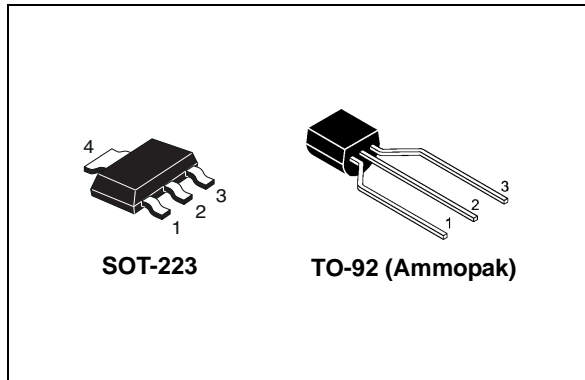


## N-channel 600 V, 13 $\Omega$ typ., 0.3 A Zener-protected SuperMESH™ Power MOSFETs in SOT-223 and TO-92 packages

Datasheet - production data



### Features

Order codes	$V_{DS}$	$R_{DS(on)max}$	$I_D$	$P_{TOT}$
STN1NK60Z	600 V	15 $\Omega$	0.3 A	3.3 W
STQ1NK60ZR-AP				3 W

- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- ESD improved capability
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of dv/dt capability for the most demanding applications.

Figure 1. Internal schematic diagram

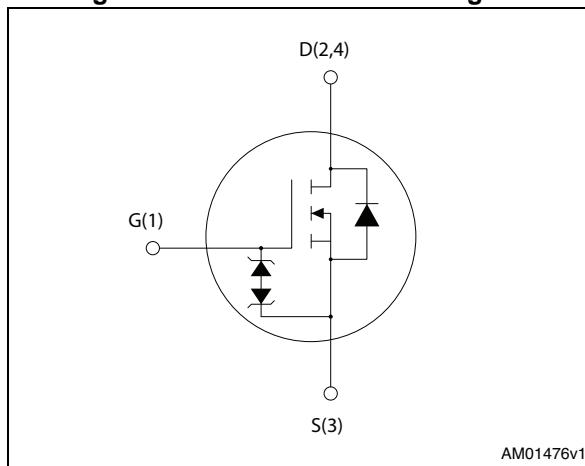


Table 1. Device summary

Order codes	Marking	Package	Packaging
STN1NK60Z	1NK60Z	SOT-223	Tape and reel
STQ1NK60ZR-AP	1NK60ZR	TO-92	Ammopak

# Contents

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- 2      Electrical characteristics ..... 4**
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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		SOT-223	TO-92	
$V_{DS}$	Drain-source voltage	600		V
$V_{GS}$	Gate-source voltage	± 30		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	0.3		A
$I_D$	Drain current (continuous) at $T_C = 100\text{ °C}$	0.189		A
$I_{DM}^{(1)}$	Drain current (pulsed)	1.2		A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	3.3	3	W
	Derating factor	0.026	0.024	W/°C
ESD	Human body model C=100 pF, R=1.5 kΩ	800		V
$dv/dt^{(2)}$	Peak diode recovery voltage slope	4.5		V/ns
$T_J$	Operating junction temperature	- 55 to 150		°C
$T_{stg}$	Storage temperature			°C

1. Pulse width limited by safe operating area
2.  $I_{SD} \leq 0.3\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\%V_{(BR)DSS}$

**Table 3. Thermal resistance**

Symbol	Parameter	Value		Unit
		SOT-223	TO-92	
$R_{thj-amb}$	Thermal resistance junction-ambient max	38 <sup>(1)</sup>	120	°C/W
$R_{thj-lead}$	Thermal resistance junction-lead max		40	°C/W

1. When mounted on 1 inch<sup>2</sup> FR-4 board, 2 Oz Cu, t < 30 s.

**Table 4. Avalanche data**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )	0.3	A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	60	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	$V_{GS} = 0, I_D = 1\text{ mA}$	600			V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0, V_{DS} = 600\text{ V}$			1	$\mu\text{A}$
		$V_{GS} = 0, V_{DS} = 600\text{ V}, T_C = 125\text{ °C}$			50	$\mu\text{A}$
$I_{GSS}$	Gate body leakage current	$V_{DS} = 0, V_{GS} = \pm 20\text{ V}$			$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 50\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on- resistance	$V_{GS} = 10\text{ V}, I_D = 0.4\text{ A}$		13	15	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 15\text{ V}, I_D = 0.4\text{ A}$	-	0.5		S
$C_{ISS}$	Input capacitance	$V_{GS} = 0, V_{DS} = 25\text{ V}, f = 1\text{ MHz}$	-	94		pF
$C_{OSS}$	Output capacitance		-	17.6		pF
$C_{RSS}$	Reverse transfer capacitance		-	2.8		pF
$C_{OSS\text{ eq}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0, V_{DS} = 0\text{ to }480\text{ V}$	-	11		pF
$Q_g$	Total gate charge	$V_{DD} = 480\text{ V}, I_D = 0.8\text{ A}$	-	4.9	6.9	nC
$Q_{gs}$	Gate-source charge	$V_{GS} = 10\text{ V}$	-	1		nC
$Q_{gd}$	Gate-drain charge	(see Figure 19)	-	2.7		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 7. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}$ , $I_D = 0.4\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see Figure 18)	-	5.5	-	ns
$t_r$	Rise time		-	5	-	ns
$t_{d(off)}$	Turn-off delay time		-	13	-	ns
$t_f$	Fall time		-	28	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		0.8	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		2.4	A
$V_{SD}^{(2)}$	Forward on voltage	$V_{GS}=0$ , $I_{SD} = 0.8\text{ A}$	-		1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 0.8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 20\text{ V}$	-	135		ns
$Q_{rr}$	Reverse recovery charge		-	216		nC
$I_{RRM}$	Reverse recovery current		-	3.2		A
$t_{rr}$	Reverse recovery time	$I_{SD} = 0.8\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 20\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$	-	140		ns
$Q_{rr}$	Reverse recovery charge		-	224		nC
$I_{RRM}$	Reverse recovery current		-	3.2		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
$V_{(BR)GSO}$	Gate-source breakdown voltage	$I_{GS} = \pm 1\text{ mA}$ , $I_D=0$	30	-	-	V

The built-in back-to-back Zener diodes have specifically been designed to enhance the device's ESD capability. 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 SOT-223

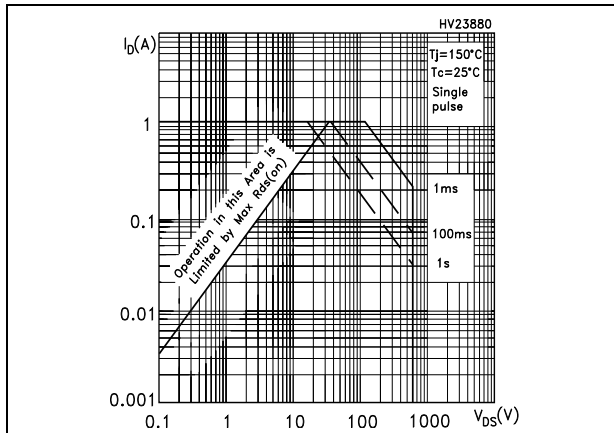


Figure 3. Thermal impedance for SOT-223

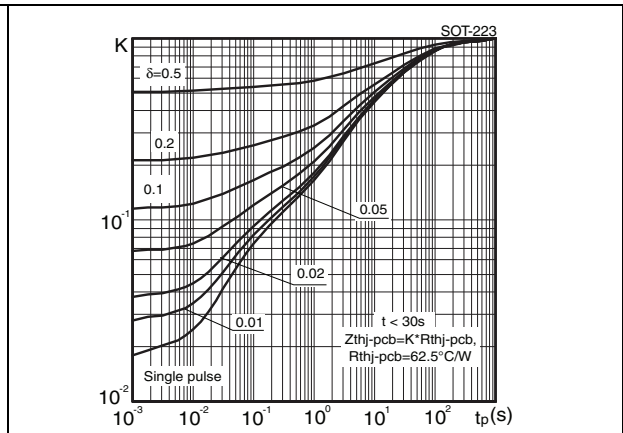


Figure 4. Safe operating area for TO-92

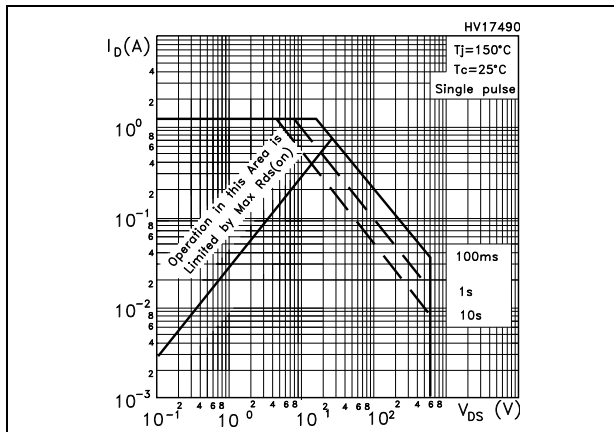


Figure 5. Thermal impedance for TO-92

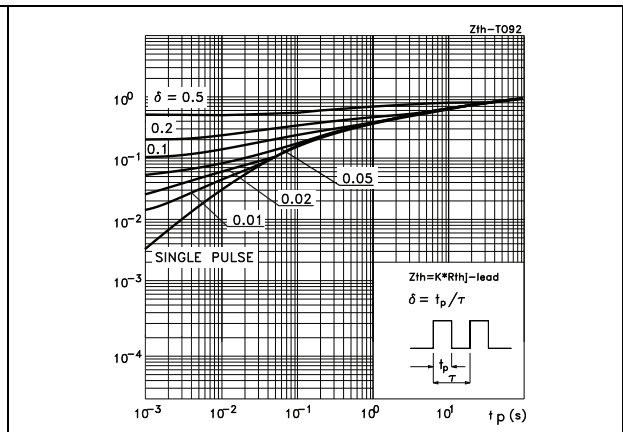


Figure 6. Output characteristics

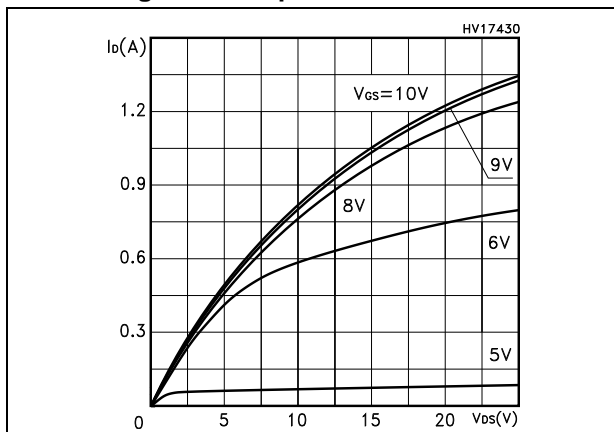


Figure 7. Transfer characteristics

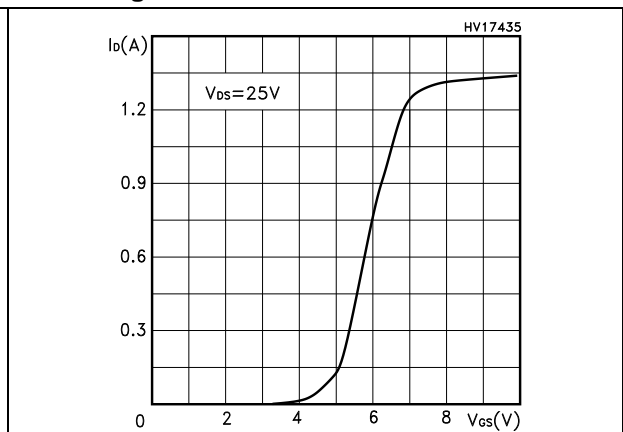


Figure 8. Transconductance

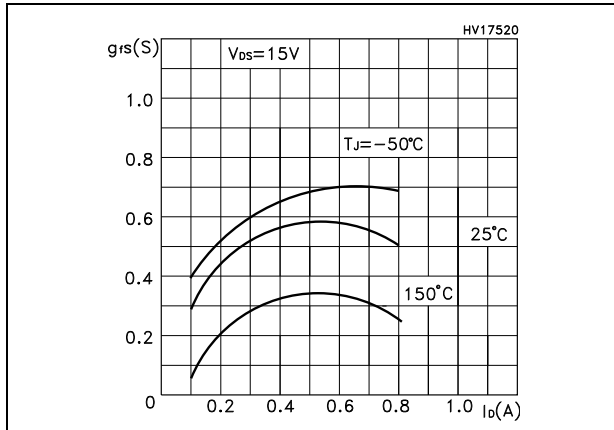


Figure 9. Static drain-source on-resistance

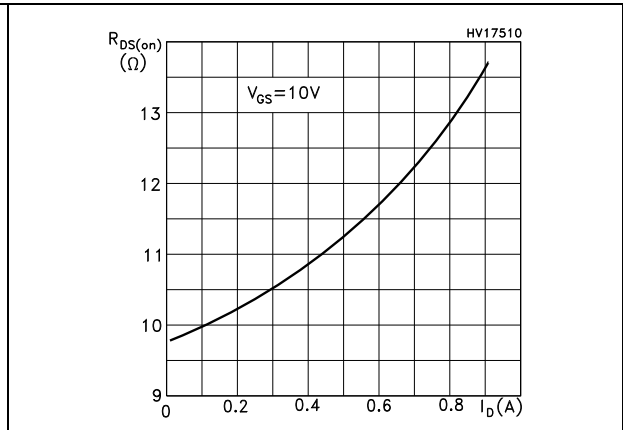


Figure 10. Gate charge vs gate-source voltage

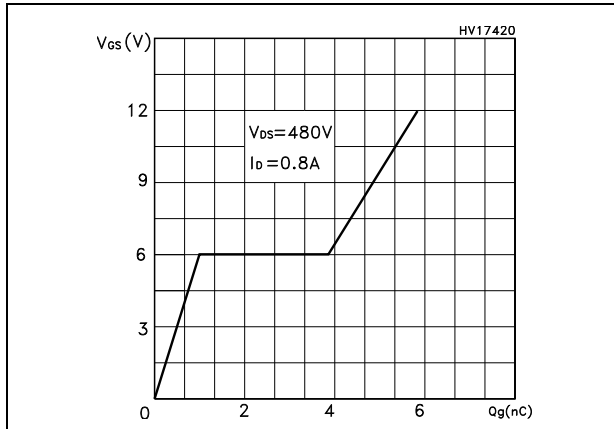


Figure 11. Capacitance variations

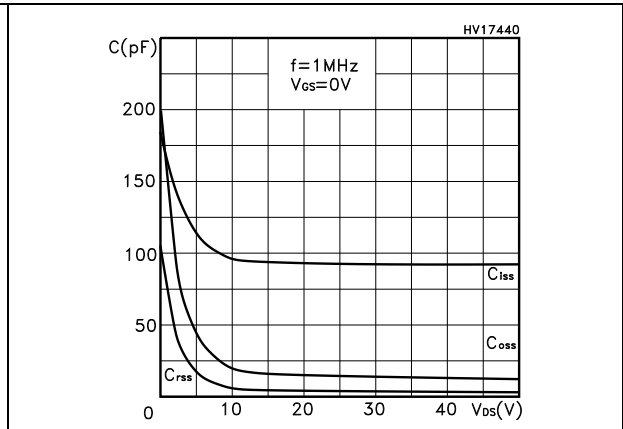


Figure 12. Normalized gate threshold voltage vs temperature

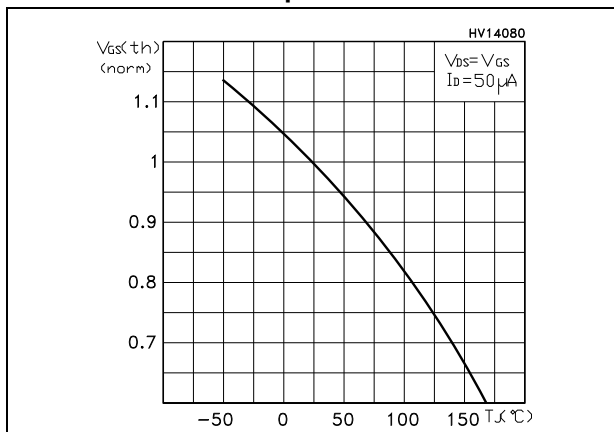


Figure 13. Normalized on-resistance vs temperature

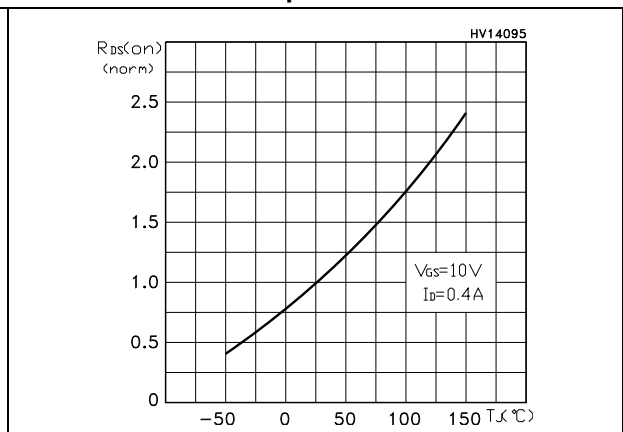


Figure 14. Source-drain diode forward characteristics

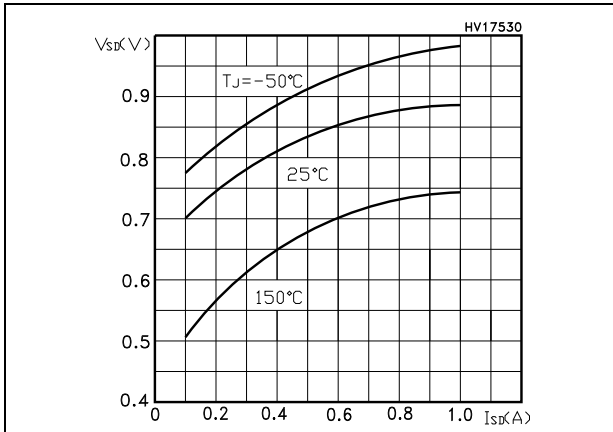


Figure 15. Normalized  $V_{BR(DSS)}$  vs temperature

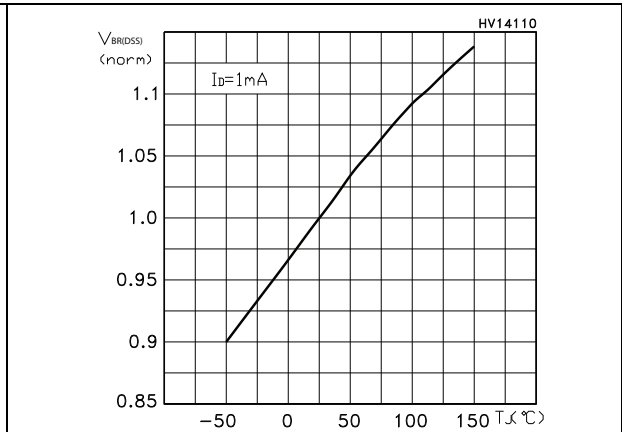


Figure 16. Maximum avalanche energy vs temperature

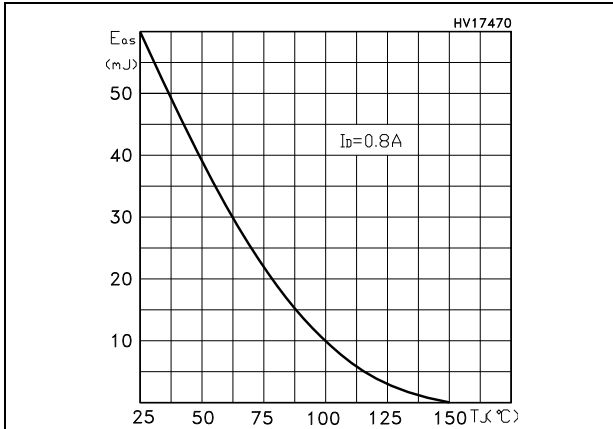
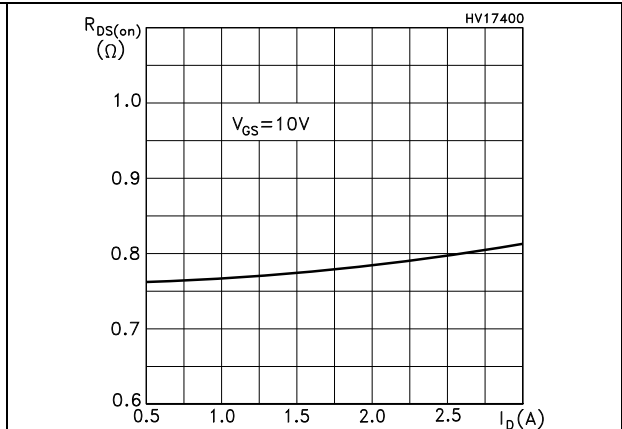


Figure 17. Max Id current vs Tc





### 3 Test circuits

Figure 18. Switching times test circuit for resistive load

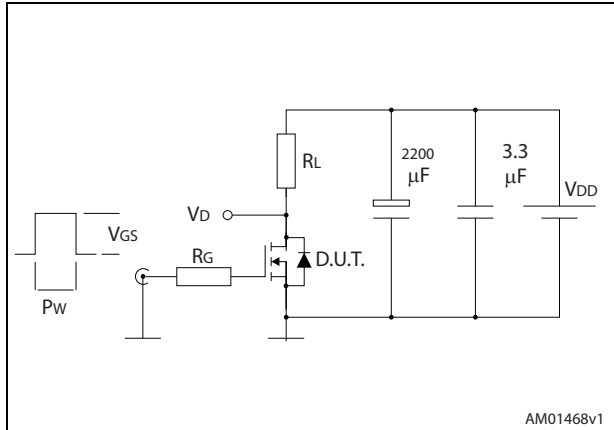


Figure 19. Gate charge test circuit

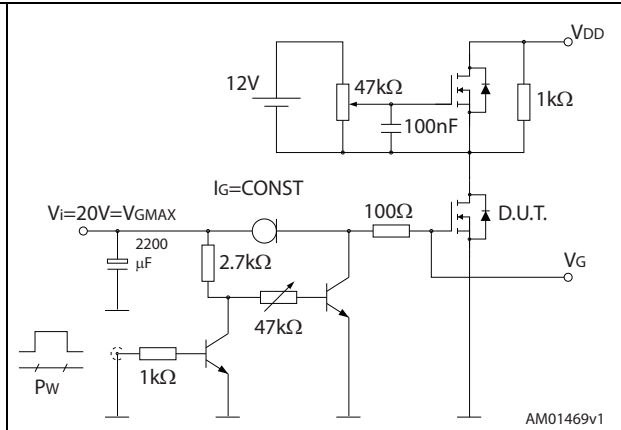


Figure 20. Test circuit for inductive load switching and diode recovery times

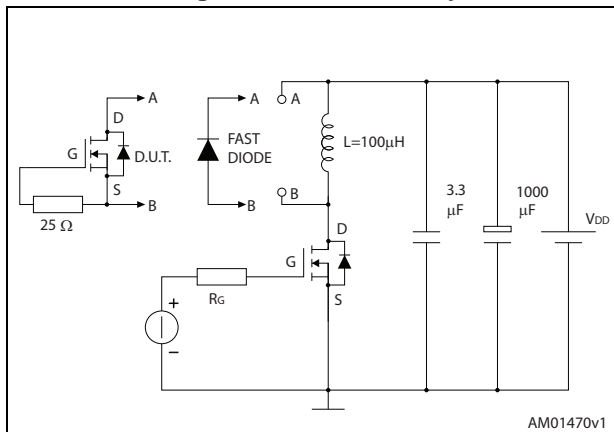


Figure 21. Unclamped inductive load test circuit

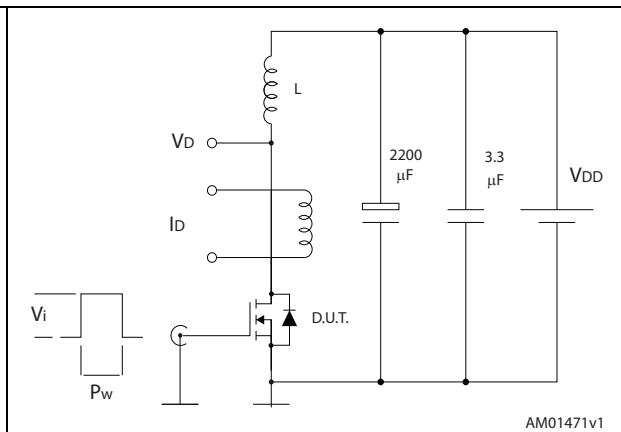


Figure 22. Unclamped inductive waveform

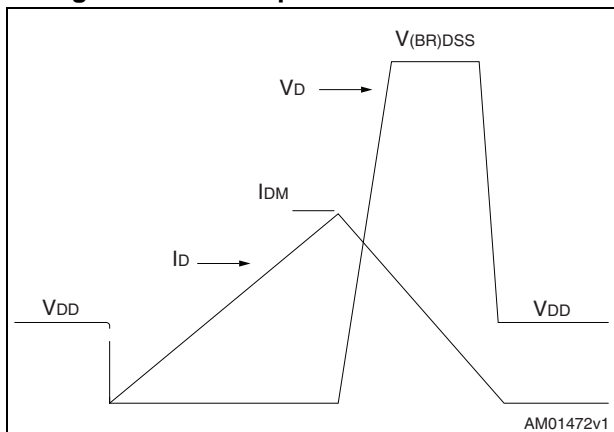
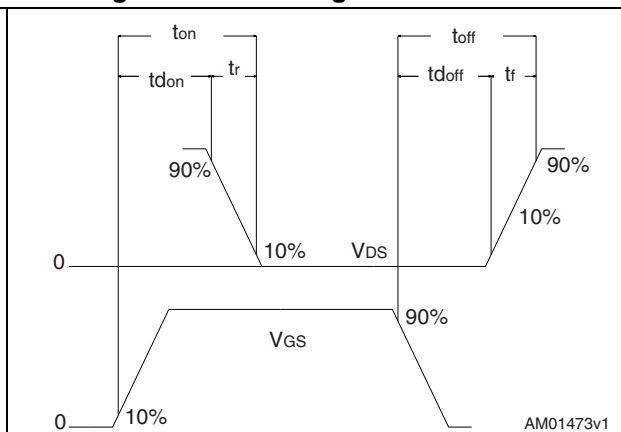


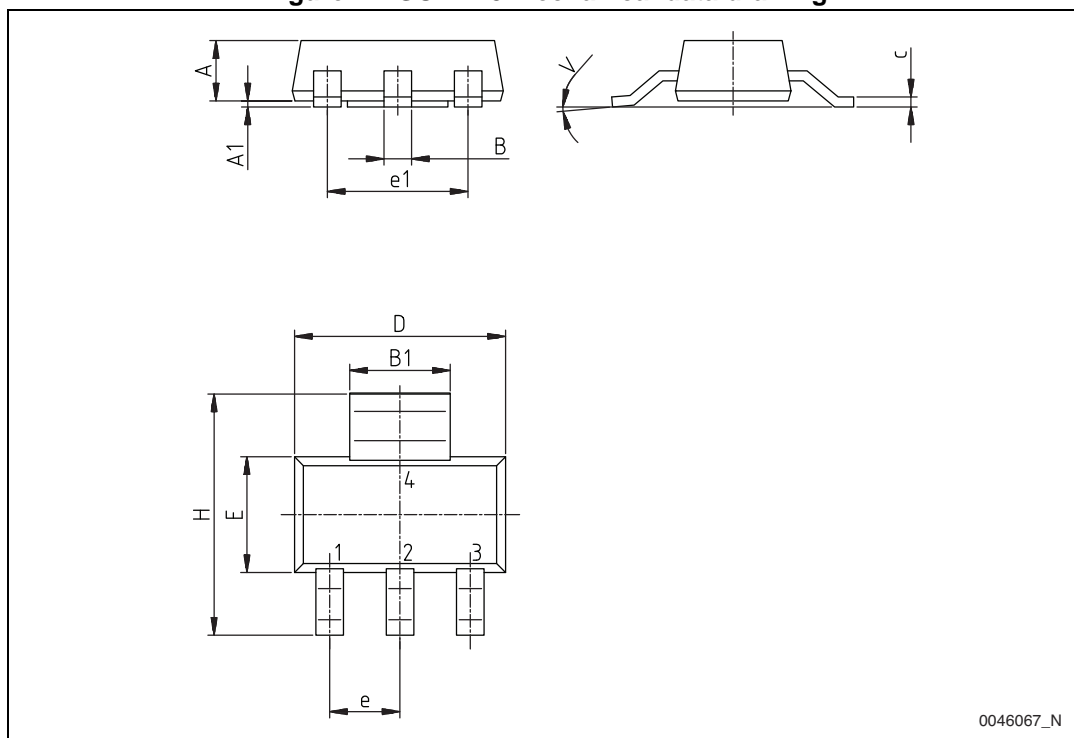
Figure 23. Switching time waveform



## 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<sup>®</sup> is an ST trademark.

Figure 24. SOT-223 mechanical data drawing

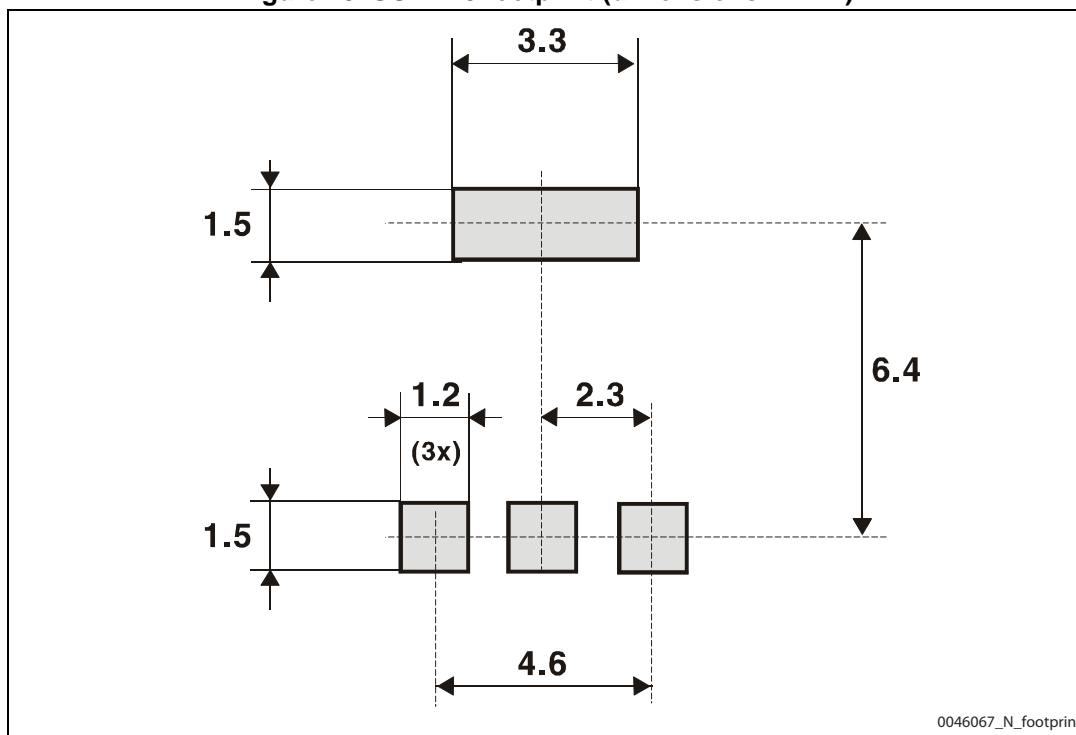


0046067\_N

Table 10. SOT-223 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.80
A1	0.02		0.10
B	0.60	0.70	0.85
B1	2.9	3.0	3.15
c	0.24	0.26	0.35
D	6.30	6.50	6.70
e		2.30	6.70
e1		4.60	
E	3.30	3.50	3.70
H	6.70	7.0	7.30
V			10°

Figure 25. SOT-223 footprint (dimensions in mm)



4.1 SOT-223, STN1NK60Z

4.2 TO-92 ammopack, STQ1NK60ZR-AP

Figure 26. TO-92 ammopack mechanical data drawing

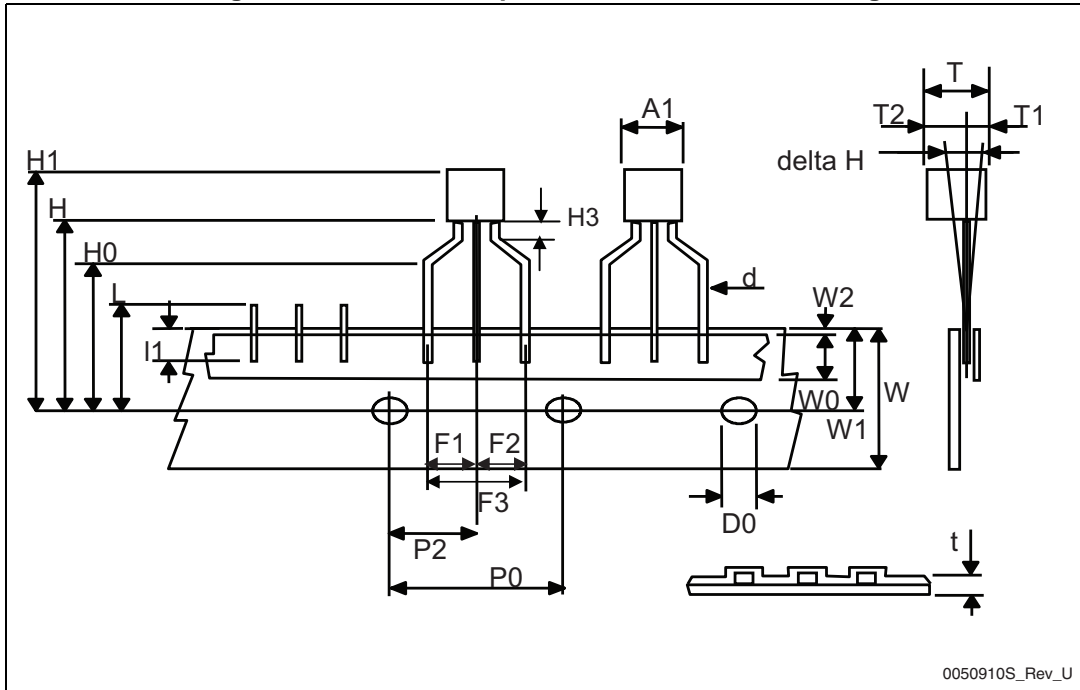


Table 11. TO-92 ammpack mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A1			4.80
T			3.80
T1			1.60
T2			2.30
d	0.45	0.47	0.48
P0	12.50	12.70	12.90
P2	5.65	6.35	7.05
F1, F2	2.40	2.50	2.94
F3	4.98	5.08	5.48
delta H	-2.00		2.00
W	17.50	18.00	19.00
W0	5.5	6.00	6.5
W1	8.50	9.00	9.25
W2			0.50
H		18.50	21
H3	0.5	1	2
H0	15.50	16.00	18.8
H1		25.0	27.0
D0	3.80	4.00	4.20
t			0.90
L			11.00
l1	3.00		
delta P	-1.00		1.00

## 5 Packaging mechanical data

Figure 27. Tape for SOT-223 (dimensions are in mm)

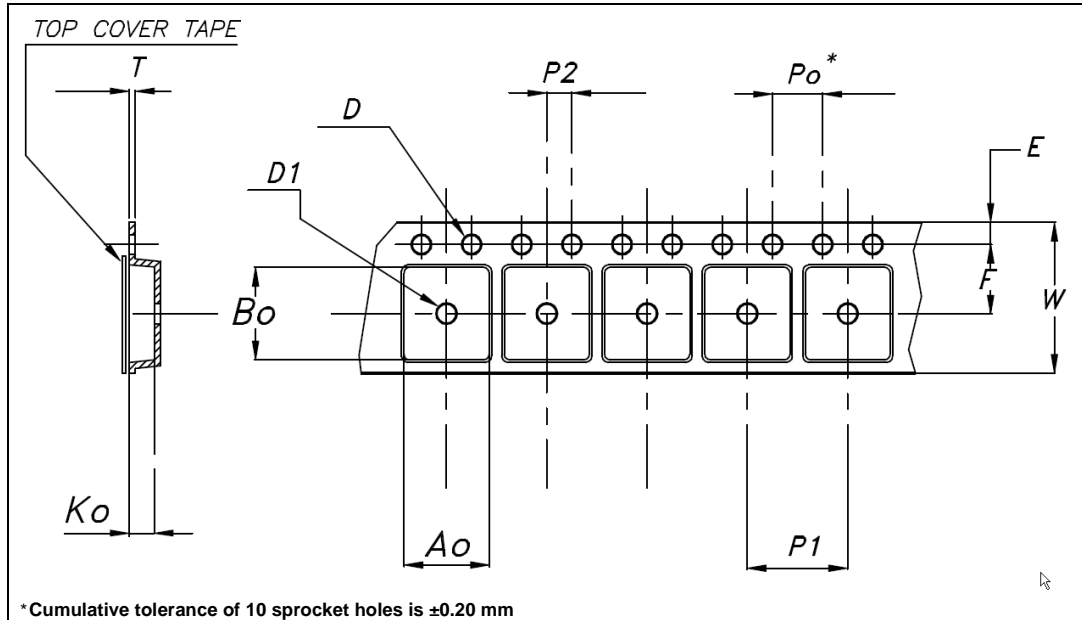


Figure 28. Reel for TO-223 (dimensions are in mm)

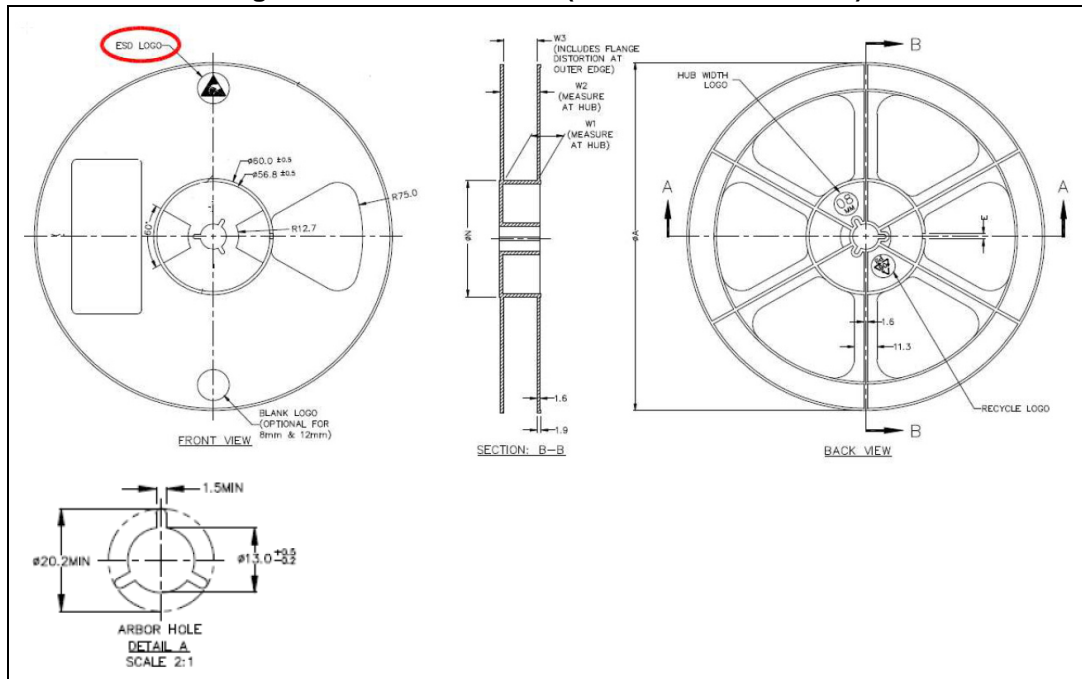


Table 12. SOT-223 tape and reel mechanical data

Tape				Reel		
Dim.	mm			Dim.	mm	
	Min.	Typ.	Max.		Min.	Max.
A0	6.75	6.85	6.95	A		180
B0	7.30	7.40	7.50	N	60	
K0	1.80	1.90	2.00	W1		12.4
F	5.40	5.50	5.60	W2		18.4
E	1.65	1.75	1.85	W3	11.9	15.4
W	11.7	12	12.3			
P2	1.90	2	2.10	Base quantity pcs		1000
P0	3.90	4	4.10	Bulk quantity pcs		1000
P1	7.90	8	8.10			
T	0.25	0.30	0.35			
D $\phi$	1.50	1.55	1.60			
D1 $\phi$	1.50	1.60	1.70			



## 6 Revision history

**Table 13. Revision history**

Date	Revision	Changes
19-Mar-2003	3	First electronic version
15-May-2003	4	Removed DPAK
09-Jun-2003	5	Final datasheet
17-Nov-2004	6	Inserted SOT-223
15-Feb-2005	7	Modified <a href="#">Figure 4</a> .
07-Sep-2005	8	Inserted ecopack indication
22-Feb-2006	9	The document has been reformatted
01-Jun-2007	10	Order code table on first page has been updated
19-Jul-2007	11	<a href="#">Table 1: Device summary</a> has been updated
05-Jan-2011	12	Corrected <a href="#">Figure 2: Safe operating area for SOT-223</a> and <a href="#">Figure 3: Thermal impedance for SOT-223</a>
05-Jun-2014	13	<ul style="list-style-type: none"> <li>– Updated title.</li> <li>– Updated derating factor in <a href="#">Table 2: Absolute maximum ratings</a>.</li> <li>– Updated <a href="#">Section 4: Package mechanical data</a>.</li> <li>– Minor text changes.</li> </ul>
04-Jul-2014	14	– Updated <a href="#">Section 3: Test circuits</a> .

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