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## N-channel 600 V, 1.7 $\Omega$ typ., 4 A Zener-protected SuperMESH™ Power MOSFETs in TO-220 and TO-220FP packages

Datasheet - production data

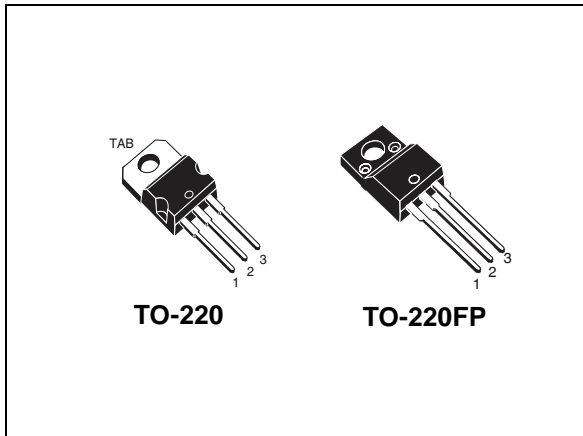
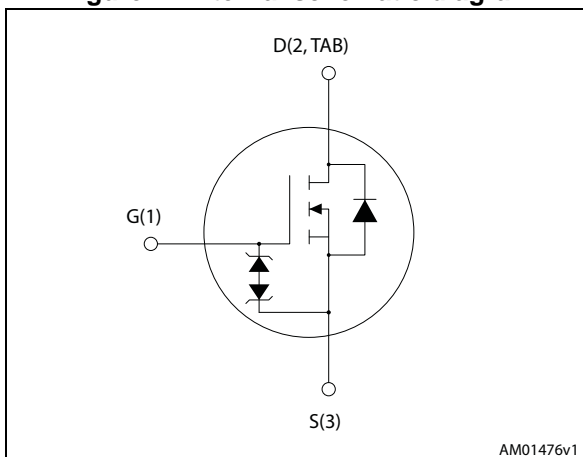


Figure 1. Internal schematic diagram



### Features

Order codes	$V_{DS}$	$R_{DS(on)}$ max.	$P_{TOT}$	$I_D$
STP4NK60Z	600 V	2 $\Omega$	70 W	4 A
STP4NK60ZFP				

- 100% avalanche tested
- Very low intrinsic capacitances
- Zener-protected

### 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.

Table 1. Device summary

Order codes	Marking	Packages	Packaging
STP4NK60Z	P4NK60Z	TO-220	Tube
STP4NK60ZFP	P4NK60ZFP	TO-220FP	

# 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	600		V
$V_{GS}$	Gate- source voltage	± 30		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	4	4 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	2.5	2.5 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	16	16 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	70	25	W
	Derating factor	0.56	0.2	W/°C
ESD	Gate-source human body model (C=100 pF, R=1.5 kΩ)	3		kV
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 s; $T_C=25\text{ °C}$ )		2500	V
$T_{stg}$	Storage temperature	-55 to 150		°C
$T_j$	Max operating junction temperature	150		°C

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 4\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq T_{JMAX}$ .

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	1.79	5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	62.5		°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_{jmax}$ )	4	A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ )	120	mJ

## 2 Electrical characteristics

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

**Table 5. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$ $V_{DS} = 600\text{ V}, T_C = 125\text{ °C}$			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	$V_{DS} = V_{GS}, I_D = 50\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}, I_D = 2\text{ A}$		1.7	2	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15\text{ V}, I_D = 2\text{ A}$	-	3		S
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}, f = 1\text{ MHz},$ $V_{GS} = 0$	-	510		pF
$C_{oss}$	Output capacitance		-	67		pF
$C_{rss}$	Reverse transfer capacitance		-	13		pF
$C_{oss\text{ eq.}}^{(2)}$	Equivalent output capacitance	$V_{DS} = 0, V_{DS} = 0\text{ to }480\text{ V}$	-	38.5		pF
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, I_D = 2\text{ A},$ $R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> )	-	12		ns
$t_r$	Rise time		-	9.5		ns
$t_{d(off)}$	Turn-off delay time		-	29		ns
$t_f$	Fall time		-	16.5		ns
$t_{r(Voff)}$	Off-voltage rise time	$V_{DD} = 480\text{ V}, I_D = 4\text{ A},$ $R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$ (see <a href="#">Figure 19</a> )	-	12		ns
$t_f$	Fall time		-	12		ns
$t_c$	Cross-over time		-	19.5		ns
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 4\text{ A},$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18</a> )	-	18.8	26	nC
$Q_{gs}$	Gate-source charge		-	3.8		nC
$Q_{gd}$	Gate-drain charge		-	9.8		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. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		4	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		16	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 4\text{ A}, V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 4\text{ A}, di/dt = 100\text{ A}/\mu\text{s}$	-	400		ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 24\text{ V}, T_j = 150\text{ }^\circ\text{C}$	-	1700		nC
$I_{RRM}$	Reverse recovery current	(see <a href="#">Figure 19</a> )	-	8.5		A

1. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%
2. Pulse width limited by safe operating area

Table 8. Gate-source Zener diode

Symbol	Parameter	Test conditions	Min	Typ.	Max.	Unit
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{GS} = \pm 1\text{ mA}, I_D = 0$	30	-	-	V

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

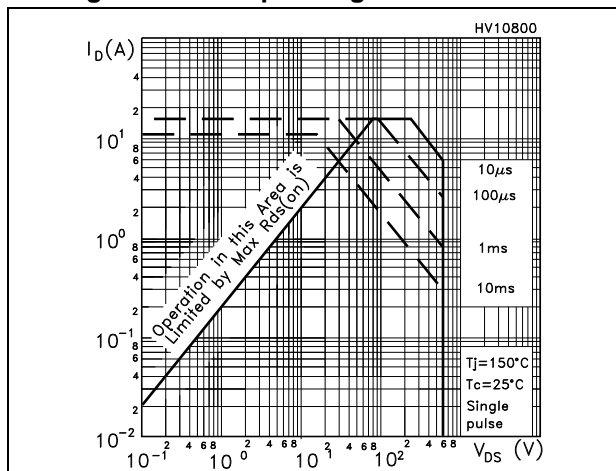


Figure 3. Thermal impedance for TO-220

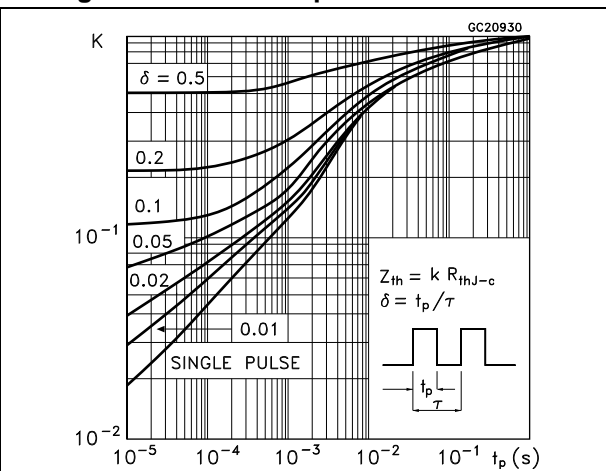


Figure 4. Safe operating area for TO-220FP

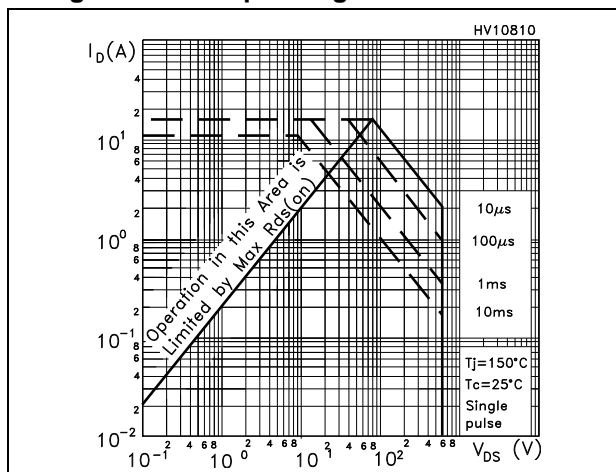


Figure 5. Thermal impedance for TO-220FP

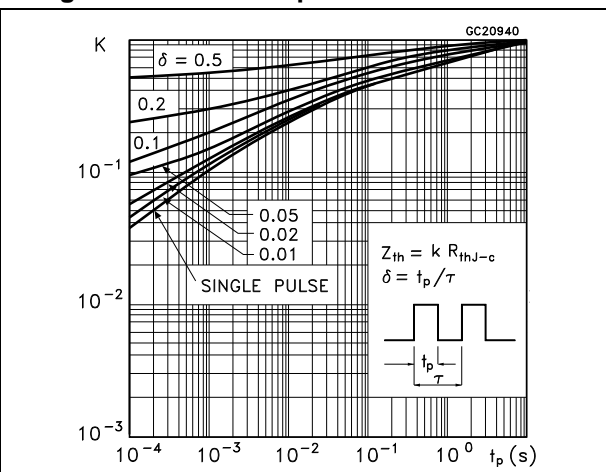


Figure 6. Output characteristics

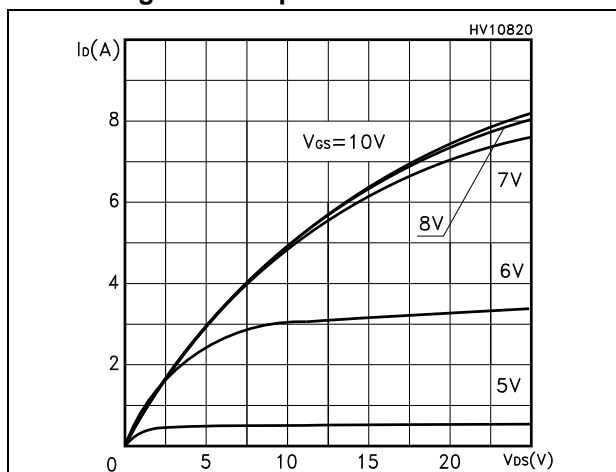


Figure 7. Transfer characteristics

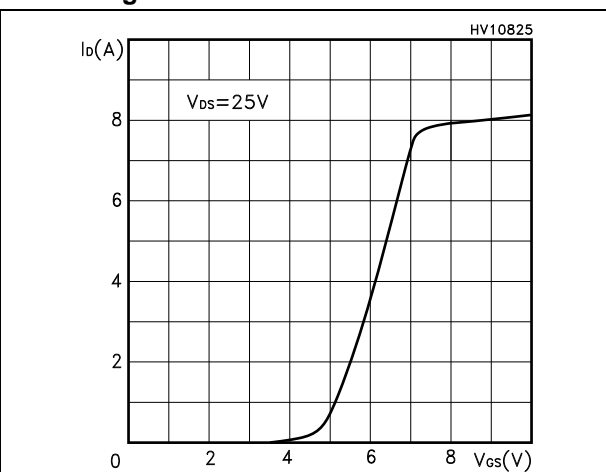


Figure 8. Transconductance

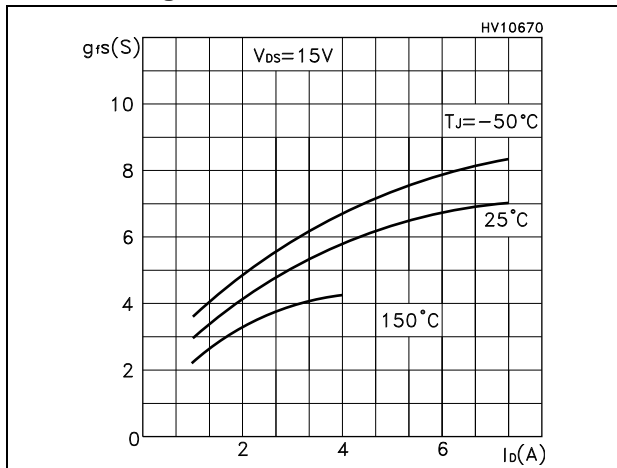


Figure 9. Static drain-source on-resistance

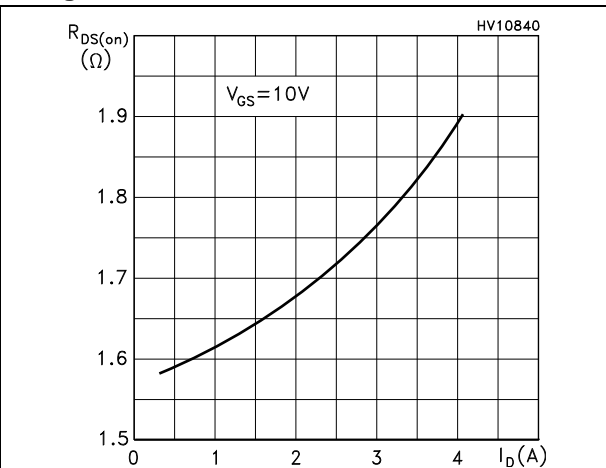


Figure 10. Gate charge vs gate-source voltage

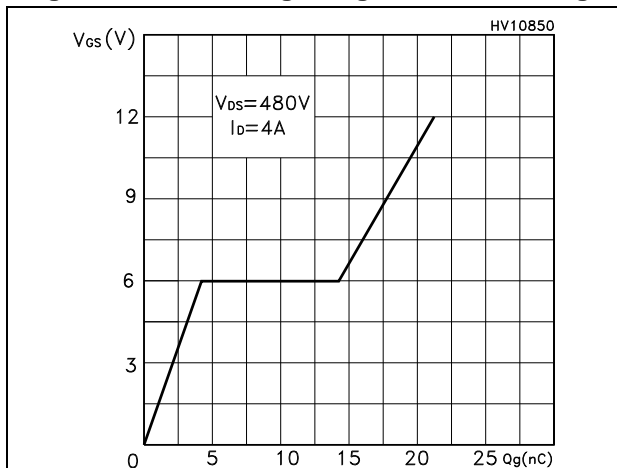


Figure 11. Capacitance variations

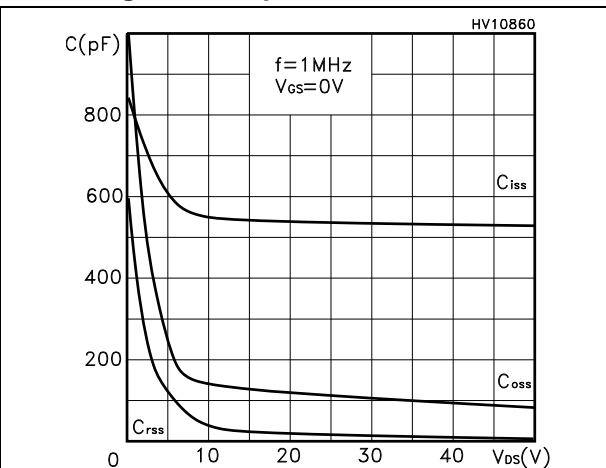


Figure 12. Normalized gate threshold voltage vs temperature

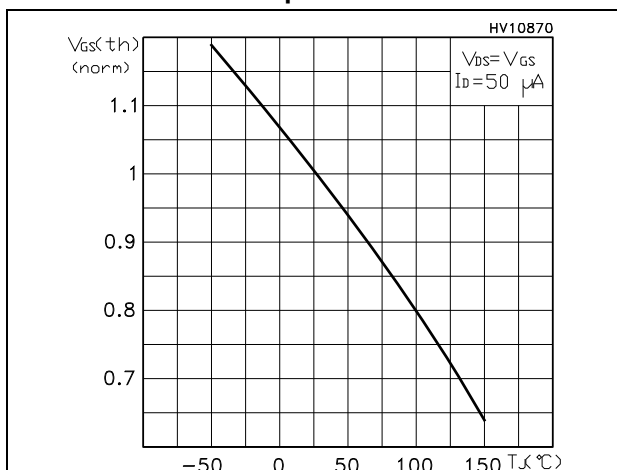


Figure 13. Normalized  $R_{DS(on)}$  vs temperature

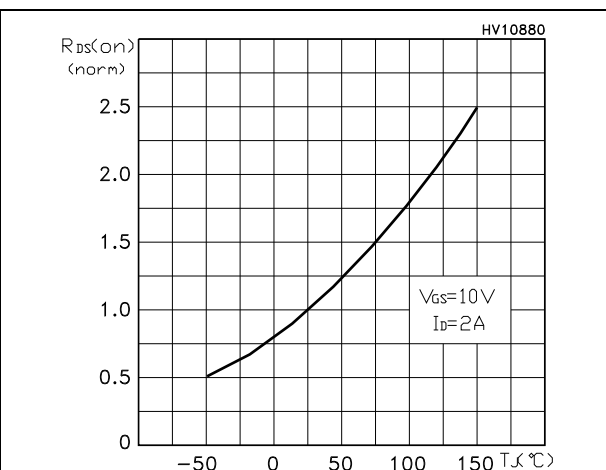




Figure 14. Source-drain diode forward characteristic

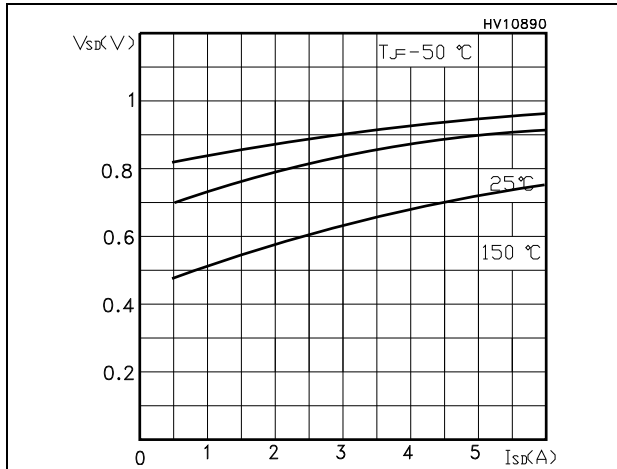


Figure 15. Normalized  $V_{DS}$  vs temperature

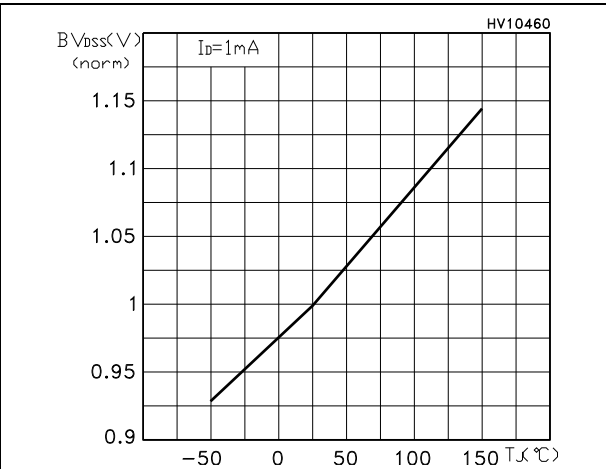
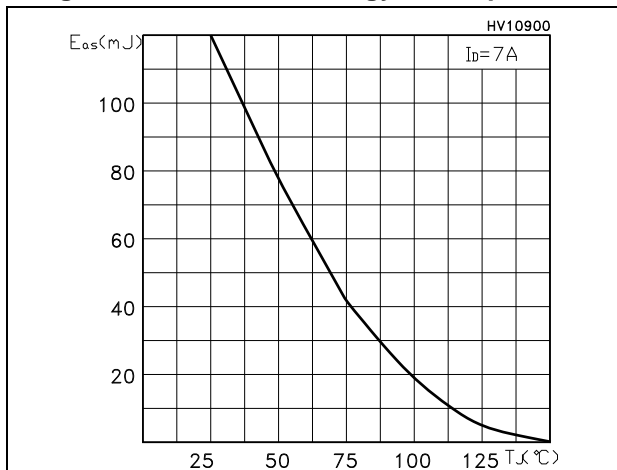


Figure 16. Avalanche energy vs temperature



### 3 Test circuits

Figure 17. Switching times test circuit for resistive load

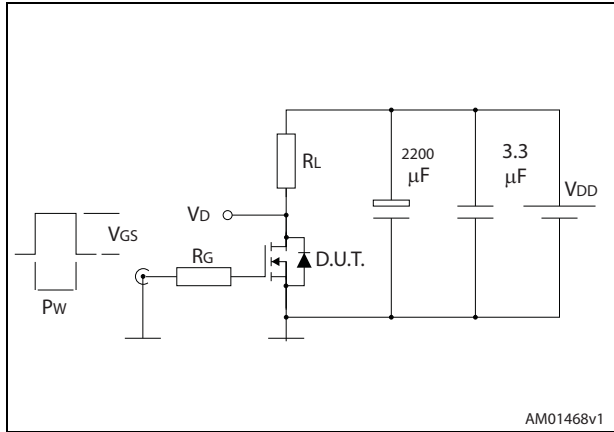


Figure 18. Gate charge test circuit

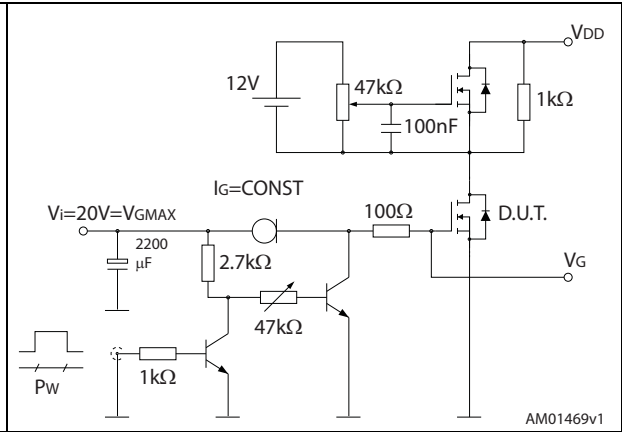


Figure 19. Test circuit for inductive load switching and diode recovery times

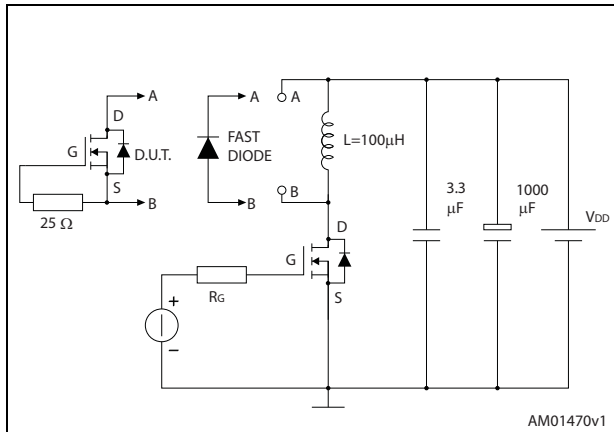


Figure 20. Unclamped inductive load test circuit

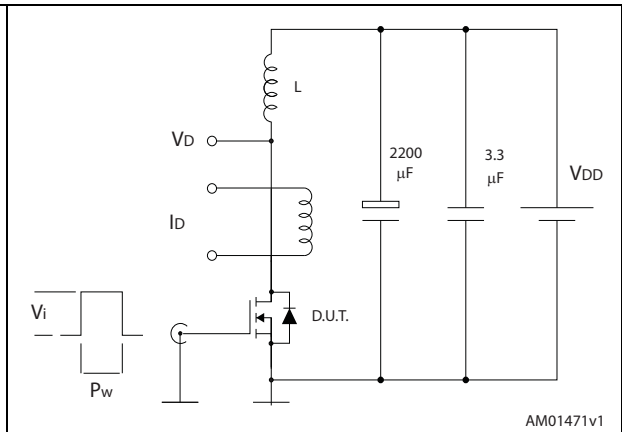


Figure 21. Unclamped inductive waveform

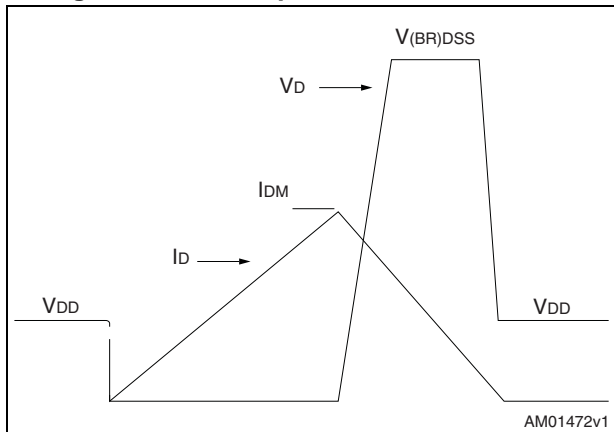
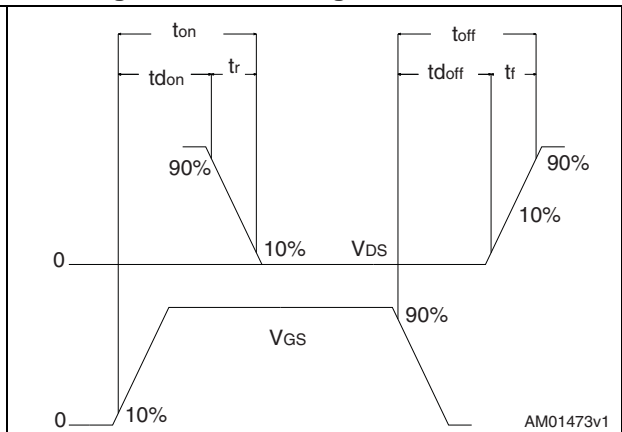


Figure 22. Switching time waveform



## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

Figure 23. TO-220 type A drawing

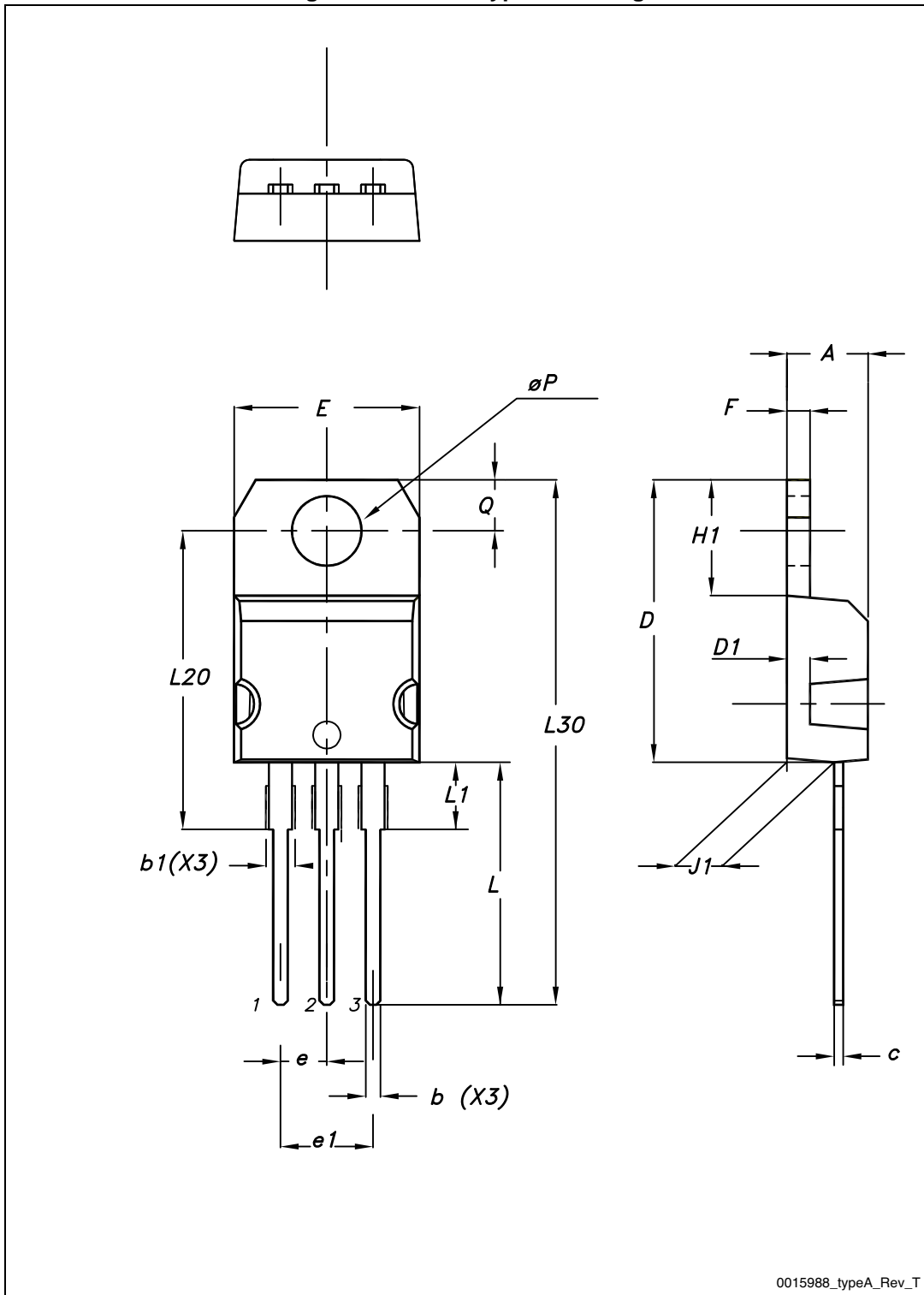
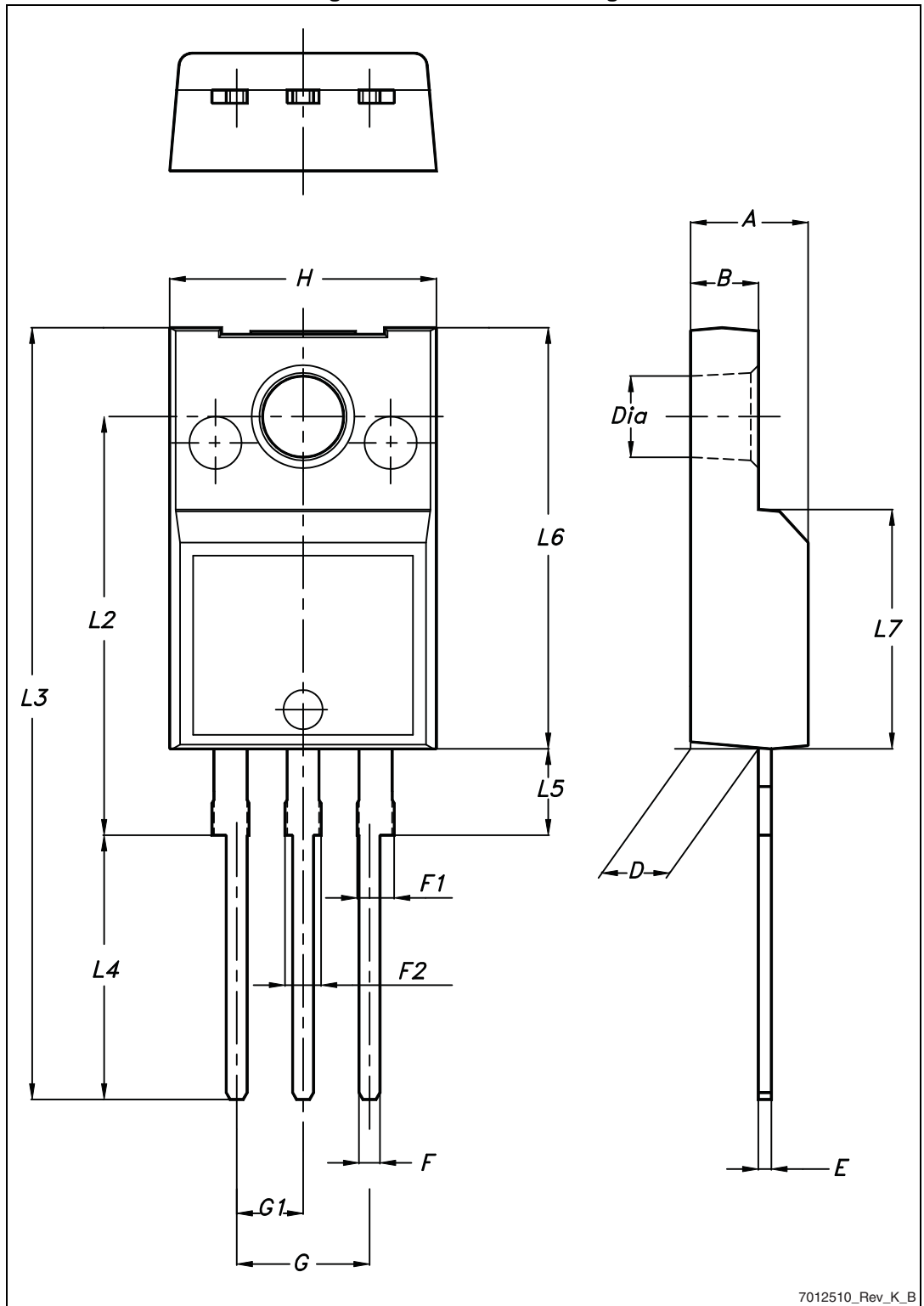


Table 9. TO-220 type A mechanical data

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 24. TO-220FP drawing



7012510\_Rev\_K\_B

Table 10. 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

## 5 Revision history

**Table 11. Document revision history**

Date	Revision	Changes
19-Jul-2013	1	First release. Part numbers previously included in datasheet DocID8882
22-Jan-2014	2	– Modified: figure in cover page – Minor text changes



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