



## **INA131**

# Precision G = 100 INSTRUMENTATION AMPLIFIER

## **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**

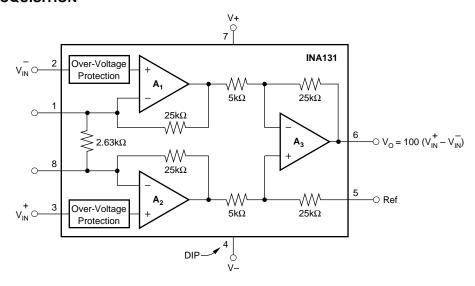
- BRIDGE AMPLIFIER
- THERMOCOUPLE AMPLIFIER
- RTD SENSOR AMPLIFIER
- MEDICAL INSTRUMENTATION
- DATA ACQUISITION

## DESCRIPTION

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 ( $50\mu V$  max), drift ( $0.25\mu V/^{\circ}C$  max), and high CMR (110dB min). Internal input protection can withstand up to  $\pm 40V$  inputs without damage.

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



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## **SPECIFICATIONS**

At  $T_A$  = +25°C,  $V_S$  = ±15V,  $R_L$  = 2k $\Omega$ , unless otherwise noted.

			INA131BP		INA131AP			
ARAMETER CONDITIONS		MIN TYP		MAX	MIN	TYP	MAX	UNITS
INPUT Offset Voltage, RTI Initial vs Temperature vs Power Supply Long-Term Stability Impedance, Differential Common-Mode Input Common-Mode Range Safe Input Voltage Common-Mode Rejection	$T_A = +25^{\circ}C$ $T_A = T_{MIN} \text{ to } T_{MAX}$ $V_S = \pm 2.25 \text{V to } \pm 18 \text{V}$ $V_{CM} = \pm 10 \text{V}, \ \Delta R_S = 1 \text{k}\Omega$	±11	±10 ±0.1 0.5 0.2 10 <sup>10</sup>    6 10 <sup>10</sup>    6 ±13.5	±50 ±0.25 3	*	±25 ±0.25 * * * * *	±125 ±1 *	μV μV/°C μV/V μV/mo Ω    pF Ω    pF V V
BIAS CURRENT vs Temperature	Gin : C		±0.5 ±8	±2		*	±5	nA pA/°C
OFFSET CURRENT vs Temperature			±0.5 ±8	±2		* *	±5	nA pA/°C
NOISE VOLTAGE, RTI f = 10Hz f = 100Hz f = 10Hz f = 10Hz $f_B = 0.1Hz$ to $10Hz$ Noise Current f = 10Hz f = 10Hz f = 10Hz f = 0.1Hz to $100Hz$	$R_S = 0\Omega$		16 12 12 12 0.4 0.4 0.2 18			* * * * * * * *		nV/√Hz nV/√Hz nV/√Hz nV/√Hz μVp-p pA/√Hz pA/√Hz pAp-p
GAIN Gain Error <sup>(1)</sup> Resistor Value <sup>(2)</sup>			±0.01 ±10	±0.024 ±40		*	±0.1	% %
Gain vs Temperature Nonlinearity			±5 ±0.0003	±10 ±0.002		*	±20 ±0.004	ppm/°C % of FSR
OUTPUT Voltage  Load Capacitance, max Short Circuit Current	$\begin{split} &I_O=5\text{mA, T}_{\text{MIN}} \text{ to T}_{\text{MAX}} \\ &V_S=\pm11.4\text{V, R}_{\text{L}}=2k\Omega \\ &V_S=\pm2.25\text{V, R}_{\text{L}}=2k\Omega \\ &\text{Stable Operation} \end{split}$	±13.5 ±10 ±1	±13.7 10.5 1.5 1000 +20/-15		* * *	* * * *		V V V pF mA
FREQUENCY RESPONSE Bandwidth, –3dB Slew Rate Settling Time, 0.01% Overload Recovery	$V_O = \pm 10V$ 50% Overdrive	0.3	70 0.7 100 20		*	* * * *		kHz V/μs μs μs
POWER SUPPLY Voltage Range Current	V <sub>IN</sub> = 0V	±2.25	±15 ±2.2	±18 ±3	*	* *	*	V mA
TEMPERATURE RANGE Specification Operating $\theta_{\mathrm{JA}}$		-40 -40	100	85 125	*	*	*	°C/W

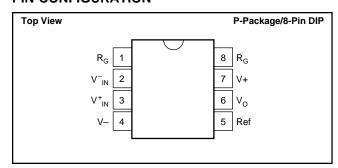
<sup>\*</sup> Specification same as INA131BP.

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

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#### **PIN CONFIGURATION**



#### PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	TEMPERATURE RANGE	
INA131AP	8-Pin Plastic DIP	006	-40°C to +85°C	
INA131BP	8-Pin Plastic DIP	006	-40°C to +85°C	

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

#### **ABSOLUTE MAXIMUM RATINGS(1)**

Supply Voltage	
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.



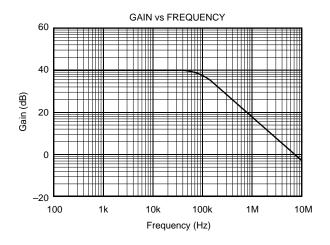
This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

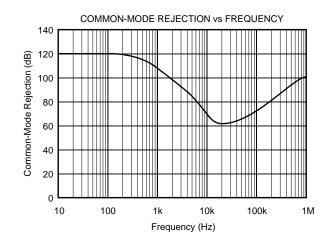
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

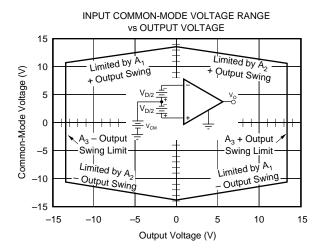
**INA131** 

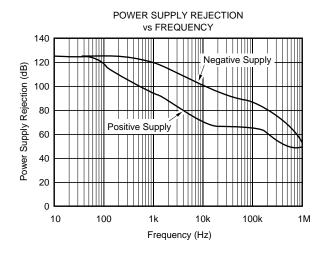
# **TYPICAL PERFORMANCE CURVES**

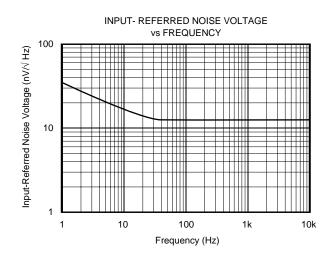
At 25°C,  $V_s = \pm 15V$ , unless otherwise noted.

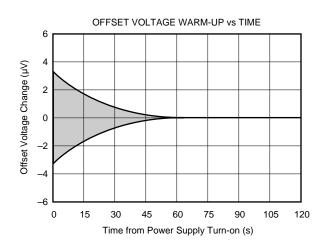








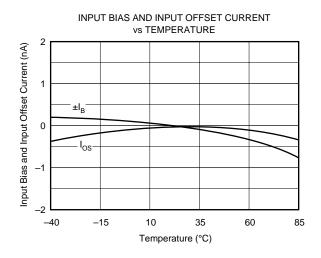


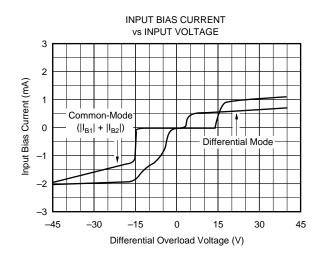


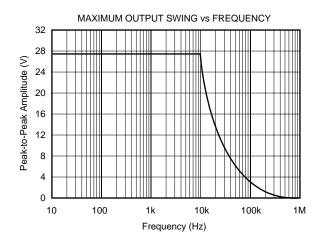


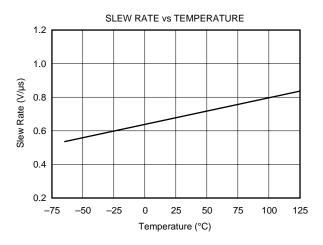
# **TYPICAL PERFORMANCE CURVES (CONT)**

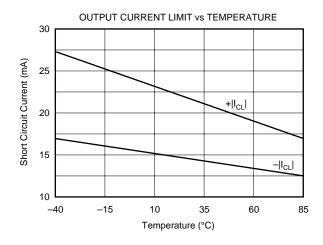
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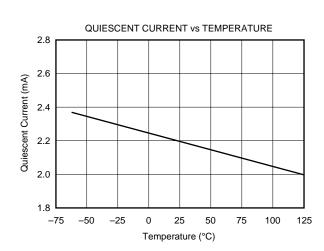






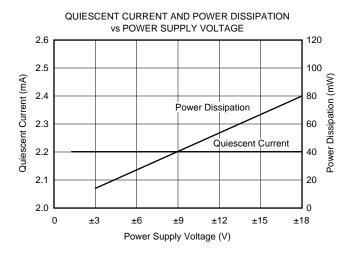


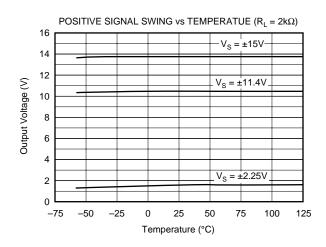


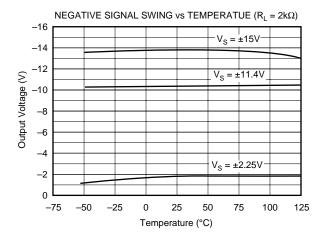


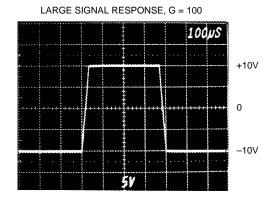
# **TYPICAL PERFORMANCE CURVES (CONT)**

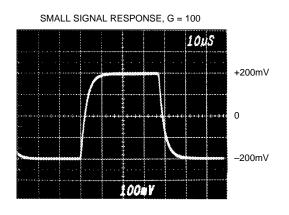
At 25°C,  $V_S = \pm 15V$ , unless otherwise noted.

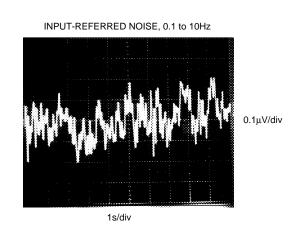












## APPLICATION INFORMATION

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  $5\Omega$  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  $R_G$  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  $\pm 40\%$ . The nominal gain with an external  $R_{\rm G}$  resistor can be calculated by:

$$G = 100 + \frac{250 \text{ k}\Omega}{R_G} \tag{1}$$

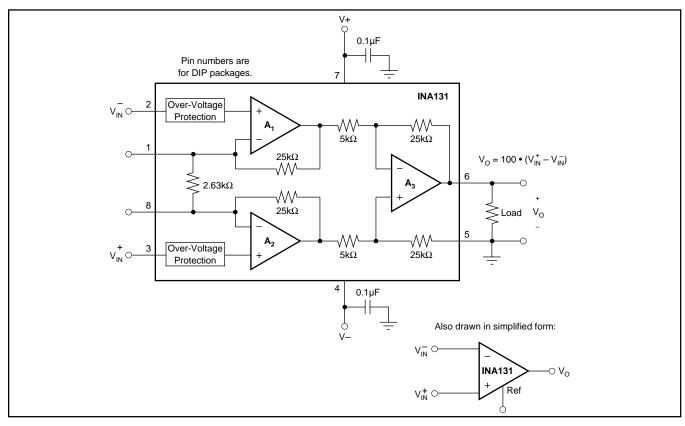
Where:  $R_G$  is the external gain resistor. Accuracy of the 250k $\Omega$  term is  $\pm 40\%$ .

The stability and temperature drift of the external gain setting resistor,  $R_{G_i}$  also affects gain.  $R_{G_i}$ '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  $1k\Omega$ , the INA103 may provide lower noise. For source impedances greater than  $50k\Omega$ , the INA111 FET-Input Instrumentation Amplifier may provide lower noise.

Low frequency noise of the INA131 is approximately  $0.4\mu Vp$ -p measured from 0.1 to 10Hz. This is approximately one-tenth the noise of state-of-the-art chopper-stabilized amplifiers.



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FIGURE 1. Basic Connections.

#### **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.

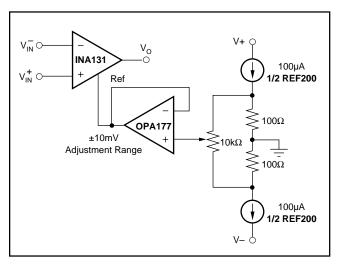


FIGURE 2. Optional Trimming of Output Offset Voltage.

#### INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA131 is extremely high—approximately  $10^{10}\Omega$ . However, a path must be provided for the input bias current of both inputs. This input bias current is typically less than  $\pm 1 \text{nA}$  (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  $\pm 13.75$ V (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,  $A_1$  and  $A_2$ . The 5V/V output stage gain of the INA131 reduces this effect. Compared to the

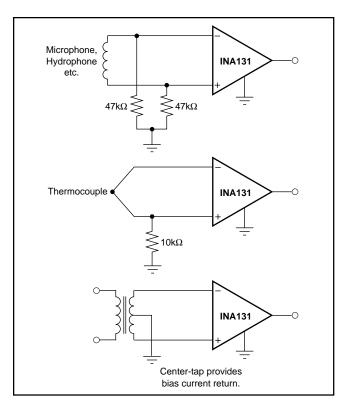


FIGURE 3. Providing an Input Common-Mode Current Path.

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.

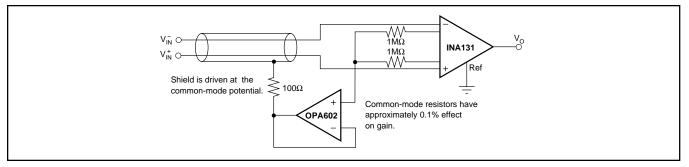


FIGURE 4. Shield Driver Circuit.

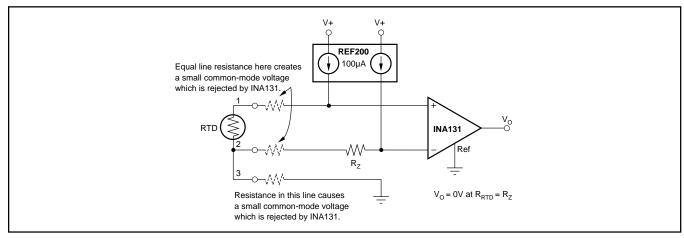


FIGURE 5. RTD Temperature Measurement Circuit.

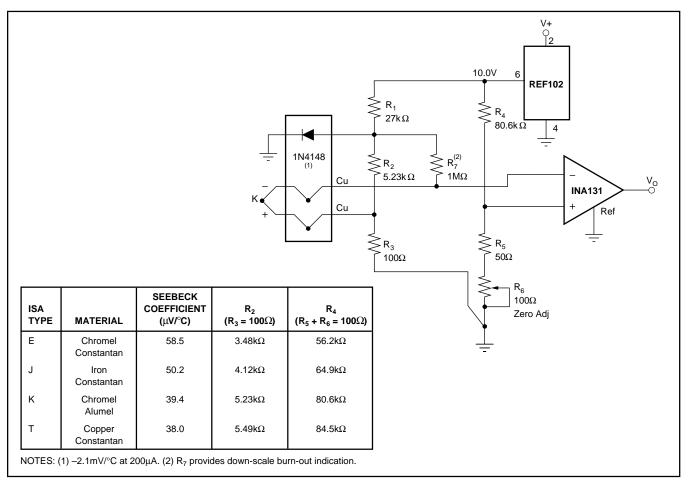


FIGURE 6. Thermocouple Amplifier with Cold Junction Compensation.

**INA131** 

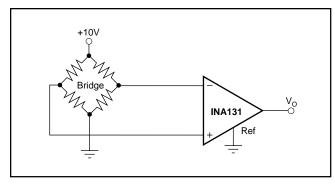


FIGURE 7. Bridge Transducer Amplifier.

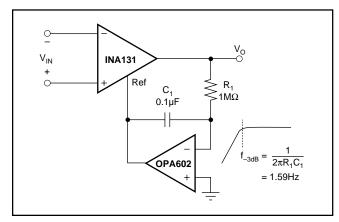


FIGURE 8. AC-Coupled Instrumentation Amplifier.

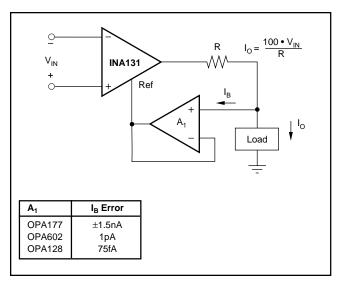


FIGURE 9. Differential Voltage to Current Converter.

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#### PACKAGING INFORMATION

Orderable part number	Status (1)	Material type	Package   Pins	Package qty   Carrier	RoHS	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking (6)
INA131AP	Active	Production	PDIP (P)   8	50   TUBE	Yes	Call TI	N/A for Pkg Type	-40 to 85	INA131AP
INA131AP.A	Active	Production	PDIP (P)   8	50   TUBE	Yes	Call TI	N/A for Pkg Type	-40 to 85	INA131AP

<sup>(1)</sup> Status: For more details on status, see our product life cycle.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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<sup>(4)</sup> Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

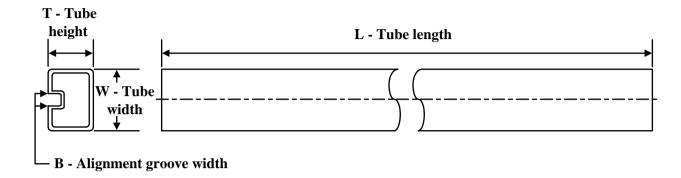
<sup>(5)</sup> MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

## **PACKAGE MATERIALS INFORMATION**

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### **TUBE**



#### \*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
INA131AP	Р	PDIP	8	50	506	13.97	11230	4.32
INA131AP.A	Р	PDIP	8	50	506	13.97	11230	4.32

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