FEATURES
- Slew Rate: 30V/μs
- Gain-Bandwidth Product: 35MHz
- Settling Time (0.01%): 3μs
- Overdrive Recovery: 0.4μs
- Gain Error: 0.05% Max
- Gain Drift: 5ppm/°C
- Gain Nonlinearity: 16ppm Max
- Offset Voltage (Input + Output): 600μV Max
  – Drift with Temperature: 2μV/°C
- Input Bias Current: 40pA Max
- Input Offset Current: 40pA Max
  – Drift with Temperature (to 70°C): 0.5pA/°C

APPLICATIONS
- Fast Settling Analog Signal Processing
- Multiplexed Input Data Acquisition Systems
- High Source Impedance Signal Amplification from
  High Resistance Bridges, Capacitance Sensors,
  Photodetector Sensors
- Bridge Amplifier with < 1Hz Lowpass Filtering

DESCRIPTION
The LT®1102 is the first fast FET input instrumentation
amplifier offered in the low cost, space saving 8-pin
packages. Fixed gains of 10 and 100 are provided with
excellent gain accuracy (0.01%) and non-linearity (3ppm).
No external gain setting resistor is required.

Slew rate, settling time, gain-bandwidth product,
overdrive recovery time are all improved compared to
competitive high speed instrumentation amplifiers.

Industry best speed performance is combined with
impressive precision specifications: less than 10pA input
bias and offset currents, 180μV offset voltage. Unlike
other FET input instrumentation amplifiers, on the LT1102
there is no output offset voltage contribution to total error,
and input bias currents do not double with every 10°C rise
in temperature. Indeed, at 70°C ambient temperature the
input bias current is only 40pA.

LT, LT, LTC and LTM are registered trademarks of Linear Technology Corporation.
LT1102

**ABSOLUTE MAXIMUM RATINGS** (Note 1)

Supply Voltage ...................................................... ±20V
Differential Input Voltage .................................. ±40V
Input Voltage ........................................................ ±20V

Output Short-Circuit Duration ...................... Indefinite
Operating Temperature Range
LT1102I ..................................................................... –40°C to 85°C
LT1102AC/LT1102C ........................................... 0°C to 70°C
LT1102AM/LT1102M (OBSOLET).............–55°C to 125°C
Storage Temperature Range ...................... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .......... 300°C

**PACKAGE/ORDER INFORMATION**

Consider the N8 Package for Alternate Source

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

\( V_S = \pm 15V, \) \( V_{CM} = 0V, \) \( T_A = 25^\circ C, \) \( G = 10 \) or \( 100, \) unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1102AM/AC MIN</th>
<th>LT1102AM/AC TYP</th>
<th>LT1102AM/AC MAX</th>
<th>LT1102M/IC MIN</th>
<th>LT1102M/IC TYP</th>
<th>LT1102M/IC MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( G_E )</td>
<td>Gain Error</td>
<td>( V_O = \pm 10V, R_L = 50k ) or ( 2k )</td>
<td>0.010</td>
<td>0.050</td>
<td>0.012</td>
<td>0.070</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( G_{NL} )</td>
<td>Gain Nonlinearity</td>
<td>( G = 100, R_L = 50k )</td>
<td>3</td>
<td>14</td>
<td>4</td>
<td>18</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 100, R_L = 2k )</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>25</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 10, R_L = 50k ) or ( 2k )</td>
<td>7</td>
<td>16</td>
<td>7</td>
<td>30</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{OS} )</td>
<td>Input Offset Voltage</td>
<td></td>
<td>180</td>
<td>600</td>
<td>200</td>
<td>900</td>
<td>μV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{OS} )</td>
<td>Input Offset Current</td>
<td></td>
<td>3</td>
<td>40</td>
<td>4</td>
<td>60</td>
<td>pA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_B )</td>
<td>Input Bias Current</td>
<td></td>
<td>±3</td>
<td>±40</td>
<td>±4</td>
<td>±60</td>
<td>pA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( e_n )</td>
<td>Input Noise Voltage</td>
<td>( 0.1Hz ) to ( 10Hz )</td>
<td>2.8</td>
<td>2.8</td>
<td>μV/√Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \epsilon_n )</td>
<td>Input Noise Voltage Density</td>
<td>( f_O = 10Hz )</td>
<td>37</td>
<td>37</td>
<td>nV/√Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( f_O = 1000Hz ) (Note 2)</td>
<td>19</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( f_O = 1000Hz, 10Hz ) (Note 3)</td>
<td>1.5</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>fA/√Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{OL} )</td>
<td>Maximum Output Voltage Swing</td>
<td>( R_L = 50k )</td>
<td>±13.0</td>
<td>±13.5</td>
<td>±13.0</td>
<td>±13.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( R_L = 2k )</td>
<td>±12.0</td>
<td>±13.0</td>
<td>±12.0</td>
<td>±13.0</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( BW )</td>
<td>Bandwidth</td>
<td>( G = 100 ) (Note 4)</td>
<td>120</td>
<td>220</td>
<td>100</td>
<td>220</td>
<td>kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 10 ) (Note 4)</td>
<td>2.0</td>
<td>3.5</td>
<td>1.7</td>
<td>3.5</td>
<td>MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( SR )</td>
<td>Slew Rate</td>
<td>( G = 100, V_{IN} = \pm 0.13V, V_O = \pm 5V )</td>
<td>12</td>
<td>17</td>
<td>10</td>
<td>17</td>
<td>V/μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 10, V_{IN} = \pm 1V, V_O = \pm 5V )</td>
<td>21</td>
<td>30</td>
<td>18</td>
<td>30</td>
<td>V/μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overdrive Recovery</td>
<td>50% Overdrive (Note 5)</td>
<td>400</td>
<td>400</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( ST )</td>
<td>Settling Time</td>
<td>( V_O = 20V ) Step (Note 4)</td>
<td>1.8</td>
<td>4.0</td>
<td>1.8</td>
<td>4.0</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 10 ) to 0.05%</td>
<td>3.0</td>
<td>6.5</td>
<td>3.0</td>
<td>6.5</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 10 ) to 0.01%</td>
<td>7</td>
<td>13</td>
<td>7</td>
<td>13</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( G = 100 ) to 0.05%</td>
<td>9</td>
<td>18</td>
<td>9</td>
<td>18</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### ELECTRICAL CHARACTERISTICS

\( V_S = \pm 15V, V_{CM} = 0V, \text{Gain} = 10 \text{ or } 100, -55^\circ C \leq T_A \leq 125^\circ C \) for AM/M grades, 
\(-40^\circ C \leq T_A \leq 85^\circ C \) for I grades, unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1102AM</th>
<th>LT1102M/I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MIN</td>
</tr>
<tr>
<td>GE</td>
<td>Gain Error</td>
<td>G = 100, ( V_O = \pm 10V, R_L = 50k ) or 2k</td>
<td>0.10</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 10, ( V_O = \pm 10V, R_L = 50k ) or 2k</td>
<td>0.05</td>
<td>0.12</td>
</tr>
<tr>
<td>TCGE</td>
<td>Gain Error Drift</td>
<td>(Note 6)</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 100, ( R_L = 50k ) or 2k</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>GNL</td>
<td>Gain Nonlinearity</td>
<td>G = 100, ( R_L = 50k ) or 2k</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 100, ( R_L = 2k )</td>
<td>28</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 10, ( R_L = 50k ) or 2k</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>VOS</td>
<td>Input Offset Voltage</td>
<td></td>
<td>300</td>
<td>1400</td>
</tr>
<tr>
<td>∆VOS/∆T</td>
<td>Input Offset Voltage Drift</td>
<td>(Note 6)</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Ios</td>
<td>Input Offset Current</td>
<td></td>
<td>0.3</td>
<td>4</td>
</tr>
<tr>
<td>Ib</td>
<td>Input Bias Current</td>
<td></td>
<td>±2</td>
<td>±10</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common Mode Rejection Ratio</td>
<td>( V_{CM} = \pm 10.3V )</td>
<td>82</td>
<td>97</td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>( V_S = \pm 10V ) ( \text{to} \pm 17V )</td>
<td>88</td>
<td>100</td>
</tr>
<tr>
<td>Is</td>
<td>Supply Current</td>
<td></td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Vo</td>
<td>Maximal Output Voltage Swing</td>
<td>( R_L = 50k ) ( \text{or} \ 2k )</td>
<td>±12.5</td>
<td>±13.2</td>
</tr>
</tbody>
</table>

\( V_S = \pm 15V, V_{CM} = 0V, \text{Gain} = 10 \text{ or } 100, 0^\circ C \leq T_A \leq 70^\circ C \), unless otherwise noted.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT1102AC</th>
<th>LT1102C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MIN</td>
</tr>
<tr>
<td>GE</td>
<td>Gain Error</td>
<td>G = 100, ( V_O = \pm 10V, R_L = 50k ) or 2k</td>
<td>0.04</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 10, ( V_O = \pm 10V, R_L = 50k ) or 2k</td>
<td>0.03</td>
<td>0.09</td>
</tr>
<tr>
<td>TCGE</td>
<td>Gain Error Drift</td>
<td>(Note 6)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 100, ( R_L = 50k ) or 2k</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>GNL</td>
<td>Gain Nonlinearity</td>
<td>G = 100, ( R_L = 50k ) or 2k</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 100, ( R_L = 2k )</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G = 10, ( R_L = 50k ) or 2k</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>VOS</td>
<td>Input Offset Voltage</td>
<td></td>
<td>230</td>
<td>1000</td>
</tr>
<tr>
<td>∆VOS/∆T</td>
<td>Input Offset Voltage Drift</td>
<td>(Note 6)</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Ios</td>
<td>Input Offset Current</td>
<td></td>
<td>10</td>
<td>150</td>
</tr>
<tr>
<td>∆Ios/∆T</td>
<td>Input Offset Current Drift</td>
<td>(Note 6)</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>Ib</td>
<td>Input Bias Current</td>
<td></td>
<td>±40</td>
<td>±300</td>
</tr>
<tr>
<td>∆Ib/∆T</td>
<td>Input Bias Current Drift</td>
<td>(Note 6)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common Mode Rejection Ratio</td>
<td>( V_{CM} = \pm 10.3V )</td>
<td>83</td>
<td>98</td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>( V_S = \pm 10V ) ( \text{to} \pm 17V )</td>
<td>87</td>
<td>101</td>
</tr>
<tr>
<td>Is</td>
<td>Supply Current</td>
<td></td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Vo</td>
<td>Maximal Output Voltage Swing</td>
<td>( R_L = 50k ) ( \text{or} \ 2k )</td>
<td>±12.8</td>
<td>±13.4</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS

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

Note 2: This parameter is tested on a sample basis only.

Note 3: Current noise is calculated from the formula:

\[ I_n = (2q|I_b|/2) \]

where \( q = 1.6 \times 10^{-19} \) coulomb. The noise of source resistors up to 1GΩ swamps the contribution of current noise.

Note 4: This parameter is not tested. It is guaranteed by design and by inference from the slew rate measurement.

Note 5: Overdrive recovery is defined as the time delay from the removal of an input overdrive to the output’s return from saturation to linear operation.

50% overdrive equals \( V_{IN} = \pm 2V \) (G = 10) or \( V_{IN} = \pm 200mV \) (G = 100).

Note 6: This parameter is not tested. It is guaranteed by design and by inference from other tests.

TYPICAL PERFORMANCE CHARACTERISTICS

Small Signal Response, G = 10
(Input = 50mV Pulse)

Small Signal Response, G = 100
(Input = 5mV Pulse)

Slew Rate, G = 100
(Input = \( \pm 130mV \) Pulse)

Settling Time, G = 10
(Input From –10V to 10V)

Settling Time, G = 10
(Input From 10V to –10V)

Settling Time, G = 100
(Input From –10V to 10V)

Settling Time, G = 100
(Input From 10V to –10V)
### Capacitive Load Handling

- **VS = ±15V**
- **TA = 25°C**
- **G = 10**
- **G = 100**

### Output Impedance vs Frequency

- **VS = ±15V**
- **TA = 25°C**
- **G = 10**
- **G = 100**

### Gain vs Frequency

- **VS = ±15V**
- **TA = 25°C**
- **G = 10**
- **G = 100**

### Undistorted Output vs Frequency

- **VS = ±15V**
- **TA = 25°C**

### Voltage Noise vs Frequency

- **1/f CORNER = 28Hz**

### Input Bias Current Over the Common Mode Range

- **VS = ±15V**
- **TA = 25°C TO 70°C**

### Warm-Up Drift

- **VS = ±15V**
- **TA = 25°C**

### Common Mode Range vs Temperature

- **G = 10**
- **G = 100**

### Supply Current vs Temperature

- **VS = ±15V**
- **VS = ±10V**
TYPICAL PERFORMANCE CHARACTERISTICS

Short-Circuit Current vs Time

Gain Error vs Temperature

Gain Nonlinearity Over Temperature

Distribution of Offset Voltage

Gain Nonlinearity Over Temperature
In the two op amp instrumentation amplifier configuration, the first amplifier is basically in unity gain, and the second amplifier provides all the voltage gain. In the LT1102, the second amplifier is decompensated for gain of 10 stability, therefore high slew rate and bandwidth are achieved. Common mode rejection versus frequency is also optimized in the G = 10 mode, because the bandwidths of the two op amps are similar. When G = 100, this statement is no longer true; however, by connecting an 18pF capacitor between pins 1 and 2, a common mode AC gain is created to cancel the inherent roll-off. From 200Hz to 30kHz, CMRR versus frequency is improved by an order of magnitude.

**Input Protection**

Instrumentation amplifiers are often used in harsh environments where overload conditions can occur. The LT1102 employs FET input transistors, consequently the differential input voltage can be ±30V (with ±15V supplies, ±36V with ±18V supplies). Some competitive instrumentation amplifiers have NPN inputs which are protected by back-to-back diodes. When the differential input Voltage exceeds ±13V on these competitive devices, input current increases to milliampere level; more than ±10V differential voltage can cause permanent damage.

When the LT1102 inputs are pulled below the negative supply or above the positive supply, the inputs will clamp a diode voltage below or above the supplies. No damage will occur if the input current is limited to 20mA.

**Gains Between 10 and 100**

Gains between 10 and 100 can be achieved by connecting two equal resistors (= RX) between pins 1 and 2 and pins 7 and 8.

\[
\text{Gain} = 10 + \frac{R_X}{R + R_X/90}
\]

The nominal value of R is 1.84kΩ. The usefulness of this method is limited by the fact that R is not controlled to better than ±10% absolute accuracy in production. However, on any specific unit, 90R can be measured between Pins 1 and 2.
**Gain = 20, 110, or 200 Instrumentation Amplifiers**

**Differential Output**

**Single Ended Output**

**Multiplexed Input Data Acquisition**

Voltage Programmable Current Source is Simple and Precise

Dynamic Response of the Current Source
Basic Connections

Input
6
5
8
7
4
1
2
V–
V+
REF
GAIN = 100

Output
3
LT1102
8
NC
V–
V+
GAIN = 10

Settling Time Test Circuit

Input
6
5
8
7
4
1
2
V–
V+
REF
GAIN = 10

Output
3
LT1102
8
NC
V–
V+
GAIN = 10

Offset Nulling

Input
6
5
8
7
4
1
2
V–
V+
REF
GAIN = 10

Output
3
LT1102
8
NC
V–
V+
GAIN = 10

*Gain* degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.

Gain degradation is approximately 0.018%.
**PACKAGE DESCRIPTION**

**H Package**

8-Lead TO-5 Metal Can (.230 Inch PCD)
(Reference LTC DWG # 05-08-1321)

**J8 Package**

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

**OBsolete PACKages**
N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)

NOTE:
1. DIMENSIONS ARE IN INCHES/MILLIMETERS
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)