



# STP5NK65ZFP

N-channel 650 V, 1.5  $\Omega$ , 4.5 A TO-220FP  
Zener-protected SuperMESH™ Power MOSFET

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>	P <sub>w</sub>
STP5NK65ZFP	650 V	< 1.8 $\Omega$	4.5 A	25 W

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

## Applications

- Switching application

## 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 Power MOSFETs including revolutionary MDmesh™ products

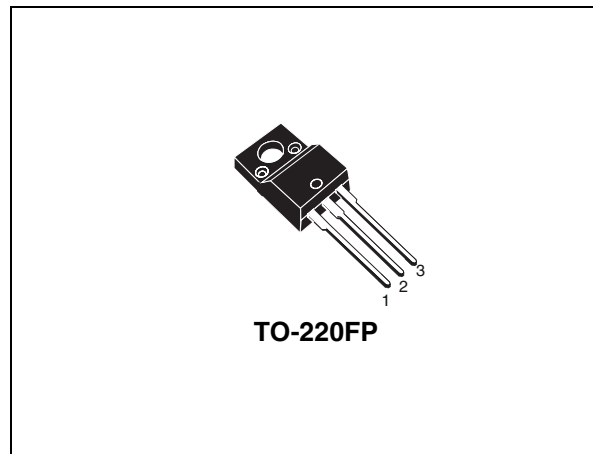


Figure 1. Internal schematic diagram

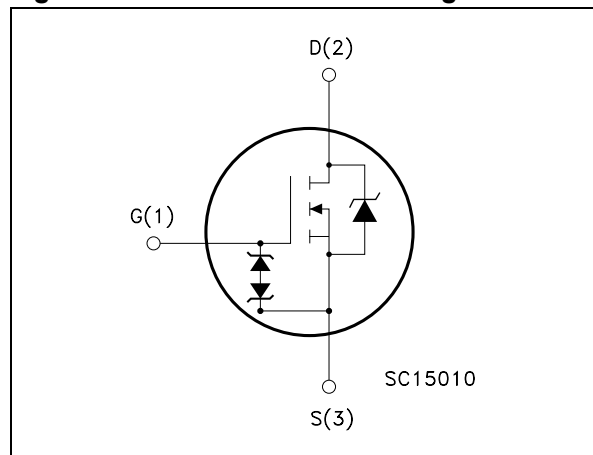


Table 1. Device summary

Order codes	Marking	Package	Packaging
STP5NK65ZFP	P5NK65ZFP	TO-220FP	Tube

# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{DS}$	Drain-source voltage ( $V_{GS} = 0$ )	650	V
$V_{GS}$	Gate- source voltage	$\pm 30$	V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	4.5 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	3.1 <sup>(1)</sup>	A
$I_{DM}$ <sup>(2)</sup>	Drain current (pulsed)	18 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	25	W
	Derating factor	0.6	W/ $^\circ\text{C}$
$V_{ESD(G-S)}$	Gate source ESD (HBM-C=100 pF, R=1.5 k $\Omega$ )	2000	V
$dv/dt$ <sup>(3)</sup>	Peak diode recovery voltage slope	4.5	V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{ s}; T_C=25\text{ }^\circ\text{C}$ )	2500	V
$T_j$ $T_{stg}$	Operating junction temperature Storage temperature	-55 to 150	V

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 5.7\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ .

**Table 3. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case Max	5	V
$R_{thj-amb}$	Thermal resistance junction-ambient Max	62.5	V
$T_l$	Maximum lead temperature for soldering purpose	300	A

**Table 4. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)	4.2	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	170	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>(BR)DSS</sub>	Drain-source breakdown voltage	I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0	650	-	-	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 @ 125 °C	-	-	1 50	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 20 V	-	-	±10	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 50 μA	3	3.75	4.5	V
R <sub>DS(on)</sub>	Static drain-source on resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.1 A	-	1.5	1.8	Ω

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g <sub>fs</sub> <sup>(1)</sup>	Forward transconductance	V <sub>DS</sub> = 10 V, I <sub>D</sub> = 2.1 A	-	5	-	S
C <sub>iss</sub> C <sub>oss</sub> C <sub>rss</sub>	Input capacitance Output capacitance Reverse transfer capacitance	V <sub>DS</sub> = 25 V, f = 1MHz, V <sub>GS</sub> = 0	-	680 80 17	-	pF pF pF
C <sub>oss eq.</sub> <sup>(2)</sup>	Equivalent output capacitance	V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 480 V	-	98	-	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> = 520 V, I <sub>D</sub> = 4.5 A, V <sub>GS</sub> = 10 V <i>Figure 16</i>	-	25 4.4 13.7	35	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 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t <sub>d(on)</sub> t <sub>r</sub> t <sub>d(off)</sub> t <sub>f</sub>	Turn-on delay time Rise time Turn-off-delay time Fall time	V <sub>DD</sub> = 325 V, I <sub>D</sub> = 2.1 A, R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V <i>Figure 15</i>	-	20 15 140 40	-	ns ns ns ns
t <sub>r(Voff)</sub> t <sub>f</sub> t <sub>c</sub>	Off-voltage rise time Fall time Cross-over time	V <sub>DD</sub> = 325 V, I <sub>D</sub> = 2.1 A, R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V <i>Figure 15</i>	-	12 7 15	-	ns ns ns

**Table 8. Source Drain Diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM}^{(1)}$	Source-drain current Source-drain current (pulsed)		-	-	4.5 18	A A
$V_{SD}^{(2)}$	Forward On voltage	$I_{SD} = 4.5\text{ A}, V_{GS} = 0$	-	-	1.6	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_{SD} = 4.5\text{ A},$ $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 100\text{ V}, T_j = 150\text{ }^\circ\text{C}$ <i>Figure 20</i>	-	375 1.76 10	-	ns nC 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
$BV_{GSO}$	Gate-source breakdown voltage	$I_{gs} = \pm 1\text{ mA}$ (open drain)	30	-	-	V

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

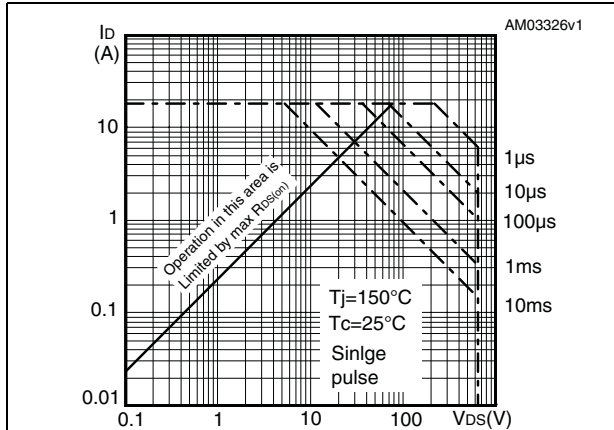


Figure 3. Thermal impedance

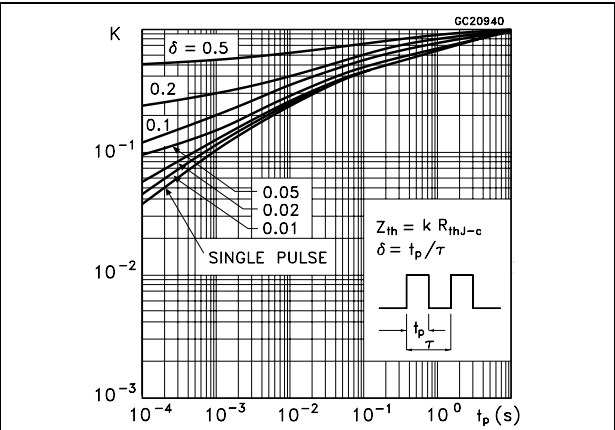


Figure 4. Output characteristics

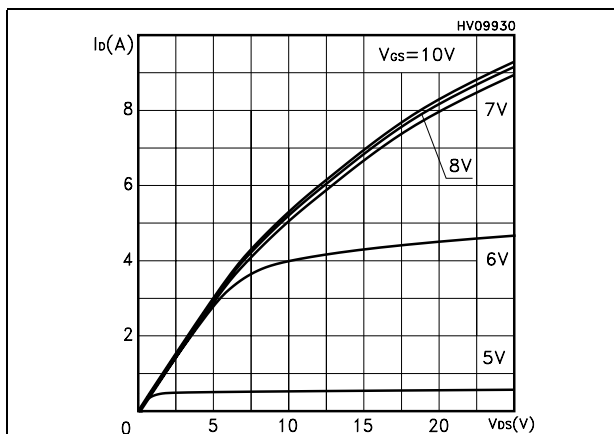


Figure 5. Transfer characteristics

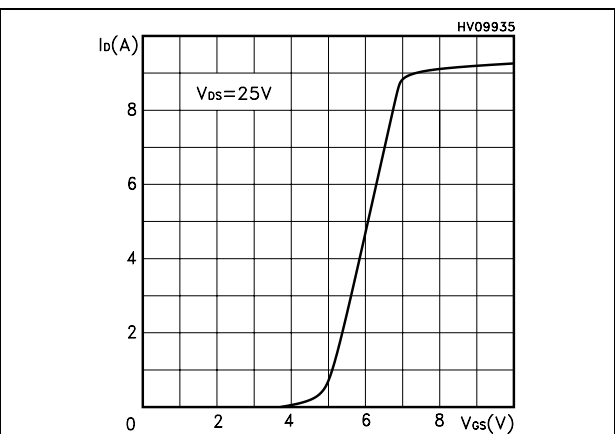


Figure 6. Transconductance

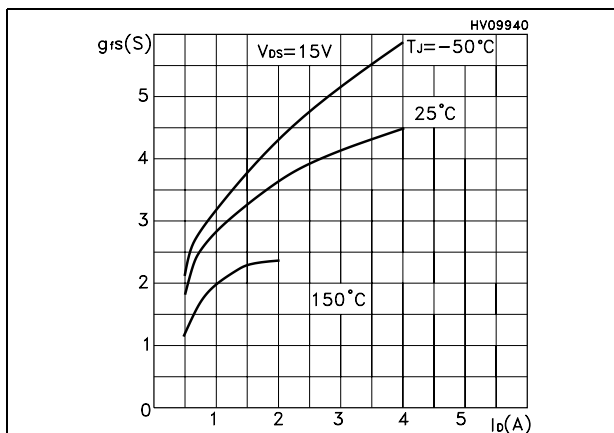


Figure 7. Static drain source on resistance

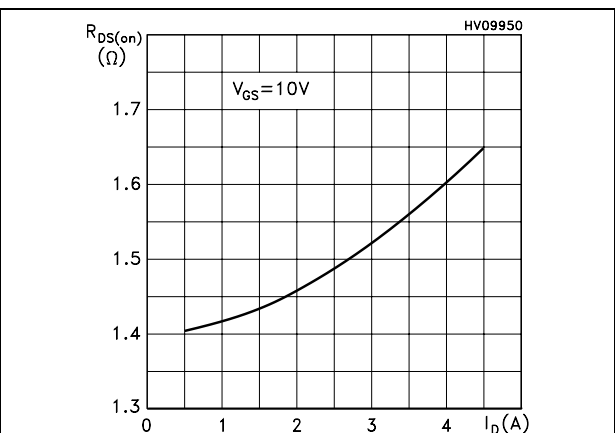


Figure 8. Gate charge vs gate-source voltage Figure 9. Capacitance variations

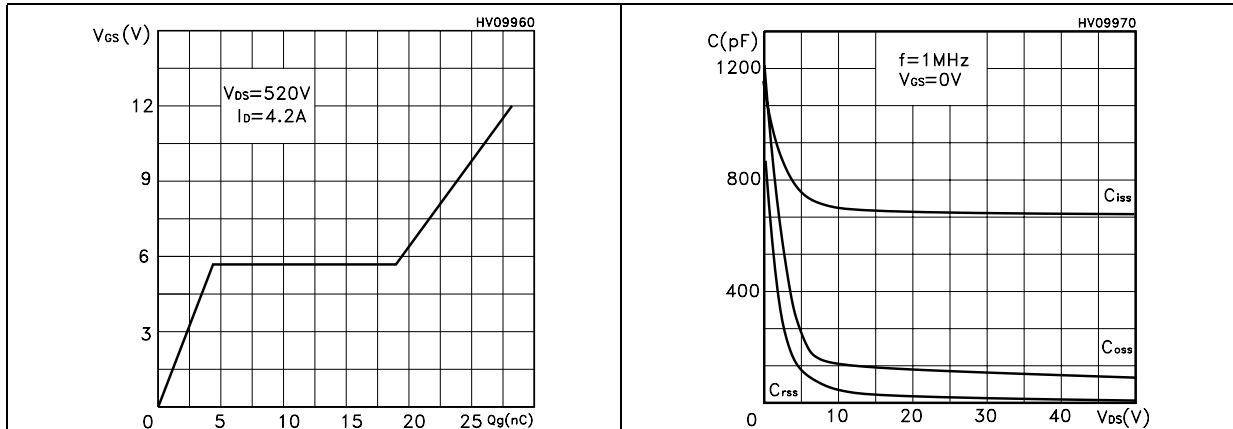


Figure 10. Normalized gate threshold voltage vs temperature Figure 11. Normalized on resistance vs temperature

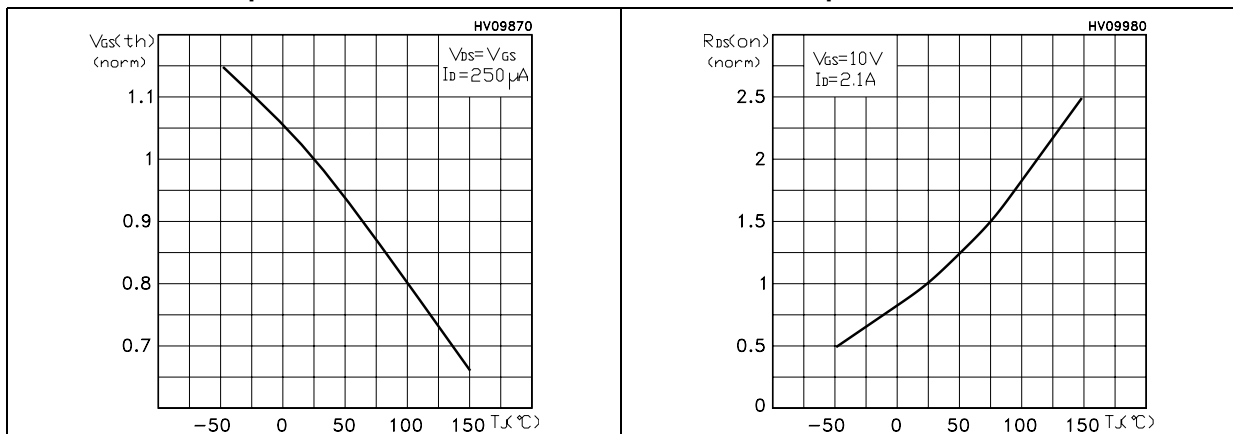


Figure 12. Source-drain diode forward characteristics Figure 13. Avalanche energy vs starting  $T_J$

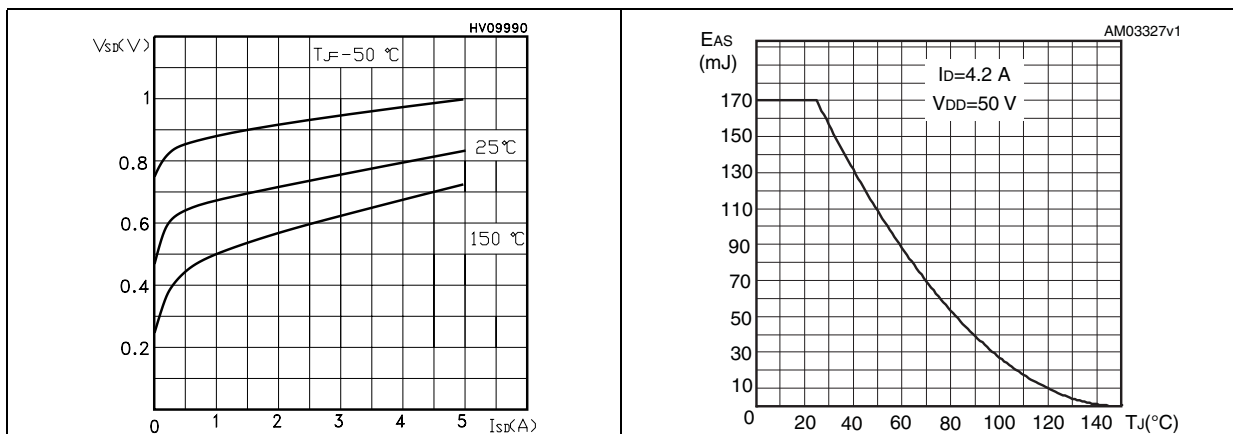
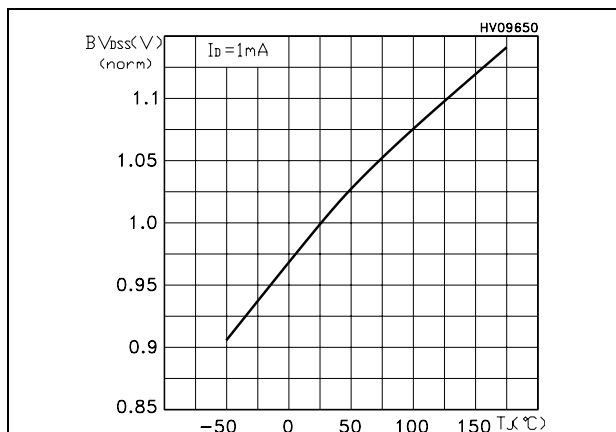


Figure 14. Normalized  $BV_{DSS}$  vs temperature



### 3 Test circuits

Figure 15. Switching times test circuit for resistive load

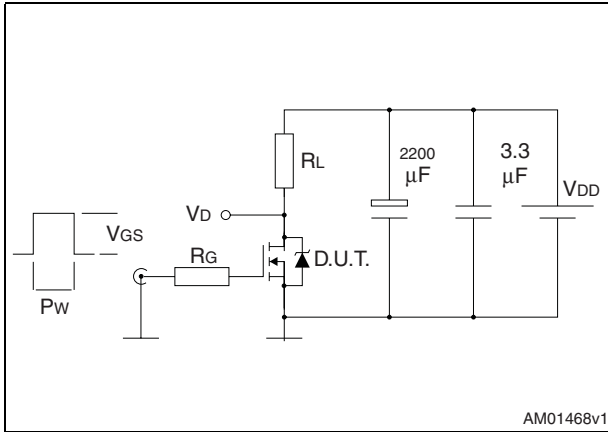


Figure 16. Gate charge test circuit

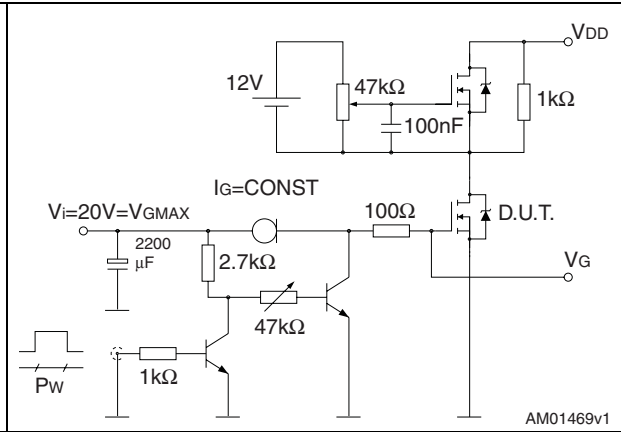


Figure 17. Test circuit for inductive load switching and diode recovery times

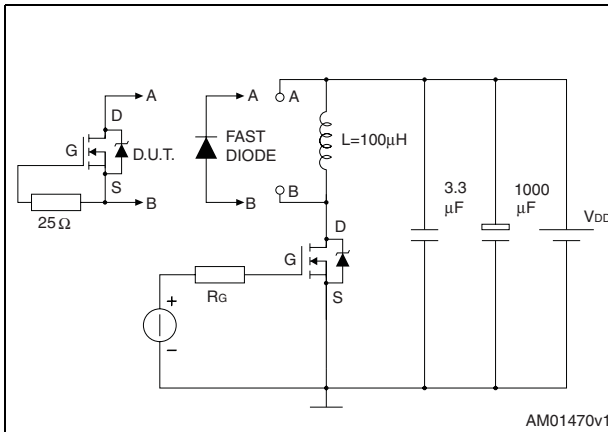


Figure 18. Unclamped inductive load test circuit

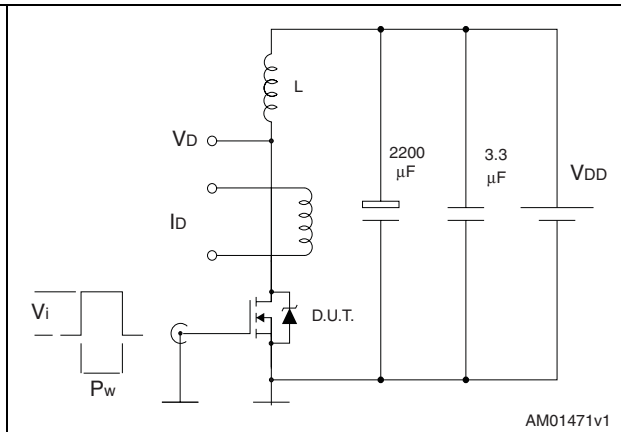


Figure 19. Unclamped inductive waveform

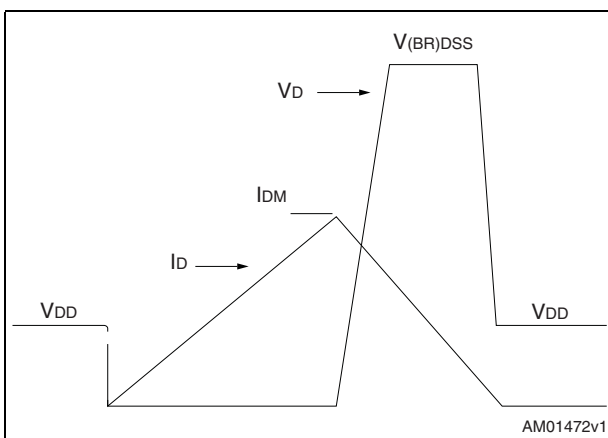
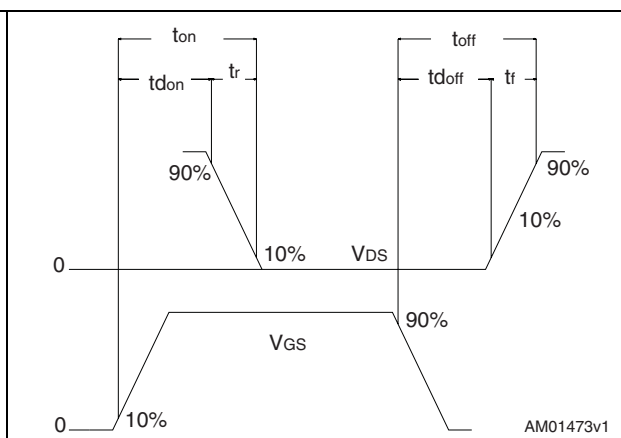


Figure 20. Switching time waveform



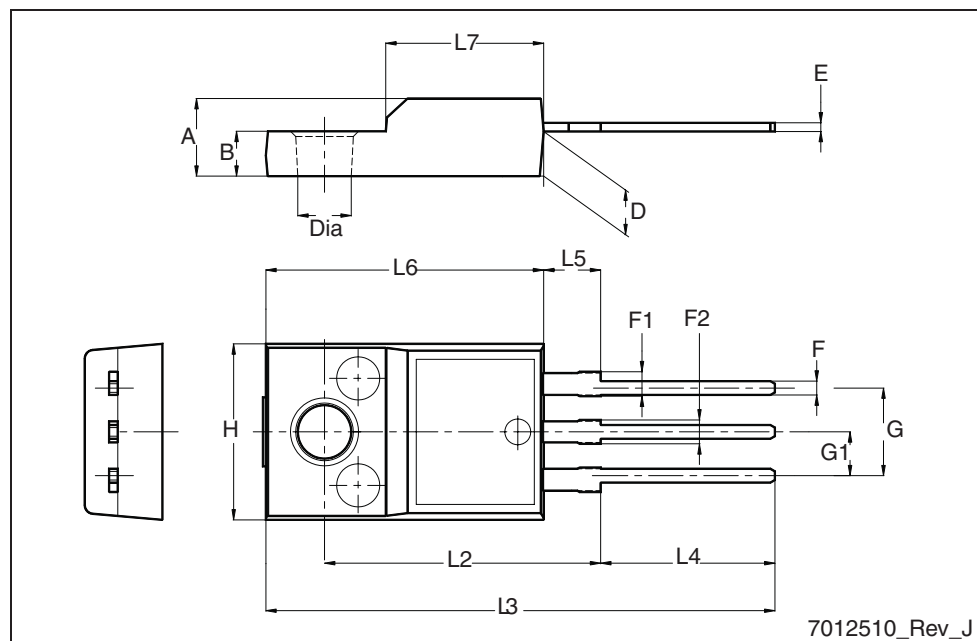


## 4 Package mechanical data

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

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		1.5
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



## 5 Revision history

Table 10. Document revision history

Date	Revision	Changes
16-Apr-2009	1	First issue

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