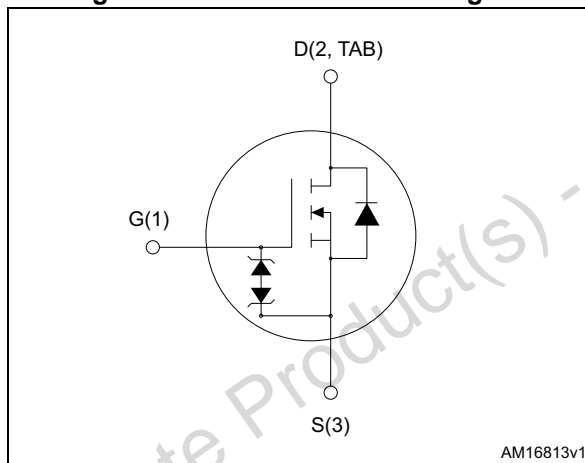


Figure 1. Internal schematic diagram



### Features

Type	V <sub>DS</sub>	R <sub>DS(on)</sub> max.	I <sub>D</sub>	P <sub>TOT</sub>
STF9NK60ZD	600 V	< 0.95 $\Omega$	7 A	30 W
STP9NK60ZD	600 V	< 0.95 $\Omega$	7 A	125 W

- Very high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Low intrinsic capacitances
- Fast internal recovery diode

### Application

- Switching applications

### Description

The SuperFREDMesh™ series associates all advantages of reduced on-resistance, Zener gate protection and very high dv/dt capability with a fast body-drain recovery diode. Such series complements the "FDmesh™" advanced technology.

Table 1. Device summary

Order code	Marking	Package	Packaging
STF9NK60ZD	F9NK60ZD	TO-220FP	Tube
STP9NK60ZD	P9NK60ZD	TO-220	Tube



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Obsolete Product(s) - Obsolete Product(s)





# 1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$V_{DS}$	Drain-source voltage	600		V
$V_{GS}$	Gate-source voltage	$\pm 30$		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$	7	7 <sup>(1)</sup>	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$	4.3	4.3 <sup>(1)</sup>	A
$I_{DM}^{(2)}$	Drain current (pulsed)	28	28 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$	125	30	W
	Derating factor	1	0.24	W/ $^{\circ}\text{C}$
$V_{ESD(G-S)}$	Gate-source ESD (HBM-C=100 pF, R=1.5 k $\Omega$ )	4000		V
$dv/dt^{(3)}$	Peak diode recovery voltage slope	15		V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; $T_C = 25\text{ }^{\circ}\text{C}$ )		2500	V
$T_j$ $T_{stg}$	Operating junction temperature Storage temperature	-55 to 150		$^{\circ}\text{C}$

1. Limited only by maximum temperature allowed.
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 7\text{ A}$ ,  $di/dt \leq 500\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\%V_{(BR)DSS}$ .

Table 3. Thermal data

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$R_{thj-pcb}$	Thermal resistance junction-pcb max. (when mounted on minimum footprint)	30		$^{\circ}\text{C}/\text{W}$
$R_{thj-case}$	Thermal resistance junction-case max.	1	4.16	$^{\circ}\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-ambient max.	62.5		$^{\circ}\text{C}/\text{W}$
$T_I$	Maximum lead temperature for soldering purpose	300		$^{\circ}\text{C}$



Table 4. Avalanche characteristics

Symbol	Parameter	Max. value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max.)	7	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	235	mJ



## 2 Electrical characteristics

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

**Table 5. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(\text{BR})\text{DSS}}$	Drain-source breakdown voltage	$I_D = 1\text{ mA}$ , $V_{\text{GS}} = 0$	600			V
$I_{\text{DSS}}$	Zero gate voltage drain current ( $V_{\text{GS}} = 0$ )	$V_{\text{DS}} = \text{max. rating}$ $V_{\text{DS}} = \text{max. rating}$ , $T_C = 125\text{ }^{\circ}\text{C}$			1 50	$\mu\text{A}$ $\mu\text{A}$
$I_{\text{GSS}}$	Gate-body leakage current ( $V_{\text{DS}} = 0$ )	$V_{\text{GS}} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{\text{GS(th)}}$	Gate threshold voltage	$V_{\text{DS}} = V_{\text{GS}}$ , $I_D = 100\text{ }\mu\text{A}$	2.5	3.5	4.5	V
$R_{\text{DS(on)}}$	Static drain-source on-resistance	$V_{\text{GS}} = 10\text{ V}$ , $I_D = 3.5\text{ A}$		0.85	0.95	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{\text{fs}}^{(1)}$	Forward transconductance	$V_{\text{DS}} = 15\text{ V}$ , $I_D = 3.5\text{ A}$	-	5.3		S
$C_{\text{iss}}$ $C_{\text{oss}}$ $C_{\text{rss}}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{\text{DS}} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{\text{GS}} = 0$	-	1110 135 30		pF pF pF
$C_{\text{oss eq}}^{(2)}$	Equivalent output capacitance	$V_{\text{GS}} = 0$ , $V_{\text{DS}} = 0\text{ to }480\text{ V}$	-	72		pF
$Q_g$ $Q_{\text{gs}}$ $Q_{\text{gd}}$	Total gate charge Gate-source charge Gate-drain charge	$V_{\text{DD}} = 480\text{ V}$ , $I_D = 7\text{ A}$ , $V_{\text{GS}} = 10\text{ V}$ (see <a href="#">Figure 17</a> )	-	41 8.7 21	53	nC nC nC

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

2.  $C_{\text{oss eq}}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{\text{oss}}$  when  $V_{\text{DS}}$  increases from 0 to 80%  $V_{\text{DSS}}$ .



Table 7. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 3.5\text{ A}$ $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ <a href="#">Figure 16</a>	-	11.4	-	ns
$t_r$	Rise time			13.6		ns
$t_{d(off)}$	Turn-off-delay time			23.1		ns
$t_f$	Fall time			15		ns
$t_{r(Voff)}$	Off-voltage rise time	$V_{DD} = 480\text{ V}$ , $I_D = 7\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ <a href="#">Figure 16</a>	-	11	-	ns
$t_f$	Fall time			8		ns
$t_c$	Cross-overtime			20		ns

Table 8. Source-drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		7	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				28	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 7\text{ A}$ , $V_{GS} = 0$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 7\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 30\text{ V}$ <a href="#">Figure 21</a>	-	130		ns
$Q_{rr}$	Reverse recovery charge			550		nC
$I_{RRM}$	Reverse recovery current			8.4		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 7\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 30\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ <a href="#">Figure 21</a>	-	176		ns
$Q_{rr}$	Reverse recovery charge			880		nC
$I_{RRM}$	Reverse recovery current			10		A

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

Table 9. Gate-source Zener diode

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

1. 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.



## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

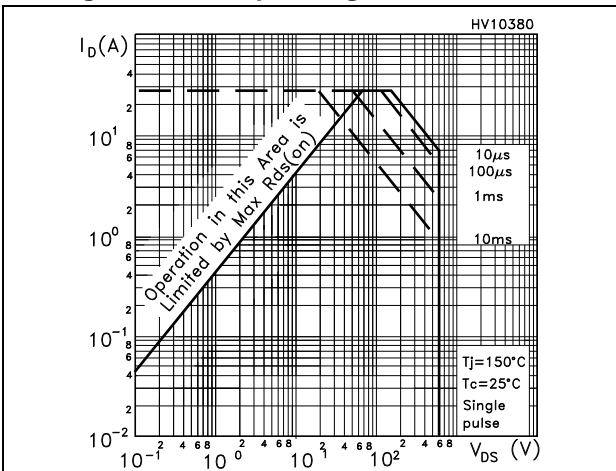


Figure 3. Thermal impedance for TO-220

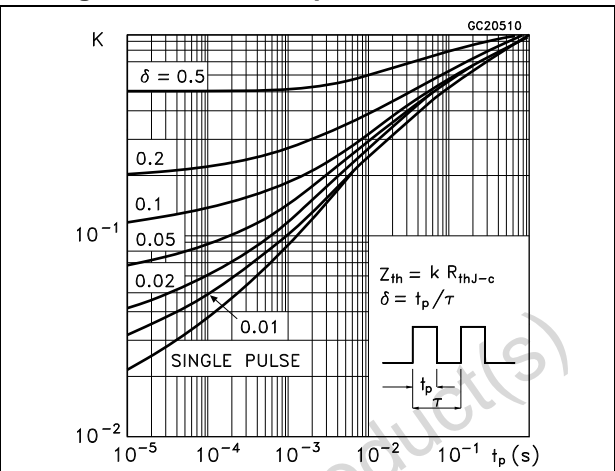


Figure 4. Safe operating area for TO-220FP

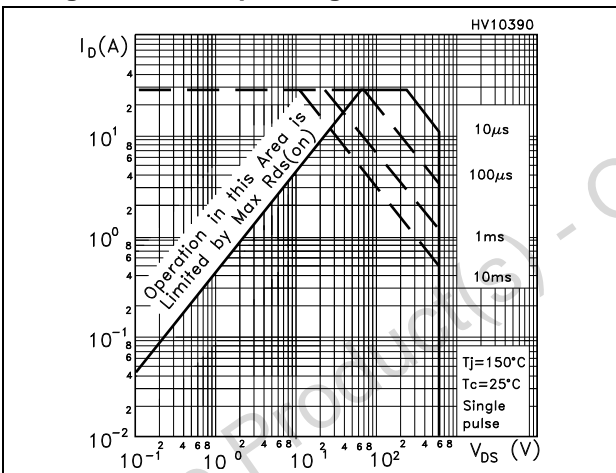


Figure 5. Thermal impedance for TO-220FP

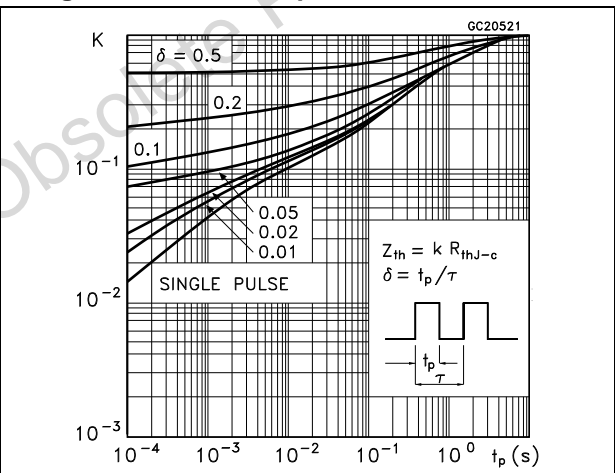


Figure 6. Output characteristics

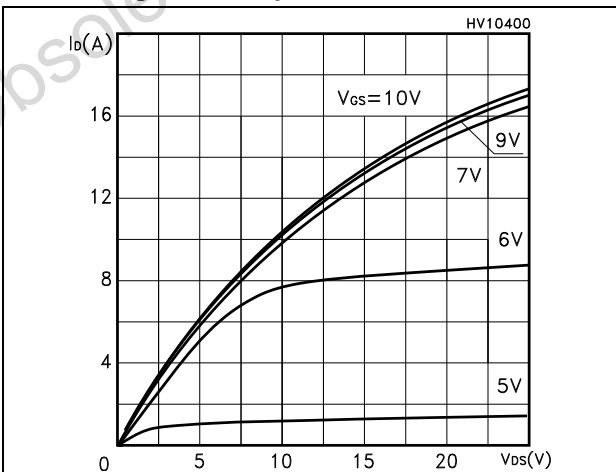


Figure 7. Transfer characteristics

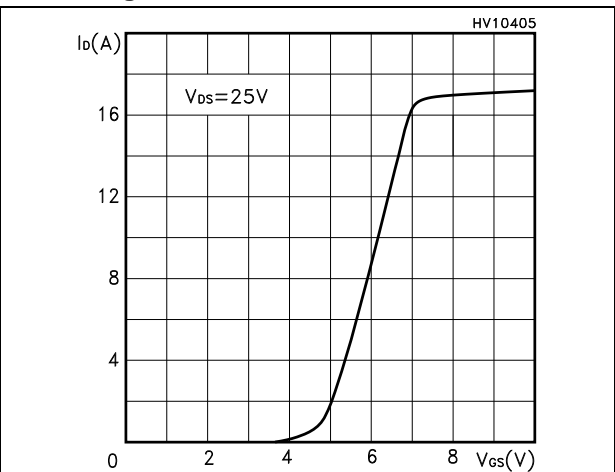




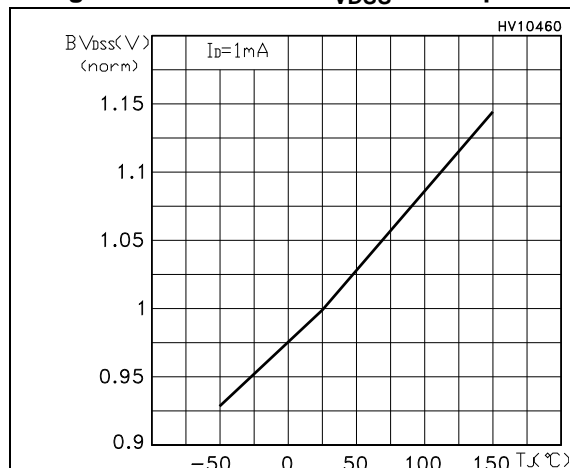
Figure 8. Normalized  $B_{V_{DS}}$  vs temperature

Figure 9. Static drain-source on-resistance

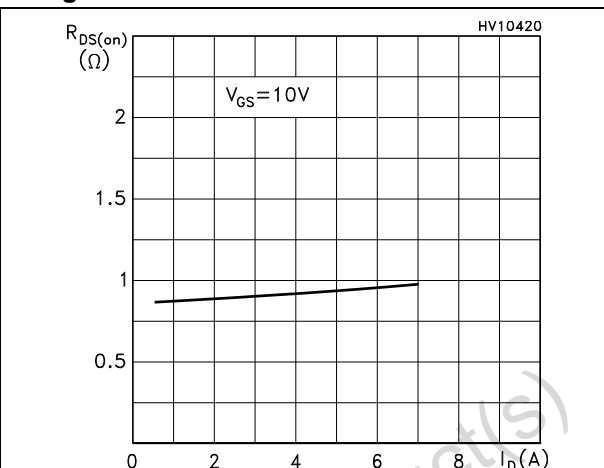


Figure 10. Gate charge vs gate-source voltage

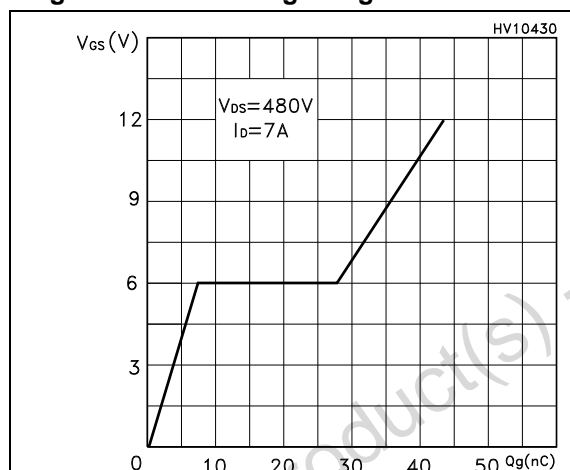


Figure 11. Capacitance variations

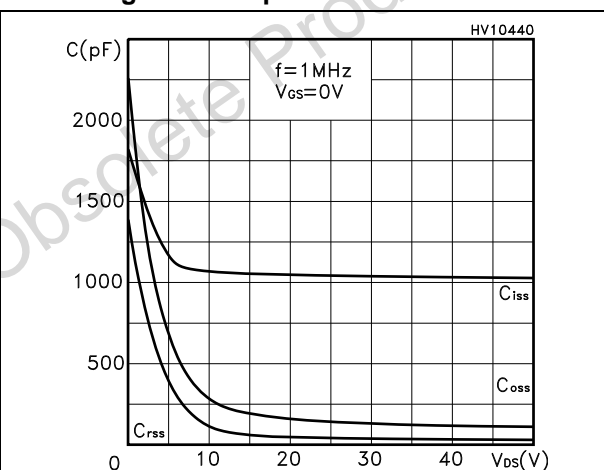


Figure 12. Normalized gate threshold voltage vs temperature

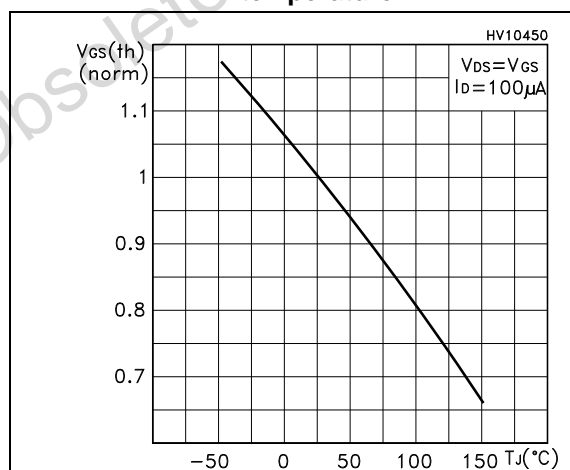


Figure 13. Normalized on-resistance vs temperature

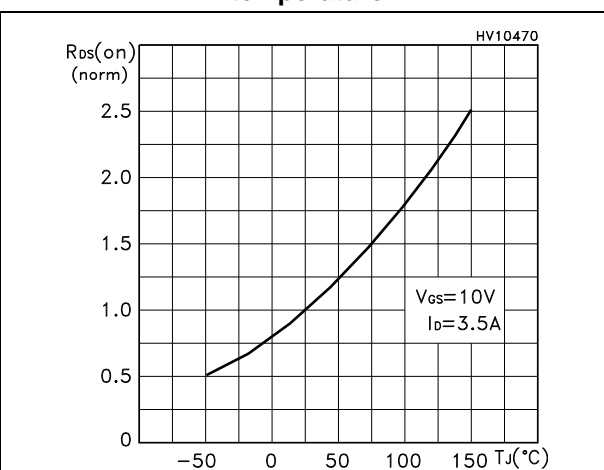




Figure 14. Source-drain diode forward characteristics

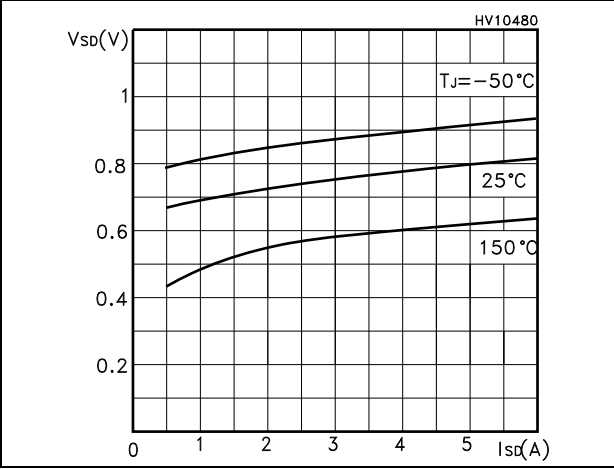
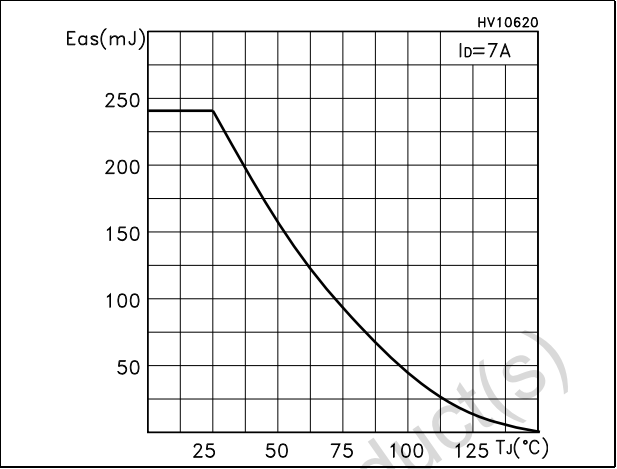


Figure 15. Maximum avalanche energy vs temperature





### 3 Test circuits

Figure 16. Switching time test circuit for resistive load

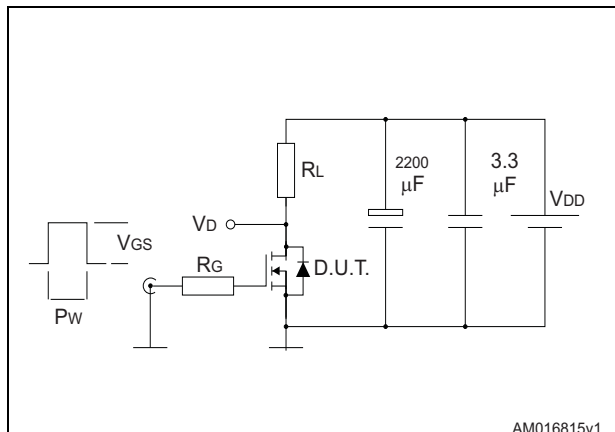


Figure 17. Gate charge test circuit

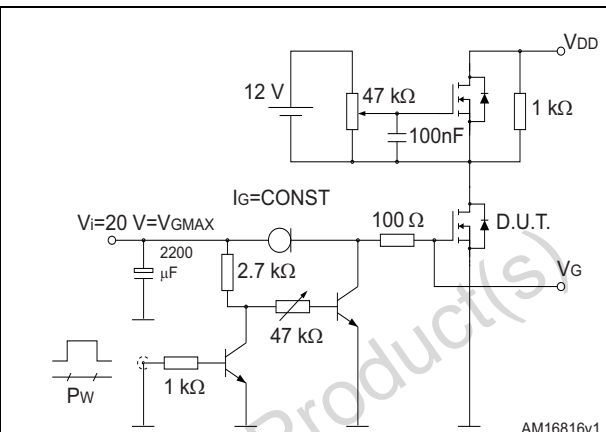


Figure 18. Test circuit for inductive load switching and diode recovery times

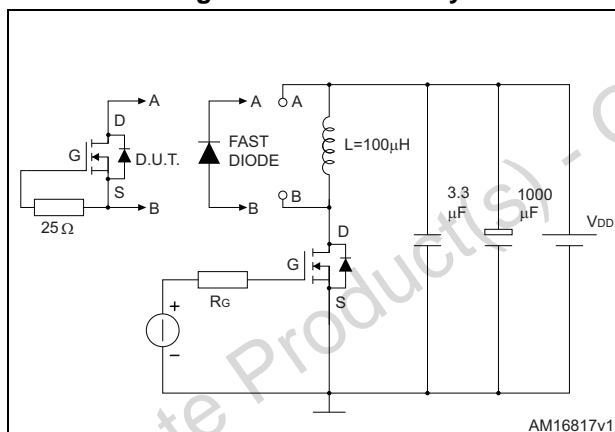


Figure 19. Unclamped inductive load test circuit

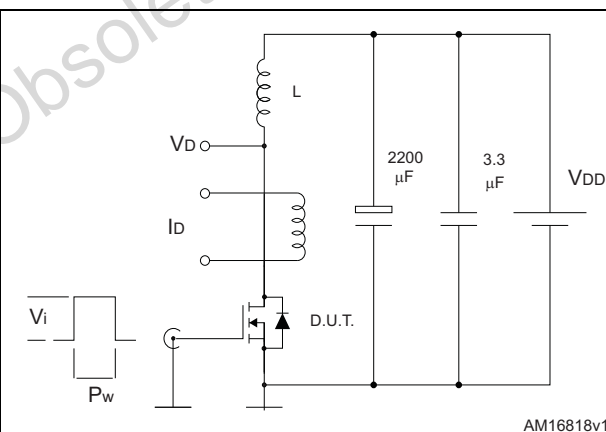


Figure 20. Unclamped inductive waveform

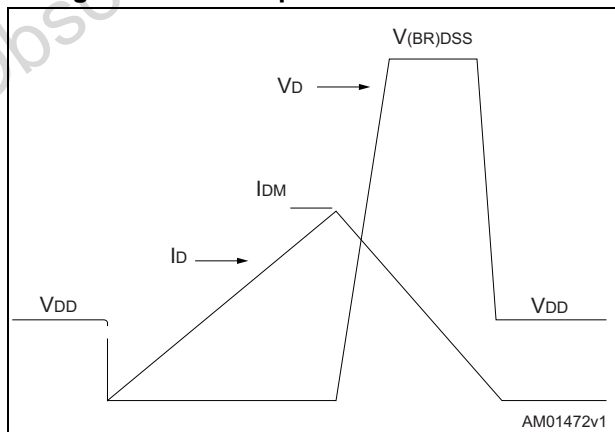
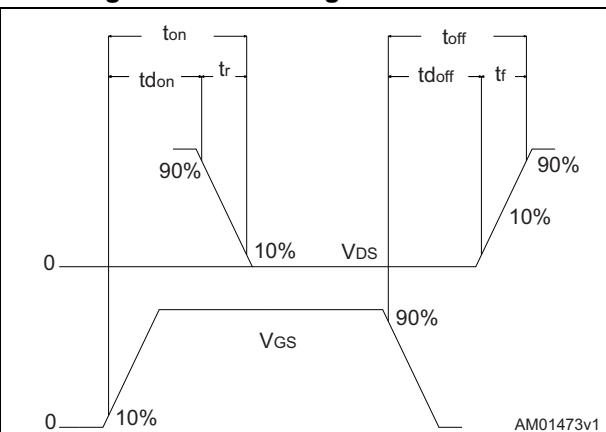


Figure 21. Switching time waveform





## 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<sup>®</sup> is an ST trademark.

**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



Figure 22. TO-220 drawing

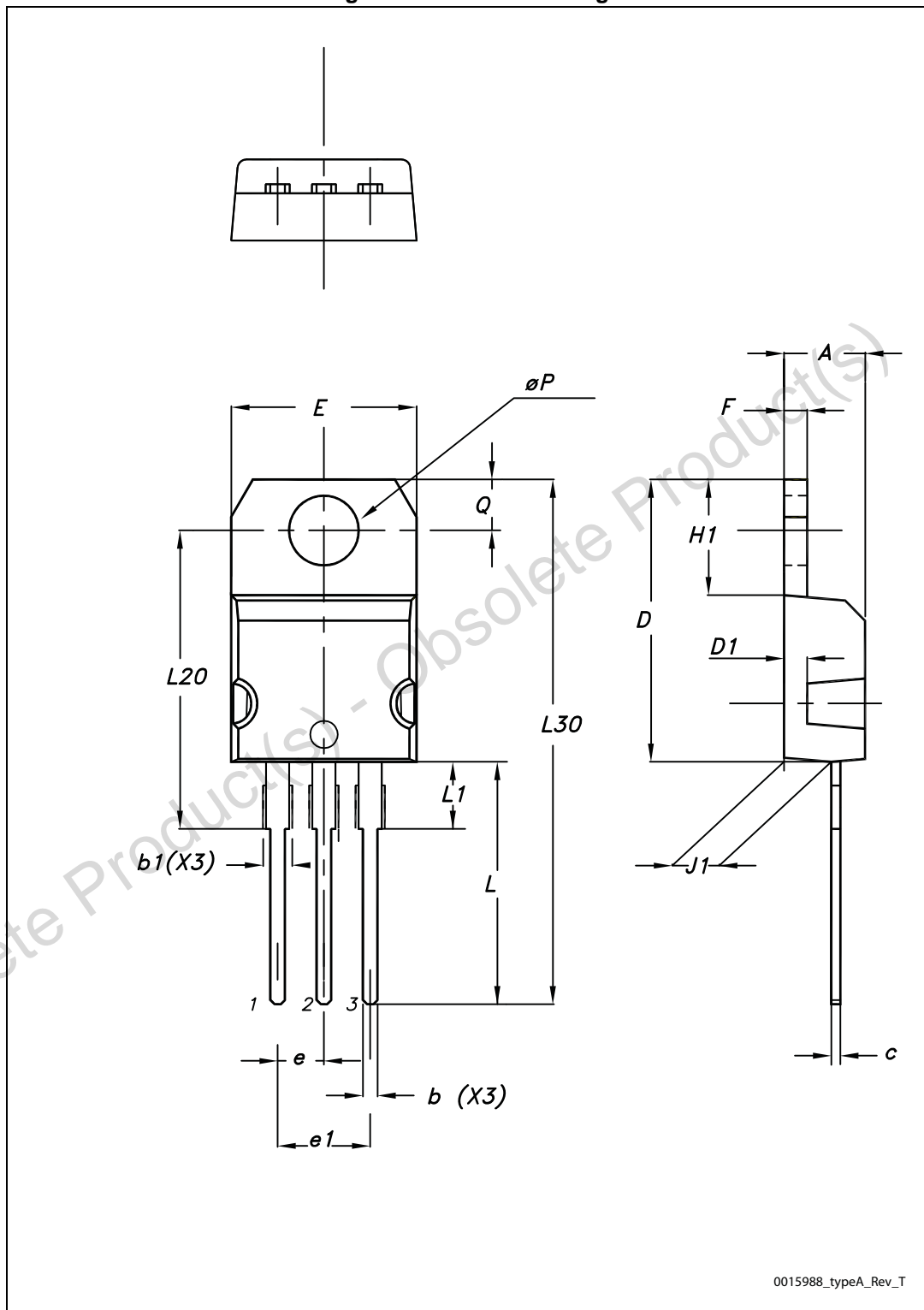


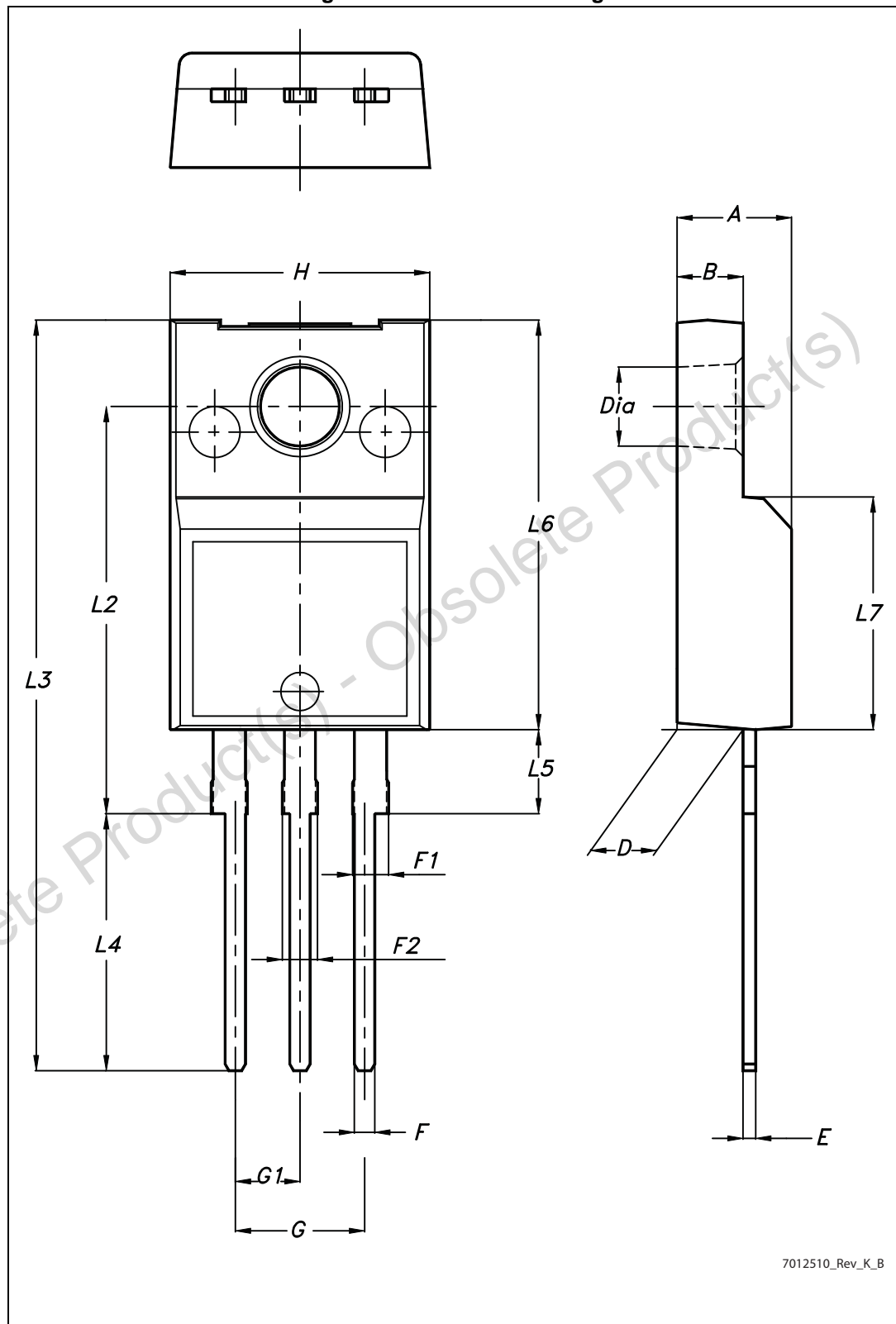


Table 11. TO-220FP mechanical data

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





## 5 Revision history

**Table 12. Document revision history**

Date	Revision	Changes
19-Jul-2013	1	First release. The part numbers STF9NK60ZD and STP9NK60ZD were previously included in datasheet with DocID9573.



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