

## Low voltage adjustable shunt reference

### Features

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

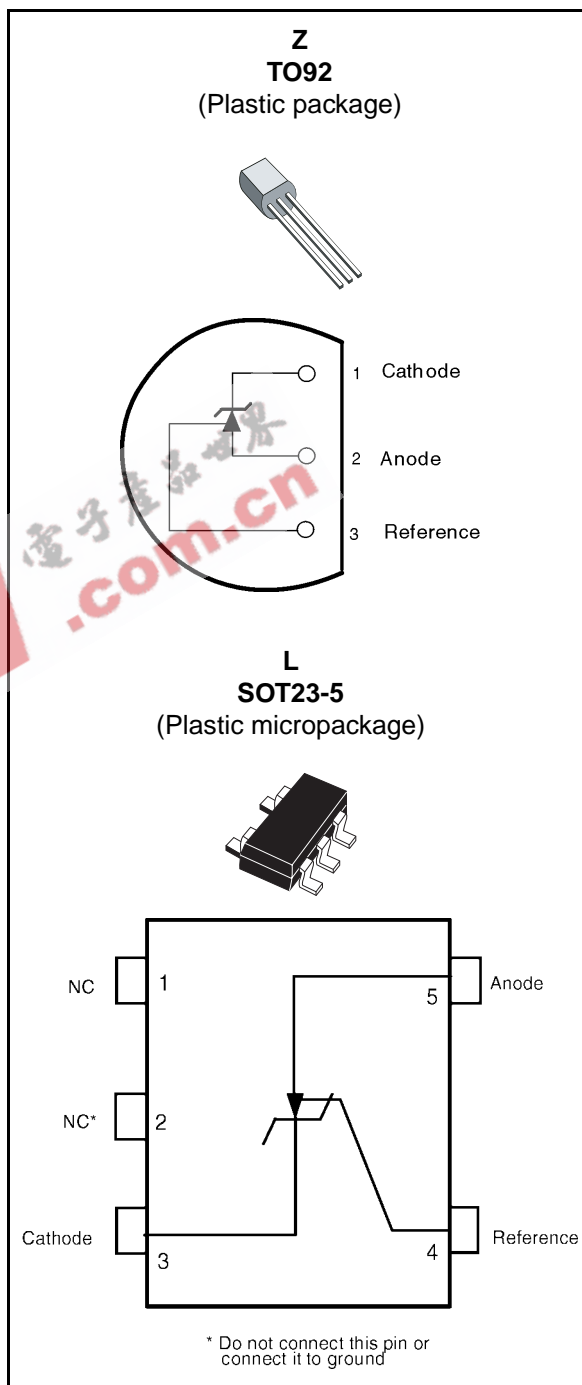
### Description

The TS431 is a low-voltage, three-terminal, programmable shunt voltage reference.

The output voltage can be set to any value between  $V_{ref}$  (1.24V) and 6V with two external resistors.

The TS431 is able to operate at a lower voltage (1.24V) and lower cathode current than the widely used TL431 and TL1431 shunt voltage reference.

When driving an optocoupler, the TS431 is particularly useful for regulating 3.3V switching power supplies.



# 1 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 <sup>(1)</sup><br>TO92 package<br>SOT23-5 package | 625<br>500  | mW   |
| $T_{stg}$ | Storage temperature range   | -65 to +150 | °C   |

1.  $T_{junction}=150^{\circ}C$ ,  $T_{amb}=25^{\circ}C$  with  
 $R_{THj-a}=200^{\circ}C/W$  for TO92 package and  
 $R_{THj-a}=250^{\circ}C/W$  for SOT23-5L package

**Table 2. Operating conditions**

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

## 2 Electrical characteristics

**Table 3.**  $T_{amb} = 25^{\circ}\text{C}$  (unless otherwise specified)

| Symbol                                   | Parameter  | Test conditions  | Min.                    | Typ.     | Max.                    | Unit          |
|--|--|--|-------------------------|----------|-------------------------|---------------|
| $V_{ref}$                                | Output voltage<br>$V_{KA} = V_{ref}$ @ $I_k = 100\mu\text{A}$                        | TS431<br>TS431A<br>TS431B  | 1.215<br>1.228<br>1.234 | 1.240    | 1.265<br>1.252<br>1.246 | V             |
| $\Delta V_{ref}$                         | Output voltage change <sup>(1) (2)</sup><br>$I_k = 100\mu\text{A}, V_{KA} = V_{ref}$ | $0 < T_{amb} < +70^{\circ}\text{C}$<br>$-40 < T_{amb} < +85^{\circ}\text{C}$<br>$-40 < T_{amb} < +105^{\circ}\text{C}$<br>$-40 < T_{amb} < +125^{\circ}\text{C}$ |                         |          | 9<br>16<br>18<br>21     | mV            |
| $\frac{ \Delta V_{ref} }{\Delta V_{ka}}$ | 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>$-40 < T_{amb} < +85^{\circ}\text{C}$<br>$-40 < T_{amb} < +125^{\circ}\text{C}$                           |                         | 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                     | $\Omega$      |

- 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.

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

**Figure 1.** Output voltage change over temperature range

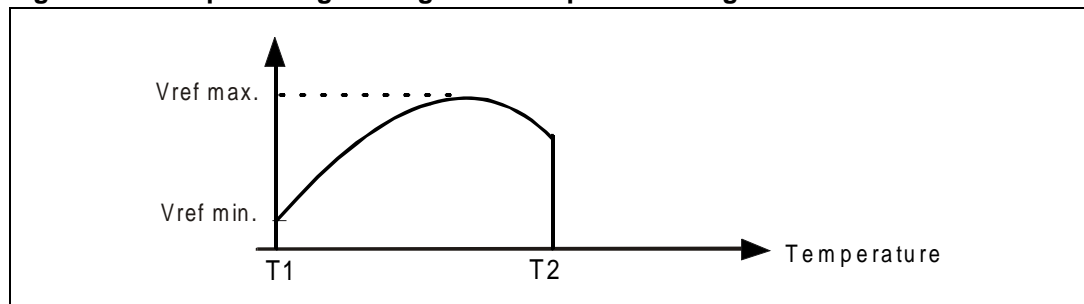


Figure 2. Reference voltage vs. temperature

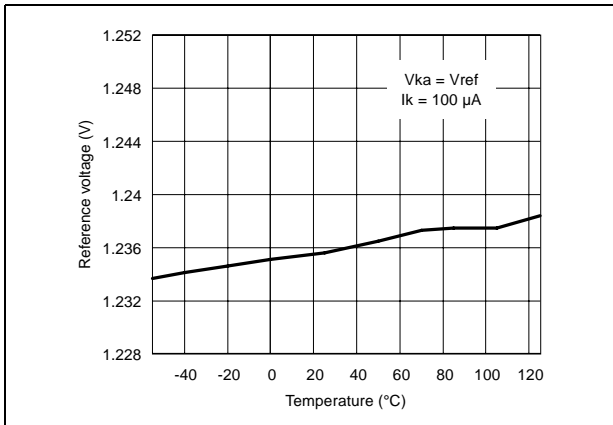


Figure 3. Test circuit for  $V_{KA} = V_{ref}$

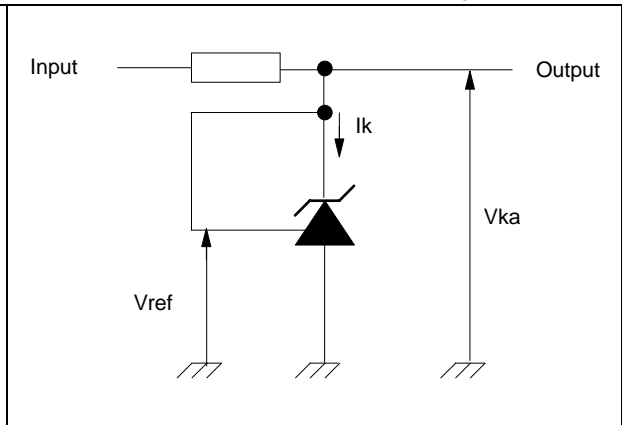


Figure 4. Cathode voltage vs. cathode current

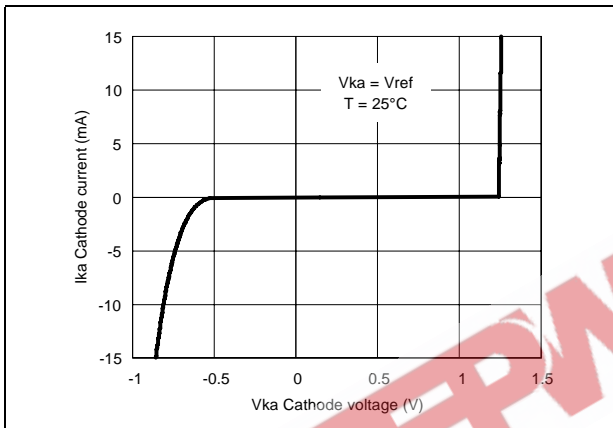


Figure 5. Cathode voltage vs. cathode current

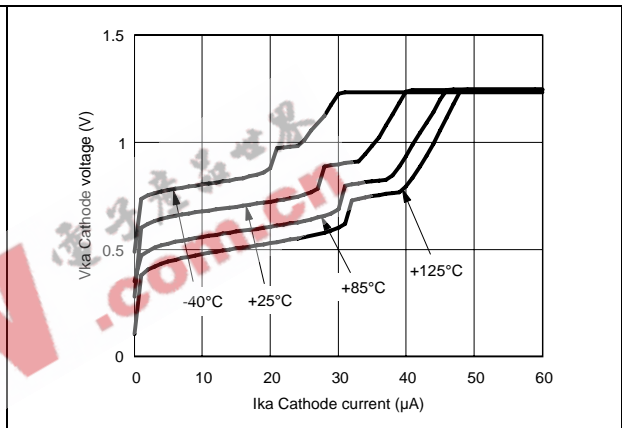


Figure 6. Reference input current vs. temperature

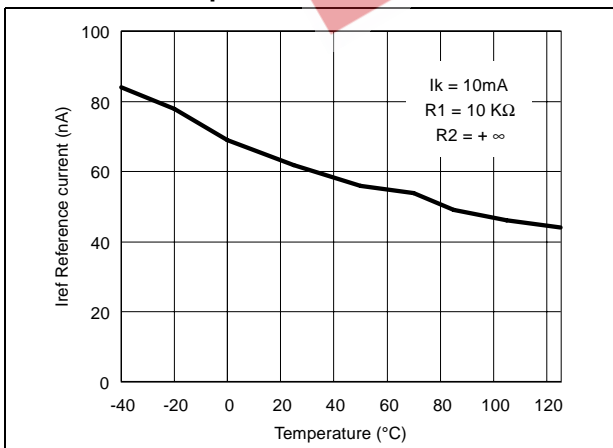


Figure 7. Static impedance vs. temperature

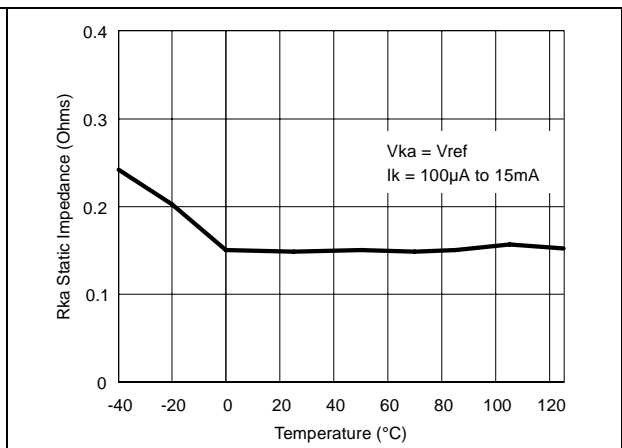


Figure 8. Off-state current vs. temperature

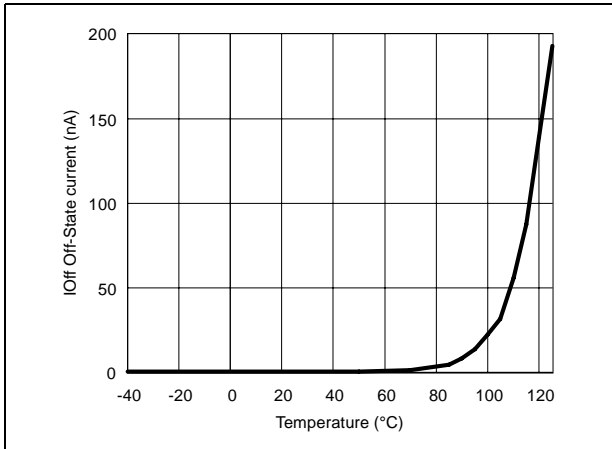


Figure 9. Test circuit for off-state current measurement

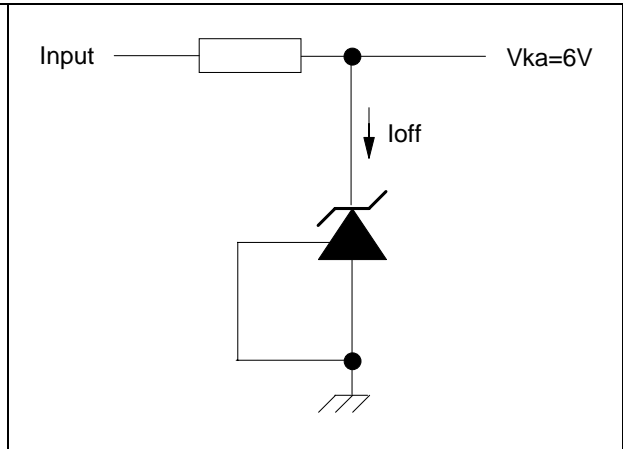


Figure 10. Ratio of change in reference input voltage to change in V<sub>KA</sub> voltage vs. temperature

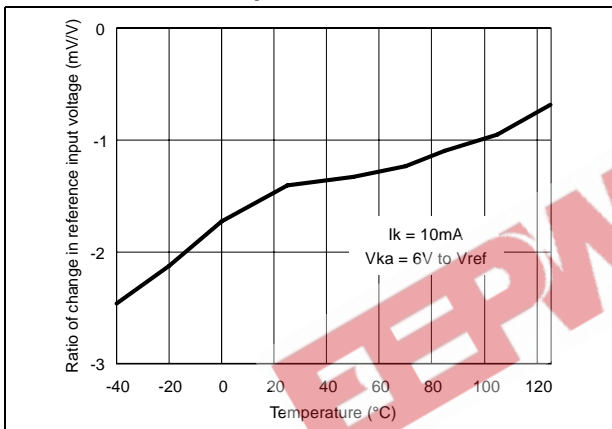


Figure 11. Test circuit for V<sub>KA</sub> > V<sub>ref</sub>

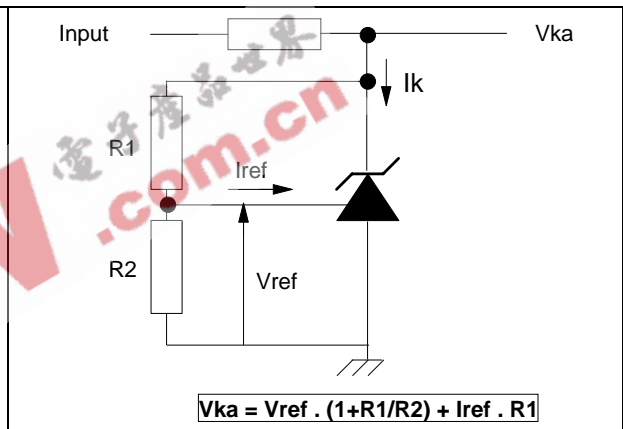


Figure 12. Phase and gain vs. frequency

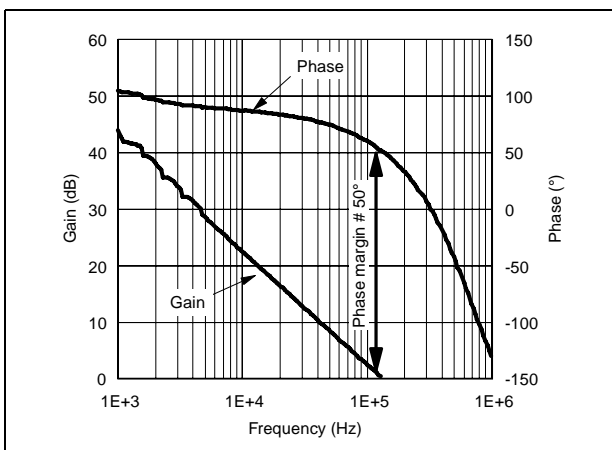


Figure 13. Test circuit for phase and gain measurement

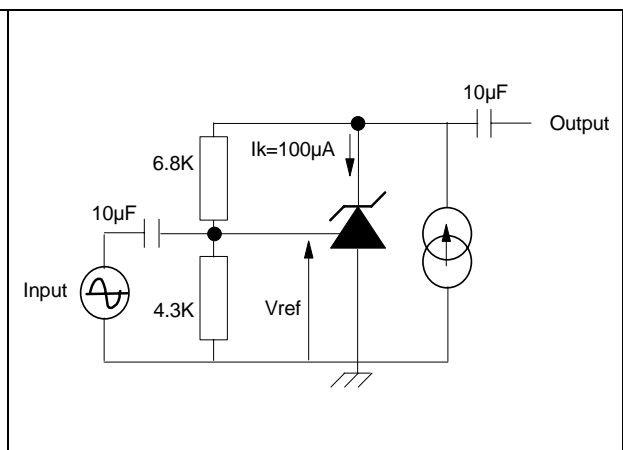


Figure 14. Pulse response at  $I_k=100\mu A$

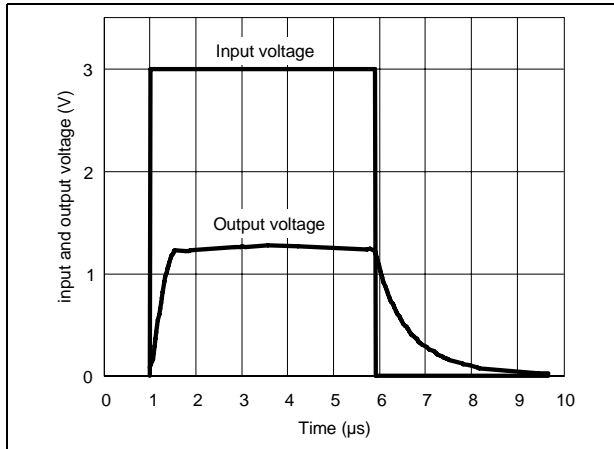


Figure 15. Test circuit for pulse response at  $I_k=100\mu A$

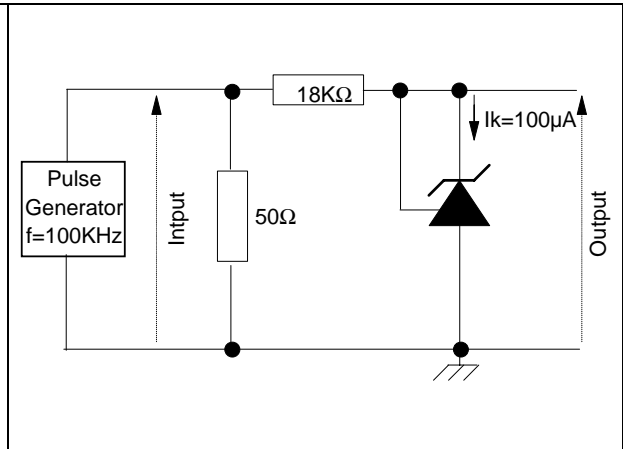


Figure 16. Pulse response at  $I_k=1mA$

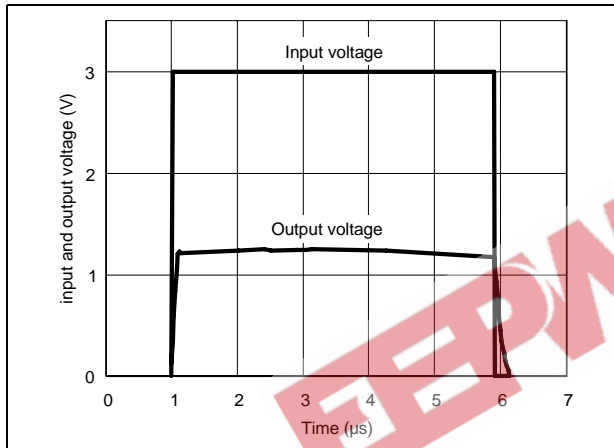


Figure 17. Test circuit for pulse response at  $I_k=1mA$

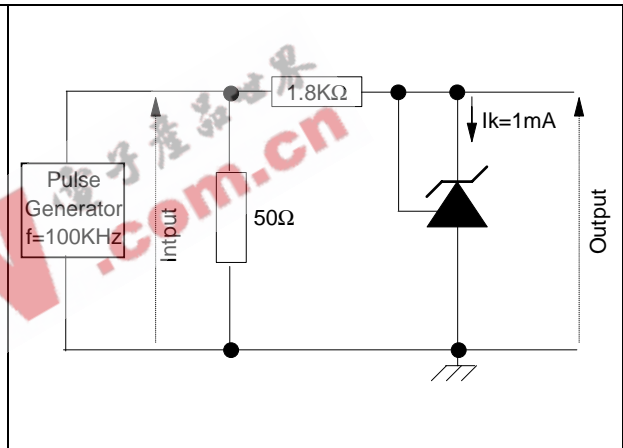
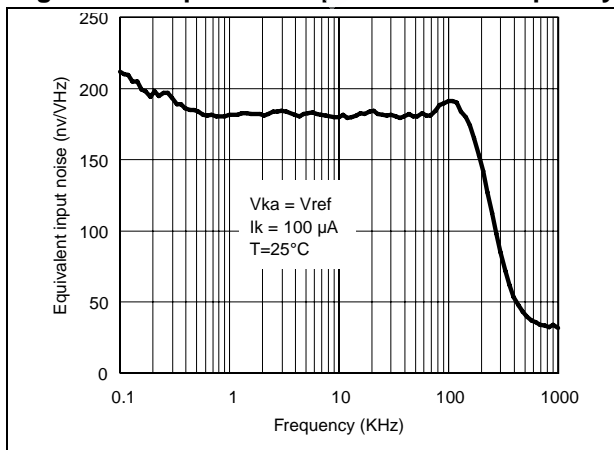


Figure 18. Equivalent input noise vs. frequency



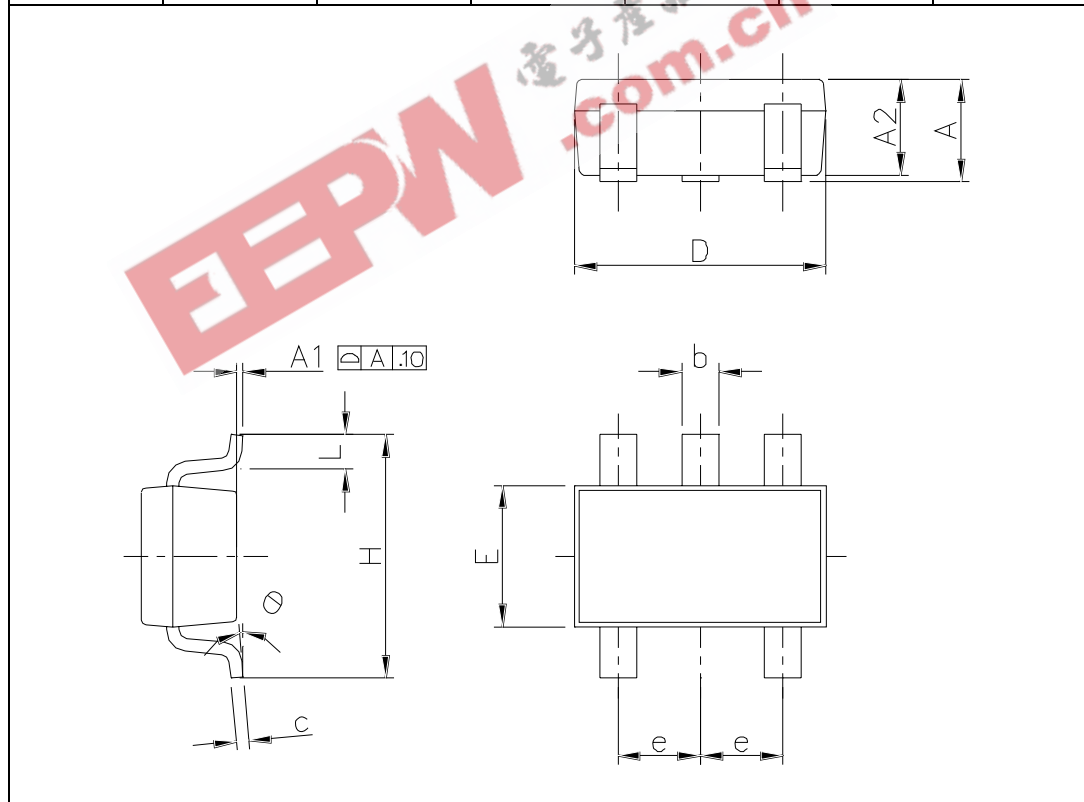
### 3 Package information

In order to meet environmental requirements, STMicroelectronics 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 STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

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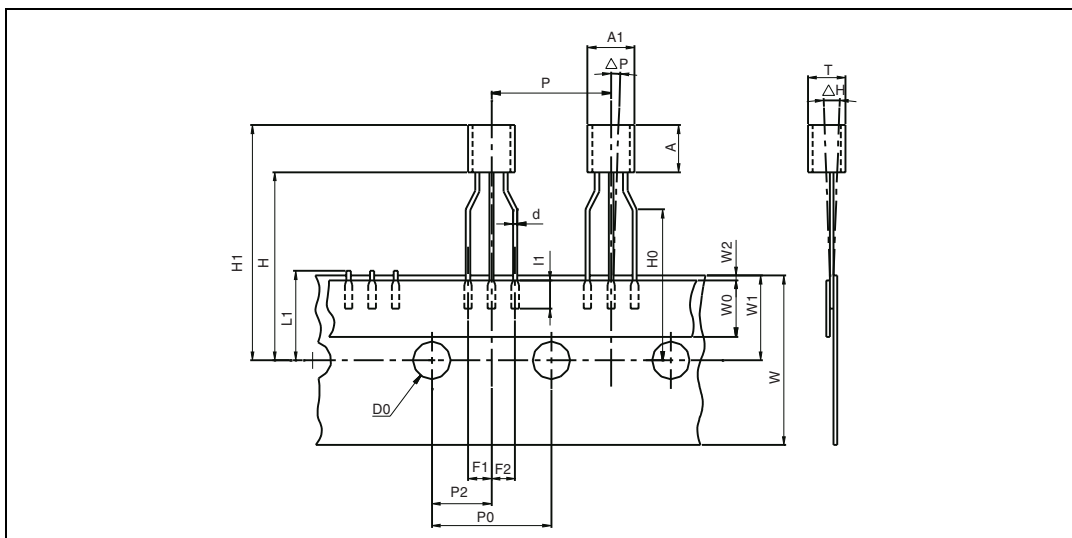
### 3.1 SOT23-5 package mechanical data

| Ref. | 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 |



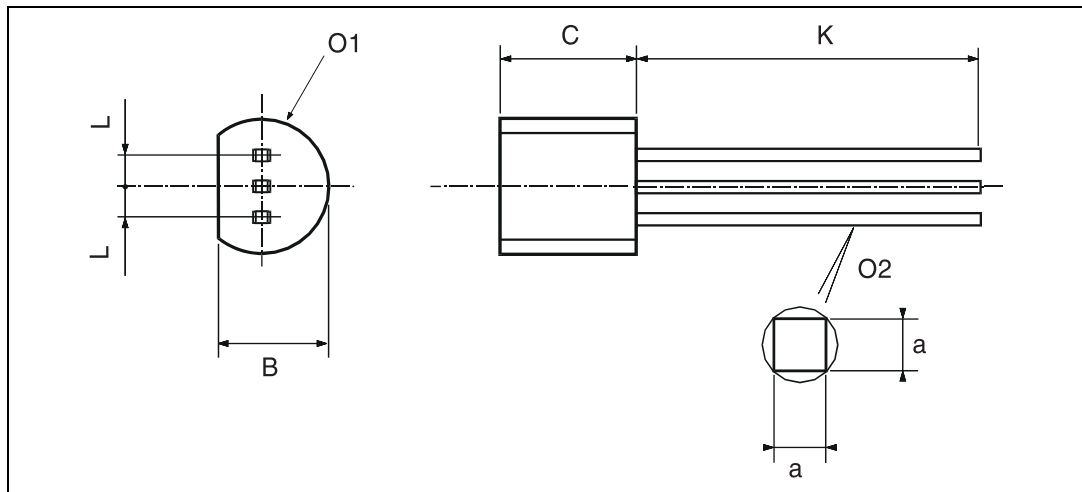


### 3.2 TO92 (tape ammo pack and tape & reel) package data



| Dim.  | Millimeters |      |      | 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 |

### 3.3 TO92 (bulk) package mechanical data



| Dim. | 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 |        |        |

## 4 Ordering information

**Table 4. Order codes**

| Part number               | Temperature range | Package                             | Packing  | Marking |
|---------------------------|-------------------|-------------------------------------|--|---------|
| TS431ILT                  | -40°C, + 125°C    | SOT23-5                             | Tape & reel  | L272    |
| TS431AILT                 |                   |                                     |  | L271    |
| TS431BILT                 |                   |                                     |  | L270    |
| TS431IYLT <sup>(1)</sup>  |                   | SOT23-5<br>(automotive grade level) |  | L274    |
| TS431AIYLT <sup>(1)</sup> |                   |                                     |  | L276    |
| TS431BIYLT <sup>(1)</sup> |                   |                                     |  | L273    |
| TS431IZ/IZT/IZ-AP         |                   | TO92                                | Bulk (Z),<br>Tape & reel (ZT) or<br>Ammo pack (AP) | TS431I  |
| TS431AIZ/AIZT/AIZ-AP      |                   |                                     |  | TS431AI |
| TS431BIZ/BIZT/BIZ-AP      |                   |                                     |  | TS431BI |

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

## 5 Revision history

**Table 5. 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 <a href="#">Table 3</a> 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 <a href="#">Table 4: Order codes</a> , and re-ordered order codes.  |

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