# Programmable Shunt Regulator

## KA431A, KA431L

### Description

The KA431A and KA431L are three−terminal adjustable regulators with a guaranteed thermal stability over the 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 Ω. Active output circuitry 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 Ω (Typical)
- Sink Current Capability: 1.0 to 100 mA
- Equivalent Full−Range Temperature Coefficient of 50 ppm/°C (Typical)
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
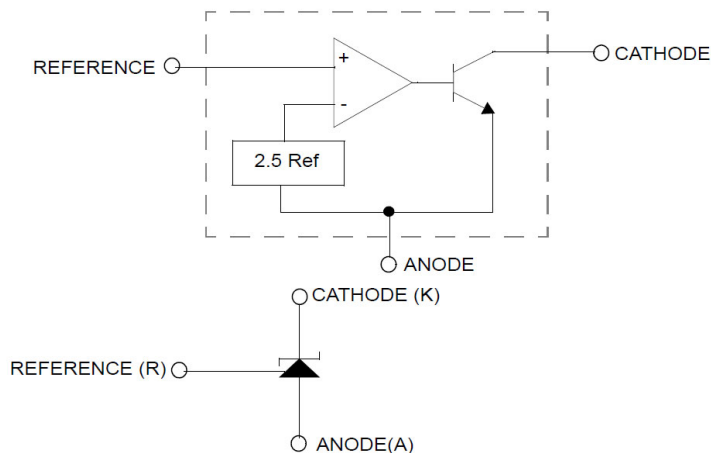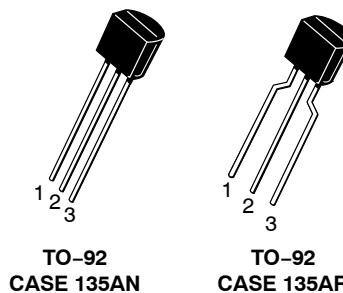- Low Output Noise Voltage
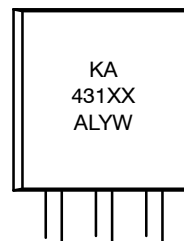- Fast Turn−on Response



**Figure 1. Block Diagram**

**ON Semiconductor®**

| TO−92 | TO−92 |
|---|---|
| CASE 135AN | CASE 135AR |

**MARKING DIAGRAM**



```
KA
431XX
ALYW
```

| KA431XX | = Specific Device Code |
|---|---|
| A | = Assembly Location |
| L | = Wafer Lot |
| YW | = Assembly Start Week |

**PIN CONNECTIONS**



1 – Ref
2 – Anode
3 – Cathode
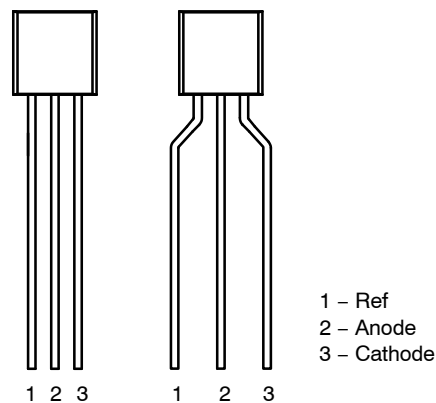
**ORDERING INFORMATION**

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

# KA431A, KA431L

**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 | −25 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 | 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 $T_A = 25°C$ unless otherwise noted)

| Symbol | Parameter | Conditions | | KA431A Min | KA431A Typ | KA431A Max | KA431L Min | KA431L Typ | KA431L Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference Input Voltage | $V_{KA} = V_{REF}$, $I_{KA} = 10$ mA | | 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 | $V_{KA} = V_{REF}$, $I_{KA} = 10$ mA $T_{MIN} \leq T_A \leq T_{MAX}$ (Note 1) | | − | 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 | $I_{KA} = 10$ mA | $\Delta V_{KA} = 10$ V−$V_{REF}$ | − | −1.0 | −2.7 | − | −1.0 | −2.7 | mV/V |
| | | | $\Delta V_{KA} = 36$ V−10 V | − | −0.5 | −2.0 | − | −0.5 | −2.0 | |
| $I_{REF}$ | Reference Input Current | $I_{KA} = 10$ mA, R1 = 10 kΩ, R2 = ∞ | | − | 1.5 | 4.0 | − | 1.5 | 4.0 | μA |
| $\Delta I_{REF}/\Delta T$ | Deviation of Reference Input Current Over Full Temperature Range | $I_{KA} = 10$ mA, R1 = 10 kΩ, R2 = ∞, $T_A$ = Full Range | | − | 0.4 | 1.2 | − | 0.4 | 1.2 | μA |
| $I_{KA(MIN)}$ | Minimum Cathode Current for Regulation | $V_{KA} = V_{REF}$ | | − | 0.45 | 1.00 | − | 0.45 | 1.00 | mA |
| $I_{KA(OFF)}$ | Off − Stage Cathode Current | $V_{KA} = 36$ V, $V_{REF} = 0$ | | − | 0.05 | 1.00 | − | 0.05 | 1.00 | μA |
| $Z_{KA}$ | Dynamic Impedance | $V_{KA} = V_{REF}$, $I_{KA} = 1$ to 100 mA, $f \geq 1.0$ kHz | | − | 0.15 | 0.50 | − | 0.15 | 0.50 | Ω |

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. $T_{MIN} = −25°C$, $T_{MAX} = +85°C$.

# KA431A, KA431L

## TEST CIRCUIT



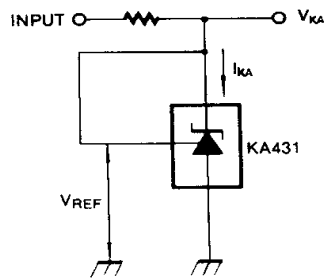**Figure 2. Test Circuit for $V_{KA} = V_{REF}$**
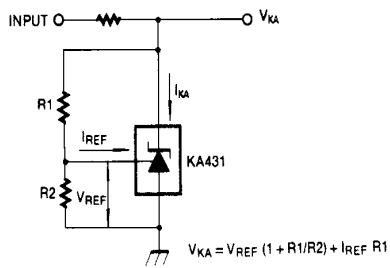


$$V_{KA} = V_{REF} (1 + R1/R2) + I_{REF} R1$$

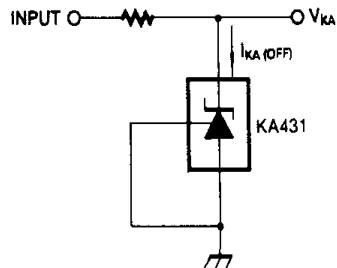**Figure 3. Test Circuit for $V_{KA} \geq V_{REF}$**



**Figure 4. Test Circuit for $I_{KA(OFF)}$**
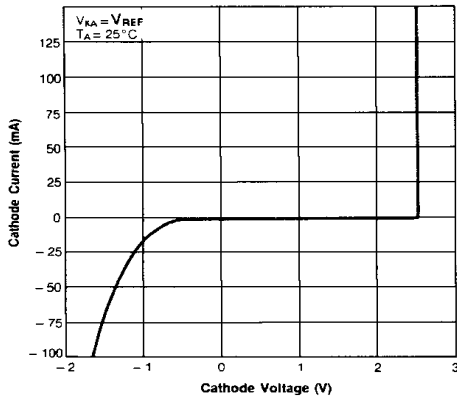
## TYPICAL PERFORMANCE CHARACTERISTICS



**Figure 5. Cathode Current vs. Cathode Voltage**
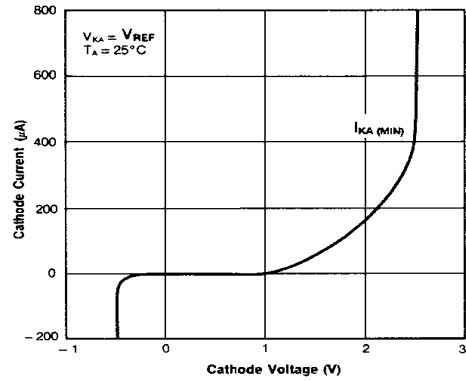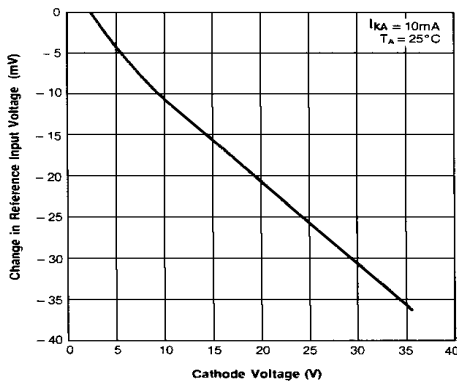


**Figure 6. Cathode Current vs. Cathode Voltage**

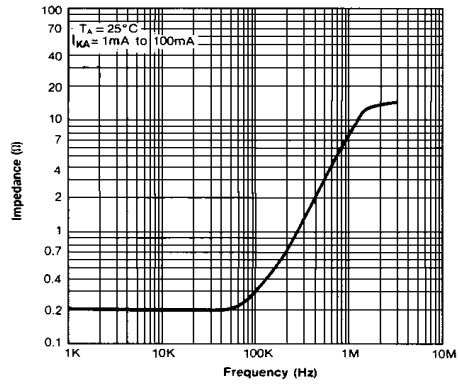

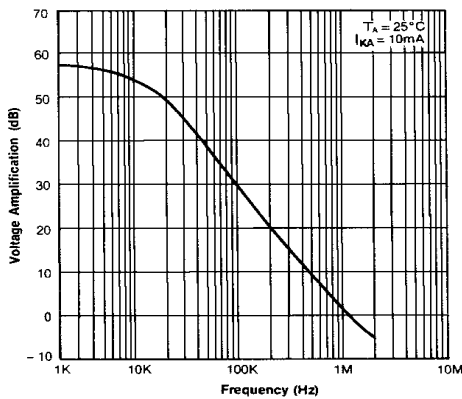**Figure 7. Change in Reference Input Voltage vs. Cathode Voltage**



**Figure 8. Dynamic Impedance Frequency**



**Figure 9. Small Signal Voltage Amplification vs. Frequency**
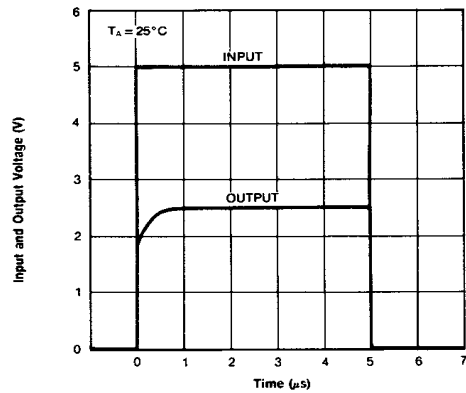


**Figure 10. Pulse Response**

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
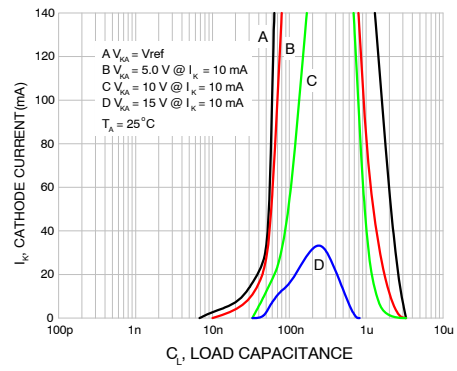


**Figure 11. Stability Boundary Conditions**

# KA431A, KA431L

## TYPICAL APPLICATION



$$V_O = \left(1 + \frac{R_1}{R_2}\right) \cdot V_{REF}$$
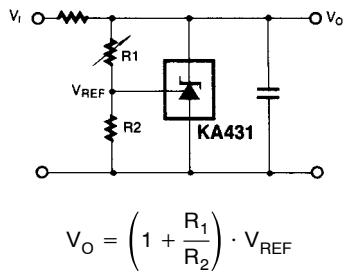
**Figure 12. Shunt Regulator**



$$V_O = V_{REF} \cdot \left(1 + \frac{R_1}{R_2}\right)$$
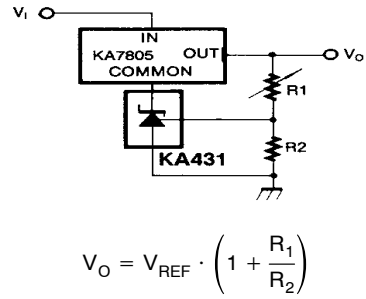
**Figure 13. Output Control for Three−Terminal Fixed Regulator**



$$V_O = \left(1 + \frac{R_1}{R_2}\right) \cdot V_{REF}$$
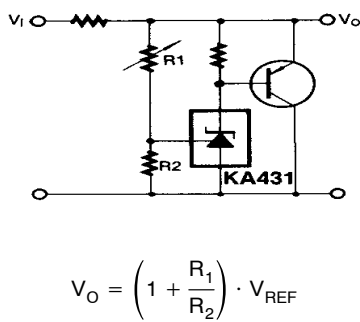
**Figure 14. High−Current Shunt Regulator**



$$I_O = \frac{V_{REF}}{R_{CL}}$$
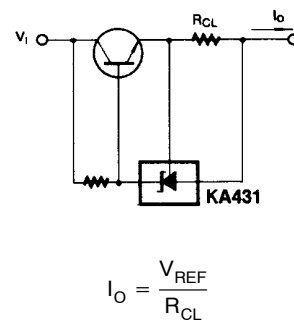
**Figure 15. Current Limit or Current Source**



$$I_O = \frac{V_{REF}}{R_S}$$
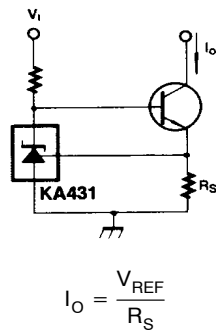
**Figure 16. Constant−Current Sink**

## ORDERING INFORMATION

| Part Number | Operating Temperature Range | Output Voltage Tolerance | Tom Mark | Package | Packing Method |
|---|---|---|---|---|---|
| KA431AZBU | −25 ~ +85°C | 1% | KA431AZ | TO−92 | Bulk |
| KA431AZTA | | | KA431AZ | TO−92 | Ammo |
| KA431LZTA | | 0.5% | KA431LZ | TO−92 | Ammo |

**TO−92 3 4.825x4.76**
CASE 135AN
ISSUE O

DATE 31 JUL 2016
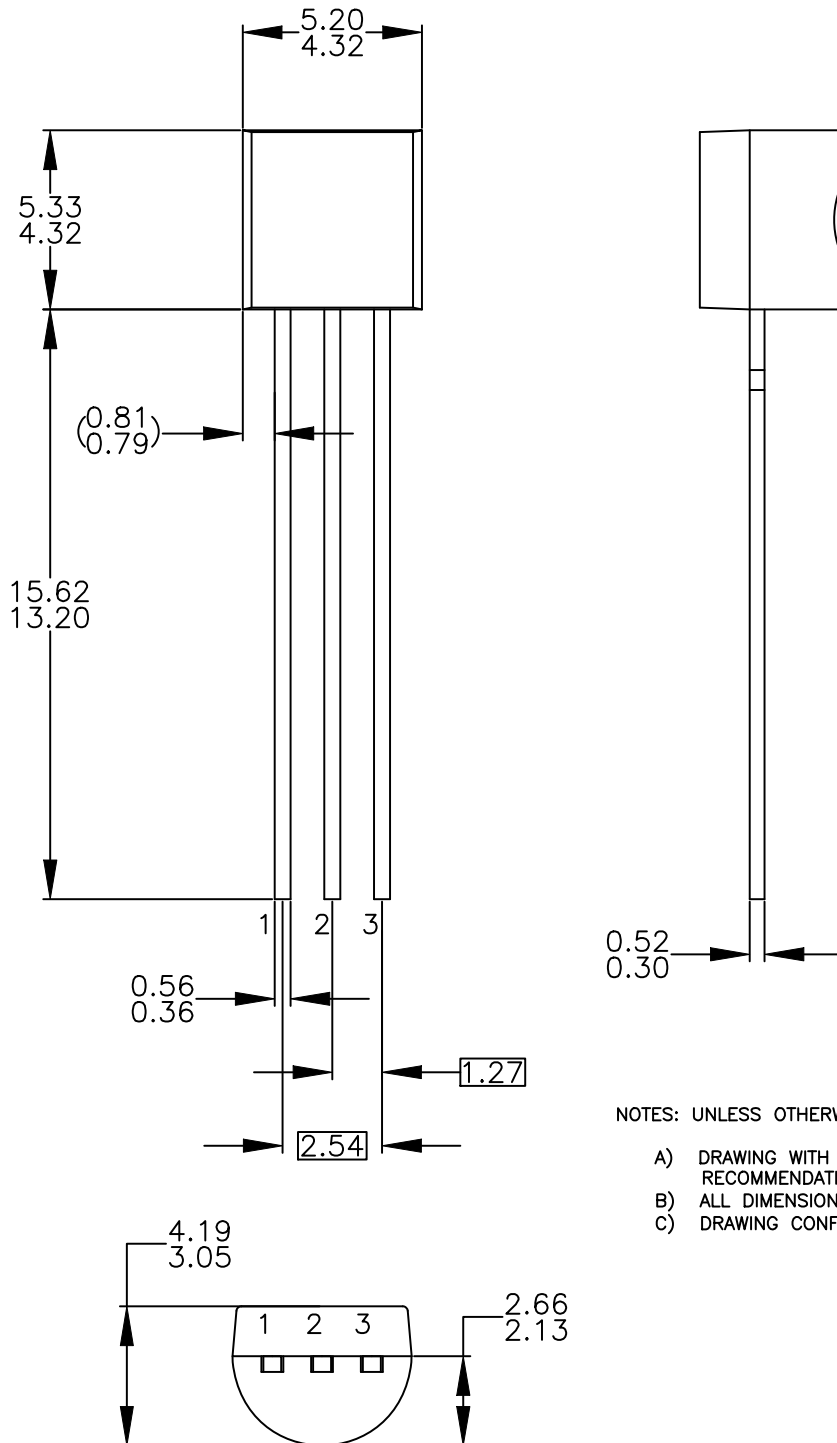


5.20
4.32

5.33
4.32

(0.81)
(0.79)

15.62
13.20

1   2   3

0.56
0.36

1.27

2.54

0.52
0.30

4.19
3.05

1   2   3

2.66
2.13

NOTES: UNLESS OTHERWISE SPECIFIED

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DATE 30 SEP 2016

5.20
4.32

5.33
4.32

3.44
2.54

13.00
10.50

1    2    3

0.56
0.36

2.80
2.40

0.52
0.30

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   RECOMMENDATIONS.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DRAWING CONFORMS TO ASME Y14.5M-1994

4.19
3.05

1   2   3

2.66
2.13

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## PUBLICATION ORDERING INFORMATION

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