



# STP9NK65Z STP9NK65ZFP

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

## Features

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

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

## Applications

- Switching applications

## Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

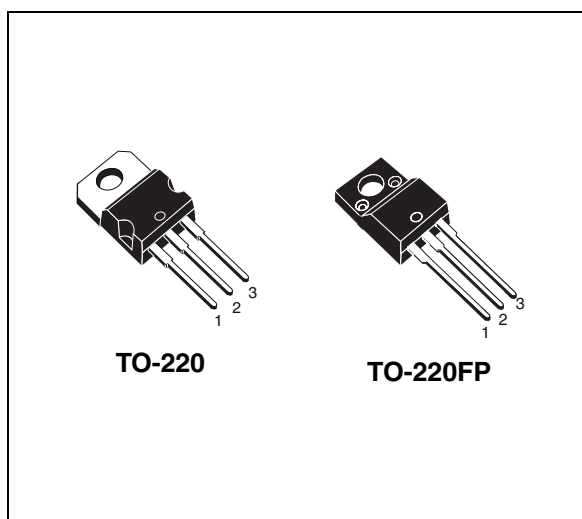


Figure 1. Internal schematic diagram

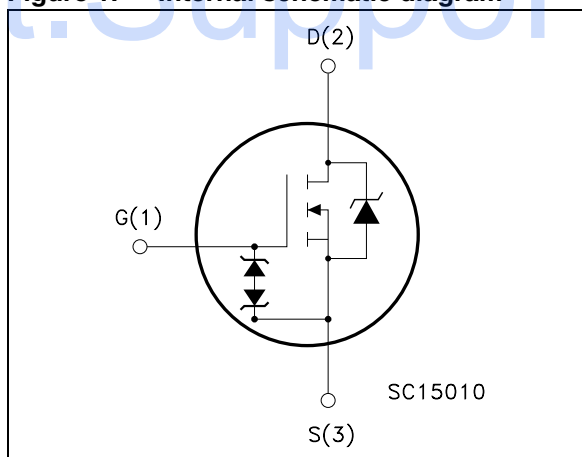


Table 1. Device summary

Order codes	Marking	Package	Packaging
STP9NK65Z	P9NK65Z	TO-220	Tube
STP9NK65ZFP	P9NK65ZFP	TO-220FP	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/ $^\circ\text{C}$
$V_{ESD(G-S)}$	Gate source ESD(HBM-C=100 pF, R=1.5 k $\Omega$ )	4000		V
dv/dt <sup>(3)</sup>	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		$^\circ\text{C}$
$T_{stg}$	Storage temperature	-55 to 150		$^\circ\text{C}$

- 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	
$R_{thj-case}$	Thermal resistance junction-case max	1	4.2	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-ambient max	62.5		$^\circ\text{C}/\text{W}$
$T_l$	Maximum lead temperature for soldering purpose	300		$^\circ\text{C}$

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_{jmax}$ )	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 ( $V_{GS} = 0$ )	$I_D = 1 \text{ mA}$	650			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 650 \text{ V}$ $V_{DS} = 650 \text{ V}, @ 125^{\circ}\text{C}$			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
$C_{oss\ eq}^{(2)}$	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 3</a> )	-	41 7.5 22	-	nC nC nC

1. Pulsed: pulse duration=300 $\mu\text{s}$ , 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 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 2</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 2</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	$I_{SD} = 6.4 \text{ A},$ $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 50 \text{ V}, T_j = 150 \text{ }^\circ\text{C}$ (see <a href="#">Figure 4</a> )	-	400		ns
$Q_{rr}$	Reverse recovery charge			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%

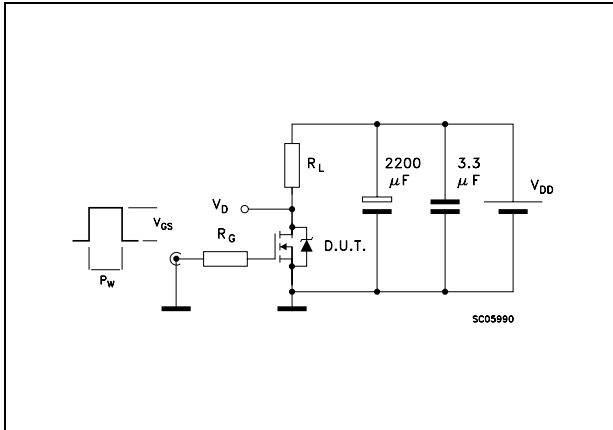
**Table 9. Gate-source zener diode**

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

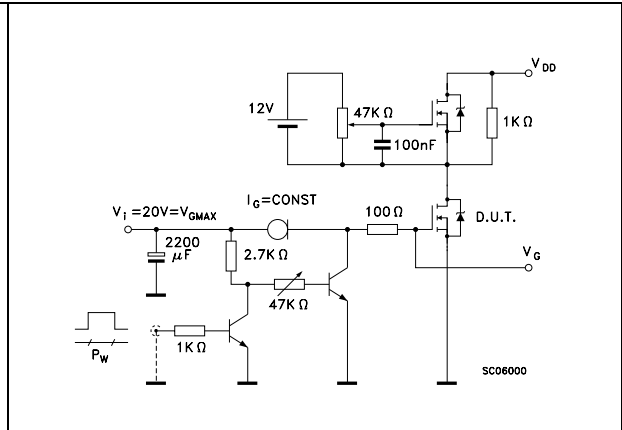
1. The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve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

### 3 Test circuits

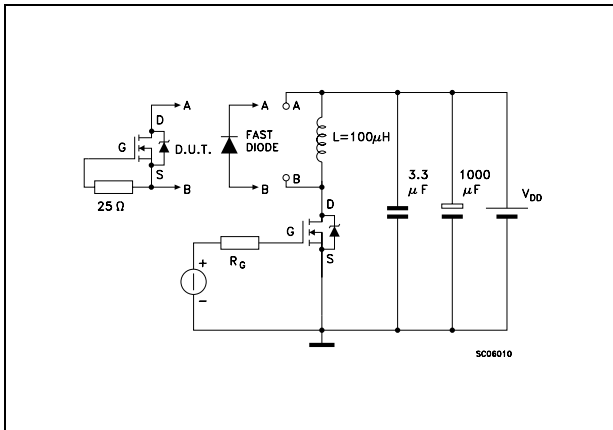
**Figure 2. Switching times test circuit for resistive load**



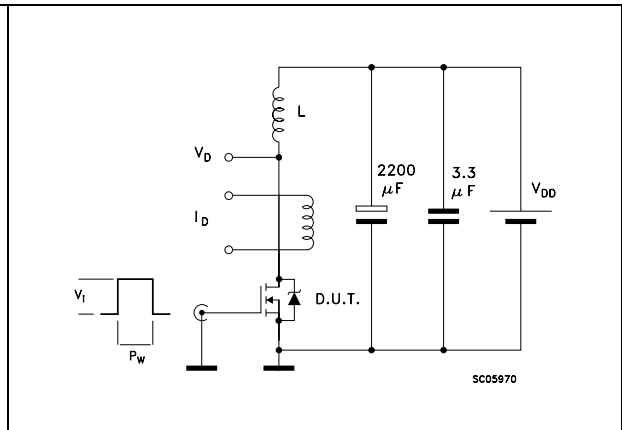
**Figure 3. Gate charge test circuit**



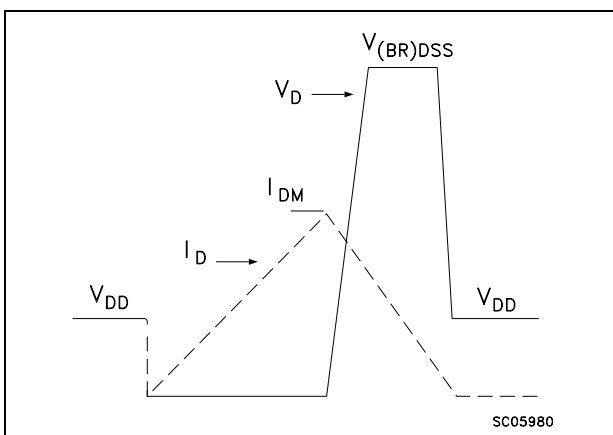
**Figure 4. Test circuit for inductive load switching and diode recovery times**



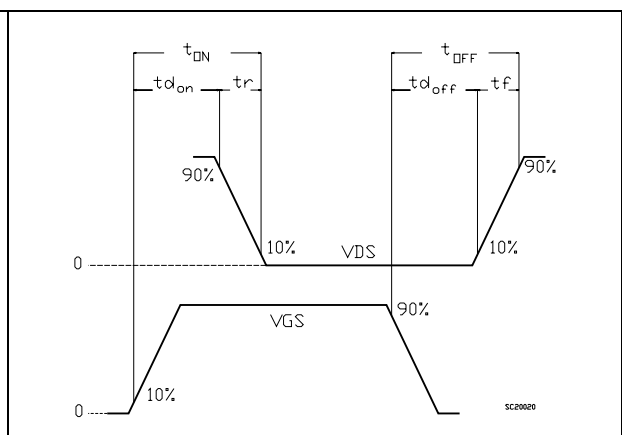
**Figure 5. Unclamped Inductive load test circuit**



**Figure 6. Unclamped inductive waveform**



**Figure 7. Switching time waveform**



### 3.1 Electrical characteristics (curves)

Figure 8. Safe operating area for TO-220

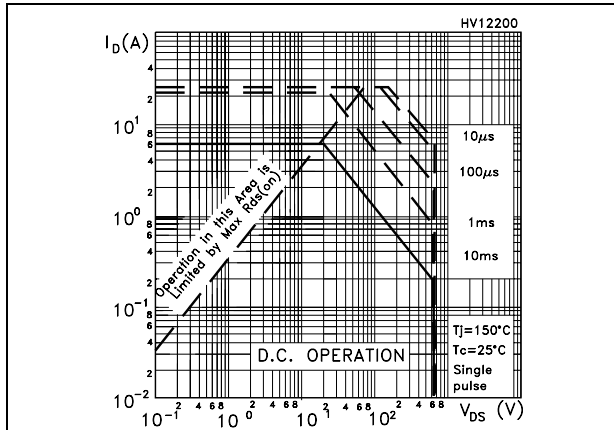


Figure 9. Thermal impedance for TO-220

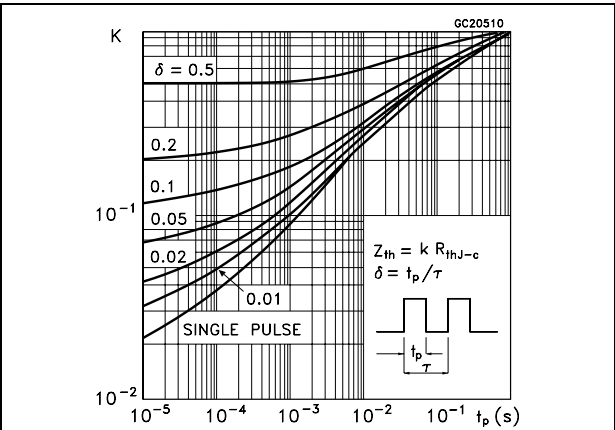


Figure 10. Safe operating area for TO-220FP

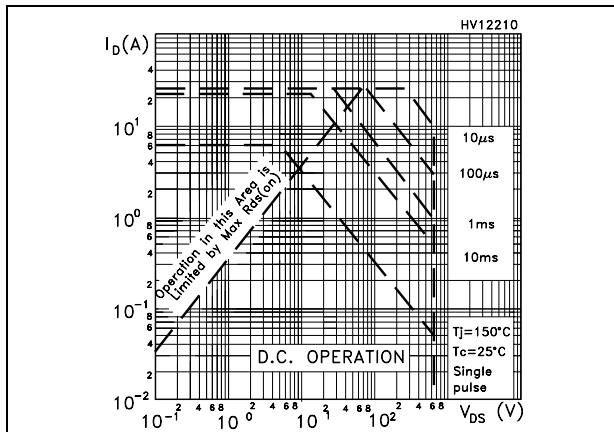


Figure 11. Thermal impedance for TO-220FP

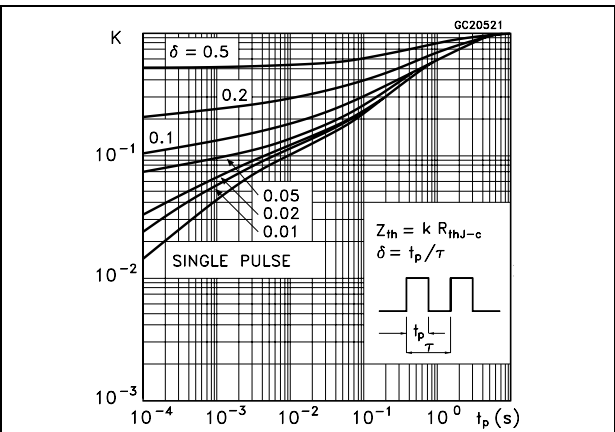


Figure 12. Output characteristics

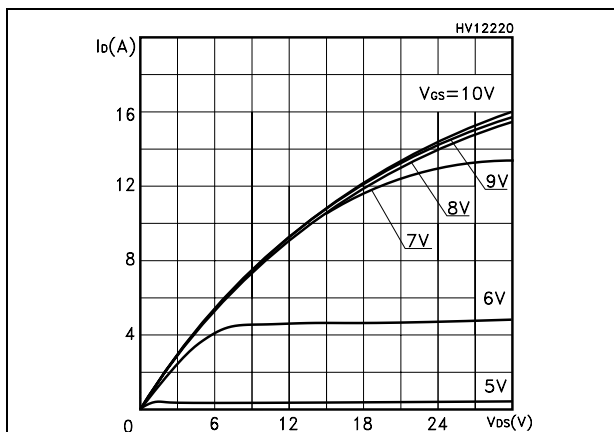


Figure 13. Transfer characteristics

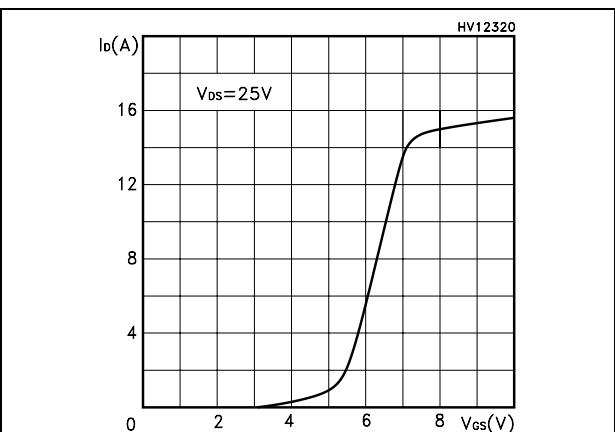


Figure 14. Transconductance

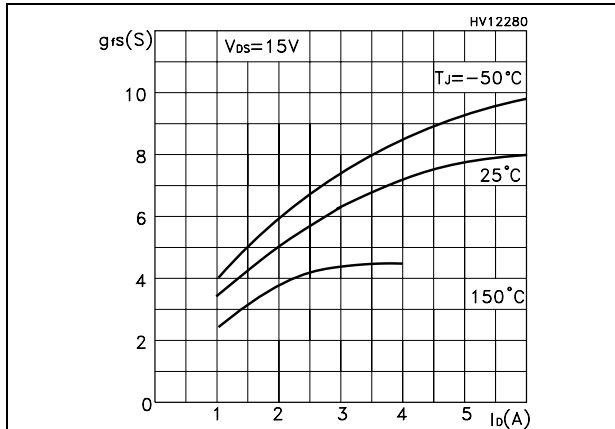


Figure 15. Static drain-source on resistance

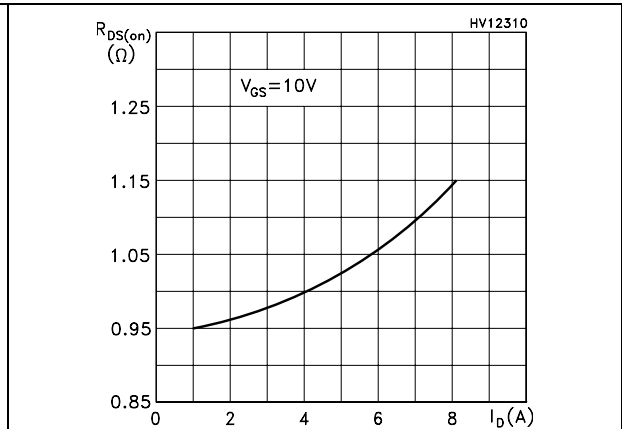


Figure 16. Gate charge vs gate-source voltage

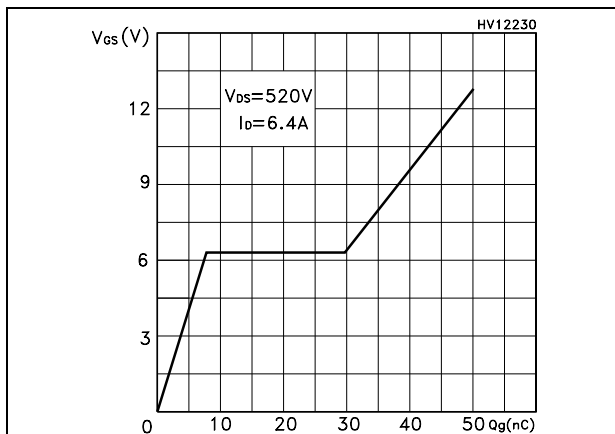


Figure 17. Capacitance variations

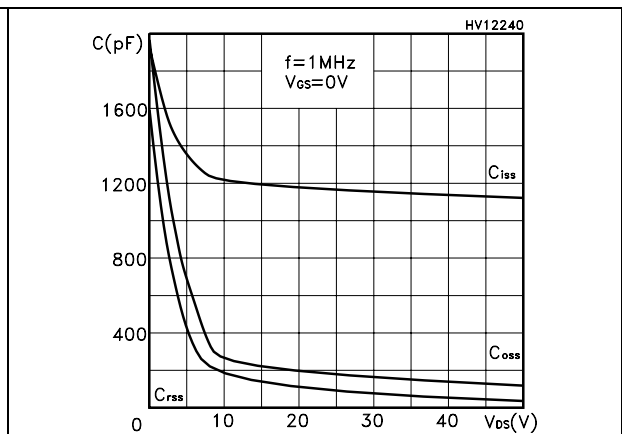


Figure 18. Normalized gate threshold voltage vs temperature

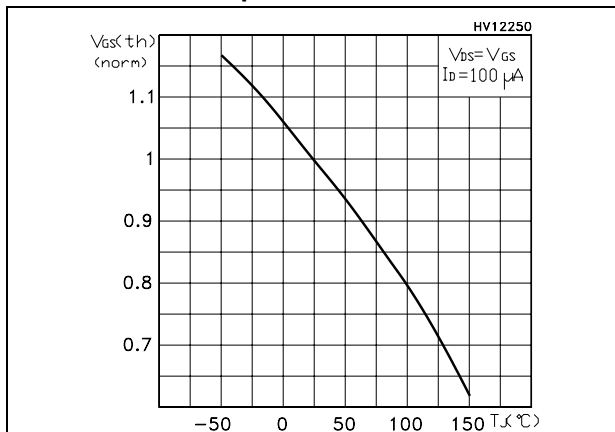


Figure 19. Normalized on resistance vs temperature

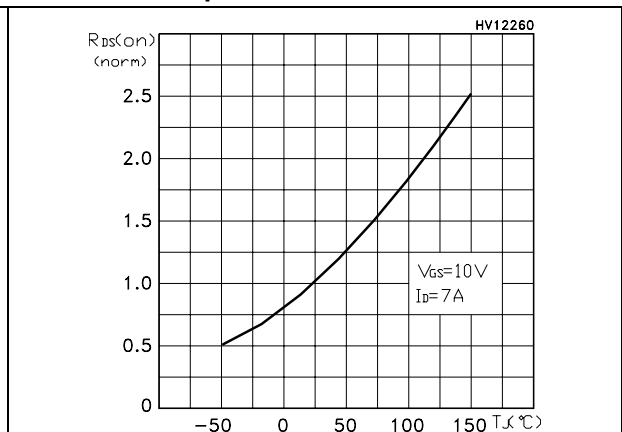




Figure 20. Source-drain diode forward characteristics

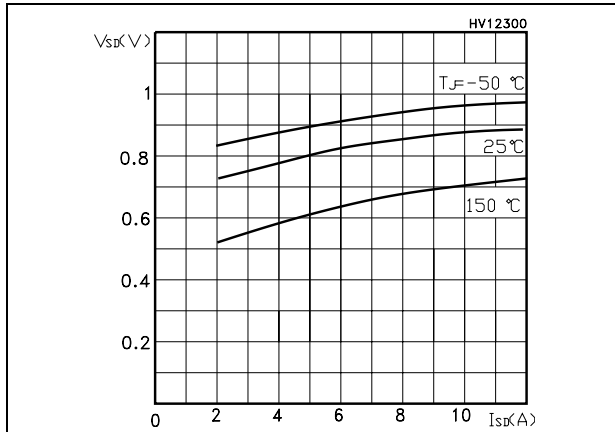


Figure 21. Normalized  $BV_{DSS}$  vs temperature

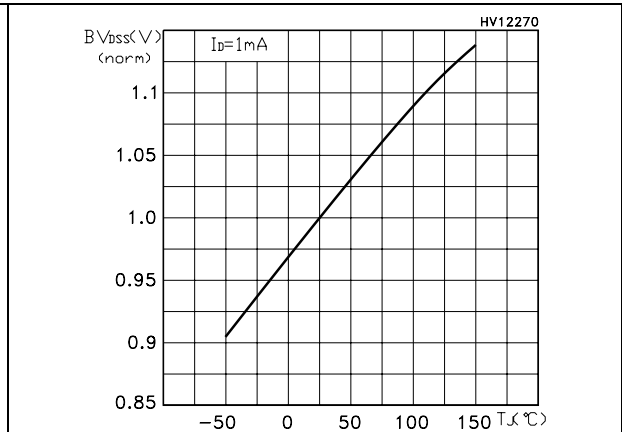
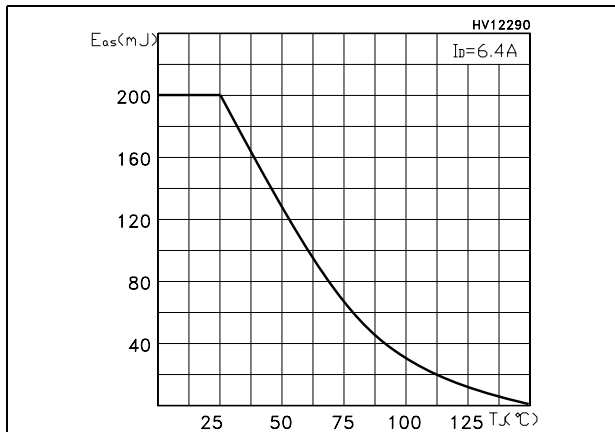


Figure 22. Maximum avalanche energy vs temperature



## 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](http://www.st.com). ECOPACK® is an ST trademark.

Table 10. 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	
∅P	3.75		3.85
Q	2.65		2.95

Figure 23. TO-220 type A drawing

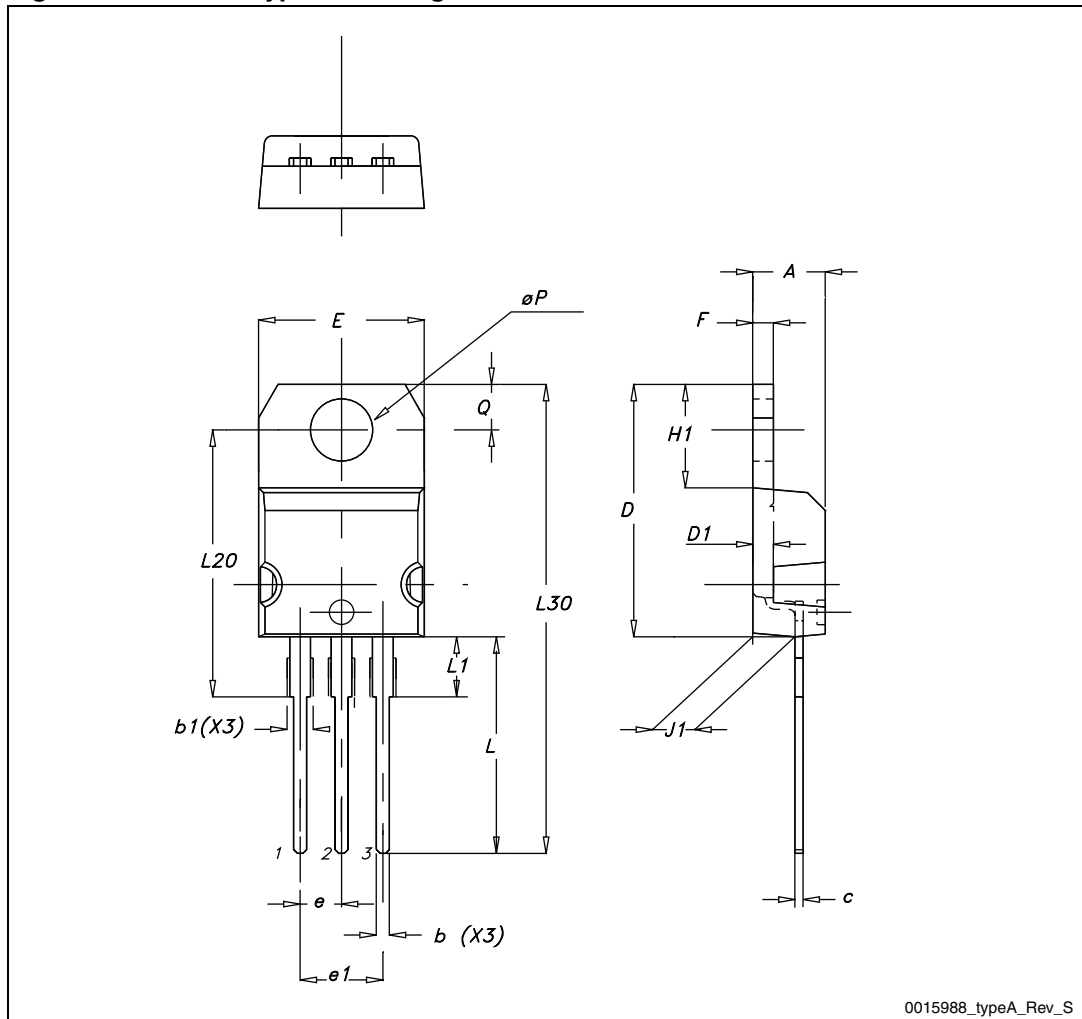
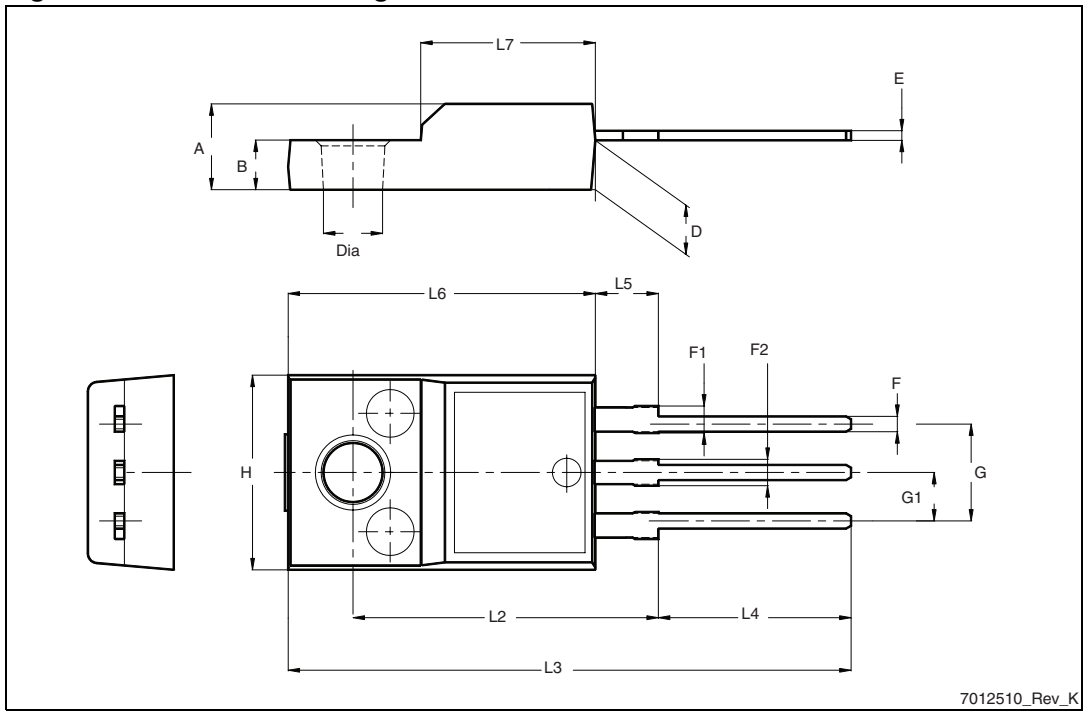


Table 11. TO-220FP mechanical data

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

## 5 Revision history

Table 12. Document revision history

Date	Revision	Changes
11-Sep-2006	2	Complete version
19-Dec-2007	3	The document has been reformatted
26-Jan-2012	4	<ul style="list-style-type: none"><li>– Minor text changes</li><li>– Modified: <i>Features</i> in cover page</li><li>– Updated: <i>Section 4: Package mechanical data</i></li></ul>

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