



# STP9NK65Z STP9NK65ZFP

N-channel 650 V - 1  $\Omega$  - 6.4 A TO-220 / TO-220FP  
Zener-protected SuperMESH™ Power MOSFET

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>	P <sub>w</sub>
STP9NK65ZFP	650 V	< 1.2 $\Omega$	6.4 A	125 W
STP9NK65Z	650 V	< 1.2 $\Omega$	6.4 A	30 W

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability

## 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. Such series complements ST full range of high voltage MOSFETs including revolutionary MDmesh™ products.

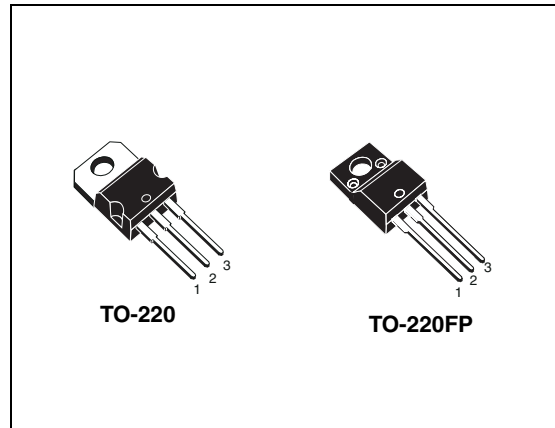


Figure 1. Internal schematic diagram

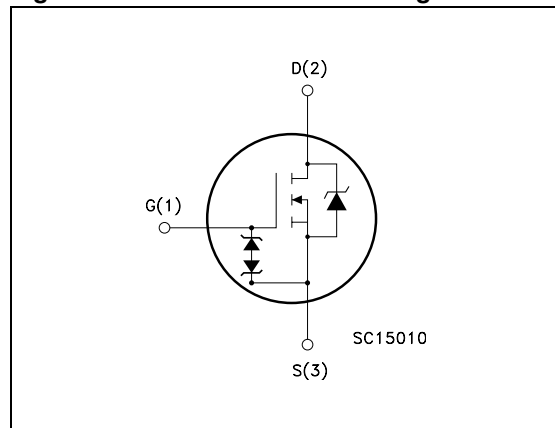


Table 1. Device summary

Order codes	Marking	Package	Packaging
STP9NK65ZFP	P9NK65ZFP	TO-220FP	Tube
STP9NK65Z	P9NK65Z	TO-220	Tube

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$V_{DS}$	Drain-source voltage ( $V_{GS} = 0$ )	650		V
$V_{GS}$	Gate- source voltage	$\pm 30$		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	6.4	6.4 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	4	4 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	25.6	25.6 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	125	30	W
	Derating factor	1	0.24	W/°C
$V_{ESD(G-S)}$	Gate source ESD(HBM-C=100 pF, R=1.5 kΩ)	4000		V
$dv/dt^{(3)}$	Peak diode recovery voltage slope	4.5		V/ns
$V_{ISO}$	Insulation withstand voltage (DC)	-	2500	V
$T_j$	Operating junction temperature	-55 to 150		°C
$T_{stg}$	Storage temperature	-55 to 150		°C

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- $I_{SD} \leq 6.4\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq 80\%V_{(BR)DSS}$

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
Rthj-case	Thermal resistance junction-case max	1	4.2	°C/W
Rthj-amb	Thermal resistance junction-ambient max	62.5		°C/W
$T_I$	Maximum lead temperature for soldering purpose	300		°C

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ Max)	6.4	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j=25\text{ }^\circ\text{C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ )	200	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1 \text{ mA}$ , $V_{GS} = 0$	650			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating}$ $V_{DS} = \text{Max rating, @ } 125^{\circ}\text{C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20 \text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 100 \mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10 \text{ V}$ , $I_D = 3.2 \text{ A}$		1	1.2	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15 \text{ V}$ , $I_D = 3.2 \text{ A}$		6		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 25 \text{ V}$ , $f = 1 \text{ MHz}$ , $V_{GS} = 0$		1145 130 28		pF pF pF
$C_{oss \text{ eq}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0$ , $V_{DS} = 0 \text{ to } 400 \text{ V}$		55		pF
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 520 \text{ V}$ , $I_D = 6.4 \text{ A}$ , $V_{GS} = 10 \text{ V}$ (see <a href="#">Figure 18</a> )		41 7.5 22		nC nC nC

1. Pulsed: pulse duration=300 $\mu\text{s}$ , 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
$t_{d(on)}$ $t_r$	Turn-on delay time Rise time	$V_{DD} = 325\text{ V}$ , $I_D = 3.2\text{ A}$ $R_G = 4.7\ \Omega$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> )		20 12		ns ns
$t_{d(off)}$ $t_f$	Turn-off delay time Fall time	$V_{DD} = 325\text{ V}$ , $I_D = 3.2\text{ A}$ $R_G = 4.7\ \Omega$ $V_{GS} = 10\text{ V}$ (See <a href="#">Figure 17</a> )		45 15		ns ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				6.4	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				25.6	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 6.4\text{ A}$ , $V_{GS} = 0$			1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 6.4\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$		400		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 50\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 19</a> )		2600		nC
$I_{RRM}$	Reverse recovery current			13		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	$I_{gs} = \pm 1\text{ mA}$ (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

Figure 3. Thermal impedance for TO-220

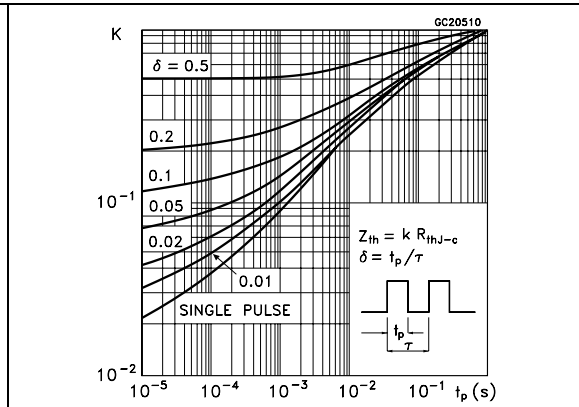
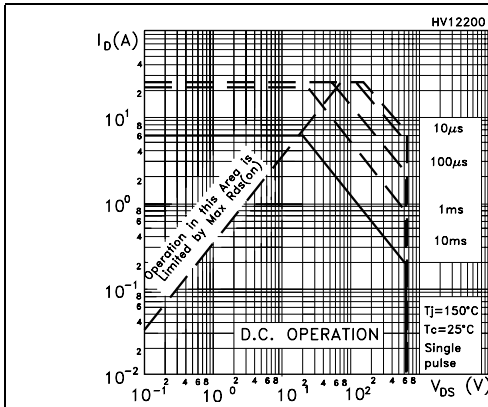


Figure 4. Safe operating area for TO-220FP

Figure 5. Thermal impedance for TO-220FP

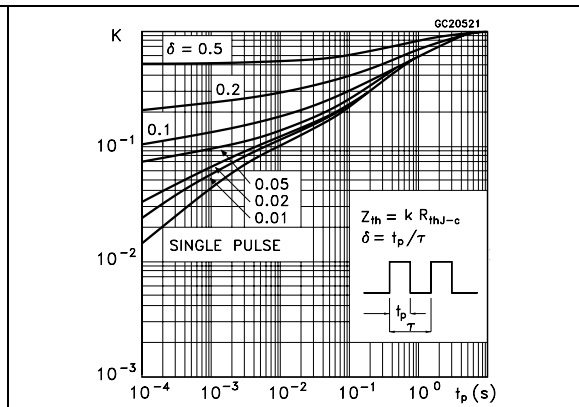
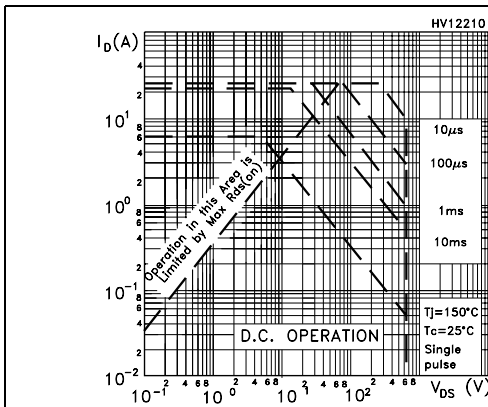


Figure 6. Output characteristics

Figure 7. Transfer characteristics

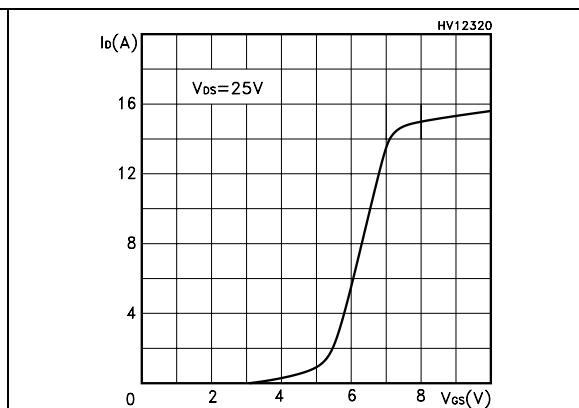
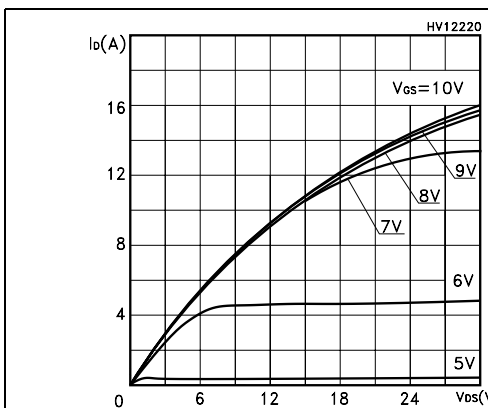


Figure 8. Transconductance

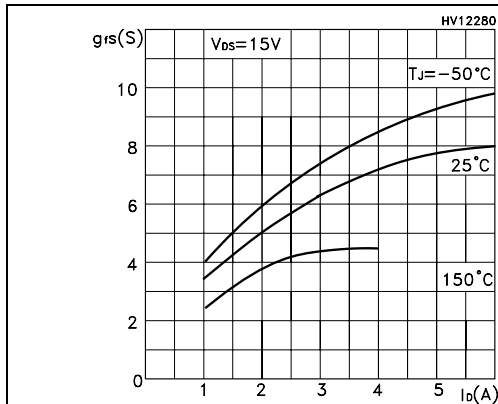


Figure 9. Static drain-source on resistance

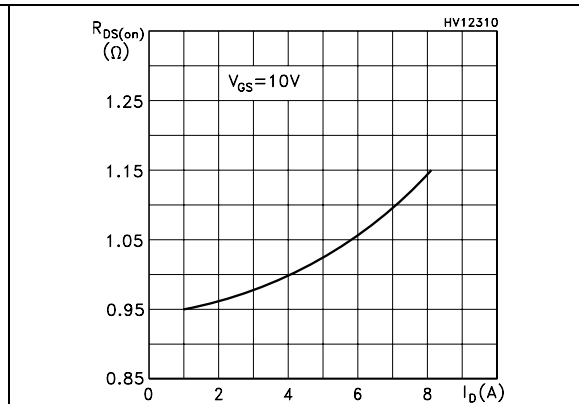


Figure 10. Gate charge vs gate-source voltage Figure 11. Capacitance variations

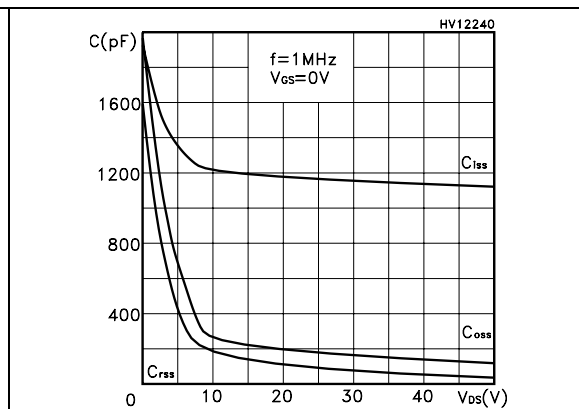
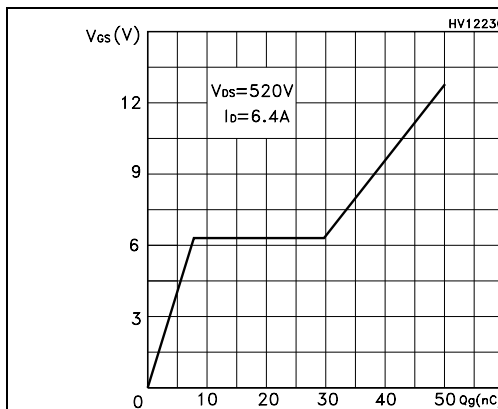


Figure 12. Normalized gate threshold voltage vs temperature

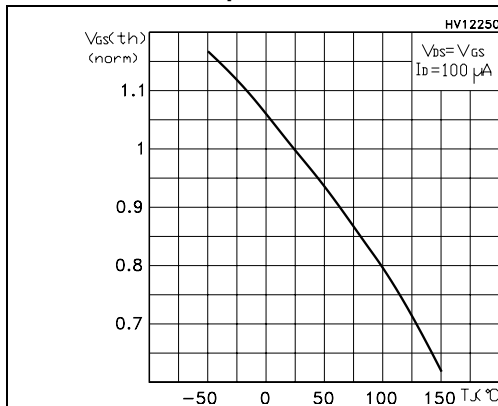


Figure 13. Normalized on resistance vs temperature

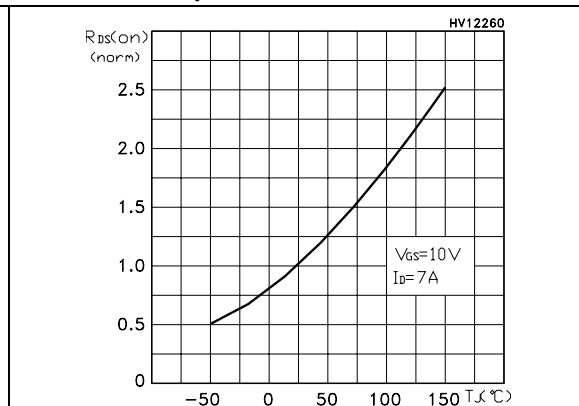


Figure 14. Source-drain diode forward characteristics

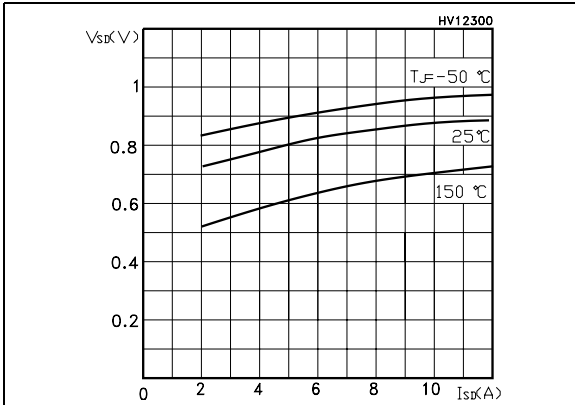


Figure 15. Normalized  $BV_{DSS}$  vs temperature

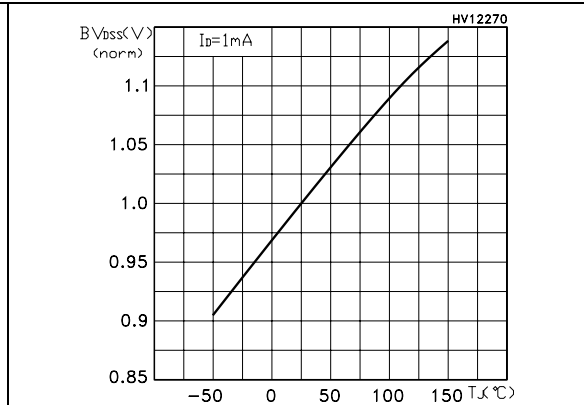
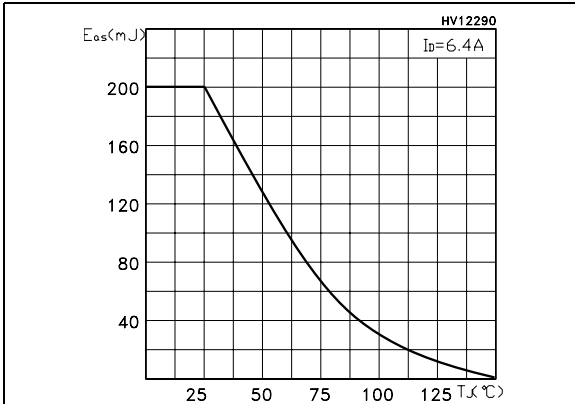


Figure 16. Maximum avalanche energy vs temperature





### 3 Test circuits

Figure 17. Switching times test circuit for resistive load

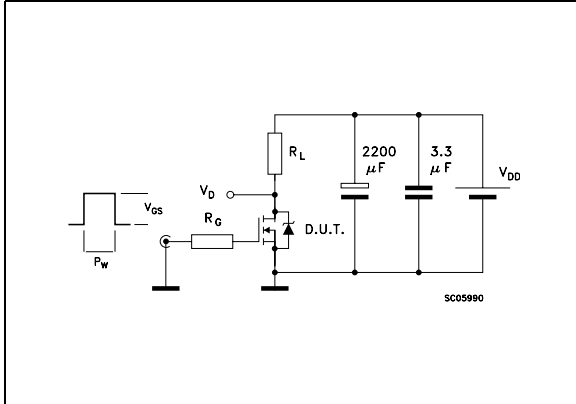


Figure 18. Gate charge test circuit

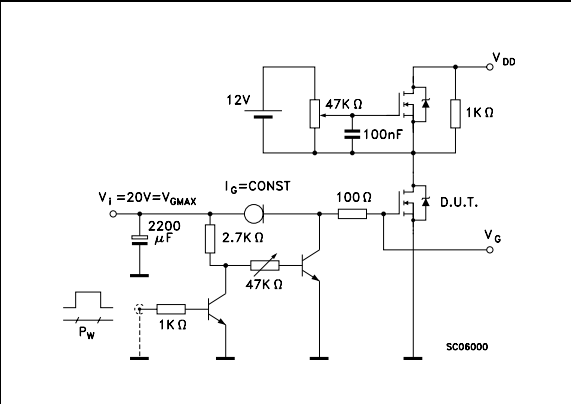


Figure 19. Test circuit for inductive load switching and diode recovery times

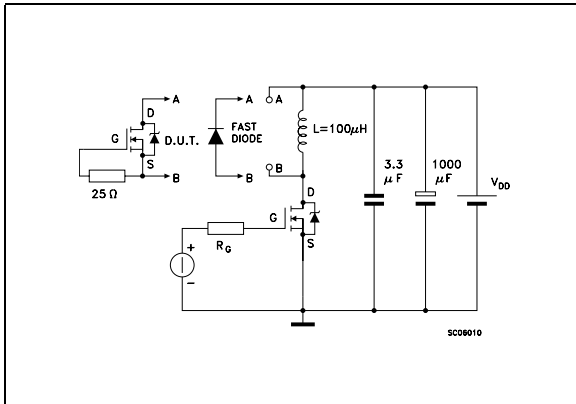


Figure 20. Unclamped Inductive load test circuit

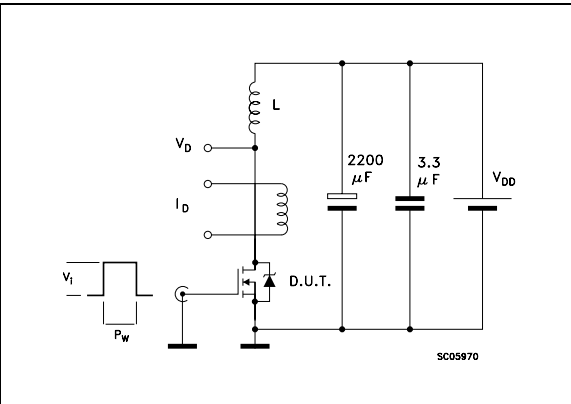


Figure 21. Unclamped inductive waveform

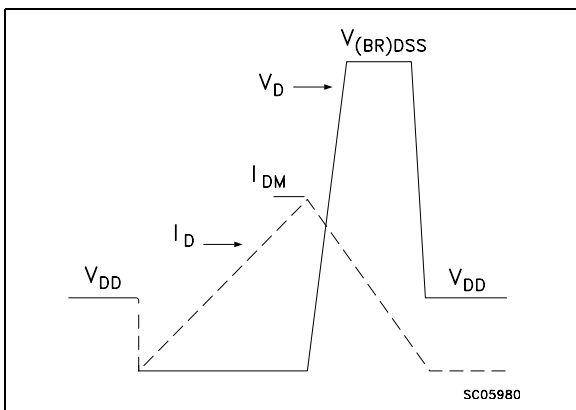
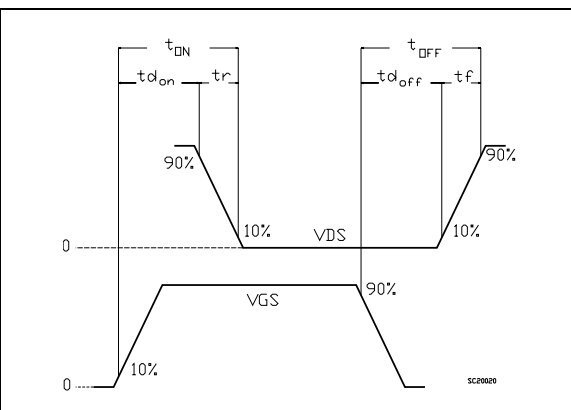


Figure 22. Switching time waveform

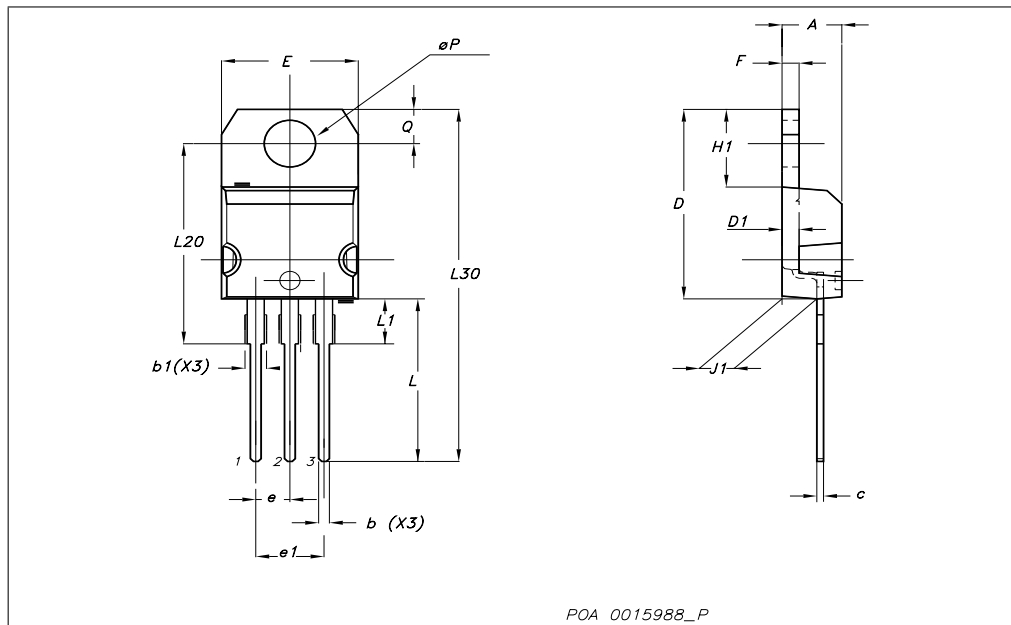


## 4 Package mechanical data

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)

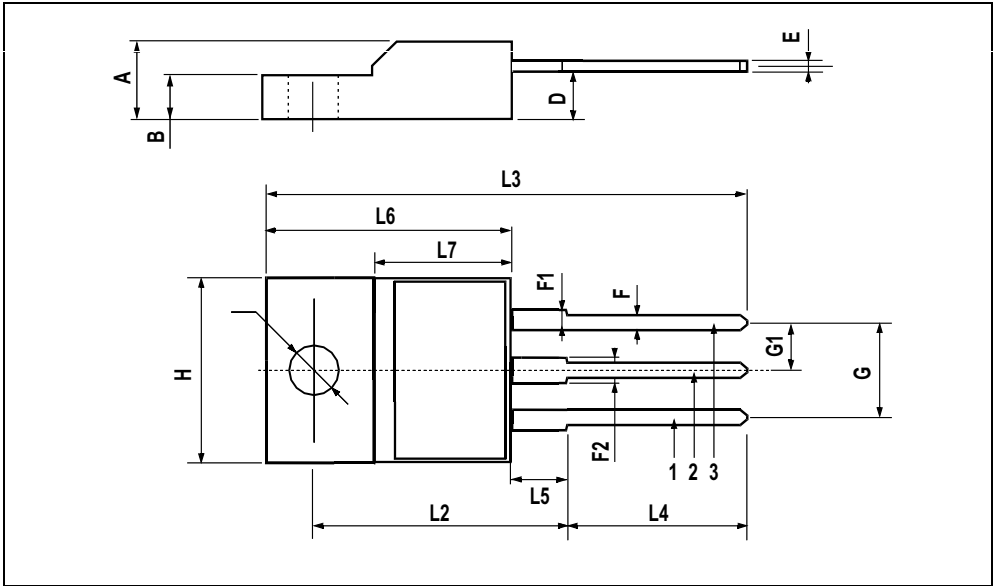
TO-220 mechanical data

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



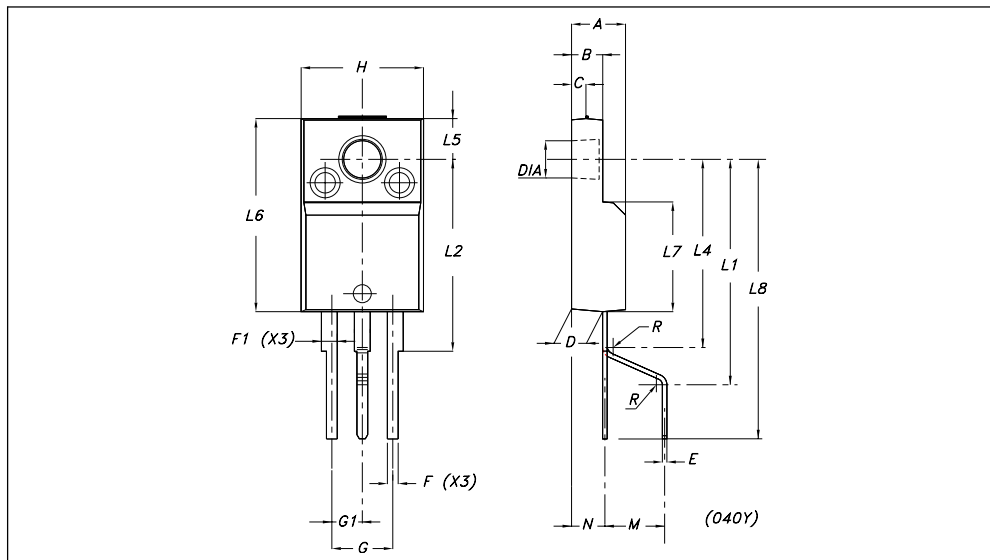
**TO-220FP MECHANICAL DATA**

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-220FP(040Y) 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	0.009		0.106
C	1		1.4	0.039		0.055
D	2.4		2.75	0.094		0.108
E	0.4		0.7	0.015		0.027
F	0.75		1	0.029		0.039
F1	1.15		1.7	0.045		0.066
G	4.68		5.48	0.184		0.215
G1	2.24		2.84	0.088		0.111
H	10		10.4	0.393		0.409
L1	18.4		19.2	0.724		0.755
L2		16			0.629	
L4	15.3		16.1	0.602		0.633
L5		3.4			0.133	
L6	15.9		16.4	0.625		0.665
L7	9		9.3	0.354		0.366
L8	22.5		23.6	0.885		0.929
M	4.6		5.4	0.181		0.212
N	2.29		3.29	0.090		0.129
Dia	3		3.2			
R	0.5			0.019		



## 5 Revision history

Table 10. Document revision history

Date	Revision	Changes
11-Sep-2006	2	Complete version
19-Dec-2007	3	The document has been reformatted

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