



# 2N7000 2N7002

N-channel 60 V, 1.8  $\Omega$ , 0.35 A, SOT23-3L, TO-92  
STripFET™ Power MOSFET

## Features

Type	V <sub>DSS</sub>	R <sub>DS(on)</sub> max	I <sub>D</sub>
2N7000	60 V	< 5 $\Omega$ (@10V)	0.35 A
2N7002	60 V	< 5 $\Omega$ (@10V)	0.20 A

- Low Q<sub>g</sub>
- Low threshold drive

## Application

- Switching applications

## Description

This Power MOSFET is the second generation of STMicroelectronics unique “single feature size” strip-based process. The resulting transistor shows extremely high packing density for low on-resistance, rugged avalanche characteristics and less critical alignment steps therefore a remarkable manufacturing reproducibility.

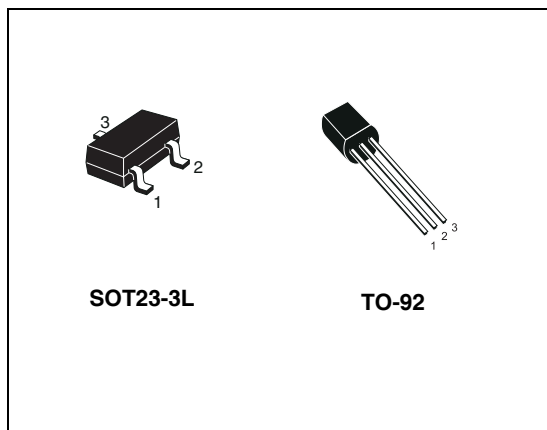


Figure 1. Internal schematic diagram

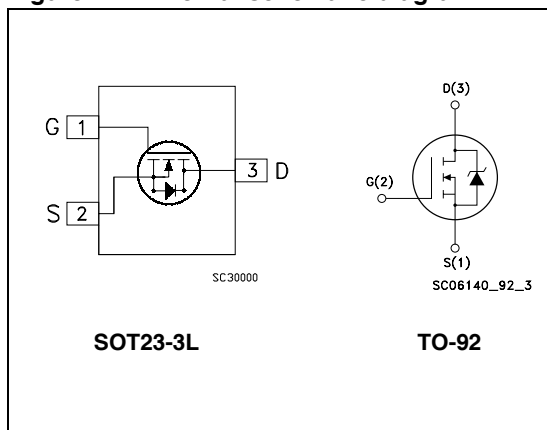


Table 1. Device summary

Order codes	Marking	Package	Packaging
2N7000	2N7000G	TO-92	Bulk
2N7002	ST2N	SOT23-3L	Tape and reel

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      **Revision history** ..... 13



# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-92	SOT23-3L	
$V_{DS}$	Drain-source voltage ( $V_{GS} = 0$ )	60		V
$V_{DGR}$	Drain-gate voltage ( $R_{GS} = 20\text{ k}\Omega$ )	60		V
$V_{GS}$	Gate- source voltage	$\pm 18$		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	0.35	0.20	A
$I_{DM}^{(1)}$	Drain current (pulsed)	1.4	1	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	1	0.35	W

1. Pulse width limited by safe operating area

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-92	SOT23-3L	
$R_{thj-amb}$	Thermal resistance junction-ambient max	125	357.1 <sup>(1)</sup>	$^\circ\text{C/W}$
$T_J$	Operating junction temperature	- 55 to 150		$^\circ\text{C}$
$T_{stg}$	Storage temperature			

1. When mounted on 1inch<sup>2</sup> FR-4, 2 Oz copper board.

## 2 Electrical characteristics

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

**Table 4. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 250\text{ }\mu\text{A}$ , $V_{GS} = 0$	60			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{max rating}$ $V_{DS} = \text{max rating}$ , $T_C = 125\text{ }^{\circ}\text{C}$			1 10	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 18\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$	1	2.1	3	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{ V}$ , $I_D = 0.5\text{ A}$ $V_{GS} = 4.5\text{ V}$ , $I_D = 0.5\text{ A}$		1.8 2	5 5.3	$\Omega$ $\Omega$

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 10\text{ V}$ , $I_D = 0.5\text{ A}$		0.6		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$		43 20 6		pF pF pF
$t_{d(on)}$ $t_r$ $t_{d(off)}$ $t_f$	Turn-on delay time Rise time Turn-off delay time Fall time	$V_{DD} = 30\text{ V}$ , $I_D = 0.5\text{ A}$ $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 4.5\text{ V}$ (see <a href="#">Figure 16</a> )		5 15 7 8		ns ns ns ns
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$V_{DD} = 30\text{ V}$ , $I_D = 1\text{ A}$ , $V_{GS} = 5\text{ V}$ (see <a href="#">Figure 17</a> )		1.4 0.8 0.5	2	nC nC nC

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

**Table 6. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current				0.35	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				1.40	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 1\text{ A}$ , $V_{GS} = 0$			1.2	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 1\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_{DD} = 20\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 18</a> )		32		ns
$Q_{rr}$	Reverse recovery charge			25		nC
$I_{RRM}$	Reverse recovery current			1.6		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 2. Safe operating area for TO-92

Figure 3. Thermal impedance for TO-92

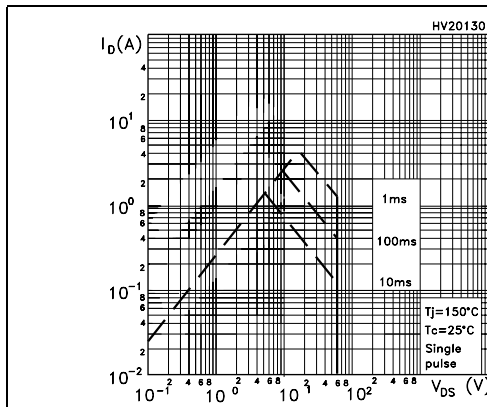


Figure 4. Safe operating area for SOT23-3L

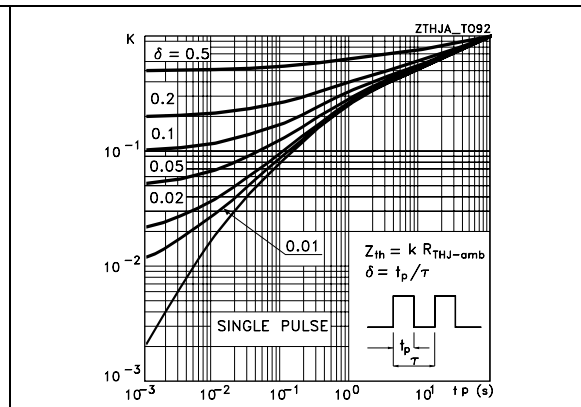


Figure 5. Thermal impedance for SOT23-3L

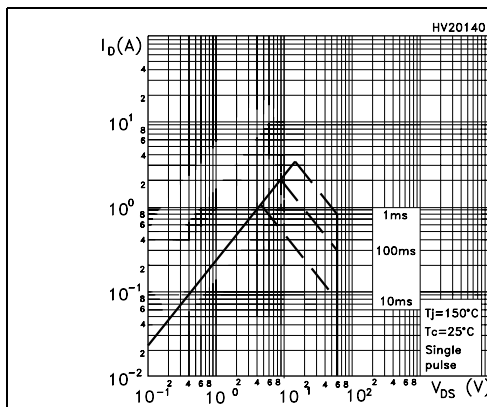


Figure 6. Output characteristics

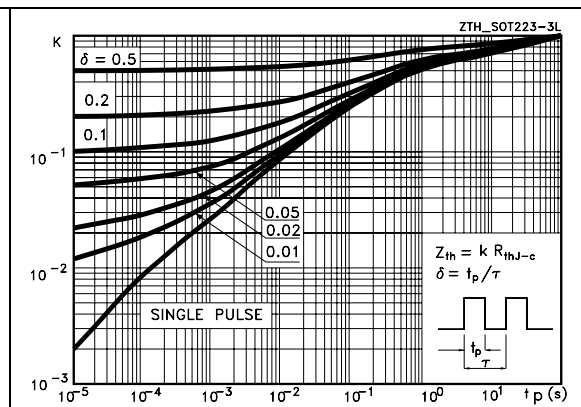


Figure 7. Transfer characteristics

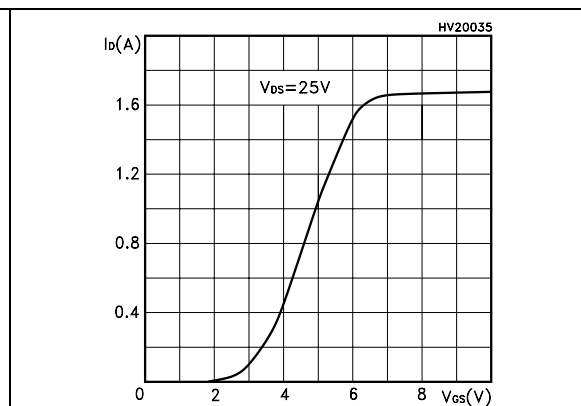
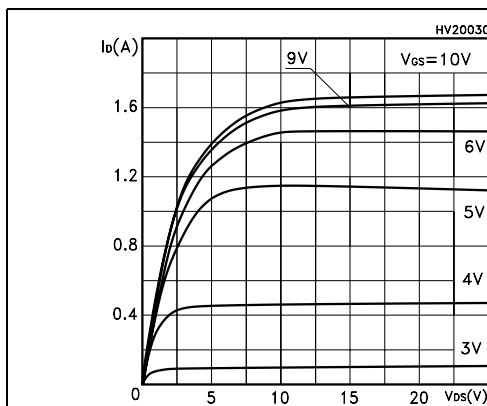


Figure 8. Transconductance

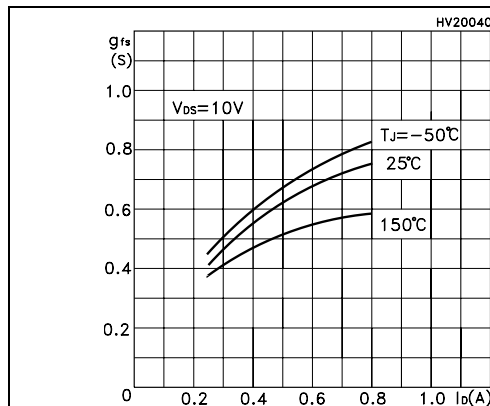


Figure 9. Static drain-source on resistance

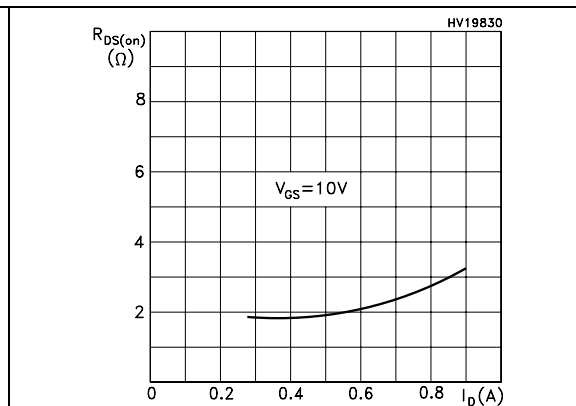


Figure 10. Gate charge vs gate-source voltage

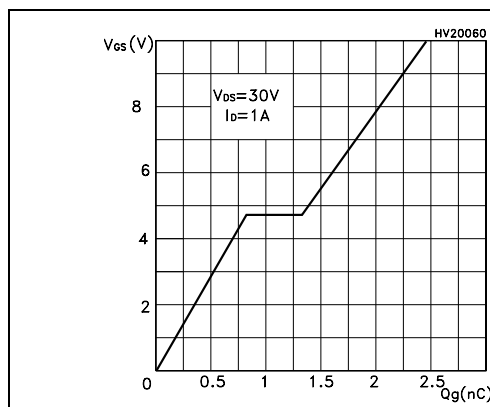


Figure 11. Capacitance variations

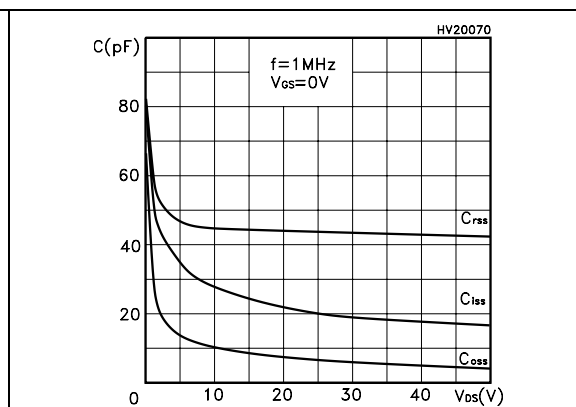


Figure 12. Normalized gate threshold voltage vs temperature

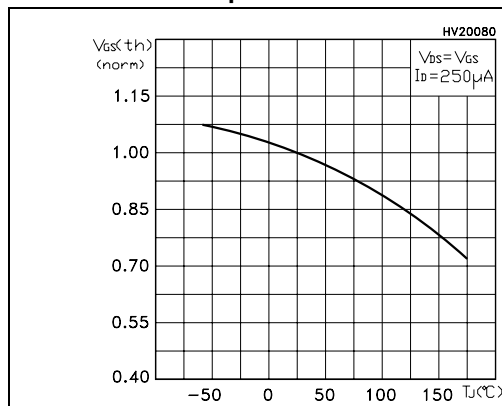


Figure 13. Normalized on resistance vs temperature

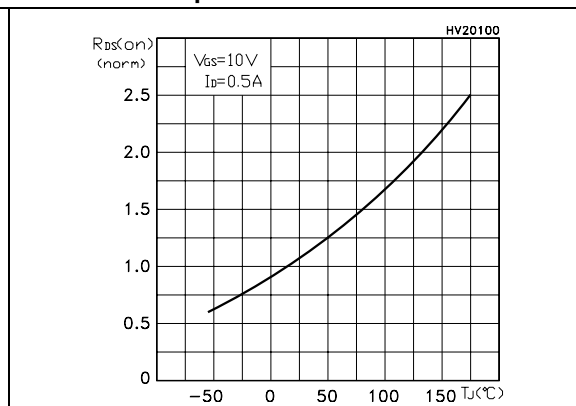


Figure 14. Source-drain diode forward characteristics

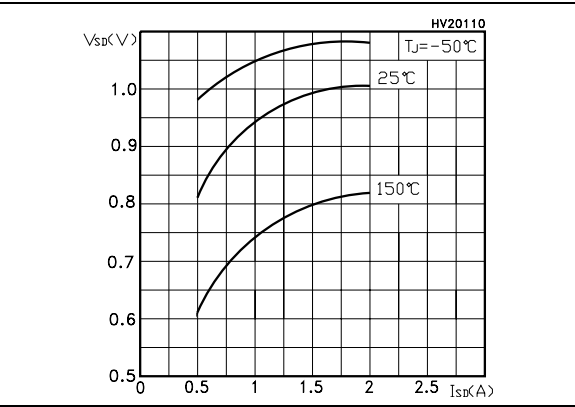
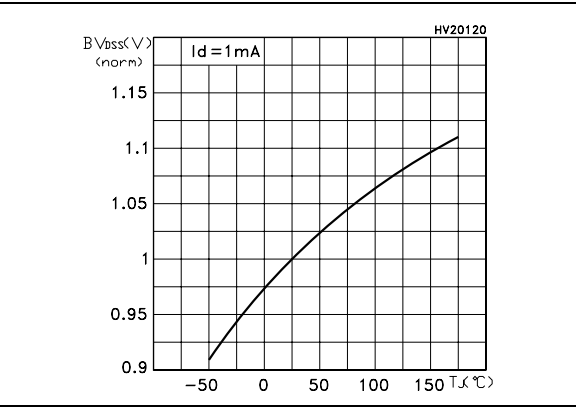


Figure 15. Normalized  $B_{VDSS}$  vs temperature





### 3 Test circuits

Figure 16. Switching times test circuit for resistive load

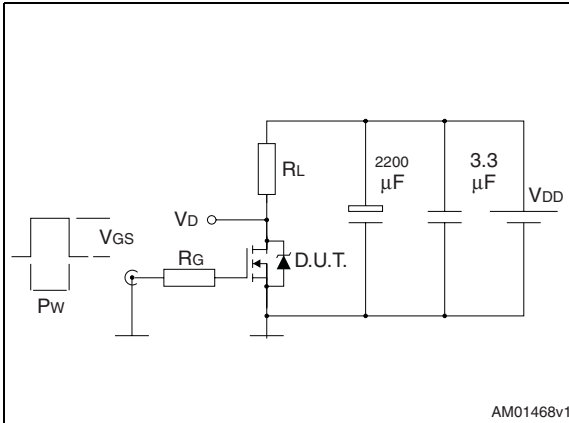


Figure 17. Gate charge test circuit

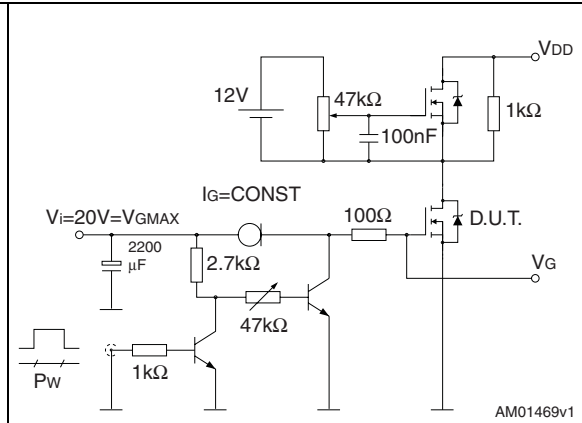


Figure 18. Test circuit for inductive load switching and diode recovery times

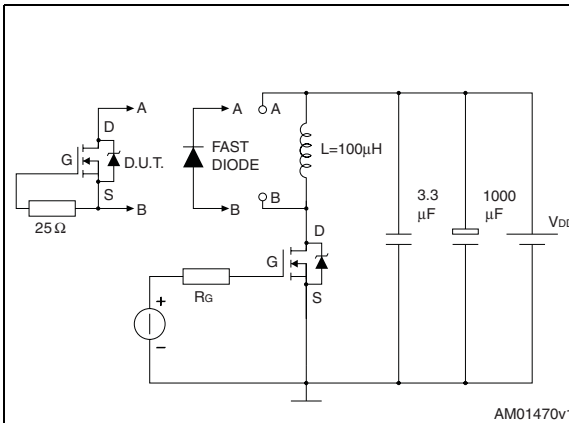


Figure 19. Unclamped Inductive load test circuit

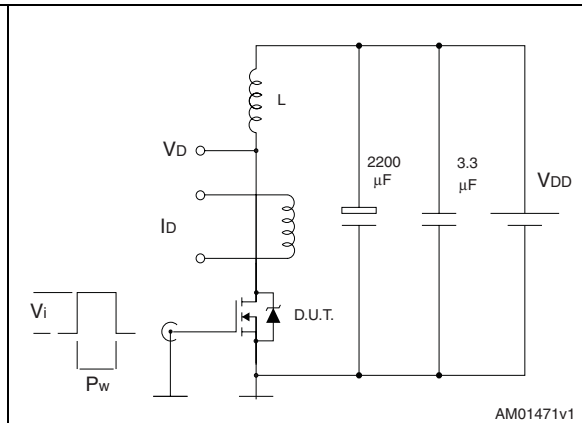


Figure 20. Unclamped inductive waveform

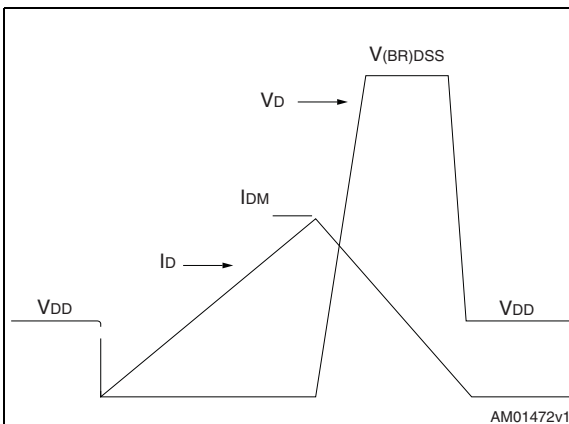
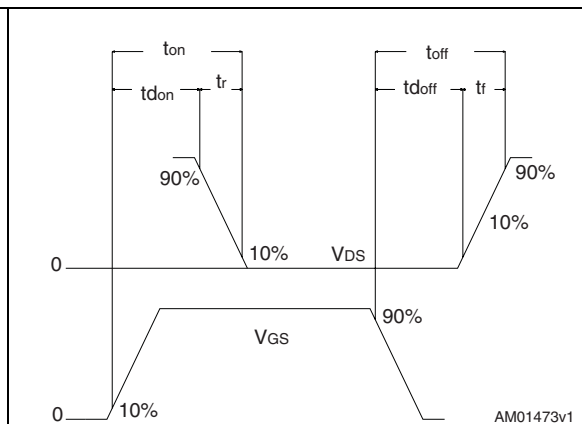


Figure 21. Switching time waveform



## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in 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)

Table 7. TO-92 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.32		4.95
b	0.36		0.51
D	4.45		4.95
E	3.30		3.94
e	2.41		2.67
e1	1.14		1.40
L	12.70		15.49
R	2.16		2.41
S1	0.92		1.52
W	0.41		0.56
V		5°	

Figure 22. TO-92 drawing

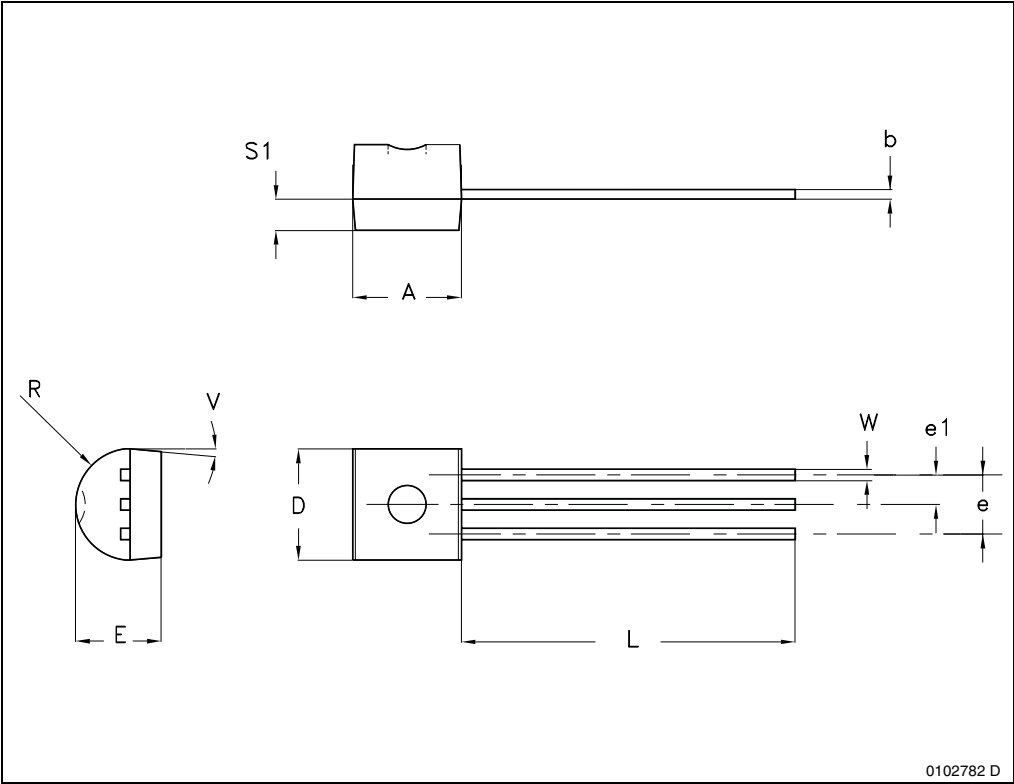
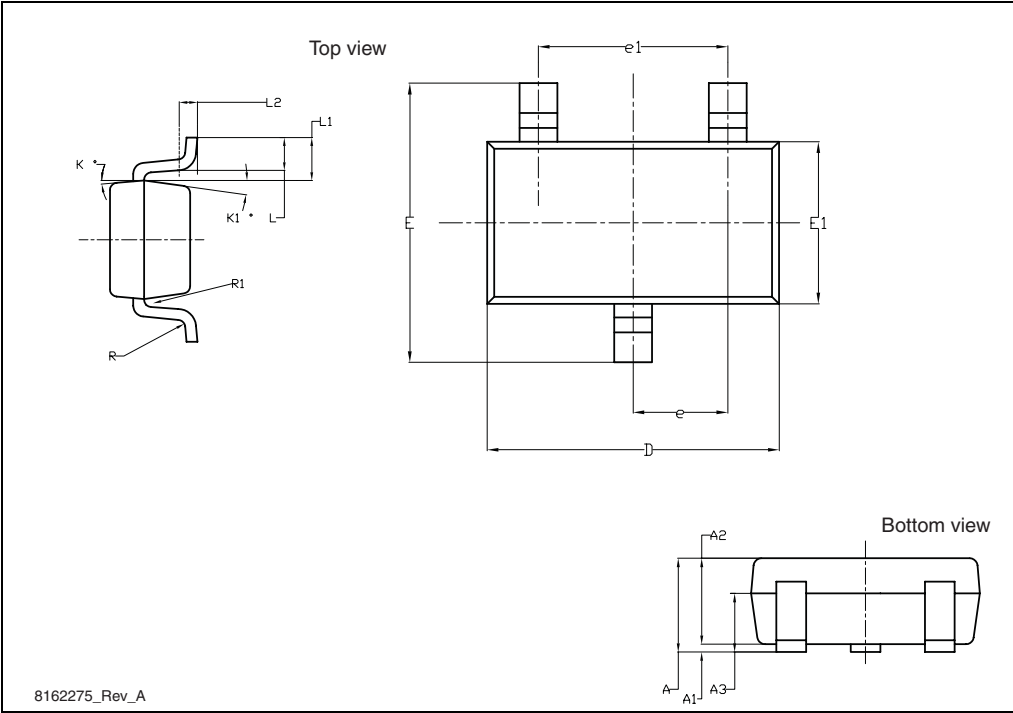


Table 8. SOT23-3L mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.25
A1	0		0.15
A2	1.00		1.20
A3	0.60		0.70
D	2.826		3.026
E	2.60		3.00
E1	1.526		1.726
e		0.95	
e1		1.90	
L	0.35		0.60
L1		0.59	
L2		0.25	
R	0.05		
R1	0.05		0.20
K	3°		7°
K1	6°		10°

Figure 23. SOT23-3L drawing



## 5 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
09-Oct-2004	1	First document
22-Jun-2004	2	Complete document
06-Apr-2005	3	New typ and max value inserted for $V_{gs(th)}$
19-Apr-2005	4	The document has been reformatted
26-Apr-2005	5	New Pin configuration for TO-92
28-Apr-2005	6	Pin configuration change again
19-Jun-2006	7	New template, no content change
03-Sep-2007	8	Corrected marking on first page
04-Nov-2008	9	<ul style="list-style-type: none"><li>– Updated <a href="#">Table 7: TO-92 mechanical data</a> and <a href="#">Figure 22: TO-92 drawing</a>.</li><li>– Updated <a href="#">Table 8: SOT23-3L mechanical data</a> and <a href="#">Figure 23: SOT23-3L drawing</a>.</li></ul>

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2008 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)