



# STF10N65K3, STFI10N65K3, STP10N65K3

N-channel 650 V, 0.75  $\Omega$  typ., 10 A Zener-protected SuperMESH3™ Power MOSFET in TO-220FP, I<sup>2</sup>PAKFP and TO-220 packages

Datasheet – production data

## Features

Order codes	V <sub>DS</sub>	R <sub>DS(on) max</sub>	I <sub>D</sub>	P <sub>TOT</sub>
STF10N65K3	650 V	1 $\Omega$	10 A	35 W
STFI10N65K3				150 W
STP10N65K3				

- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- Very low intrinsic capacitances
- Improved diode reverse recovery characteristics
- Zener-protected

## Applications

- Switching applications

## Description

These SuperMESH3™ Power MOSFETs are the result of improvements applied to STMicroelectronics' SuperMESH™ technology, combined with a new optimized vertical structure. These devices boast an extremely low on-resistance, superior dynamic performance and high avalanche capability, rendering them suitable for the most demanding applications.

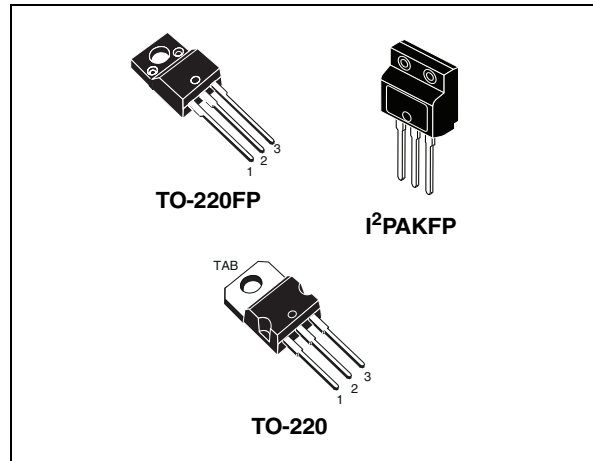


Figure 1. Internal schematic diagram

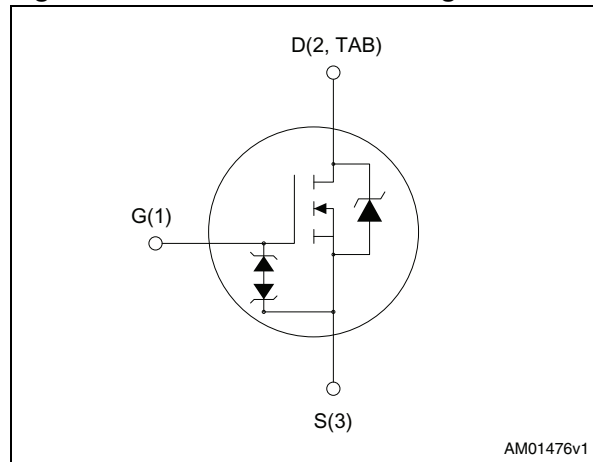


Table 1. Device summary

Order codes	Marking	Package	Packaging
STF10N65K3	10N65K3	TO-220FP	Tube
STFI10N65K3		I <sup>2</sup> PAKFP	
STP10N65K3		TO-220	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220FP I <sup>2</sup> PAKFP	TO-220	
V <sub>DS</sub>	Drain source voltage	650		V
V <sub>GS</sub>	Gate-source voltage	± 30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	10		A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	6.3		A
I <sub>DM</sub> <sup>(1)</sup>	Drain current (pulsed)	40		A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	35	150	W
I <sub>AR</sub>	Max current during repetitive or single pulse avalanche (pulse width limited by T <sub>JMAX</sub> )	7.2		A
E <sub>AS</sub>	Single pulse avalanche energy <sup>(2)</sup>	212		mJ
	Derating factor	0.28	1.2	W/°C
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	12		V/ns
ESD	Gate-source human body model (R = 1.5 kΩ, C = 100 pF)	2.8		kV
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; 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. Pulse width limited by safe operating area.
2. Starting T<sub>j</sub> = 25 °C, I<sub>D</sub> = I<sub>AR</sub>, V<sub>DD</sub> = 50 V
3. I<sub>SD</sub> ≤ 10 A, di/dt = 100 A/μs, V<sub>Peak</sub> < V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220FP I <sup>2</sup> PAKFP	TO-220	
R <sub>thj-case</sub>	Thermal resistance junction-case max	3.57	0.83	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.5		°C/W

## 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> = 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> = 650 V V <sub>DS</sub> = 650 V, 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> = ± 20 V			±10	μA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 100 μA	3		4.5	V
R <sub>DS(on)</sub>	Static drain-source on-resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 3.6 A		0.75	1	Ω

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>DS</sub> = 25 V, f = 1 MHz, V <sub>GS</sub> = 0	-	1180	-	pF
C <sub>oss</sub>	Output capacitance			125		pF
C <sub>rss</sub>	Reverse transfer capacitance			14		pF
C <sub>oss eq.</sub>	Equivalent output capacitance	V <sub>DS</sub> = 0 to 520 V, V <sub>GS</sub> = 0	-	77	-	pF
R <sub>G</sub>	Intrinsic gate resistance	f = 1 MHz open drain	-	3	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 520 V, I <sub>D</sub> = 7.2 A,	-	42	-	nC
Q <sub>gs</sub>	Gate-source charge	V <sub>GS</sub> = 10 V		7.4		nC
Q <sub>gd</sub>	Gate-drain charge	(see <a href="#">Figure 18</a> )		23		nC

**Table 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 310\text{ V}$ , $I_D = 3.5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> )	-	14.5	-	ns
$t_r$	Rise time			14		ns
$t_{d(off)}$	Turn-off-delay time			44		ns
$t_f$	Fall time			35		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		7.2	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				28.8	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 7\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 7\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see <a href="#">Figure 22</a> )	-	320		ns
$Q_{rr}$	Reverse recovery charge			2		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			13		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 7\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 22</a> )	-	410		ns
$Q_{rr}$	Reverse recovery charge			2.9		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			14		A

1. Pulse width limited by safe operating area.

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

**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-220FP and I<sup>2</sup>PAKFP

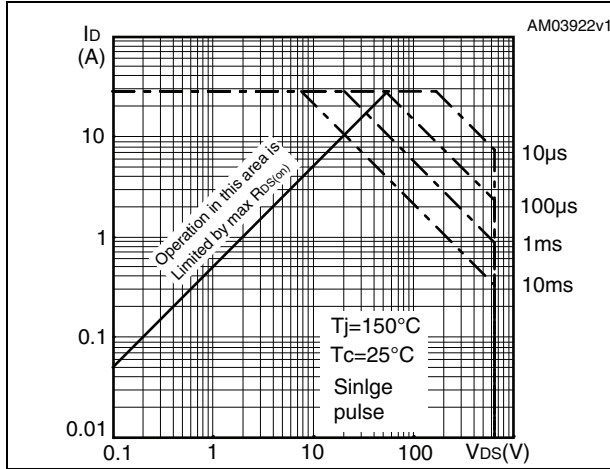


Figure 3. Thermal impedance for TO-220FP and I<sup>2</sup>PAKFP

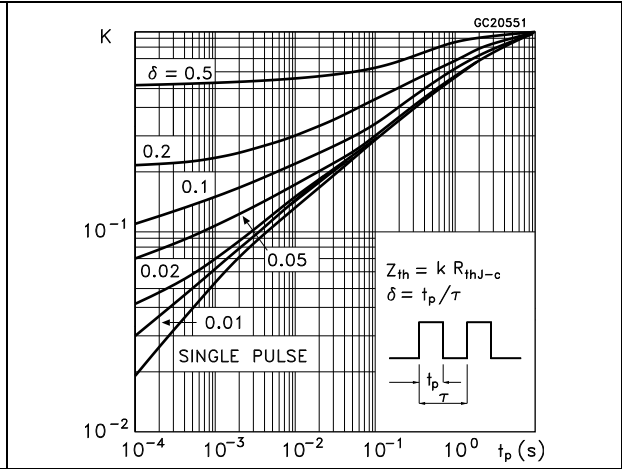


Figure 4. Safe operating area for TO-220

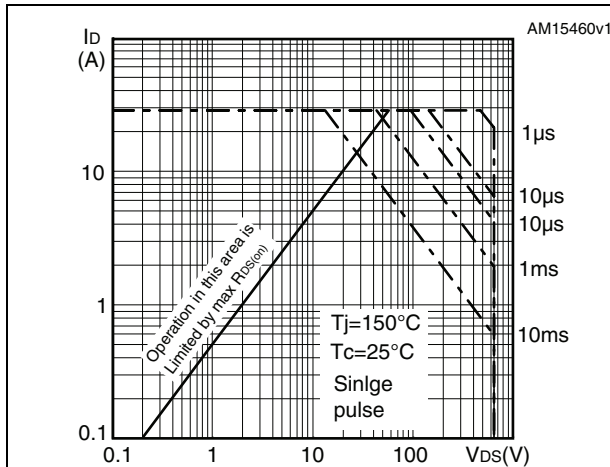


Figure 5. Thermal impedance for TO-220

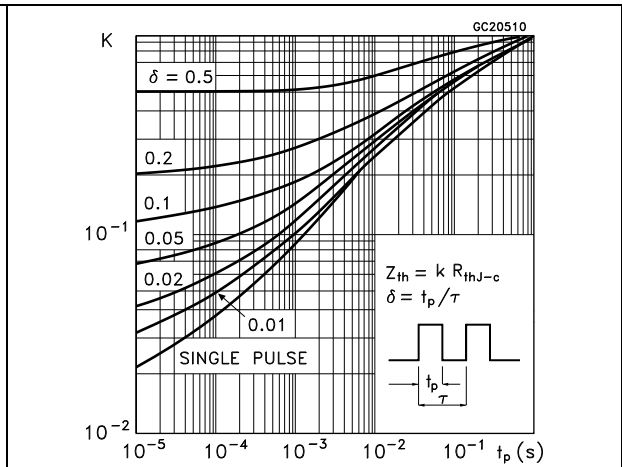


Figure 6. Output characteristics

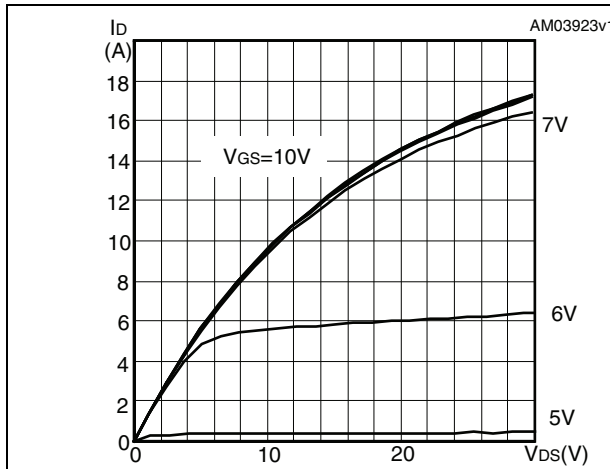


Figure 7. Transfer characteristics

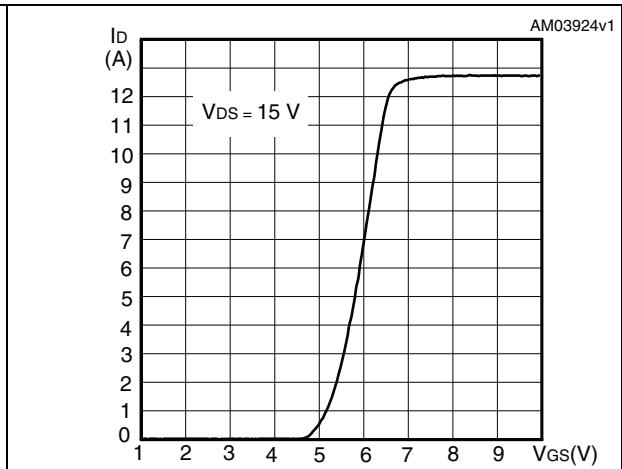


Figure 8. Normalized  $BV_{DSS}$  vs temperature

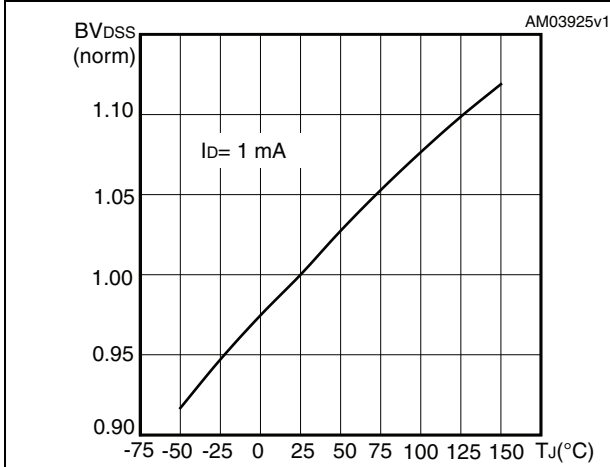


Figure 9. Static drain-source on resistance

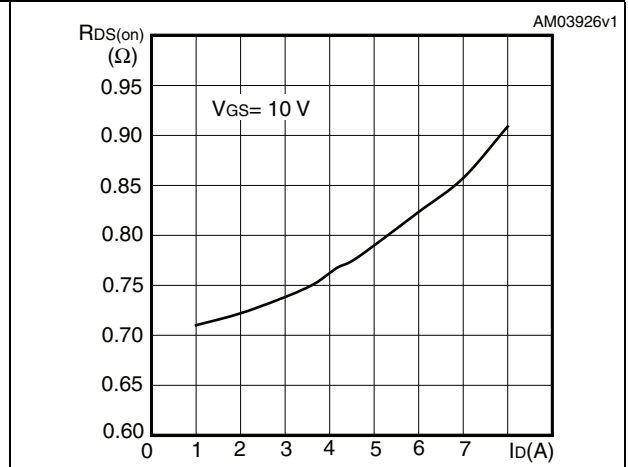


Figure 10. Output capacitance stored energy

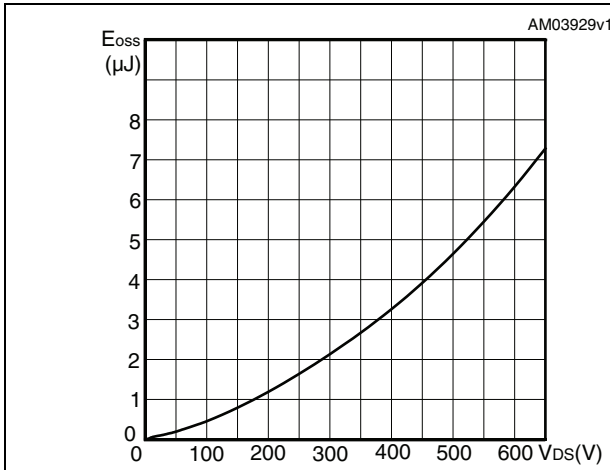


Figure 11. Capacitance variations

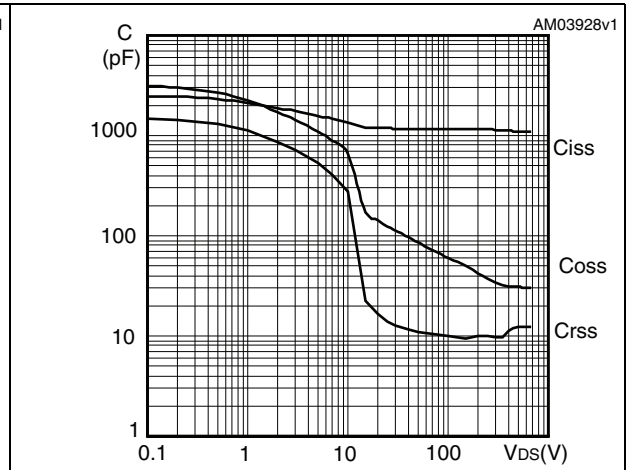


Figure 12. Gate charge vs gate-source voltage

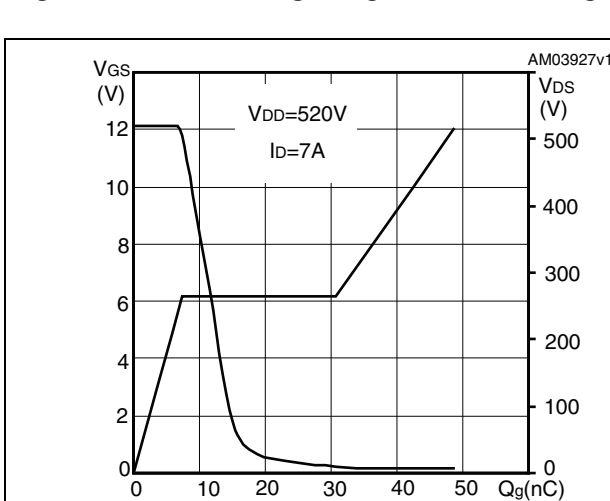


Figure 13. Normalized on-resistance vs temperature

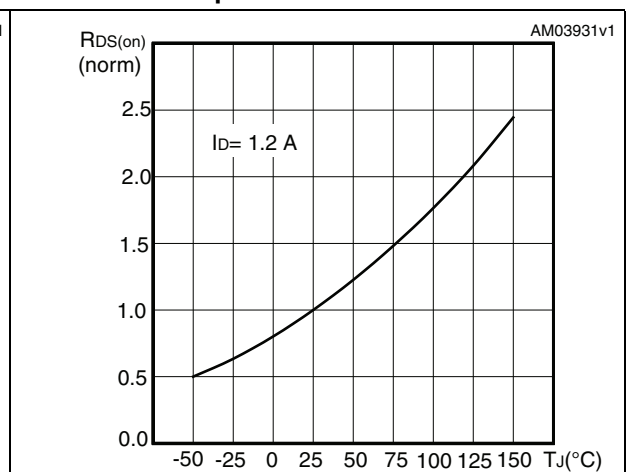


Figure 14. Normalized gate threshold voltage vs temperature

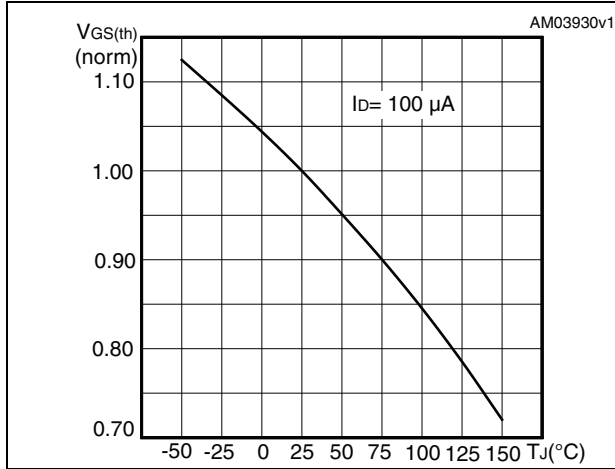


Figure 15. Maximum avalanche energy vs temperature

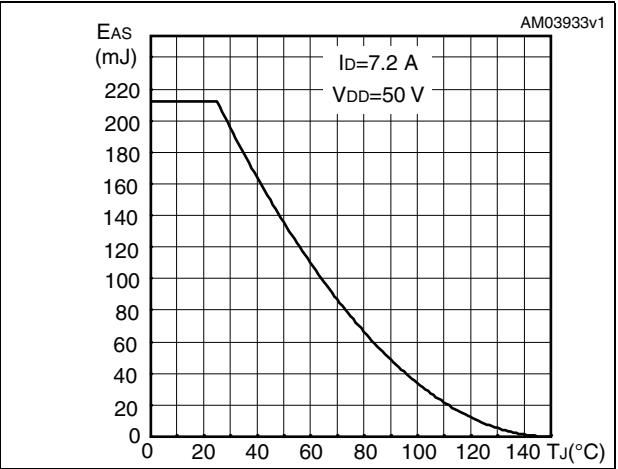
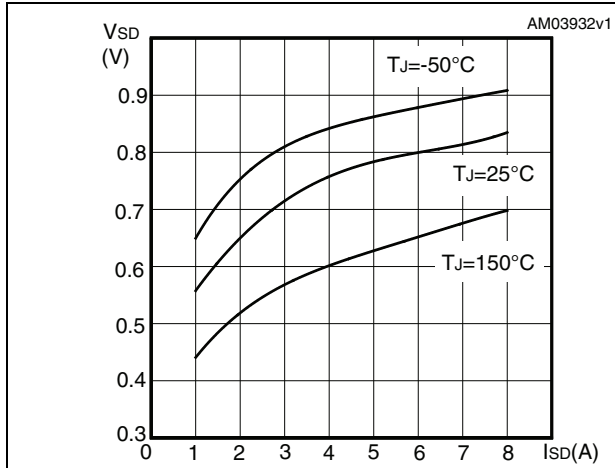


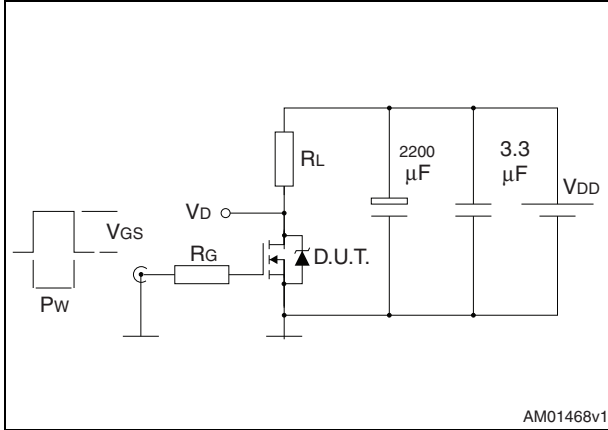
Figure 16. Source-drain diode forward characteristics





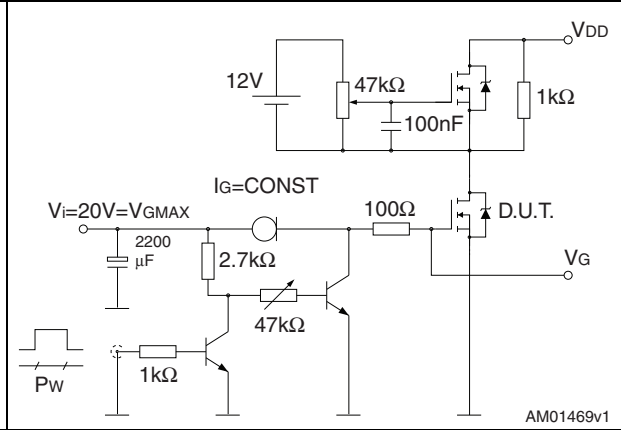
### 3 Test circuits

**Figure 17. Switching times test circuit for resistive load**



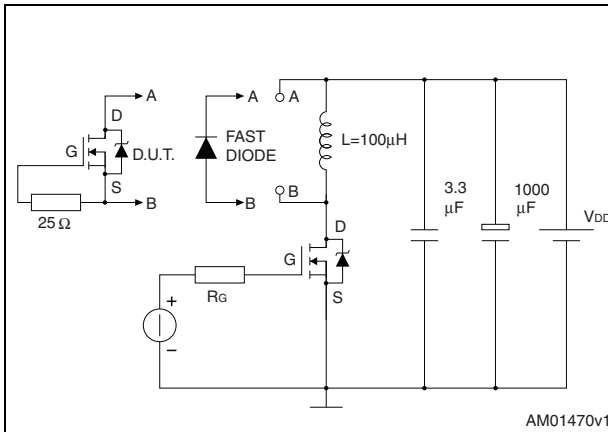
AM01468v1

**Figure 18. Gate charge test circuit**



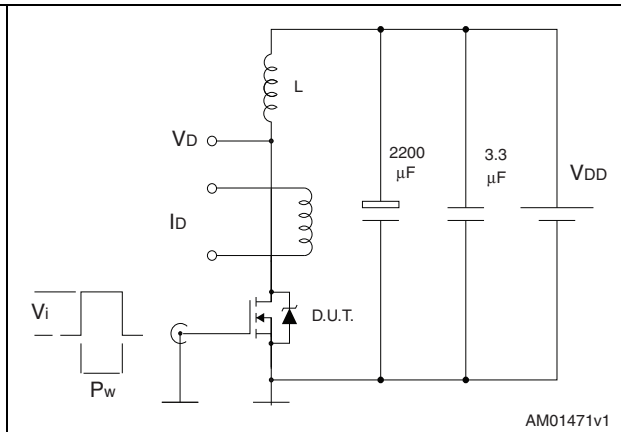
AM01469v1

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



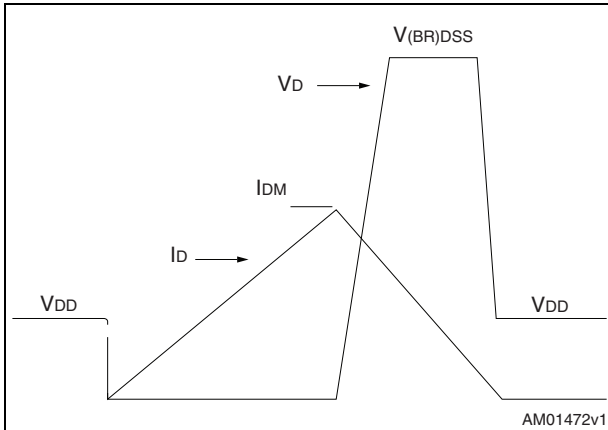
AM01470v1

**Figure 20. Unclamped inductive load test circuit**



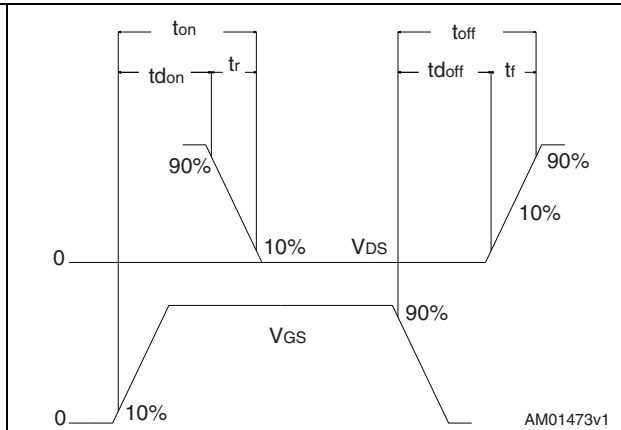
AM01471v1

**Figure 21. Unclamped inductive waveform**



AM01472v1

**Figure 22. Switching time waveform**



AM01473v1

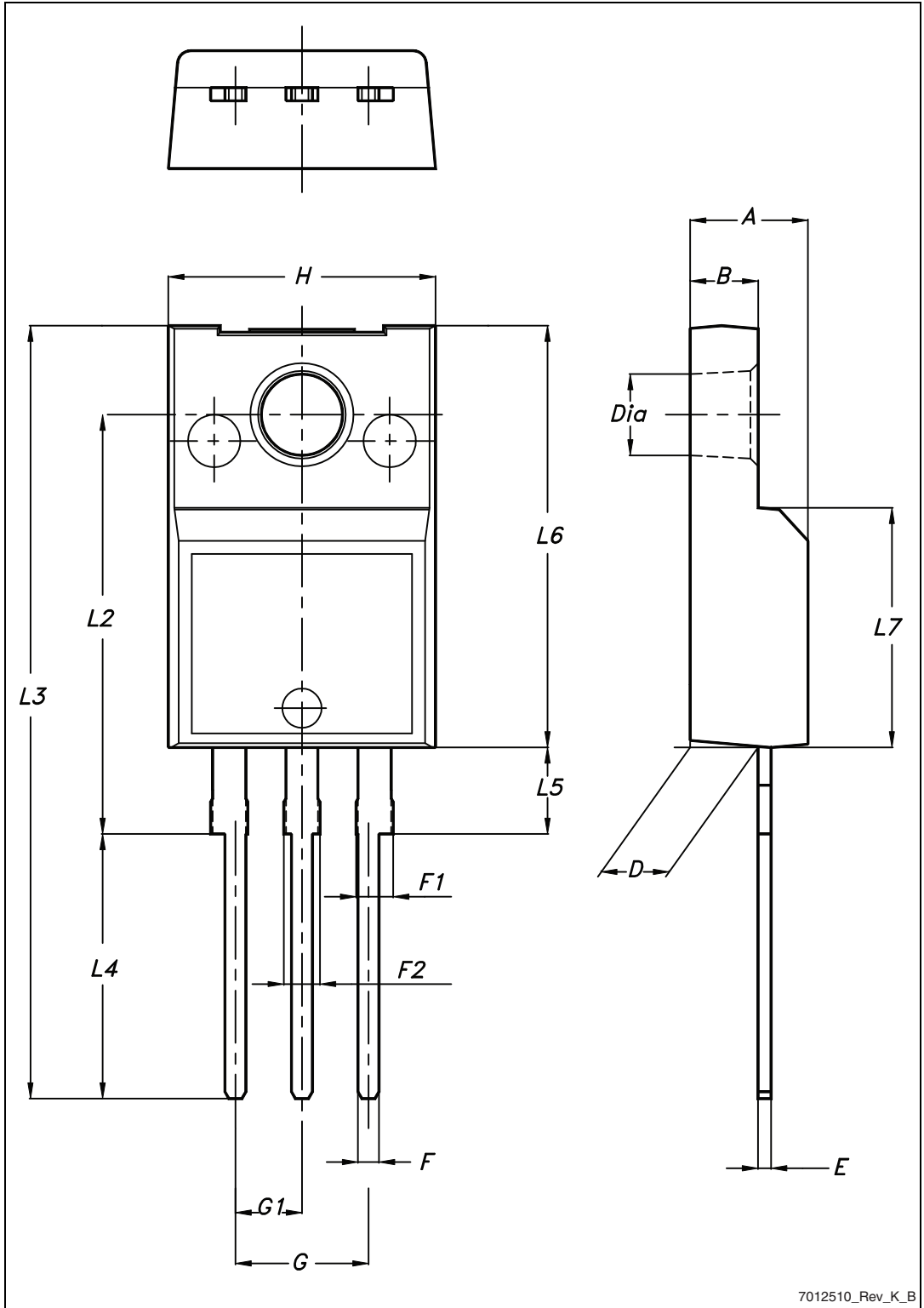
## 4 Package mechanical data

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.

Table 9. 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 23. TO-220FP drawing



7012510\_Rev\_K\_B

Table 10. I<sup>2</sup>PAKFP mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
D1	0.65		0.85
E	0.45		0.70
F	0.75		1.00
F1			1.20
G	4.95	-	5.20
H	10.00		10.40
L1	21.00		23.00
L2	13.20		14.10
L3	10.55		10.85
L4	2.70		3.20
L5	0.85		1.25
L6	7.30		7.50

Figure 24. I<sup>2</sup>PAKFP drawing

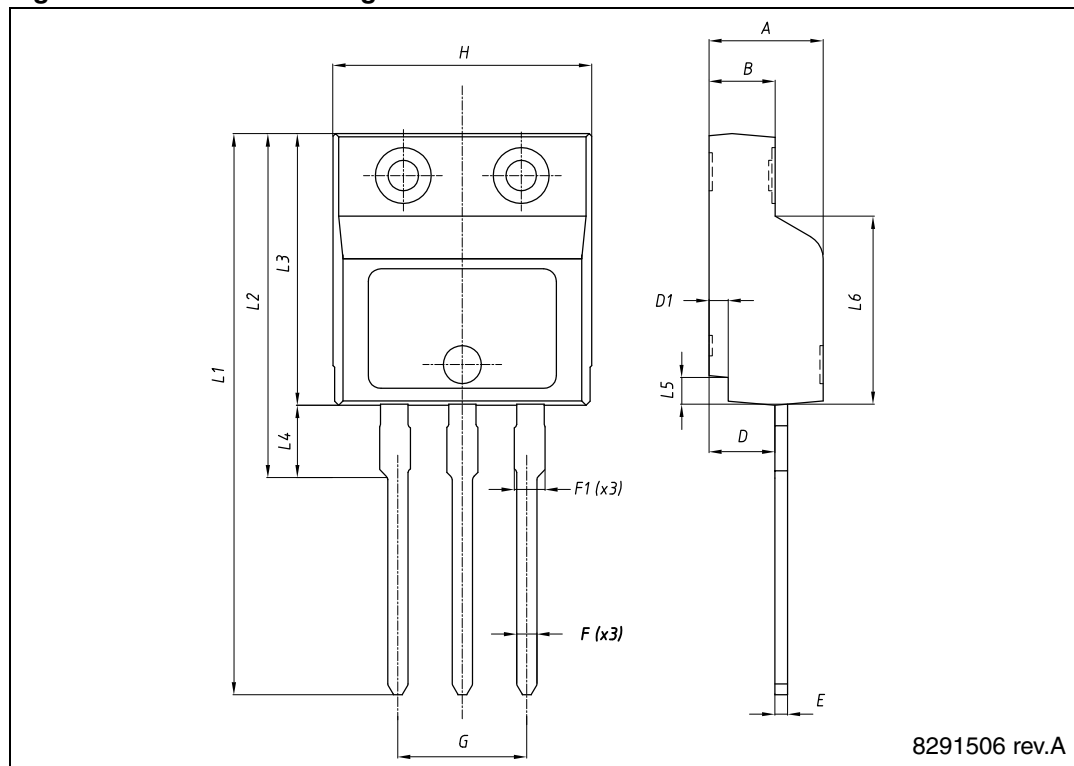
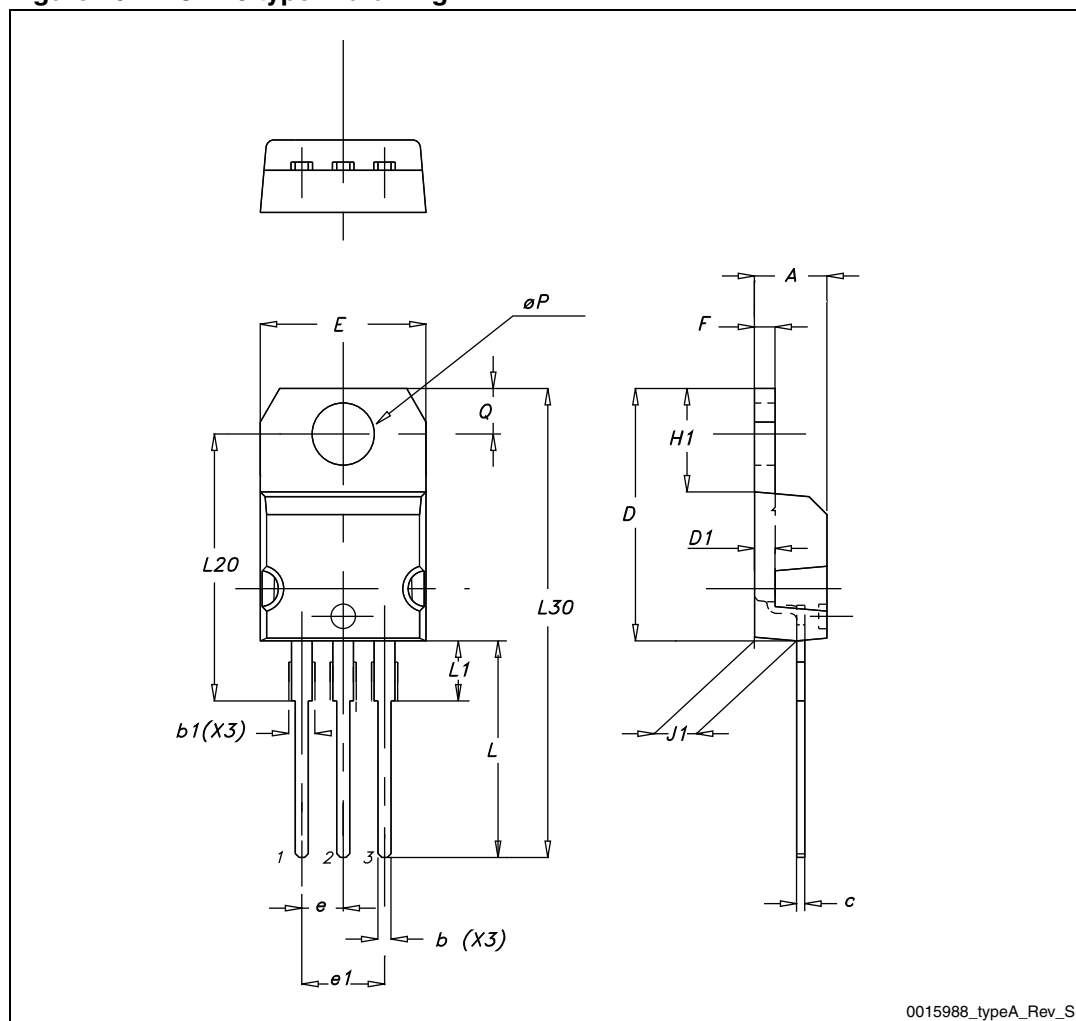


Table 11. TO-220 type A mechanical data

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	
ØP	3.75		3.85
Q	2.65		2.95

Figure 25. TO-220 type A drawing



## 5 Revision history

**Table 12. Document revision history**

Date	Revision	Changes
30-Jun-2009	1	First release
14-Nov-2011	2	Updated mechanical data and <a href="#">Section 2.1: Electrical characteristics (curves)</a> . Minor text changes.
14-Nov-2012	3	<ul style="list-style-type: none"><li>– Added: <math>I^2</math>PAKFP and TO-220</li><li>– Deleted: <math>T_1</math> row</li><li>– Added: <math>R_{DS(on)}</math> typical value, <a href="#">Figure 4</a> and <a href="#">5</a></li><li>– Modified: <a href="#">Figure 2</a></li><li>– Updated: <a href="#">Section 4: Package mechanical data</a></li></ul>



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