



# STB13NK60ZT4, STP13NK60Z STP13NK60ZFP, STW13NK60Z

N-channel 600 V, 0.48  $\Omega$ , 13 A, TO-220, TO-220FP, D<sup>2</sup>PAK  
TO-247 Zener-protected SuperMESH™ Power MOSFET

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on) max</sub>	I <sub>D</sub>	P <sub>w</sub>
STB13NK60ZT4	600 V	<0.55 $\Omega$	13 A	150 W
STP13NK60ZFP	600 V	<0.55 $\Omega$	13 A	35 W
STP13NK60Z	600 V	<0.55 $\Omega$	13 A	150 W
STW13NK60Z	600 V	<0.55 $\Omega$	13 A	150 W

- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability

## Application

- Switching applications

## Description

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications.

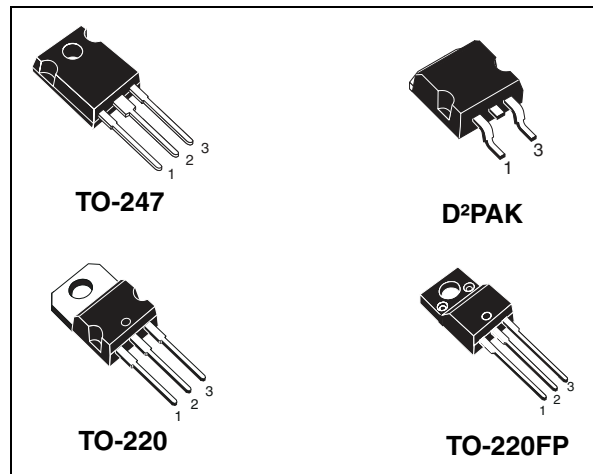


Figure 1. Internal schematic diagram

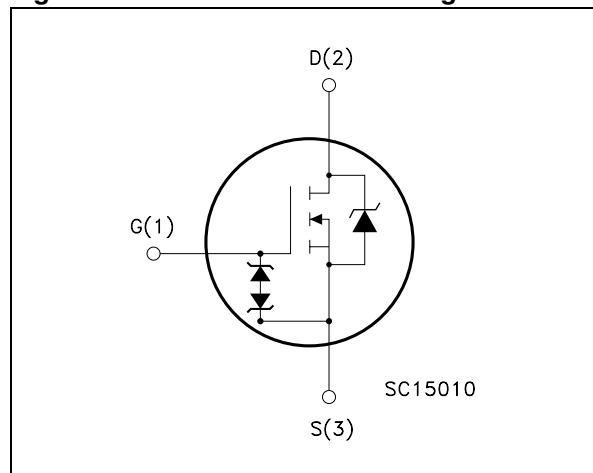


Table 1. Device summary

Order codes	Marking	Package	Packaging
STB13NK60ZT4	B13NK60Z	D <sup>2</sup> PAK	Tape and reel
STP13NK60ZFP	P13NK60ZFP	TO-220FP	Tube
STP13NK60Z	P13NK60Z	TO-220	Tube
STW13NK60Z	W13NK60Z	TO-247	Tube

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220 / TO-247 D <sup>2</sup> PAK	TO-220FP	
V <sub>DS</sub>	Drain-source voltage (V <sub>GS</sub> = 0)	600		V
V <sub>GS</sub>	Gate-source voltage	± 30		V
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 25 °C	13	13 <sup>(1)</sup>	A
I <sub>D</sub>	Drain current (continuous) at T <sub>C</sub> = 100 °C	8.2	8.2 <sup>(1)</sup>	A
I <sub>DM</sub> <sup>(2)</sup>	Drain current (pulsed)	52	52 <sup>(1)</sup>	A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	150	35	W
	Derating factor	1.20	0.27	W/°C
Vesd(G-S)	G-S ESD (HBM C=100pF, R=1.5 kΩ)	4000		V
dv/dt <sup>(3)</sup>	Peak diode recovery voltage slope	4.5		V/ns
V <sub>ISO</sub>	Insulation withstand voltage (AC)	--	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> ≤ 13 A, di/dt ≤ 200 A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>J</sub> ≤ T<sub>JMAX</sub>

**Table 3. Thermal data**

Symbol	Parameter	Value			Unit
		TO-220 TO-247	D <sup>2</sup> PAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case max	0.83		3.6	°C/W
R <sub>thj-pcb</sub> <sup>(1)</sup>	Thermal resistance junction-pcb max	--	60	--	°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

1. When mounted on minimum footprint

**Table 4. Avalanche characteristics**

Symbol	Parameter	Max value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)	10	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j=25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ )	400	mJ

## 2 Electrical characteristics

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

**Figure 2. 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 ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating},$ $V_{DS} = \text{Max rating}, T_c = 125\text{ °C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 100\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}, I_D = 4.5\text{ A}$		0.48	0.55	$\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 8\text{ V}, I_D = 5\text{ A}$	-	11		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 25\text{ V}, f = 1\text{ MHz}, V_{GS} = 0$	-	2030 210 48		pF pF pF
$C_{oss\text{ eq.}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$	-	125		pF
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 480\text{ V}, I_D = 10\text{ A}$ $V_{GS} = 10\text{ V}$ (see Figure 21)	-	66 11 33	92	nC nC nC

1. Pulsed: pulse duration = 300 $\mu\text{s}$ , duty cycle 1.5%
2.  $C_{oss\text{ eq.}}$  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 6. Switching times**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$	Turn-on delay time Rise time	$V_{DD}=300\text{ V}$ , $I_D=5\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ (see Figure 20)	-	22 14	-	ns ns
$t_{d(off)}$ $t_f$	Turn-off delay time Fall time	$V_{DD}=300\text{ V}$ , $I_D=5\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ (see Figure 20)	-	61 12	-	ns ns
$t_{r(Voff)}$ $t_f$ $t_c$	Off-voltage rise time Fall time Cross-over time	$V_{DD}=480\text{ V}$ , $I_D=10\text{ A}$ , $R_G=4.7\ \Omega$ , $V_{GS}=10\text{ V}$ (see Figure 20)	-	10 9 20	-	ns ns ns

**Table 7. Gate-source Zener diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$BV_{GSO}$	Gate-source breakdown voltage	$I_{GS}=\pm 1\text{ mA}$ (open drain)	30	-	-	V

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

**Table 8. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$ $I_{SDM}^{(1)}$	Source-drain current Source-drain current (pulsed)		-		10 40	A A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD}=10\text{ A}$ , $V_{GS}=0$	-		1.6	V
$t_{rr}$ $Q_{rr}$ $I_{RRM}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_{SD}=10\text{ A}$ , $di/dt=100\text{ A}/\mu\text{s}$ , $V_{DD}=35\text{ V}$ , $T_j=150\text{ }^\circ\text{C}$	-	570 4.5 16		ns $\mu\text{C}$ 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 3. Safe operating area for TO-220/D<sup>2</sup>PAK

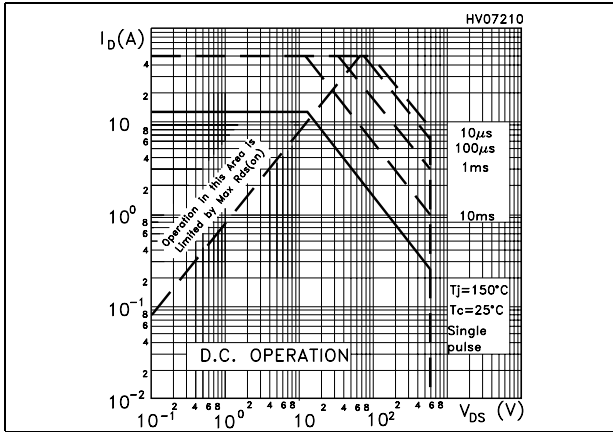


Figure 4. Thermal impedance for TO-220/D<sup>2</sup>PAK

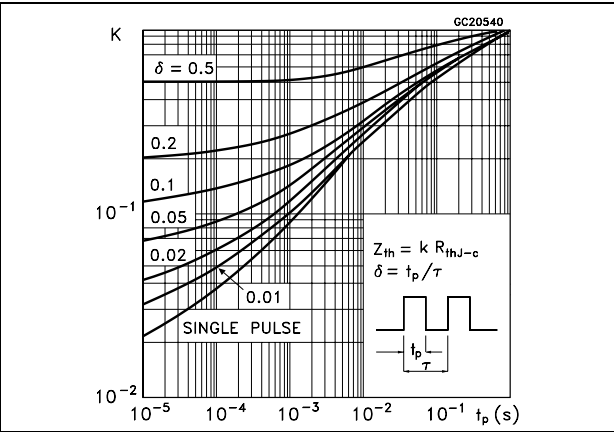


Figure 5. Safe operating area for TO-220FP

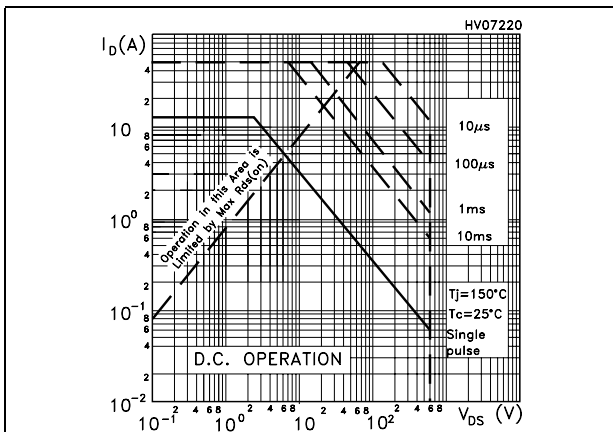


Figure 6. Thermal impedance for TO-220FP

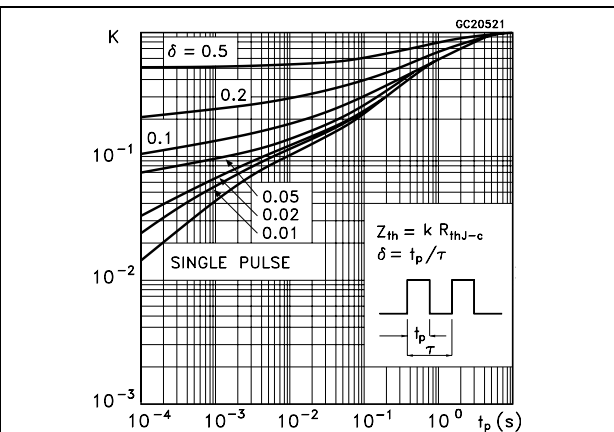


Figure 7. Safe operating area for TO-247

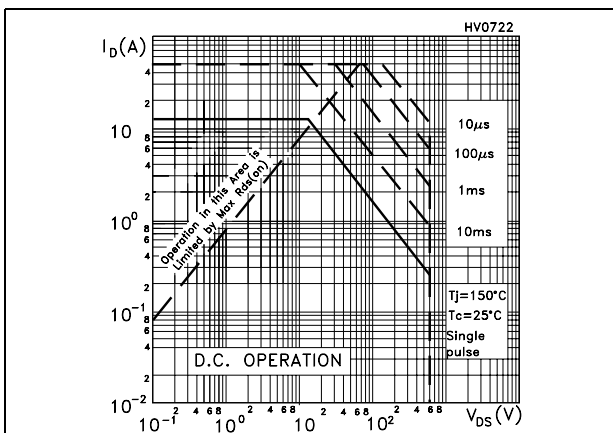


Figure 8. Thermal impedance for TO-247

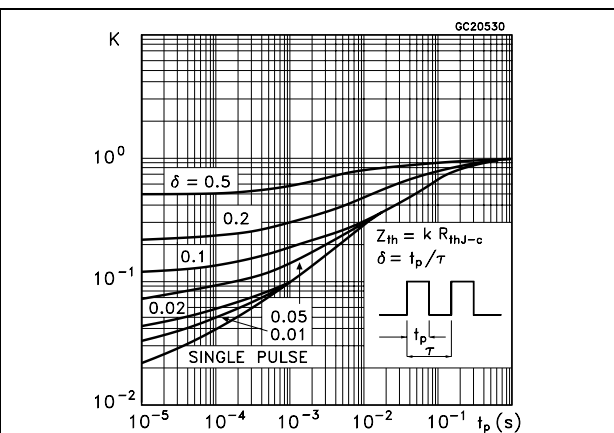


Figure 9. Output characteristics

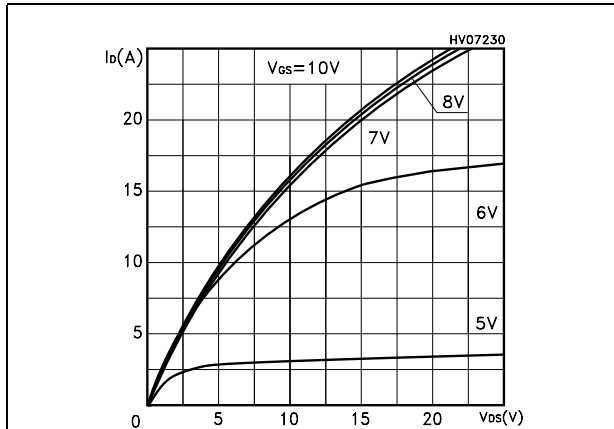


Figure 10. Transfer characteristics

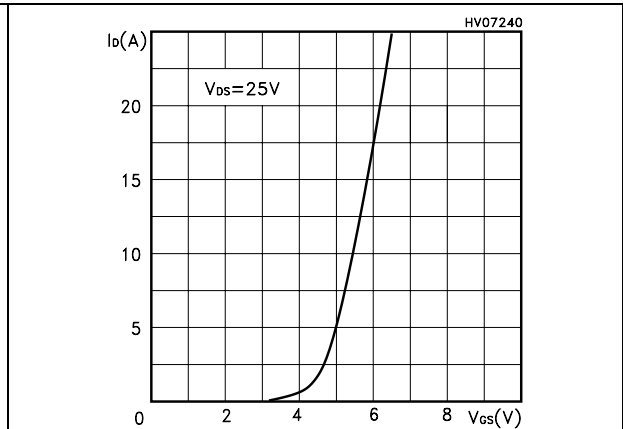


Figure 11. Transconductance

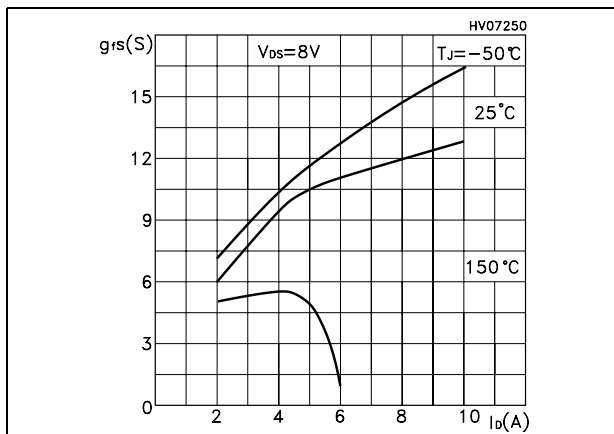


Figure 12. Static drain-source on resistance

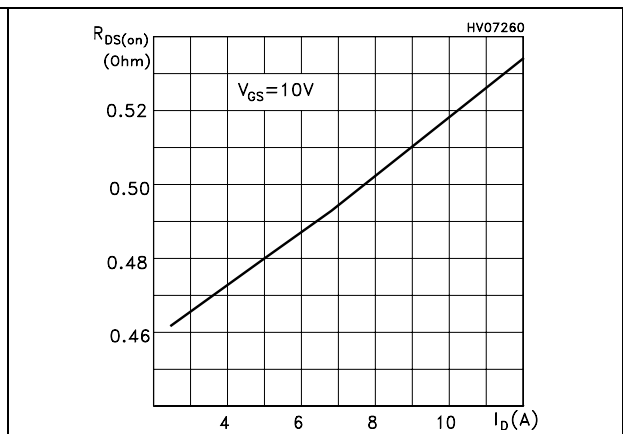


Figure 13. Gate charge vs gate-source voltage Figure 14. Capacitance variations

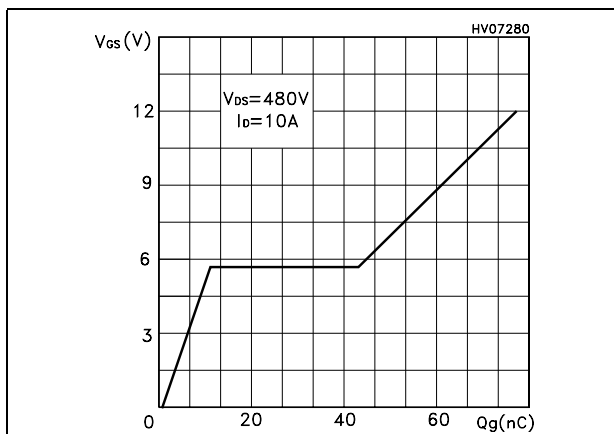


Figure 14. Capacitance variations

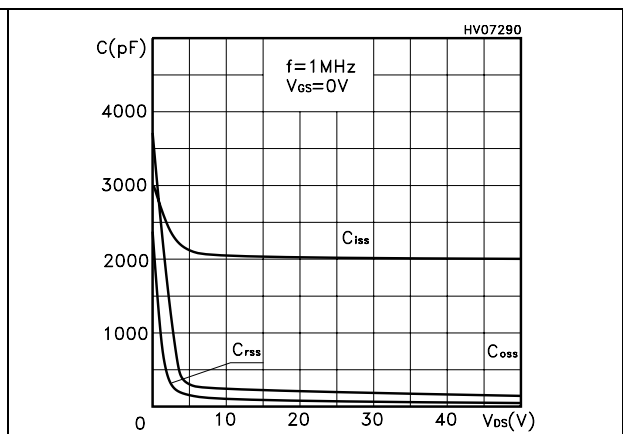




Figure 15. Normalized gate threshold voltage vs temperature

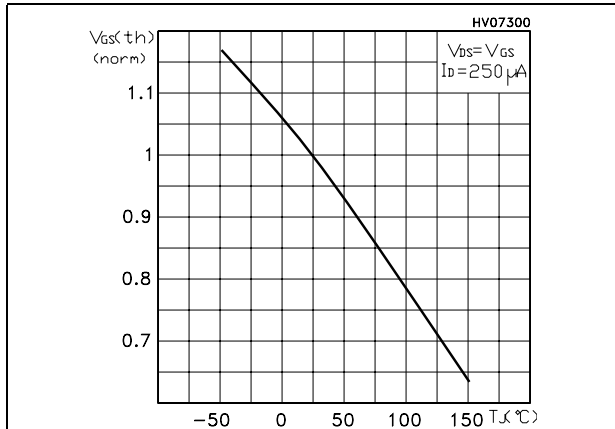


Figure 16. Normalized on resistance vs temperature

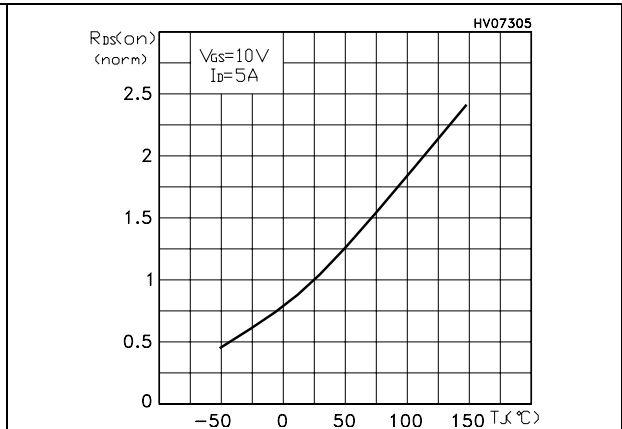


Figure 17. Source-drain diode forward characteristics

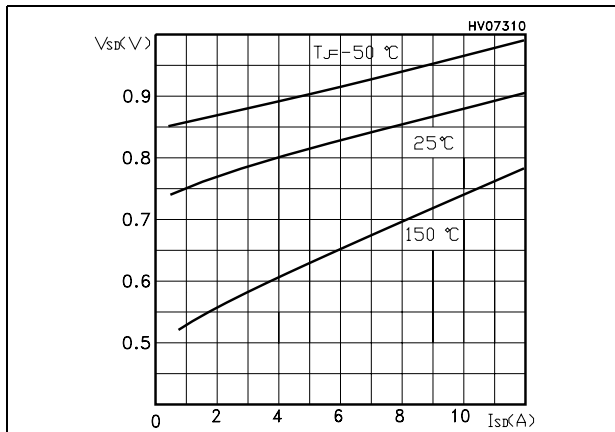


Figure 18. Normalized BV<sub>DSS</sub> vs temperature

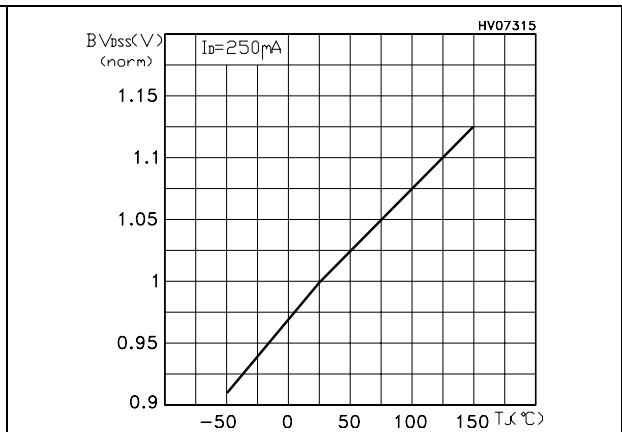
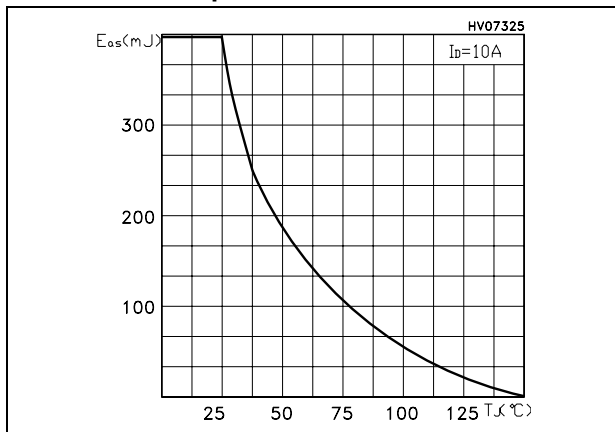
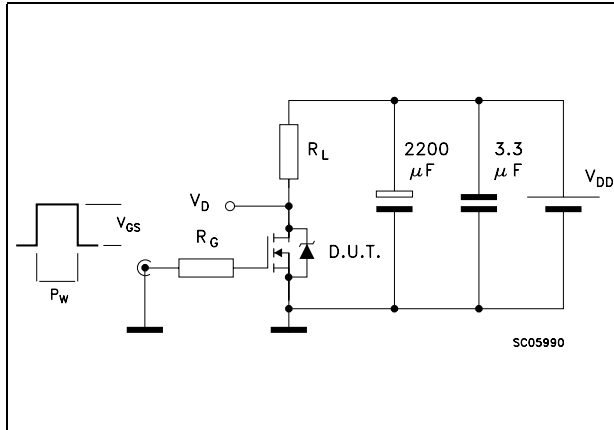


Figure 19. Maximum avalanche energy vs temperature

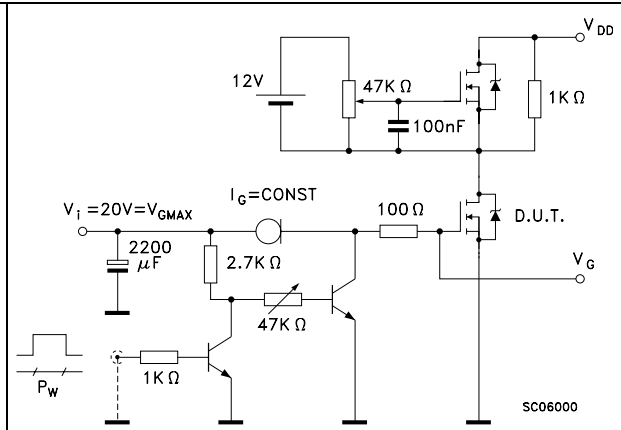


### 3 Test circuits

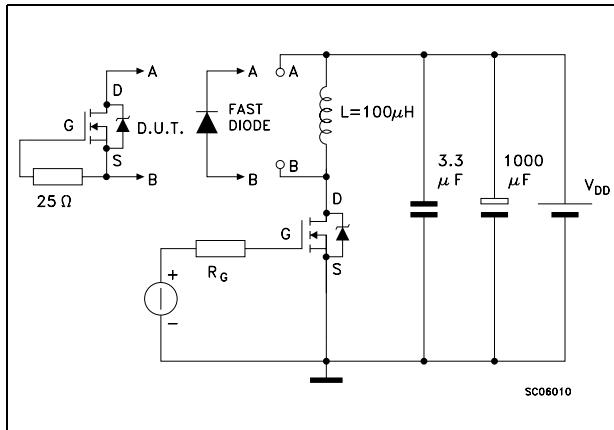
**Figure 20. Switching times test circuit for resistive load**



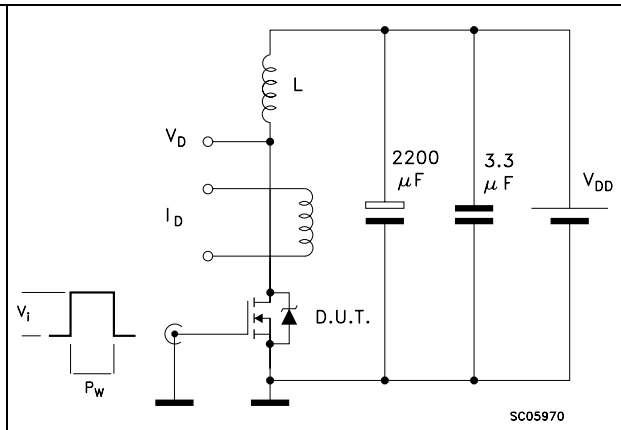
**Figure 21. Gate charge test circuit**



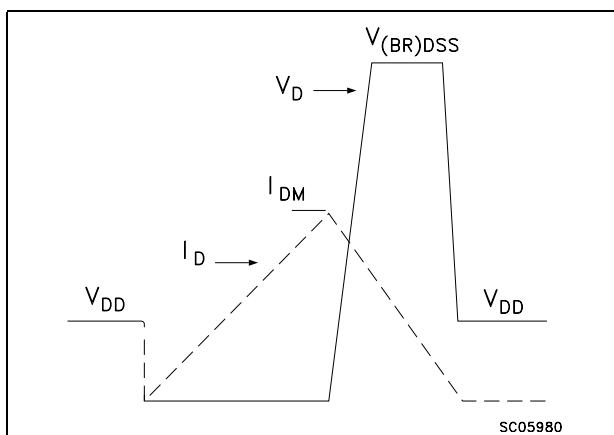
**Figure 22. Test circuit for inductive load switching and diode recovery times**



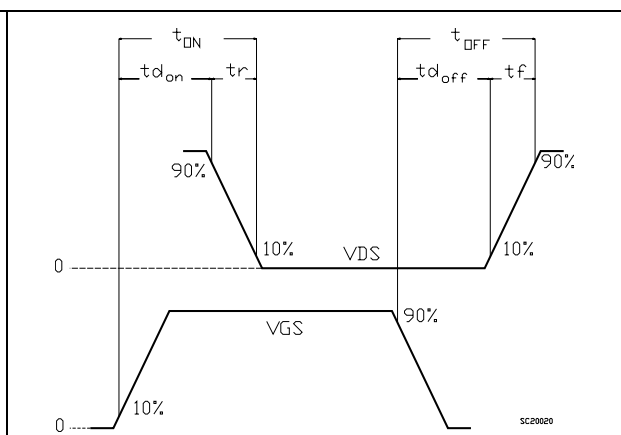
**Figure 23. Unclamped inductive load test circuit**



**Figure 24. Unclamped inductive waveform**



**Figure 25. Switching time waveform**

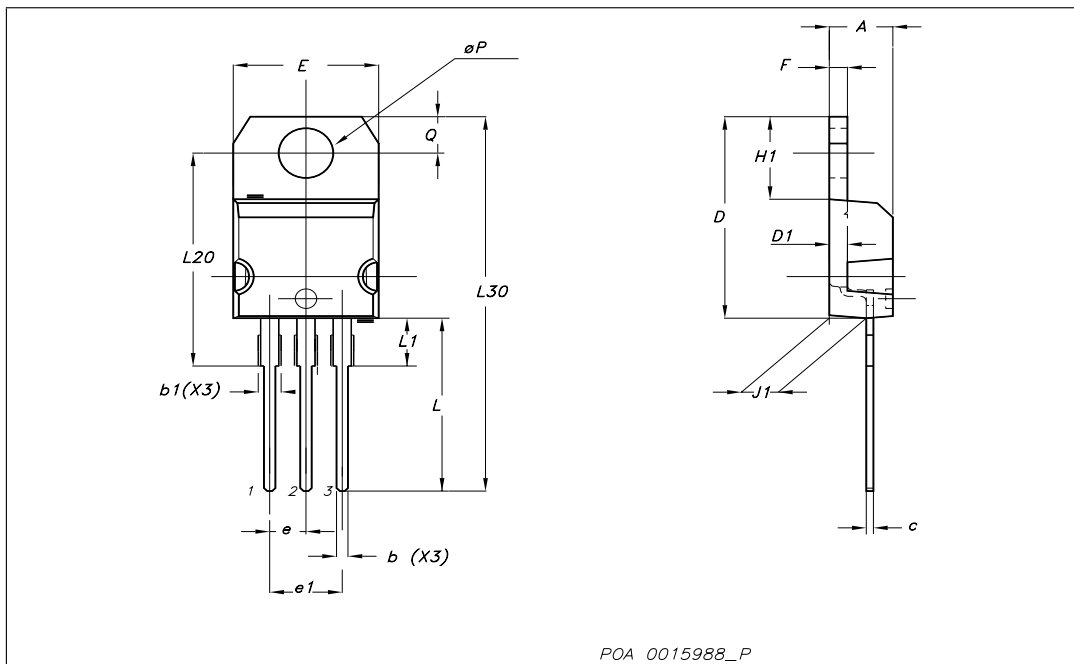


## 4 Package mechanical data

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.

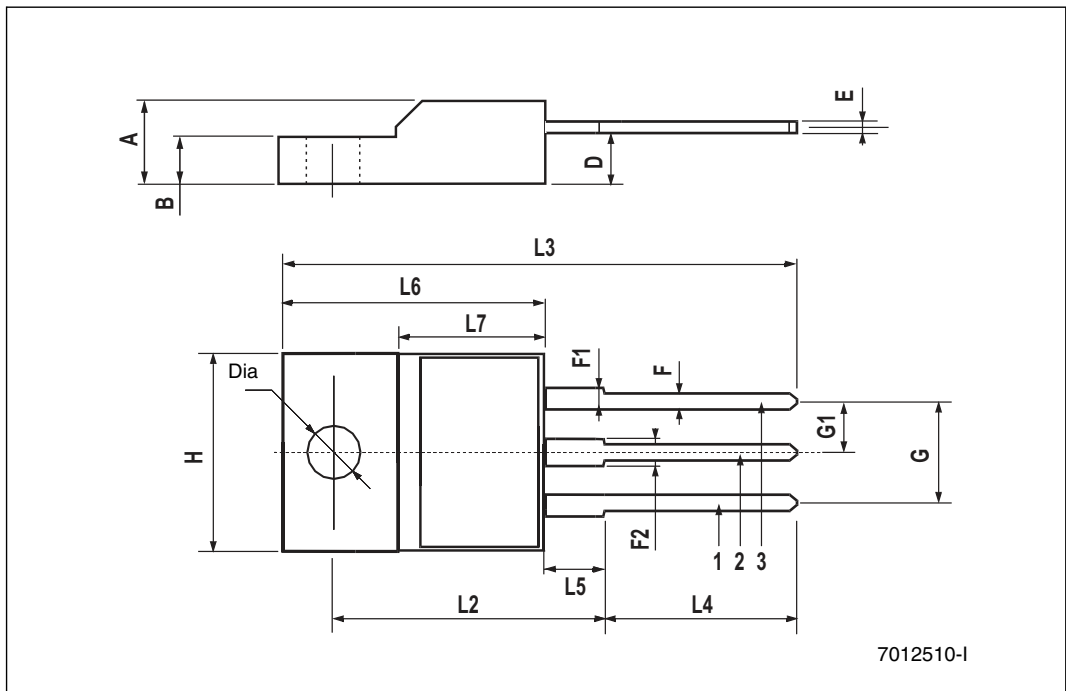
TO-220 mechanical data

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	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.6		0.62
D1		1.27			0.050	
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		0.051
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	
∅P	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



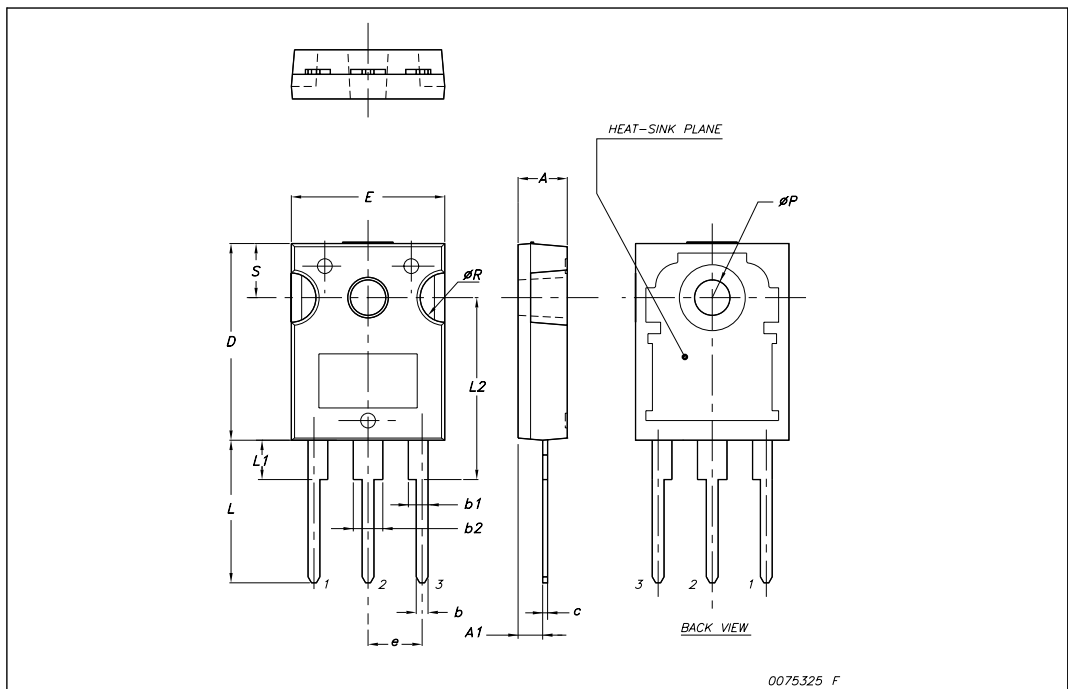
**TO-220FP mechanical data**

Dim.	mm.			inch		
	Min.	Typ	Max.	Min.	Typ.	Max.
A	4.40		4.60	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		0.70	0.017		0.027
F	0.75		1.00	0.030		0.039
F1	1.15		1.50	0.045		0.067
F2	1.15		1.50	0.045		0.067
G	4.95		5.20	0.195		0.204
G1	2.40		2.70	0.094		0.106
H	10		10.40	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.80		10.60	0.385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.90		16.40	0.626		0.645
L7	9		9.30	0.354		0.366
Dia	3		3.2	0.118		0.126



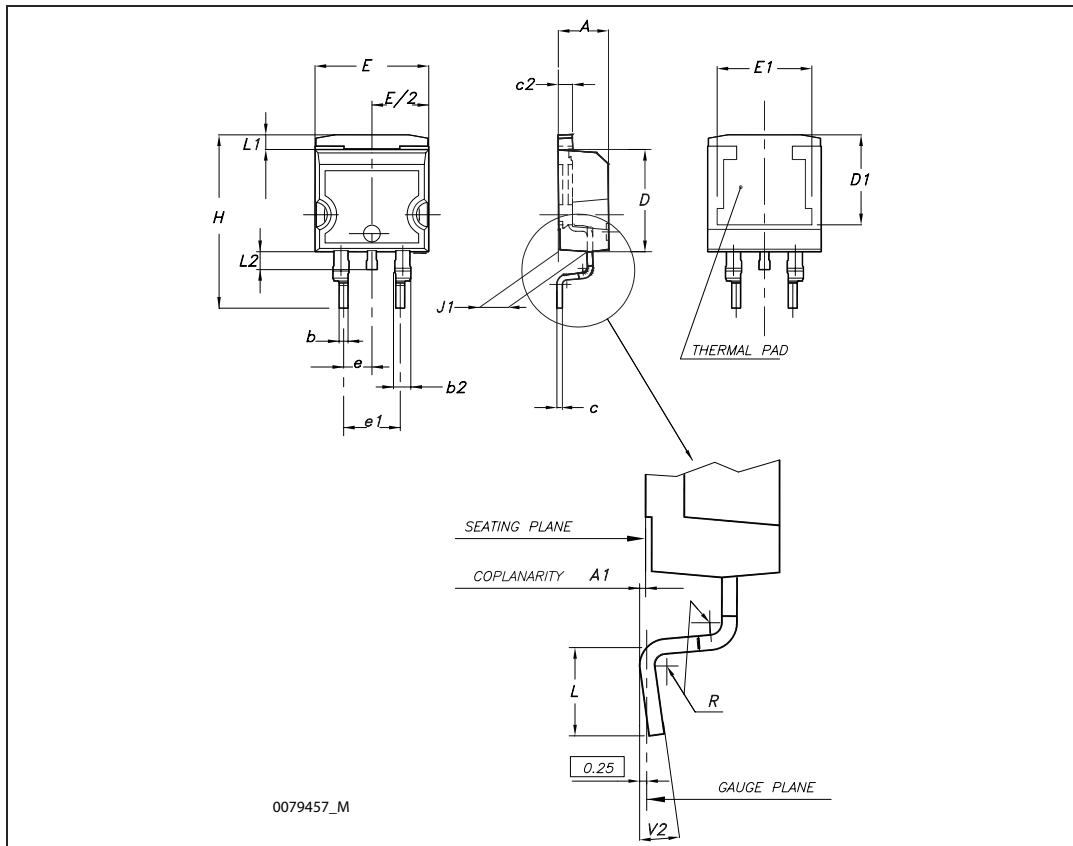
**TO-247 Mechanical data**

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	



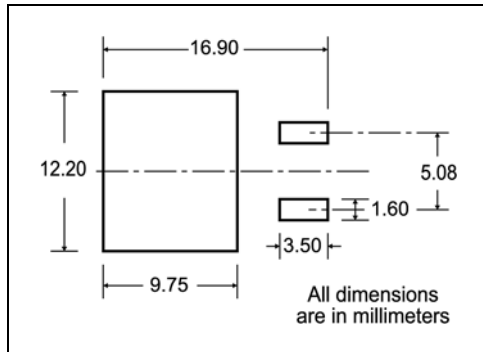
**D<sup>2</sup>PAK (TO-263) mechanical data**

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	4.40		4.60	0.173		0.181
A1	0.03		0.23	0.001		0.009
b	0.70		0.93	0.027		0.037
b2	1.14		1.70	0.045		0.067
c	0.45		0.60	0.017		0.024
c2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1	7.50			0.295		
E	10		10.40	0.394		0.409
E1	8.50			0.334		
e		2.54			0.1	
e1	4.88		5.28	0.192		0.208
H	15		15.85	0.590		0.624
J1	2.49		2.69	0.099		0.106
L	2.29		2.79	0.090		0.110
L1	1.27		1.40	0.05		0.055
L2	1.30		1.75	0.051		0.069
R		0.4			0.016	
V2	0°		8°	0°		8°



# 5 Packing 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

\* on sales type



## 6 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
20-Sep-2005	4	
05-Oct-2005	5	Inserted ECOPACK® indication
29-Feb-2008	6	V <sub>ISO</sub> parameter on <a href="#">Table</a> has been updated
15-Apr-2009	7	Order codes in <a href="#">Table 1: Device summary</a> has been changed

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