Quad Precision Op Amp (LT1014)
Dual Precision Op Amp (LT1013)

FEATURES

- Single Supply Operation
  - Input Voltage Range Extends to Ground
  - Output Swings to Ground While Sinking Current
- Pin Compatible to 1458 and 324 with Precision Specs
- Guaranteed Offset Voltage: 150µV Max
- Guaranteed Low Drift: 2µV/°C Max
- Guaranteed Offset Current: 0.8nA Max
- Guaranteed High Gain
  - 5mA Load Current: 1.5 Million Min
  - 17mA Load Current: 0.8 Million Min
- Guaranteed Low Supply Current: 500µA Max
- Low Voltage Noise, 0.1Hz to 10Hz: 0.55µVP-P
- Low Current Noise—Better than OP-07, 0.07pA/√Hz

APPLICATIONS

- Battery-Powered Precision Instrumentation
- Strain Gauge Signal Conditioners
- Thermocouple Amplifiers
- Instrumentation Amplifiers
- 4mA to 20mA Current Loop Transmitters
- Multiple Limit Threshold Detection
- Active Filters
- Multiple Gain Blocks

DESCRIPTION

The LT® 1014 is the first precision quad operational amplifier which directly upgrades designs in the industry standard 14-pin DIP LM324/LM348/OP-11/4156 pin configuration. It is no longer necessary to compromise specifications, while saving board space and cost, as compared to single operational amplifiers.

The LT1014’s low offset voltage of 50µV, drift of 0.3µV/°C, offset current of 0.15nA, gain of 8 million, common mode rejection of 117dB and power supply rejection of 120dB qualify it as four truly precision operational amplifiers. Particularly important is the low offset voltage, since no offset null terminals are provided in the quad configuration. Although supply current is only 350µA per amplifier, a new output stage design sources and sinks in excess of 20mA of load current, while retaining high voltage gain.

Similarly, the LT1013 is the first precision dual op amp in the 8-pin industry standard configuration, upgrading the performance of such popular devices as the MC1458/MC1558, LM158 and OP-221. The LT1013’s specifications are similar to (even somewhat better than) the LT1014’s.

Both the LT1013 and LT1014 can be operated off a single 5V power supply: input common mode range includes ground; the output can also swing to within a few millivolts of ground. Crossover distortion, so apparent on previous single-supply designs, is eliminated. A full set of specifications is provided with ±15V and single 5V supplies.

TYPICAL APPLICATION

3-Channel Thermocouple Thermometer

USE TYPE K THERMOCOUPLES. ALL RESISTORS = 1% FILM.
COLD JUNCTION COMPENSATION ACCURATE
TO ±1°C FROM 0°C TO 60°C.
USE 4TH AMPLIFIER FOR OUTPUT C.

LT1014 Distribution of Offset Voltage

For more information www.linear.com/LT1013
## ABSOLUTE MAXIMUM RATINGS (Note 1)

- Supply Voltage: \( \pm 22 \) V
- Differential Input Voltage: \( \pm 30 \) V
- Input Voltage: Equal to Positive Supply Voltage
- Output Short-Circuit Duration: Indefinite
- Storage Temperature Range: All Grades: \(-65^\circ C \) to \(150^\circ C\)

### Operating Temperature Range

- LT1013AM/LT1013M/LT1013C/LT1013D
  - LT1014AM/LT1014M/LT1014C/LT1014D
  
  **LT1013M/LT1014M**
  - \(-55^\circ C \) to \(125^\circ C\)

**LT1013I/LT1014I**
- \(0^\circ C \) to \(70^\circ C\)
- \(0^\circ C \) to \(85^\circ C\)

### Lead Temperature (Soldering, 10 sec.)
- \(300^\circ C\)

### Pin Configuration

- **LT1013**
  - **Top View**
  - **Note:** This pin configuration differs from the standard 8-pin dual-in-line configuration.
  - \(T_{J\text{MAX}} = 150^\circ C, \theta_J = 130^\circ C/W\)

- **LT1014**
  - **Top View**
  - **Note:** This pin configuration differs from the standard 14-pin dual-in-line configuration.
  - \(T_{J\text{MAX}} = 150^\circ C, \theta_J = 130^\circ C/W\)

### Additional Information

- For more information: [www.linear.com/LT1013](http://www.linear.com/LT1013)
# ORDER INFORMATION

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<td>LT1014CJ</td>
<td>14-Lead CERDIP</td>
<td>0°C to 70°C (OBSOLETE)</td>
</tr>
</tbody>
</table>

Consult LTC Marketing for parts specified with wider operating temperature ranges.

For more information on lead free part marking, go to: [http://www.linear.com/leadfree/](http://www.linear.com/leadfree/)

For more information on tape and reel specifications, go to: [http://www.linear.com/tapeandreel/](http://www.linear.com/tapeandreel/). Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.
## LT1013/LT1014

### ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ C, \ V_S = \pm 15V, \ V_{CM} = 0V$ unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1013AM/AC</th>
<th>LT1014AM/AC</th>
<th>LT1013C/D/I/M</th>
<th>LT1014C/D/I/M</th>
<th>UNITS</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIN         TYP         MAX</td>
<td>MIN         TYP         MAX</td>
<td>MIN         TYP         MAX</td>
<td></td>
<td></td>
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<tr>
<td>$V_{OS}$</td>
<td>Input Offset Voltage</td>
<td>LT1013</td>
<td>40          150</td>
<td>60          300</td>
<td>200          800</td>
<td>µV</td>
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<tr>
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<td>LT1014</td>
<td>50          180</td>
<td>60          300</td>
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<td>µV</td>
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<td></td>
<td>LT1013D/I, LT1014D/I</td>
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<td></td>
<td>µV</td>
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<td>Long-Term Input Offset Voltage Stability</td>
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<td>0.4</td>
<td>0.5</td>
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<td>µV/Mo.</td>
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<td>$I_{SO}$</td>
<td>Input Offset Current</td>
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<td>0.15         0.8</td>
<td>0.2          1.5</td>
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<td>nA</td>
<td></td>
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<td>$I_B$</td>
<td>Input Bias Current</td>
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<td>12           20</td>
<td>15           30</td>
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<td>nA</td>
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<tr>
<td>$e_n$</td>
<td>Input Noise Voltage</td>
<td>0.1Hz to 10Hz</td>
<td>0.55</td>
<td>0.55</td>
<td></td>
<td>µV/√Hz</td>
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<tr>
<td>$e_n$</td>
<td>Input Noise Voltage Density</td>
<td>$f_0 = 10Hz$</td>
<td>24</td>
<td>24</td>
<td></td>
<td>nV/√Hz</td>
<td></td>
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<tr>
<td>$e_n$</td>
<td>Input Noise Current Density</td>
<td>$f_0 = 10Hz$</td>
<td>0.07</td>
<td>0.07</td>
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<td>µA/√Hz</td>
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<td>$I_{IN}$</td>
<td>Input Noise Current Density</td>
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<tr>
<td>$R_{IN}$</td>
<td>Input Resistance – Differential Common Mode</td>
<td>(Note 2)</td>
<td>100          400</td>
<td>70           300</td>
<td>70           300</td>
<td>MΩ</td>
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<td></td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
<td></td>
<td>GΩ</td>
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<tr>
<td>$A_{VOL}$</td>
<td>Large-Signal Voltage Gain</td>
<td>$V_D = \pm 10V, R_L = 2k$</td>
<td>1.5</td>
<td>8.0</td>
<td>12</td>
<td>7.0</td>
<td>V/µV</td>
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<tr>
<td></td>
<td></td>
<td>$V_D = \pm 10V, R_L = 600Ω$</td>
<td>0.8</td>
<td>2.5</td>
<td>0.5</td>
<td>2.0</td>
<td>V/µV</td>
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<tr>
<td></td>
<td>Input Voltage Range</td>
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<td>13.8</td>
<td>13.5</td>
<td>13.8</td>
<td>V</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-15.0</td>
<td>-15.3</td>
<td>-15.0</td>
<td>-15.3</td>
<td>V</td>
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<td>$CMRR$</td>
<td>Common Mode Rejection Ratio</td>
<td>$V_{CM} = 13.5V, –15.0V$</td>
<td>100</td>
<td>117</td>
<td>97</td>
<td>114</td>
<td>dB</td>
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<tr>
<td>$PSRR$</td>
<td>Power Supply Rejection Ratio</td>
<td>$V_S = \pm 2V to \pm 18V$</td>
<td>103</td>
<td>120</td>
<td>100</td>
<td>117</td>
<td>dB</td>
</tr>
<tr>
<td>$CMRR$</td>
<td>Common Mode Rejection Ratio</td>
<td>$V_{CM} = 13.5V, –15.0V$</td>
<td>100</td>
<td>117</td>
<td>97</td>
<td>114</td>
<td>dB</td>
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<tr>
<td>$V_{OUT}$</td>
<td>Output Voltage Swing</td>
<td>$R_L = 2k$</td>
<td>±13</td>
<td>±14</td>
<td>±12.5</td>
<td>±14</td>
<td>V</td>
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<tr>
<td></td>
<td>Slew Rate</td>
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<td>0.4</td>
<td>0.2</td>
<td>0.4</td>
<td>V/µs</td>
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<td>$I_S$</td>
<td>Supply Current Per Amplifier</td>
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<td>0.35</td>
<td>0.50</td>
<td>0.35</td>
<td>0.55</td>
<td>mA</td>
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</table>

$T_A = 25^\circ C, \ V_S^+ = 5V, \ V_S^- = 0V, \ V_{OUT} = 1.4V, \ V_{CM} = 0V$ unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1013AM/AC</th>
<th>LT1014AM/AC</th>
<th>LT1013C/D/I/M</th>
<th>LT1014C/D/I/M</th>
<th>UNITS</th>
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<td>MIN         TYP         MAX</td>
<td>MIN         TYP         MAX</td>
<td>MIN         TYP         MAX</td>
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<tr>
<td>$V_{OS}$</td>
<td>Input Offset Voltage</td>
<td>LT1013</td>
<td>60           250</td>
<td>90           450</td>
<td>250          950</td>
<td>µV</td>
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<td>LT1014</td>
<td>70           280</td>
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<td></td>
<td>µV</td>
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<td>LT1013D/I, LT1014D/I</td>
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<td>µV</td>
</tr>
<tr>
<td>$I_{OS}$</td>
<td>Input Offset Current</td>
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<td>0.3          2.0</td>
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<td>$I_B$</td>
<td>Input Bias Current</td>
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<td>18           50</td>
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<td>nA</td>
<td></td>
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<tr>
<td>$A_{VOL}$</td>
<td>Large-Signal Voltage Gain</td>
<td>$V_D = 5mV to 4V, R_L = 500Ω$</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
<td>V/µV</td>
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<tr>
<td>$V_{OUT}$</td>
<td>Output Voltage Swing</td>
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<td>3.5          -0.3</td>
<td>3.5          -0.3</td>
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<td>V</td>
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<tr>
<td>$V_{OUT}$</td>
<td>Output Voltage Swing</td>
<td>Output Low, No Load</td>
<td>15          25</td>
<td>15           25</td>
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<td>Output Low, 600Ω to Ground</td>
<td>5           10</td>
<td>5           10</td>
<td></td>
<td>mV</td>
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<td>Output Low, $I_{SINK} = 1mA$</td>
<td>220         350</td>
<td>220         350</td>
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<td>Output High, No Load</td>
<td>4.0          4.4</td>
<td>4.0          4.4</td>
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<td>V</td>
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<td></td>
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<td>Output High, 600Ω to Ground</td>
<td>3.4          4.0</td>
<td>3.4          4.0</td>
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<td>V</td>
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<td>Supply Current Per Amplifier</td>
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<td>mA</td>
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For more information [www.linear.com/LT1013](http://www.linear.com/LT1013)
### ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range

\[-55°C ≤ T_A ≤ 125°C\]. \(V_S = ±15V\), \(V_{CM} = 0V\) unless otherwise noted.

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<th>PARAMETER</th>
<th>CONDITIONS</th>
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<th>LT1014AM</th>
<th>LT1013M/LT1014M</th>
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<td>TYP</td>
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<td>TYP</td>
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<td>V_{OS}</td>
<td>Input Offset Voltage</td>
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<td>300</td>
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<td>●</td>
<td>80</td>
<td>450</td>
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<tr>
<td></td>
<td></td>
<td>●</td>
<td>120</td>
<td>450</td>
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<tr>
<td></td>
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<td>●</td>
<td>250</td>
<td>900</td>
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<tr>
<td></td>
<td></td>
<td>●</td>
<td>500</td>
<td>1500</td>
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<td>●</td>
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<td>(Note 3)</td>
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<td></td>
<td>●</td>
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<td>2.0</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td>●</td>
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<td>A_{VOL}</td>
<td>Large-Signal Voltage Gain</td>
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<td>CMRR</td>
<td>Common Mode Rejection</td>
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<td>97</td>
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<td>PSRR</td>
<td>Power Supply Rejection</td>
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<td>V_{OUT}</td>
<td>Output Voltage Swing</td>
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<td>±13.8</td>
<td>±12</td>
<td>±13.8</td>
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<td></td>
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<td>●</td>
<td>3.2</td>
<td>3.8</td>
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<td>I_{S}</td>
<td>Supply Current Per Amplifier</td>
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<td>0.60</td>
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<td></td>
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<td>0.34</td>
<td>0.55</td>
<td>0.34</td>
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</table>
**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the temperature range –40°C ≤ T_A ≤ 85°C for LT1013I, LT1014I, 0°C ≤ T_A ≤ 70°C for LT1013C, LT1013D, LT1014C, LT1014D. V_S = ±15V, V_CM = 0V unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1013AC</th>
<th>LT1014AC</th>
<th>LT1013C/D/I</th>
<th>LT1014C/D/I</th>
<th>UNITS</th>
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<td>TYP</td>
<td>MAX</td>
<td>MIN</td>
<td>TYP</td>
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<td>V_Os</td>
<td>Input Offset Voltage</td>
<td>LT1013D/I, LT1014D/I</td>
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<td>240</td>
<td>● 65</td>
<td>270</td>
<td>● 80</td>
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<td>LT1013C/D/I, LT1014C/D/I</td>
<td>● 75</td>
<td>350</td>
<td>● 85</td>
<td>380</td>
<td>● 100</td>
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<td>(Note 3)</td>
<td>● 0.3</td>
<td>2.0</td>
<td>● 0.4</td>
<td>2.0</td>
<td>0.4</td>
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<td>I(OS)</td>
<td>Input Offset Current</td>
<td>V_S = 5V, 0V; V_O = 1.4V</td>
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<td>1.5</td>
<td>● 0.4</td>
<td>1.7</td>
<td>0.3</td>
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<td>I_B</td>
<td>Input Bias Current</td>
<td>V_S = 5V, 0V; V_O = 1.4V</td>
<td>● 13</td>
<td>25</td>
<td>13</td>
<td>25</td>
<td>16</td>
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<td>A_VOL</td>
<td>Large-Signal Voltage Gain</td>
<td>V_O = ±10V, R_L = 2k</td>
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<td>0.7</td>
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<td>CMRR</td>
<td>Common Mode Rejection Ratio</td>
<td>V_CM = 13.0V, –15.0V</td>
<td>● 98</td>
<td>116</td>
<td>98</td>
<td>116</td>
<td>94</td>
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<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>V_S = ±2V to ±18V</td>
<td>● 101</td>
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<td>101</td>
<td>119</td>
<td>97</td>
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<td>V_OUT</td>
<td>Output Voltage Swing</td>
<td>R_L = 2k, V_S = 5V, 0V; R_L = 600Ω</td>
<td>● ±12.5</td>
<td>±13.9</td>
<td>±12.5</td>
<td>±13.9</td>
<td>±12.0</td>
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<td>Output Low</td>
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<td>6</td>
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<td></td>
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<td>Output High</td>
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<td>3.9</td>
<td>3.3</td>
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<tr>
<td>I_S</td>
<td>Supply Current per Amplifier</td>
<td>V_S = 5V, 0V; V_O = 1.4V</td>
<td>● 0.36</td>
<td>0.55</td>
<td>0.36</td>
<td>0.55</td>
<td>0.37</td>
</tr>
</tbody>
</table>

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** This parameter is guaranteed by design and is not tested. Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers; i.e., out of 100 LT1014s (or 100 LT1013s) typically 240 op amps (or 120 ) will be better than the indicated specification.

**Note 3:** This parameter is not 100% tested.
TYPICAL PERFORMANCE CHARACTERISTICS

Offset Voltage Drift with Temperature of Representative Units

Common Mode Rejection Ratio vs Frequency

Power Supply Rejection Ratio vs Frequency

Warm-Up Drift

Offset Voltage vs Balanced Source Resistance

0.1Hz to 10Hz Noise

Noise Spectrum

10Hz Voltage Noise Distribution

Supply Current vs Temperature

For more information www.linear.com/LT1013
TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias Current vs Common Mode Voltage

![Graph showing Input Bias Current vs Common Mode Voltage](image)

Input Offset Current vs Temperature

![Graph showing Input Offset Current vs Temperature](image)

Output Saturation vs Sink Current vs Temperature

![Graph showing Output Saturation vs Sink Current vs Temperature](image)

Input Bias Current vs Temperature

![Graph showing Input Bias Current vs Temperature](image)

Small-Signal Transient Response, $V_S = \pm 15V$

![Graph showing Small-Signal Transient Response](image)

Large-Signal Transient Response, $V_S = \pm 15V$

![Graph showing Large-Signal Transient Response](image)

Small-Signal Transient Response, $V_S = 5V, 0V$

![Graph showing Small-Signal Transient Response](image)

Large-Signal Transient Response, $V_S = 5V, 0V$

![Graph showing Large-Signal Transient Response](image)

Small-Signal Transient Response, $V_S = 5V, 0V$

![Graph showing Small-Signal Transient Response](image)

Large-Signal Transient Response, $V_S = 5V, 0V$

![Graph showing Large-Signal Transient Response](image)

For more information, visit www.linear.com/LT1013
TYPICAL PERFORMANCE CHARACTERISTICS

Output Short-Circuit Current vs Time

Voltage Gain vs Load Resistance

Voltage Gain vs Frequency

Gain, Phase vs Frequency

Channel Separation vs Frequency

APPLICATIONS INFORMATION

Single Supply Operation

The LT1013/LT1014 are fully specified for single supply operation, i.e., when the negative supply is 0V. Input common mode range includes ground; the output swings within a few millivolts of ground. Single supply operation, however, can create special difficulties, both at the input and at the output. The LT1013/LT1014 have specific circuitry which addresses these problems.

At the input, the driving signal can fall below 0V—inadvertently or on a transient basis. If the input is more than a few hundred millivolts below ground, two distinct problems can occur on previous single supply designs, such as the LM124, LM158, OP-20, OP-21, OP-220, OP-221, OP-420:

a) When the input is more than a diode drop below ground, unlimited current will flow from the substrate (V– terminal) to the input. This can destroy the unit. On the LT1013/LT1014, the 400Ω resistors, in series with the input (see Schematic Diagram), protect the devices even when the input is 5V below ground.
b) When the input is more than 400mV below ground (at 25°C), the input stage saturates (transistors Q3 and Q4) and phase reversal occurs at the output. This can cause lock-up in servo systems. Due to a unique phase reversal protection circuitry (Q21, Q22, Q27, Q28), the LT1013/LT1014’s outputs do not reverse, as illustrated below, even when the inputs are at −1.5V.

There is one circumstance, however, under which the phase reversal protection circuitry does not function: when the other op amp on the LT1013, or one specific amplifier of the other three on the LT1014, is driven hard into negative saturation at the output.

Phase reversal protection does not work on amplifier:
A when D’s output is in negative saturation. B’s and C’s outputs have no effect.
B when C’s output is in negative saturation. A’s and D’s outputs have no effect.
C when B’s output is in negative saturation. A’s and D’s outputs have no effect.

D when A’s output is negative saturation. B’s and C’s outputs have no effect.

At the output, the aforementioned single supply designs either cannot swing to within 600mV of ground (OP-20) or cannot sink more than a few microamperes while swinging to ground (LM124, LM158). The LT1013/LT1014’s all-NPN output stage maintains its low output resistance and high gain characteristics until the output is saturated.

In dual supply operations, the output stage is crossover distortion-free.

Comparator Applications

The single supply operation of the LT1013/LT1014 lends itself to its use as a precision comparator with TTL compatible output:

In systems using both op amps and comparators, the LT1013/LT1014 can perform multiple duties; for example, on the LT1014, two of the devices can be used as op amps and the other two as comparators.
APPLICATIONS INFORMATION

Low Supply Operation
The minimum supply voltage for proper operation of the LT1013/LT1014 is 3.4V (three Ni-Cad batteries). Typical supply current at this voltage is 290µA, therefore power dissipation is only one milliwatt per amplifier.

Noise Testing
For applications information on noise testing and calculations, please see the LT1007 or LT1008 data sheet.

TYPICAL APPLICATIONS

50MHz Thermal RMS-to-DC Converter

5V Single Supply Dual Instrumentation Amplifier

For more information www.linear.com/LT1013
Typical Applications

Hot-Wire Anemometer

- Remove lamp's glass envelope from 328 lamp.
- A1 servos #328 lamp to constant temperature.
- A2-A3 furnish linear output vs flow rate.
- *1% resistor.

Liquid Flowmeter

- Supplied with YSI thermistor network.
- T1, T2 YSI thermistor network = #44201.
- Flow in pipe is inversely proportional to resistance of T1–T2 temperature difference.
- A1–A2 provide gain. A3–A4 provide linearized frequency output.

For more information www.linear.com/LT1013
**TYPICAL APPLICATIONS**

### 5V Powered Precision Instrumentation Amplifier

- TO INPUT CABLE SHIELDS
- 200k* 5V
- 10k* RG (TYP 2k)
- 10k 200k* 5V
- 10k 10k 10k 10k

*1% FILM RESISTOR. MATCH 10k's 0.05%

GAIN EQUATION: \[ A = \frac{400,000}{RG} + 1. \]

†FOR HIGH SOURCE IMPEDANCES, USE 2N2222 AS DIODES.

### 9V Battery Powered Strain Gauge Signal Conditioner

- TO A/D RATIO REFERENCE
- 2N2219
- 330Ω
- 4.7k
- 0.01
- 100k
- 15k
- 0.068
- 1N4148
- 22M
- 0.068
- 0.068
- 3k
- 15k
- 74C221
- 13
- 9V
- 0.068
- 14
- 499
- 0.068
- 0.068
- 6

SAMPLED OPERATION GIVES LOW AVERAGE OPERATING CURRENT ≈ 650µA.

4.7k-0.01µF RC PROTECTS STRAIN BRIDGE FROM LONG TERM DRIFTS DUE TO HIGH ∆V/∆T STEPS.
5V Powered Motor Speed Controller
No Tachometer Required

MOTOR = CANON–FN30–R13N1B.
A1 DUTY CYCLE MODULATES MOTOR.
A2 SAMPLES MOTORS BACK EMF.

5V Powered EEPROM Pulse Generator

MEETS ALL $V_{pp}$ PROGRAMMING SPECS WITH NO TRIMS AND RUNS OFF 5V SUPPLY—NO EXTERNAL HIGH VOLTAGE SUPPLY REQUIRED. SUITABLE FOR BATTERY POWERED USE (600µA QUIESCENT CURRENT).
*1% METAL FILM.
**TYPICAL APPLICATIONS**

5V Powered 4mA to 20mA Current Loop Transmitter†

![Circuit Diagram 1](image1.jpg)

† 12-BIT ACCURACY. * 1% FILM. T1 = PICO-31080.

Fully Floating Modification to 4mA-20mA Current Loop†

![Circuit Diagram 2](image2.jpg)

† 8-BIT ACCURACY.
TYPICAL APPLICATIONS

5V Powered, Linearized Platinum RTD Signal Conditioner

![Circuit Diagram]

ALL RESISTORS ARE TRW-MAR-6 METAL FILM.
RATIO MATCH 2M–200k ± 0.01%.
TRIM SEQUENCE:
SET SENSOR TO 0° VALUE.
ADJUST ZERO FOR 0V OUT.
SET SENSOR TO 100°C VALUE.
ADJUST GAIN FOR 1.000V OUT.
SET SENSOR TO 400°C.
ADJUST LINEARITY FOR 4.000V OUT, REPEAT AS REQUIRED.

Strain Gauge Bridge Signal Conditioner

![Circuit Diagram]

* 1% FILM RESISTOR.
CIRCLED LETTER IS PIN NUMBER.
For more information www.linear.com/LT1013
TYPICAL APPLICATIONS

Low Dropout Regulator for 6V Battery

Voltage Controlled Current Source with Ground Referred Input and Output
Low Power, 5V Driven, Temperature Compensated Crystal Oscillator (TXCO)†

* 1% FILM
3.5MHz XTL = AT CUT – 35°20'
MOUNT Rf NEAR XTL
3mA POWER DRAIN
† THERMISTOR-AMPLIFIER-VARACTOR NETWORK GENERATES A TEMPERATURE COEFFICIENT OPPOSITE THE CRYSTAL TO MINIMIZE OVERALL OSCILLATOR DRIFT

LT1013/14 TA21
6V to ±15V Regulating Converter

For more information www.linear.com/LT1013
For more information www.linear.com/LT1013
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LT1013#packaging for the most recent package drawings.

H Package
8-Lead TO-5 Metal Can (.200 Inch PCD)
(Reference LTC DWG # 05-08-1320)

J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)

J Package
14-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)

OBSOLETE PACKAGES
PACKAGE DESCRIPTION

Please refer to [www.linear.com/product/LT1013#packaging](http://www.linear.com/product/LT1013#packaging) for the most recent package drawings.

### N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510 Rev I)

**Dimensions:**
- **MIN:** 0.008 ± 0.015
- **TYP:** 0.035
- **MAX:** 0.088 ± 0.015
- **TYP:** 0.005
- **MIN:** 0.003
- **MAX:** 0.016
- **MIN:** 0.100
- **MAX:** 0.255 ± 0.015

**Tolerances:**
- **MIN:** ± 0.003
- **MAX:** ± 0.015

**Note:**
- Dimensions are in inches.
- Mold flash or protrusions shall not exceed 0.010 inch (0.254 mm).
- These dimensions do not include mold flash or protrusions.

### N Package
14-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)

**Dimensions:**
- **MIN:** 0.008 ± 0.015
- **TYP:** 0.035
- **MAX:** 0.088 ± 0.015
- **TYP:** 0.005
- **MIN:** 0.003
- **MAX:** 0.016
- **MIN:** 0.100
- **MAX:** 0.255 ± 0.015

**Tolerances:**
- **MIN:** ± 0.003
- **MAX:** ± 0.015

**Note:**
- Dimensions are in inches.
- Mold flash or protrusions shall not exceed 0.010 inch (0.254 mm).
**PACKAGE DESCRIPTION**

Please refer to [http://www.linear.com/product/LT1013#packaging](http://www.linear.com/product/LT1013#packaging) for the most recent package drawings.

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**S8 Package**

8-Lead Plastic Small Outline (Narrow .150 Inch)

(Reference LTC DWG # 05-08-1610 Rev G)

---

**SW Package**

XX-Lead Plastic Small Outline (Wide .300 Inch)

(Reference LTC DWG # 05-08-1620)
**REVISION HISTORY** *(Revision history begins at Rev D)*

<table>
<thead>
<tr>
<th>REV</th>
<th>DATE</th>
<th>DESCRIPTION</th>
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| D   | 05/10 | Updates to Typical Application “Hot-Wire Anemometer”  
   |       | Updated Related Parts                          | 12          |
|     |       |                                                  | 26          |
| E   | 05/16 | Corrected Package Drawing                        | 24          |
# LT1013/LT1014

## Typical Application

### Step-Up Switching Regulator for 6V Battery

![Circuit Diagram](image)

**LT1013**

**5V**

**8**

**4**

**6**

**7**

**3**

**2**

**1.2V**

**2N2222**

**22k**

**220pF**

**1M**

**300Ω**

**LT1013**

**1N5821**

**100k**

**5.6k**

**1MHY**

**22k**

**2N2222**

**5.6k**

**0.1**

**LT = AIE–VERNITRON 24–104**

**78% EFFICIENCY**

## Related Parts

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<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
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<td>Dual/Quad 50µA Single Supply Precision Amplifier</td>
<td>50µA Max I_S, 70µV Max V_OS</td>
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<tr>
<td>LT2178/LT2179</td>
<td>Dual/Quad 17µA Single Supply Precision Amplifier</td>
<td>17µA Max I_S, 70µV Max V_OS</td>
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<tr>
<td>LTC6081/LTC6082</td>
<td>Dual/Quad 400µA Precision Rail-to-Rail Amplifier</td>
<td>V_S = 2.7V to 6V, 400µA Max I_S, 70µV V_OS 0.8µV/°C TCV_OS</td>
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<tr>
<td>LTC6078/LTC6079</td>
<td>Dual/Quad 72µA Precision Rail-to-Rail Amplifier</td>
<td>V_S = 2.7V to 6V, 72µA Max I_S, 25µV V_OS 0.7µV/°C TCV_OS</td>
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