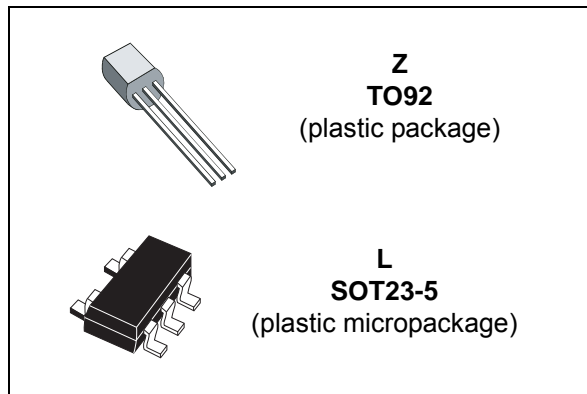


## Adjustable shunt voltage reference IC (automotive for SOT23-5)

Datasheet - production data



### Description

The TS431 is a low-voltage, three-terminal, adjustable shunt voltage reference. The output voltage can be set to any value between  $V_{ref}$  (1.24 V) and 6 V using two external resistors. The TS431 is able to operate at a lower voltage (1.24 V) and lower cathode current than the widely-used TL431 and TL1431 shunt voltage reference. When driving an optocoupler, the TS431 is particularly suitable for regulating 3.3 V switching power supplies.

### Features



- AEC-Q100 qualified (SOT23-5)
- Low voltage operation: 1.24 to 6 V
- 2%, 1% and 0.5% voltage precision
- Wide operating range cathode current: 60  $\mu$ A to 30 mA
- Low output impedance: 0.2  $\Omega$
- Typically stable for any capacitive loads
- ESD protection:
- Human body model: 2 kV
  - Machine model: 200 V
- 100 ppm/ $^{\circ}$ C temperature coefficient
- Automotive grade version available

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# 1 Pinout

Figure 1. Pinout Z TO92 (plastic package)

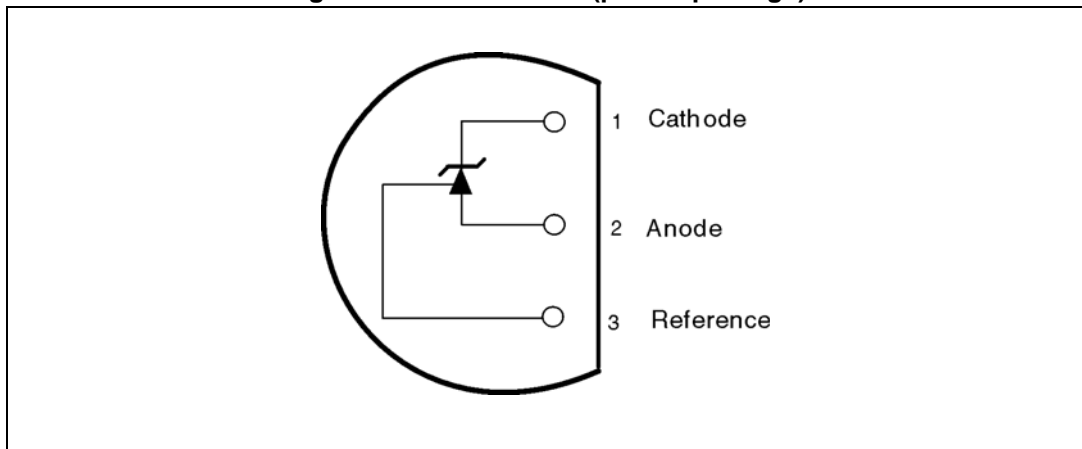
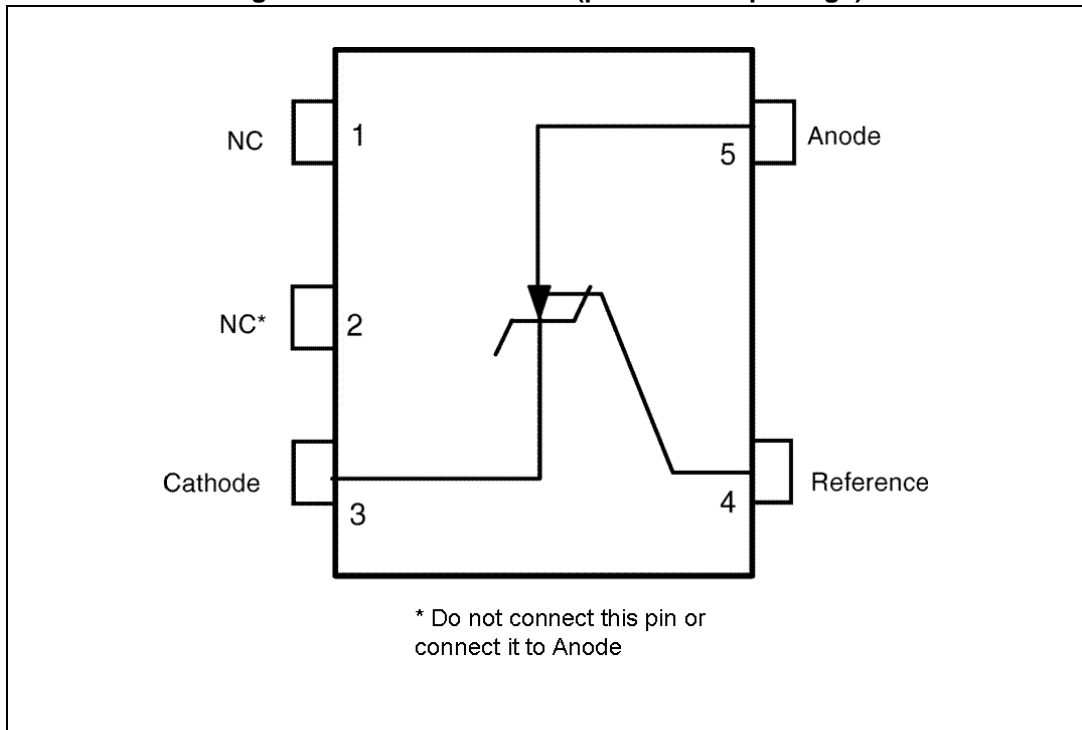


Figure 2. Pinout L SOT23-5 (plastic micropackage)



## 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{KA}$	Cathode to anode voltage	10	V
$I_k$	Continuous cathode current range	-20 to +40	mA
$I_{ref}$	Reference input current range	-0.05 to +3	mA
$P_d$	Power dissipation TO92 package SOT23-5 package	625 500	mW
$T_{stg}$	Storage temperature range	-65 to +150	°C

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{KA}$	Cathode to anode voltage	1.24 to 6	V
$I_k$	Cathode current <sup>(1)</sup>	0.06 to 30	mA
$T_{oper}$	Operating free air temperature range	-40 to +125	°C

1. Please refer to [Section 4: Application information](#) for more details.

**Table 3. Thermal data**

Symbol	Parameter	TO-92	SOT23-5L	Unit
$R_{thJC}$	Thermal resistance junction to case	57	136	°C/W
$R_{thJA}$	Thermal resistance junction to ambient	200	250	°C/W

### 3 Electrical characteristics

Table 4.  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{ref}$	Output voltage $V_{KA} = V_{ref}$ at $I_k = 100\text{ }\mu\text{A}$	TS431 TS431A TS431B	1.215 1.228 1.234	1.240 1.240 1.240	1.265 1.252 1.246	V
$\Delta V_{ref}$	Output voltage change <sup>(1) (2)</sup> $I_k = 100\text{ }\mu\text{A}$ , $V_{KA} = V_{ref}$	$0 < T_{amb} < +70\text{ °C}$ $-40 < T_{amb} < +85\text{ °C}$ $-40 < T_{amb} < +105\text{ °C}$ $-40 < T_{amb} < +125\text{ °C}$	- - - -	- - - -	9 16 18 21	mV
$\left  \frac{\Delta V_{ref}}{\Delta V_{ka}} \right $	Ratio of change in reference input voltage to change in cathode to anode voltage	$I_k = 10\text{ mA}$ $V_{KA} = 6\text{ V to } V_{ref}$	-	1.8	2.7	mV/V
$I_{ref}$	Reference input current	$I_k = 10\text{ mA}$	-	70	160	nA
$\Delta I_{ref}$	Reference input current deviation over temperature range	$I_k = 10\text{ mA}$ , $R_1 = 10\text{ k}\Omega$ , $R_2 = \infty$ $-40 < T_{amb} < +85\text{ °C}$ $-40 < T_{amb} < +125\text{ °C}$	- -	70 90	160 240	nA
$I_{min}$	Minimum cathode current for regulation	$V_{KA} = V_{ref}$	-	40	60	$\mu\text{A}$
$I_{off}$	Off-state cathode current	$V_{KA} = 6\text{ V}$ , $V_{ref} = 0$	-	0.001	0.1	$\mu\text{A}$
$R_{KA}$	Static impedance	$V_{KA} = V_{ref}$ , $I_k = 0.1\text{ to }15\text{ mA}$	-	0.2	0.4	$\Omega$

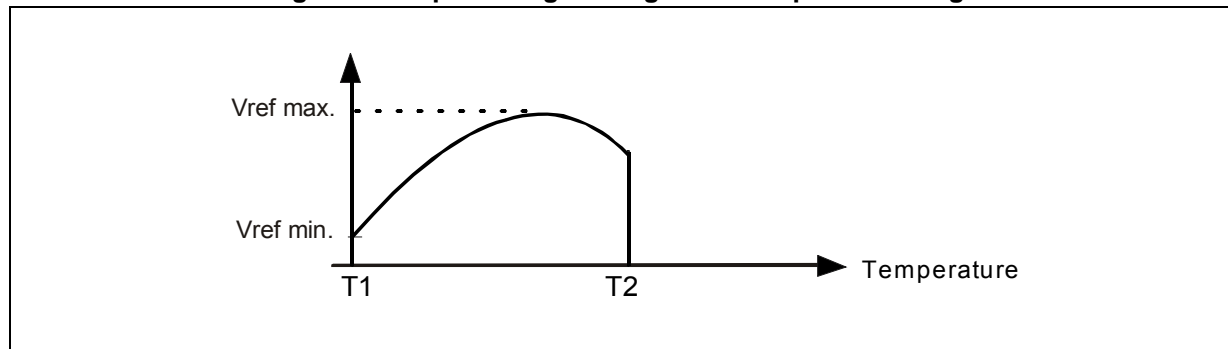
- Limits are 100% production tested at 25 °C. Behavior at the temperature range limits is guaranteed through correlation and by design.
- See definition below.

#### Definition of output voltage change over temperature range

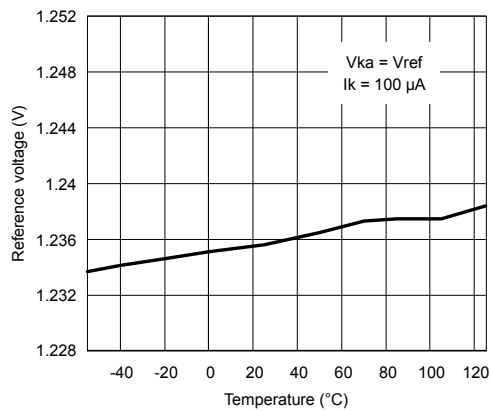
$\Delta V_{ref}$  is defined as the difference between the maximum and minimum values obtained over the full temperature range.

$$\Delta V_{ref} = V_{ref\ max} - V_{ref\ min}$$

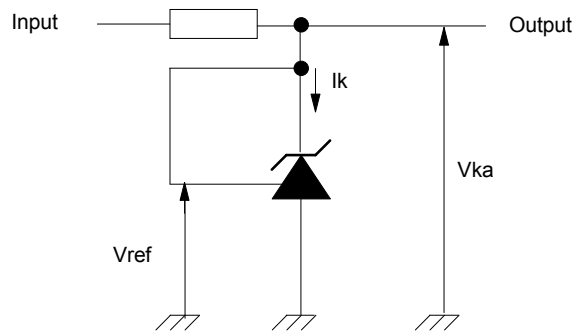
Figure 3. Output voltage change over temperature range



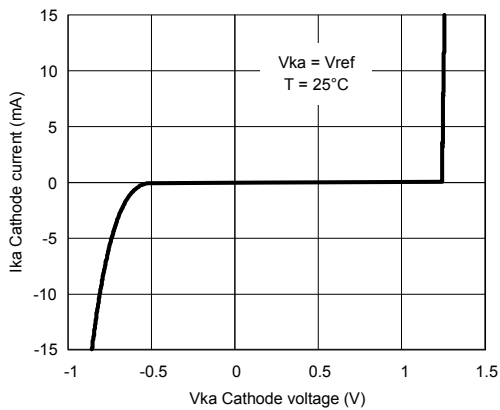
**Figure 4. Reference voltage vs. temperature**



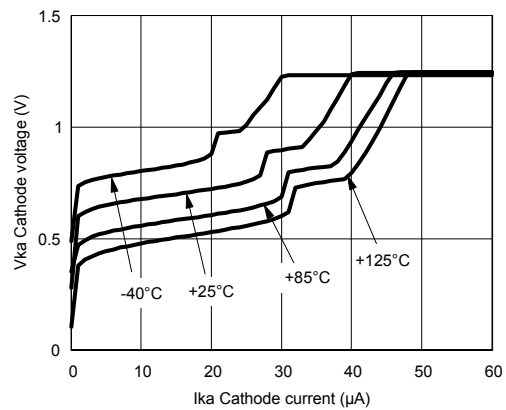
**Figure 5. Test circuit for  $V_{KA} = V_{ref}$**



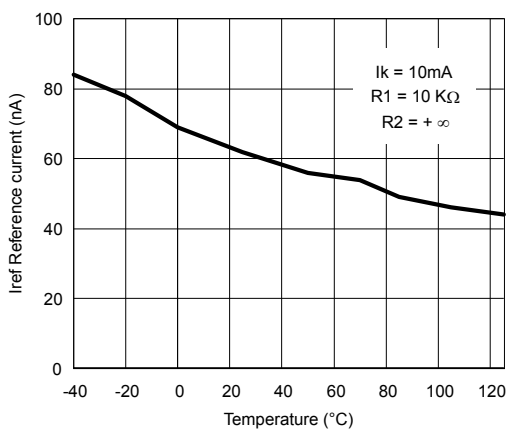
**Figure 6. Cathode voltage vs. cathode current**



**Figure 7. Cathode voltage vs. cathode current**



**Figure 8. Reference input current vs. temperature**



**Figure 9. Static impedance vs. temperature**

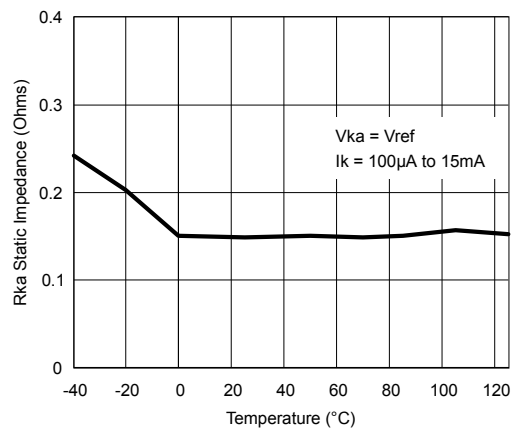


Figure 10. Off-state current vs. temperature

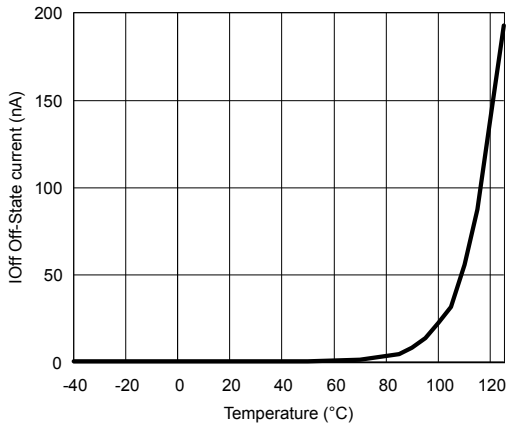


Figure 11. Test circuit for off-state current measurement

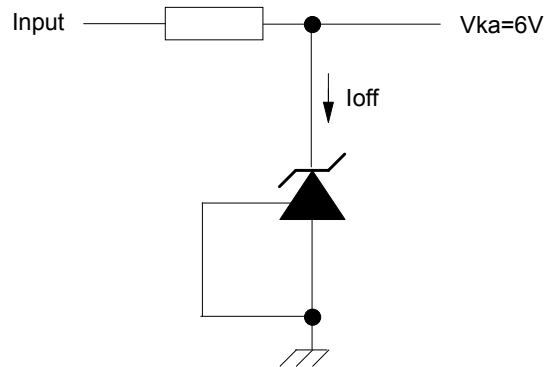


Figure 12. Ratio of change in reference input voltage to change in V<sub>KA</sub> voltage vs. temperature

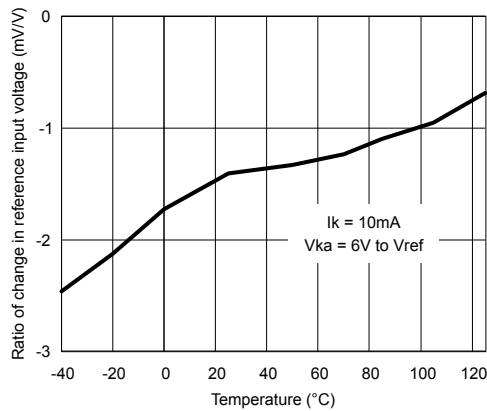


Figure 13. Test circuit for V<sub>KA</sub> > V<sub>ref</sub>

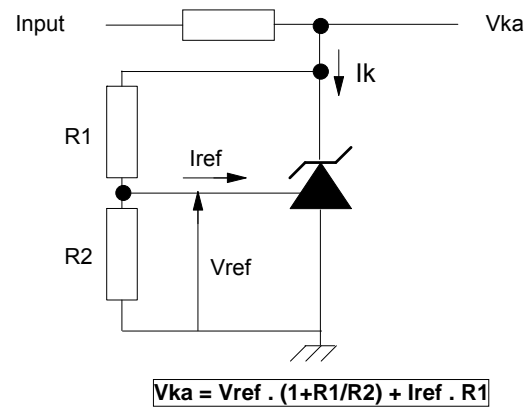


Figure 14. Phase and gain vs. frequency

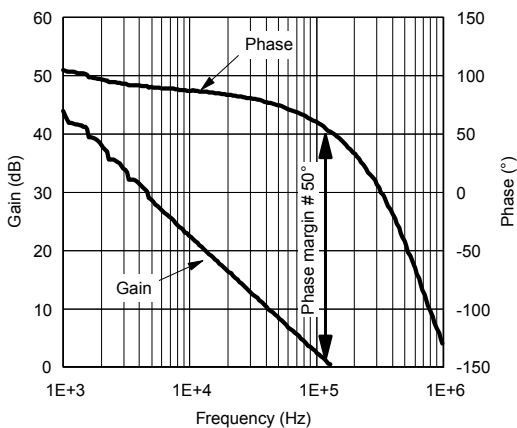


Figure 15. Test circuit for phase and gain measurement

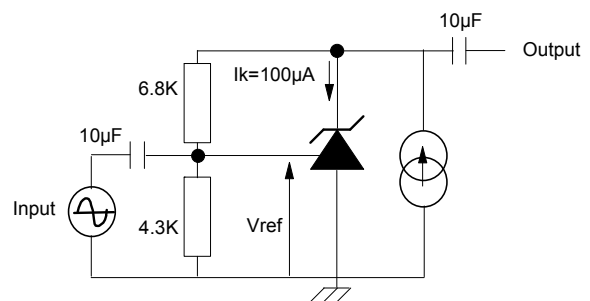


Figure 16. Pulse response at  $I_k = 100 \mu A$

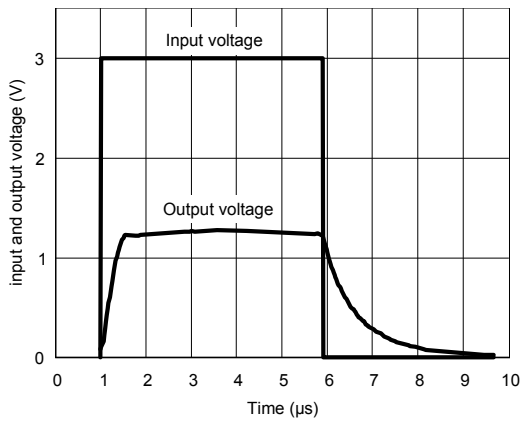


Figure 17. Test circuit for pulse response at  $I_k = 100 \mu A$

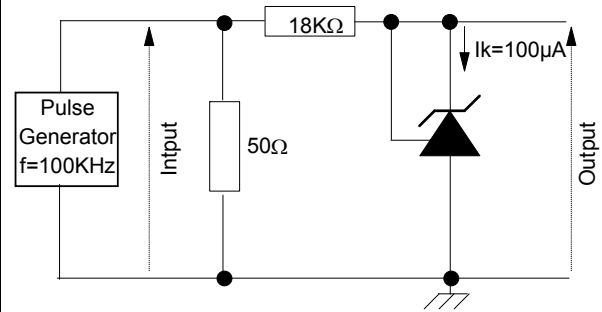


Figure 18. Pulse response at  $I_k = 1 mA$

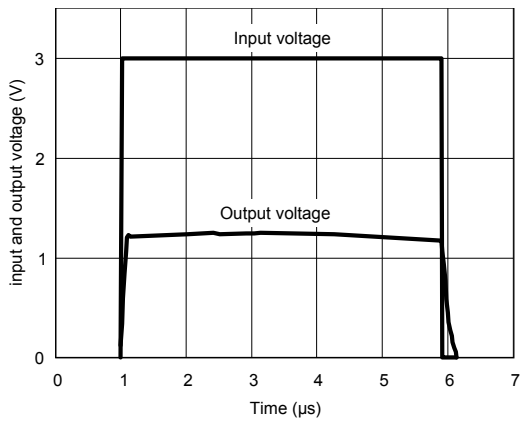


Figure 19. Test circuit for pulse response at  $I_k = 1 mA$

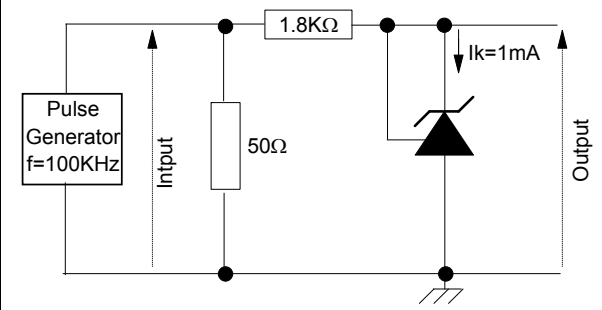
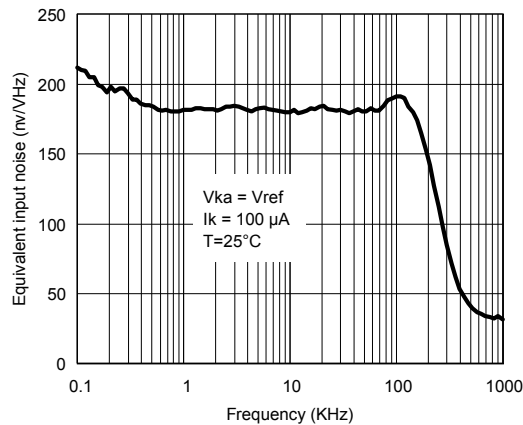


Figure 20. Equivalent input noise vs. frequency





## 4 Application information

The TS431 is a general-purpose low-power adjustable shunt voltage reference, capable of operating with a cathode current as low as 60  $\mu\text{A}$  and up to 30 mA.

The main static parameters of the TS431 voltage reference are specified in [Table 4 on page 5](#).

Since the TS431 is designed for general-purpose applications with a broad range of cathode currents, voltages and loads, when designing with the device in applications requiring fast dynamic response (turn-on/off and/or pulsed load conditions) it should be considered that upon application of power, the time required for the  $V_{KA}$  voltage to reach its final value within a specified error range depends on several factors, among which the temperature, cathode current and capacitive load inrush current are the most influential. The dynamic response of the device to fast turn-on/off, load and temperature changes is optimized when the cathode current is not in the lower end of the operating range ( $I_K > 500 \mu\text{A}$ ).

## 5 Package information

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.

## 5.1 SOT23-5 package information

Figure 21. SOT23-5 package outline

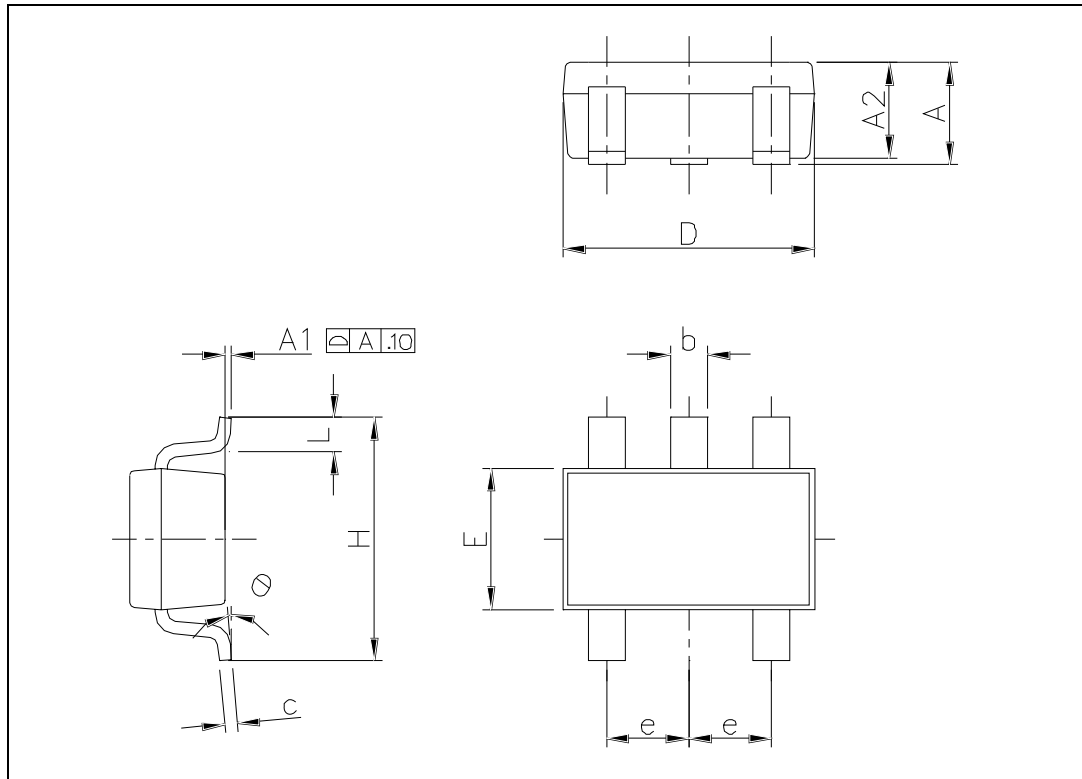


Table 5. SOT23-5 package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	-	1.45	0.035	-	0.057
A1	0.00	-	0.15	0.00	-	0.006
A2	0.90	-	1.30	0.035	-	0.051
b	0.35	-	0.50	0.014	-	0.02
C	0.09	-	0.20	0.003	-	0.008
D	2.80	-	3.00	0.110	-	0.118
H	2.60	-	3.00	0.102	-	0.118
E	1.50	-	1.75	0.059	-	0.069
e	-	0.95	-	-	0.037	-
e1	-	1.9	-	-	0.075	-
L	0.35	-	0.55	0.014	-	0.022

## 5.2 TO92 (tape ammopack and tape and reel) package information

Figure 22. TO92 (tape ammopack and tape and reel) package outline

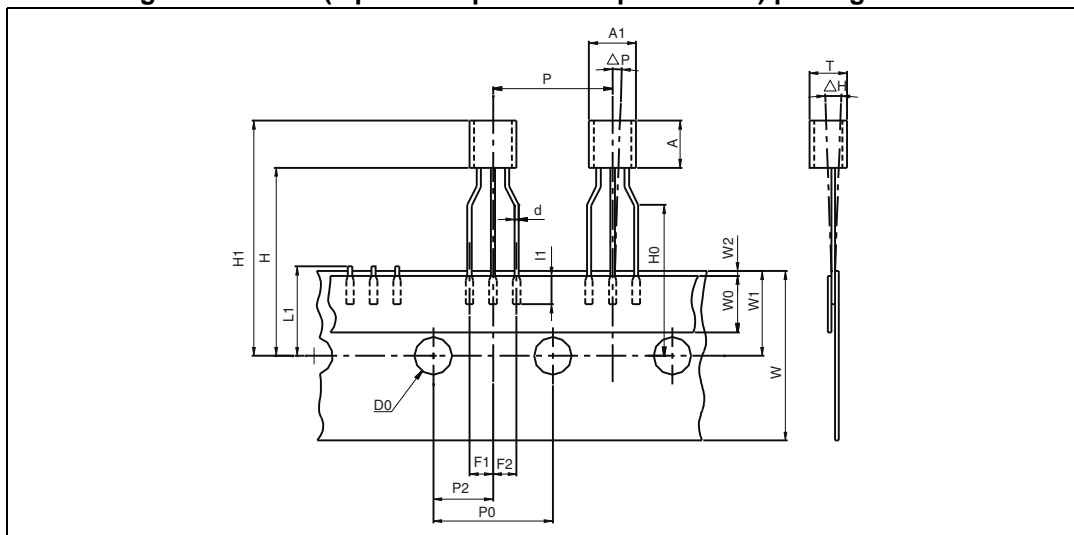


Table 6. TO92 (tape ammopack and tape and reel) package mechanical data

Symbol	Dimensions (millimeters)			Dimensions (Inches)		
	Min.	Typ.	Max.	Min.	Typ.	Max.
AL	-	-	5.0	-	-	0.197
A	-	-	5.0	-	-	0.197
T	-	-	4.0	-	-	0.157
d	-	0.45	-	-	0.018	-
l1	2.5	-	-	0.098	-	-
P	11.7	12.7	13.7	0.461	0.500	0.539
PO	12.4	12.7	13	0.488	0.500	0.512
P2	5.95	6.35	6.75	0.234	0.250	0.266
F1/F2	2.4	2.5	2.8	0.094	0.098	0.110
Δh	-1	0	1	-0.039	0	0.039
ΔP	-1	0	1	-0.039	0	0.039
W	17.5	18.0	19.0	0.689	0.709	0.748
W0	5.7	6	6.3	0.224	0.236	0.248
W1	8.5	9	9.75	0.335	0.354	0.384
W2	-	-	0.5	-	-	0.020
H	-	-	20	-	-	0.787
H0	15.5	16	16.5	0.610	0.630	0.650
H1	-	-	25	-	-	0.984
DO	3.8	4.0	4.2	0.150	0.157	0.165
L1	-	-	11	-	-	0.433

### 5.3 TO92 (bulk) package information

Figure 23. TO92 (bulk) package outline

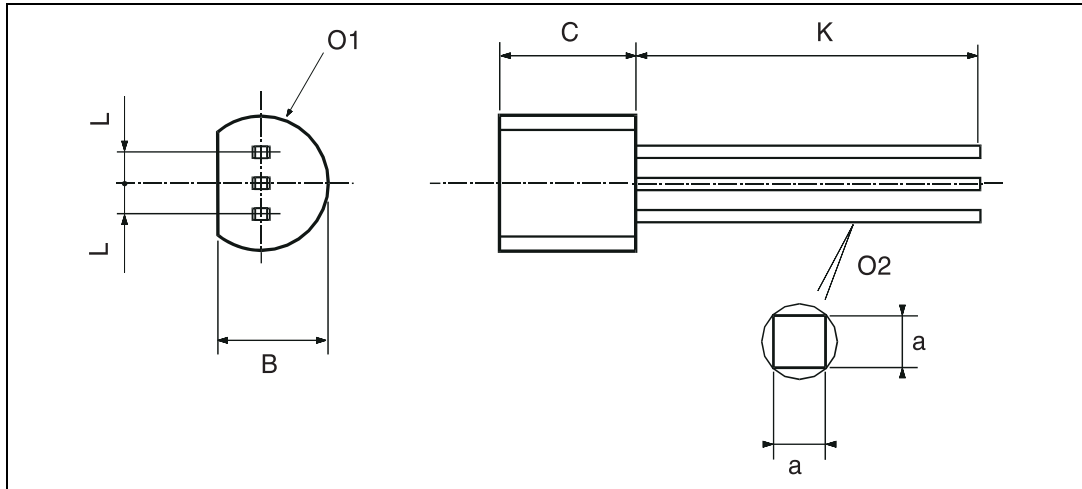


Table 7. TO92 (bulk) package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
L	-	1.27	-	-	0.05	-
B	3.2	3.7	4.2	0.126	0.1457	0.1654
O1	4.45	5.00	5.2	0.1752	0.1969	0.2047
C	4.58	5.03	5.33	0.1803	0.198	0.2098
K	12.7	-	-	0.5	-	-
O2	0.407	0.5	0.508	0.016	0.0197	0.02
a	0.35	-	-	0.0138	-	-

## 6 Ordering information

**Table 8. Order codes**

Order codes	Precision	Temp. range	Packages	Packing	Marking
TS431ILT	2%	-40 °C, + 125 °C	SOT23-5	Tape and reel	L272
TS431AILT	1%				L271
TS431BILT	0.5%				L270
TS431IYLT <sup>(1)</sup>	2%		SOT23-5 (automotive grade level)		L274
TS431AIYLT <sup>(1)</sup>	1%				L276
TS431BIYLT <sup>(1)</sup>	0.5%				L273
TS431IZ/IZT/IZ-AP	2%		TO92	Bulk (Z), tape and reel (ZT) or ammpack (AP)	TS431I
TS431AIZ/AIZT/AIZ-AP	1%				TS431AI
TS431BIZ/BIZT/BIZ-AP	0.5%				TS431BI

1. Qualification and characterization according to AEC-Q100 and AEC-Q003 or equivalent, advanced screening according to AEC-Q001 and AEC-Q002 or equivalent.

## 7 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
1-Sep-2003	1	Initial release.
1-Oct-2005	2	PPAP references inserted in the datasheet. See the order codes table. Minor changes to formatting and grammar.
2-Jan-2006	3	TS431AIYLT PPAP reference inserted. See the order codes table.
22-Sep-2006	4	Included footnote on automotive grade qualification to order codes table. Updated package information (changed mils to inches).
25-Apr-2007	5	Resized graphics on cover page. Moved definition of output voltage change from <i>Table 3</i> footnote to separate section below table. Corrected errors in SOT23-5 package mechanical data. Removed erroneous drawing for TO92 tape & reel package.
30-Aug-2007	6	Updated drawing for TO92 bulk package. Modified footnote related to automotive grade qualification in <i>Table 5: Order codes</i> , and re-ordered order codes.
27-Aug-2010	7	Modified note for package SOT23-5 on page 1.
15-Nov-2012	8	Modified note 1 <i>Table 5 on page 12</i> .
17-Dec-2012	9	Added note 1 <i>Table 2 on page 2</i> and <i>Section 3 on page 7</i> .
12-Mar-2013	10	Added features Automotive grade version available in cover page.
30-Nov-2017	11	Added automotive qualification for SOT23-5 in the whole document. Updated main title on page 1. Added Section 1: Pinout on page 3. Updated Table 1 on page 4 (removed note 1). Added Table 3 on page 4. Minor modifications throughout document.
27-Jun-2018	12	Added precision value in <i>Table 8: Order codes</i> .

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