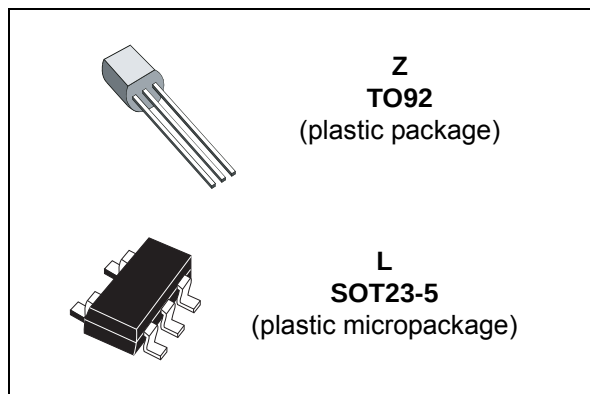


## Adjustable shunt voltage reference IC (automotive for SOT23-5)

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

# Contents

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# 1 Pinout

Figure 1. Pinout Z TO92 (plastic package)

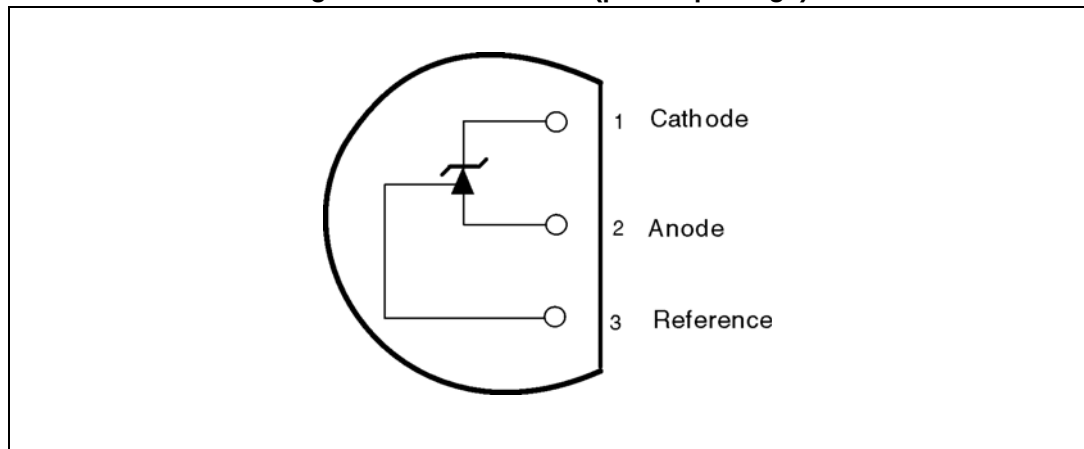
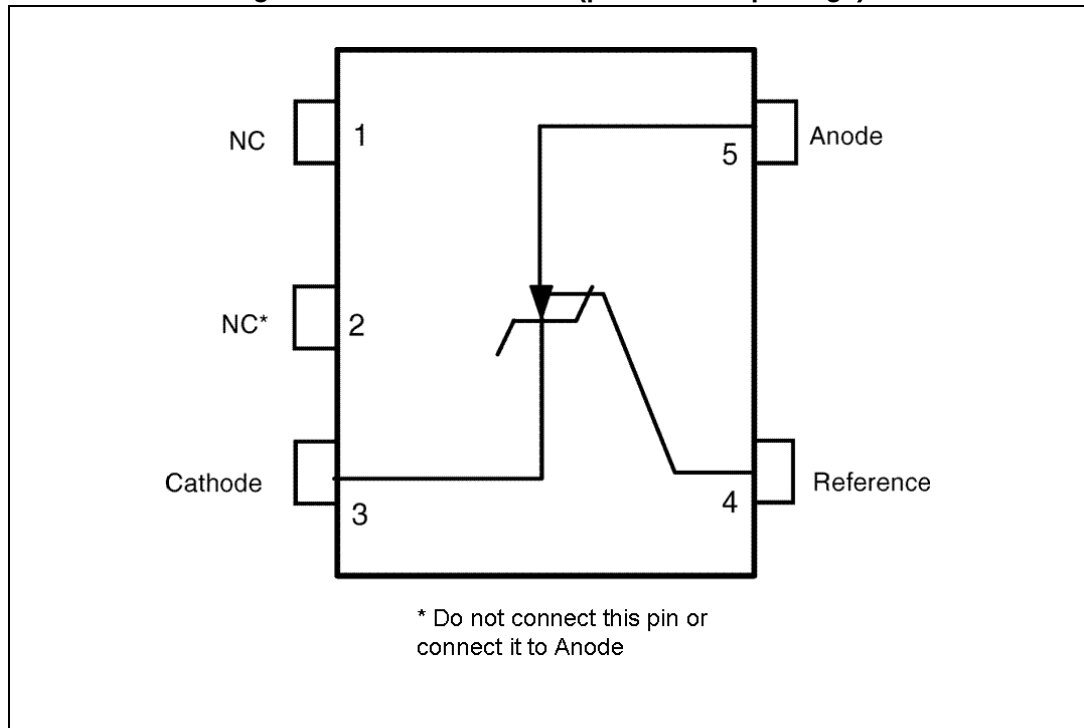


Figure 2. Pinout L SOT23-5 (plastic micropackage)



## 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<br>TO92 package<br>SOT23-5 package | 625<br>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<br>$V_{KA} = V_{ref}$ at $I_k = 100\text{ }\mu\text{A}$                          | TS431<br>TS431A<br>TS431B                                                                                                                | 1.215<br>1.228<br>1.234 | 1.240<br>1.240<br>1.240 | 1.265<br>1.252<br>1.246 | V             |
| $\Delta V_{ref}$                                      | Output voltage change <sup>(1) (2)</sup><br>$I_k = 100\text{ }\mu\text{A}$ , $V_{KA} = V_{ref}$ | $0 < T_{amb} < +70\text{ °C}$<br>$-40 < T_{amb} < +85\text{ °C}$<br>$-40 < T_{amb} < +105\text{ °C}$<br>$-40 < T_{amb} < +125\text{ °C}$ | -<br>-<br>-<br>-        | -<br>-<br>-<br>-        | 9<br>16<br>18<br>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                | $I_k = 10\text{ mA}$<br>$V_{KA} = 6\text{ V to } V_{ref}$                                                                                | -                       | 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                                        | $I_k = 10\text{ mA}$ , $R_1 = 10\text{ k}\Omega$ , $R_2 = \infty$<br>$-40 < T_{amb} < +85\text{ °C}$<br>$-40 < T_{amb} < +125\text{ °C}$ | -<br>-<br>-             | 70<br>90                | 160<br>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                     | $\Omega$      |

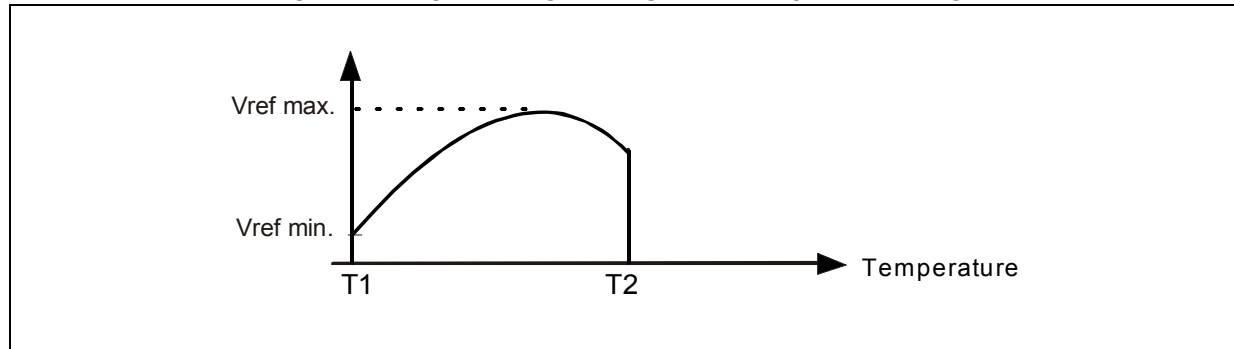
1. Limits are 100% production tested at 25 °C. Behavior at the temperature range limits is guaranteed through correlation and by design.
2. See definition below.

#### 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.

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

Figure 3. Output voltage change over temperature range



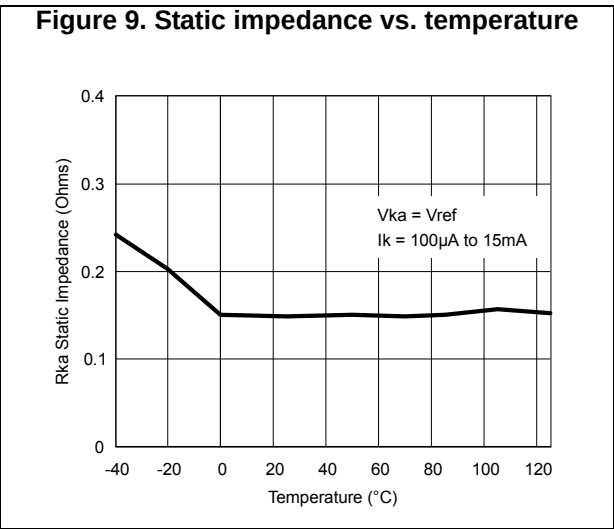
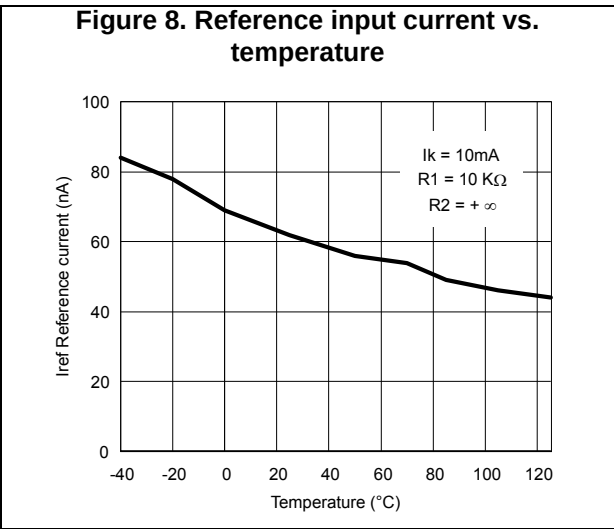
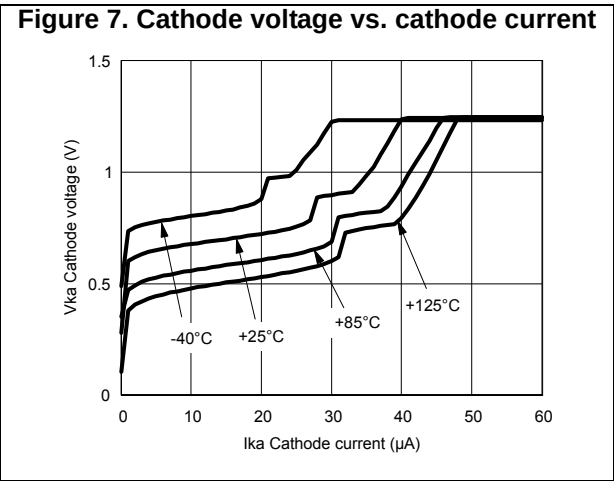
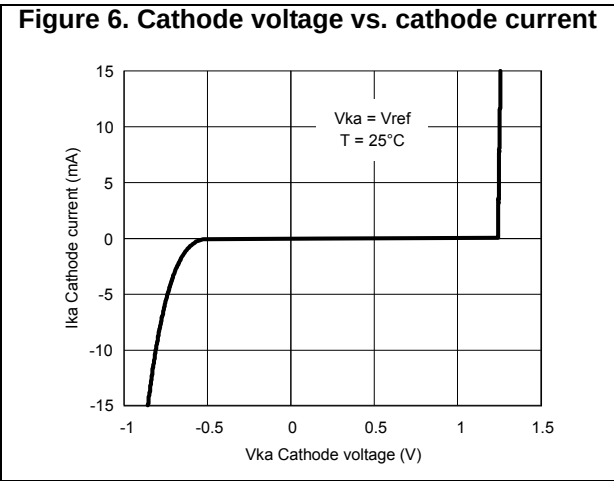
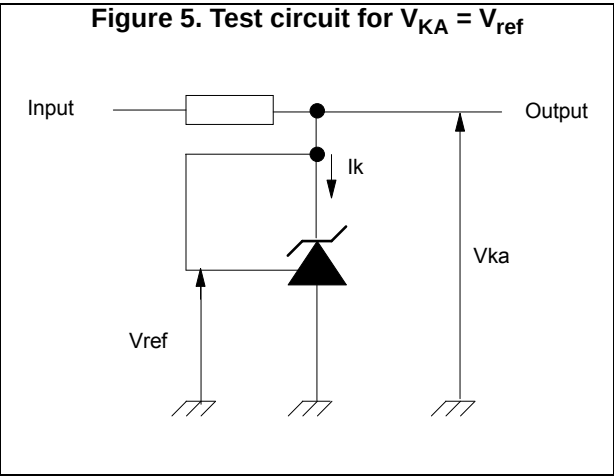
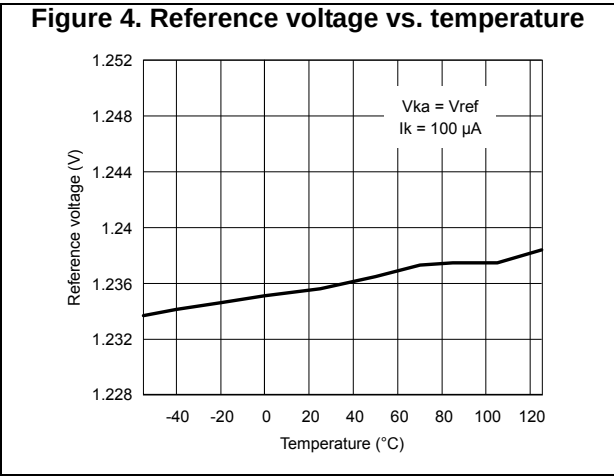


Figure 10. Off-state current vs. temperature

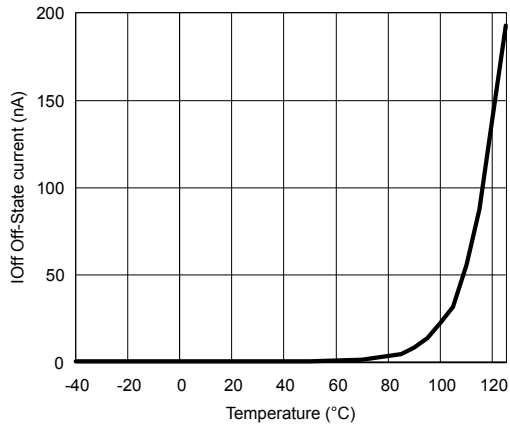


Figure 11. Test circuit for off-state current measurement

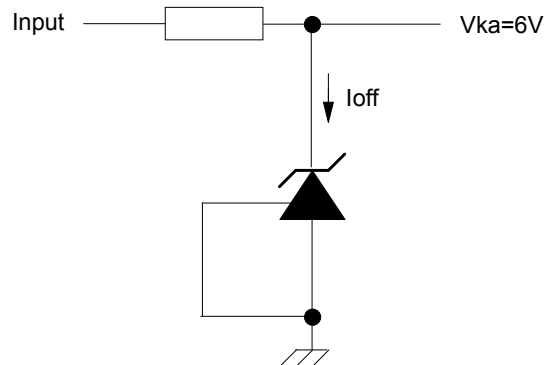
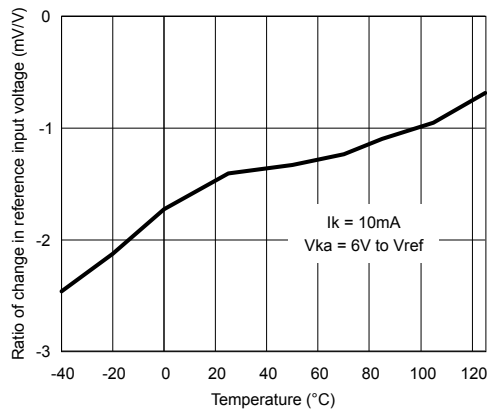
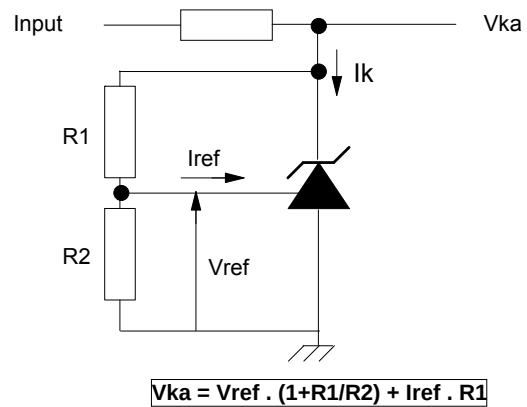
Figure 12. Ratio of change in reference input voltage to change in  $V_{KA}$  voltage vs. temperatureFigure 13. Test circuit for  $V_{KA} > V_{ref}$ 

Figure 14. Phase and gain vs. frequency

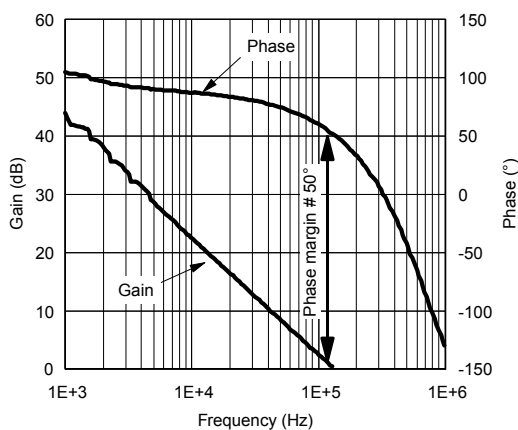


Figure 15. Test circuit for phase and gain measurement

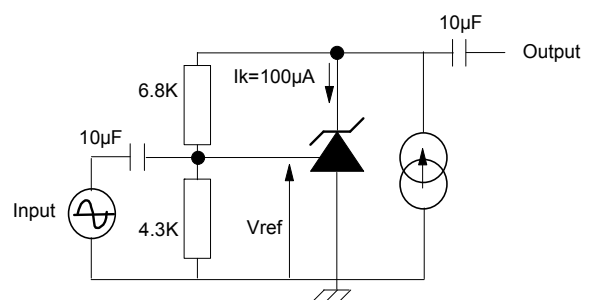


Figure 16. Pulse response at  $I_k = 100 \mu A$

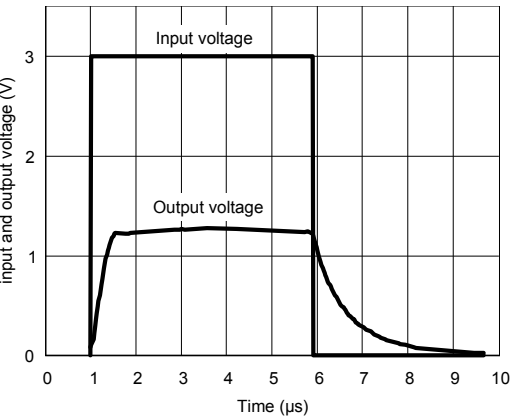


Figure 17. Test circuit for pulse response at  $I_k = 100 \mu A$

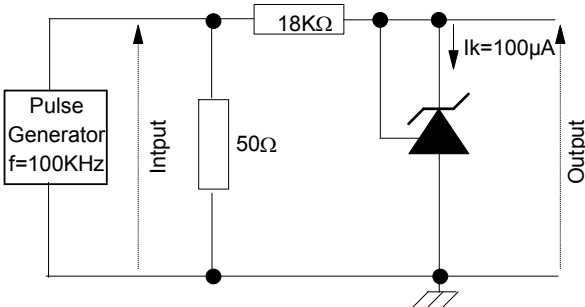


Figure 18. Pulse response at  $I_k = 1 mA$

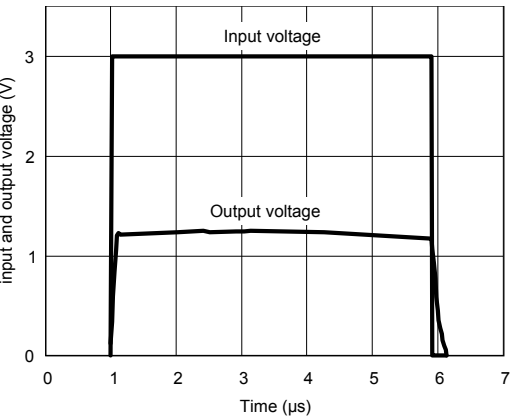


Figure 19. Test circuit for pulse response at  $I_k = 1 mA$

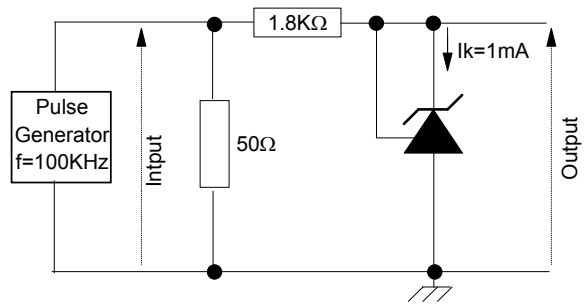
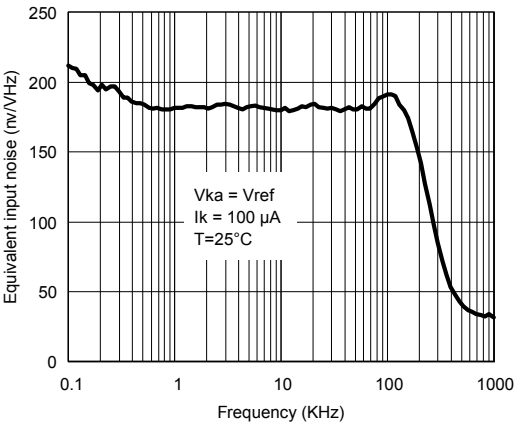


Figure 20. Equivalent input noise vs. frequency





## 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® 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.

## 5.1 SOT23-5 package information

Figure 21. SOT23-5 package outline

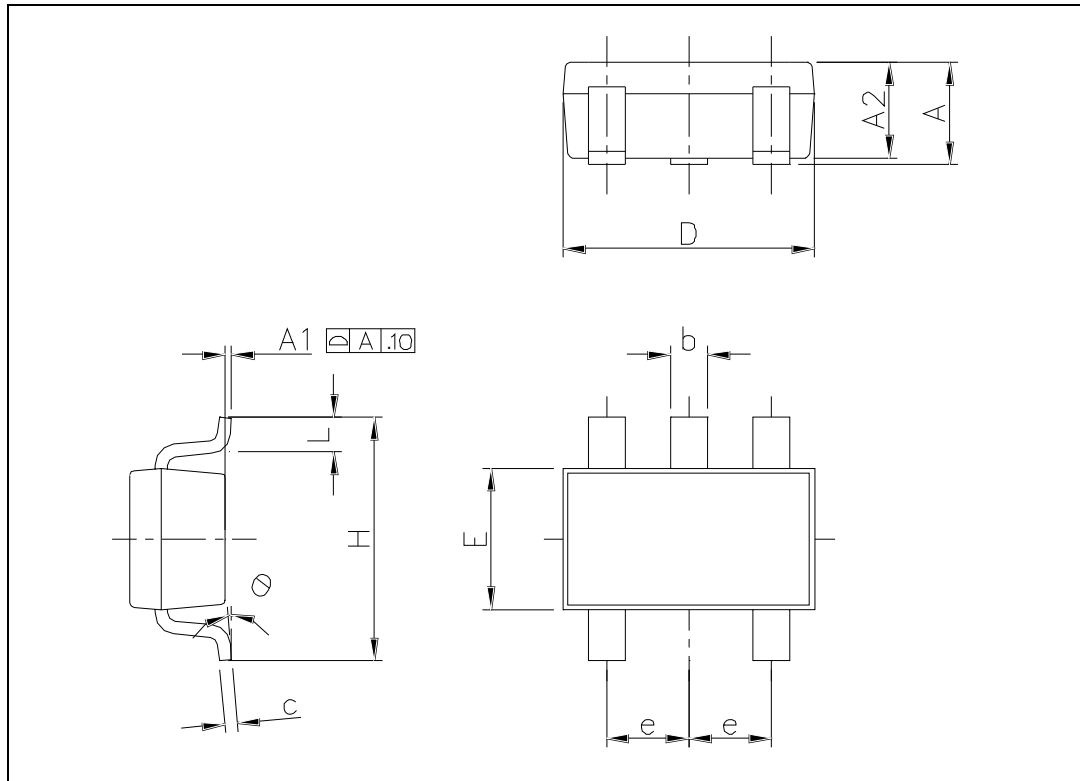


Table 5. SOT23-5 package mechanical data

| 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 ammpack and tape and reel) package information

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

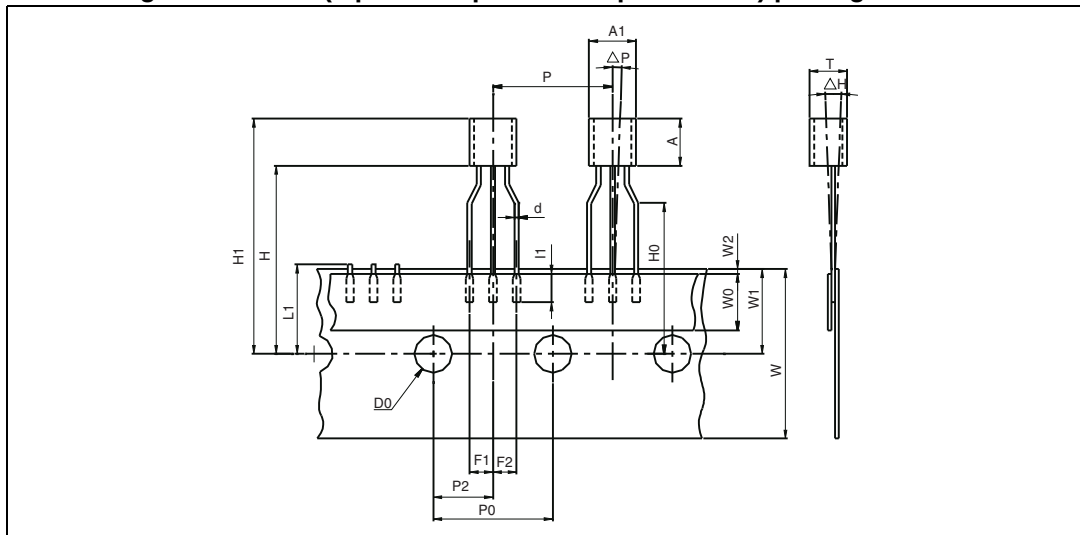


Table 6. TO92 (tape ammpack and tape and reel) package mechanical data

| 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

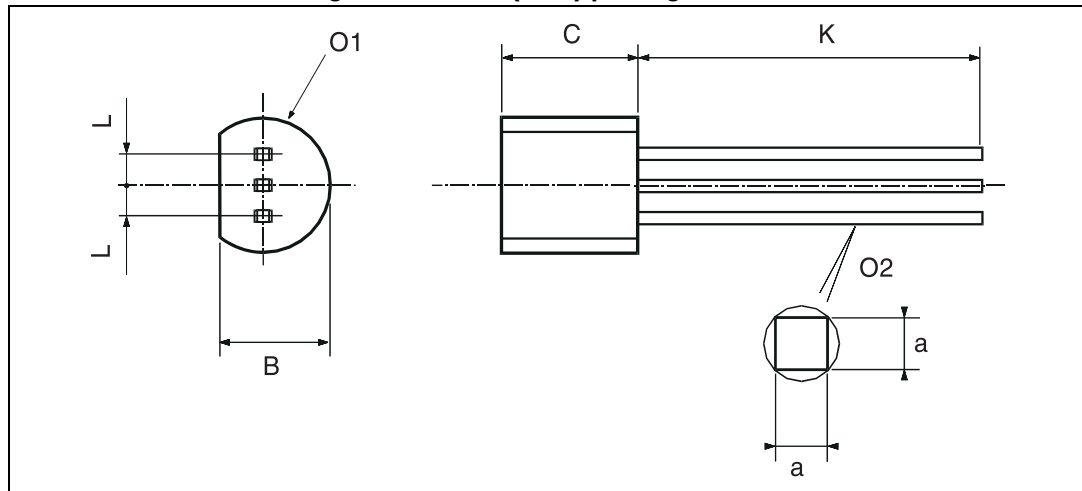


Table 7. TO92 (bulk) package mechanical data

| 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<br>(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),<br>tape and reel (ZT)<br>or ammopack (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.<br>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.<br>Updated package information (changed mils to inches).                                                                                                                              |
| 25-Apr-2007 | 5        | Resized graphics on cover page.<br>Moved definition of output voltage change from <i>Table 3</i> footnote to separate section below table.<br>Corrected errors in SOT23-5 package mechanical data.<br>Removed erroneous drawing for TO92 tape & reel package.   |
| 30-Aug-2007 | 6        | Updated drawing for TO92 bulk package.<br>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.<br>Updated main title on page 1.<br>Added Section 1: Pinout on page 3.<br>Updated Table 1 on page 4 (removed note 1).<br>Added Table 3 on page 4.<br>Minor modifications throughout document. |
| 27-Jun-2018 | 12       | Added precision value in <i>Table 8: Order codes</i> .                                                                                                                                                                                                          |

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