

## Programmable shunt voltage reference

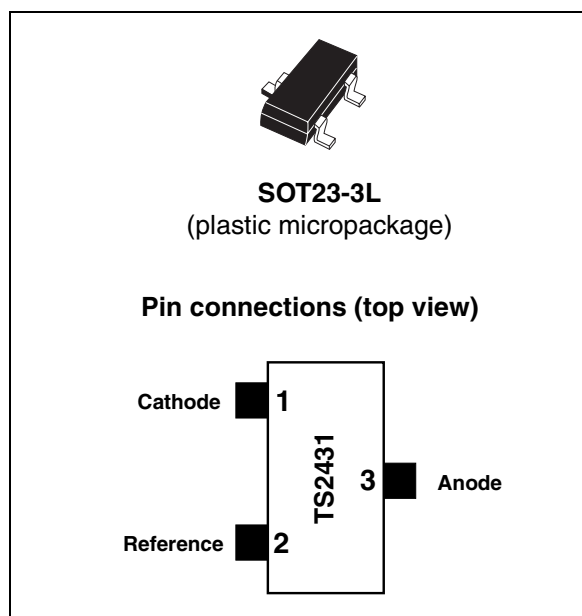
Datasheet — production data

### Features

- Adjustable output voltage: 2.5 to 24 V
- Precision selection at 25 °C:  $\pm 2\%$ ,  $\pm 1\%$  and  $\pm 0.5\%$
- Sink current capability: 1 to 100 mA
- Industrial temperature range: - 40 to +105 °C
- Performances compatible with industry-standard TL431

### Applications

- Computers
- Instrumentation
- Battery chargers
- Switch mode power supplies
- Battery-operated equipment



### Description

The TS2431 is a programmable shunt voltage reference with guaranteed temperature stability over the entire temperature range of operation - 40 to + 105 °C. The output voltage may be set to any value between 2.5 and 24 V with an external resistor bridge. Available in a SOT23-3L surface mount package, the device can be implemented in applications where space-saving is of utmost importance.

**Table 1. Device summary**

Order codes	Temperature range	Package	Packing	Precision	Marking
TS2431ILT	-40 to +105°C	SOT23-3L	Tape and reel	2%	L285
TS2431AILT				1%	L286
TS2431BILT				0.5%	L287

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# 1 Absolute maximum ratings and operating conditions

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>ka</sub>	Cathode to anode voltage	25	V
I <sub>K</sub>	Reverse breakdown current	-100 to +150	mA
I <sub>REF</sub>	Reference input current range	-0.05 to +10	mA
P <sub>d</sub>	Power dissipation <sup>(1)</sup> SOT23-3L	360	mW
T <sub>std</sub>	Storage temperature	-65 to +150	°C
ESD	Human body model (HBM) <sup>(2)</sup>	2	kV
	Machine model (MM) <sup>(3)</sup>	200	V
T <sub>LEAD</sub>	Lead temperature (soldering, 10 seconds)	260	°C

1. P<sub>d</sub> has been calculated with T<sub>amb</sub> = 25°C, T<sub>junction</sub> = 150°C, R<sub>thjc</sub> = 110°C/W and R<sub>thja</sub> = 340°C/W for the SOT23-3 package.
2. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
3. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.

**Table 3. Operating conditions**

Symbol	Parameter	Value	Unit
V <sub>KA</sub>	Cathode to anode voltage	V <sub>REF</sub> to 24	V
I <sub>K</sub>	Cathode operating current <sup>(1)</sup>	1 to 100	mA
T <sub>oper</sub>	Operating free air temperature range	- 40 to + 105	°C

1. Maximum power dissipation must be strictly observed to avoid damaging the component.

## 2 Electrical characteristics

**Table 4. Electrical characteristics (T<sub>amb</sub> = 25 °C unless otherwise specified)**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V <sub>REF</sub>	Reference input voltage	V <sub>K</sub> = V <sub>REF</sub> I <sub>K</sub> = 10 mA		2.5		V
		TS2431 (2%)	2.45		2.55	
		TS2431A (1%)	2.475		2.525	
		TS2431B (0.5%)	2.488		2.512	
		TS2431B (1%), I <sub>K</sub> =1mA	2.475		2.525	
ΔV <sub>REF</sub>	Reference input voltage deviation over temperature V <sub>K</sub> = V <sub>REF</sub> I <sub>K</sub> = 10 mA <sup>(1)</sup> <sup>(2)</sup>	0 °C < T < +70 °C		10	20	mV
		-40 °C < T < +85 °C		17	30	
		-40 °C < T < +105 °C		20	35	
T <sub>C</sub>	Temperature coefficient <sup>(2)</sup>	-40 °C < T < +105 °C		50	100	ppm/°C
I <sub>KMIN</sub>	Minimum operating current	T = 25 °C		0.3	0.8	mA
		-40 °C < T < +105 °C			1	
$\left  \frac{\Delta V_{ref}}{\Delta V_K} \right $	Ratio of change in reference input voltage to change in cathode to anode voltage	I <sub>K</sub> = 10 mA V <sub>ka</sub> = 24 to 2.5 V		0.3	2	mV/V
I <sub>REF</sub>	Reference input current I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = +∞ <sup>(3)</sup>	T = 25 °C		0.5	2.5	μA
		-40 °C < T < +105 °C			3	
ΔI <sub>REF</sub>	Reference input current deviation I <sub>K</sub> = 10 mA, R1 = 10 kΩ, R2 = +∞ <sup>(3)</sup>	-40 °C < T < +105 °C		0.4	1.2	μA
I <sub>OFF</sub>	Off-state cathode current	V <sub>K</sub> = 24 V, V <sub>REF</sub> = GND		10	500	nA
Z <sub>KA</sub>	Reverse dynamic impedance	V <sub>K</sub> = V <sub>REF</sub> ΔI <sub>K</sub> = 1 to 50 mA, f < 10 kHz		0.5	0.75	W
E <sub>N</sub>	Wide band noise	I <sub>K</sub> = 10 mA 10 Hz < f < 10 kHz		300		nV/√Hz

1. Limits are 100% production tested at 25° C. Limits over temperature are guaranteed through correlation and by design.
2. |ΔV<sub>REF</sub>| is defined as the difference between the maximum and minimum values of V<sub>REF</sub> obtained over the full temperature range.
3. Refer to [Figure 4: Test circuit for V<sub>ka</sub> = V<sub>ref</sub> on page 5](#).

Figure 1. Reference voltage vs. temperature

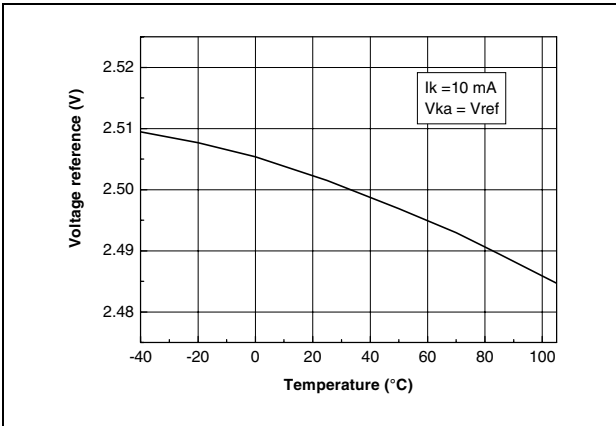


Figure 2. Cathode voltage vs. cathode current

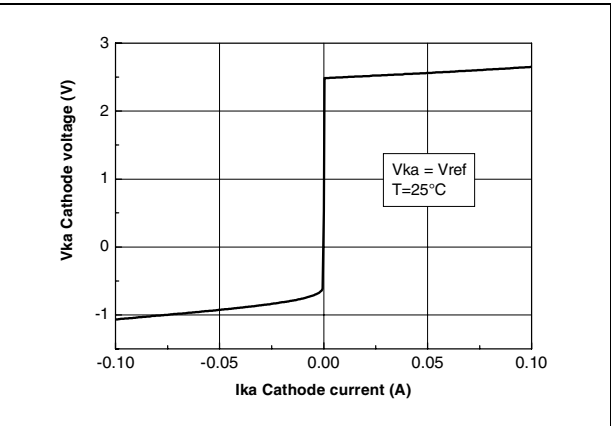


Figure 3. Reference input current vs. temperature

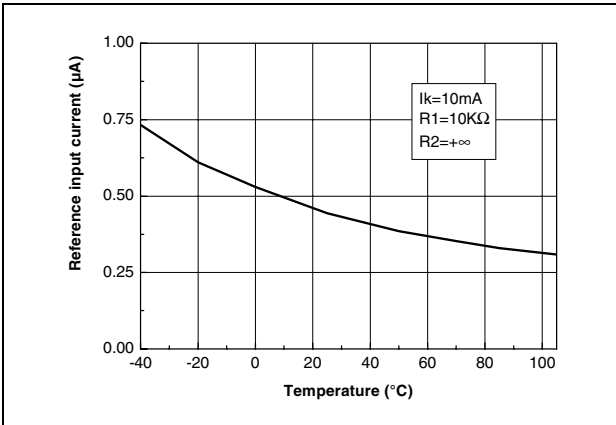


Figure 4. Test circuit for  $V_{ka} = V_{ref}$

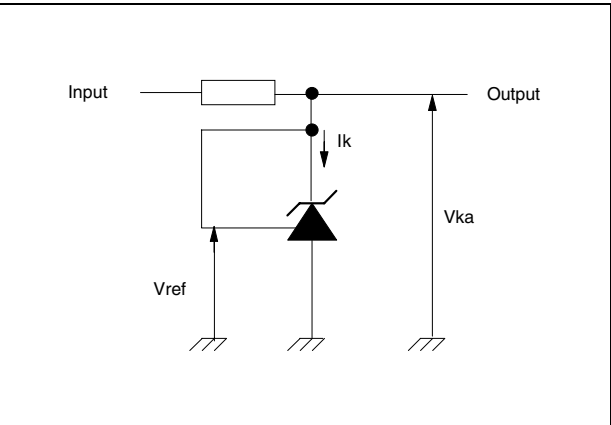


Figure 5. Cathode voltage vs. cathode current

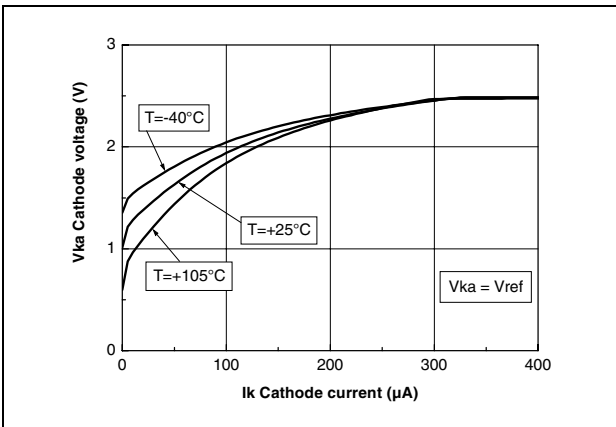


Figure 6. Dynamic impedance vs. frequency

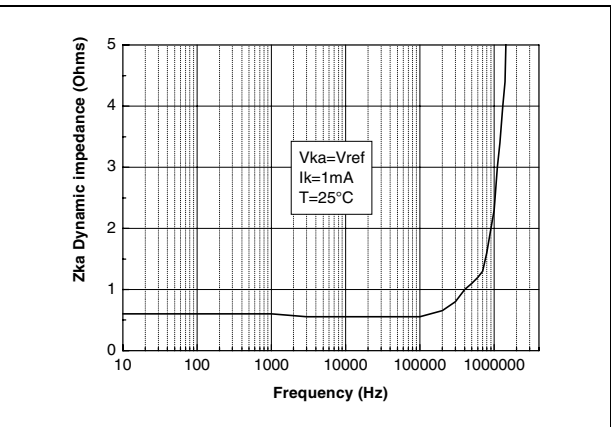


Figure 7. Off-state current vs. temperature

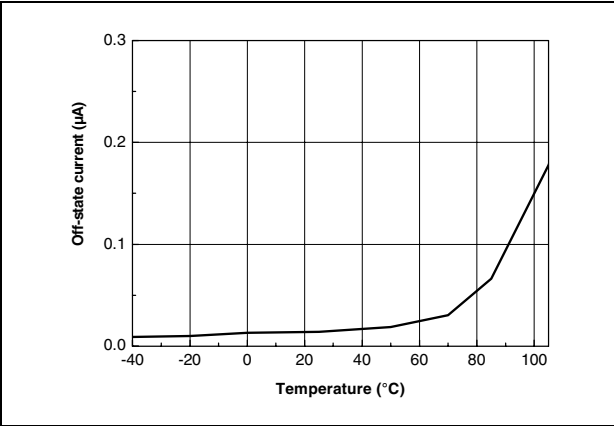


Figure 8. Ratio of change in reference input voltage to change in Vka voltage vs. temperature

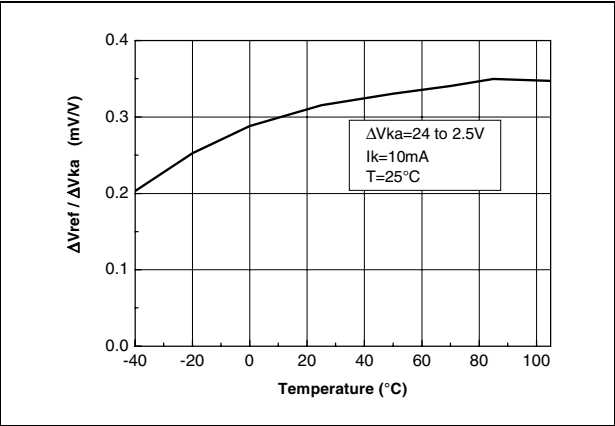


Figure 9. Phase and gain vs. frequency

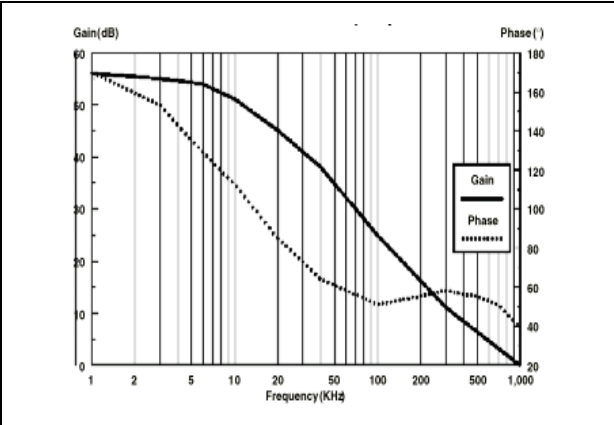


Figure 10. Test circuit for off-state current measurement

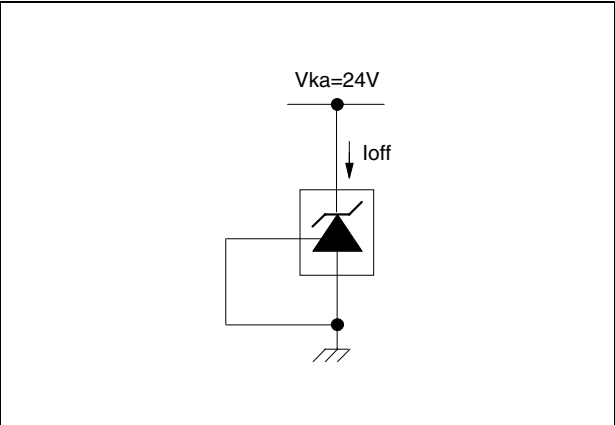


Figure 11. Test circuit for Vka > Vref

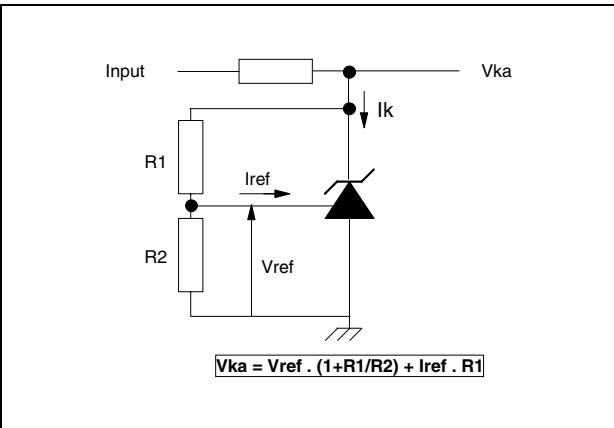


Figure 12. Test circuit for phase and gain measurement

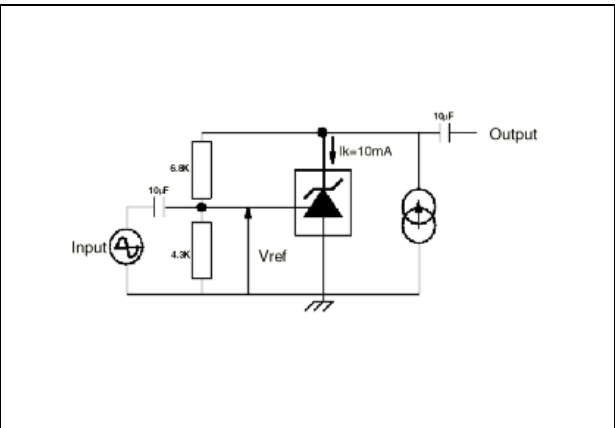


Figure 13. Pulse response at  $I_k = 0$  to 1 mA

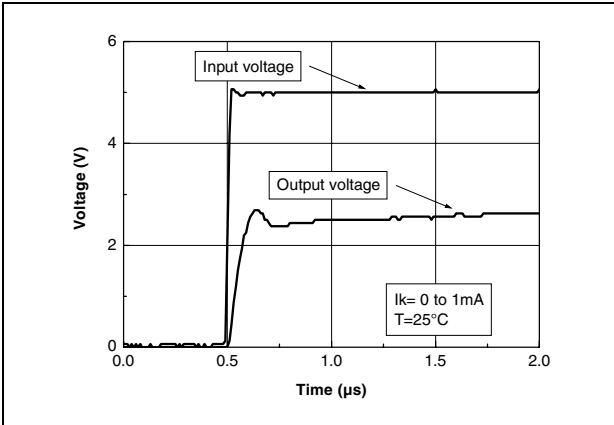


Figure 14. Pulse response at  $I_k = 1$  to 0 mA

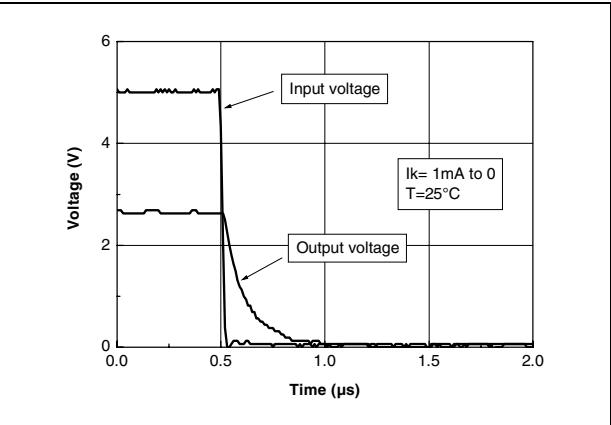


Figure 15. Stability boundary conditions

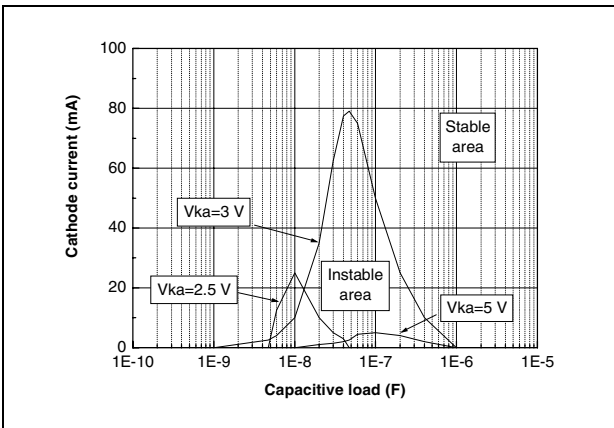


Figure 16. Test circuit for pulse response at  $I_k = 1$  mA

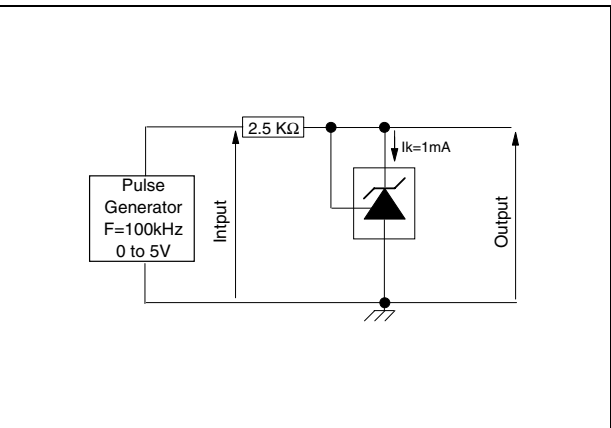


Figure 17. Equivalent input noise vs. frequency

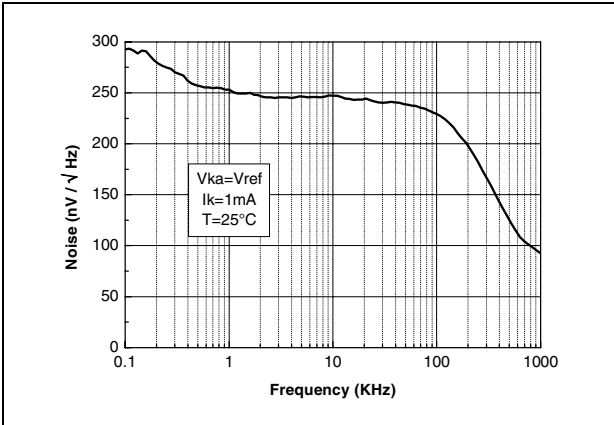
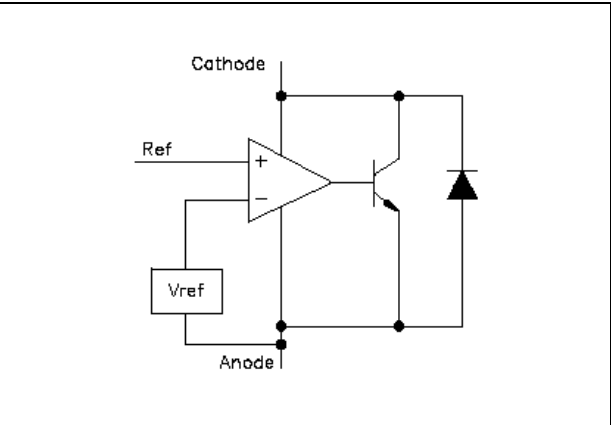


Figure 18. Block diagram



### 3 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.



### 3.1 SOT23-3L package information

Figure 19. SOT23-3L package mechanical drawing

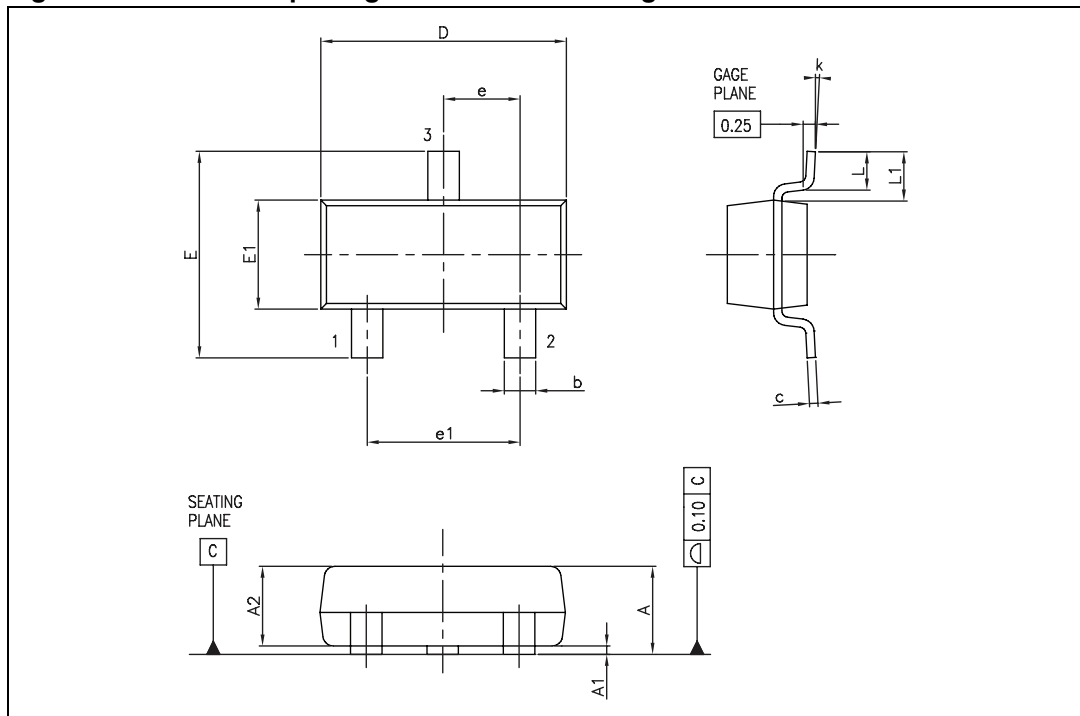


Table 5. SOT23-3L package mechanical data

Dimensions						
Ref.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.89		1.12	0.035		0.044
A1	0.01		0.10	0.0004		0.004
A2	0.88	0.95	1.02	0.035	0.037	0.040
b	0.30		0.50	0.012		0.020
c	0.08		0.20	0.003		0.008
D	2.80	2.90	3.04	0.110	0.114	0.120
E	2.10		2.64	0.083		0.104
E1	1.20	1.30	1.40	0.047	0.051	0.055
e		0.95			0.037	
e1		1.90			0.075	
L	0.40	0.50	0.60	0.016	0.020	0.024
L1		0.54			0.021	
k	0d		8d			

## 4 Revision history

**Table 6. Document revision history**

Date	Revision	Changes
01-Feb-2002	1	Initial release.
10-Sep-2009	2	Updated document format. Modified footnote 1 under <a href="#">Table 2: Absolute maximum ratings on page 3</a> . Added HBM and MM notes under <a href="#">Table 2</a> .
11-May-2012	3	Removed: automotive grade order codes <a href="#">Table 1 on page 1</a> .
22-Nov-2012	4	Added min. and max. values test condition TS2431B (1%), $I_K = 1 \text{ mA}$ <a href="#">Table 4 on page 4</a> .

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