



STD9NM60N STF9NM60N, STP9NM60N

N-channel 600 V, 0.63 Ω , 6.5 A TO-220, TO-220FP, DPAK
MDmesh™ II Power MOSFET

Features

Order codes	V _{DSS} (@T _{jmax})	R _{DS(on)} max.	I _D
STD9NM60N	650 V	< 0.745 Ω	6.5 A
STF9NM60N			
STP9NM60N			

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

Application

Switching applications

Description

This series of devices is realized with the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new 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.

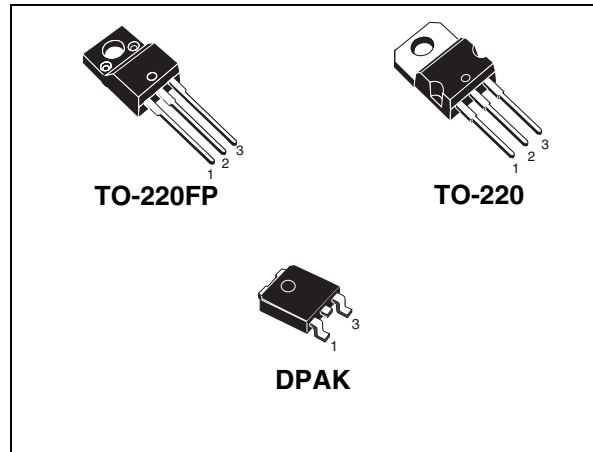


Figure 1. Internal schematic diagram

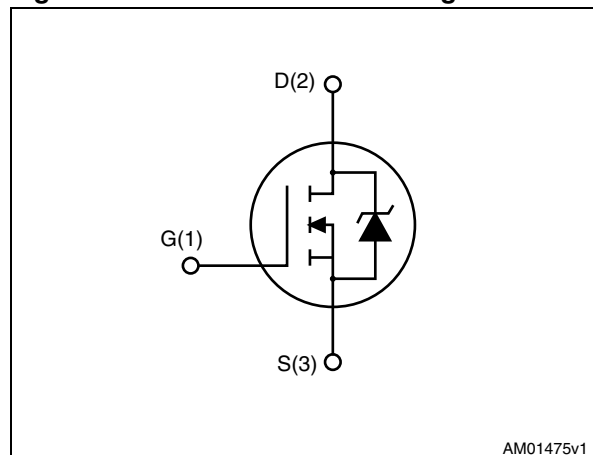


Table 1. Device summary

Order codes	Marking	Packages	Packaging
STD9NM60N	9NM60N	DPAK	Tape and reel
STF9NM60N		TO-220FP	Tube
STP9NM60N		TO-220	

Contents

1	Electrical ratings	3
2	Electrical characteristics	4
2.1	Electrical characteristics (curves)	6
3	Test circuits	9
4	Package mechanical data	10
5	Package mechanical data	14
6	Revision history	15

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220, DPAK	TO-220FP	
V_{DS}	Drain-source voltage ($V_{GS} = 0$)	600		V
V_{GS}	Gate- source voltage	± 25		V
I_D	Drain current (continuous) at $T_C = 25\text{ °C}$	6.5	6.5 ⁽¹⁾	A
I_D	Drain current (continuous) at $T_C = 100\text{ °C}$	4	4 ⁽¹⁾	A
$I_{DM}^{(2)}$	Drain current (pulsed)	26	26 ⁽¹⁾	A
P_{TOT}	Total dissipation at $T_C = 25\text{ °C}$	70	25	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
T_{stg}	Storage temperature	- 55 to 150		°C
T_j	Max. operating junction temperature	150		°C

- Limited only by maximum temperature allowed
- Pulse width limited by safe operating area
- $I_{SD} \leq 6.5\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$, $V_{DD} = 80\% V_{(BR)DSS}$

Table 3. Thermal data

Symbol	Parameter	Value			Unit
		DPAK	TO-220	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	1.79		5	°C/W
$R_{thj-pcb}^{(1)}$	Thermal resistance junction-pcb minimum footprint	50			°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max		62.5		°C/W
T_l	Maximum lead temperature for soldering purpose		300		°C

- When mounted on 1inch² FR-4 board, 2 oz Cu

Table 4. Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not-repetitive (pulse width limited by T_j Max)	2.5	A
E_{AS}	Single pulse avalanche energy (starting $T_j = 25\text{ °C}$, $I_D = I_{AR}$, $V_{DD} = 50\text{ V}$)	115	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	$I_D = 1\text{ mA}$, $V_{GS} = 0$	600			V
I_{DSS}	Zero gate voltage drain current ($V_{GS} = 0$)	$V_{DS} = \text{max rating}$ $V_{DS} = \text{max rating}$, @125 °C			1 100	μA μA
I_{GSS}	Gate-body leakage current ($V_{DS} = 0$)	$V_{GS} = \pm 20\text{ V}$			100	nA
$V_{GS(th)}$	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	$V_{GS} = 10\text{ V}$, $I_D = 3.25\text{ A}$		0.63	0.745	Ω

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{iss}	Input capacitance	$V_{DS} = 50\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$	-	452	-	pF
C_{oss}	Output capacitance			30		pF
C_{rss}	Reverse transfer capacitance			1.45		pF
$C_{oss\text{ eq.}}^{(1)}$	Equivalent output capacitance	$V_{GS} = 0$, $V_{DS} = 0\text{ to }480\text{ V}$	-	79	-	pF
Q_g	Total gate charge	$V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$, $V_{GS} = 10\text{ V}$, <i>(see Figure 18)</i>	-	17.4	-	nC
Q_{gs}	Gate-source charge			3		nC
Q_{gd}	Gate-drain charge			9.7		nC
R_g	Gate input resistance	f=1 MHz Gate DC Bias=0 Test signal level=20 mV open drain	-	4.8	-	Ω

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_{DS} .

Table 7. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 480\text{ V}$, $I_D = 6.5\text{ A}$ $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ <i>(see Figure 17)</i>	-	28	-	ns
t_r	Rise time		-	23	-	ns
$t_{d(off)}$	Turn-off delay time		-	52.5	-	ns
t_f	Fall time		-	26.7	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-drain current		-		6.5	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				26	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 6.5\text{ A}$, $V_{GS} = 0$	-		1.6	V
t_{rr}	Reverse recovery time	$I_{SD} = 6.5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ <i>(see Figure 22)</i>	-	264		ns
Q_{rr}	Reverse recovery charge		-	1.9		μC
I_{RRM}	Reverse recovery current		-	14.6		A
t_{rr}	Reverse recovery time	$I_{SD} = 6.5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$, $T_j = 150\text{ }^\circ\text{C}$ <i>(see Figure 22)</i>	-	324		ns
Q_{rr}	Reverse recovery charge		-	2.3		μC
I_{RRM}	Reverse recovery current		-	14.2		A

1. Pulse width limited by safe operating area
2. Pulsed: Pulse duration = 300 μs , duty cycle 1.5%

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

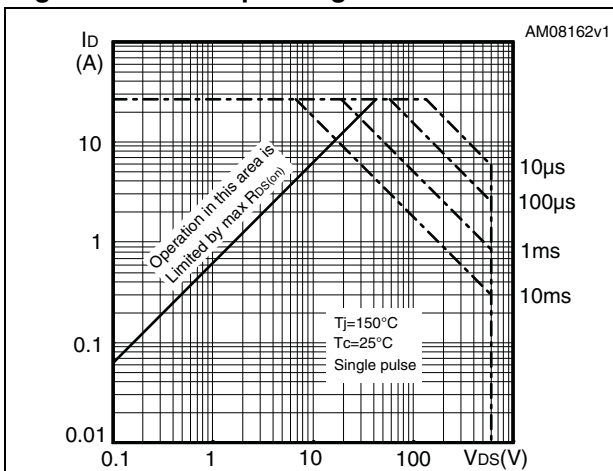


Figure 3. Thermal impedance for TO-220

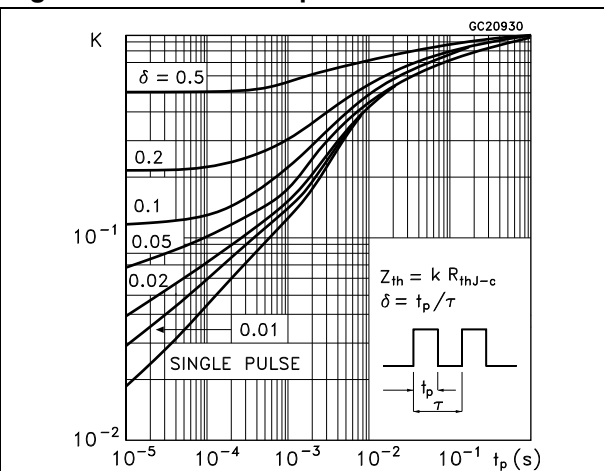


Figure 4. Safe operating area for DPAK

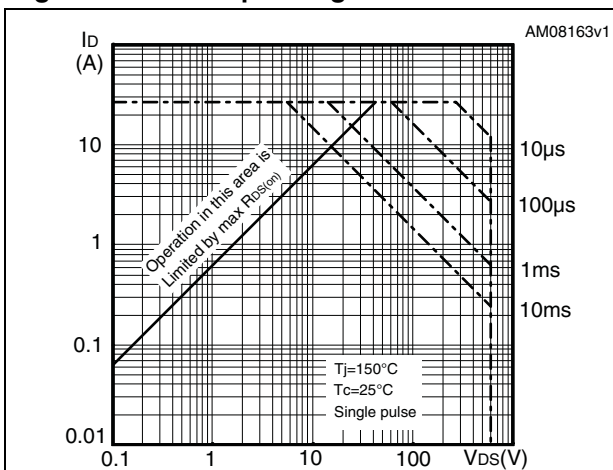


Figure 5. Thermal impedance for DPAK

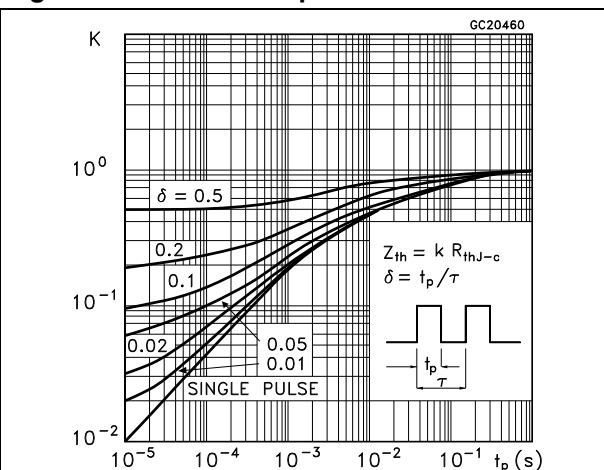


Figure 6. Safe operating area for TO-220FP

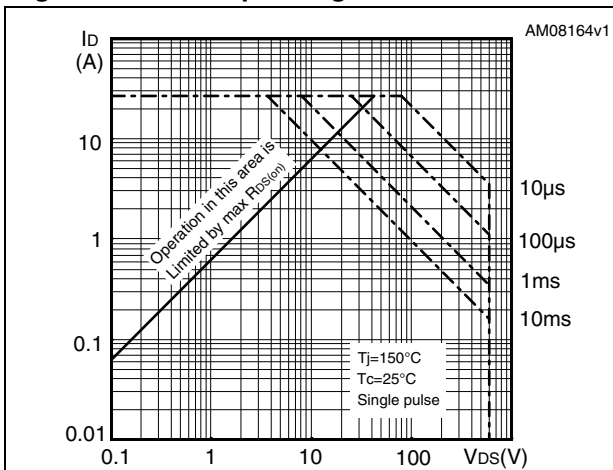


Figure 7. Thermal impedance for TO-220FP

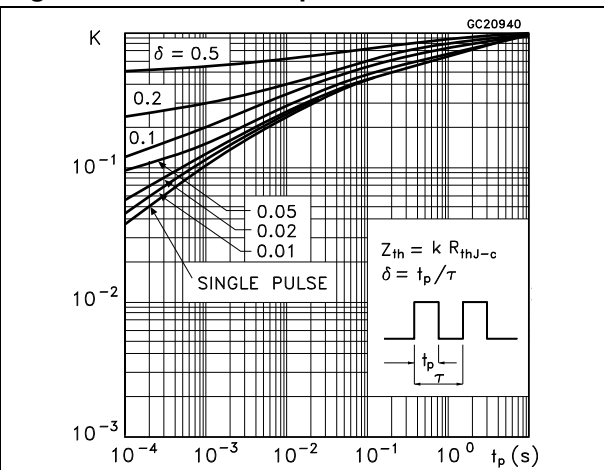


Figure 8. Output characteristics

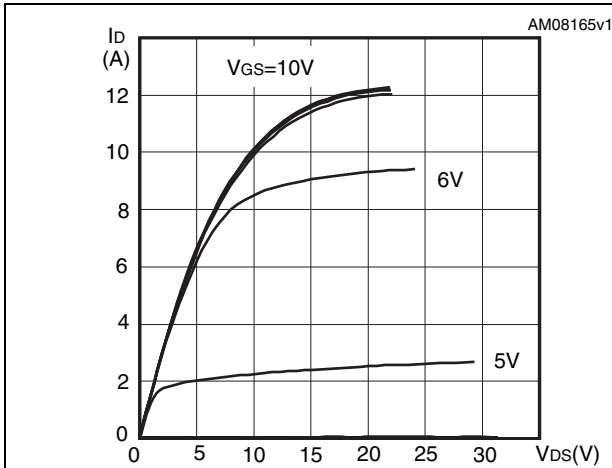


Figure 9. Transfer characteristics

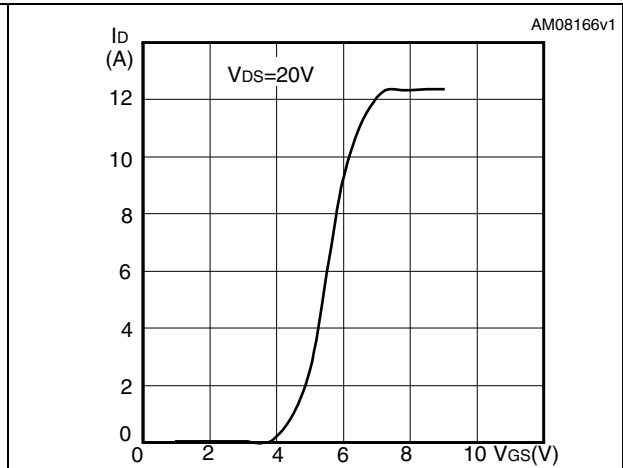


Figure 10. Gate charge vs gate-source voltage

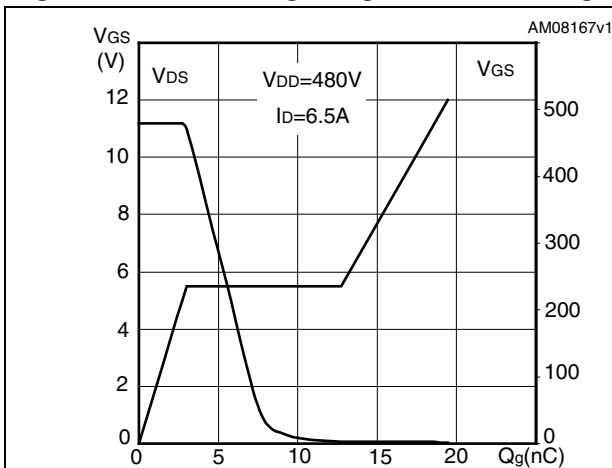


Figure 11. Static drain-source on resistance

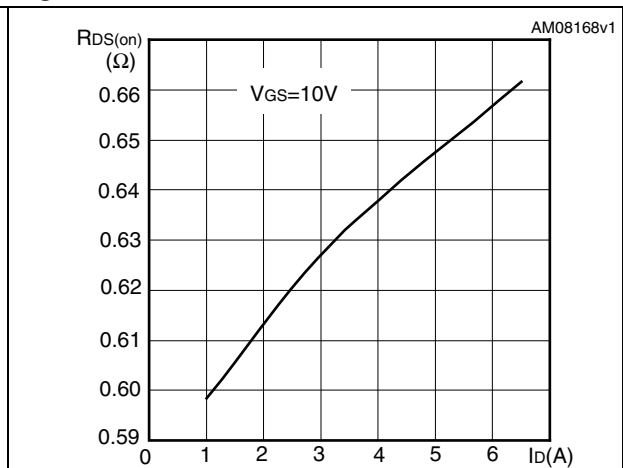


Figure 12. Capacitance variations

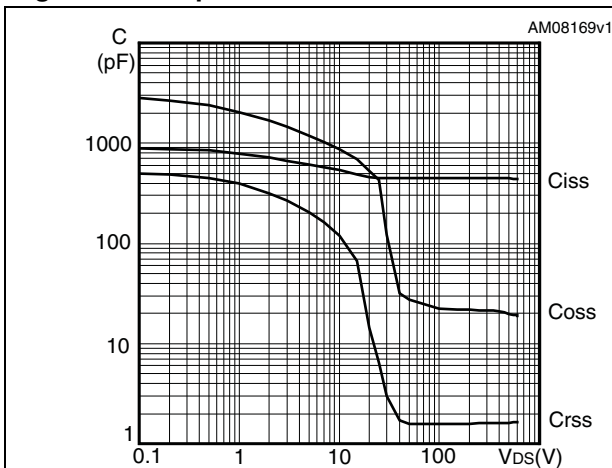


Figure 13. Output capacitance stored energy

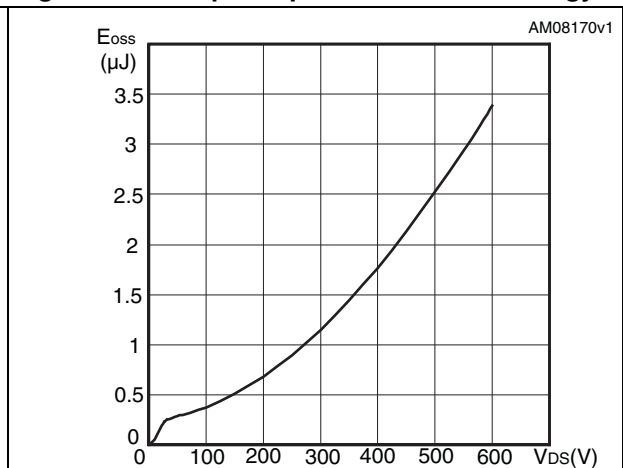


Figure 14. Normalized gate threshold voltage vs temperature

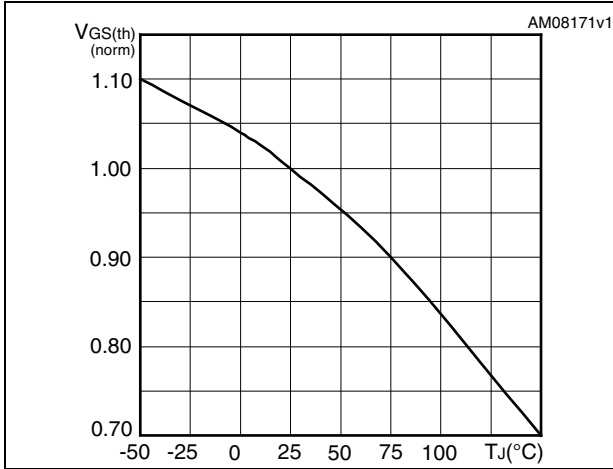


Figure 15. Normalized on resistance vs temperature

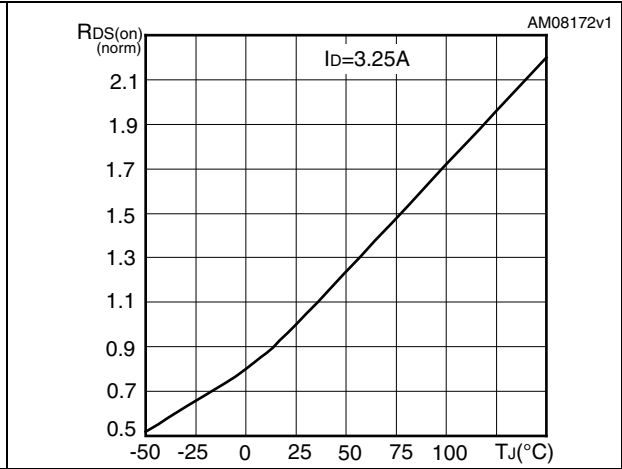
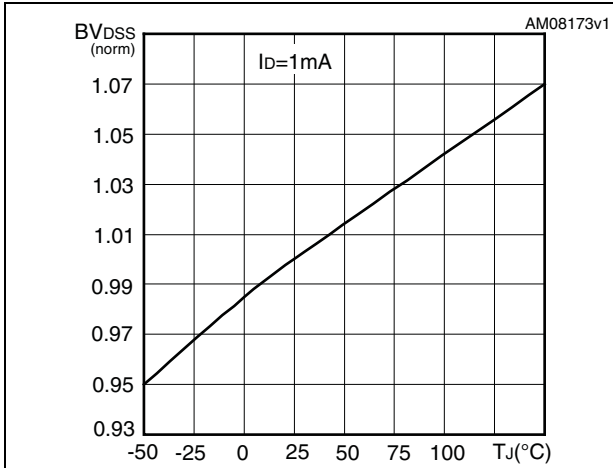


Figure 16. Normalized B_{VDSS} vs temperature



3 Test circuits

Figure 17. Switching times test circuit for resistive load

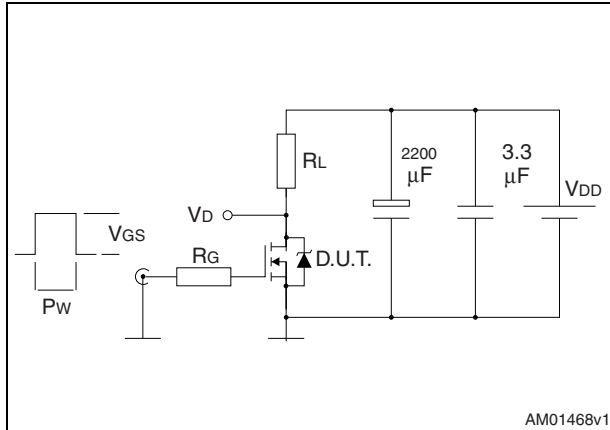


Figure 18. Gate charge test circuit

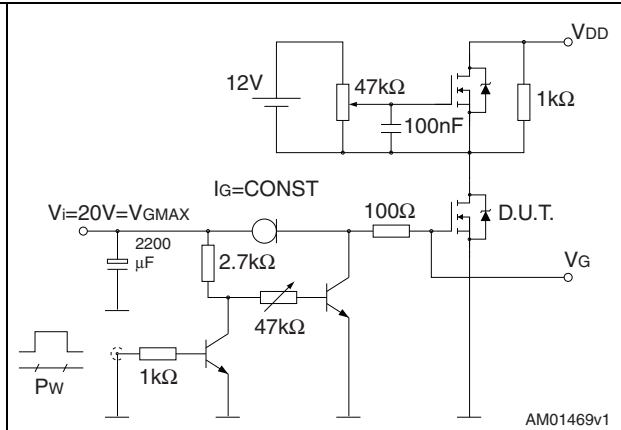


Figure 19. Test circuit for inductive load switching and diode recovery times

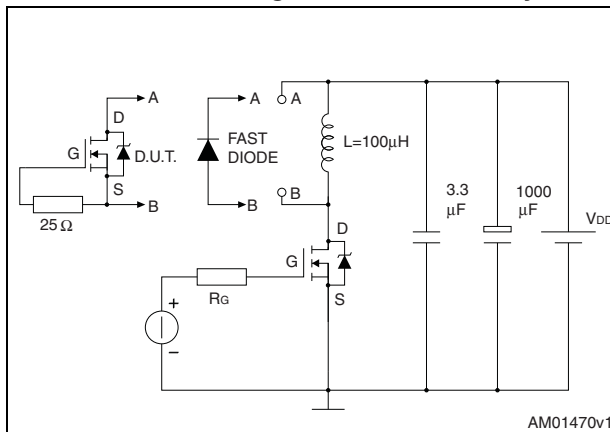


Figure 20. Unclamped inductive load test circuit

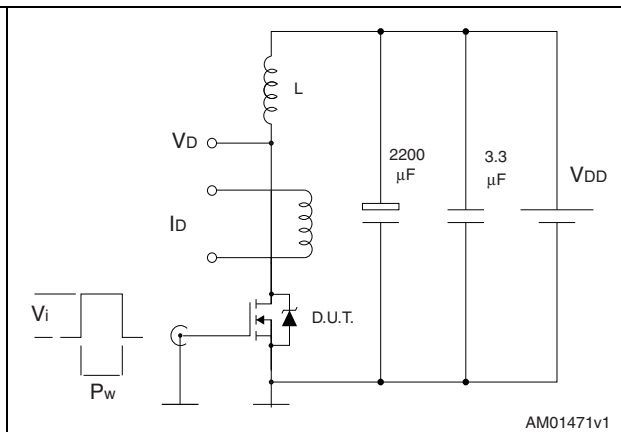


Figure 21. Unclamped inductive waveform

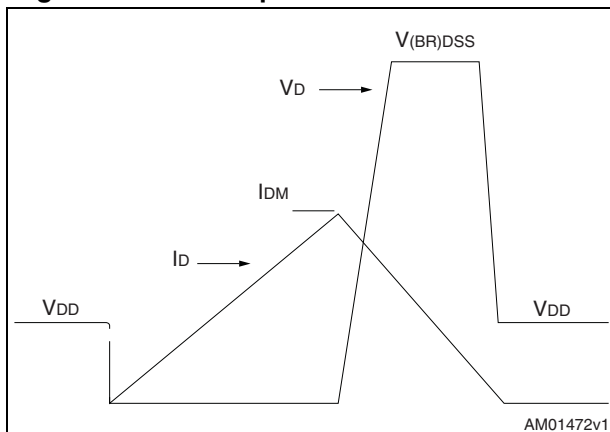
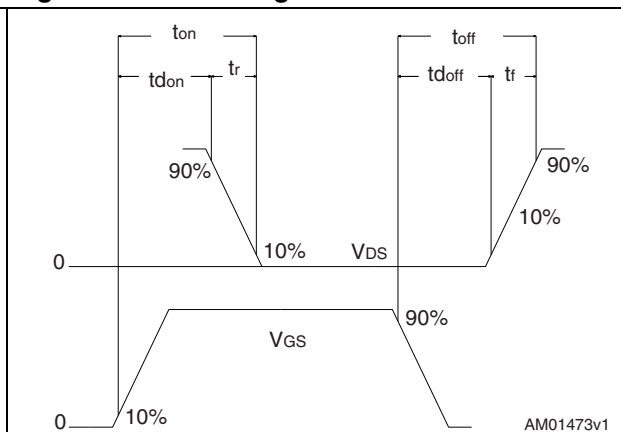


Figure 22. Switching time waveform



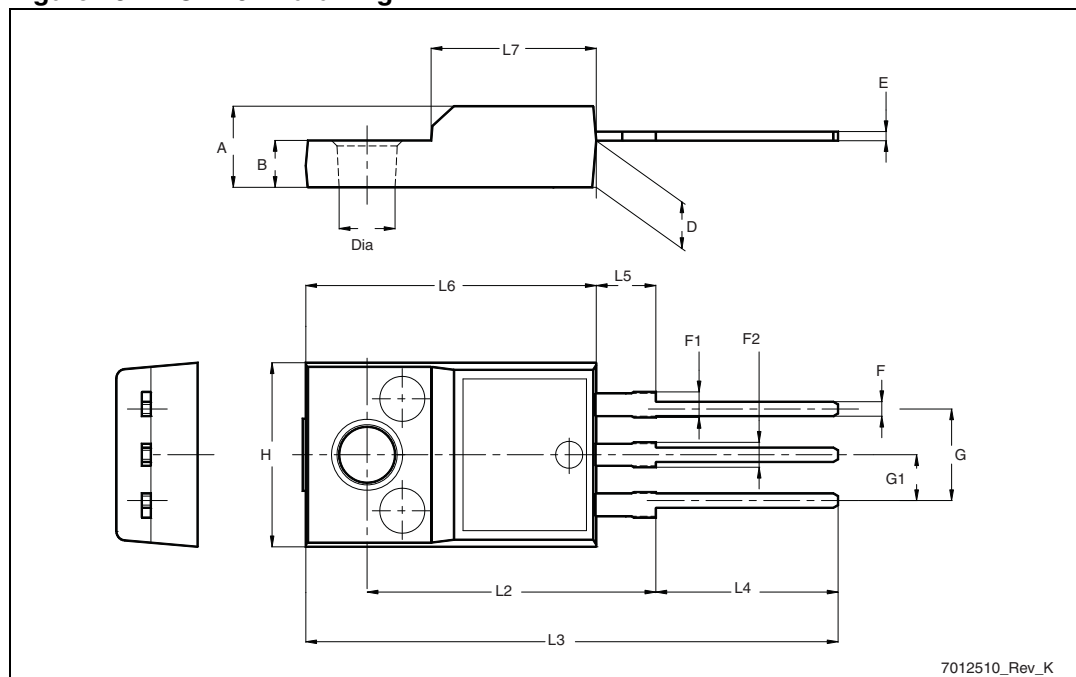
4 Package mechanical data

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

Table 9. TO-220FP mechanical data

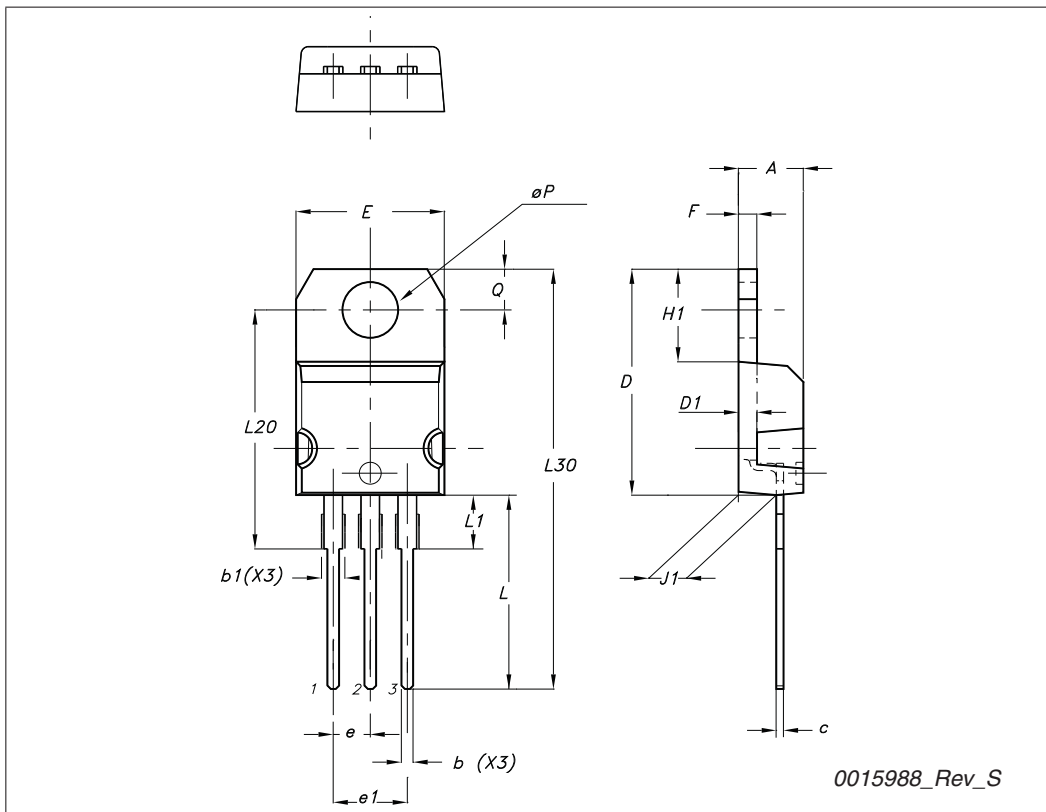
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 23. TO-220FP drawing



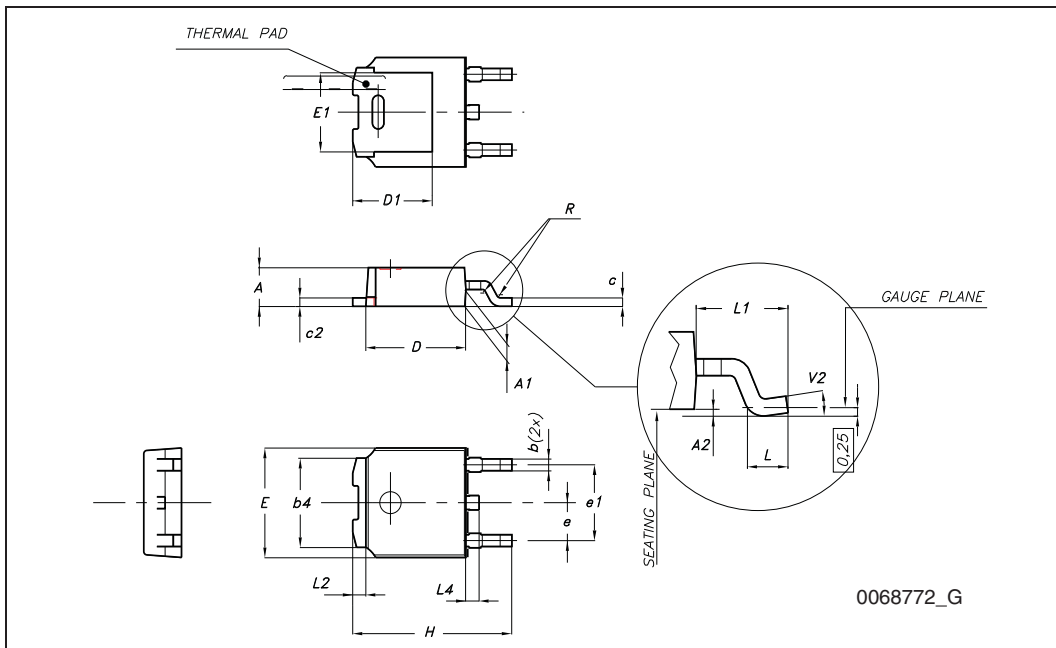
TO-220 type A mechanical data

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



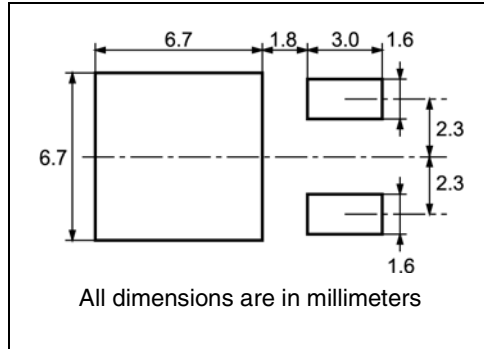
TO-252 (DPAK) mechanical data

DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1		5.10	
E	6.40		6.60
E1		4.70	
e		2.28	
e1	4.40		4.60
H	9.35		10.10
L	1		
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0°		8°



5 Package mechanical data

DPAK FOOTPRINT



TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

G measured at hub

REEL MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	16.4	18.4	0.645	0.724
N	50		1.968	
T		22.4		0.881

TAPE MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	6.8	7	0.267	0.275
B0	10.4	10.6	0.409	0.417
B1		12.1		0.476
D	1.5	1.6	0.059	0.063
D1	1.5		0.059	
E	1.65	1.85	0.065	0.073
F	7.4	7.6	0.291	0.299
K0	2.55	2.75	0.100	0.108
P0	3.9	4.1	0.153	0.161
P1	7.9	8.1	0.311	0.319
P2	1.9	2.1	0.075	0.082
R	40		1.574	
W	15.7	16.3	0.618	0.641

TOP COVER TAPE

User Direction of Feed

FEED DIRECTION

Bending radius R min.

10 pitches cumulative tolerance on tape +/- 0.2 mm

6 Revision history

Table 10. Document revision history

Date	Revision	Changes
20-Oct-2010	1	First release.

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