

# Programmable Shunt Regulator

## LM431A, LM431B, LM431C

### Description

The LM431A/LM431B/LM431C are three-terminal output adjustable regulators with thermal stability over the full operating temperature range. The output voltage can be set to any value between  $V_{REF}$  (approximately 2.5 V) and 36 V with two external resistors. These devices have a typical dynamic output impedance of 0.2  $\Omega$ . Active output circuit provides a sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications.

### Features

- Programmable Output Voltage to 36 V
- Low Dynamic Output Impedance: 0.2  $\Omega$  (Typical)
- Sink Current Capability: 1.0 to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/ $^{\circ}$ C (Typical)
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response

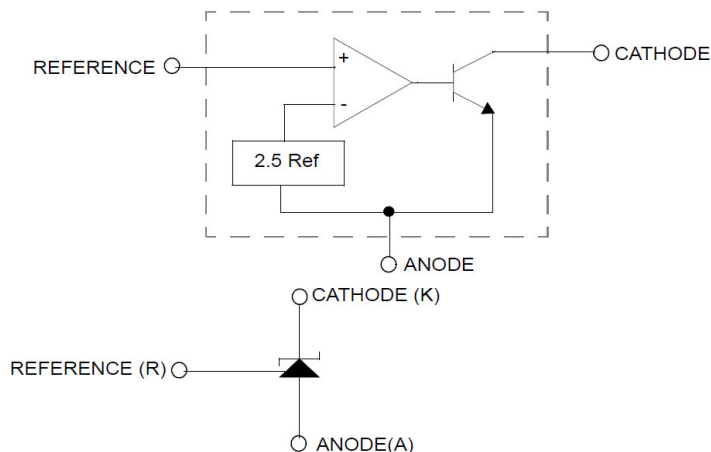
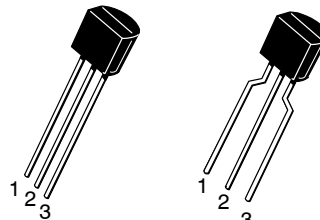


Figure 1. Block Diagram



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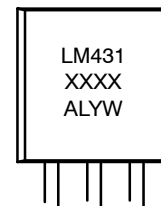
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TO-92  
CASE 135AN

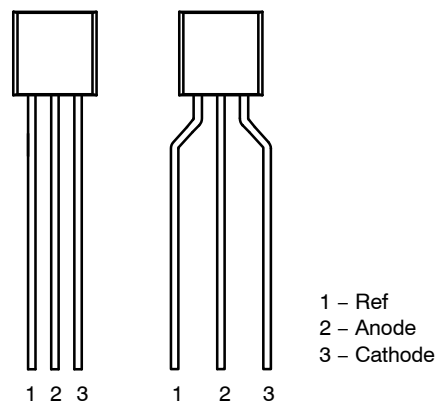
TO-92  
CASE 135AR

### MARKING DIAGRAM



LM431XXXX = Specific Device Code  
 A = Assembly Location  
 L = Wafer Lot  
 YW = Assembly Start Week

### PIN CONNECTIONS



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 6 of this data sheet.

# LM431A, LM431B, LM431C

## ABSOLUTE MAXIMUM RATINGS

| Symbol          | Parameter                               | Value        | Unit |
|-----------------|---|--------------|------|
| $V_{KA}$        | Cathode Voltage                         | 37           | V    |
| $I_{KA}$        | Cathode Current Range (Continuous)      | -100 to +150 | mA   |
| $I_{REF}$       | Reference Input Current Range           | -0.05 to +10 | mA   |
| $P_D$           | Power Dissipation                       | 770          | mW   |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 160          | °C/W |
| $T_{OPR}$       | Operating Temperature Range – LM431xC   | -25 to +85   | °C   |
|                 | Operating Temperature Range – LM431xI   | -40 to +85   | °C   |
| $T_J$           | Junction Temperature                    | 150          | °C   |
| $T_{STG}$       | Storage Temperature Range               | -65 to +150  | °C   |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## RECOMMENDED OPERATING CONDITIONS

| Symbol   | Parameter       | Min       | Max | Unit |
|----------|-----------------|-----------|-----|------|
| $V_{KA}$ | Cathode Voltage | $V_{REF}$ | 36  | V    |
| $I_{KA}$ | Cathode Current | 1.0       | 100 | mA   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## ELECTRICAL CHARACTERISTICS (Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted)

| Symbol                         | Parameter   | Conditions  | LM431A                                      |       |       | LM431B |       |       | LM431C |       |       | Unit          |      |
|--------------------------------|---|---|---|-------|-------|--------|-------|-------|--------|-------|-------|---------------|------|
|                                |   |   | Min   | Typ   | Max   | Min    | Typ   | Max   | Min    | Typ   | Max   |               |      |
| $V_{REF}$                      | Reference Input Voltage   | $V_{KA} = V_{REF}, I_{KA} = 10\text{ mA}$   | 2.450                                       | 2.500 | 2.550 | 2.470  | 2.495 | 2.520 | 2.482  | 2.495 | 2.508 | V             |      |
| $\Delta V_{REF}/\Delta T$      | Deviation of Reference Input Voltage Over-Temperature                       | $V_{KA} = V_{REF}, I_{KA} = 10\text{ mA}$<br>$T_{MIN} \leq T_A \leq T_{MAX}$ (Note 1)   | -   | 4.5   | 17.0  | -      | 4.5   | 17.0  | -      | 4.5   | 17.0  | mV            |      |
| $\Delta V_{REF}/\Delta V_{KA}$ | Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage | $I_{KA} = 10\text{ mA}$   | $\Delta V_{KA} = 10\text{ V} - V_{REF}$     | -     | -1.0  | -2.7   | -     | -1.0  | -2.7   | -     | -1.0  | -2.7          | mV/V |
|                                |   |   | $\Delta V_{KA} = 36\text{ V} - 10\text{ V}$ | -     | -0.5  | -2.0   | -     | -0.5  | -2.0   | -     | -0.5  | -2.0          |      |
| $I_{REF}$                      | Reference Input Current   | $I_{KA} = 10\text{ mA}, R_1 = 10\text{ k}\Omega, R_2 = \infty$                          | -   | 1.5   | 4.0   | -      | 1.5   | 4.0   | -      | 1.5   | 4.0   | $\mu\text{A}$ |      |
| $\Delta I_{REF}/\Delta T$      | Deviation of Reference Input Current Over Full Temperature Range            | $I_{KA} = 10\text{ mA}, R_1 = 10\text{ k}\Omega, R_2 = \infty, T_A = \text{Full Range}$ | -   | 0.4   | 1.2   | -      | 0.4   | 1.2   | -      | 0.4   | 1.2   | $\mu\text{A}$ |      |
| $I_{KA(MIN)}$                  | Minimum Cathode Current for Regulation                                      | $V_{KA} = V_{REF}$  | -   | 0.45  | 1.00  | -      | 0.45  | 1.00  | -      | 0.45  | 1.00  | mA            |      |
| $I_{KA(OFF)}$                  | Off – Stage Cathode Current   | $V_{KA} = 36\text{ V}, V_{REF} = 0$   | -   | 0.05  | 1.00  | -      | 0.05  | 1.00  | -      | 0.05  | 1.00  | $\mu\text{A}$ |      |
| $Z_{KA}$                       | Dynamic Impedance   | $V_{KA} = V_{REF}, I_{KA} = 1\text{ to }100\text{ mA}$ ,<br>$f \geq 1.0\text{ kHz}$     | -   | 0.15  | 0.50  | -      | 0.15  | 0.50  | -      | 0.15  | 0.50  | $\Omega$      |      |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. LM431xC:  $T_{MIN} = -25^\circ\text{C}$ ,  $T_{MAX} = +85^\circ\text{C}$

LM431xI:  $T_{MIN} = -40^\circ\text{C}$ ,  $T_{MAX} = +85^\circ\text{C}$

# LM431A, LM431B, LM431C

## TEST CIRCUIT

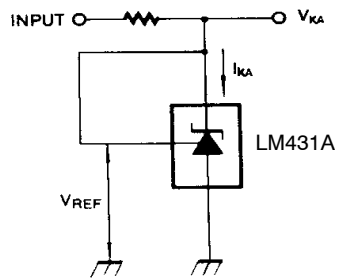


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

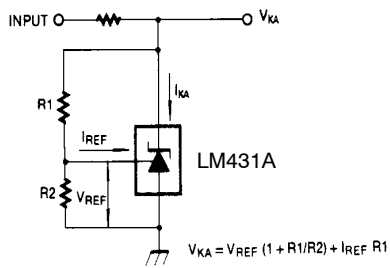


Figure 3. Test Circuit for  $V_{KA} \geq V_{REF}$

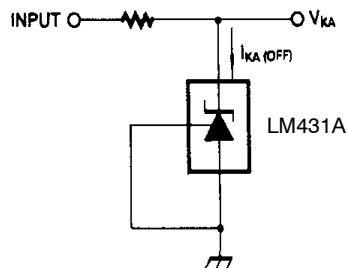


Figure 4. Test Circuit for  $I_{KA(OFF)}$

# LM431A, LM431B, LM431C

## TYPICAL PERFORMANCE CHARACTERISTICS

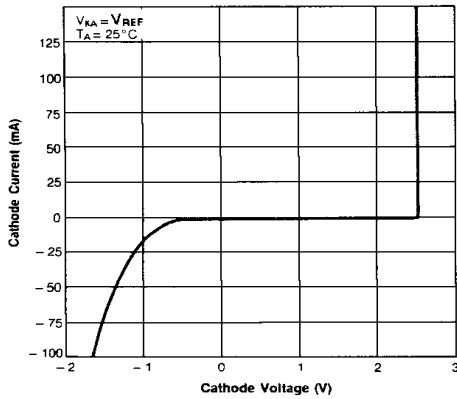


Figure 5. Cathode Current vs. Cathode Voltage

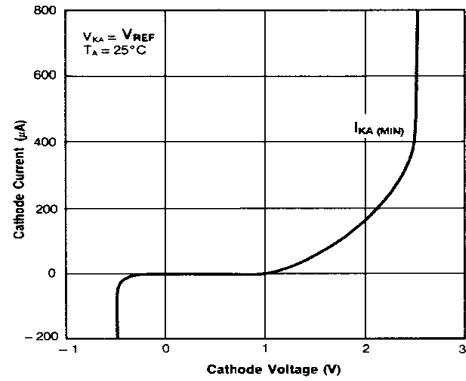


Figure 6. Cathode Current vs. Cathode Voltage



Figure 7. Change in Reference Input Voltage vs. Cathode Voltage

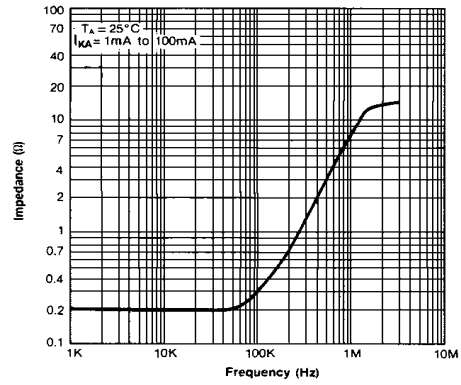


Figure 8. Dynamic Impedance Frequency

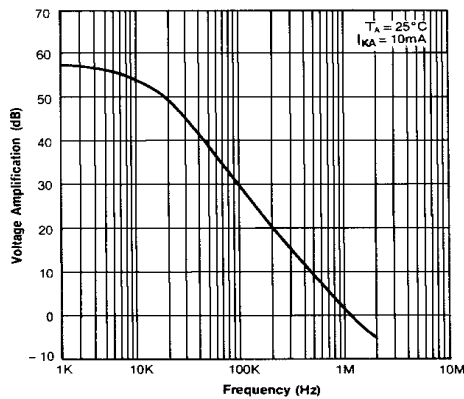


Figure 9. Small Signal Voltage Amplification vs. Frequency

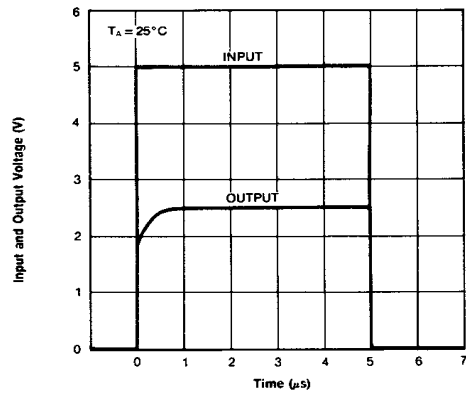


Figure 10. Pulse Response

# LM431A, LM431B, LM431C

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

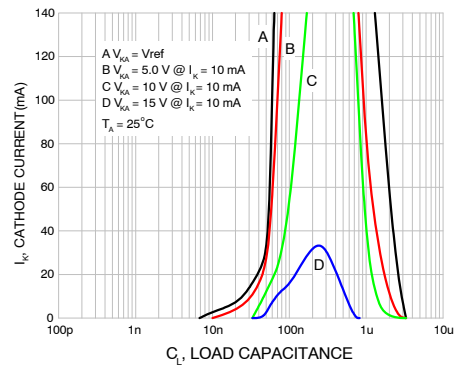


Figure 11. Stability Boundary Conditions

# LM431A, LM431B, LM431C

## TYPICAL APPLICATION

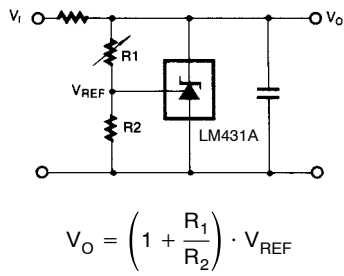


Figure 12. Shunt Regulator

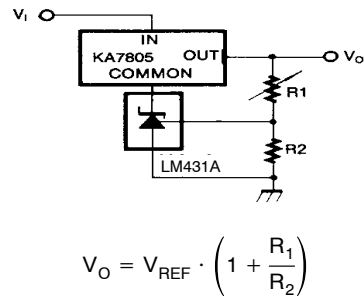


Figure 13. Output Control for Three-Terminal Fixed Regulator

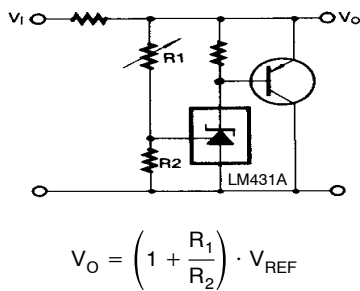


Figure 14. High-Current Shunt Regulator

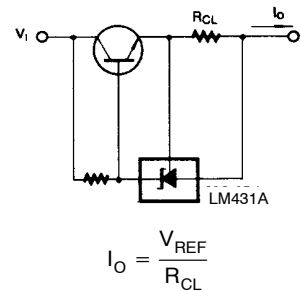


Figure 15. Current Limit or Current Source

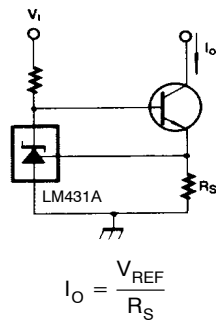


Figure 16. Constant-Current Sink

### ORDERING INFORMATION

| Part Number | Operating Temperature Range | Output Voltage Tolerance | Tom Mark | Package | Packing Method† |
|-------------|-----------------------------|--------------------------|----------|---------|-----------------|
| LM431CCZ    | -25 ~ +85°C                 | 0.5%                     | LM431CCZ | TO-92   | Bulk            |
| LM431BCZX   |                             | 1%                       | LM431BCZ | TO-92   | Tape and Reel   |
| LM431BCZXA  |                             |                          | LM431BCZ | TO-92   | Ammo            |
| LM431ACZ    |                             | 2%                       | LM431ACZ | TO-92   | Bulk            |
| LM431ACZX   |                             |                          | LM431ACZ | TO-92   | Tape and Reel   |
| LM431BIZX   | -40 ~ +85°C                 | 1%                       | LM431BIZ | TO-92   | Tape and Reel   |
| LM431AIZ    |                             | 2%                       | LM431AIZ | TO-92   | Bulk            |

†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.

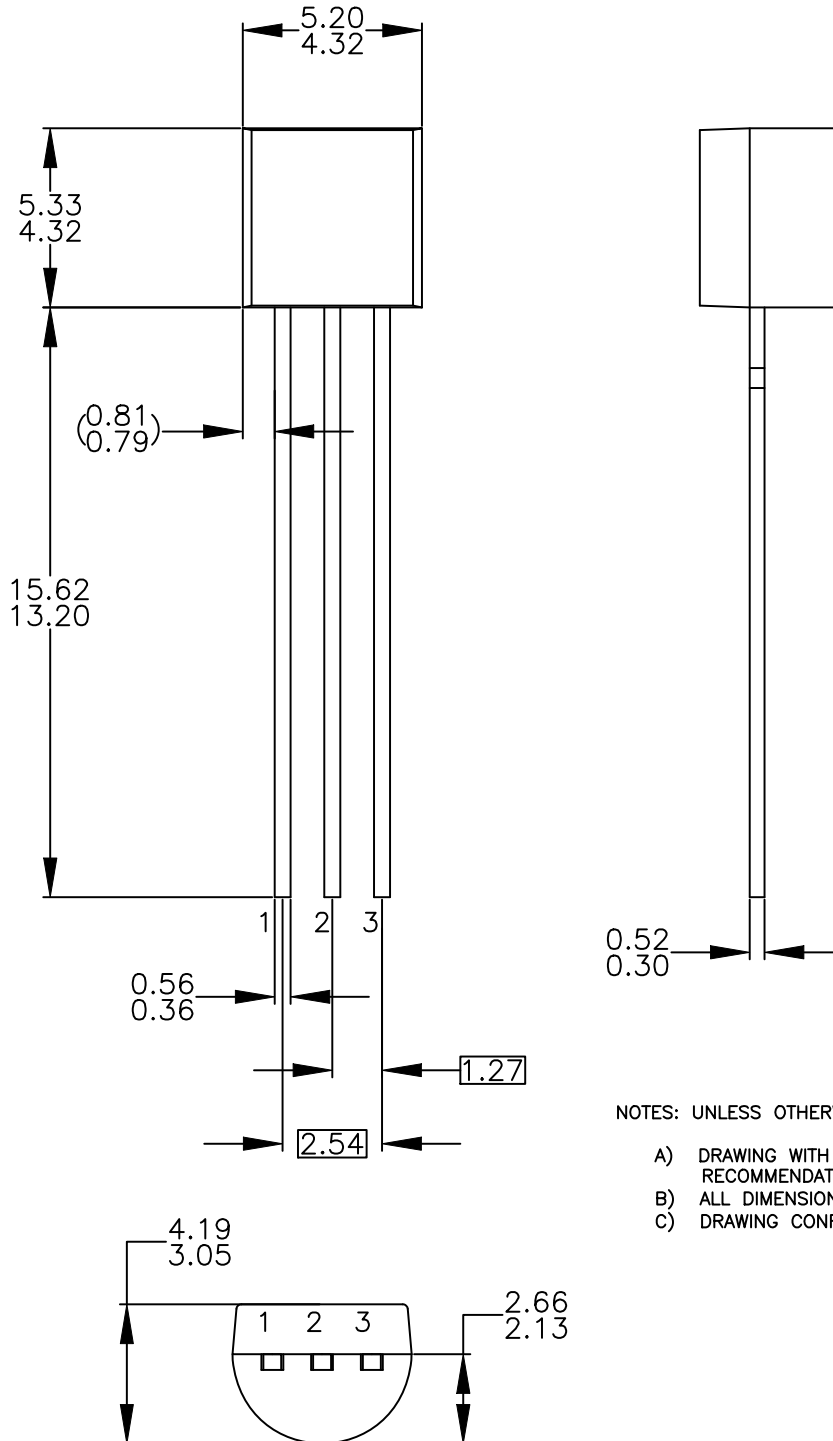
**MECHANICAL CASE OUTLINE**  
**PACKAGE DIMENSIONS**

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