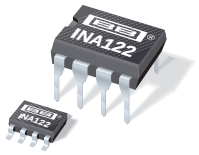
BURR-BROWN®

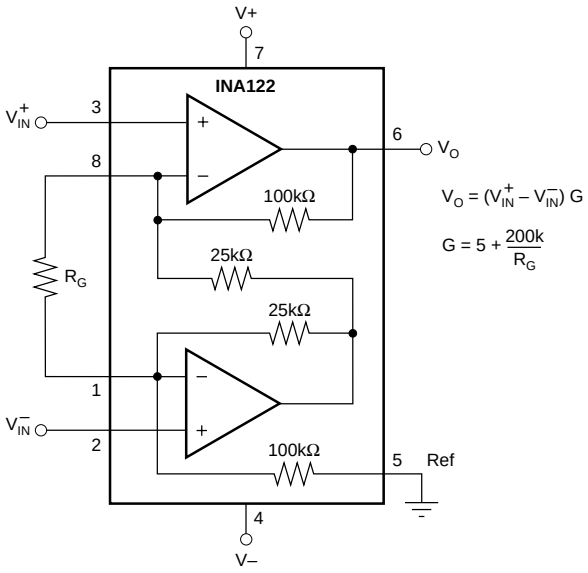


INA122

Single Supply, *Micro*Power INSTRUMENTATION AMPLIFIER

FEATURES

- LOW QUIESCENT CURRENT: 60μA
- WIDE POWER SUPPLY RANGE
  - Single Supply: 2.2V to 36V
  - Dual Supply: –0.9/+1.3V to ±18V
- COMMON-MODE RANGE TO (V–)–0.1V
- RAIL-TO-RAIL OUTPUT SWING
- LOW OFFSET VOLTAGE: 250μV max
- LOW OFFSET DRIFT: 3μV/°C max
- LOW NOISE: 60nV/√Hz
- LOW INPUT BIAS CURRENT: 25nA max
- 8-PIN DIP AND SO-8 SURFACE-MOUNT



APPLICATIONS

- PORTABLE, BATTERY OPERATED SYSTEMS
- INDUSTRIAL SENSOR AMPLIFIER: Bridge, RTD, Thermocouple
- PHYSIOLOGICAL AMPLIFIER: ECG, EEG, EMG
- MULTI-CHANNEL DATA ACQUISITION

DESCRIPTION

The INA122 is a precision instrumentation amplifier for accurate, low noise differential signal acquisition. Its two-op-amp design provides excellent performance with very low quiescent current, and is ideal for portable instrumentation and data acquisition systems.

The INA122 can be operated with single power supplies from 2.2V to 36V and quiescent current is a mere 60μA. It can also be operated from dual supplies. By utilizing an input level-shift network, input common-mode range extends to 0.1V below negative rail (single supply ground).

A single external resistor sets gain from 5V/V to 10000V/V. Laser trimming provides very low offset voltage (250μV max), offset voltage drift (3μV/°C max) and excellent common-mode rejection.

Package options include 8-pin plastic DIP and SO-8 surface-mount packages. Both are specified for the –40°C to +85°C extended industrial temperature range.

International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111 • Twx: 910-952-1111
Internet: http://www.burr-brown.com/ • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

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SPECIFICATIONS

At T_A = +25°C, V_S = +5V, R_L = 20kΩ connected to V_S/2, unless otherwise noted.

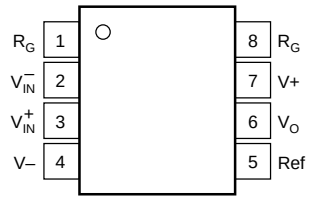
PARAMETER	CONDITIONS	INA122P, U			INA122PA, UA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT								
Offset Voltage, RTI			±100	±250		±150	±500	µV
vs Temperature			±1	±3		*	±5	µV/°C
vs Power Supply (PSRR)	V_S = +2.2V to +36V		10	30		*	100	µV/V
Input Impedance			10^{10} || 3			*		Ω || pF
Safe Input Voltage	R_S = 0	(V–)–0.3		(V+)+0.3	*		*	V
	R_S = 10kΩ	(V–)–40		(V+)+40	*		*	V
Common-Mode Voltage Range		0		3.4	*		*	V
Common-Mode Rejection	V_{CM} = 0V to 3.4V	83	96		76	90		dB
INPUT BIAS CURRENT			–10	–25		*	–50	nA
vs Temperature			±40			*		pA/°C
Offset Current			±1	±2		*	±5	nA
vs Temperature			±40			*		pA/°C
GAIN			G = 5 to 10k			*		V/V
Gain Equation			G = 5 + 200kΩ/R_G			*		V/V
Gain Error	G = 5		±0.05	±0.1		*	±0.15	%
vs Temperature	G = 5		5	10		*	*	ppm/°C
Gain Error	G = 100		±0.3	±0.5		*	±1	%
vs Temperature	G = 100		±25	±100		*	*	ppm/°C
Nonlinearity	G = 100, V_O = –14.85V to +14.9V		±0.005	±0.012		*	±0.024	%
NOISE (RTI)								
Voltage Noise, f = 1kHz			60			*		nV/√Hz
f = 100Hz			100			*		nV/√Hz
f = 10Hz			110			*		nV/√Hz
f_B = 0.1Hz to 10Hz			2			*		µVp-p
Current Noise, f = 1kHz			80			*		fA/√Hz
f_B = 0.1Hz to 10Hz			2			*		pAp-p
OUTPUT								
Voltage, Positive	V_S = ±15V	(V+)–0.1	(V+)–0.05		*	*		V
Negative	V_S = ±15V	(V–)+0.15	(V–)+0.1		*	*		V
Short-Circuit Current	Short-Circuit to Ground		+3/–30			*		mA
Capacitive Load Drive			1			*		nF
FREQUENCY RESPONSE								
Bandwidth, –3dB	G = 5		120			*		kHz
	G = 100		5			*		kHz
	G = 500		0.9			*		kHz
Slew Rate			+0.08/–0.16			*		V/µs
Settling Time, 0.01%	G = 5		350			*		µs
	G = 100		450			*		µs
	G = 500		1.8			*		ms
Overload Recovery	50% Input Overload		3			*		µs
POWER SUPPLY								
Voltage Range, Single Supply		+2.2	+5	+36	*	*	*	V
Dual Supplies		–0.9/+1.3		±18	*	*	*	V
Current	I_O = 0		60	85		*	*	µA
TEMPERATURE RANGE								
Specification		–40		+85	*		*	°C
Operation		–55		+85	*		*	°C
Storage		–55		+125	*		*	°C
Thermal Resistance, θ_{JA}								
8-Pin DIP			150			*		°C/W
SO-8 Surface-Mount			150			*		°C/W

* Specification same as INA122P, INA122U.

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PIN CONFIGURATION

Top View **8-Pin DIP, SO-8**



ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage, V+ to V–	36V
Signal Input Terminals, Voltage[2]	(V–)–0.3V to (V+)+0.3V
Current[2]	5mA
Output Short Circuit	Continuous
Operating Temperature	–40°C to +125°C
Storage Temperature	–55°C to +125°C
Lead Temperature (soldering, 10s)	+300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. (2) Input terminals are internally diode-clamped to the power supply rails. Input signals that can exceed the supply rails by more than 0.3V should be current-limited to 5mA or less.

PACKAGE INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER[1]
INA122PA	8-Pin DIP	006
INA122P	8-Pin DIP	006
INA122UA	SO-8 Surface Mount	182
INA122U	SO-8 Surface Mount	182

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

ELECTROSTATIC DISCHARGE SENSITIVITY

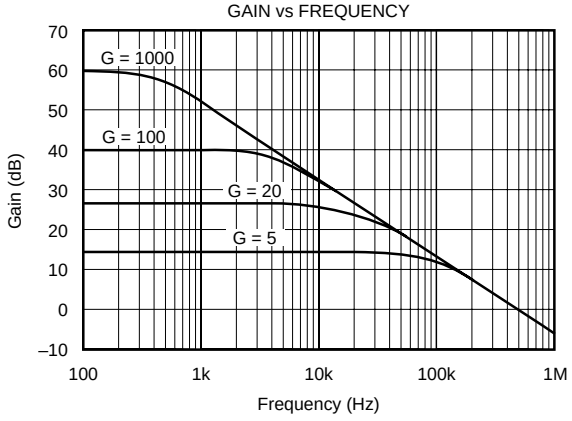
This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

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.

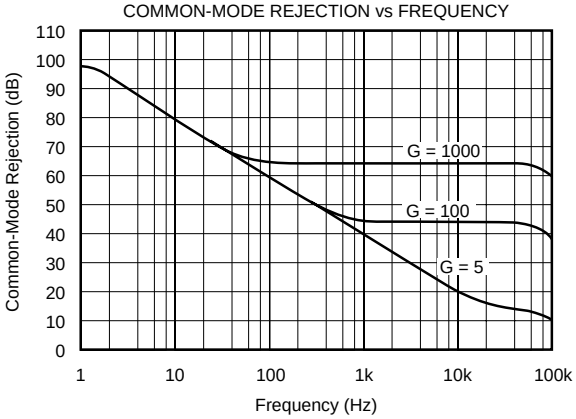
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_S = ±5V, unless otherwise noted.

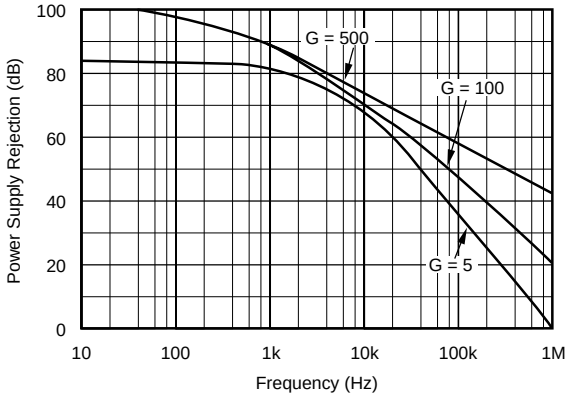
GAIN vs FREQUENCY



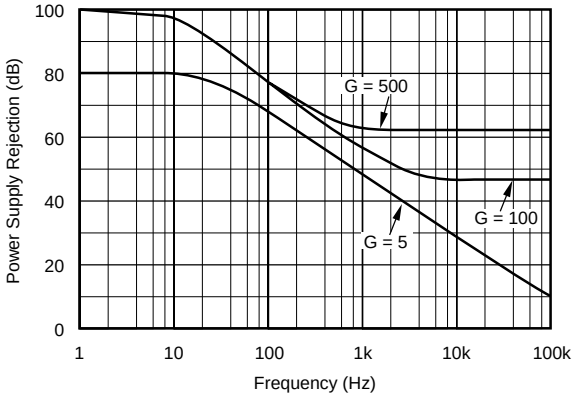
COMMON-MODE REJECTION vs FREQUENCY



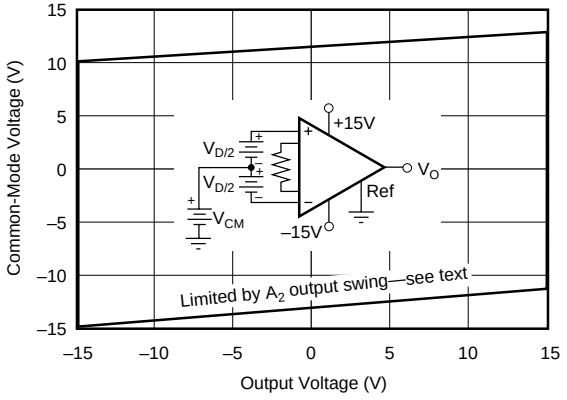
POSITIVE POWER SUPPLY REJECTION vs FREQUENCY



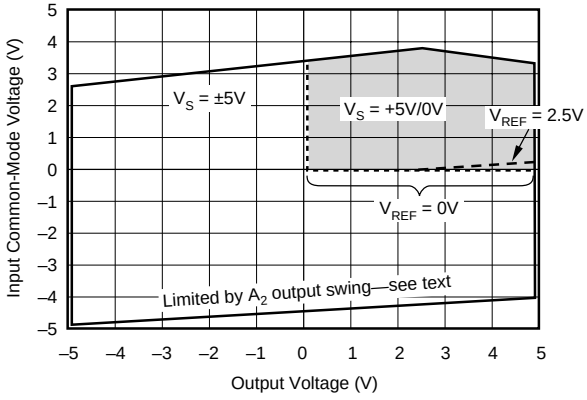
NEGATIVE POWER SUPPLY REJECTION vs FREQUENCY



INPUT COMMON-MODE RANGE vs OUTPUT VOLTAGE, V_S = ±15V, G = 5



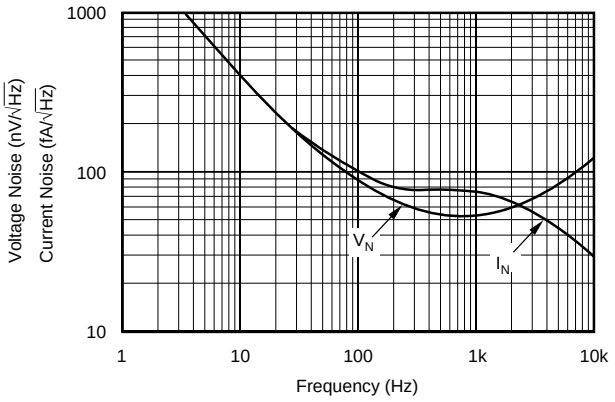
INPUT COMMON-MODE VOLTAGE vs OUTPUT VOLTAGE, V_S = ±5V, G = 5



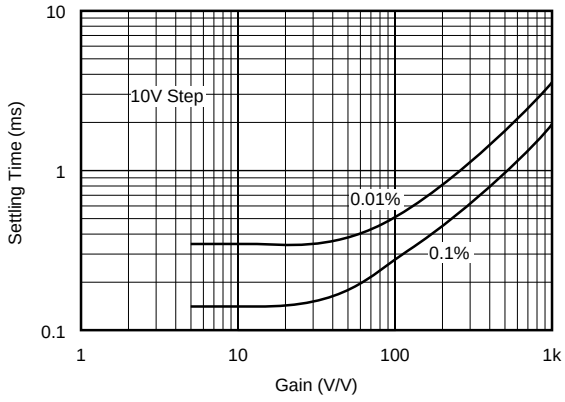
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±5V, unless otherwise noted.

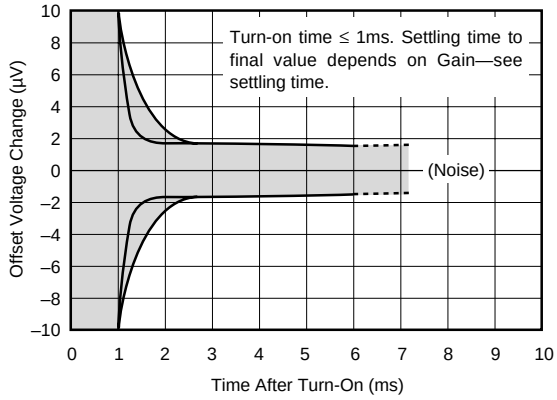
VOLTAGE and CURRENT NOISE DENSITY vs FREQUENCY (RTI)



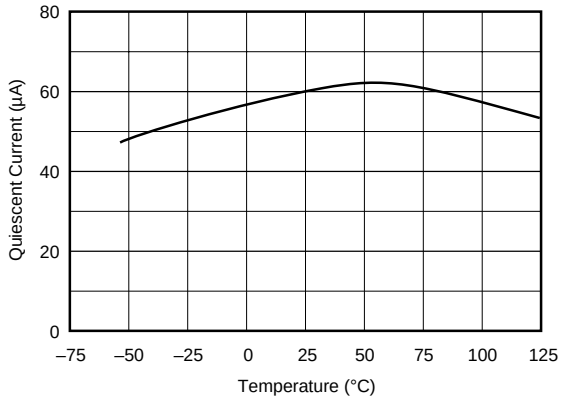
SETTLING TIME vs GAIN



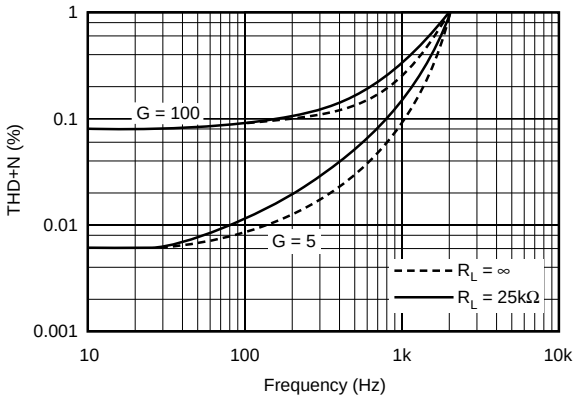
INPUT-REFERRED OFFSET VOLTAGE WARM-UP



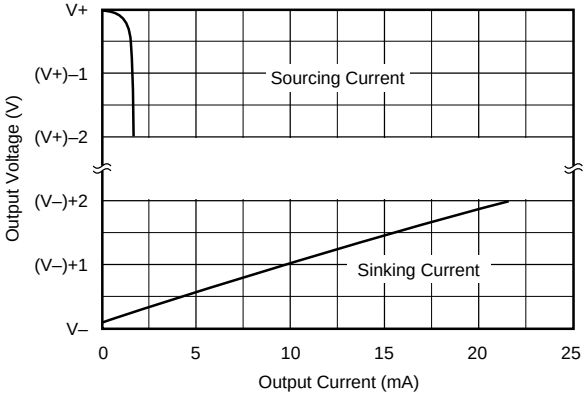
QUIESCENT CURRENT vs TEMPERATURE



TOTAL HARMONIC DISTORTION+NOISE vs FREQUENCY



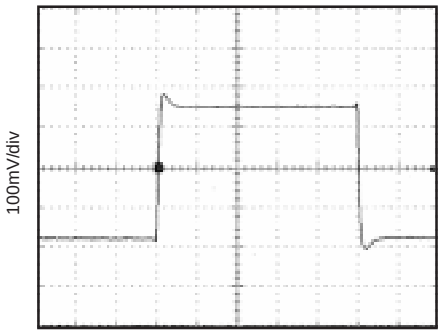
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



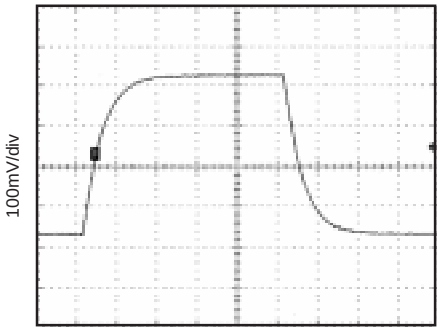
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±5V, unless otherwise noted.

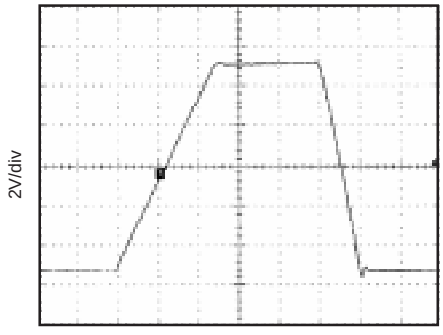
SMALL-SIGNAL STEP RESPONSE
G = 5



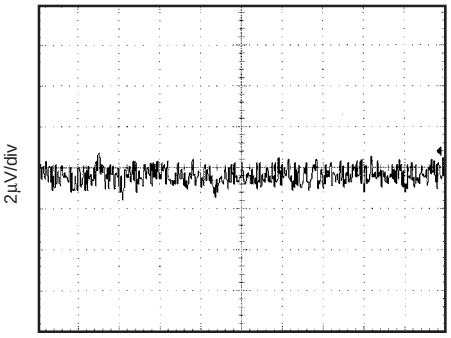
SMALL-SIGNAL STEP RESPONSE
G = 100



LARGE-SIGNAL STEP RESPONSE
G = 5



INPUT-REFERRED NOISE VOLTAGE
0.1Hz to 10Hz



APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA122. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins.

The output is referred to the output reference (Ref) terminal which is normally grounded. This must be a low-impedance connection to ensure good common-mode rejection. A resistance of 10Ω in series with the Ref pin will cause a typical device to degrade to approximately 80dB CMR.

SETTING THE GAIN

Gain of the INA122 is set by connecting a single external resistor, R_G, as shown:

$$G = 5 + \frac{200k\Omega}{R_G} \quad (1)$$

Commonly used gains and R_G resistor values are shown in Figure 1.

The 200kΩ term in equation 1 comes from the internal metal film resistors which are laser trimmed to accurate absolute values. The accuracy and temperature coefficient of these resistors are included in the gain accuracy and drift specifications of the INA122.

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).

OFFSET TRIMMING

The INA122 is laser trimmed for low offset voltage and offset voltage drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The voltage applied to the Ref terminal is added to the output signal. An op amp buffer is used to provide low impedance at the Ref terminal to preserve good common-mode rejection.

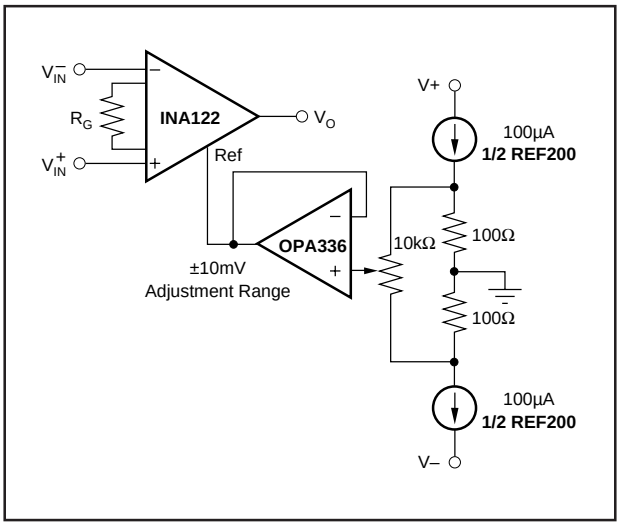


FIGURE 2. Optional Trimming of Output Offset Voltage.

INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA122 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 approximately –10nA (current flows out of the input terminals). High input impedance means that this input bias current changes very little with varying input voltage.

DESIRED GAIN (V/V)	R_G (Ω)	NEAREST 1% R_G VALUE
5	NC	NC
10	40k	40.2k
20	13.33k	13.3k
50	4444	4420
100	2105	2100
200	1026	1020
500	404	402
1000	201	200
2000	100.3	100
5000	40	40.2
10000	20	20

NC: No Connection.

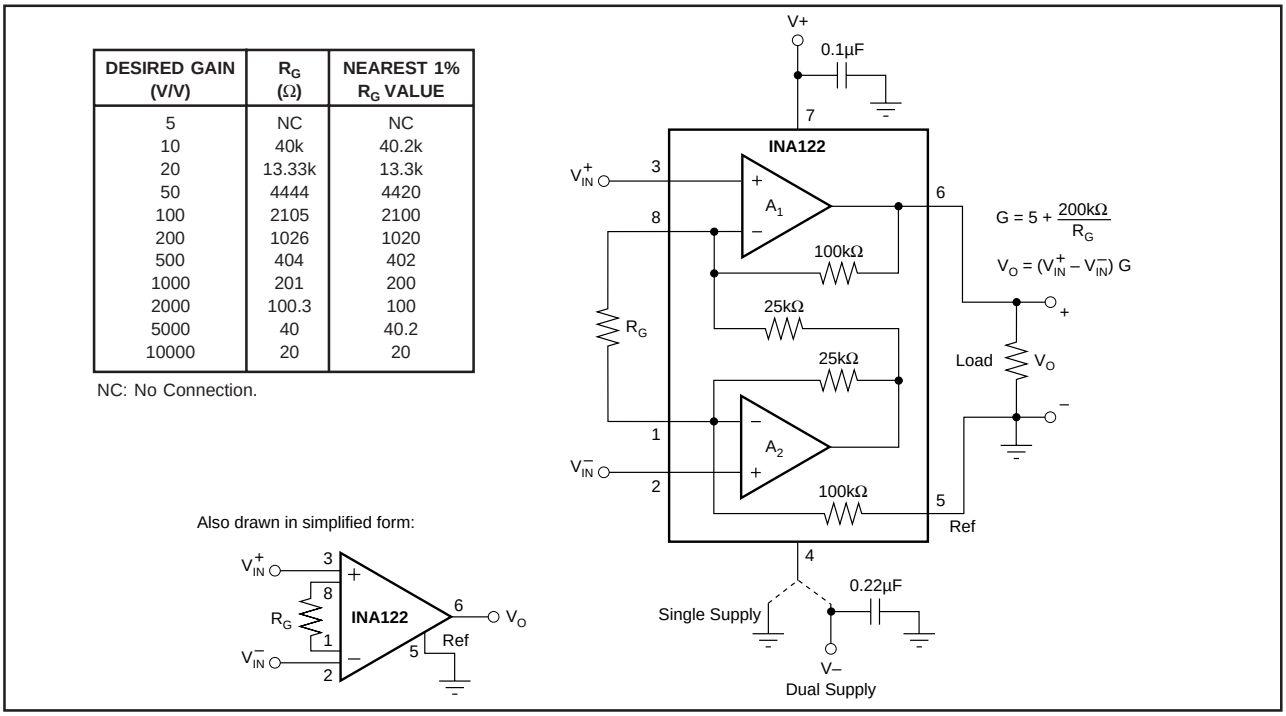


FIGURE 1. Basic Connections.

Input circuitry must provide a path for this input bias current for proper operation. Figure 3 shows various provisions for an input bias current path. Without a bias current path, the inputs will float to a potential which exceeds the common-mode range of the INA122 and the input amplifiers will saturate.

If the differential source resistance is low, the bias current return path can be connected to one input (see the thermocouple example in Figure 3). With higher source impedance, using two equal resistors provides a balanced input with possible advantages of lower input offset voltage due to bias current and better high-frequency common-mode rejection.

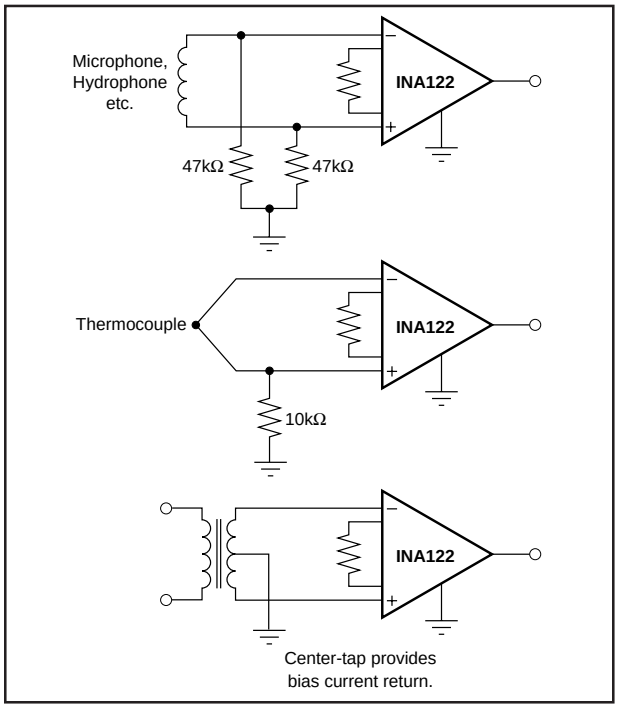


FIGURE 3. Providing an Input Common-Mode Current Path.

INPUT PROTECTION

The inputs of the INA122 are protected with internal diodes connected to the power supply rails (Figure 4). These diodes will clamp the applied signal to prevent it from damaging the input circuitry. If the input signal voltage can exceed the power supplies by more than 0.3V, the input signal current should be limited to less than 5mA to protect the internal clamp diodes. This can generally be done with a series input resistor. Some signal sources are inherently current-limited and do not require limiting resistors.

INPUT COMMON-MODE RANGE

The common-mode range for some common operating conditions is shown in the typical performance curves. The INA122 can operate over a wide range of power supply and V_{REF} configurations, making it impractical to provide a comprehensive guide to common-mode range limits for all possible conditions. The most commonly overlooked overload condition occurs by attempting to exceed the output swing of A_2, an internal circuit node that cannot be measured. Calculating the expected voltages at A_2's output (see equation in Figure 4) provides a check for the most common overload conditions.

The design of A_1 and A_2 are identical and their outputs can swing to within approximately 100mV of the power supply rails, depending on load conditions. When A_2's output is saturated, A_1 can still be in linear operation, responding to changes in the non-inverting input voltage. This may give the appearance of linear operation but the output voltage is invalid.

A single supply instrumentation amplifier has special design considerations. Using commonly available single-supply op amps to implement the two-op amp topology will not yield equivalent performance. For example, consider the condition where both inputs of common single-supply op amps are

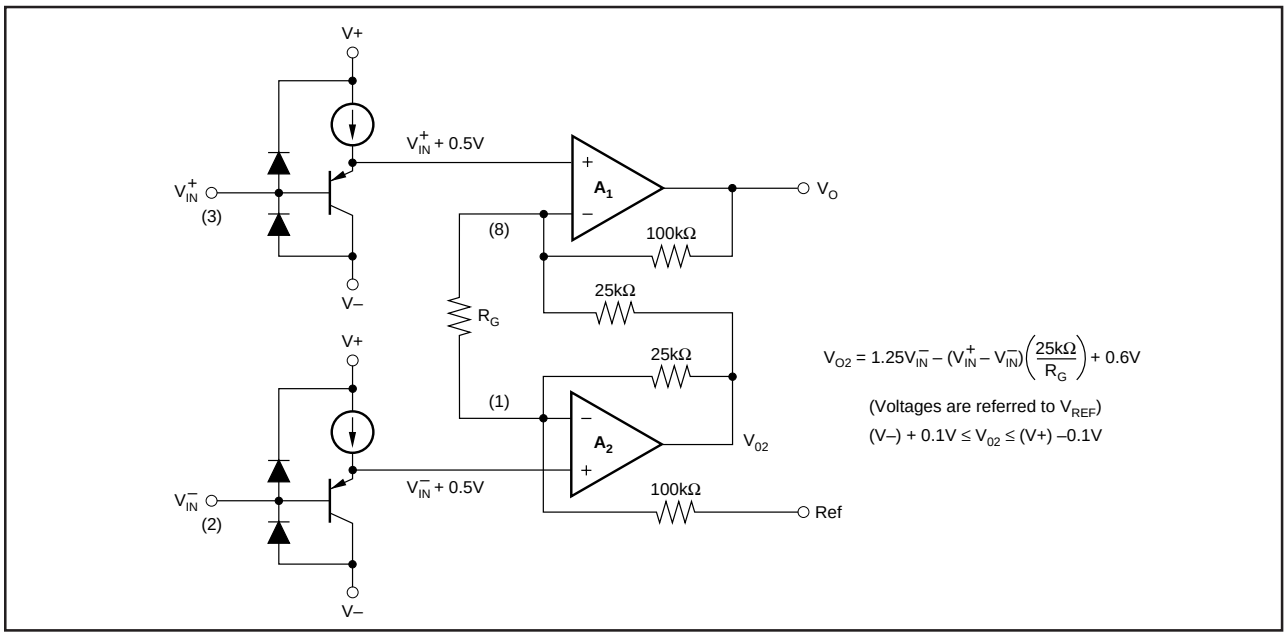


FIGURE 4. INA122 Simplified Circuit Diagram.

equal to 0V. The outputs of both A_1 and A_2 must be 0V. But any small positive voltage applied to V_{IN}^+ requires that A_2's output must swing below 0V, which is clearly impossible without a negative power supply.

To achieve common-mode range that extends to single-supply ground, the INA122 uses precision level-shifting buffers on its inputs. This shifts both inputs by approximately +0.5V, and through the feedback network, shifts A_2's output by approximately +0.6V. With both inputs and V_{REF} at single-supply, A_2's output is well within its linear range. A positive V_{IN}^+ causes A_2's output to swing below 0.6V.

As a result of this input level-shifting, the voltages at pin 1 and pin 8 are not equal to their respective input terminal voltages (pins 2 and 3). For most applications, this is not important since only the gain-setting resistor connects to these pins.

LOW VOLTAGE OPERATION

The INA122 can be operated on a single power supply as low as +2.2V (or a total of +2.2V on dual supplies). Performance remains excellent throughout the power supply range up to +36V (or ±18V). Most parameters vary only slightly throughout this supply voltage range—see typical performance curves.

Operation at very low supply voltage requires careful attention to ensure that the common-mode voltage remains within its linear range.

LOW QUIESCENT CURRENT OPERATION

The INA122 maintains its low quiescent current (60µA) while the output is within linear operation (up to 200mV from the supply rails). When the input creates a condition that overdrives the output into saturation, quiescent current increases. With V_O overdriven into the positive rail, the quiescent current increases to approximately 400µA. Likewise, with V_O overdriven into the negative rail (single supply ground) the quiescent current increases to approximately 200µA.

OUTPUT CURRENT RANGE

Output sourcing and sinking current values versus the output voltage ranges are shown in the typical performance curves. The positive and negative current limits are not equal. Positive output current sourcing will drive moderate to high load impedances. Battery operation normally requires the careful management of power consumption to keep load impedances very high throughout the design.

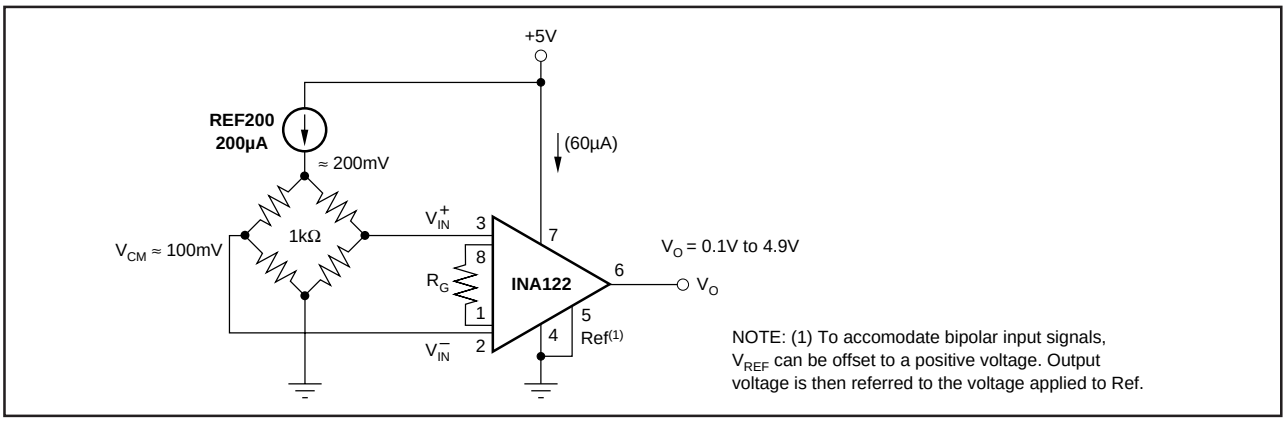


FIGURE 5. Micropower Single Supply Bridge Amplifier.

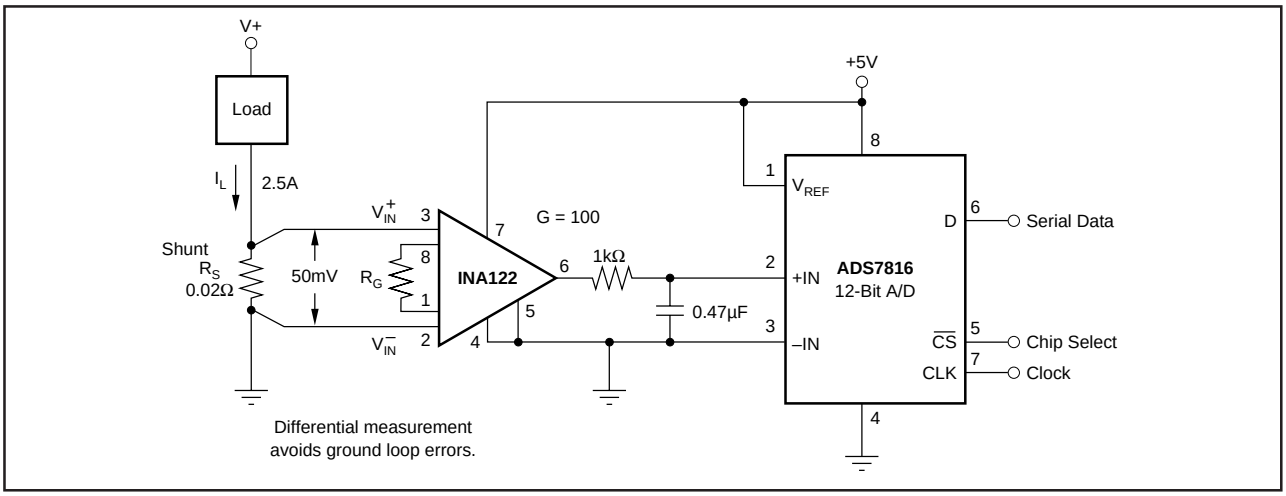


FIGURE 6. Single-Supply Current Shunt Measurement.

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