

N-channel 600 V, 1.06  $\Omega$  typ., 4.5 A MDmesh™ M2 Power MOSFETs in TO-220FP, TO-220 and IPAK packages

Datasheet - production data

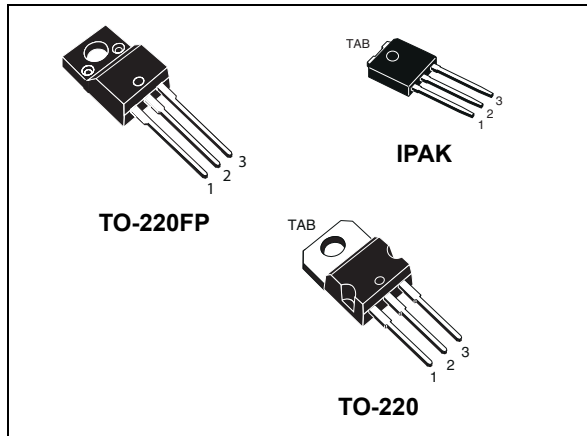
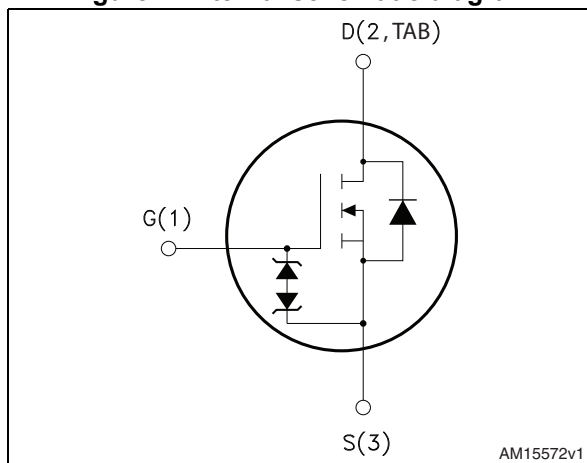


Figure 1. Internal schematic diagram



## Features

Order code	$V_{DS} @ T_{Jmax}$	$R_{DS(on) max}$	$I_D$
STF6N60M2	650 V	1.2 $\Omega$	4.5 A
STP6N60M2			
STU6N60M2			

- Extremely low gate charge
- Excellent output capacitance ( $C_{OSS}$ ) profile
- 100% avalanche tested
- Zener-protected

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, the devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high efficiency converters.

Table 1. Device summary

Order code	Marking	Package	Packing
STF6N60M2	6N60M2	TO-220FP	Tube
STP6N60M2		TO-220	
STU6N60M2		IPAK	

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220FP	TO-220, IPAK	
$V_{GS}$	Gate-source voltage	± 25		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	4.5 <sup>(1)</sup>	4.5	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	2.9 <sup>(1)</sup>	2.9	A
$I_{DM}^{(2)}$	Drain current (pulsed)	18 <sup>(1)</sup>	18	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	20	60	W
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{ s}$ ; $T_C=25\text{ °C}$ )	2500		V
$dv/dt^{(3)}$	Peak diode recovery voltage slope	15		V/ns
$dv/dt^{(4)}$	MOSFET $dv/dt$ ruggedness	50		
$T_{stg}$	Storage temperature	- 55 to 150		°C
$T_j$	Operating junction temperature			

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 4.5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD}=400\text{ V}$
- $V_{DS} \leq 480\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220FP	TO-220	IPAK	
$R_{thj-case}$	Thermal resistance junction-case max	6.25	2.08		°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	62.5		100	°C/W

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	1	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j=25\text{ °C}$ , $I_D=I_{AR}$ ; $V_{DD}=50$ )	86	mJ

## 2 Electrical characteristics

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

**Table 5. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0$	600			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{DS} = 600\text{ V}$ , $T_C = 125\text{ °C}$			100	$\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 25\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	2	3	4	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 2.25\text{ A}$		1.06	1.2	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$	-	232	-	pF
$C_{oss}$	Output capacitance		-	14	-	pF
$C_{rss}$	Reverse transfer capacitance		-	0.7	-	pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0$ to $480\text{ V}$ , $V_{GS} = 0$	-	71	-	pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz}$ open drain	-	6.5	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}$ , $I_D = 4.5\text{ A}$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 18</a> )	-	8	-	nC
$Q_{gs}$	Gate-source charge		-	1.7	-	nC
$Q_{gd}$	Gate-drain charge		-	4	-	nC

1.  $C_{oss\text{ eq.}}$  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
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 1.65\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> and <a href="#">Figure 22</a> )	-	9.5	-	ns
$t_r$	Rise time		-	7.4	-	ns
$t_{d(off)}$	Turn-off delay time		-	24	-	ns
$t_f$	Fall time		-	22.5	-	ns

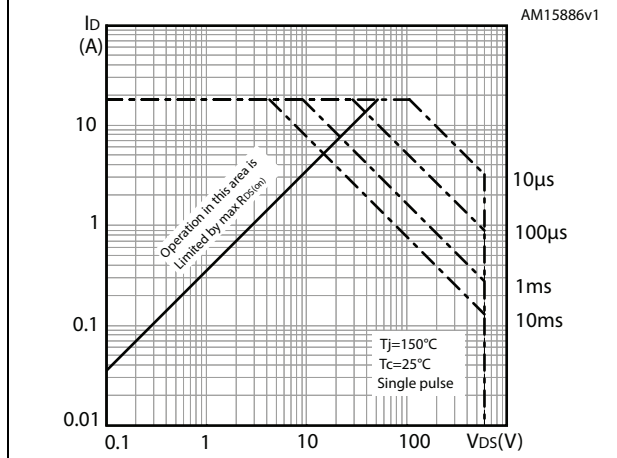
Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		4.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		18	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 4.5 \text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 4.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ (see <a href="#">Figure 19</a> )	-	274		ns
$Q_{rr}$	Reverse recovery charge		-	1.47		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	10.7		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 4.5 \text{ A}$ , $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ , $T_J = 150 \text{ }^\circ\text{C}$ (see <a href="#">Figure 19</a> )	-	376		ns
$Q_{rr}$	Reverse recovery charge		-	1.96		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	10.5		A

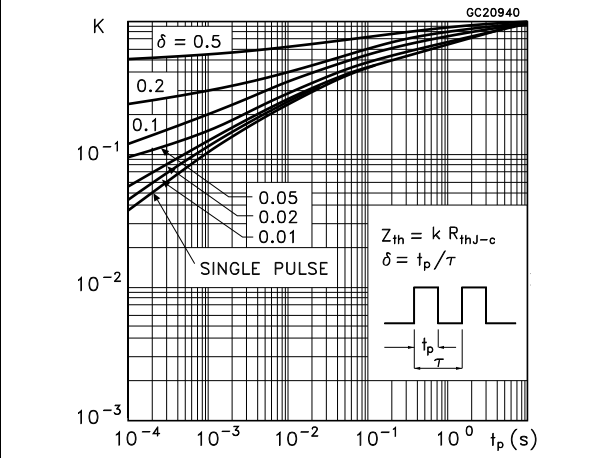
1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

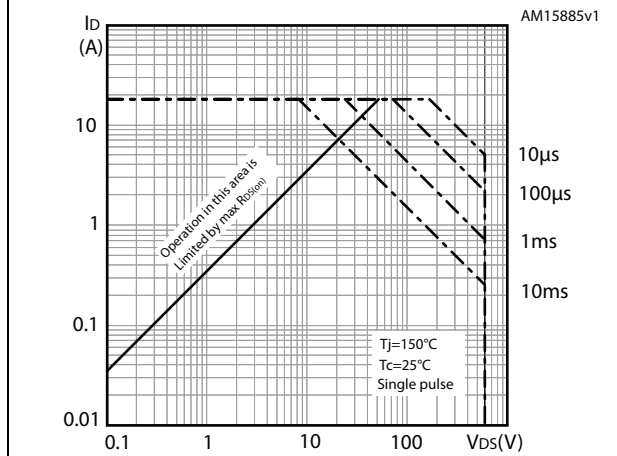
**Figure 2. Safe operating area for TO-220FP**



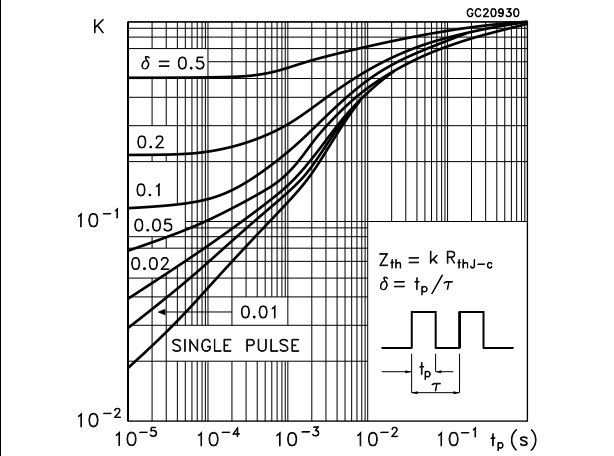
**Figure 3. Thermal impedance for TO-220FP**



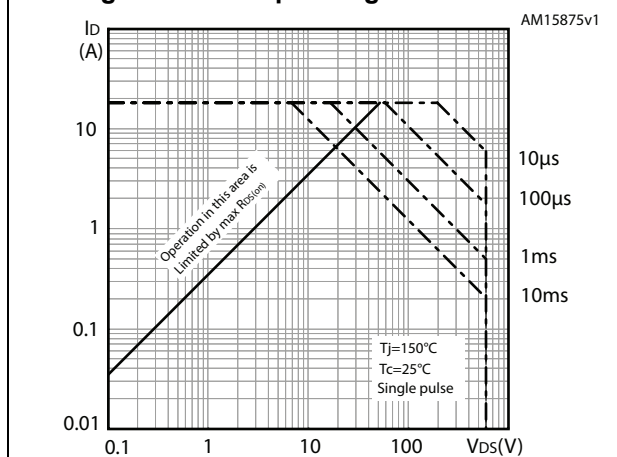
**Figure 4. Safe operating area for TO-220**



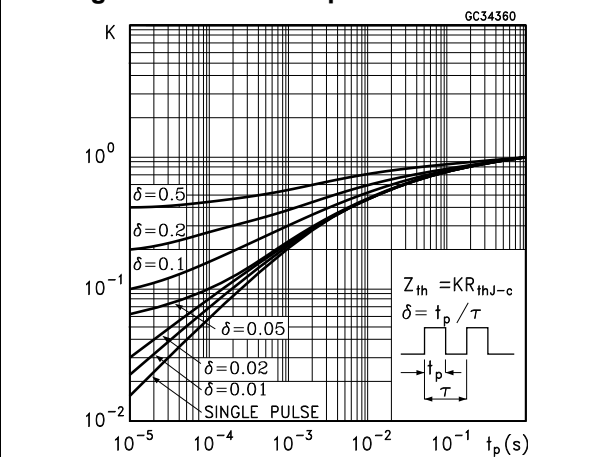
**Figure 5. Thermal impedance for TO-220**

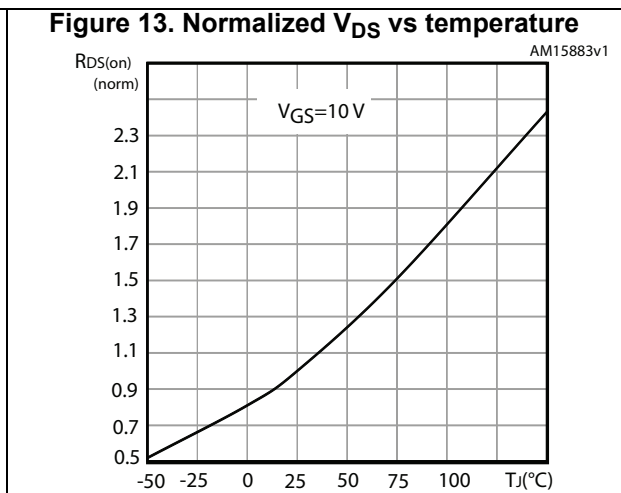
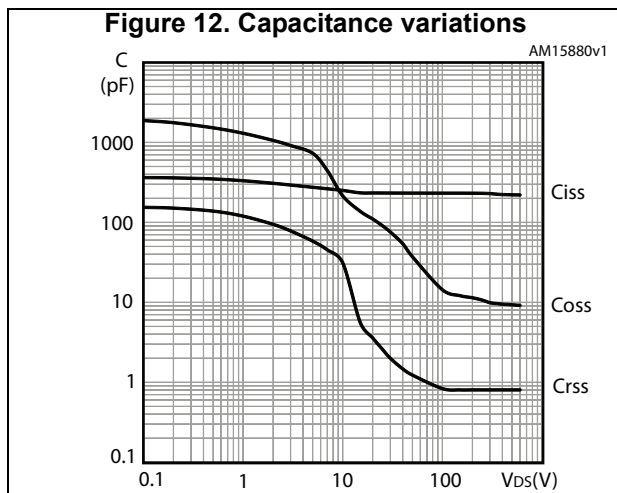
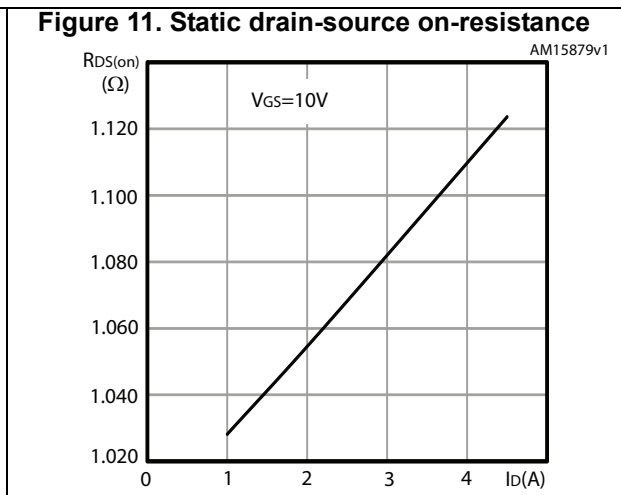
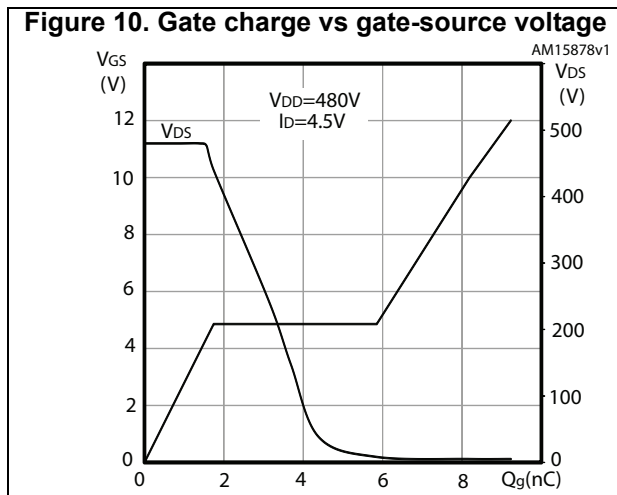
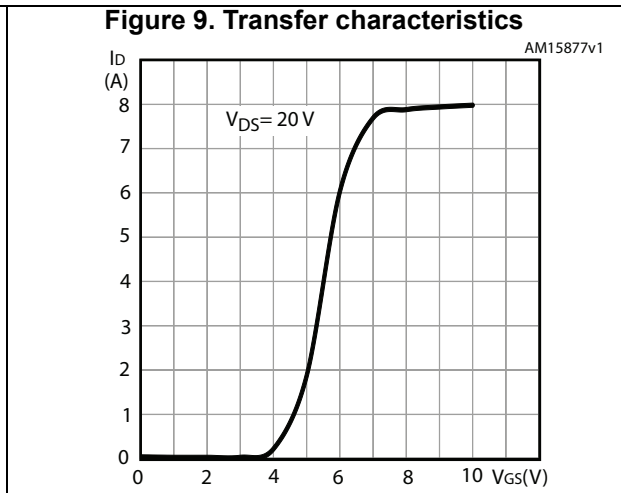
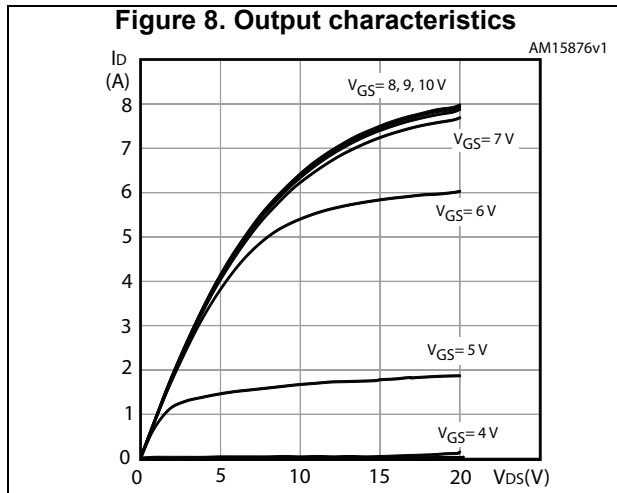


**Figure 6. Safe operating area for IPAK**

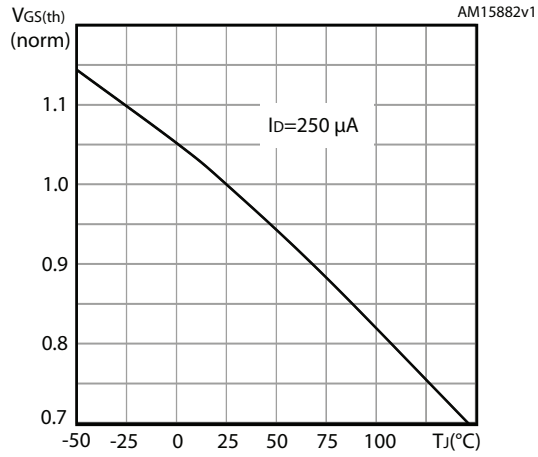


**Figure 7. Thermal impedance for IPAK**

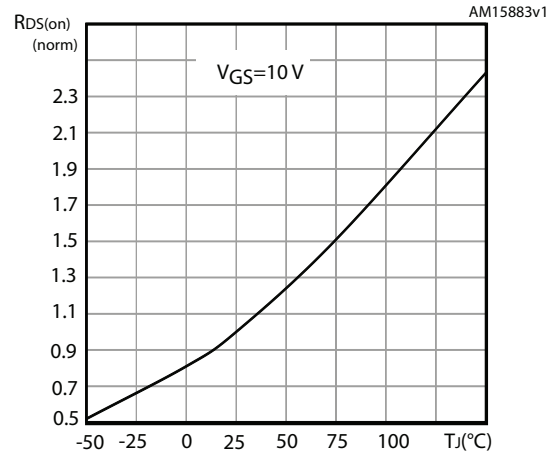




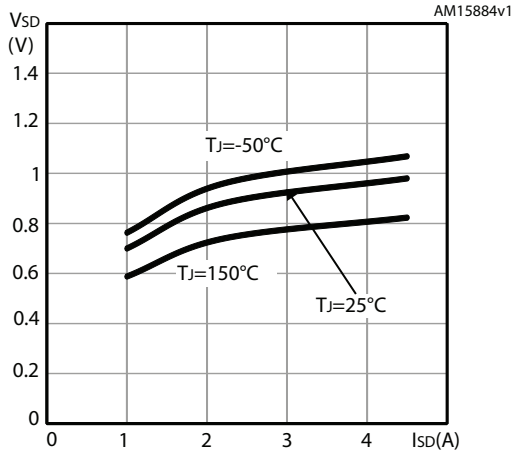
**Figure 14. Normalized gate threshold voltage vs temperature**



**Figure 15. Normalized on-resistance vs temperature**



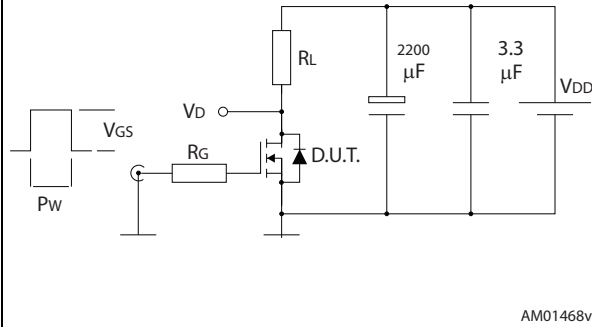
**Figure 16. Source-drain diode forward characteristics**





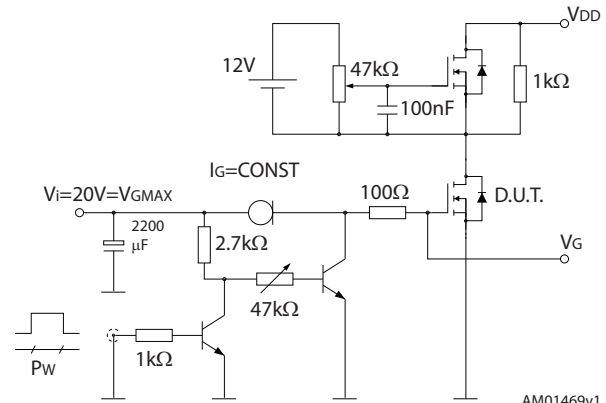
### 3 Test circuits

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



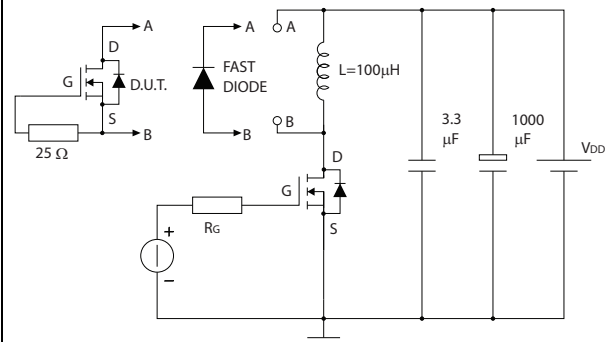
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**Figure 18. Gate charge test circuit**



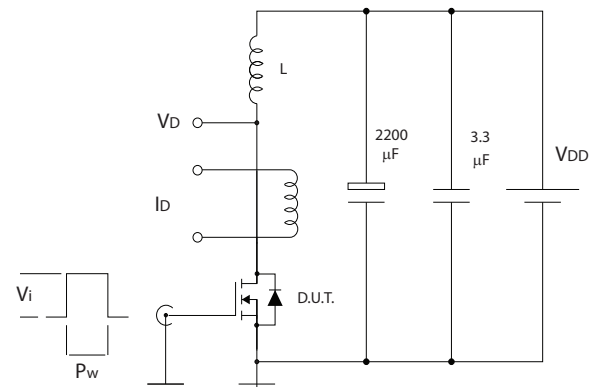
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**Figure 19. Test circuit for inductive load switching and diode recovery times**



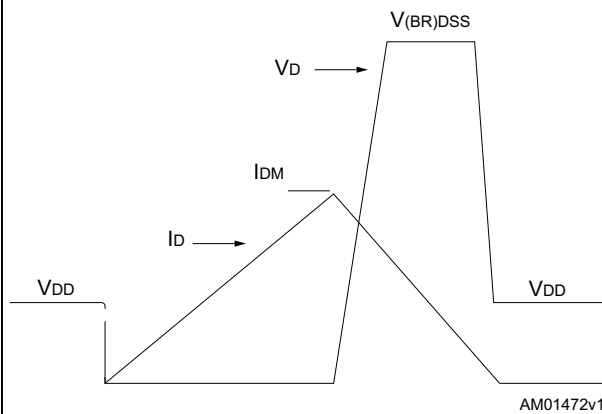
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**Figure 20. Unclamped inductive load test circuit**



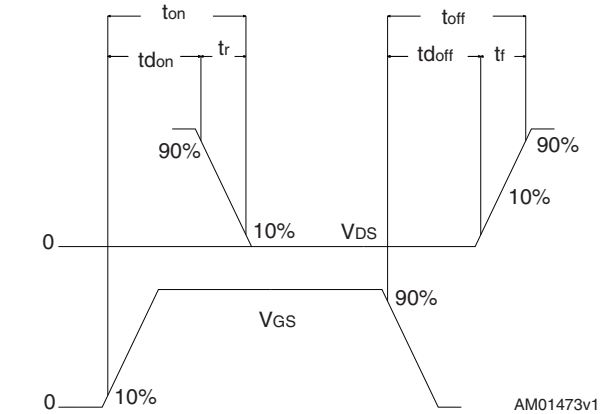
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**Figure 21. Unclamped inductive waveform**



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**Figure 22. Switching time waveform**



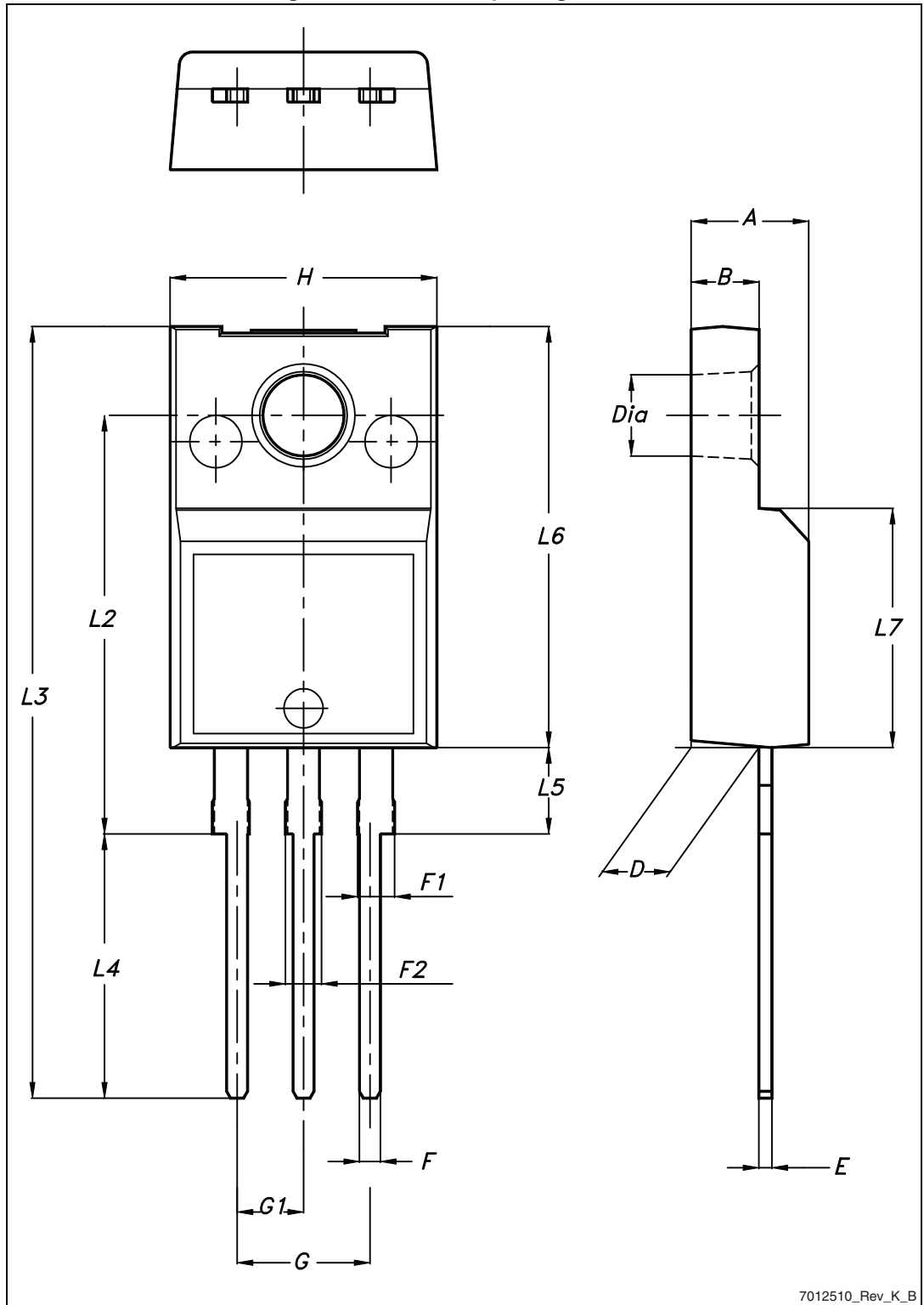
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## 4 Package information

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.

### 4.1 TO-220FP package information

Figure 23. TO-220FP package outline



7012510\_Rev\_K\_B

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

### 4.2 TO-220 package information

Figure 24. TO-220 type A package outline

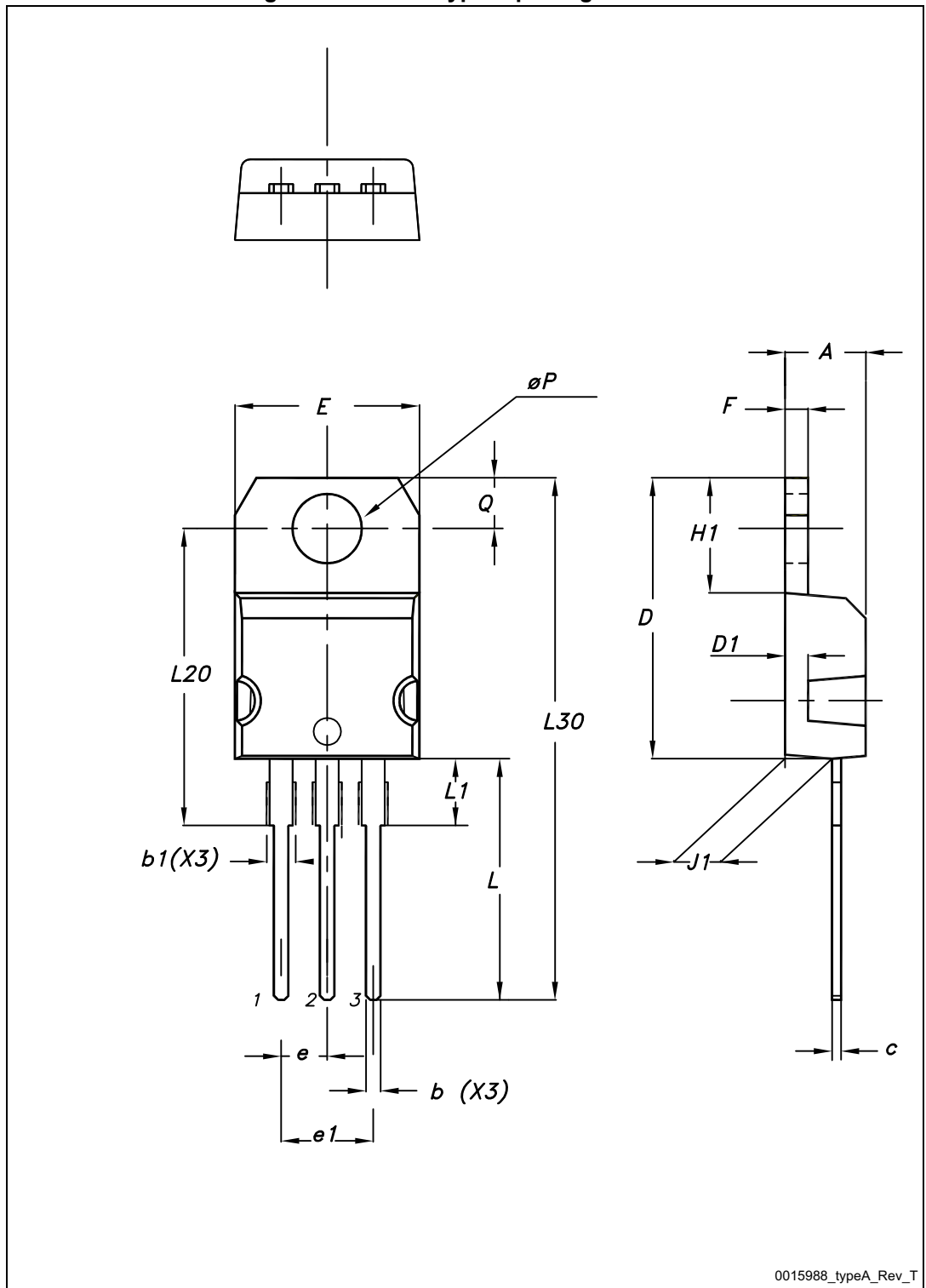


Table 10. TO-220 type A mechanical data

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	
ØP	3.75		3.85
Q	2.65		2.95

### 4.3 IPAK(TO-251) package information

Figure 25. IPAK (TO-251) type A package outline

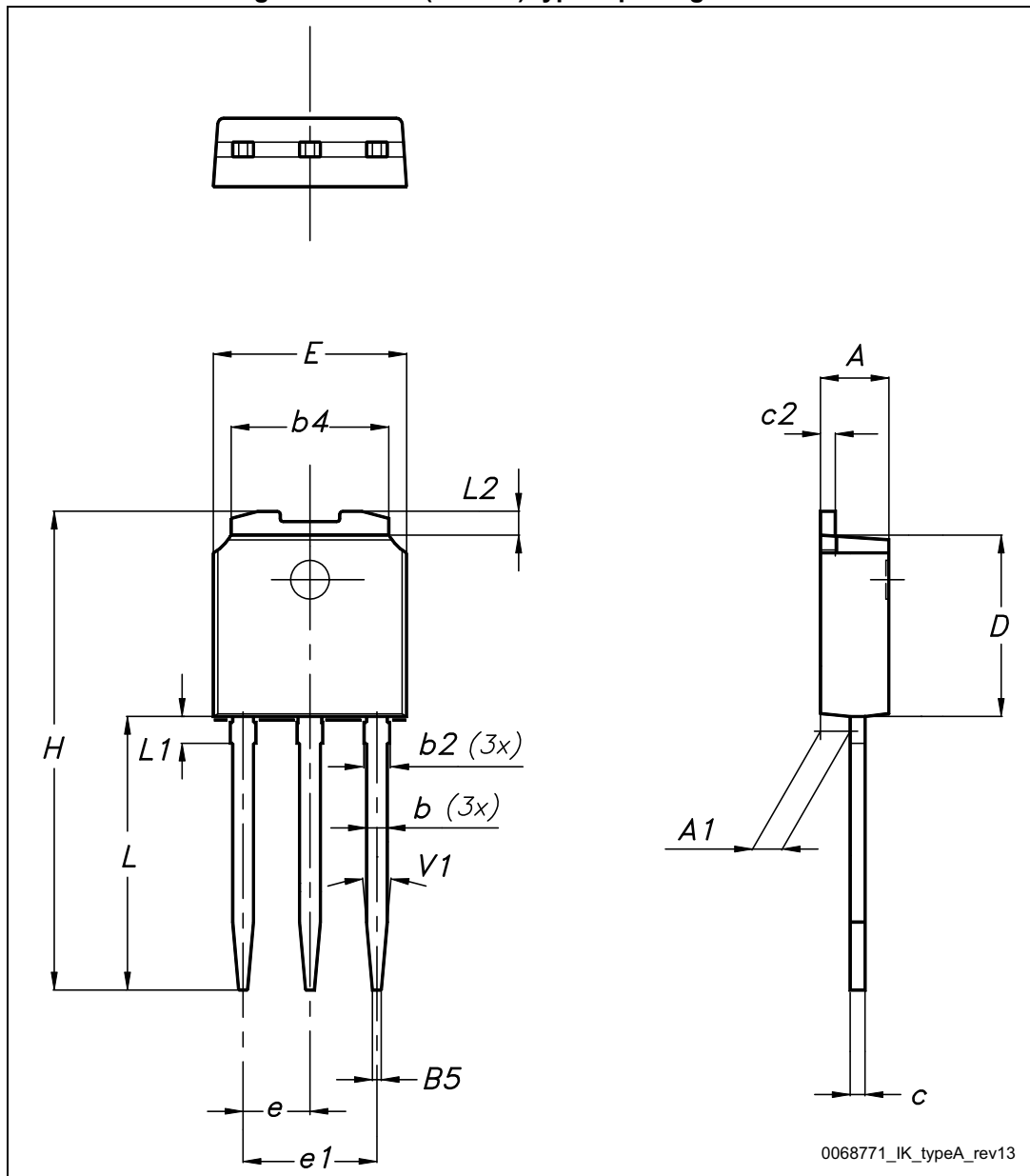


Table 11. IPAK (TO-251) type A mechanical data

DIM	mm.		
	min.	typ.	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
B5		0.30	
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
L1	0.80		1.20
L2		0.80	1.00
V1		10°	



## 5 Revision history

Table 12. Document revision history

Date	Revision	Changes
11-Jun-2013	1	First release.
01-Oct-2015	2	Updated title, features and description. Updated <a href="#">Table 2.: Absolute maximum ratings</a> and <a href="#">Table 8.: Source drain diode</a> . Updated <a href="#">4.3: IPAK(TO-251) package information</a> . Minor text changes.

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