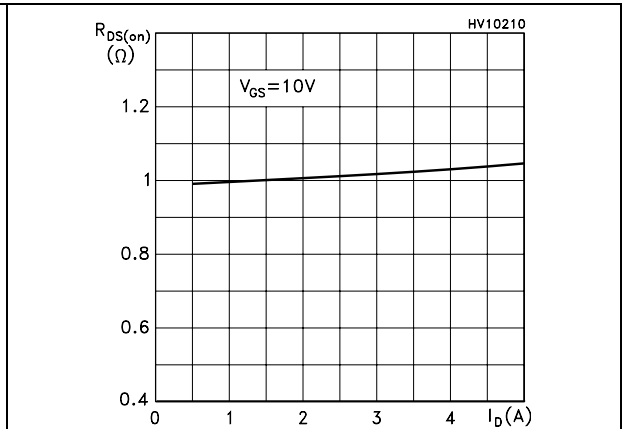


Figure 10. Gate charge vs gate-source voltage Figure 11. Capacitance variations

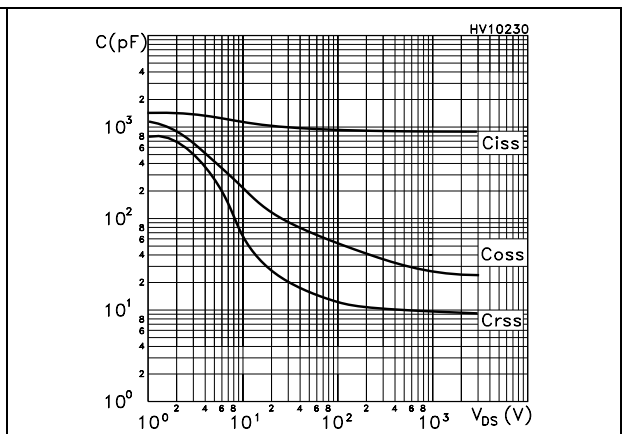
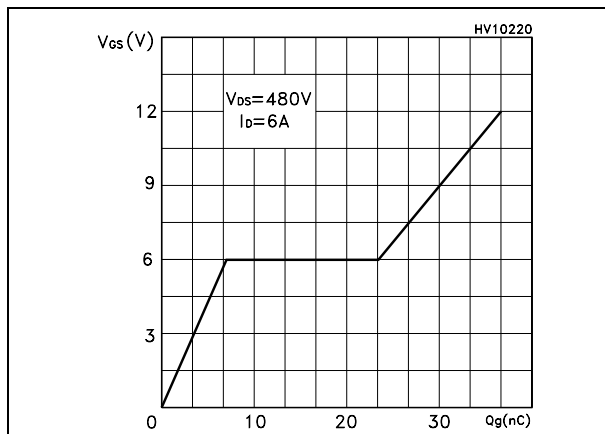


Figure 12. Normalized gate threshold voltage vs temperature

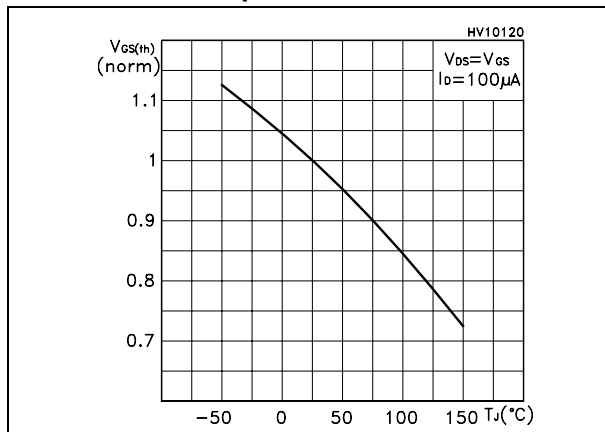


Figure 13. Normalized on resistance vs temperature

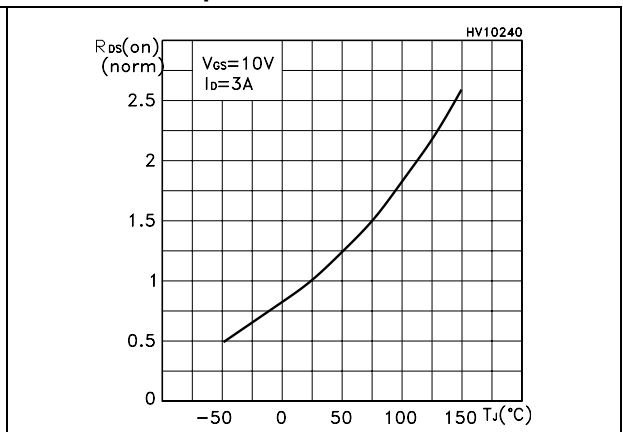


Figure 14. Source-drain diode forward characteristics

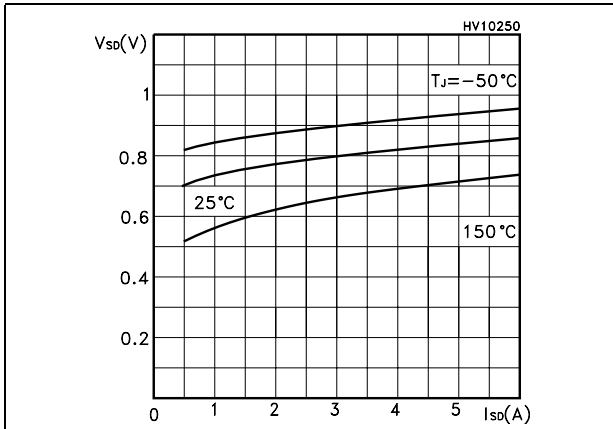


Figure 15. Normalized  $B_{VDSS}$  vs temperature

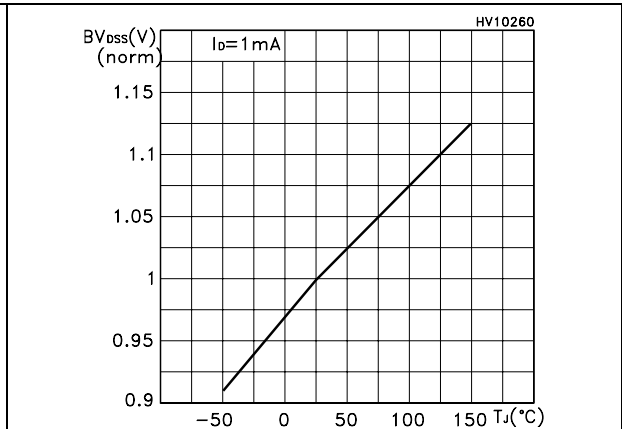
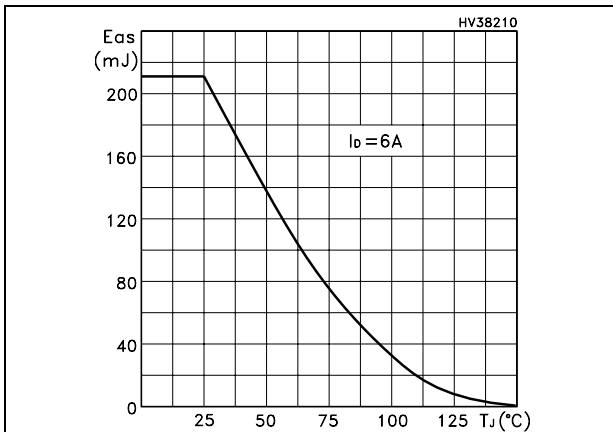


Figure 16. Maximum avalanche energy vs temperature





### 3 Test circuit

Figure 17. Switching times test circuit for resistive load

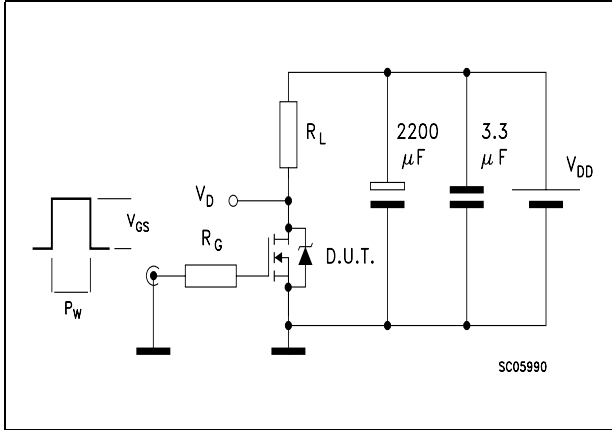


Figure 18. Gate charge test circuit

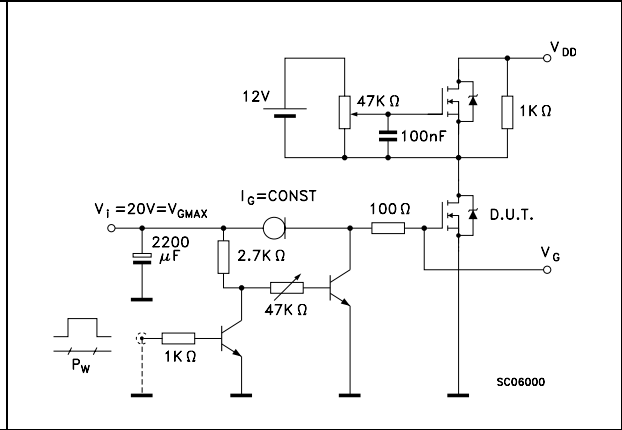


Figure 19. Test circuit for inductive load switching and diode recovery times

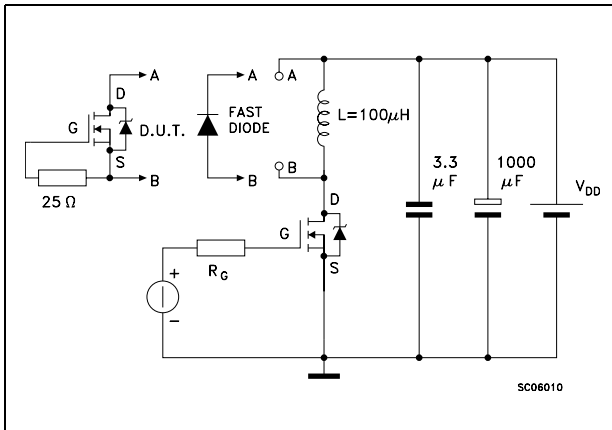


Figure 20. Unclamped Inductive load test circuit

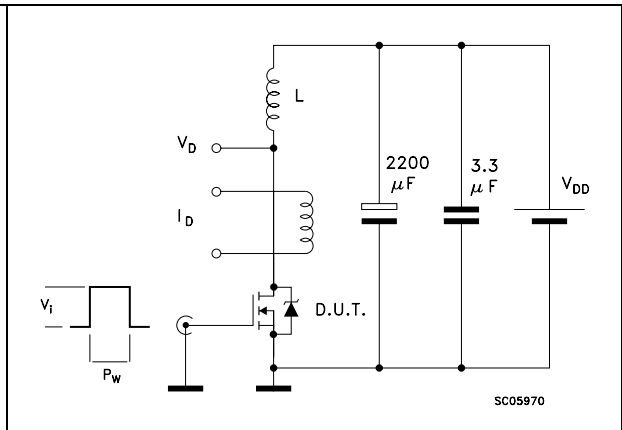


Figure 21. Unclamped inductive waveform

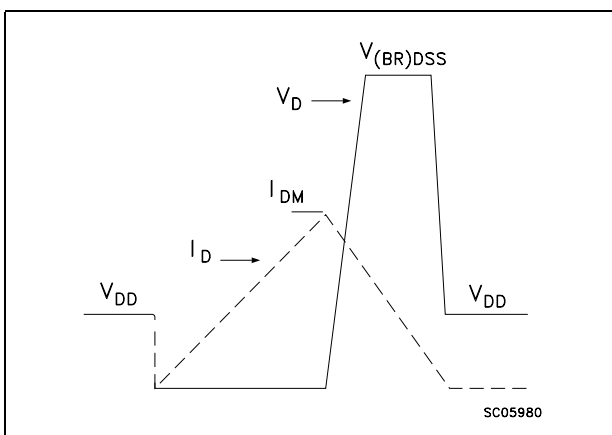
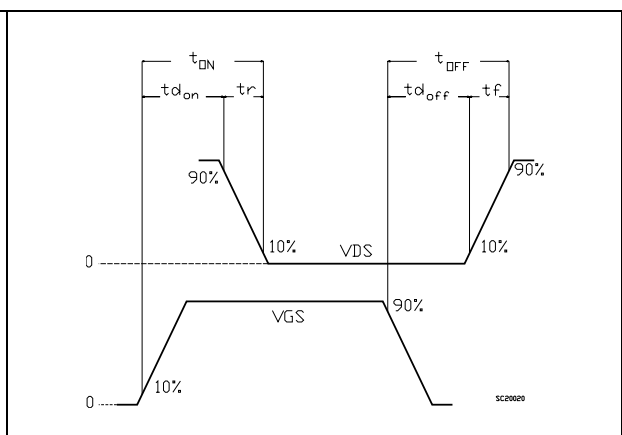


Figure 22. Switching time waveform

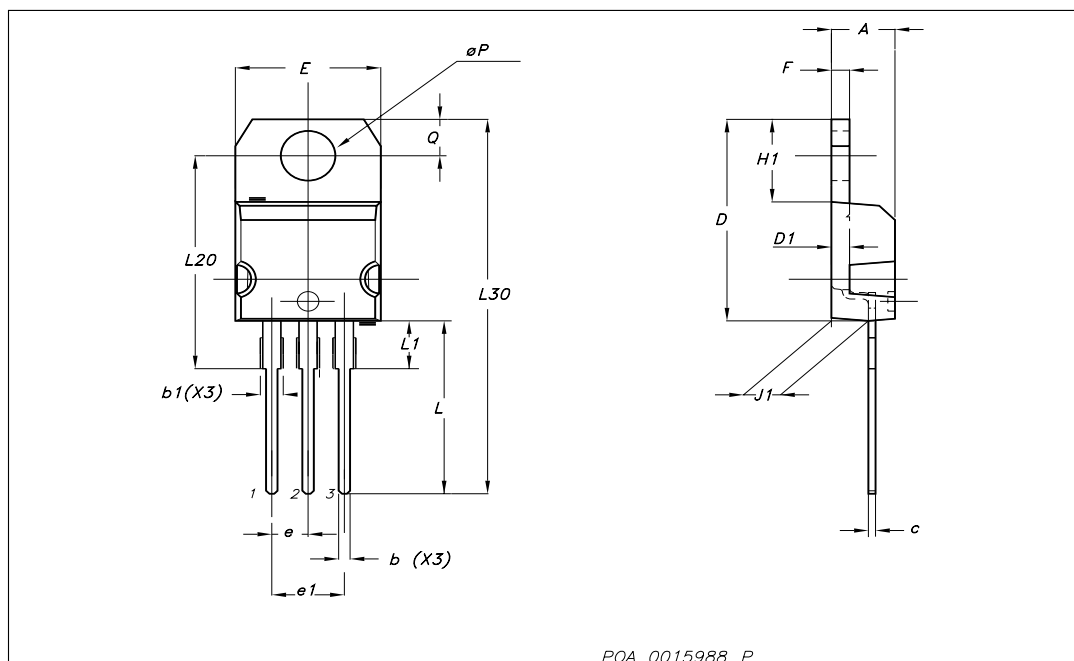


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in 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)

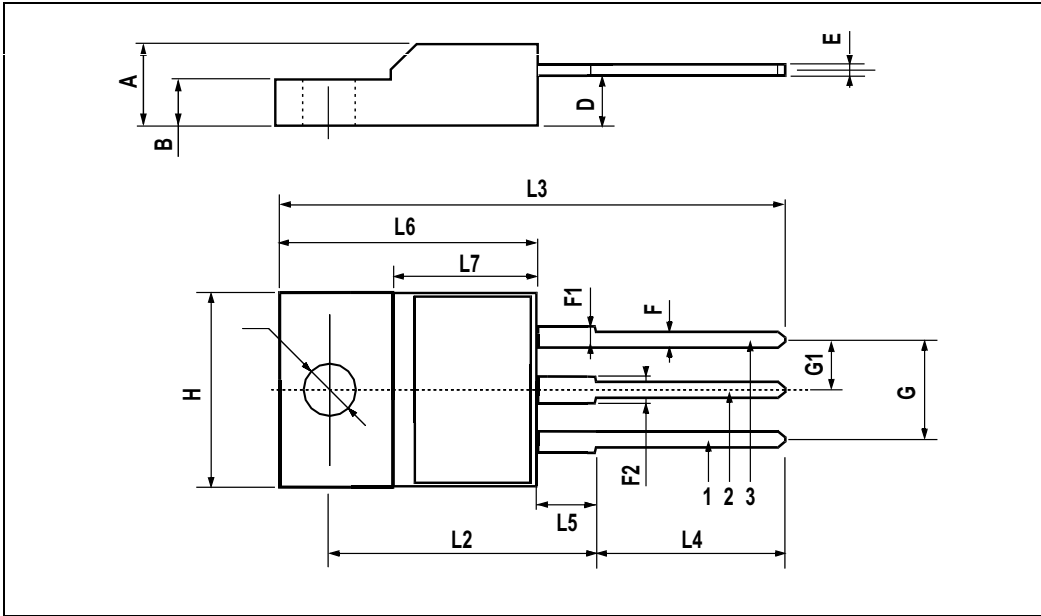
## TO-220 mechanical data

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	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.6		0.62
D1		1.27			0.050	
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		0.051
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	
∅P	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



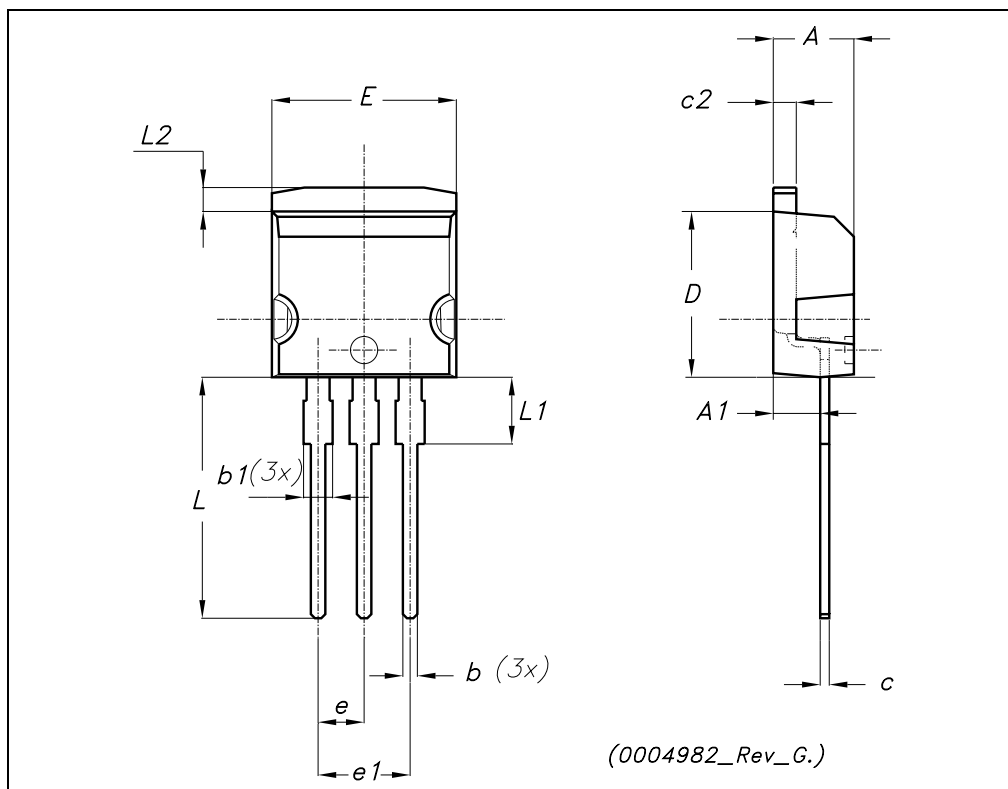
**TO-220FP MECHANICAL DATA**

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



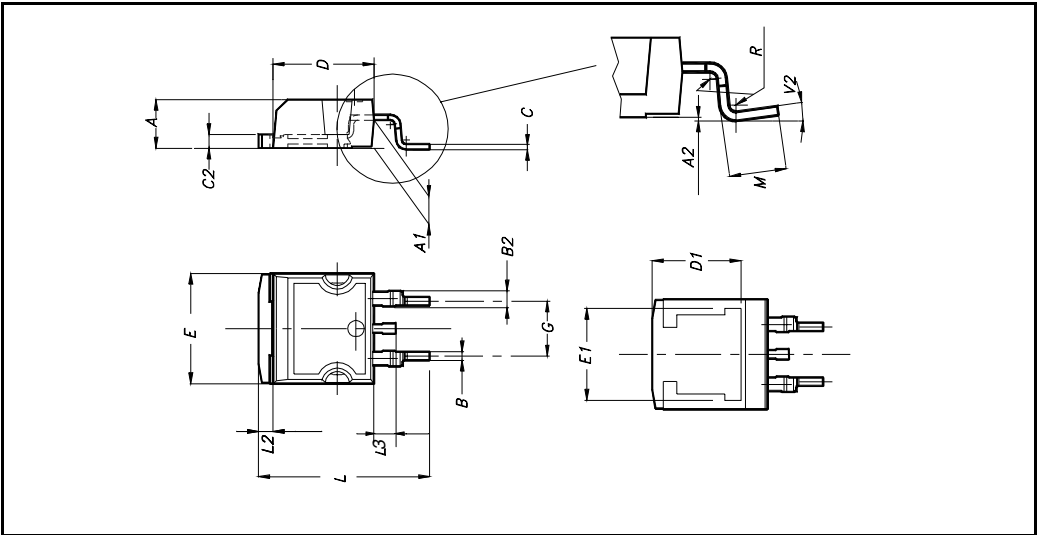
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

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



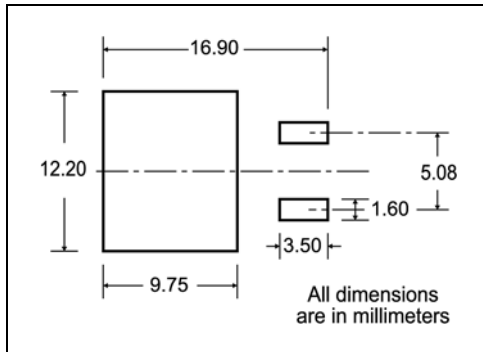
**D<sup>2</sup>PAK MECHANICAL DATA**

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°			



# 5 Packing mechanical data

## D<sup>2</sup>PAK FOOTPRINT



## TAPE AND REEL SHIPMENT

**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

**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

\* on sales type

## 6 Revision history

Table 10. Document revision history

Date	Revision	Changes
14-Jan-2004	4	Initial electronic version
23-Aug-2005	5	Inserted ecopack label
04-Oct-2005	6	Modified header
23-May-2007	7	Added <i>Figure 16: Maximum avalanche energy vs temperature</i>
22-Nov-2007	8	<i>Figure 11: Capacitance variations</i> has been updated



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