The INA131 is a low cost, general purpose G = 100 instrumentation amplifier offering excellent accuracy. Its 3-op amp design and small size make it ideal for a wide range of applications.

On-chip laser trimmed resistors accurately set a fixed gain of 100. The INA131 is laser trimmed to achieve very low offset voltage (50µV max), drift (0.25µV/°C max), and high CMR (110dB min). Internal input protection can withstand up to ±40V inputs without damage.

The INA131 is available in an 8-pin plastic DIP. They are specified over the –40°C to +85°C temperature range.

**FEATURES**

- LOW OFFSET VOLTAGE: 50µV max
- LOW DRIFT: 0.25µV/°C max
- LOW INPUT BIAS CURRENT: 2nA max
- HIGH COMMON-MODE REJECTION: 110dB min
- INPUT OVERVOLTAGE PROTECTION: ±40V
- WIDE SUPPLY RANGE: ±2.25 to ±18V
- LOW QUIESCENT CURRENT: 3mA
- 8-PIN PLASTIC DIP

**APPLICATIONS**

- BRIDGE AMPLIFIER
- THERMOCOUPLE AMPLIFIER
- RTD SENSOR AMPLIFIER
- MEDICAL INSTRUMENTATION
- DATA ACQUISITION
## SPECIFICATIONS

At $T_A = +25^\circ C$, $V_S = \pm15V$, $R_L = 2k\Omega$, unless otherwise noted.

### INPUT

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Voltage, RTI</td>
<td>Initial $T_A = +25^\circ C$</td>
<td>±10</td>
<td>±50</td>
<td>±25</td>
<td>±25</td>
<td>±125</td>
<td>µV</td>
<td></td>
</tr>
<tr>
<td>vs Temperature</td>
<td>$T_A = T_{MIN}$ to $T_{MAX}$</td>
<td>±0.1</td>
<td>±0.25</td>
<td>±0.25</td>
<td>±1</td>
<td>µV/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs Power Supply</td>
<td>$V_S = \pm2.25V$ to $\pm18V$</td>
<td>0.5</td>
<td>3</td>
<td>*</td>
<td>*</td>
<td>µV/V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term Stability</td>
<td>Impedance, Differential $10^6%$</td>
<td>0.2</td>
<td>*</td>
<td>*</td>
<td>µΩ/pF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common-Mode Impedance</td>
<td>Input Common-Mode Range</td>
<td>±11</td>
<td>±13.5</td>
<td>*</td>
<td>*</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe Input Voltage</td>
<td></td>
<td>±40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common-Mode Rejection</td>
<td>$V_{CM} = \pm10V$, $\Delta R_L = 1k\Omega$</td>
<td>110</td>
<td>120</td>
<td>106</td>
<td>110</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### BIAS CURRENT

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>vs Temperature</td>
<td></td>
<td>±0.5</td>
<td>±2</td>
<td>*</td>
<td>±5</td>
<td>nA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Current</td>
<td>vs Temperature</td>
<td>±8</td>
<td></td>
<td>*</td>
<td></td>
<td>pA/°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NOISE VOLTAGE, RTI

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f = 10Hz$</td>
<td>$R_S = 0\Omega$</td>
<td>16</td>
<td></td>
<td>*</td>
<td></td>
<td>nV/√Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f = 100Hz$</td>
<td></td>
<td>12</td>
<td></td>
<td>*</td>
<td></td>
<td>nV/√Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f = 1kHz$</td>
<td></td>
<td>12</td>
<td></td>
<td>*</td>
<td></td>
<td>nV/√Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f = 10kHz$</td>
<td></td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
<td>µV/p-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f_B = 0.1Hz$ to $10Hz$</td>
<td>Noise Current</td>
<td>0.4</td>
<td></td>
<td>*</td>
<td></td>
<td>pA/p-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f = 1kHz$</td>
<td>0.2</td>
<td></td>
<td>*</td>
<td></td>
<td>pA/√Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f_B = 0.1Hz$ to $100Hz$</td>
<td>18</td>
<td></td>
<td>*</td>
<td></td>
<td>pA/p-p</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### GAIN

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain Error$^{(1)}$</td>
<td>$\pm0.01$</td>
<td>±0.024</td>
<td>*</td>
<td>±0.1</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistor Value$^{(2)}$</td>
<td>$\pm10$</td>
<td>±40</td>
<td></td>
<td>*</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain vs Temperature</td>
<td>Nonlinearity</td>
<td>±5</td>
<td>±10</td>
<td>*</td>
<td>±20</td>
<td>ppm/°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OUTPUT

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>$I_O = 5mA$, $T_{MIN}$ to $T_{MAX}$</td>
<td>±13.5</td>
<td>±13.7</td>
<td>*</td>
<td>*</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_S = \pm11.4V$, $R_L = 2k\Omega$</td>
<td>±10</td>
<td>10.5</td>
<td>*</td>
<td>*</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Capacitance, max Stable</td>
<td>$V_S = \pm2.25V$, $R_L = 2k\Omega$</td>
<td>±1</td>
<td>1.5</td>
<td>*</td>
<td>*</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Circuit Current</td>
<td>Voltage</td>
<td>1000</td>
<td></td>
<td>*</td>
<td>±0.004</td>
<td>% of FSR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FREQUENCY RESPONSE

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth, –3dB</td>
<td></td>
<td>70</td>
<td></td>
<td>*</td>
<td></td>
<td>kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slew Rate</td>
<td>$V_O = \pm10V$</td>
<td>0.3</td>
<td>0.7</td>
<td>*</td>
<td>*</td>
<td>V/µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settling Time, 0.01%</td>
<td>Overload Recovery</td>
<td>100</td>
<td></td>
<td>*</td>
<td>µs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage</td>
<td>20</td>
<td></td>
<td>*</td>
<td>µs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### POWER SUPPLY

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>$V_M = 0V$</td>
<td>±2.25</td>
<td>±15</td>
<td>±18</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>V</td>
</tr>
<tr>
<td>Current</td>
<td>$V_M = 0V$</td>
<td>±2.25</td>
<td>±2</td>
<td>±3</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>mA</td>
</tr>
</tbody>
</table>

### TEMPERATURE RANGE

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td>$\theta_{JA}$</td>
<td>–40</td>
<td>85</td>
<td>*</td>
<td>*</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating</td>
<td>$\theta_{JA}$</td>
<td>–40</td>
<td>125</td>
<td>*</td>
<td>*</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^*$ Specification same as INA131BP.

NOTES: (1) $R_L = 10k\Omega$. (2) Absolute value of internal gain-setting resistors. (Gain depends on resistor ratios.)

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user’s own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.
PIN CONFIGURATION

Top View

R₀ 1
Vᵢ⁻ 2
Vᵢₚ 3
Vᵢ⁻ 4
R₀ 8
Vₚ 7
Vᵢ₀ 6
Ref 5

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage .......................................................... ±18V
Input Voltage Range .................................................. ±40V
Output Short Circuit (to ground) .................................. Continuous
Operating Temperature ................................................. –40°C to +125°C
Storage Temperature .................................................. –40°C to +125°C
Junction Temperature .................................................. +150°C
Lead Temperature (soldering –10s) .................................. +300°C

NOTE: (1) Stresses above these ratings may cause permanent damage.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE</th>
<th>PACKAGE DRAWING NUMBER(1)</th>
<th>TEMPERATURE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INA131AP</td>
<td>8-Pin Plastic DIP</td>
<td>006</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>INA131BP</td>
<td>8-Pin Plastic DIP</td>
<td>006</td>
<td>–40°C to +85°C</td>
</tr>
</tbody>
</table>

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.
TYPICAL PERFORMANCE CURVES

At 25°C, $V_s = \pm 15V$, unless otherwise noted.

1. **Gain vs Frequency**
   - Frequency (Hz): 100, 1k, 10k, 100k, 1M, 10M
   - Gain (dB)

2. **Common-Mode Rejection vs Frequency**
   - Frequency (Hz): 10, 100, 1k, 10k, 1M, 10M
   - Common-Mode Rejection (dB)

3. **Input Common-Mode Voltage Range vs Output Voltage**
   - Output Voltage (V): -15, -10, 0, 5, 15, -5
   - Common-Mode Voltage (V)

4. **Power Supply Rejection vs Frequency**
   - Frequency (Hz): 10, 100, 1k, 10k, 1M, 10M
   - Power Supply Rejection (dB)

5. **Input-Referred Noise Voltage vs Frequency**
   - Frequency (Hz): 1, 10, 100, 1k, 10k
   - Input-Referred Noise Voltage (nV/√Hz)

6. **Offset Voltage Warm-Up vs Time**
   - Time from Power Supply Turn-on (s): 0, 15, 30, 45, 60, 75, 90, 105, 120
   - Offset Voltage Change (µV)
TYPICAL PERFORMANCE CURVES (CONT)

At 25°C, V_s = ±15V, unless otherwise noted.

1. **Input Bias and Input Offset Current vs Temperature**
   - Shows the variation of input bias and input offset current with temperature.

2. **Input Bias Current vs Input Voltage**
   - Displays the input bias current as a function of input voltage.
   - Distinguishes between common-mode and differential-mode currents.

3. **Maximum Output Swing vs Frequency**
   - Illustrates the peak-to-peak amplitude of the output swing versus frequency.

4. **Slew Rate vs Temperature**
   - Graph depicting the slew rate in volts per second (V/µs) as a function of temperature.

5. **Output Current Limit vs Temperature**
   - Shows the limit of short-circuit current with temperature.

6. **Quiescent Current vs Temperature**
   - Displays the quiescent current as a function of temperature.

These graphs provide a comprehensive view of the performance characteristics of the device across various conditions.
TYPICAL PERFORMANCE CURVES (CONT)

At 25°C, $V_s = \pm 15V$, unless otherwise noted.

- **Large Signal Response, $G = 100$**

- **Small Signal Response, $G = 100$**

- **Positive Signal Swing vs Temperature ($R_L = 2k\Omega$)**

- **Negative Signal Swing vs Temperature ($R_L = 2k\Omega$)**

- **Quiescent Current and Power Dissipation vs Power Supply Voltage**

- **Input-Referred Noise, 0.1 to 10Hz**
APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA131. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown.

The output is referred to the output reference (Ref) terminal which is normally grounded. This must be a low-impedance connection to assure good common-mode rejection. A resistance of 5Ω in series with the Ref pin will cause a device with 110dB CMR to degrade to approximately 106dB CMR.

SETTING THE GAIN

No external resistors are required for G = 100. On-chip laser-trimmed resistors set the gain, providing excellent gain accuracy and temperature stability. Gain is distributed between the input and output stages of the INA131. Bandwidth is increased by approximately five times (compared to the INA114 in G = 100). Input common-mode range is also improved (see “Input Common-Mode Range”).

Although the INA131 is primarily intended for fixed G = 100 applications, the gain can be increased by connecting an external resistor to the RG pins. The internal resistors are trimmed for precise ratios, not to absolute values, so the influence of an external resistor will vary from device to device. Absolute accuracy of the internal values is ±40%. The nominal gain with an external R_G resistor can be calculated by:

\[ G = 100 + \frac{250 \, \text{kΩ}}{R_G} \] (1)

Where: R_G is the external gain resistor.

Accuracy of the 250kΩ term is ±40%.

The stability and temperature drift of the external gain setting resistor, R_G, also affects gain. R_G's contribution to gain accuracy and drift can be directly inferred from the gain equation (1).

NOISE PERFORMANCE

The INA131 provides very low noise in most applications. For differential source impedances less than 1kΩ, the INA103 may provide lower noise. For source impedances greater than 50kΩ, the INA111 FET-Input Instrumentation Amplifier may provide lower noise.

Low frequency noise of the INA131 is approximately 0.4µVp-p measured from 0.1 to 10Hz. This is approximately one-tenth the noise of state-of-the-art chopper-stabilized amplifiers.
OFFSET TRIMMING

The INA131 is laser trimmed for very low offset voltage and drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The voltage applied to Ref terminal is summed at the output. Low impedance must be maintained at this node to assure good common-mode rejection. This is achieved by buffering trim voltage with an op amp as shown.

FIGURE 2. Optional Trimming of Output Offset Voltage.

INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA131 is extremely high—approximately 10^10 Ω. However, a path must be provided for the input bias current of both inputs. This input bias current is typically less than ±1nA (it can be either polarity due to cancellation circuitry). High input impedance means that this input bias current changes very little with varying input voltage.

Input circuitry must provide a path for this input bias current if the INA131 is to operate properly. Figure 3 shows various provisions for an input bias current path. Without a bias current return path, the inputs will float to a potential which exceeds the common-mode range of the INA131 and the input amplifiers will saturate. If the differential source resistance is low, bias current return path can be connected to one input (see thermocouple example in Figure 3). With higher source impedance, using two resistors provides a balanced input with possible advantages of lower input offset voltage due to bias current and better common-mode rejection.

INPUT COMMON-MODE RANGE

The linear common-mode range of the input op amps of the INA131 is approximately ±13.75V (or 1.25V from the power supplies). As the output voltage increases, however, the linear input range is limited by the output voltage swing of the input amplifiers, A1 and A2. The 5V/V output stage gain of the INA131 reduces this effect. Compared to the INA114 and other unity output gain instrumentation amplifiers, the INA131 provides several additional volts of input common-mode range with full output voltage swing. See the typical performance curve “Input Common-Mode Range vs Output Voltage”.

Input-overload often produces an output voltage that appears normal. For example, an input voltage of +20V on one input and +40V on the other input will obviously exceed the linear common-mode range of both input amplifiers. Since both input amplifiers are saturated to the nearly the same output voltage limit, the difference voltage measured by the output amplifier will be near zero. The output of the INA131 will be near 0V even though both inputs are overloaded.

INPUT PROTECTION

The inputs of the INA131 are individually protected for voltages up to ±40V. For example, a condition of −40V on one input and +40V on the other input will not cause damage. Internal circuitry on each input provides low series impedance under normal signal conditions. To provide equivalent protection, series input resistors would contribute excessive noise. If the input is overloaded, the protection circuitry limits the input current to a safe value (approximately 1.5mA). The typical performance curve “Input Bias Current vs Input Voltage” shows this input current limit behavior. The inputs are protected even if no power supply voltage is present.
Common-mode resistors have approximately 0.1% effect on gain.

Equal line resistance here creates a small common-mode voltage which is rejected by INA131.

Resistance in this line causes a small common-mode voltage which is rejected by INA131.

\[ V_O = 0V \text{ at } R_{RTD} = R_Z \]

### FIGURE 4. Shield Driver Circuit.

### FIGURE 5. RTD Temperature Measurement Circuit.

### FIGURE 6. Thermocouple Amplifier with Cold Junction Compensation.

<table>
<thead>
<tr>
<th>ISA Type</th>
<th>Material</th>
<th>Seebeck Coefficient (μV/°C)</th>
<th>( R_2 ) (( R_2 = 100Ω ))</th>
<th>( R_4 ) (( R_5 + R_6 = 100Ω ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Chromel</td>
<td>58.5</td>
<td>3.48kΩ</td>
<td>56.2kΩ</td>
</tr>
<tr>
<td>J</td>
<td>Iron</td>
<td>50.2</td>
<td>4.12kΩ</td>
<td>64.9kΩ</td>
</tr>
<tr>
<td>K</td>
<td>Chromel</td>
<td>39.4</td>
<td>5.23kΩ</td>
<td>80.6kΩ</td>
</tr>
<tr>
<td>T</td>
<td>Copper</td>
<td>38.0</td>
<td>5.49kΩ</td>
<td>84.5kΩ</td>
</tr>
</tbody>
</table>

NOTES: (1) –2.1mV/°C at 200μA. (2) \( R_7 \) provides down-scale burn-out indication.

NOTES: (1) –2.1mV/°C at 200μA. (2) \( R_7 \) provides down-scale burn-out indication.
FIGURE 7. Bridge Transducer Amplifier.

FIGURE 8. AC-Coupled Instrumentation Amplifier.


<table>
<thead>
<tr>
<th>$A_1$</th>
<th>$I_B$ Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA177</td>
<td>±1.5nA</td>
</tr>
<tr>
<td>OPA602</td>
<td>1pA</td>
</tr>
<tr>
<td>OPA128</td>
<td>75fA</td>
</tr>
</tbody>
</table>
IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI’s standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Customers are responsible for their applications using TI components.

In order to minimize risks associated with the customer’s applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI’s publication of information regarding any third party’s products or services does not constitute TI’s approval, warranty or endorsement thereof.

Copyright © 2000, Texas Instruments Incorporated
This datasheet has been download from:

www.datasheetcatalog.com

Datasheets for electronics components.