



# STF24NM60N, STI24NM60N STP24NM60N, STW24NM60N

N-channel 600 V, 0.168  $\Omega$ , 17 A MDmesh™ II Power MOSFET  
TO-220FP, I<sup>2</sup>PAK, TO-220 and TO-247

## Features

Order codes	V <sub>DSS</sub> (@T <sub>jmax</sub> )	R <sub>DS(on)</sub> max.	I <sub>D</sub>
STF24NM60N	650 V	< 0.19 $\Omega$	17 A
STI24NM60N	650 V	< 0.19 $\Omega$	17 A
STP24NM60N	650 V	< 0.19 $\Omega$	17 A
STW24NM60N	650 V	< 0.19 $\Omega$	17 A

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Applications

- Switching applications

## Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

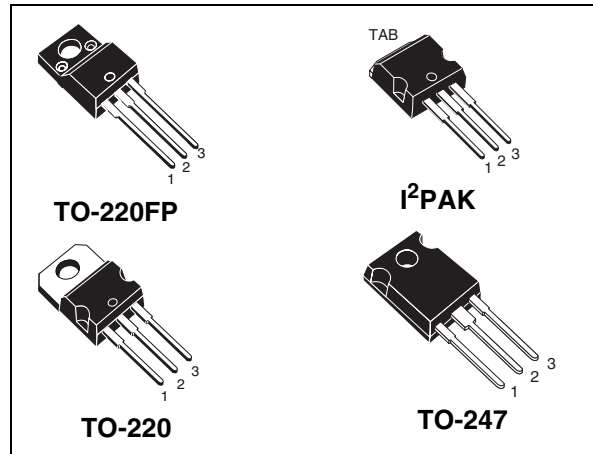


Figure 1. Internal schematic diagram

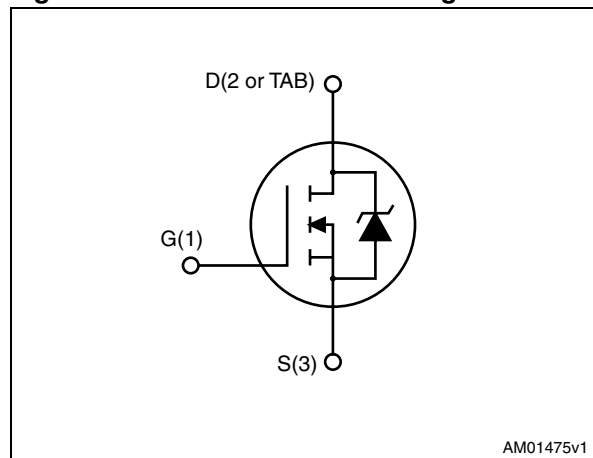


Table 1. Device summary

Order codes	Marking	Package	Packaging
STF24NM60N	24NM60N	TO-220FP	Tube
STI24NM60N		I <sup>2</sup> PAK	
STP24NM60N		TO-220	
STW24NM60N		TO-247	

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		I <sup>2</sup> PAK TO-220 TO-247	TO-220FP	
V <sub>GS</sub>	Gate- source voltage	± 30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	17	17 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	11	11 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	68	68 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	125	30	W
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	15		V/ns
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

- Limited only by maximum temperature allowed.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 17$  A,  $di/dt \leq 400$  A/ $\mu$ s, peak  $V_{DS} \leq V_{(BR)DSS}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$

**Table 3. Thermal data**

Symbol	Parameter	Value				Unit
		TO-220FP	I <sup>2</sup> PAK	TO-220	TO-247	
R <sub>thj-case</sub>	Thermal resistance junction-case max.	4	1			°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max.	62.5			50	°C/W
T <sub>J</sub>	Maximum lead temperature for soldering purpose	300				°C

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
I <sub>AR</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> max)	6	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V)	300	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 (V <sub>GS</sub> = 0)	I <sub>D</sub> = 1 mA	600			V
I <sub>DSS</sub>	Zero gate voltage drain current (V <sub>GS</sub> = 0)	V <sub>DS</sub> = 600 V V <sub>DS</sub> = 600 V, T <sub>C</sub> = 125 °C			1 100	μA μA
I <sub>GSS</sub>	Gate-body leakage current (V <sub>DS</sub> = 0)	V <sub>GS</sub> = ± 25 V			100	nA
V <sub>GS(th)</sub>	Gate threshold voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	2	3	4	V
R <sub>DS(on)</sub>	Static drain-source on resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 8 A		0.168	0.19	Ω

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C <sub>iss</sub>	Input capacitance	V <sub>DS</sub> = 50 V, f = 1 MHz, V <sub>GS</sub> = 0	-	1400	-	pF
C <sub>oss</sub>	Output capacitance			44		pF
C <sub>rss</sub>	Reverse transfer capacitance			7.4		pF
C <sub>oss eq. (1)</sub>	Equivalent output capacitance	V <sub>DS</sub> = 0 to 480 V, V <sub>GS</sub> = 0	-	190	-	pF
R <sub>g</sub>	Gate input resistance	f = 1 MHz open drain	-	5	-	Ω
Q <sub>g</sub>	Total gate charge	V <sub>DD</sub> = 480 V, I <sub>D</sub> = 17 A, V <sub>GS</sub> = 10 V <i>(see Figure 19)</i>	-	46	-	nC
Q <sub>gs</sub>	Gate-source charge			7		nC
Q <sub>gd</sub>	Gate-drain charge			23		nC

1. C<sub>o(eff)</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>DS</sub>.

**Table 7. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 8.5\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 18)	-	11.5	-	ns
$t_{r(v)}$	Voltage rise time			16.5		ns
$t_{d(off)}$	Turn-off-delay time			73		ns
$t_{f(i)}$	Fall time			37		ns

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$I_{SD}$	Source-drain current		-		17	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				68	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 17\text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 17\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see Figure 20)	-	340		ns
$Q_{rr}$	Reverse recovery charge			4.6		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			27		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 17\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ $T_J = 150\text{ }^\circ\text{C}$ (see Figure 20)	-	404		ns
$Q_{rr}$	Reverse recovery charge			5.7		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current			28		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

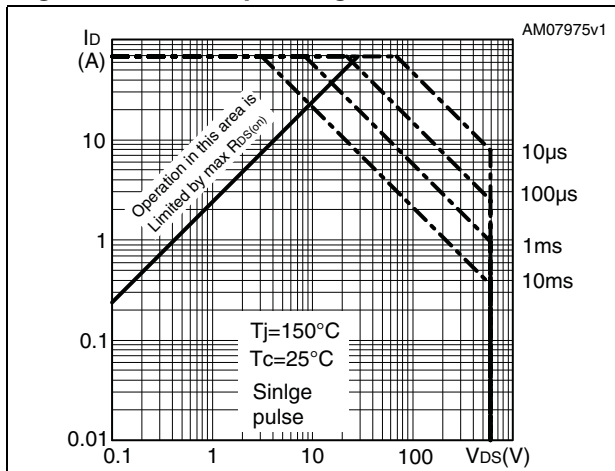


Figure 3. Thermal impedance for TO-220FP

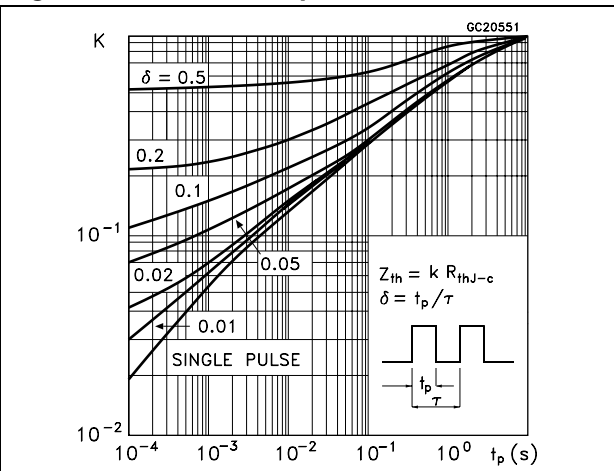


Figure 4. Safe operating area for I<sup>2</sup>PAK and TO-220

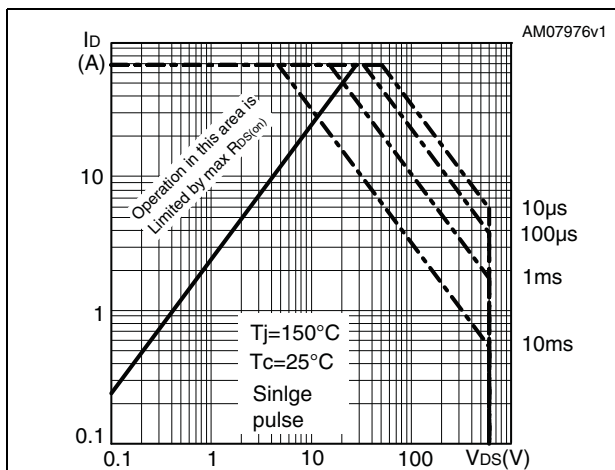


Figure 5. Thermal impedance for I<sup>2</sup>PAK and TO-220

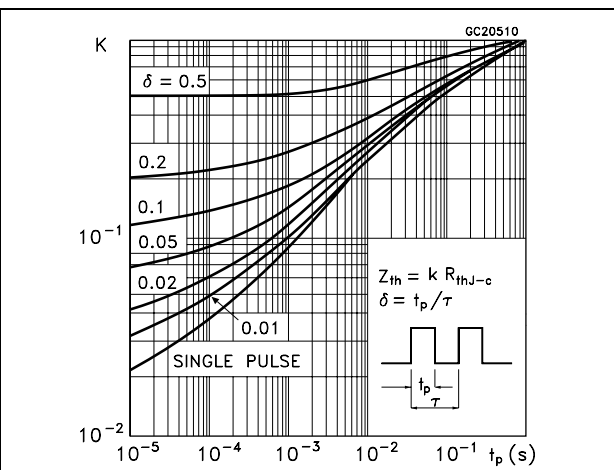


Figure 6. Safe operating area for TO-247

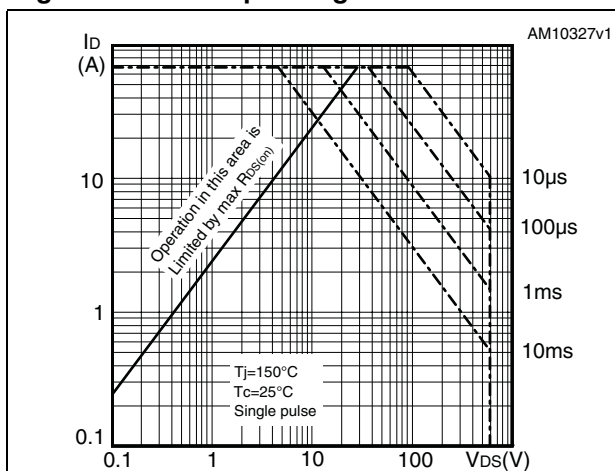


Figure 7. Thermal impedance for TO-247

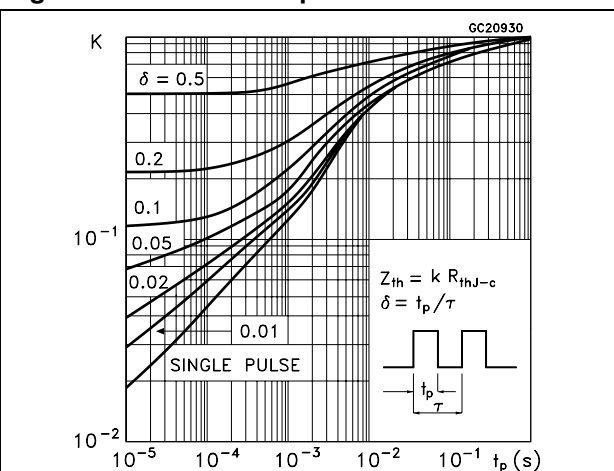


Figure 8. Output characteristics

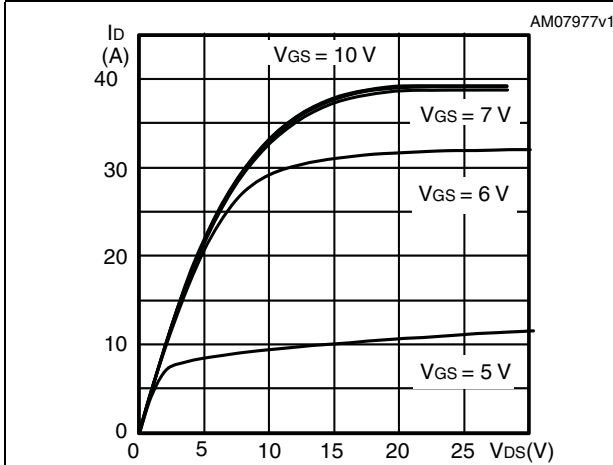


Figure 9. Transfer characteristics

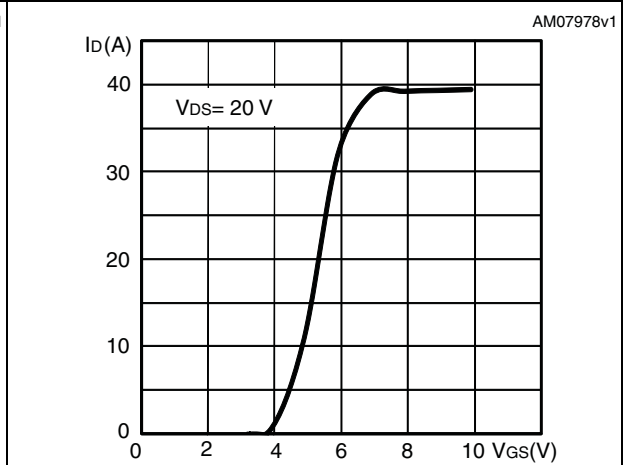


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

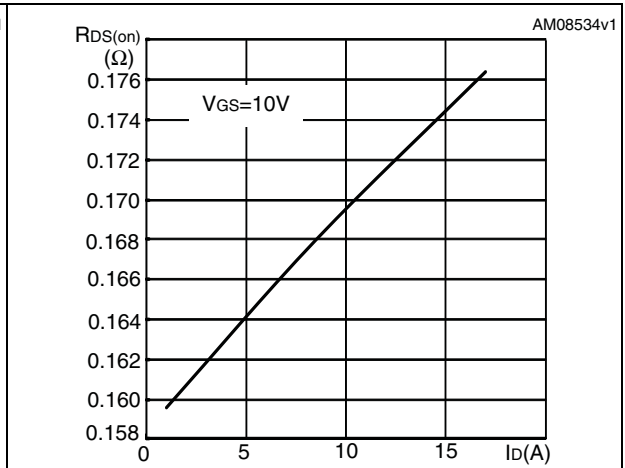
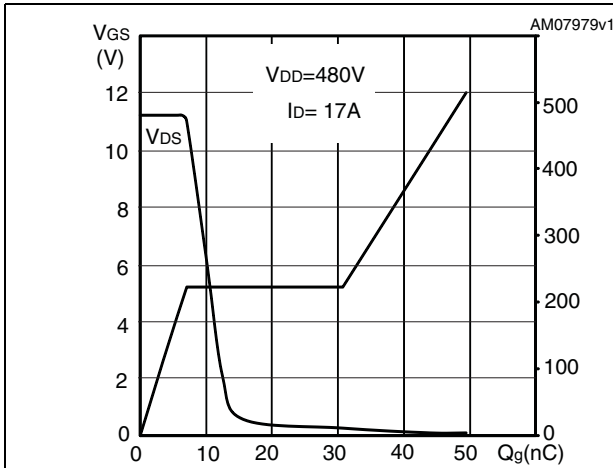


Figure 12. Capacitance variations

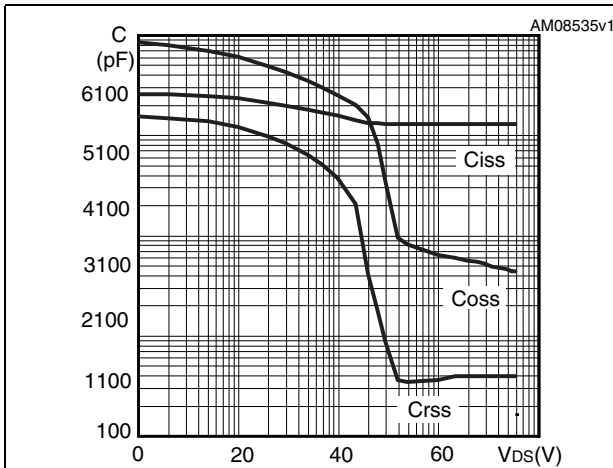


Figure 13. Output capacitance stored energy

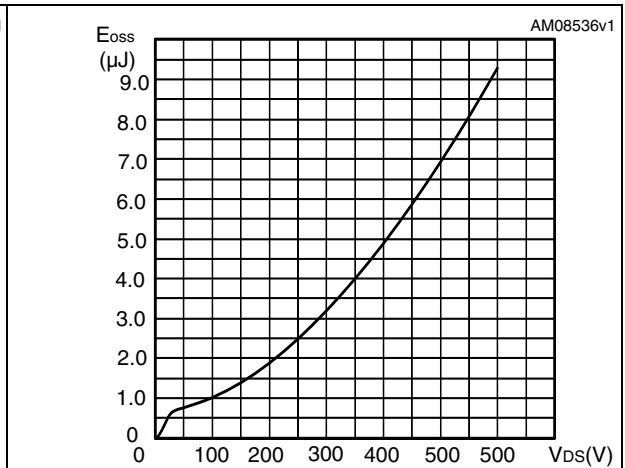


Figure 14. Normalized gate threshold voltage vs temperature

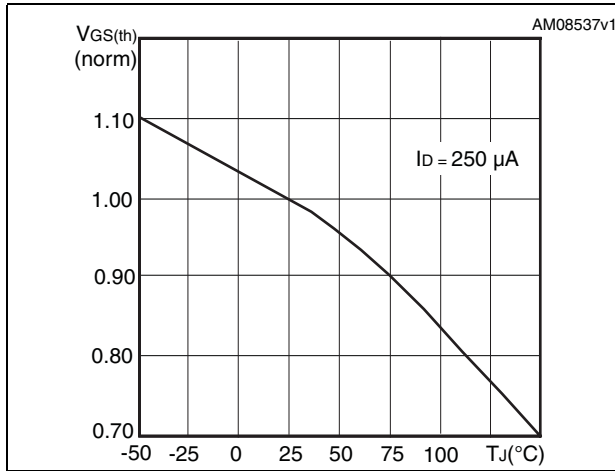


Figure 15. Normalized on resistance vs temperature

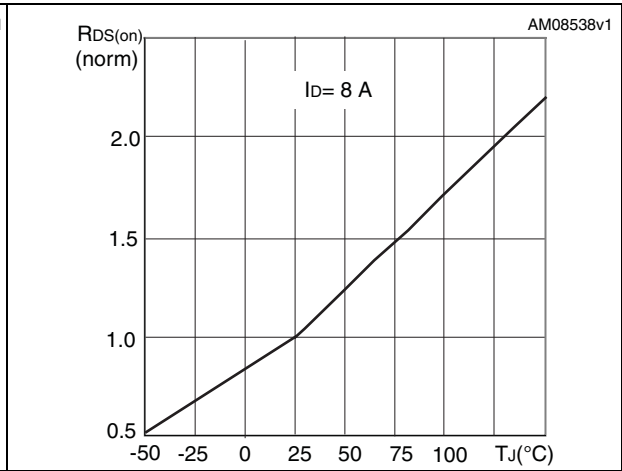


Figure 16. Normalized B<sub>V</sub>DSS vs temperature

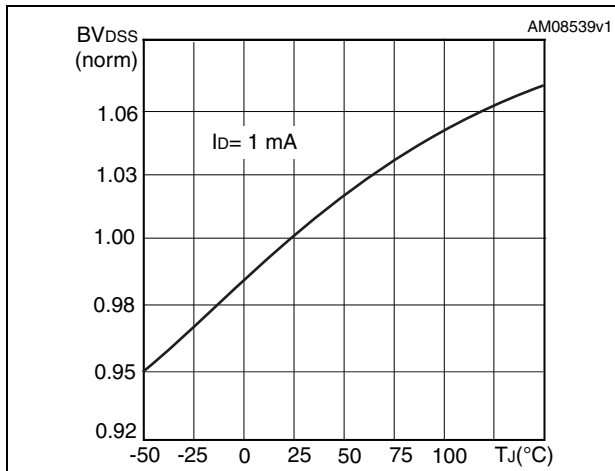
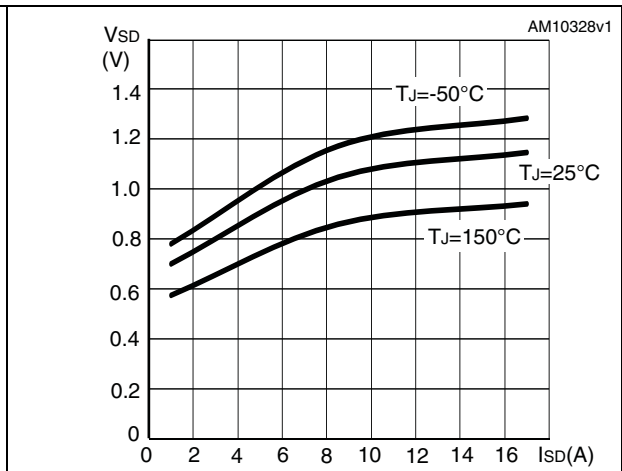


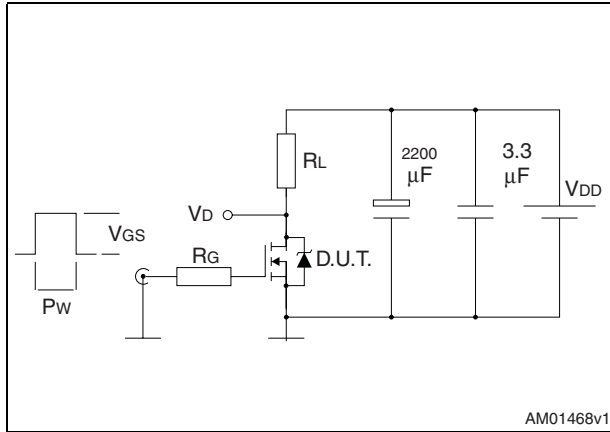
Figure 17. Source-drain diode forward characteristics



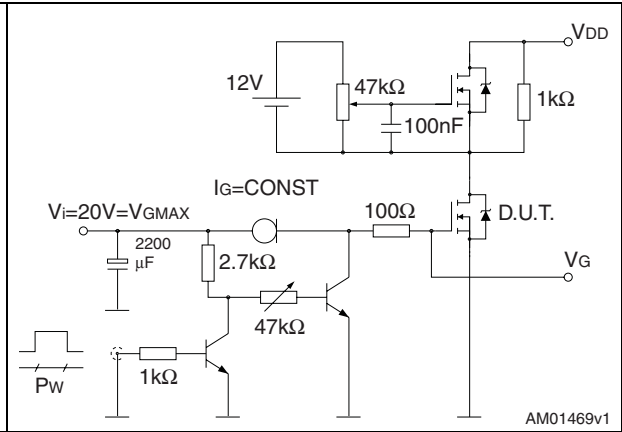


### 3 Test circuits

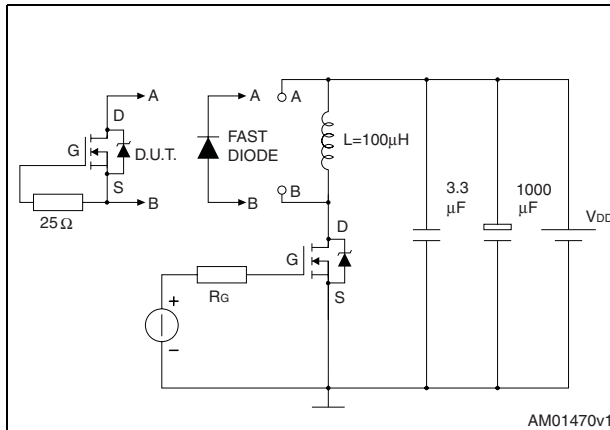
**Figure 18. Switching times test circuit for resistive load**



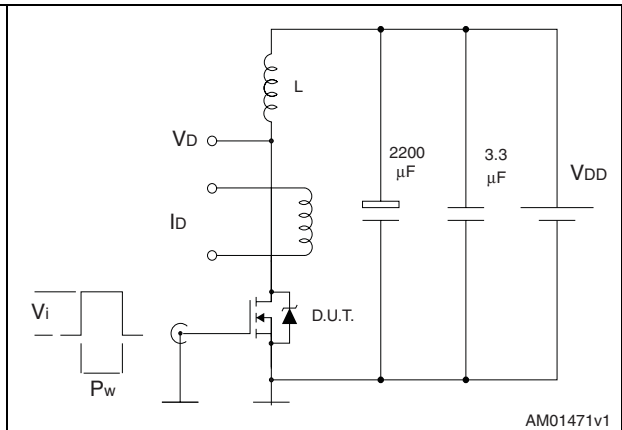
**Figure 19. Gate charge test circuit**



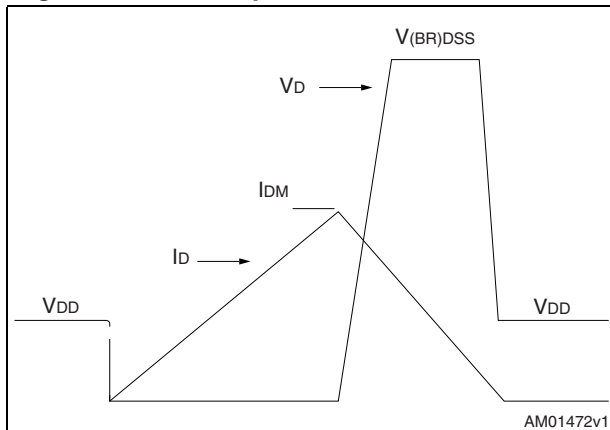
**Figure 20. Test circuit for inductive load switching and diode recovery times**



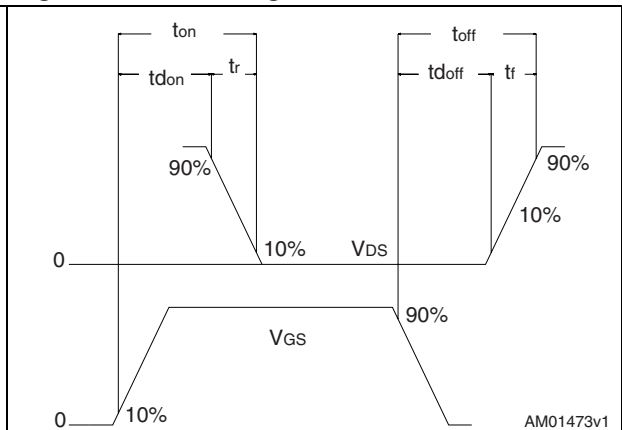
**Figure 21. Unclamped inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**



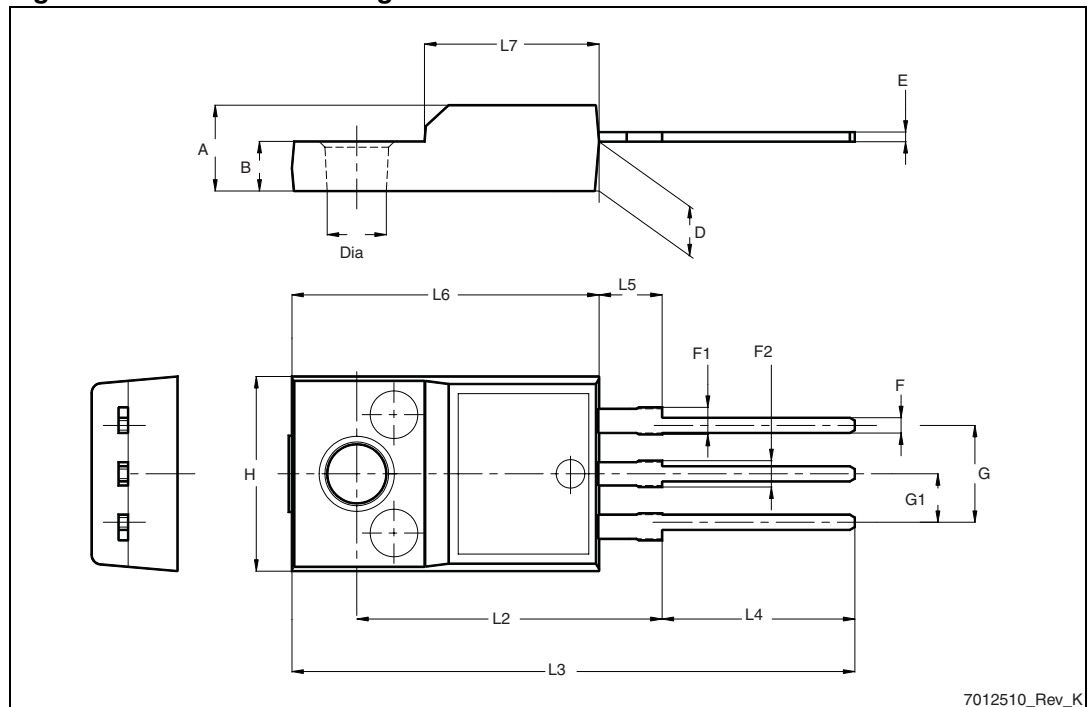
## 4 Package mechanical data

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 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 24. TO-220FP drawing



7012510\_Rev\_K

Table 10. I<sup>2</sup>PAK (TO-262) mechanical data

DIM.	mm.		
	min.	typ	max.
A	4.40		4.60
A1	2.40		2.72
b	0.61		0.88
b1	1.14		1.70
c	0.49		0.70
c2	1.23		1.32
D	8.95		9.35
e	2.40		2.70
e1	4.95		5.15
E	10		10.40
L	13		14
L1	3.50		3.93
L2	1.27		1.40

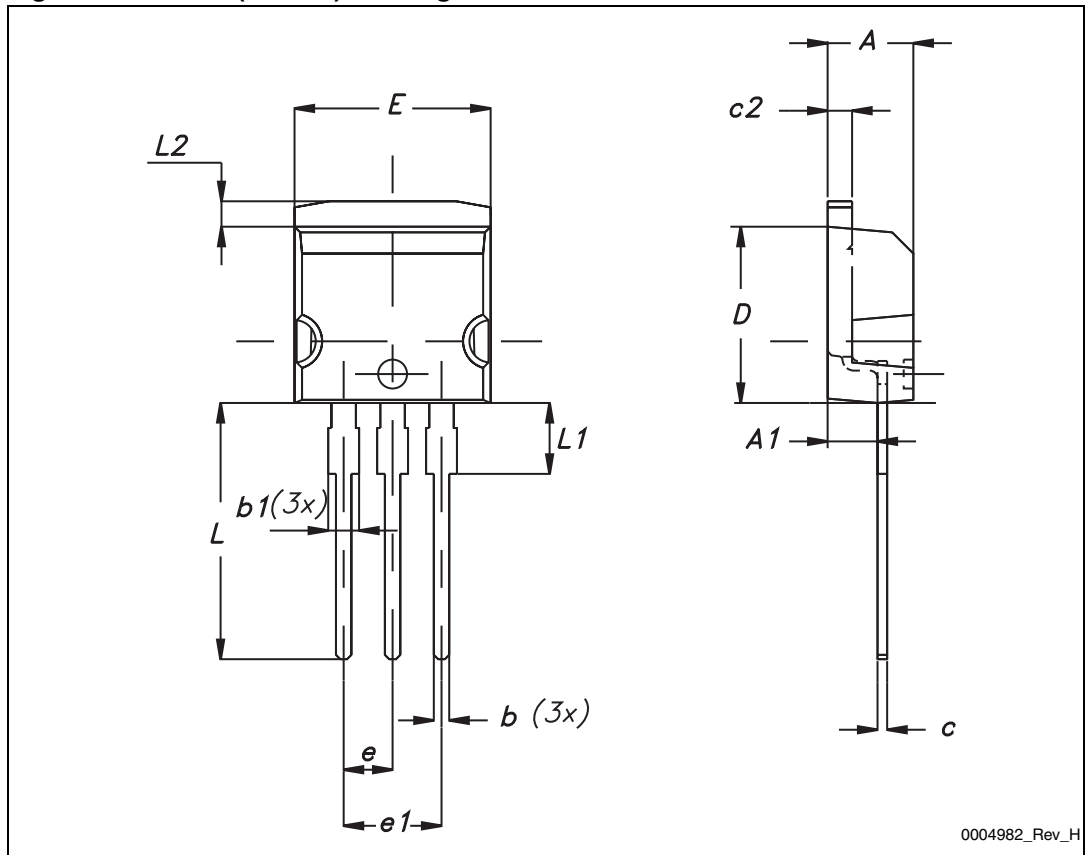
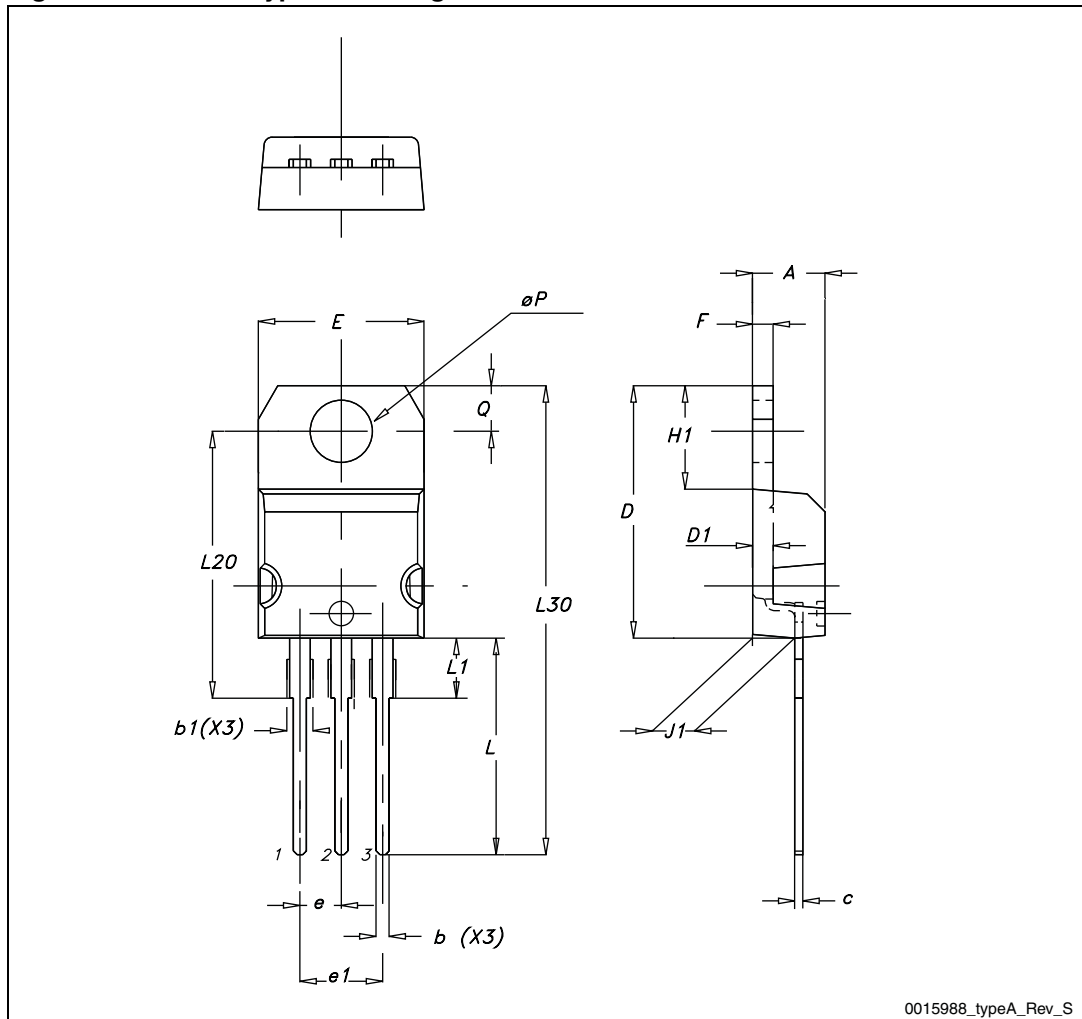
Figure 25. I<sup>2</sup>PAK (TO-262) drawing

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 26. TO-220 type A drawing



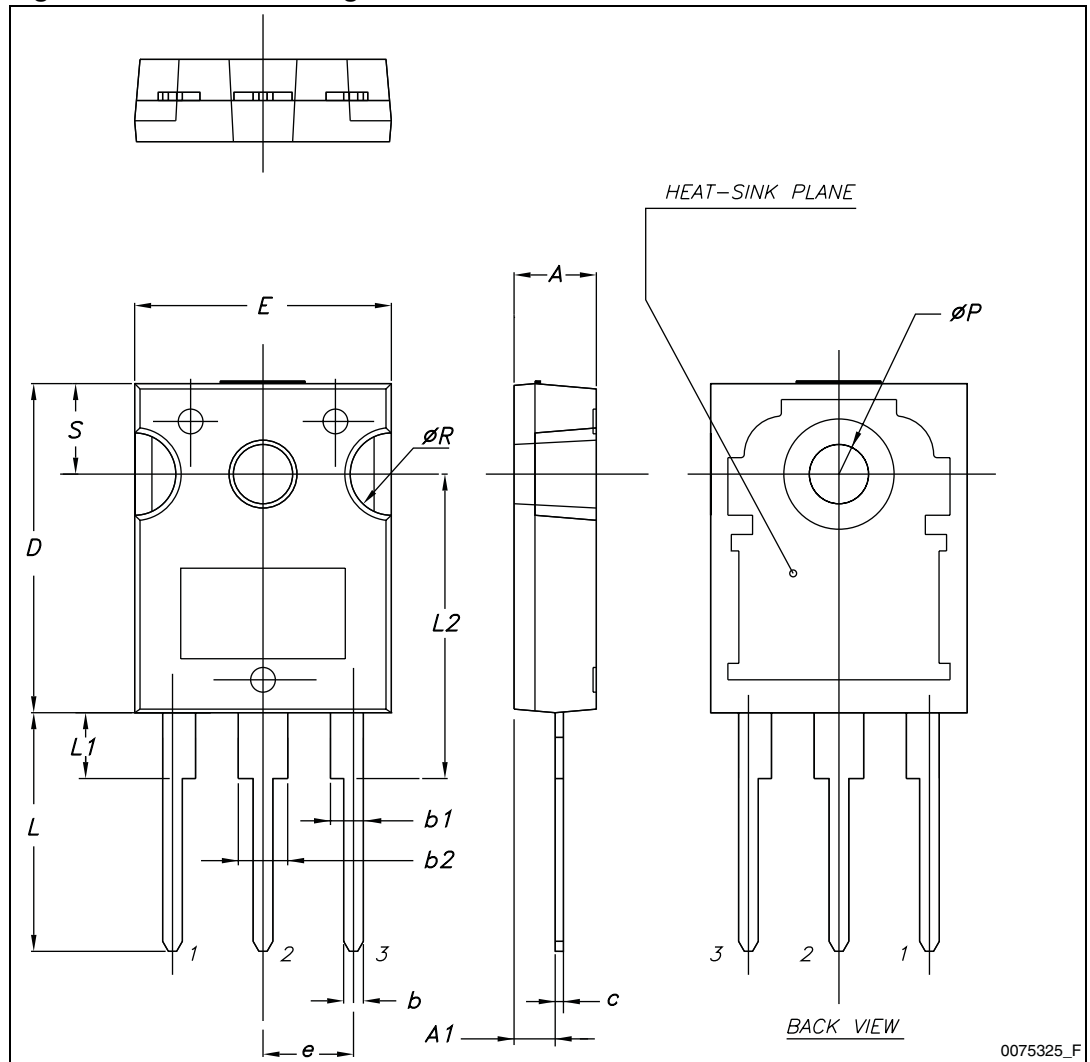
0015988\_typeA\_Rev\_S

Table 12. TO-247 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e		5.45	
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S		5.50	



Figure 27. TO-247 drawing



0075325\_F

## 5 Revision history

**Table 13. Document revision history**

Date	Revision	Changes
05-Jan-2011	1	First release.
01-Jul-2011	2	– Corrected $R_{thj-amb}$ value (see <a href="#">Table 3: Thermal data</a> ) – Added new package and mechanical data: TO-247.
22-Aug-2011	3	Inserted device in I <sup>2</sup> PAK: – updated <a href="#">Table 1: Device summary</a> , <a href="#">Table 2: Absolute maximum ratings</a> , <a href="#">Table 3: Thermal data</a> – inserted new mechanical data in <a href="#">Section 4: Package mechanical data</a>

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