



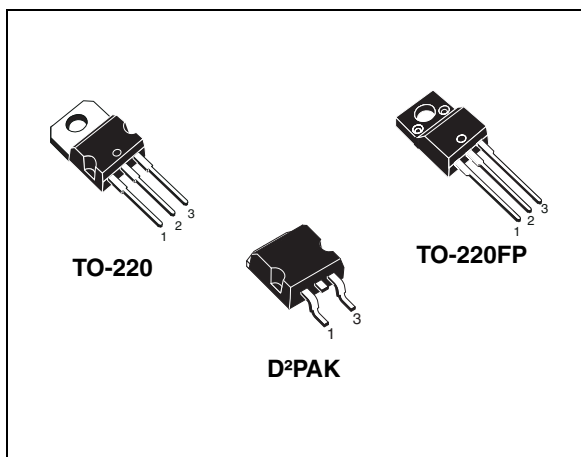
# STB9NK60ZD STF9NK60ZD - STP9NK60ZD

N-channel 600V -  $0.85\Omega$  - 7A - D<sup>2</sup>PAK/TO-220FP/TO-220  
SuperFREDMesh™ Power MOSFET

## General features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>	P <sub>w</sub>
STB9NK60ZD	600V	<0.95Ω	7A	125W
STF9NK60ZD	600V	<0.95Ω	7A	30W
STP9NK60ZD	600V	<0.95Ω	7A	125W

- Very high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Low intrinsic capacitances
- Fast internal recovery diode



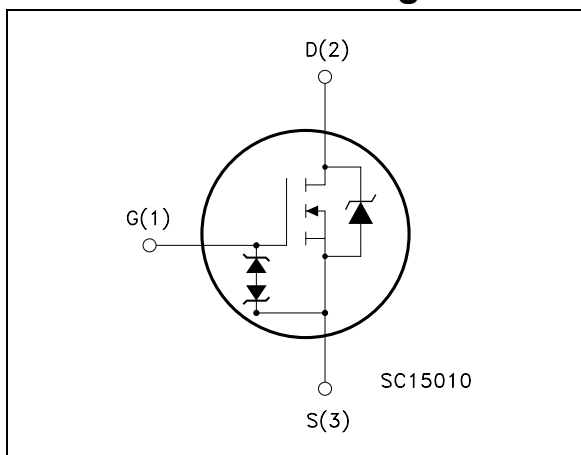
## Description

The SuperFREDMesh™ series associates all advantages of reduced on-resistance, zener gate protection and very high dv/dt capability with a Fast body-drain recovery diode. Such series complements the “FDmesh™” advanced technology.

## Applications

- Switching application

## Internal schematic diagram



## Order codes

Part number	Marking	Package	Packaging
STB9NK60ZD	B9NK60ZD	D <sup>2</sup> PAK	Tape & reel
STF9NK60ZD	F9NK60ZD	TO-220FP	Tube
STP9NK60ZD	P9NK60ZD	TO-220	Tube

# Contents

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		D <sup>2</sup> PAK/TO-220	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	7	7 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100°C	4.3	4.3 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	28	28 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25°C	125	30	W
	Derating factor	1	0.24	W/°C
V <sub>ESD(G-S)</sub>	Gate source ESD (HBM-C=100pF, R=1.5KΩ)	4000		V
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15		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>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> ≤ 7A, di/dt ≤ 500A/μs, V<sub>DD</sub> = 80%V<sub>(BR)DSS</sub>

**Table 2. Thermal data**

		TO-220/D <sup>2</sup> PAK	TO-220FP	
R <sub>thj-pcb</sub>	Thermal resistance junction-pcb Max (when mounted on minimum footprint)	30	--	°C/W
R <sub>thj-case</sub>	Thermal resistance junction-case Max	1	4.16	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient Max	62.5		°C/W
T <sub>l</sub>	Maximum lead temperature for soldering purpose	300		°C

**Table 3. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)	7	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> = 50V)	235	mJ

## 2 Electrical characteristics

(T<sub>case</sub> = 25°C unless otherwise specified)

**Table 4. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	I <sub>D</sub> = 1mA, V <sub>GS</sub> = 0	600			V
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, T <sub>C</sub> = 125°C			1 50	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 20V			±10	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 100μA	2.5	3.5	4.5	V
R <sub>DS(on)</sub>	Static drain-source on resistance	V <sub>GS</sub> = 10V, I <sub>D</sub> = 3.5A		0.85	0.95	Ω

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g <sub>fs</sub> <sup>(1)</sup>	Forward transconductance	V <sub>DS</sub> = 15V, I <sub>D</sub> = 3.5A		5.3		S
C <sub>iss</sub> C <sub>OSS</sub> C <sub>rss</sub>	Input capacitance Output capacitance Reverse transfer capacitance	V <sub>DS</sub> = 25V, f = 1 MHz, V <sub>GS</sub> = 0		1110 135 30		pF pF pF
C <sub>OSS eq</sub> <sup>(2)</sup>	Equivalent output capacitance	V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 480V		72		pF
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> = 480V, I <sub>D</sub> = 7A, V <sub>GS</sub> = 10V <i>(see Figure 16)</i>		41 8.7 21	53	nC nC nC

1. Pulsed: Pulse duration = 300 μs, 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 6. Switching times**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300V, I_D = 3.5A$ $R_G = 4.7\Omega, V_{GS} = 10V$ <i>(see Figure 15)</i>		11.4		ns
$t_r$	Rise time			13.6		ns
$t_{d(off)}$	Turn-off-delay time			23.1		ns
$t_f$	Fall time			15		ns
$t_{r(Voff)}$	Off-voltage Rise Time	$V_{DD} = 480V, I_D = 7A,$ $R_G = 4.7\Omega, V_{GS} = 10V$ <i>(see Figure 15)</i>		11		ns
$t_f$	Fall Time			8		ns
$t_c$	Cross-over Time			20		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				7	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				28	A
$V_{SD}^{(2)}$	Forward On Voltage	$I_{SD} = 7A, V_{GS} = 0$			1.6	V
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 7A, di/dt = 100A/\mu s$ $V_{DD} = 30V, T_j = 25^\circ C$ <i>(see Figure 20)</i>		130		ns
$Q_{rr}$	Reverse Recovery Charge			663		nC
$I_{RRM}$	Reverse Recovery Current			8.3		A
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 7A, di/dt = 100A/\mu s$ $V_{DD} = 30V, T_j = 150^\circ C$ <i>(see Figure 20)</i>		113		ns
$Q_{rr}$	Reverse Recovery Charge			935		nC
$I_{RRM}$	Reverse Recovery Current			10		A

1. Pulse width limited by safe operating area

2. Pulsed: Pulse duration = 300  $\mu s$ , duty cycle 1.5 %

**Table 8. Gate-source zener diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$BV_{GSO}^{(1)}$	Gate-source breakdown voltage	$I_{gs} = \pm 1mA$ (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 1. Safe operating area for TO-220 / D<sup>2</sup>PAK

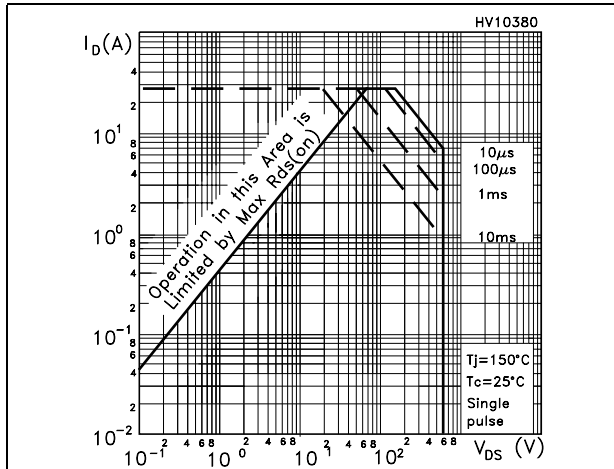


Figure 2. Thermal impedance for TO-220 / D<sup>2</sup>PAK

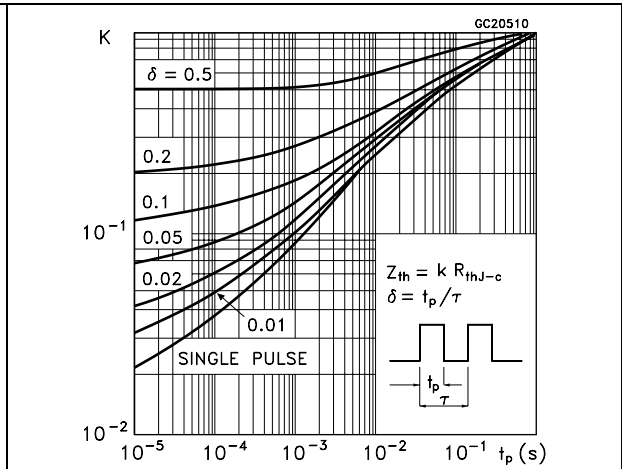


Figure 3. Safe operating area for TO-220FP

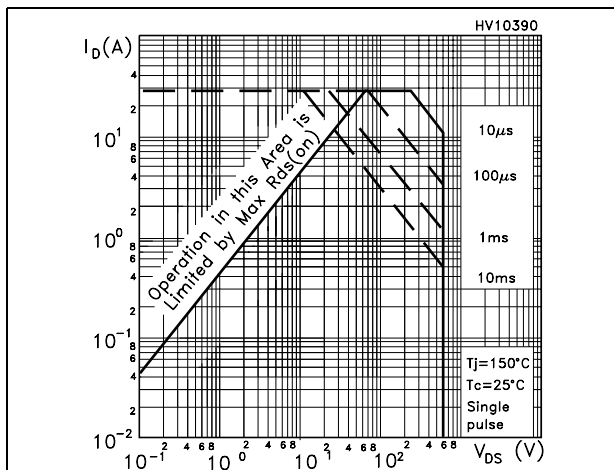


Figure 4. Thermal impedance for TO-220FP

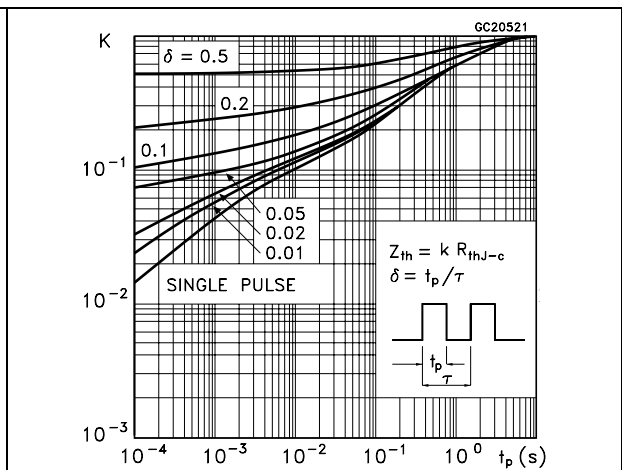


Figure 5. Output characteristics

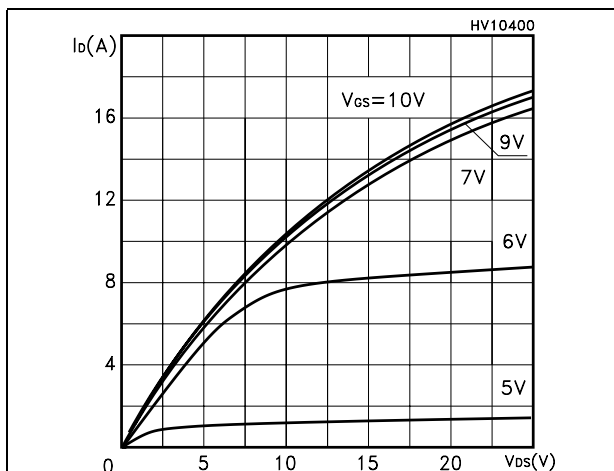


Figure 6. Transfer characteristics

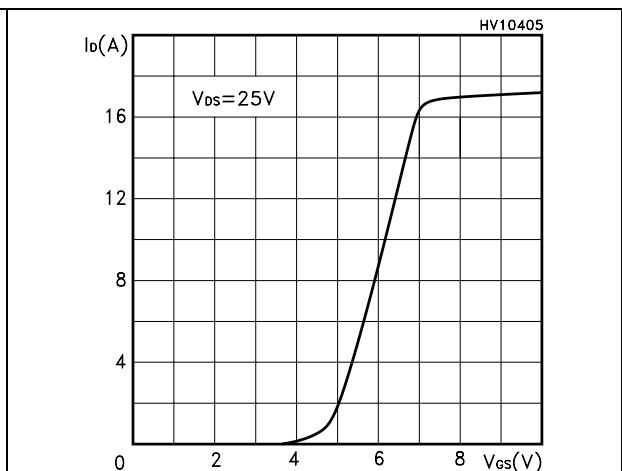


Figure 7. Normalized  $B_{VDSS}$  vs temperature

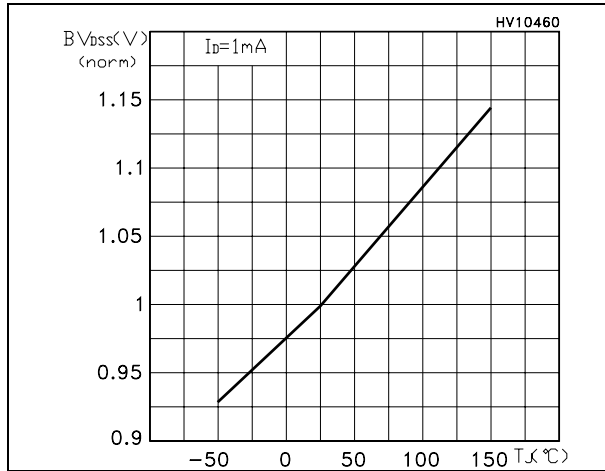


Figure 8. Static drain-source on resistance

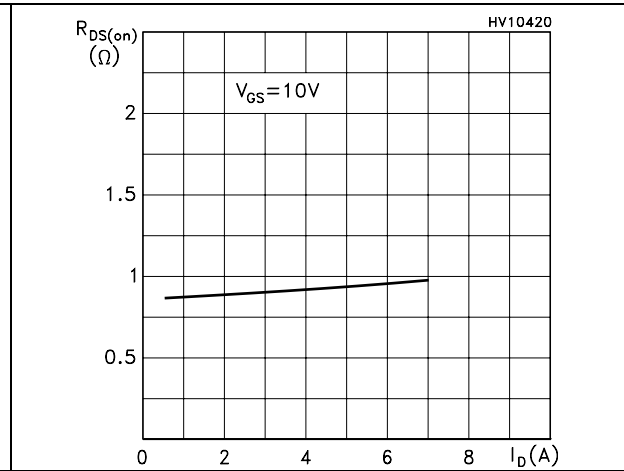


Figure 9. Gate charge vs gate-source voltage

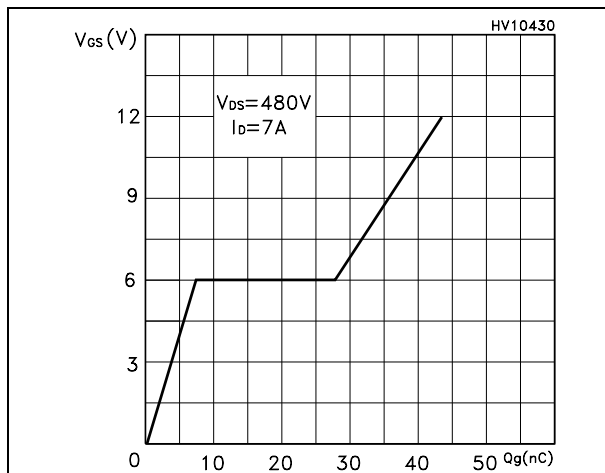


Figure 10. Capacitance variations

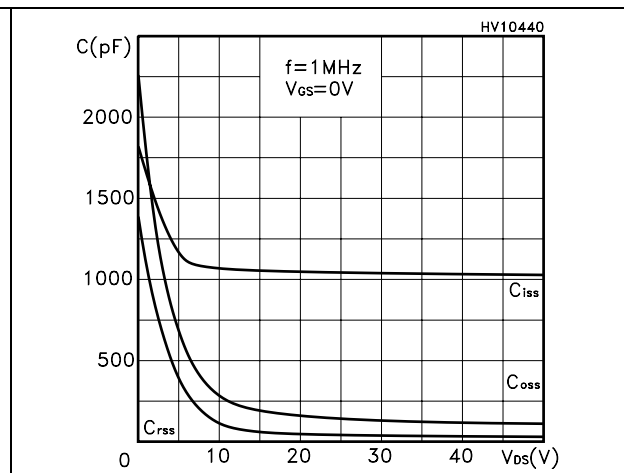


Figure 11. Normalized gate threshold voltage vs temperature

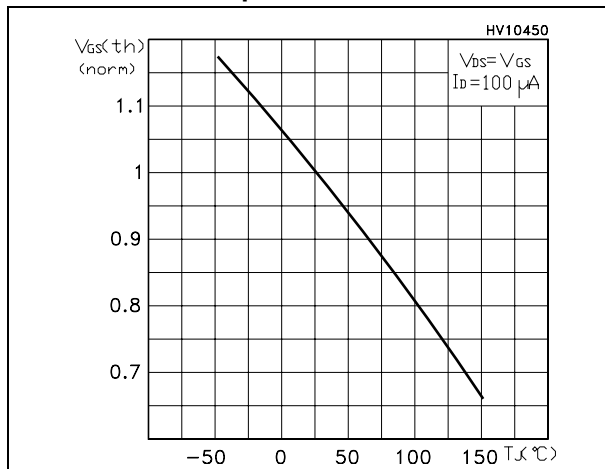


Figure 12. Normalized on resistance vs temperature

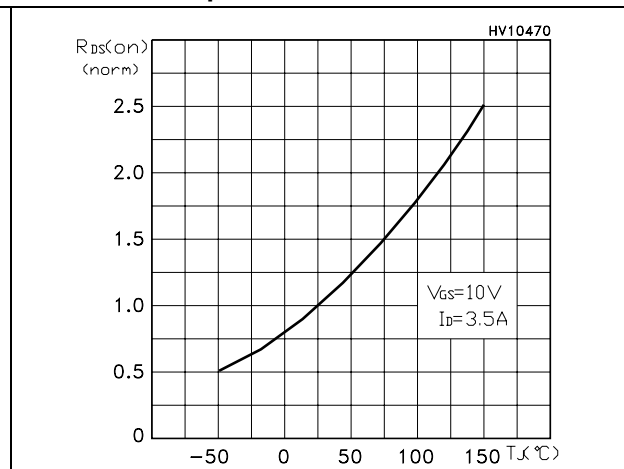


Figure 13. Source-drain diode forward characteristics

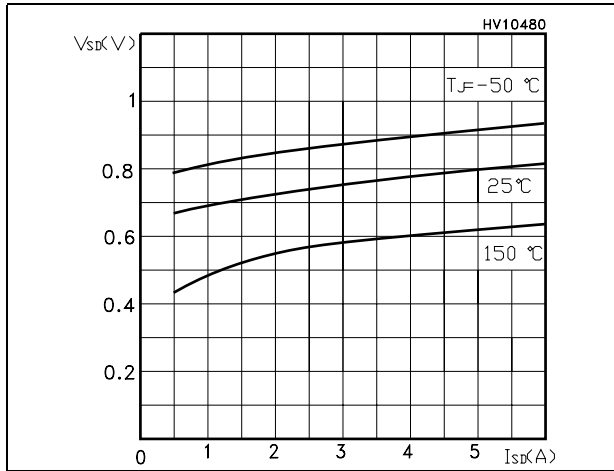
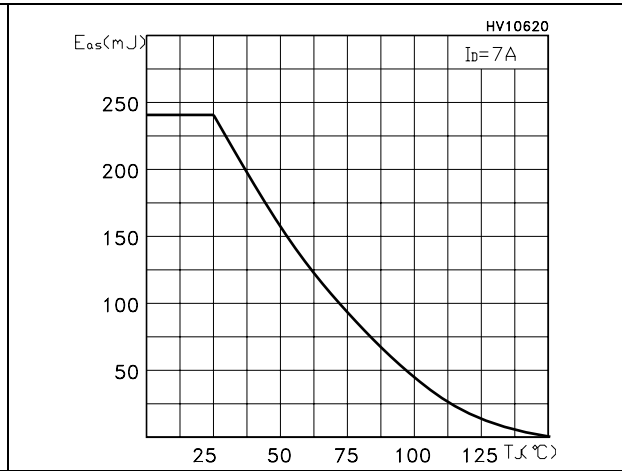


Figure 14. Maximum avalanche energy vs temperature





### 3 Test circuits

Figure 15. Switching times test circuit for resistive load



Figure 16. Gate charge test circuit

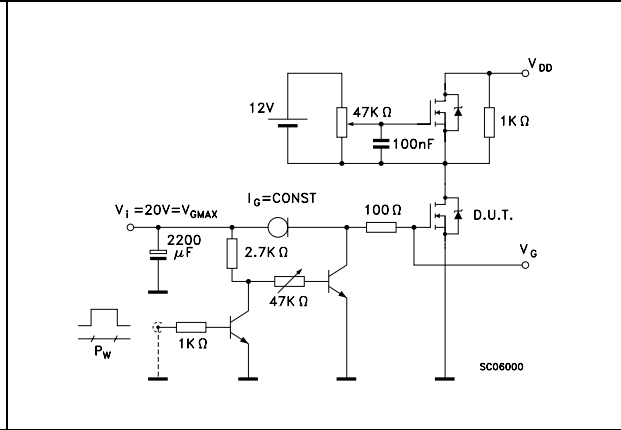


Figure 17. Test circuit for inductive load switching and diode recovery times



Figure 18. Unclamped inductive load test circuit

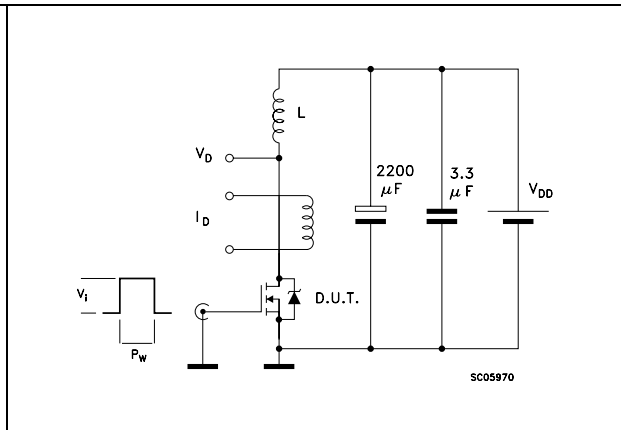
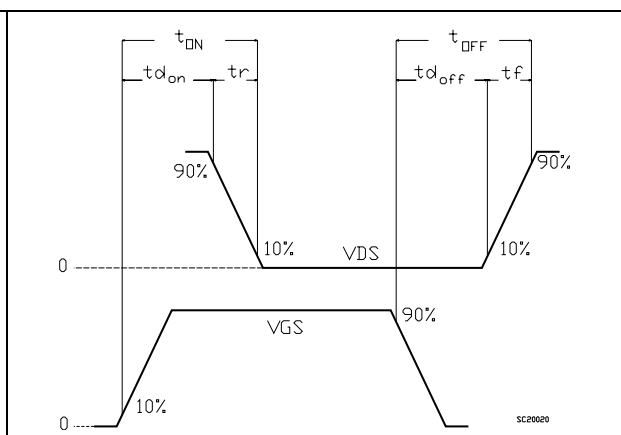


Figure 19. Unclamped inductive waveform



Figure 20. Switching time waveform

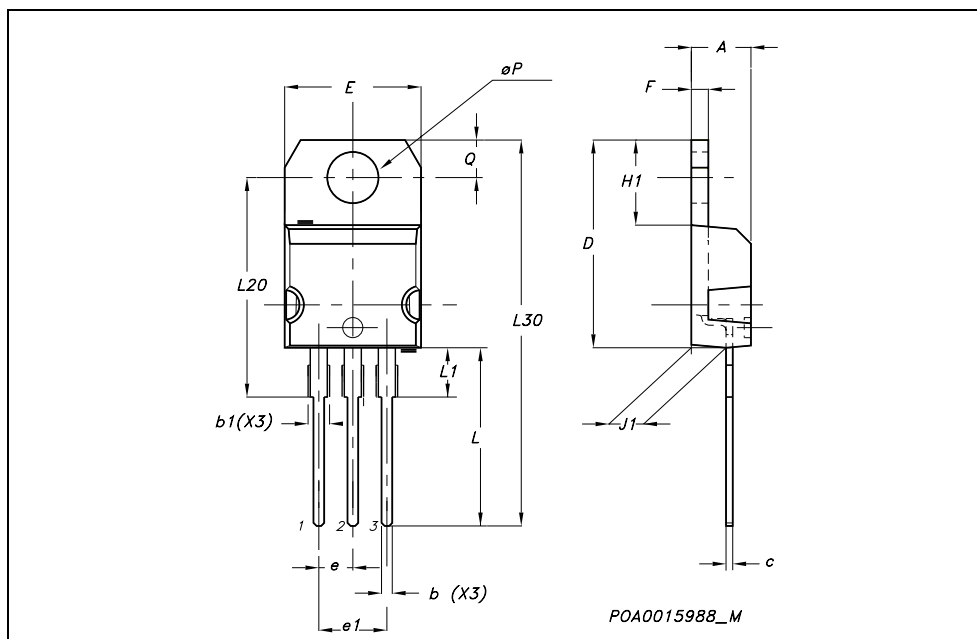


## 4 Package mechanical data

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)

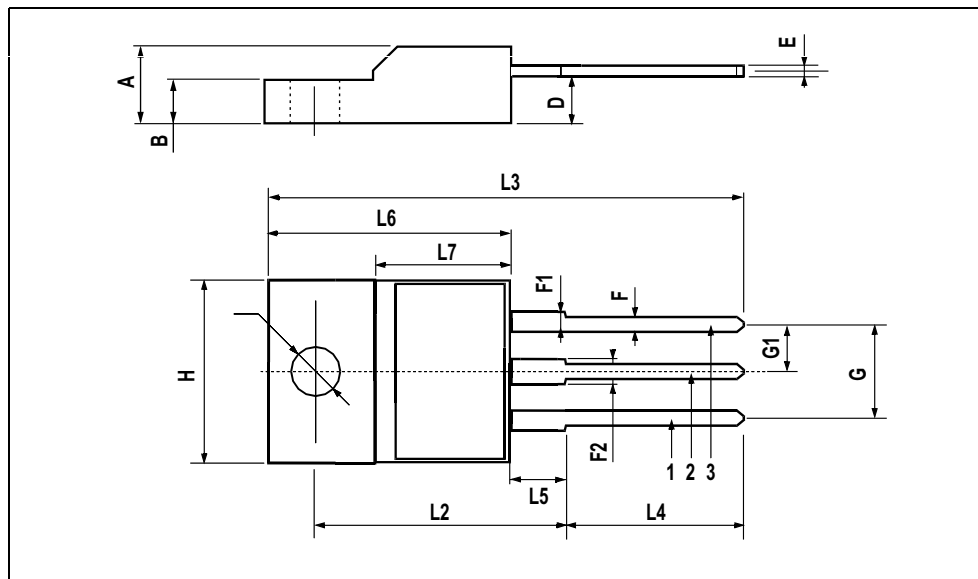
**TO-220 MECHANICAL DATA**

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



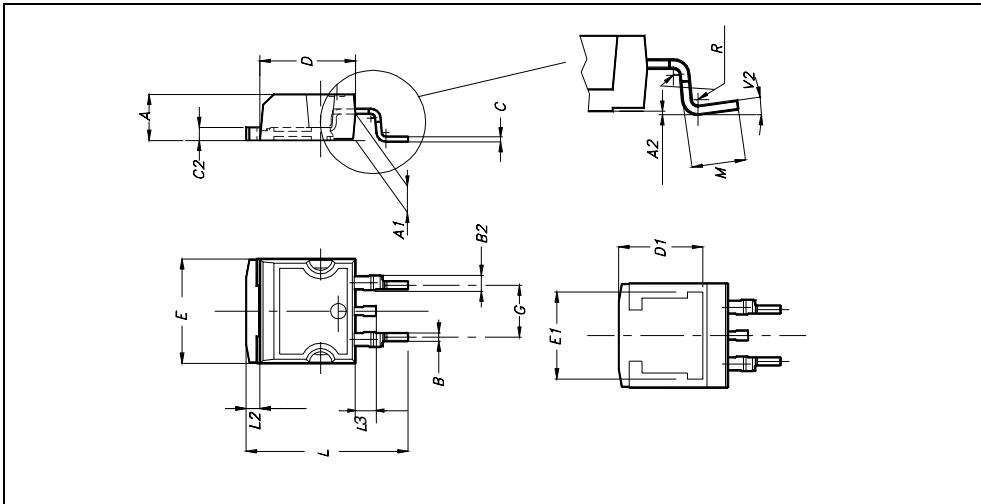
**TO-220FP MECHANICAL DATA**

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



**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 Package 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

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

FEED DIRECTION

TRL

Bending radius R min.

\* on sales type

## 6 Revision history

Table 9.

Date	Revision	Changes
29-Sep-2003	6	Data updated
09-Jun-2006	7	New template

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