LMV431/LMV431A/LMV431B Low-Voltage (1.24V) Adjustable Precision Shunt Regulators

Check for Samples: LMV431, LMV431A, LMV431B

FEATURES

- Low Voltage Operation/Wide Adjust Range (1.24V/30V)
- 0.5% Initial Tolerance (LMV431B)
- Temperature Compensated for Industrial Temperature Range (39 PPM/°C for the LMV431AI)
- Low Operation Current (55µA)
- Low Output Impedance (0.25Ω)
- Fast Turn-On Response
- Low Cost

APPLICATIONS

- Shunt Regulator
- Series Regulator
- Current Source or Sink
- Voltage Monitor
- Error Amplifier
- 3V Off-Line Switching Regulator
- Low Dropout N-Channel Series Regulator

DESCRIPTION

The LMV431, LMV431A and LMV431B are precision 1.24V shunt regulators capable of adjustment to 30V. Negative feedback from the cathode to the adjust pin controls the cathode voltage, much like a non-inverting op amp configuration (Refer to Symbol and Functional diagrams). A two resistor voltage divider terminated at the adjust pin controls the gain of a 1.24V band-gap reference. Shorting the cathode to the adjust pin (voltage follower) provides a cathode voltage of a 1.24V.

The LMV431, LMV431A and LMV431B have respective initial tolerances of 1.5%, 1% and 0.5%, and functionally lends themselves to several applications that require zener diode type performance at low voltages. Applications include a 3V to 2.7V low drop-out regulator, an error amplifier in a 3V off-line switching regulator and even as a voltage detector. These parts are typically stable with capacitive loads greater than 10nF and less than 50pF.

The LMV431, LMV431A and LMV431B provide performance at a competitive price.

Connection Diagram

Figure 1. TO-92: Plastic Package
Top View

Figure 2. SOT-23-5
Top View

Figure 3. SOT-23-3
Top View

*Pin 1 is not internally connected.
*Pin 2 is internally connected to Anode pin. Pin 2 should be either floating or connected to Anode pin.
Symbol and Functional Diagrams

Simplified Schematic

DC/AC Test Circuits for Table and Curves

Note: $V_Z = V_{REF} (1 + \frac{R1}{R2}) + I_{REF} \times R1$

Figure 4. Test Circuit for $V_Z = V_{REF}$

Figure 5. Test Circuit for $V_Z > V_{REF}$
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**ABSOLUTE MAXIMUM RATINGS (1)(2)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Temperature Range</td>
<td>−65°C to +150°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Industrial (LMV431AI, LMV431I) −40°C to +85°C</td>
</tr>
<tr>
<td></td>
<td>Commercial (LMV431AC, LMV431C, LMV431BC) 0°C to +70°C</td>
</tr>
<tr>
<td>Lead Temperature</td>
<td>TO-92 Package/SOT-23 -5,-3 Package (Soldering, 10 sec.) 265°C</td>
</tr>
<tr>
<td>Internal Power Dissipation (3)</td>
<td>TO-92</td>
</tr>
<tr>
<td></td>
<td>SOT-23-5, -3 Package 0.28W</td>
</tr>
<tr>
<td>Cathode Voltage</td>
<td>35V</td>
</tr>
<tr>
<td>Continuous Cathode Current</td>
<td>−30 mA to +30mA</td>
</tr>
<tr>
<td>Reference Input Current range</td>
<td>−0.05mA to 3mA</td>
</tr>
</tbody>
</table>

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.

(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.

(3) Ratings apply to ambient temperature at 25°C. Above this temperature, derate the TO-92 at 6.2 mW/°C, and the SOT-23-5 at 2.2 mW/°C. See derating curve in Operating Conditions section.

**OPERATING CONDITIONS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode Voltage</td>
<td>V&lt;sub&gt;REF&lt;/sub&gt; to 30V</td>
</tr>
<tr>
<td>Cathode Current</td>
<td>0.1 mA to 15mA</td>
</tr>
<tr>
<td>Temperature range</td>
<td>LMV431AI −40°C ≤ T&lt;sub&gt;A&lt;/sub&gt; ≤ 85°C</td>
</tr>
<tr>
<td>Thermal Resistance (θ&lt;sub&gt;JA&lt;/sub&gt;) (1)</td>
<td>SOT-23-5, -3 Package 455 °C/W</td>
</tr>
<tr>
<td></td>
<td>TO-92 Package</td>
</tr>
<tr>
<td></td>
<td>161 °C/W</td>
</tr>
</tbody>
</table>

Derating Curve (Slope = −1/θ<sub>JA</sub>)

(1) T<sub>J Max</sub> = 150°C, T<sub>J</sub> = T<sub>A</sub> + (θ<sub>JA</sub> P<sub>D</sub>), where P<sub>D</sub> is the operating power of the device.
Where: $T_2 - T_1 = \text{full temperature change.}$ $\propto V_{REF}$ can be positive or negative depending on whether the slope is positive or negative. Example: $V_{DEV} = 6.0mV$, $V_{REF} = 1240mV$, $T_2 - T_1 = 125^\circ C$. 

\[ \propto V_{REF} = \frac{6.0mV}{1240mV} = 4.87 \text{ ppm/}^\circ C \]

$\Delta V_{REF}$/$\Delta V_Z$ Ratio of the Change in Reference Voltage to the Change in Cathode Voltage

\[ I_{Z(MIN)} = 10mA \text{ to } 15mA \]

$\Delta V_{DEV}$ Deviation of Reference Input Voltage Over Temperature

\[ I_{Z(OFF)} = 6V, V_{REF} = 0V \]

$\propto I_{REF}$ Deviation of Reference Input Current over Temperature

$\Delta V_{REF}$ Ratio of the Change in Reference Voltage

\[ V_{Z} = 10mA \text{ (see Figure 5) } \]

$\Delta V_{Z}$ from $V_{REF}$ to 6V

$R_1 = 10k, R_2 = \infty$ and 2.6k

$V_{Z} = V_{REF}$ (see Figure 4)

$V_{Z} = 6V, V_{REF} = 0V$ (see Figure 6)

$V_{Z(MIN)} = 10k, R_2 = \infty$

$R_1 = 10mA, T_A = \text{Full Range (see Figure 5)}$

(1) Deviation of reference input voltage, $V_{DEV}$, is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

\[ V_{DEV} = \frac{V_{MAX} - V_{MIN}}{2} \]

\[ T_1, T_2 = \text{full temperature change.} \]

(2) The dynamic output impedance, $r_Z$, is defined as: $
\Delta V_Z \Delta I_Z$, When the device is programmed with two external resistors, $R_1$ and $R_2$, (see Figure 5), the dynamic output impedance of the overall circuit, $r_Z$, is defined as:

\[ r_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{1}{T_2 \left( 1 + \frac{R_1}{R_2} \right)} \]
LMV431 ELECTRICAL CHARACTERISTICS

Symbol | Parameter | Conditions | Min | Typ | Max | Unit
--- | --- | --- | --- | --- | --- | ---
$V_{REF}$ | Reference Voltage | $V_{Z} = V_{REF}, I_{Z} = 10 mA$ (See Figure 4) | $T_{A} = 25^\circ C$ | 1.222 | 1.24 | 1.258 | V
$T_{A} = Full Range$ | 1.202 | 1.278
$V_{DEV}$ | Deviation of Reference Input Voltage Over Temperature (1) | $V_{Z} = V_{REF}, I_{Z} = 10 mA, R_{1} = 10 k\Omega, R_{2} = \infty$ (See Figure 4) | $T_{A} = Full Range$ | 6 | 20 | mV
$\Delta V_{REF}$ | Ratio of the Change in Reference Voltage to the Change in Cathode Voltage | $V_{Z} = 10 mA$ (see Figure 5) | $V_{Z}$ from $V_{REF}$ to 6V | $R_{1} = 10 k\Omega, R_{2} = \infty$ and 2.6k | -1.5 | -2.7 | mV/V
$I_{REF}$ | Reference Input Current | $R_{1} = 10 k\Omega, R_{2} = \infty$ | $I_{Z} = 10 mA$ (see Figure 5) | 0.15 | 0.5 | $\mu A$
$I_{\pm I_{REF}}$ | Deviation of Reference Input Current over Temperature | $R_{1} = 10 k\Omega, R_{2} = \infty$, $I_{Z} = 10 mA, T_{A} = Full Range$ (see Figure 5) | 0.1 | 0.4 | $\mu A$
$I_{Z(MIN)}$ | Minimum Cathode Current for Regulation | $V_{Z} = V_{REF}$ (see Figure 4) | 55 | 80 | $\mu A$
$I_{Z(OFF)}$ | Off-State Current | $V_{Z} = 6V, V_{REF} = 0V$ (see Figure 6) | 0.001 | 0.1 | $\mu A$
$r_{Z}$ | Dynamic Output Impedance (2) | $V_{Z} = V_{REF}, I_{Z} = 0.1 mA$ to 15mA | Frequency = 0Hz (see Figure 4) | 0.25 | 0.4 | $\Omega$

(1) Deviation of reference input voltage, $V_{DEV}$, is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

\[ V_{DEV} = V_{MAX} - V_{MIN} \]

The average temperature coefficient of the reference input voltage, $\alpha_{V_{REF}}$, is defined as:

\[ \alpha_{V_{REF}} = \frac{\Delta V_{DEV}}{V_{DEV}(at 25^\circ C)} \times 10^{6} = \frac{\Delta V_{Z}}{V_{Z}(at 25^\circ C)} \times 10^{6} \]

Where: $T_{2} - T_{1} = full temperature change$. $\alpha_{V_{REF}}$ can be positive or negative depending on whether the slope is positive or negative. Example: $V_{DEV} = 6.0 mV, V_{REF} = 1240 mV, T_{2} - T_{1} = 125^\circ C$.

\[ \alpha_{V_{REF}} = \frac{6.0 mV}{125^\circ C} = +39 \text{ ppm/}^\circ C \]

(2) The dynamic output impedance, $r_{Z}$, is defined as: $r_{Z} = \frac{\Delta V_{Z}}{\Delta V_{Z}}$. When the device is programmed with two external resistors, $R_{1}$ and $R_{2}$, (see Figure 5), the dynamic output impedance of the overall circuit, $r_{Z}$, is defined as:

\[ r_{Z} = \frac{\Delta V_{Z}}{\Delta V_{Z}} = \left[ r_{Z} \left( 1 + \frac{R_{1}}{R_{2}} \right) \right] \]
**LMV431 AC ELECTRICAL CHARACTERISTICS**

\( T_A = 25^\circ C \) unless otherwise specified

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{REF} )</td>
<td>Reference Voltage</td>
<td>( V_Z = V_{REF}, I_Z = 10 \text{mA} ) (See Figure 4) ( T_A = 25^\circ C )</td>
<td>1.228</td>
<td>1.24</td>
<td>1.252</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_A = \text{Full Range} )</td>
<td>1.221</td>
<td>1.259</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{DEV} )</td>
<td>Deviation of Reference Input Voltage Over Temperature (1)</td>
<td>( V_Z = V_{REF}, I_Z = 10 \text{mA}, \ T_A = \text{Full Range} ) (See Figure 4)</td>
<td>4</td>
<td>12</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>( \Delta V_{REF} / \Delta V_Z )</td>
<td>Ratio of the Change in Reference Voltage to the Change in Cathode Voltage</td>
<td>( I_Z = 10 \text{mA} ) (see Figure 5) ( V_Z ) from ( V_{REF} ) to 6V ( R_1 = 10k, R_2 = \infty \text{ and } 2.6k )</td>
<td>-1.5</td>
<td>-2.7</td>
<td></td>
<td>mV/ V</td>
</tr>
<tr>
<td>( I_{REF} )</td>
<td>Reference Input Current</td>
<td>( R_1 = 1 \text{k}\Omega, R_2 = \infty ) ( I_l = 10 \text{mA} ) (see Figure 5)</td>
<td>0.15</td>
<td>0.50</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( = I_{REF} )</td>
<td>Deviation of Reference Input Current over Temperature</td>
<td>( R_1 = 10 \text{k}\Omega, R_2 = \infty ) ( I_l = 10 \text{mA}, T_A = \text{Full Range} ) (see Figure 5)</td>
<td>0.05</td>
<td>0.3</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{Z\text{(MIN)}} )</td>
<td>Minimum Cathode Current for Regulation</td>
<td>( V_Z = V_{REF} ) (see Figure 4)</td>
<td>55</td>
<td>80</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{Z\text{(OFF)}} )</td>
<td>Off-State Current</td>
<td>( V_Z = 6V, V_{REF} = 0V ) (see Figure 6)</td>
<td>0.001</td>
<td>0.1</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( r_Z )</td>
<td>Dynamic Output Impedance (2)</td>
<td>( V_Z = V_{REF}, I_Z = \text{0.1mA to 15mA} ) Frequency = 0 Hz (see Figure 4)</td>
<td>0.25</td>
<td>0.4</td>
<td></td>
<td>( \Omega )</td>
</tr>
</tbody>
</table>

(1) Deviation of reference input voltage, \( V_{DEV} \), is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

\[
V_{DEV} = V_{MAX} - V_{MIN}
\]

The average temperature coefficient of the reference input voltage, \( \alpha_{V_{REF}} \), is defined as:

\[
\alpha_{V_{REF}} = \frac{V_{REF} \text{ppm} / ^\circ C}{T_2 - T_1} = \frac{V_{DEV}}{V_{REF} \text{at } 25^\circ C} \left( \frac{T_2 - T_1}{10^6} \right)
\]

Where: \( T_2 - T_1 = \text{full temperature change} \). \( \alpha_{V_{REF}} \) can be positive or negative depending on whether the slope is positive or negative. Example: \( \Delta V_{DEV} = 6.0 \text{mV}, V_{REF} = 1240 \text{mV}, T_2 - T_1 = 125^\circ C \).

\[
\alpha_{V_{REF}} = \frac{6.0 \text{mV}}{1240 \text{mV}} \left( \frac{125^\circ C - 25^\circ C}{10^6} \right) = +39 \text{ppm/}^\circ C
\]

(2) The dynamic output impedance, \( r_Z \), is defined as:

\[
r_Z = \frac{\Delta V_Z}{\Delta I_Z}
\]

When the device is programmed with two external resistors, \( R_1 \) and \( R_2 \), (see Figure 5), the dynamic output impedance of the overall circuit, \( r_Z \), is defined as:

\[
r_Z = \frac{\Delta V_Z}{\Delta I_Z} = \left[ r_Z \left( 1 + \frac{R_1}{R_2} \right) \right]
\]
LMV431A ELECTRICAL CHARACTERISTICS

\( T_A = 25^\circ C \) unless otherwise specified

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{REF} )</td>
<td>Reference Voltage</td>
<td>( \frac{V_Z}{V_{REF}} = 10mA ) ( T_A = 25^\circ C ) ( T_A = \text{Full Range} )</td>
<td>1.228</td>
<td>1.24</td>
<td>1.252</td>
<td>V</td>
</tr>
<tr>
<td>( V_{DEV} )</td>
<td>Deviation of Reference Input Voltage over Temperature ((1))</td>
<td>( V_Z = V_{REF}, I_Z = 10mA ) ( T_A = \text{Full Range} ) (See Figure 4)</td>
<td>20</td>
<td>6</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>( \Delta V_{REF}/ \Delta V_Z )</td>
<td>Ratio of the Change in Reference Voltage to the Change in Cathode Voltage</td>
<td>( I_Z = 10mA ) (see Figure 5) ( V_Z ) from ( V_{REF} ) to 6V ( R_1 = 10k, R_2 = \infty ) and 2.6k</td>
<td>-1.5</td>
<td>-2.7</td>
<td></td>
<td>mV/V</td>
</tr>
<tr>
<td>( I_{REF} )</td>
<td>Reference Input Current</td>
<td>( R_1 = 10k \Omega, R_2 = \infty ) ( I_I = 10mA ) (see Figure 5)</td>
<td>0.15</td>
<td>0.5</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( = I_{REF} )</td>
<td>Deviation of Reference Input Current over Temperature</td>
<td>( R_1 = 10k \Omega, R_2 = \infty ) ( I_I = 10mA ) ( T_A = \text{Full Range} ) (see Figure 5)</td>
<td>0.1</td>
<td>0.4</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{Z(MIN)} )</td>
<td>Minimum Cathode Current for Regulation</td>
<td>( V_Z = V_{REF}(\text{see Figure 4}) )</td>
<td>55</td>
<td>80</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{Z(OFF)} )</td>
<td>Off-State Current</td>
<td>( V_Z = 6V, V_{REF} = 0V ) (see Figure 6)</td>
<td>0.001</td>
<td>0.1</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( r_Z )</td>
<td>Dynamic Output Impedance ((2))</td>
<td>( V_Z = V_{REF}, I_Z = 0.1mA ) to 15mA Frequency = 0Hz (see Figure 4)</td>
<td>0.25</td>
<td>0.4</td>
<td></td>
<td>( \Omega )</td>
</tr>
</tbody>
</table>

\( (1) \) Deviation of reference input voltage, \( V_{DEV} \), is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

\[
V_{DEV} = V_{MAX} - V_{MIN}
\]

The average temperature coefficient of the reference input voltage, \( \propto V_{REF} \), is defined as:

\[
\propto V_{REF} = \frac{V_{MAX} - V_{MIN}}{T_2 - T_1} = \left[ \frac{V_{DEV}}{T_2 - T_1} \right] \quad \text{ppm/}^\circ C
\]

Where: \( T_2 - T_1 = \text{full temperature change} \). \( \propto V_{REF} \) can be positive or negative depending on whether the slope is positive or negative. Example: \( V_{DEV} = 6.0mV, \propto V_{REF} = 1240mV, T_2 - T_1 = 125^\circ C \).

\( \propto V_{REF} = \frac{6.0 \text{mV}}{1240 \text{mV}} \left[ \frac{125^\circ C}{125^\circ C} \right] = +39 \text{ ppm/}^\circ C \)

\( (2) \) The dynamic output impedance, \( r_Z \), is defined as: \( r_Z = \frac{\Delta V_Z}{\Delta I_Z} \). When the device is programmed with two external resistors, \( R_1 \) and \( R_2 \), (see Figure 5), the dynamic output impedance of the overall circuit, \( r_Z \), is defined as: \( r_Z = \frac{\Delta V_Z}{\Delta I_Z} = \left[ r_Z \left( 1 + \frac{R_1}{R_2} \right) \right] \)

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Product Folder Links: LMV431 LMV431A LMV431B
Where:

\[ T_2 - T_1 = \text{full temperature change}. \]

\[ \Delta V_{REF}/\Delta V_Z = \text{Ratio of the Change in Reference Voltage to the Change in Cathode Voltage} \]

\[ I_{REF} = \text{Reference Input Current} \]

\[ I_{Z(MIN)} = \text{Minimum Cathode Current for Regulation} \]

\[ I_{Z(OFF)} = \text{Off-State Current} \]

\[ r_Z = \text{Dynamic Output Impedance} \]

Deviation of reference input voltage, \( V_{DEV} \), is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

\[ V_{DEV} = V_{MAX} - V_{MIN} \]

The average temperature coefficient of the reference input voltage, \( \alpha V_{REF} \), is defined as:

\[ \alpha V_{REF} = \frac{V_{MAX} - V_{MIN}}{V_{REF} (at 25°C)} \times 10^6 \]

Where: \( T_2 - T_1 = \text{full temperature change} \). \( \alpha V_{REF} \) can be positive or negative depending on whether the slope is positive or negative. Example: \( V_{DEV} = 6.0 \text{mV}, V_{REF} = 1240 \text{mV}, T_2 - T_1 = 125°C \).

\[ \alpha V_{REF} = \frac{6.0 \text{mV}}{1240 \text{mV}} \times 10^6 = +39 \text{ ppm/°C} \]

The dynamic output impedance, \( r_Z \), is defined as:

\[ r_Z = \frac{\Delta V_Z}{\Delta V_2} \]

When the device is programmed with two external resistors, \( R_1 \) and \( R_2 \), (see Figure 5), the dynamic output impedance of the overall circuit, \( r_Z \), is defined as:

\[ r_Z = \frac{\Delta V_2}{\Delta V_Z} = r_Z \left( 1 + \frac{R_1}{R_2} \right) \]
Where: \( T_2 - T_1 = \) full temperature change.

\( \propto V_{REF} \) can be positive or negative depending on whether the slope is positive or negative. Example: \( V_{DEV} = 6.0 \text{mV}, V_{REF} = 1240 \text{mV}, T_2 - T_1 = 125 \degree \text{C}. \)

\[ \Delta V_{REF}/\Delta V_Z = \frac{V_Z}{I_Z} \]

\( V_Z = V_{REF} \text{ to 6V} \)
\( R_1 = 10k, R_2 = \infty \text{ and 2.6k} \)

\( \Delta V_{REF}/\Delta V_Z \)

\[ \propto I_{REF} \]

\( I_{IREF} \)

\( I_{Z(MIN)} \)

\( I_{Z(OFF)} \)

\( r_Z \)

\[ r_Z = \frac{\Delta V_Z}{\Delta V_{REF}} = I_Z \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \]

(1) Deviation of reference input voltage, \( V_{DEV} \), is defined as the maximum variation of the reference input voltage over the full temperature range. See following:

The average temperature coefficient of the reference input voltage, \( \propto V_{REF} \), is defined as:

\[ \frac{V_{REF}}{T_2 - T_1} \]

Where: \( T_2 - T_1 = \) full temperature change. \( \propto V_{REF} \) can be positive or negative depending on whether the slope is positive or negative. Example: \( V_{DEV} = 6.0 \text{mV}, V_{REF} = 1240 \text{mV}, T_2 - T_1 = 125 \degree \text{C}. \)

(2) The dynamic output impedance, \( r_Z \), is defined as:

\[ r_Z = \frac{\Delta V_Z}{\Delta V_{REF}} = I_Z \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \]
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 7. Reference Voltage vs. Junction Temperature

Figure 8. Reference Input Current vs. Junction Temperature

Figure 9. Cathode Current vs. Cathode Voltage 1

Figure 10. Cathode Current vs. Cathode Voltage 2

Figure 11. Delta Reference Voltage Per Off-State Cathode Current vs. Junction Temperature

Figure 12. Delta Reference Voltage Per Delta Cathode Voltage vs. Junction Temperature
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Input Voltage Noise

Test Circuit for Input Voltage Noise

Figure 13.

Figure 14.

Low Frequency Peak to Peak Noise

Test Circuit for Peak to Peak Noise (BW= 0.1Hz to 10Hz)

Figure 15.

Figure 16.

Small Signal Voltage Gain and Phase Shift

Test Circuit For Voltage Gain and Phase Shift

Figure 17.

Figure 18.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Reference Impedance

**Reference Impedance vs. Frequency**

![Graph showing Reference Impedance vs. Frequency](image)

*Figure 19.*

Test Circuit for Reference Impedance

![Test Circuit](image)

*Figure 20.*

Reference Impedance vs. Frequency

**Test Circuit for Pulse Response 1**

![Test Circuit for Pulse Response 1](image)

*Figure 21.*

Pulse Response 1

![Pulse Response 1](image)

*Time (μs)*

*Figure 22.*

Pulse Generator

f = 100 kHz

Test Circuit for Pulse Response 2

![Test Circuit for Pulse Response 2](image)

*Figure 23.*

Pulse Generator

f = 100 kHz
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Figure 25. LMV431 Stability Boundary Condition

- STABLE
- UNSTABLE REGION

TA = 25°C, IZ = 15mA

VZ = 2V
VZ = 3V

FOR VZ = VREF, STABLE FOR CL = 1pF TO 10k nF

LOAD CAPACITANCE CL (nF)

CATHODE CURRENT IZ (mA)

Figure 26. Test Circuit for VZ = VREF

Figure 27. Test Circuit for VZ = 2V, 3V

Percentage Change in VREF vs. Operating Life at 55°C

Extrapolated from life-test data taken at 125°C; the activation energy assumed is 0.7eV.

Figure 28.
TYPICAL APPLICATIONS

Series Regulator

Output Control of a Three Terminal Fixed Regulator

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

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

\[ V_{O\ MIN} = V_{REF} + 5V \]

Higher Current Shunt Regulator

Crow Bar

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

\[ V_{LIMIT} \approx \left(1 + \frac{R_1}{R_2}\right) V_{REF} \]

Over Voltage/Under Voltage Protection Circuit

Voltage Monitor

LOW LIMIT = \( V_{REF} \left(1 + \frac{R_{1B}}{R_{2B}}\right) + V_{BE} \)

HIGH LIMIT = \( V_{REF} \left(1 + \frac{R_{1A}}{R_{2A}}\right) \)

LOW LIMIT = \( V_{REF} \left(1 + \frac{R_{1B}}{R_{2B}}\right) \)

LED ON WHEN LOW LIMIT < \( V^+ \) < HIGH LIMIT

LOW LIMIT = \( V_{REF} \left(1 + \frac{R_{1B}}{R_{2B}}\right) \)

HIGH LIMIT = \( V_{REF} \left(1 + \frac{R_{1A}}{R_{2A}}\right) \)
Delay Timer

\[ \text{DELAY} = R \cdot C \cdot \ln \left( \frac{V}{V^+} \right) - \frac{V}{V^+} \]

Current Limiter or Current Source

\[ i_0 = \frac{V_{\text{REF}}}{R_{\text{CL}}} \]

Constant Current Sink

\[ i_0 = \frac{V_{\text{REF}}}{R_S} \]
## Packaging Information

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ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
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RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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**TAPE AND REEL BOX DIMENSIONS**

*All dimensions are nominal*

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Images above are just a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
NOTES: (continued)

4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

7. Board assembly site may have different recommendations for stencil design.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.
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NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
   a. Straight lead option available in bulk pack only.
   b. Formed lead option available in tape and reel or ammo pack.
   c. Specific products can be offered in limited combinations of shipping medium and lead options.
   d. Consult product folder for more information on available options.
TAPE SPECIFICATIONS

LP0003A
TO-92 - 5.34 mm max height

FOR FORMED LEAD OPTION PACKAGE
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