# TS2431

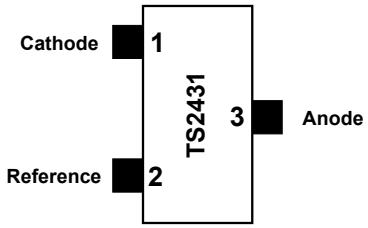
## Programmable shunt voltage reference

### Features

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

**L**
**SOT23-3L**
(plastic micropackage)

**Pin connections (top view)**




### 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 SOT23-3 surface mount package, the device can be implemented in applications where space-saving is of utmost importance.

# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| Vka | Cathode to anode voltage | 25 | V |
| $I_K$ | Reverse breakdown current | -100 to +150 | mA |
| $I_{REF}$ | Reference input current range | -0.05 to +10 | mA |
| $P_d$ | Power dissipation(1) SOT23-3 | 360 | mW |
| $T_{std}$ | Storage temperature | -65 to +150 | °C |
| ESD | Human body model (HBM)(2) | 2 | kV |
| | Machine model (MM)(3) | 200 | V |
| $T_{LEAD}$ | Lead temperature (soldering, 10 seconds) | 260 | °C |

1. Pd has been calculated with Tamb = 25°C, Tjunction = 150°C, Rthjc = 110°C/W and Rthja = 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 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{KA}$ | Cathode to anode voltage | $V_{REF}$ to 24 | V |
| $I_K$ | Cathode operating current(1) | 1 to 100 | mA |
| $T_{oper}$ | 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 3. Electrical characteristics (Tamb = 25° C unless otherwise specified)**

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference input voltage | $V_K = V_{REF}$, IK =10 mA | | 2.5 | | V |
| | | TS2431 (2%) | 2.45 | | 2.55 | |
| | | TS2431A (1%) | 2.475 | | 2.525 | |
| | | TS2431B (0.5%) | 2.488 | | 2.512 | |
| $\lvert \Delta V_{REF} \rvert$ | Reference input voltage deviation over temperature $V_K = V_{REF}$, $I_K = 10$ mA(1) (2) | 0° C < T < +70° C | | 10 | 20 | mV |
| | | -40° C < T < +85° C | | 17 | 30 | |
| | | -40° C < T < +105° C | | 20 | 35 | |
| $T_C$ | Temperature coefficient (note 2) | -40° C < T < +105° C | | 50 | 100 | ppm/°C |
| $I_{KMIN}$ | Minimum operating current | T = 25° C | | 0.3 | 0.8 | mA |
| | | -40° C < T < +105° C | | | 1 | |
| $\left\lvert \frac{\Delta Vref}{\Delta Vk} \right\rvert$ | Ratio of change in reference input voltage to change in cathode to anode voltage | $I_K$ = 10 mA<br>Vka = 24 to 2.5 V | | 0.3 | 2 | mV/V |
| $I_{REF}$ | Reference input current<br>$I_K$ = 10 mA, R1 = 10 KΩ, R2 = + ∞ (3) | T = 25° C | | 0.5 | 2.5 | µA |
| | | -40° C < T < +105° C | | | 3 | |
| $\lvert \Delta I_{REF} \rvert$ | Reference input current deviation<br>$I_K$ = 10 mA, R1 = 10 KΩ, R2 = + ∞ (3) | -40° C < T < +105° C | | 0.4 | 1.2 | µA |
| $I_{OFF}$ | Off-state cathode current | $V_K$ = 24 V, $V_{REF}$ = GND | | 10 | 500 | nA |
| $\lvert Z_{KA} \rvert$ | Reverse dynamic impedance | $V_K = V_{REF}$<br>$\Delta I_K$ = 1 to 50 mA,<br>f < 10 kHz | | 0.5 | 0.75 | W |
| $E_N$ | Wide band noise | Ik = 10 mA<br>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. $\lvert \Delta V_{REF} \rvert$ is defined as the difference between the maximum and minimum values of $V_{REF}$ obtained over the full temperature range.
3. Refer to *Figure 4: Test circuit for Vka = Vref on page 4*.

**Figure 1. Reference voltage vs temperature**

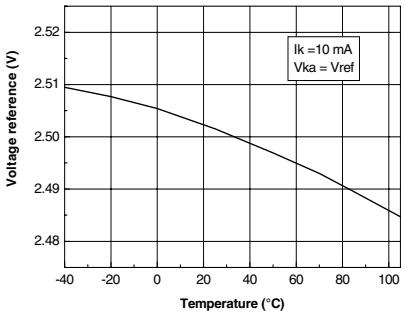



**Figure 2. Cathode voltage vs cathode current**

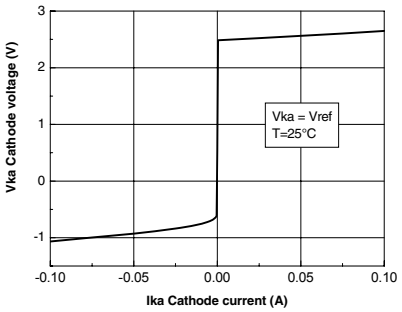



**Figure 3. Reference input current vs temperature**

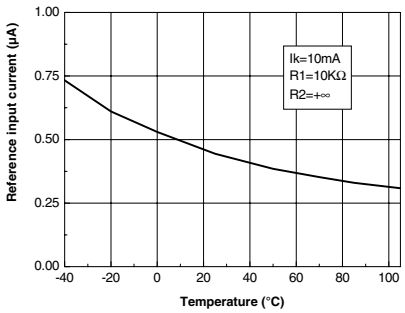



**Figure 4. Test circuit for Vka = Vref**

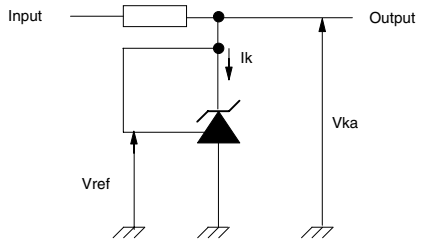



**Figure 5. Cathode voltage vs cathode current**

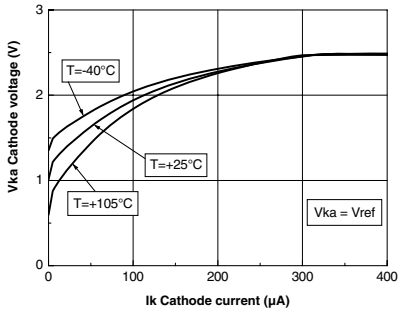



**Figure 6. Dynamic impedance vs frequency**

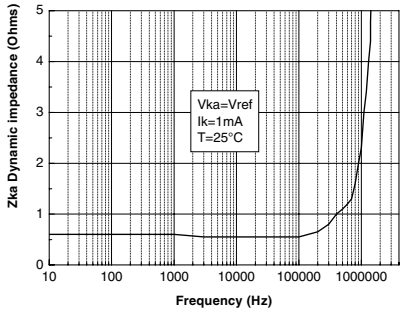


**Figure 7. Off-state current vs temperature**

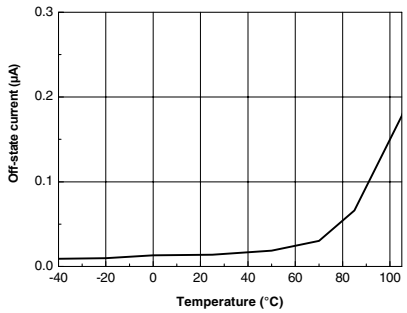



**Figure 8. Ratio of change in reference input voltage to change in Vka voltage vs temperature**

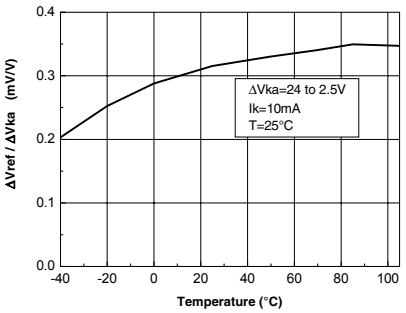



**Figure 9. Phase and gain vs frequency**

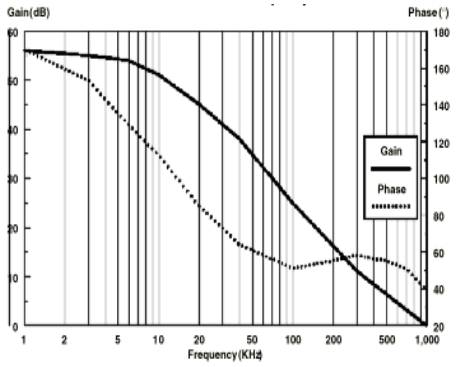



**Figure 10. Test circuit for off-state current measurement**

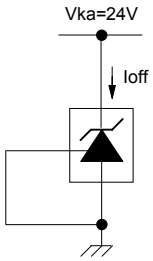



**Figure 11. Test circuit for Vka > Vref**

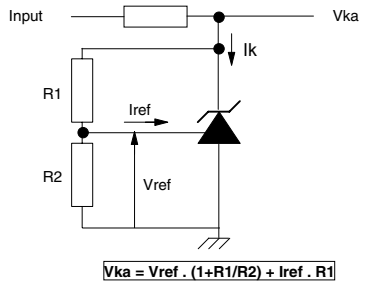



**Figure 12. Test circuit for phase and gain measurement**

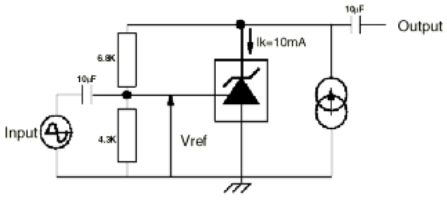


**Figure 13. Pulse response at I k = 1 mA**

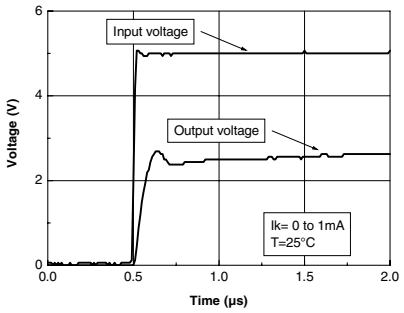



**Figure 14. Pulse response at I k = 1 mA**

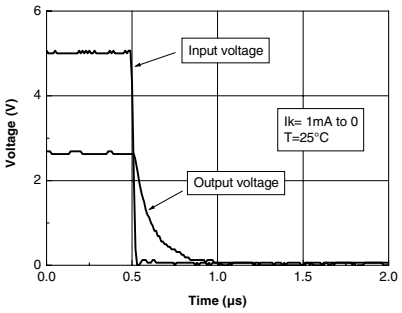



**Figure 15. Stability boundary conditions**

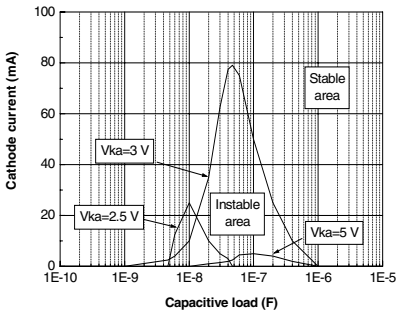



**Figure 16. Test circuit for pulse response at I k = 1 mA**

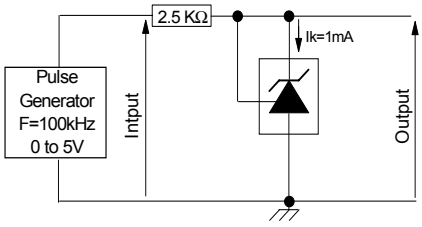



**Figure 17. Equivalent input noise vs frequency**

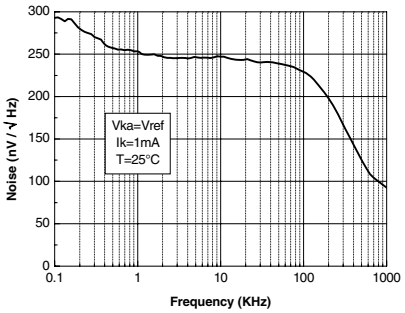
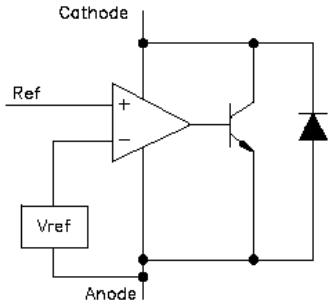



**Figure 18. Block Diagram**



# 3 Package 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*. ECOPACK® is an ST trademark.

## 3.1 SOT23-3 package information

**Figure 19. SOT23-3 package mechanical drawing**

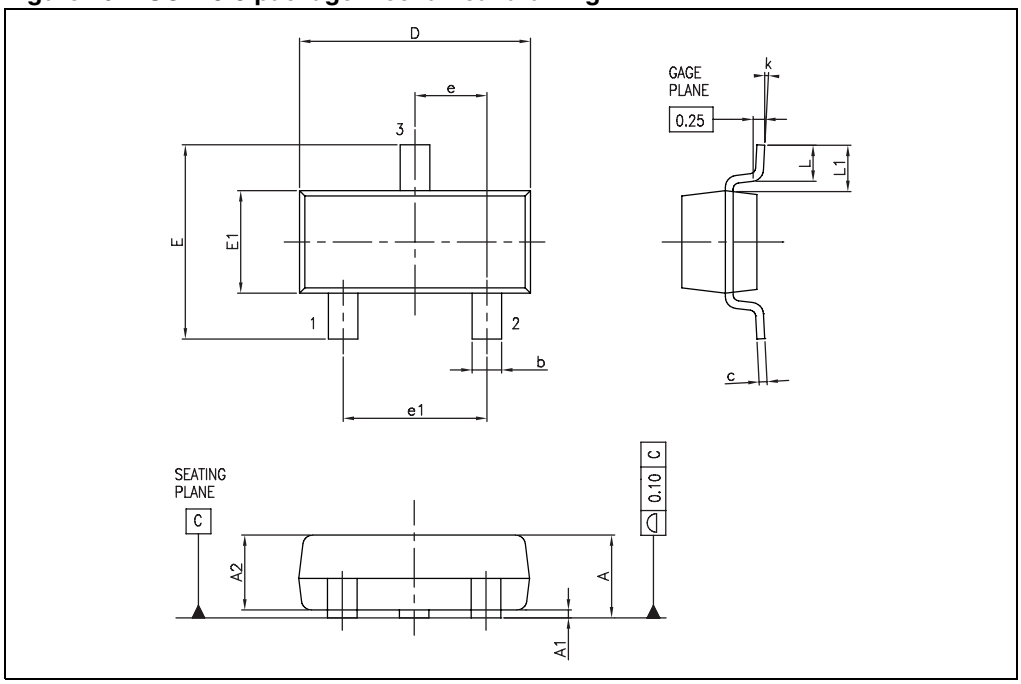



**Table 4. SOT23-3 package mechanical data**

| 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 Ordering information

**Table 5. Order codes**

| Order code | Temperature range | Package | Packing | Precision | Marking |
|---|---|---|---|---|---|
| TS2431ILT | -40 to +105°C | SOT23-3 | Tape & reel | 2% | L285 |
| TS2431AILT | | | | 1% | L286 |
| TS2431BILT | | | | 0.5% | L287 |
| TS2431IYLT(1) | | SOT23-3 (automotive grade) | | 2% | L289 |
| TS2431AIYLT(1) | | | | 1% | L290 |
| TS2431BIYLT(1) | | | | 0.5% | L291 |

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 6. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 01-Feb-2002 | 1 | Initial release. |
| 10-Sep-2009 | 2 | Updated document format.<br>Modified footnote 1 under *Table 1: Absolute maximum ratings on page 2*.<br>Added HBM and MM notes under *Table 1*.<br>Added automotive grade order codes in *Table 5: Order codes*. |

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