



# STB12NM60N/-1 - STF12NM60N STP12NM60N - STW12NM60N

N-channel 600V - 0.35Ω - 10A - D<sup>2</sup>/I<sup>2</sup>PAK - TO-220/FP - TO-247  
Second generation MDmesh™ Power MOSFET

## Features

Type	V <sub>DSS</sub> (@T <sub>jmax</sub> )	R <sub>DS(on)</sub>	I <sub>D</sub>
STB12NM60N	650V	< 0.41Ω	10A
STB12NM60N-1	650V	< 0.41Ω	10A
STF12NM60N	650V	< 0.41Ω	10A <sup>(1)</sup>
STP12NM60N	650V	< 0.41Ω	10A
STW12NM60N	650V	< 0.41Ω	10A

1. Limited only by maximum temperature allowed

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

## Description

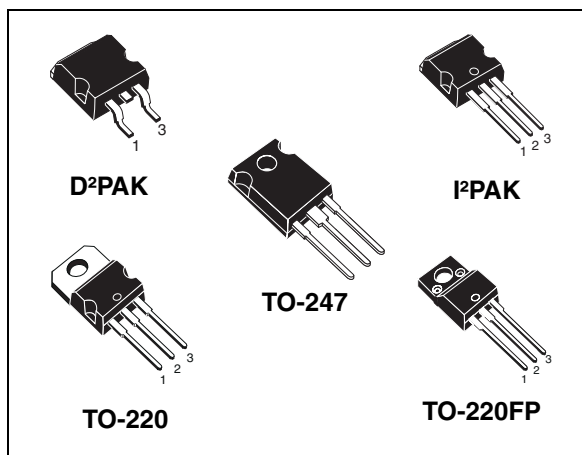
This series of devices implements second generation MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the Company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

## Application

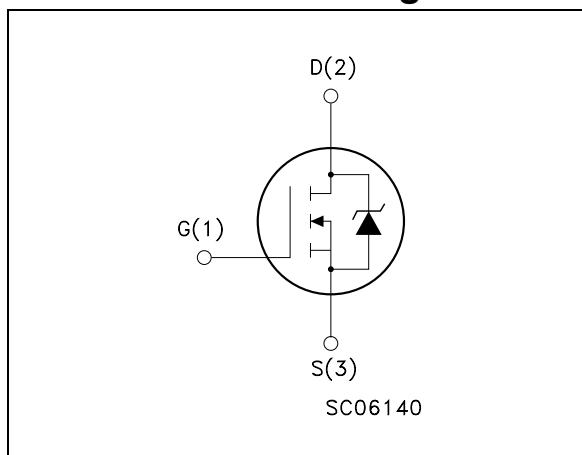
- Switching application

## Order codes

Part number	Marking	Package	Packaging
STB12NM60N	B12NM60N	D <sup>2</sup> PAK	Tape & reel
STB12NM60N-1	B12NM60N	I <sup>2</sup> PAK	Tube
STF12NM60N	F12NM60N	TO-220FP	Tube
STP12NM60N	P12NM60N	TO-220	Tube
STW12NM60N	W12NM60N	TO-247	Tube



## Internal schematic diagram



# Contents

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		D <sup>2</sup> PAK/I <sup>2</sup> PAK TO-220/TO-247	TO-220FP	
V <sub>DS</sub>	Drain-source voltage (V <sub>GS</sub> =0)	600		V
V <sub>GS</sub>	Gate-source voltage	± 25		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25°C	10	10 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100°C	6.3	6.3 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	40	40 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25°C	90	25	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=1s; 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. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 10A, di/dt ≤ 400A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 2. Thermal data**

Symbol	Parameter	D <sup>2</sup> PAK/I <sup>2</sup> PAK TO-220/TO-247	TO-220FP	Unit
R <sub>thj-case</sub>	Thermal resistance junction-case max	1.38	5	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-amb max	62.5		°C/W
T <sub>l</sub>	Maximum lead temperature for soldering purpose	300		°C

**Table 3. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
I <sub>AS</sub>	Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>j</sub> max)	3.5	A
E <sub>AS</sub>	Single pulse avalanche energy (starting T <sub>j</sub> =25°C, I <sub>D</sub> =I <sub>AS</sub> , V <sub>DD</sub> = 50V)	200	mJ

## 2 Electrical characteristics

( $T_{CASE}=25^{\circ}C$  unless otherwise specified)

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 1mA, V_{GS} = 0$	600			V
$dv/dt^{(1)}$	Drain-source voltage slope	$V_{DD} = 400V, I_D = 10A,$ $V_{GS} = 10V$		41		V/ns
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating},$ $V_{DS} = \text{Max rating}, @ 125^{\circ}C$			1 10	$\mu A$ $\mu A$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20V$			100	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250\mu A$	2	3	4	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10V, I_D = 5A$		0.35	0.41	$\Omega$

1. Characteristics value at turn off on inductive load

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15V, I_D = 5A$		8		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 50V, f = 1MHz,$ $V_{GS} = 0$		960 65 7		pF pF pF
$C_{oss\ eq.}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0V \text{ to } 480V$		180		pF
$R_g$	Gate input resistance	$f = 1MHz$ Gate DC Bias=0 Test signal level=20mV open drain		5		$\Omega$
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 480V, I_D = 10A$ $V_{GS} = 10V$ (see Figure 18)		30.5 5 16		nC nC nC

1. Pulsed: pulse duration = 300 $\mu s$ , duty cycle 1.5%

2.  $C_{oss\ eq.}$  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 6. Switching times**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300V, I_D = 5A,$ $R_G = 4.7\Omega, V_{GS} = 10V$ <i>(see Figure 17)</i>		15		ns
$t_r$	Rise time			9		ns
$t_{d(off)}$	Turn-off delay time			60		ns
$t_f$	Fall time			10		ns

**Table 7. Source drain diode**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$I_{SD}$	Source-drain current				10	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				40	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 10A, V_{GS} = 0$			1.3	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 10A, di/dt = 100A/\mu s,$ $V_{DD} = 100V, T_j = 25^\circ C$ <i>(see Figure 19)</i>		360		ns
$Q_{rr}$	Reverse recovery charge			3.5		$\mu C$
$I_{RRM}$	Reverse recovery current			20		A
$t_{rr}$	Reverse recovery time	$V_{DD} = 100V$ $di/dt = 100A/\mu s, I_{SD} = 10A$ $T_j = 150^\circ C$ <i>(see Figure 19)</i>		530		ns
$Q_{rr}$	Reverse recovery charge			5.20		$\mu C$
$I_{RRM}$	Reverse recovery current			20		A

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

## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

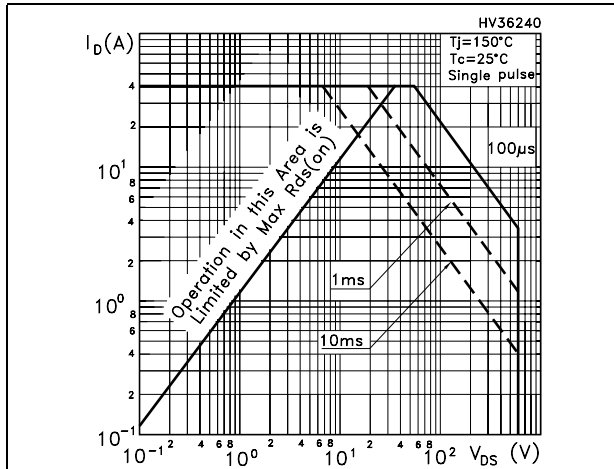


Figure 2. Thermal impedance for TO-220 / D<sup>2</sup>PAK / I<sup>2</sup>PAK

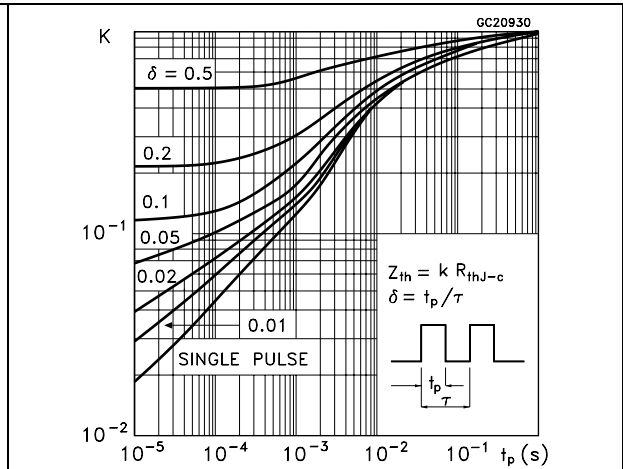


Figure 3. Safe operating area for TO-220FP

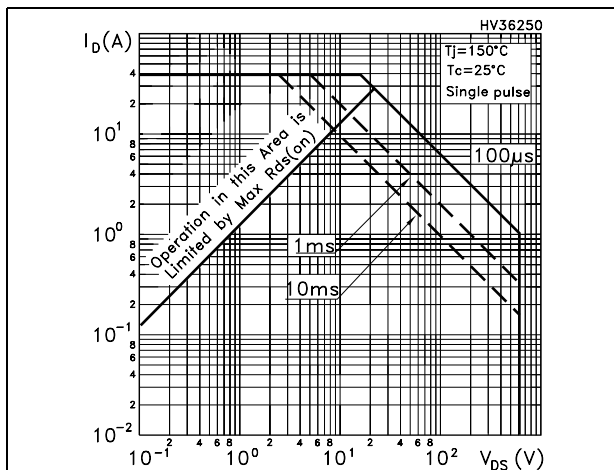


Figure 4. Thermal impedance for TO-220FP

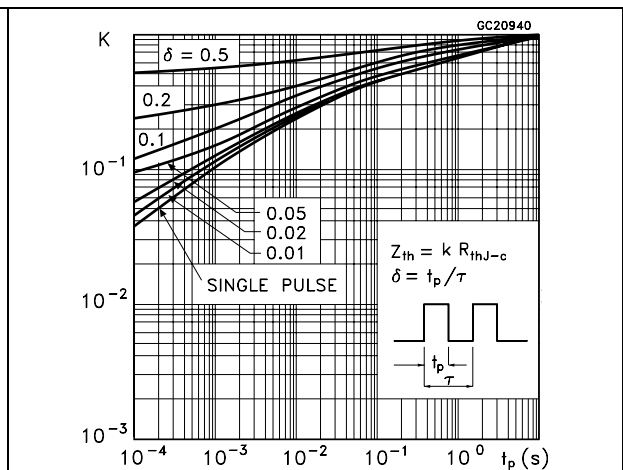


Figure 5. Safe operating area for TO-247

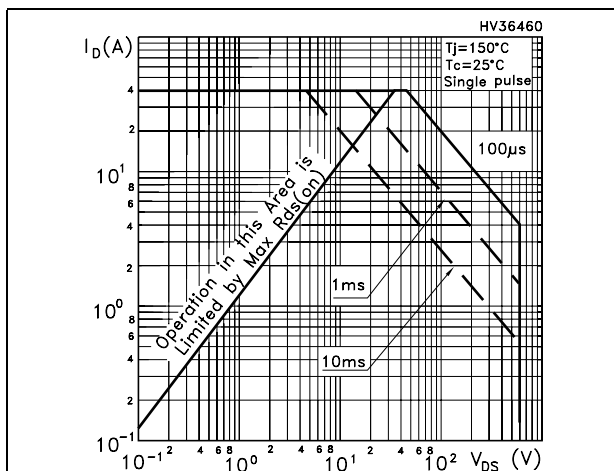


Figure 6. Thermal impedance for TO-247

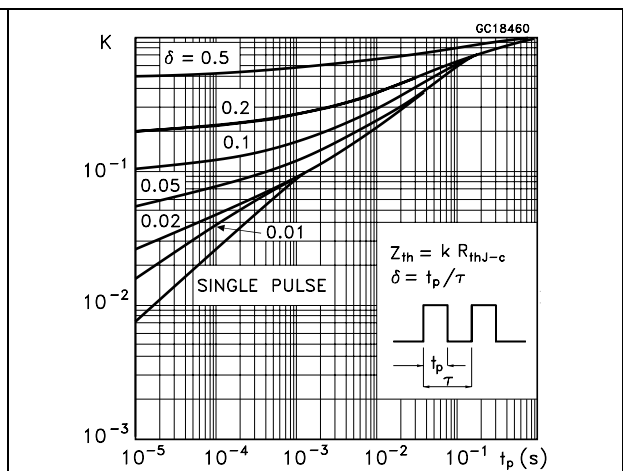


Figure 7. Output characteristics

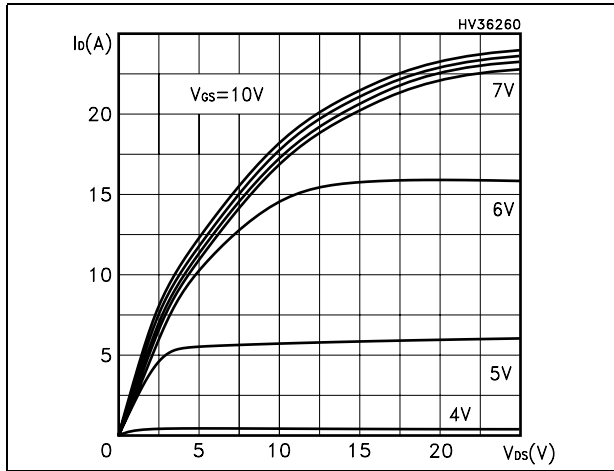


Figure 8. Transfer characteristics

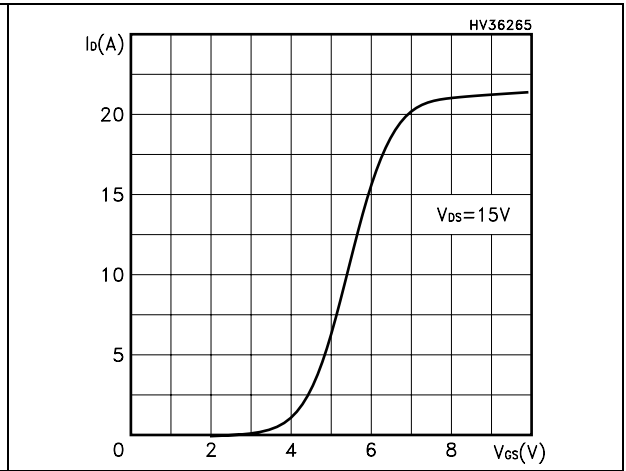


Figure 9. Transconductance

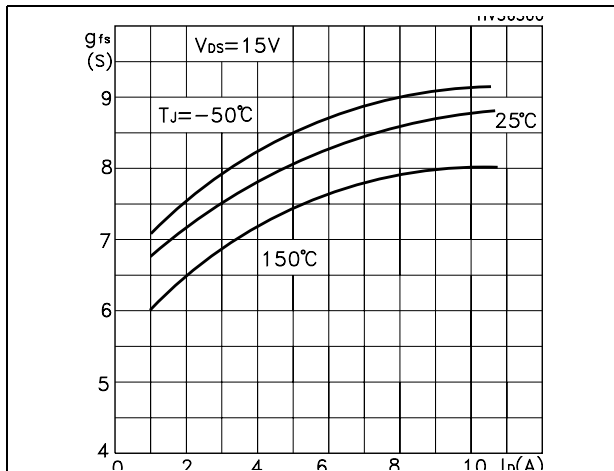


Figure 10. Static drain-source on resistance

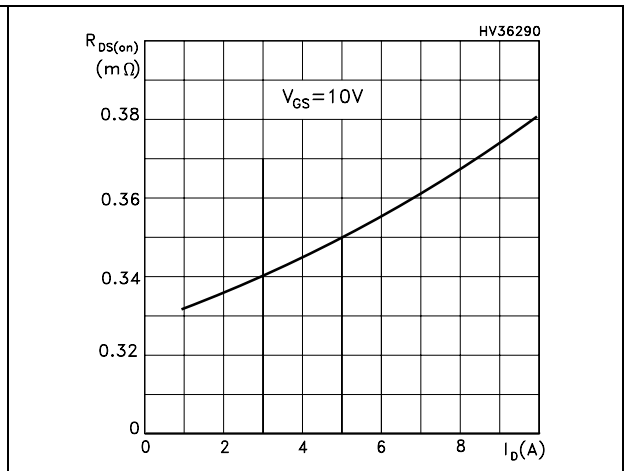


Figure 11. Gate charge vs. gate-source voltage

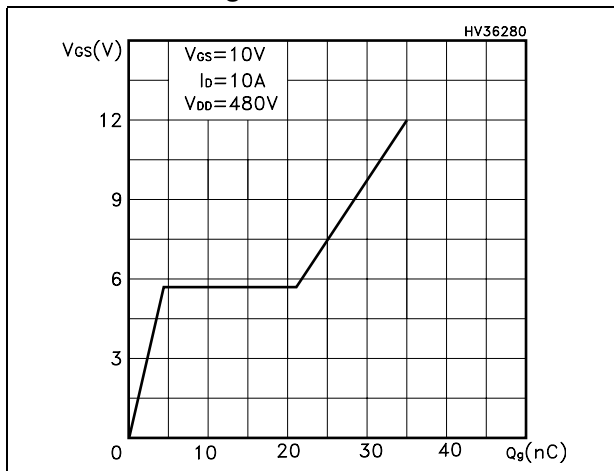


Figure 12. Capacitance variations

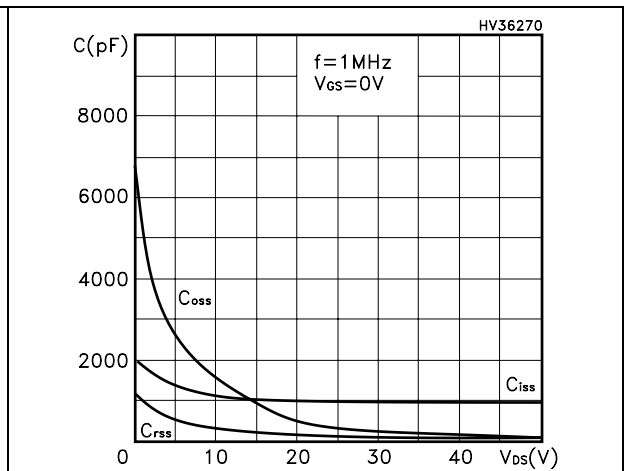


Figure 13. Normalized gate threshold voltage vs. temperature

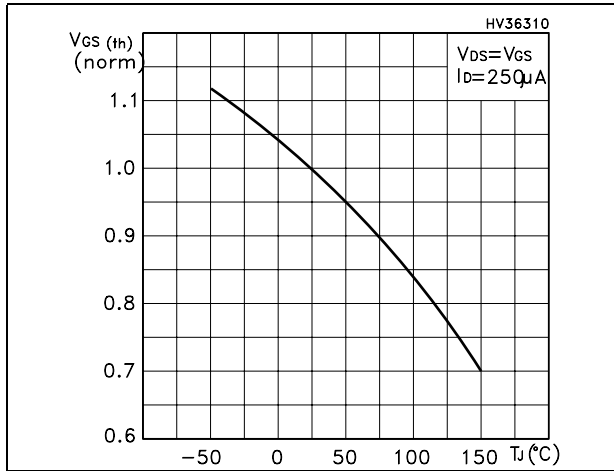


Figure 14. Normalized on resistance vs. temperature

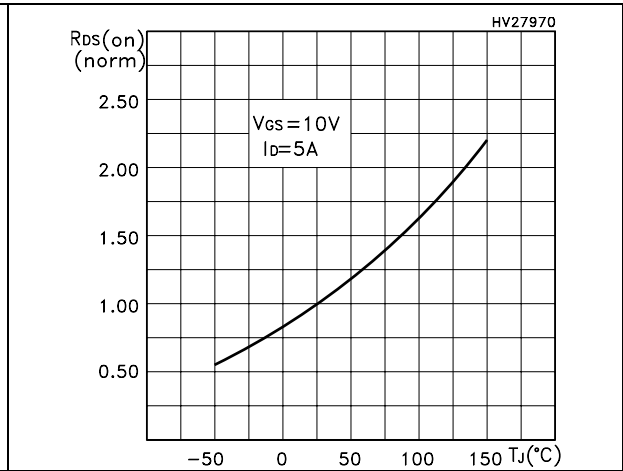


Figure 15. Source-drain diode forward characteristics

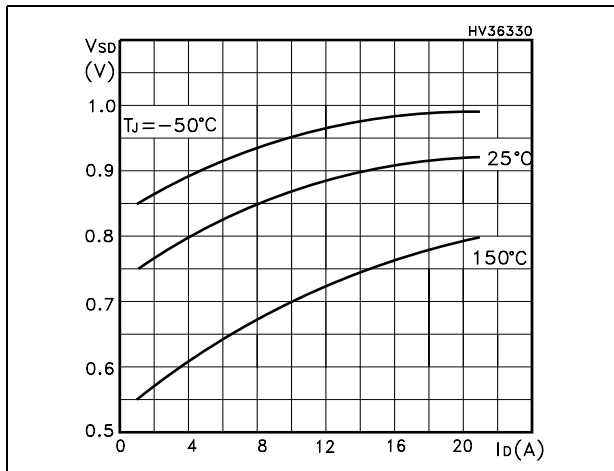
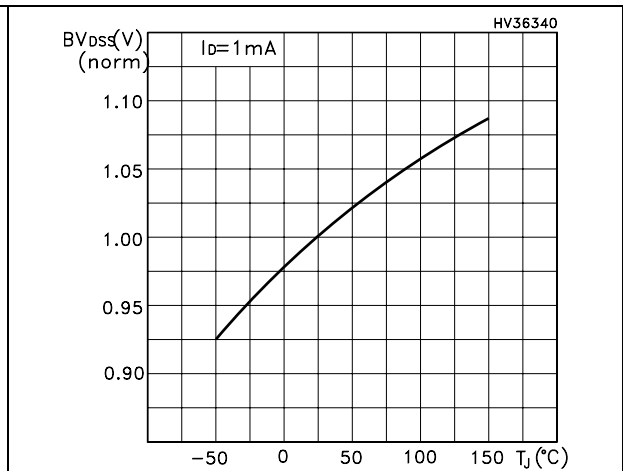


Figure 16. Normalized  $BV_{DSS}$  vs. temperature





### 3 Test circuit

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

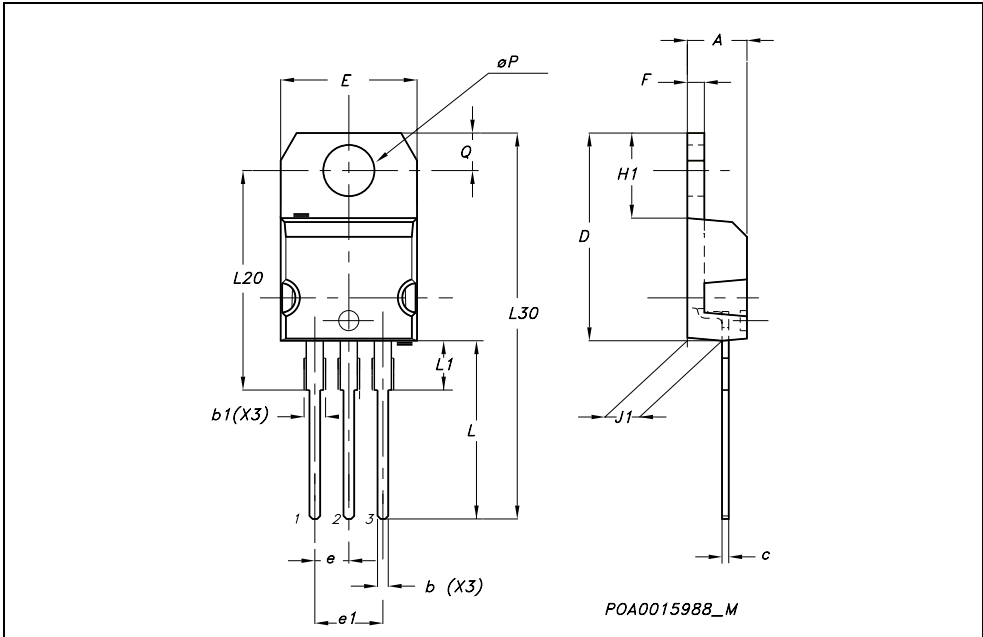


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

**TO-220 MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
øP	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



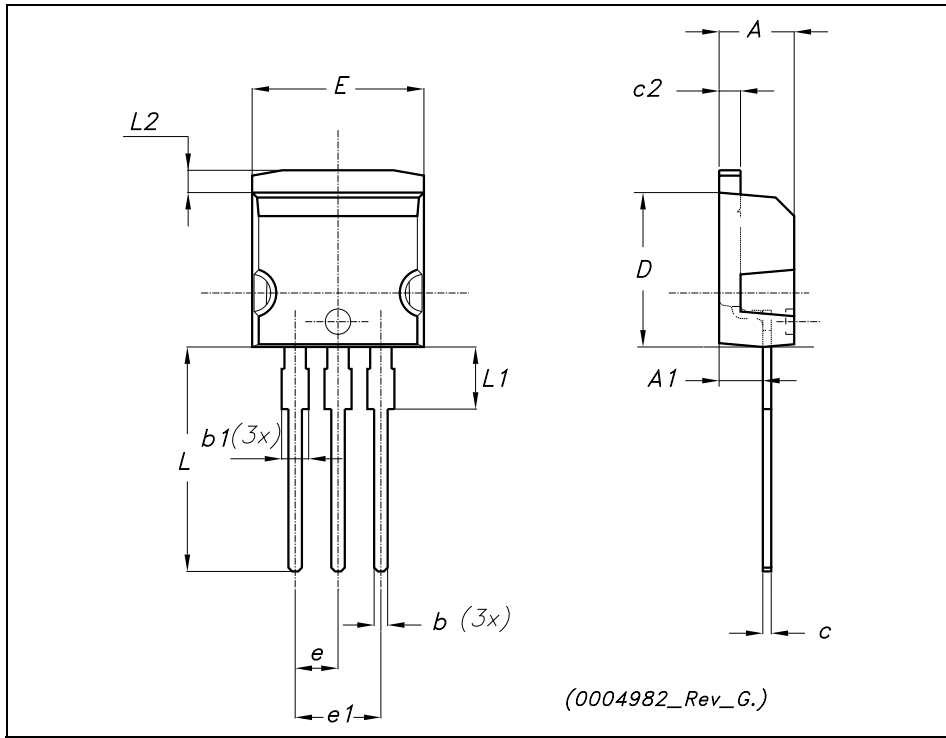
**TO-220FP MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.7	0.045		0.067
F2	1.15		1.7	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	.0385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
Ø	3		3.2	0.118		0.126



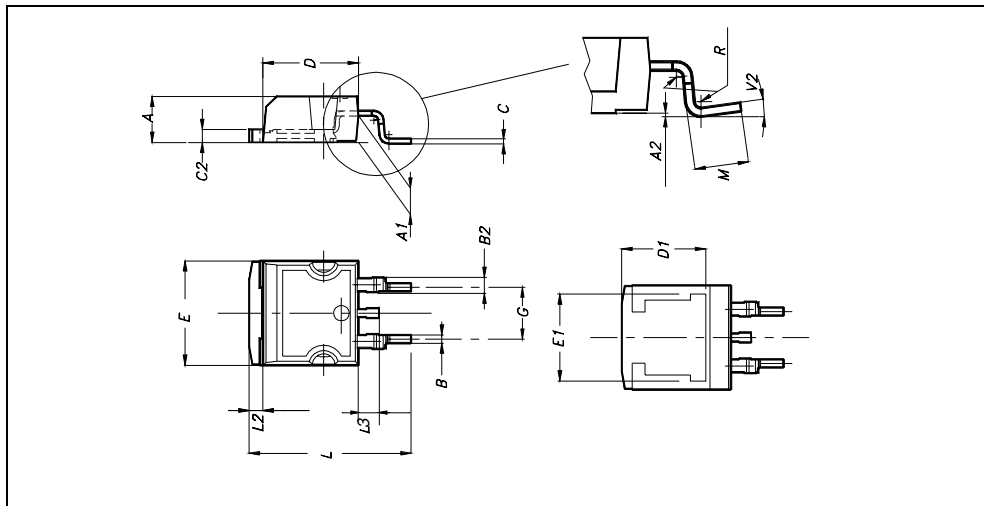
**TO-262 (I<sup>2</sup>PAK) MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
A1	2.40		2.72	0.094		0.107
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
c2	1.23		1.32	0.048		0.052
D	8.95		9.35	0.352		0.368
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
E	10		10.40	0.393		0.410
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L2	1.27		1.40	0.050		0.055



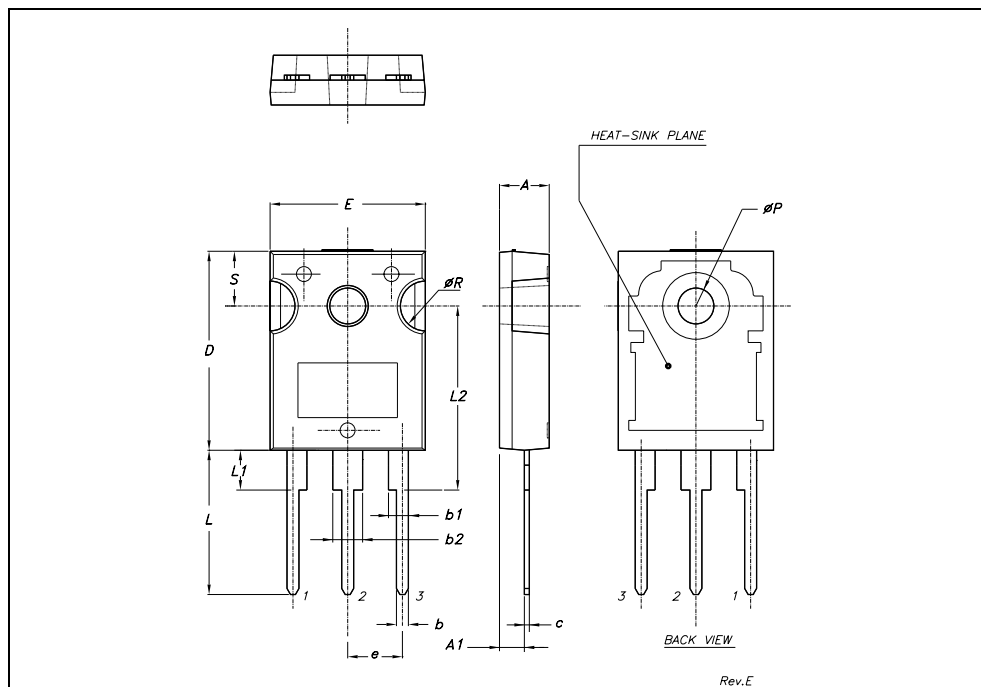
**D<sup>2</sup>PAK MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
A2	0.03		0.23	0.001		0.009
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1		8			0.315	
E	10		10.4	0.393		
E1		8.5			0.334	
G	4.88		5.28	0.192		0.208
L	15		15.85	0.590		0.625
L2	1.27		1.4	0.050		0.055
L3	1.4		1.75	0.055		0.068
M	2.4		3.2	0.094		0.126
R		0.4			0.015	
V2	0°		4°			



**TO-247 MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.85		5.15	0.19		0.20
A1	2.20		2.60	0.086		0.102
b	1.0		1.40	0.039		0.055
b1	2.0		2.40	0.079		0.094
b2	3.0		3.40	0.118		0.134
c	0.40		0.80	0.015		0.03
D	19.85		20.15	0.781		0.793
E	15.45		15.75	0.608		0.620
e		5.45			0.214	
L	14.20		14.80	0.560		0.582
L1	3.70		4.30	0.14		0.17
L2		18.50			0.728	
øP	3.55		3.65	0.140		0.143
øR	4.50		5.50	0.177		0.216
S		5.50			0.216	



# 5 Packaging mechanical data

## D<sup>2</sup>PAK FOOTPRINT



## TAPE AND REEL SHIPMENT

**TAPE MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	10.5	10.7	0.413	0.421
B0	15.7	15.9	0.618	0.626
D	1.5	1.6	0.059	0.063
D1	1.59	1.61	0.062	0.063
E	1.65	1.85	0.065	0.073
F	11.4	11.6	0.449	0.456
K0	4.8	5.0	0.189	0.197
P0	3.9	4.1	0.153	0.161
P1	11.9	12.1	0.468	0.476
P2	1.9	2.1	0.075	0.082
R	50		1.574	
T	0.25	0.35	0.0098	0.0137
W	23.7	24.3	0.933	0.956

**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	24.4	26.4	0.960	1.039
N	100		3.937	
T		30.4		1.197

BASE QTY	BULK QTY
1000	1000

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

FEED DIRECTION

TRL

Bending radius

R min.

\* on sales type



## 6 Revision history

**Table 8. Revision history**

<b>Date</b>	<b>Revision</b>	<b>Changes</b>
26-Mar-2007	1	First release
23-Apr-2007	2	Complete version

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