

# TL431, A, B Series, NCV431A, B

## Programmable Precision References

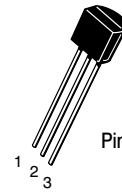
The TL431, A, B integrated circuits are three-terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from  $V_{ref}$  to 36 V with two external resistors. These devices exhibit a wide operating current range of 1.0 mA to 100 mA with a typical dynamic impedance of 0.22  $\Omega$ . The characteristics of these references make them excellent replacements for zener diodes in many applications such as digital voltmeters, power supplies, and op amp circuitry. The 2.5 V reference makes it convenient to obtain a stable reference from 5.0 V logic supplies, and since the TL431, A, B operates as a shunt regulator, it can be used as either a positive or negative voltage reference.

### Features

- Programmable Output Voltage to 36 V
- Voltage Reference Tolerance:  $\pm 0.4\%$ , Typ @ 25°C (TL431B)
- Low Dynamic Output Impedance, 0.22  $\Omega$  Typical
- Sink Current Capability of 1.0 mA to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C Typical
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Pb-Free Packages are Available

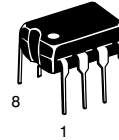


**ON Semiconductor®**



**TO-92 (TO-226)  
LP SUFFIX  
CASE 29**

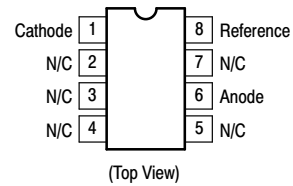
Pin 1. Reference  
2. Anode  
3. Cathode



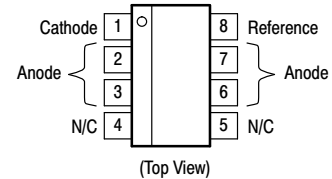
**PDIP-8  
P SUFFIX  
CASE 626**



**Micro8™  
DM SUFFIX  
CASE 846A**



**SOIC-8  
D SUFFIX  
CASE 751**



This is an internally modified SOIC-8 package. Pins 2, 3, 6 and 7 are electrically common to the die attach flag. This internal lead frame modification increases power dissipation capability when appropriately mounted on a printed circuit board. This modified package conforms to all external dimensions of the standard SOIC-8 package.

### ORDERING INFORMATION

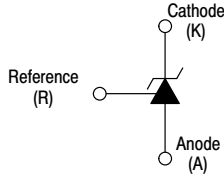
See detailed ordering and shipping information in the package dimensions section on page 13 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 16 of this data sheet.

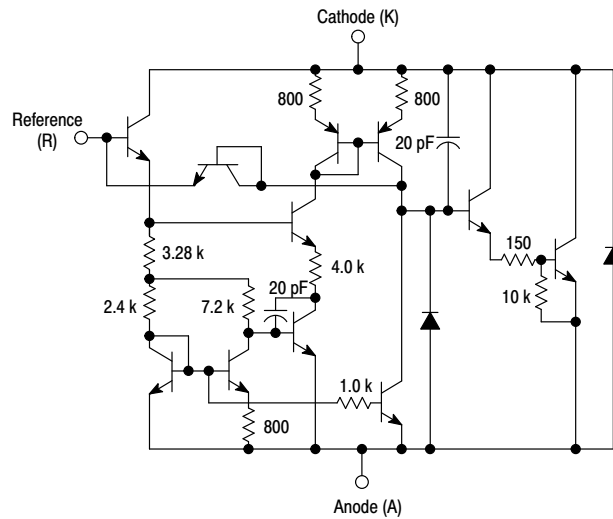
# TL431, A, B Series, NCV431A, B

## Symbol

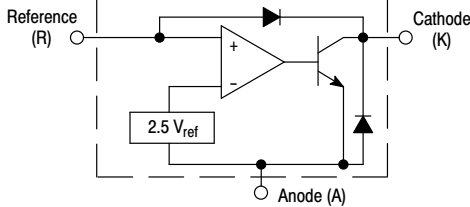


## Representative Schematic Diagram

Component values are nominal



## Representative Block Diagram



This device contains 12 active transistors.

## MAXIMUM RATINGS (Full operating ambient temperature range applies, unless otherwise noted.)

| Rating   | Symbol    | Value                                 | Unit |
|--|-----------|---------------------------------------|------|
| Cathode to Anode Voltage   | $V_{KA}$  | 37                                    | V    |
| Cathode Current Range, Continuous  | $I_K$     | -100 to +150                          | mA   |
| Reference Input Current Range, Continuous  | $I_{ref}$ | -0.05 to +10                          | mA   |
| Operating Junction Temperature   | $T_J$     | 150                                   | °C   |
| Operating Ambient Temperature Range<br>TL431I, TL431AI, TL431BI<br>TL431C, TL431AC, TL431BC<br>NCV431AI, NCV431B, TL431BV  | $T_A$     | -40 to +85<br>0 to +70<br>-40 to +125 | °C   |
| Storage Temperature Range  | $T_{stg}$ | -65 to +150                           | °C   |
| Total Power Dissipation @ $T_A = 25^\circ\text{C}$<br>Derate above 25°C Ambient Temperature<br>D, LP Suffix Plastic Package<br>P Suffix Plastic Package<br>DM Suffix Plastic Package | $P_D$     | 0.70<br>1.10<br>0.52                  | W    |
| Total Power Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above 25°C Case Temperature<br>D, LP Suffix Plastic Package<br>P Suffix Plastic Package                                 | $P_D$     | 1.5<br>3.0                            | W    |
| ESD Rating   | HBM<br>MM | >2000<br>>200                         | V    |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

| Condition                | Symbol   | Min       | Max | Unit |
|--------------------------|----------|-----------|-----|------|
| Cathode to Anode Voltage | $V_{KA}$ | $V_{ref}$ | 36  | V    |
| Cathode Current          | $I_K$    | 1.0       | 100 | mA   |

## THERMAL CHARACTERISTICS

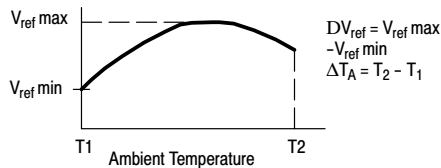
| Characteristic                          | Symbol          | D, LP Suffix Package | P Suffix Package | DM Suffix Package | Unit |
|---|-----------------|----------------------|------------------|-------------------|------|
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 178                  | 114              | 240               | °C/W |
| Thermal Resistance, Junction-to-Case    | $R_{\theta JC}$ | 83                   | 41               | -                 | °C/W |

# TL431, A, B Series, NCV431A, B

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, unless otherwise noted.)

| Characteristic   | Symbol                                 | TL431I       |              |              | TL431C        |              |               | Unit |
|--|--|--------------|--------------|--------------|---------------|--------------|---------------|------|
|  |  | Min          | Typ          | Max          | Min           | Typ          | Max           |      |
| Reference Input Voltage (Figure 1)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10 mA<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)            | V <sub>ref</sub>                       | 2.44<br>2.41 | 2.495<br>-   | 2.55<br>2.58 | 2.44<br>2.423 | 2.495<br>-   | 2.55<br>2.567 | V    |
| Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 1, 2)<br>V <sub>KA</sub> = V <sub>ref</sub> , I <sub>K</sub> = 10 mA   | ΔV <sub>ref</sub>                      | -            | 7.0          | 30           | -             | 3.0          | 17            | mV   |
| Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage<br>I <sub>K</sub> = 10 mA (Figure 2),<br>ΔV <sub>KA</sub> = 10 V to V <sub>ref</sub><br>ΔV <sub>KA</sub> = 36 V to 10 V | $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | -<br>-       | -1.4<br>-1.0 | -2.7<br>-2.0 | -<br>-        | -1.4<br>-1.0 | -2.7<br>-2.0  | mV/V |
| Reference Input Current (Figure 2)<br>I <sub>K</sub> = 10 mA, R1 = 10 k, R2 = ∞<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = T <sub>low</sub> to T <sub>high</sub> (Note 1)                              | I <sub>ref</sub>                       | -<br>-       | 1.8<br>-     | 4.0<br>6.5   | -<br>-        | 1.8<br>-     | 4.0<br>5.2    | μA   |
| Reference Input Current Deviation Over Temperature Range (Figure 2, Note 1, 4)<br>I <sub>K</sub> = 10 mA, R1 = 10 k, R2 = ∞  | ΔI <sub>ref</sub>                      | -            | 0.8          | 2.5          | -             | 0.4          | 1.2           | μA   |
| Minimum Cathode Current For Regulation<br>V <sub>KA</sub> = V <sub>ref</sub> (Figure 1)  | I <sub>min</sub>                       | -            | 0.5          | 1.0          | -             | 0.5          | 1.0           | mA   |
| Off-State Cathode Current (Figure 3)<br>V <sub>KA</sub> = 36 V, V <sub>ref</sub> = 0 V   | I <sub>off</sub>                       | -            | 20           | 1000         | -             | 20           | 1000          | nA   |
| Dynamic Impedance (Figure 1, Note 3)<br>V <sub>KA</sub> = V <sub>ref</sub> , ΔI <sub>K</sub> = 1.0 mA to 100 mA<br>f ≤ 1.0 kHz   | Z <sub>KA</sub>                        | -            | 0.22         | 0.5          | -             | 0.22         | 0.5           | Ω    |

- T<sub>low</sub> = -40°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431AIDM, TL431IDM, TL431BIDM;  
= 0°C for TL431ACP, TL431ACLP, TL431CP, TL431CLP, TL431CD, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM  
T<sub>high</sub> = +85°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431IDM, TL431AIDM, TL431BIDM  
= +70°C for TL431ACP, TL431ACLP, TL431CP, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
- The deviation parameter ΔV<sub>ref</sub> is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the reference input voltage, α<sub>V<sub>ref</sub></sub> is defined as:

$$V_{ref} \frac{\text{ppm}}{^{\circ}\text{C}} = \frac{\left( \frac{\Delta V_{ref}}{V_{ref} @ 25^{\circ}\text{C}} \right) \times 10^6}{\Delta T_A} = \frac{\Delta V_{ref} \times 10^6}{\Delta T_A (V_{ref} @ 25^{\circ}\text{C})}$$

α<sub>V<sub>ref</sub></sub> can be positive or negative depending on whether V<sub>ref</sub> Min or V<sub>ref</sub> Max occurs at the lower ambient temperature. (Refer to Figure 6.)

Example : ΔV<sub>ref</sub> = 8.0 mV and slope is positive,

$$V_{ref} @ 25^{\circ}\text{C} = 2.495 \text{ V}, \Delta T_A = 70^{\circ}\text{C} \quad \alpha V_{ref} = \frac{0.008 \times 10^6}{70 (2.495)} = 45.8 \text{ ppm}/^{\circ}\text{C}$$

- The dynamic impedance Z<sub>KA</sub> is defined as:  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$ . When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as:  $|Z_{KA}'| \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$

## TL431, A, B Series, NCV431A, B

### ORDERING INFORMATION

| Device       | Operating Temperature Range | Package Code                | Shipping Information†    | Tolerance |
|--------------|-----------------------------|-----------------------------|--------------------------|-----------|
| TL431ACD     | 0°C to 70°C                 | SOIC-8                      | 98 Units / Rail          | 1.0%      |
| TL431ACDG    |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431BCD     |                             | SOIC-8                      |                          |           |
| TL431BCDG    |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431CD      |                             | SOIC-8                      |                          |           |
| TL431CDG     |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431ACDR2   |                             | SOIC-8                      | 2500 Units / Tape & Reel | 1.0%      |
| TL431ACDR2G  |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431BCDR2   |                             | SOIC-8                      |                          |           |
| TL431BCDR2G  |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431CDR2    |                             | SOIC-8                      |                          |           |
| TL431CDR2G   |                             | SOIC-8<br>(Pb-Free)         |                          |           |
| TL431ACDMR2  |                             | Micro8                      | 4000 Units / Tape & Reel | 1.0%      |
| TL431ACDMR2G |                             | Micro8<br>(Pb-Free)         |                          |           |
| TL431BCDMR2  |                             | Micro8                      |                          |           |
| TL431BCDMR2G |                             | Micro8<br>(Pb-Free)         |                          |           |
| TL431CDMR2   |                             | Micro8                      |                          |           |
| TL431CDMR2G  |                             | Micro8<br>(Pb-Free)         |                          |           |
| TL431ACP     |                             | PDIP-8                      | 50 Units / Rail          | 1.0%      |
| TL431ACPG    |                             | PDIP-8<br>(Pb-Free)         |                          |           |
| TL431BCP     |                             | PDIP-8                      |                          |           |
| TL431BCPG    |                             | PDIP-8<br>(Pb-Free)         |                          |           |
| TL431CP      |                             | PDIP-8                      |                          |           |
| TL431CPG     |                             | PDIP-8<br>(Pb-Free)         |                          |           |
| TL431ACLP    |                             | TO-92 (TO-226)              | 2000 Units / Bag         | 1.0%      |
| TL431ACLPG   |                             | TO-92 (TO-226)<br>(Pb-Free) |                          |           |
| TL431BCLP    |                             | TO-92 (TO-226)              |                          |           |
| TL431BCLPG   |                             | TO-92 (TO-226)<br>(Pb-Free) |                          |           |
| TL431CLP     | TO-92 (TO-226)              |                             |                          |           |
| TL431CLPG    | TO-92 (TO-226)<br>(Pb-Free) |                             |                          |           |
| TL431ACLPR   | TO-92 (TO-226)              | 2000 Units / Tape & Reel    | 1.0%                     |           |
| TL431ACLPRAG | TO-92 (TO-226)<br>(Pb-Free) |                             |                          |           |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## TL431, A, B Series, NCV431A, B

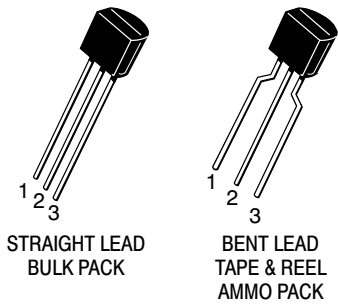
### ORDERING INFORMATION

| Device       | Operating Temperature Range | Package Code             | Shipping Information†    | Tolerance                |      |
|--------------|-----------------------------|--------------------------|--------------------------|--------------------------|------|
| TL431AIP     | -40°C to 85°C               | PDIP-8                   | 50 Units / Rail          | 1.0%                     |      |
| TL431AIPG    |                             | PDIP-8 (Pb-Free)         |                          |                          |      |
| TL431BIP     |                             | PDIP-8                   |                          |                          |      |
| TL431BIPG    |                             | PDIP-8 (Pb-Free)         |                          |                          |      |
| TL431IP      |                             | PDIP-8                   |                          |                          |      |
| TL431IPG     |                             | PDIP-8 (Pb-Free)         |                          |                          |      |
| TL431AILP    |                             | TO-92 (TO-226)           | 2000 Units / Bag         | 1.0%                     |      |
| TL431AILPG   |                             | TO-92 (TO-226)           |                          | 1.0%                     |      |
| TL431BILP    |                             | TO-92 (TO-226)           |                          | 0.4%                     |      |
| TL431BILPG   |                             | TO-92 (TO-226) (Pb-Free) |                          |                          |      |
| TL431ILP     |                             | TO-92 (TO-226)           |                          | 2.2%                     |      |
| TL431ILPG    |                             | TO-92 (TO-226) (Pb-Free) |                          |                          |      |
| TL431AILPRA  |                             | TO-92 (TO-226)           | 2000 Units / Tape & Reel | 1.0%                     |      |
| TL431AILPRAG |                             | TO-92 (TO-226) (Pb-Free) |                          |                          |      |
| TL431BILPRA  |                             | TO-92 (TO-226)           |                          |                          | 0.4% |
| TL431BILPRAG |                             | TO-92 (TO-226) (Pb-Free) |                          |                          |      |
| TL431ILPRA   |                             | TO-92 (TO-226)           |                          |                          | 2.2% |
| TL431ILPRAG  |                             | TO-92 (TO-226) (Pb-Free) |                          |                          |      |
| TL431AILPRM  |                             | TO-92 (TO-226)           | 2000 / Tape & Ammo Box   | 1.0%                     |      |
| TL431AILPRMG |                             | TO-92 (TO-226) (Pb-Free) |                          | 1.0%                     |      |
| TL431AILPRP  | TO-92 (TO-226)              | 1.0%                     |                          |                          |      |
| TL431AILPRPG | TO-92 (TO-226) (Pb-Free)    | 1.0%                     |                          |                          |      |
| TL431ILPRP   | TO-92 (TO-226)              | 2.2%                     |                          |                          |      |
| TL431ILPRPG  | TO-92 (TO-226) (Pb-Free)    | 2.2%                     |                          |                          |      |
| TL431BVD     | -40°C to 125°C              | SOIC-8                   | 98 Units / Rail          | 0.4%                     |      |
| TL431BVDR2   |                             | SOIC-8                   |                          | 2500 Units / Tape & Reel | 0.4% |
| TL431BVDR2G  |                             | SOIC-8 (Pb-Free)         | 0.4%                     |                          |      |
| TL431BVDMR2  |                             | Micro8                   | 4000 Units / Tape & Reel | 0.4%                     |      |
| TL431BVDMR2G |                             | Micro8 (Pb-Free)         |                          | 0.4%                     |      |
| TL431BVLP    |                             | TO-92 (TO-226)           | 2000 Units / Bag         | 0.4%                     |      |
| TL431BVLPG   |                             | TO-92 (TO-226) (Pb-Free) |                          | 0.4%                     |      |
| TL431BVLPRAG |                             | TO-92 (TO-226) (Pb-Free) |                          | 2000 Units / Tape & Reel | 0.4% |

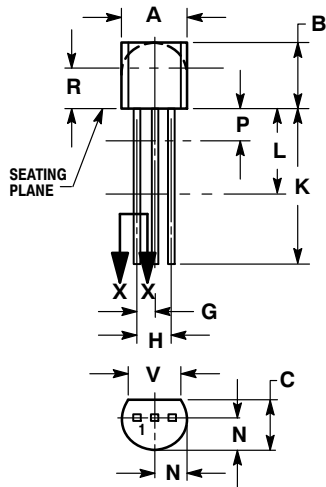
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# TL431, A, B Series, NCV431A, B

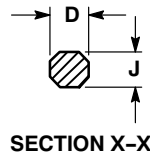
## PACKAGE DIMENSIONS



TO-92 (TO-226)  
CASE 29-11  
ISSUE AM



STRAIGHT LEAD  
BULK PACK

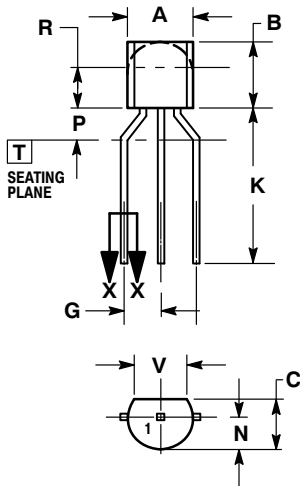


SECTION X-X

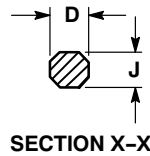
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.175  | 0.205 | 4.45        | 5.20  |
| B   | 0.170  | 0.210 | 4.32        | 5.33  |
| C   | 0.125  | 0.165 | 3.18        | 4.19  |
| D   | 0.016  | 0.021 | 0.407       | 0.533 |
| G   | 0.045  | 0.055 | 1.15        | 1.39  |
| H   | 0.095  | 0.105 | 2.42        | 2.66  |
| J   | 0.015  | 0.020 | 0.39        | 0.50  |
| K   | 0.500  | ---   | 12.70       | ---   |
| L   | 0.250  | ---   | 6.35        | ---   |
| N   | 0.080  | 0.105 | 2.04        | 2.66  |
| P   | ---    | 0.100 | ---         | 2.54  |
| R   | 0.115  | ---   | 2.93        | ---   |
| V   | 0.135  | ---   | 3.43        | ---   |



BENT LEAD  
TAPE & REEL  
AMMO PACK



SECTION X-X

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 4.45        | 5.20 |
| B   | 4.32        | 5.33 |
| C   | 3.18        | 4.19 |
| D   | 0.40        | 0.54 |
| G   | 2.40        | 2.80 |
| J   | 0.39        | 0.50 |
| K   | 12.70       | ---  |
| N   | 2.04        | 2.66 |
| P   | 1.50        | 4.00 |
| R   | 2.93        | ---  |
| V   | 3.43        | ---  |