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 $\Omega$. 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 $\Omega$ (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
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Cathode Voltage</td>
<td>37</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Cathode Current Range (Continuous)</td>
<td>−100 to +150</td>
<td>mA</td>
</tr>
<tr>
<td>I&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>Reference Input Current Range</td>
<td>−0.05 to +10</td>
<td>mA</td>
</tr>
<tr>
<td>P&lt;sub&gt;D&lt;/sub&gt;</td>
<td>Power Dissipation</td>
<td>770</td>
<td>mW</td>
</tr>
<tr>
<td>R&lt;sub&gt;θJA&lt;/sub&gt;</td>
<td>Thermal Resistance, Junction to Ambient</td>
<td>160</td>
<td>°C/W</td>
</tr>
<tr>
<td>T&lt;sub&gt;OPR&lt;/sub&gt;</td>
<td>Operating Temperature Range</td>
<td>−25 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>T&lt;sub&gt;J&lt;/sub&gt;</td>
<td>Junction Temperature</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>T&lt;sub&gt;STG&lt;/sub&gt;</td>
<td>Storage Temperature Range</td>
<td>−65 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Cathode Voltage</td>
<td>V&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Cathode Current</td>
<td>1</td>
<td>100</td>
<td>mA</td>
</tr>
</tbody>
</table>

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<sub>A</sub> = 25°C unless otherwise noted)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>KA431A</th>
<th>KA431L</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>Reference Input Voltage</td>
<td>V&lt;sub&gt;KA&lt;/sub&gt; = V&lt;sub&gt;REF&lt;/sub&gt;, I&lt;sub&gt;KA&lt;/sub&gt; = 10 mA</td>
<td>2.470</td>
<td>2.520</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;REF/ΔT&lt;/sub&gt;</td>
<td>Deviation of Reference Input Voltage Over−Temperature</td>
<td>V&lt;sub&gt;KA&lt;/sub&gt; = V&lt;sub&gt;REF&lt;/sub&gt;, I&lt;sub&gt;KA&lt;/sub&gt; = 10 mA, T&lt;sub&gt;MIN&lt;/sub&gt; ≤ T&lt;sub&gt;A&lt;/sub&gt; ≤ T&lt;sub&gt;MAX&lt;/sub&gt; (Note 1)</td>
<td>−</td>
<td>4.5</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;REF&lt;/sub&gt;/ΔV&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage</td>
<td>I&lt;sub&gt;KA&lt;/sub&gt; = 10 mA</td>
<td>ΔV&lt;sub&gt;KA&lt;/sub&gt; = 10 V−V&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>−</td>
</tr>
<tr>
<td>I&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>Reference Input Current</td>
<td>I&lt;sub&gt;KA&lt;/sub&gt; = 10 mA, R&lt;sub&gt;1&lt;/sub&gt; = 10 kΩ, R&lt;sub&gt;2&lt;/sub&gt; = ∞</td>
<td>−</td>
<td>1.5</td>
</tr>
<tr>
<td>ΔI&lt;sub&gt;REF/ΔT&lt;/sub&gt;</td>
<td>Deviation of Reference Input Current Over Full Temperature Range</td>
<td>I&lt;sub&gt;KA&lt;/sub&gt; = 10 mA, R&lt;sub&gt;1&lt;/sub&gt; = 10 kΩ, R&lt;sub&gt;2&lt;/sub&gt; = ∞, T&lt;sub&gt;A&lt;/sub&gt; = Full Range</td>
<td>−</td>
<td>0.4</td>
</tr>
<tr>
<td>I&lt;sub&gt;KA(MIN)&lt;/sub&gt;</td>
<td>Minimum Cathode Current for Regulation</td>
<td>V&lt;sub&gt;KA&lt;/sub&gt; = V&lt;sub&gt;REF&lt;/sub&gt;</td>
<td>−</td>
<td>0.45</td>
</tr>
<tr>
<td>I&lt;sub&gt;KA(OFF)&lt;/sub&gt;</td>
<td>Off  − Stage Cathode Current</td>
<td>V&lt;sub&gt;KA&lt;/sub&gt; = 36 V, V&lt;sub&gt;REF&lt;/sub&gt; = 0</td>
<td>−</td>
<td>0.05</td>
</tr>
<tr>
<td>Z&lt;sub&gt;KA&lt;/sub&gt;</td>
<td>Dynamic Impedance</td>
<td>V&lt;sub&gt;KA&lt;/sub&gt; = V&lt;sub&gt;REF&lt;/sub&gt;, I&lt;sub&gt;KA&lt;/sub&gt; = 1 to 100 mA, f ≥ 1.0 kHz</td>
<td>−</td>
<td>0.15</td>
</tr>
</tbody>
</table>

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<sub>MIN</sub> = −25°C, T<sub>MAX</sub> = +85°C.
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TEST CIRCUIT

Figure 2. Test Circuit for \( V_{\text{KA}} = V_{\text{REF}} \)

Figure 3. Test Circuit for \( V_{\text{KA}} \geq V_{\text{REF}} \)

Figure 4. Test Circuit for \( i_{\text{KA(OFF)}} \)
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
Figure 11. Stability Boundary Conditions
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TYPICAL APPLICATION

Figure 12. Shunt Regulator

\[ V_O = \left( 1 + \frac{R_1}{R_2} \right) \cdot V_{REF} \]

Figure 13. Output Control for Three-Terminal Fixed Regulator

\[ V_O = V_{REF} \cdot \left( 1 + \frac{R_1}{R_2} \right) \]

Figure 14. High-Current Shunt Regulator

\[ V_O = \left( 1 + \frac{R_1}{R_2} \right) \cdot V_{REF} \]

Figure 15. Current Limit or Current Source

\[ I_O = \frac{V_{REF}}{R_{CL}} \]

Figure 16. Constant-Current Sink

\[ I_O = \frac{V_{REF}}{R_S} \]

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating Temperature Range</th>
<th>Output Voltage Tolerance</th>
<th>Tom Mark</th>
<th>Package</th>
<th>Packing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>KA431AZBU</td>
<td>−25 ~ +85°C</td>
<td>1%</td>
<td>KA431AZ</td>
<td>TO−92</td>
<td>Bulk</td>
</tr>
<tr>
<td>KA431AZTA</td>
<td></td>
<td>1%</td>
<td>KA431AZ</td>
<td>TO−92</td>
<td>Ammo</td>
</tr>
<tr>
<td>KA431LZTA</td>
<td></td>
<td>0.5%</td>
<td>KA431LZ</td>
<td>TO−92</td>
<td>Ammo</td>
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</table>
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

TO-92 3 4.825x4.76
CASE 135AN
ISSUE 0

DATE 31 JUL 2016

NOTES: UNLESS OTHERWISE SPECIFIED
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