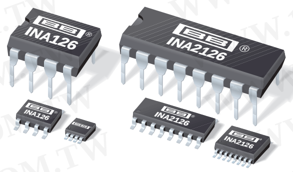
BURR - BROWN®



INA126
INA2126

*Micro*POWER INSTRUMENTATION AMPLIFIER Single and Dual Versions

FEATURES

- LOW QUIESCENT CURRENT: 175µA/chan.
- WIDE SUPPLY RANGE: ±1.35V to ±18V
- LOW OFFSET VOLTAGE: 250µV max
- LOW OFFSET DRIFT: 3µV/°C max
- LOW NOISE: 35nV/$\sqrt{Hz}$
- LOW INPUT BIAS CURRENT: 25nA max
- 8-PIN DIP, SO-8, MSOP-8 SURFACE- MOUNT DUAL: 16-Pin DIP, SO-16, SSOP-16

APPLICATIONS

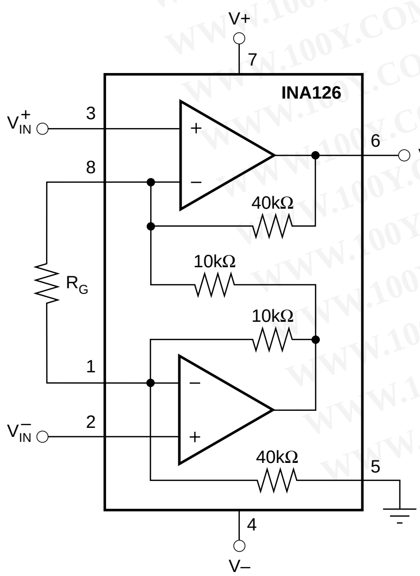
- INDUSTRIAL SENSOR AMPLIFIER: Bridge, RTD, Thermocouple
- PHYSIOLOGICAL AMPLIFIER: ECG, EEG, EMG
- MULTI-CHANNEL DATA ACQUISITION
- PORTABLE, BATTERY OPERATED SYSTEMS

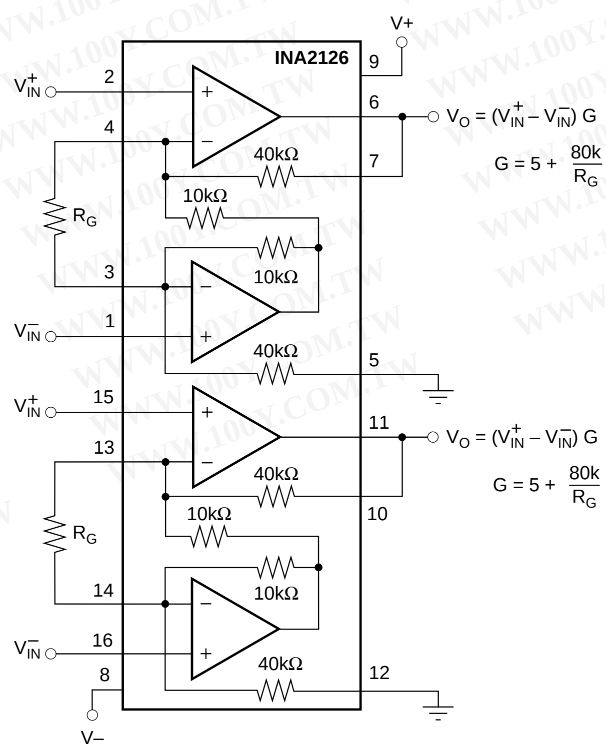
DESCRIPTION

The INA126 and INA2126 are precision instrumentation amplifiers for accurate, low noise differential signal acquisition. Their two-op-amp design provides excellent performance with very low quiescent current (175µA/chan.). This, combined with wide operating voltage range of ±1.35V to ±18V, makes them ideal for portable instrumentation and data acquisition systems.

Gain can be set from 5V/V to 10000V/V with a single external resistor. Laser trimmed input circuitry provides low offset voltage (250µV max), low offset voltage drift (3µV/°C max) and excellent common-mode rejection.

Single version package options include 8-pin plastic DIP, SO-8 surface mount, and fine-pitch MSOP-8 surface-mount. Dual version is available in the space-saving SSOP-16 fine-pitch surface mount, SO-16, and 16-pin DIP. All are specified for the –40°C to +85°C industrial temperature range.





 PDS-1365C Printed in U.S.A. September, 1997

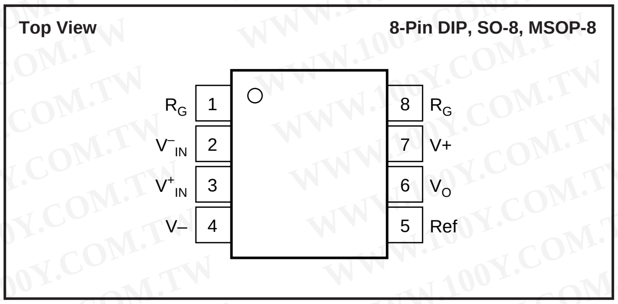
SPECIFICATIONS

At T_A = +25°C, V_S = ±15V, R_L = 25kΩ, unless otherwise noted.

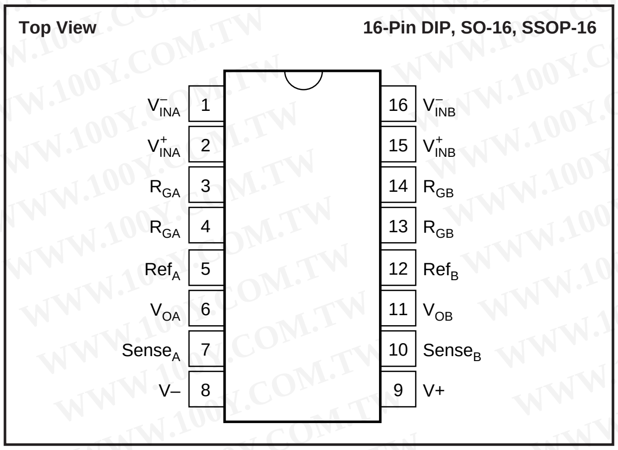
		INA126P, U, E INA2126P, U, E			INA126PA, UA, EA INA2126PA, UA, EA			
PARAMETER	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNITS**
INPUT								
Offset Voltage, RTI			±100	±250		±150	±500	µV
vs Temperature			±0.5	±3		*	±5	µV/°C
vs Power Supply (PSRR)	V_S = ±1.35V to ±18V		5	15		*	50	µV/V
Input Impedance			10^9 || 4			*		Ω || pF
Safe Input Voltage	R_S = 0	(V–)–0.5		(V+)+0.5	*		*	V
	R_S = 1kΩ	(V–)–10		(V+)+10	*		*	V
Common-Mode Voltage Range	V_O = 0V	±11.25	±11.5		*	*		V
Channel Separation (dual)	G = 5, dc		130					dB
Common-Mode Rejection	R_S = 0, V_{CM} = ±11.25V	83	94		74	90		dB
INA2126U (dual SO-16)		80	94					dB
INPUT BIAS CURRENT			–10	–25		*	–50	nA
vs Temperature			±30			*		pA/°C
Offset Current			±0.5	±2		*	±5	nA
vs Temperature			±10			*		pA/°C
GAIN			G = 5 to 10k			*		V/V
Gain Equation			G = 5 + 80kΩ/R_G			*		V/V
Gain Error	V_O = ±14V, G = 5		±0.02	±0.1		*	±0.18	%
vs Temperature	G = 5		±2	±10		*	*	ppm/°C
Gain Error	V_O = ±12V, G = 100		±0.2	±0.5		*	±1	%
vs Temperature	G = 100		±25	±100		*	*	ppm/°C
Nonlinearity	G = 100, V_O = ±14V		±0.002	±0.012		*	*	%
NOISE								
Voltage Noise, f = 1kHz			35			*		nV/√Hz
f = 100Hz			35			*		nV/√Hz
f = 10Hz			45			*		nV/√Hz
f_B = 0.1Hz to 10Hz			0.7			*		µVp-p
Current Noise, f = 1kHz			60			*		fA/√Hz
f_B = 0.1Hz to 10Hz			2			*		pAp-p
OUTPUT								
Voltage, Positive	R_L = 25kΩ	(V+)–0.9	(V+)–0.75		*	*		V
Negative	R_L = 25kΩ	(V–)+0.95	(V–)+0.8		*	*		V
Short-Circuit Current	Short-Circuit to Ground		+10/–5			*		mA
Capacitive Load Drive			1000			*		pF
FREQUENCY RESPONSE								
Bandwidth, –3dB	G = 5		200			*		kHz
	G = 100		9			*		kHz
	G = 500		1.8			*		kHz
Slew Rate	V_O = ±10V, G = 5		0.4			*		V/µs
Settling Time, 0.01%	10V Step, G = 5		30			*		µs
	10V Step, G = 100		160			*		µs
	10V Step, G = 500		1500			*		µs
Overload Recovery	50% Input Overload		4			*		µs
POWER SUPPLY								
Voltage Range		±1.35	±15	±18	*	*	*	V
Current (per channel)	I_O = 0		±175	±200		*	*	µA
TEMPERATURE RANGE								
Specification Range		–40		+85	*		*	°C
Operation Range		–55		+125	*		*	°C
Storage Range		–55		+125	*		*	°C
Thermal Resistance, θ_{JA}								
8-Pin DIP			100			*		°C/W
SO-8 Surface-Mount			150			*		°C/W
MSOP-8 Surface-Mount			200			*		°C/W
16-Pin DIP (dual)			80			*		°C/W
SO-16 (dual)			100			*		°C/W
SSOP-16 (dual)			100			*		°C/W

* Specification same as INA126P, INA126U, INA126E; INA2126P, INA2126U, INA2126E.

PIN CONFIGURATION (Single)



PIN CONFIGURATION (Dual)



ABSOLUTE MAXIMUM RATINGS[1]

Power Supply Voltage, V+ to V–	36V
Input Signal Voltage[2]	(V–)–0.7 to (V+)+0.7V
Input Signal Current[2]	10mA
Output Short Circuit	Continuous
Operating Temperature	–55°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 signal voltage is limited by internal diodes connected to power supplies. See text.

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 INFORMATION

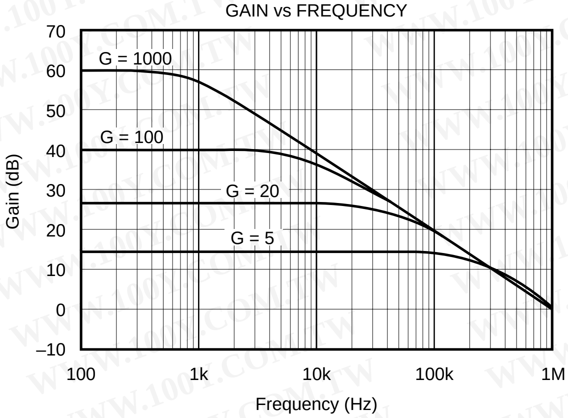
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER[1]	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA
Single					
INA126PA INA126P	8-Pin DIP 8-Pin DIP	006 006	INA126PA INA126P	INA126PA INA126P	Rails Rails
INA126UA INA126U	SO-8 SO-8	182 182	INA126UA INA126U	INA126UA INA126U	Rails or Reel Rails or Reel
INA126EA[2] " INA126E[2] "	MSOP-8 " MSOP-8 "	337 " 337 "	A26[3] " A26[3] "	INA126EA-250 INA126EA-2500 INA126E-250 INA126E-2500	Reel Only " Reel Only "
Dual					
INA2126PA INA2126P	16-Pin DIP 16-Pin DIP	180 180	INA2126PA INA2126P	INA2126PA INA2126P	Rails Rails
INA2126UA INA2126U	SO-16 SO-16	265 265	INA2126UA INA2126U	INA2126UA INA2126U	Rails Rails
INA2126EA[2] " INA2126E[2] "	SSOP-16 " SSOP-16 "	322 " 322 "	INA2126EA " INA2126E "	INA2126EA-250 INA2126EA-2500 INA2126E-250 INA2126E-2500	Reel Only " Reel Only "

NOTES: (1) For detailed drawing and dimension table, see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) MSOP-8 and SSOP-16 packages are available only on 250 or 2500 piece reels. (3) Grade designation is marked on reel.

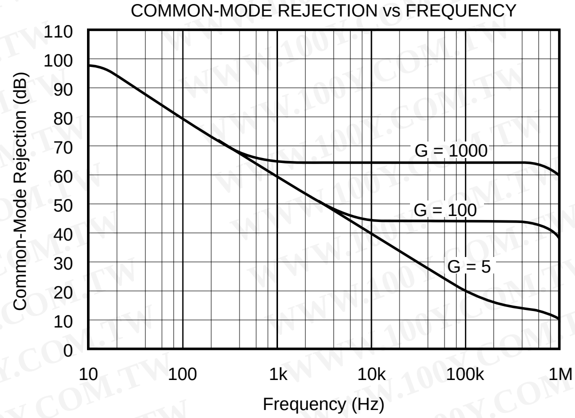
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

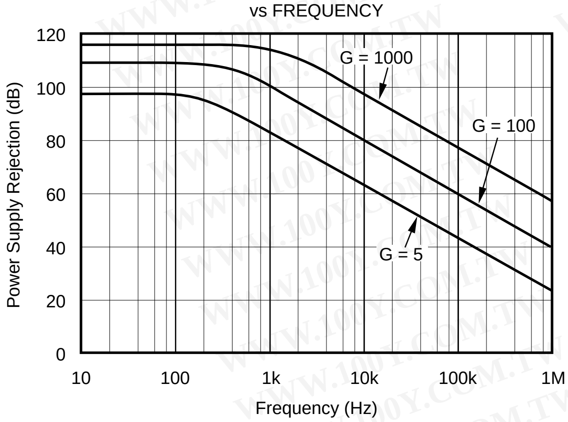
GAIN vs FREQUENCY



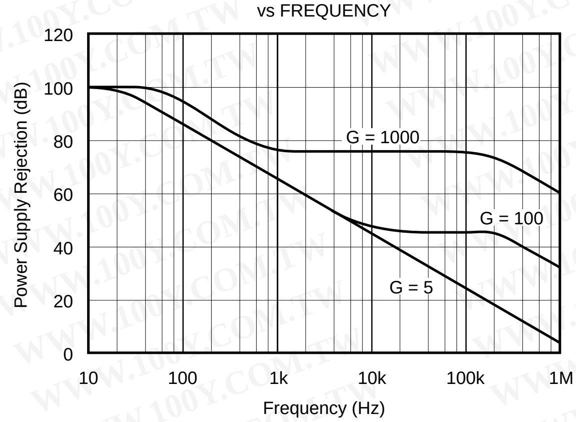
COMMON-MODE REJECTION vs FREQUENCY



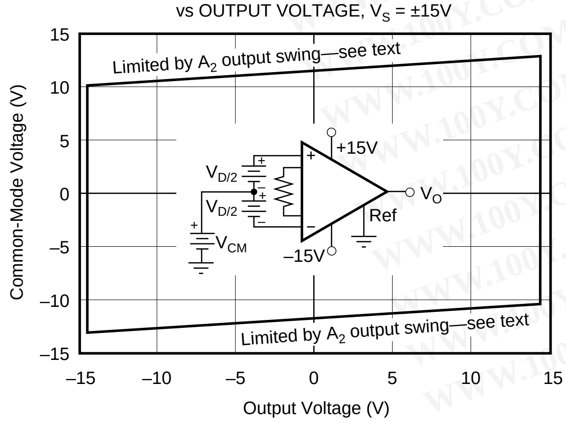
POSITIVE POWER SUPPLY REJECTION vs FREQUENCY



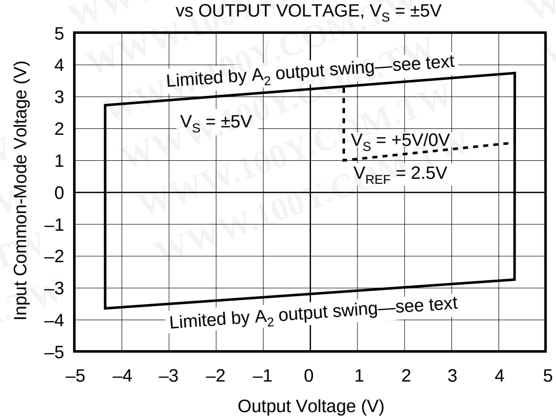
NEGATIVE POWER SUPPLY REJECTION vs FREQUENCY



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



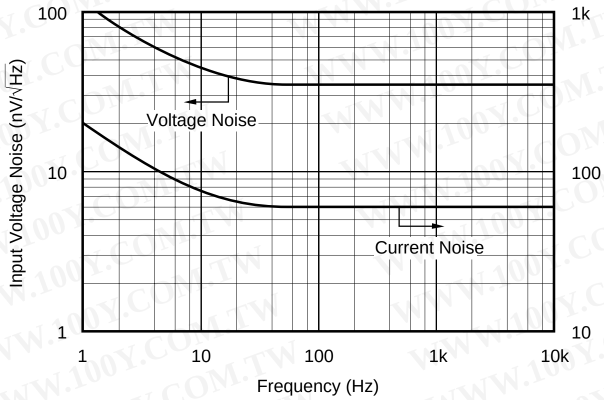
INPUT COMMON-MODE VOLTAGE RANGE vs OUTPUT VOLTAGE, V_S = ±5V



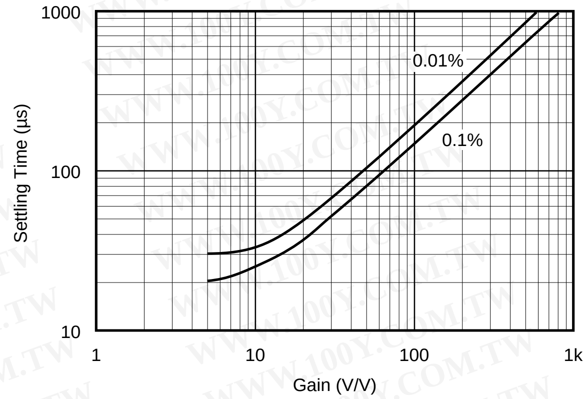
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

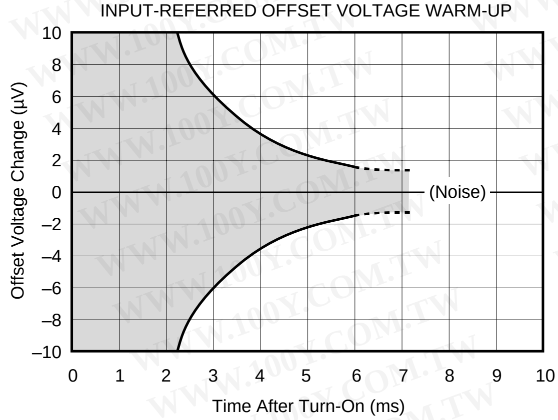
INPUT-REFERRED NOISE vs FREQUENCY



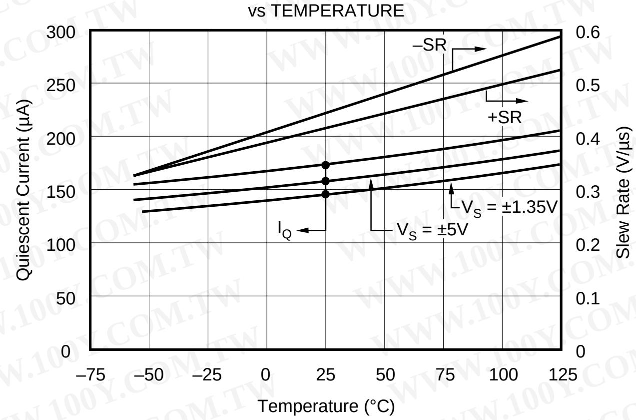
SETTLING TIME vs GAIN



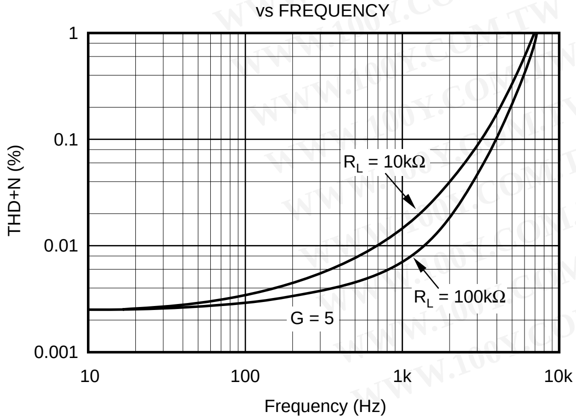
INPUT-REFERRED OFFSET VOLTAGE WARM-UP



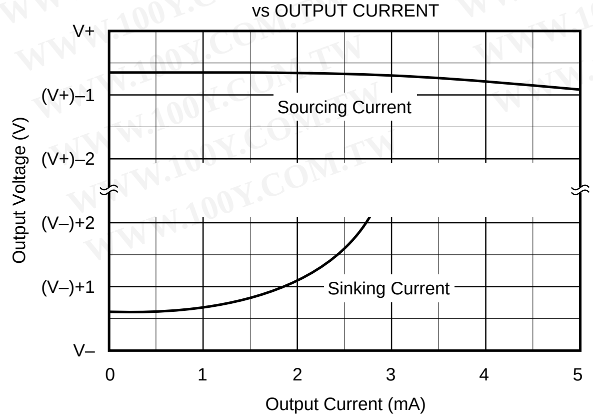
QUIESCENT CURRENT AND SLEW RATE vs TEMPERATURE



TOTAL HARMONIC DISTORTION+NOISE vs FREQUENCY



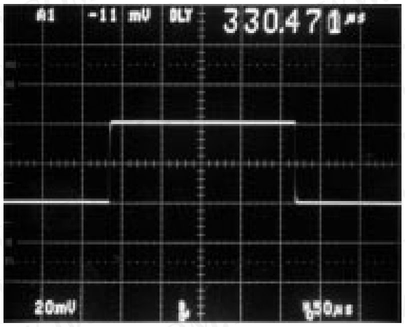
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

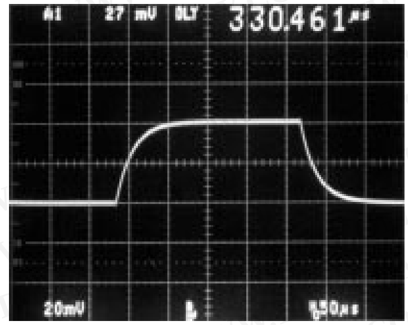
SMALL-SIGNAL RESPONSE, G = 5



20mV/div

50µs/div

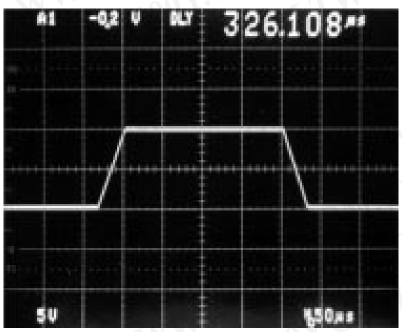
SMALL-SIGNAL RESPONSE, G = 100



20mV/div

50µs/div

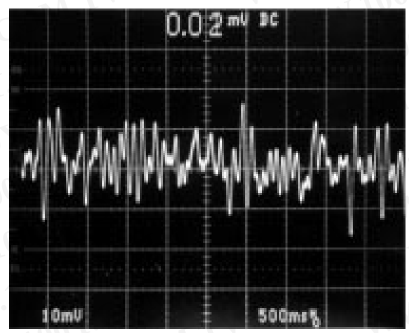
LARGE-SIGNAL RESPONSE, G = 5



5V/div

50µs/div

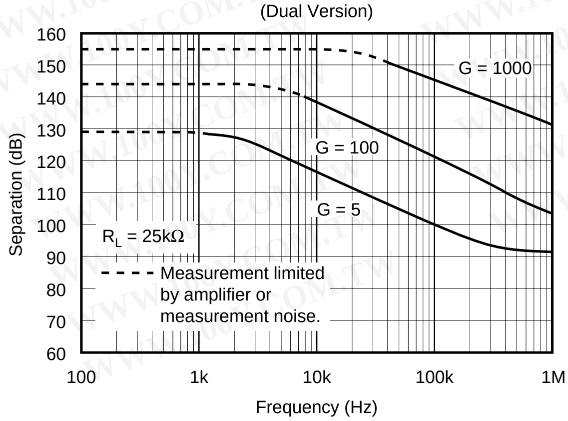
VOLTAGE NOISE, 0.1Hz to 10Hz



0.2µV/div

500ms/div

CHANNEL SEPARATION vs FREQUENCY, RTI
(Dual Version)



APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA126. 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 ensure good common-mode rejection. A resistance of 8Ω in series with the Ref pin will cause a typical device to degrade to approximately 80dB CMR.

Dual versions (INA2126) have feedback sense connections, $Sense_A$ and $Sense_B$. These must be connected to their respective output terminals for proper operation. The sense connection can be used to sense the output voltage directly at the load for best accuracy.

SETTING THE GAIN

Gain is set by connecting an external resistor, R_G, as shown:

$$G = 5 + \frac{80k\Omega}{R_G} \quad (1)$$

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

The 80kΩ 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.

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). Low resistor values required for high gain can make wiring resistance important. Sockets add to the wiring resistance, which will contribute additional gain error in gains of approximately 100 or greater.

OFFSET TRIMMING

The INA126 and INA2126 are 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.

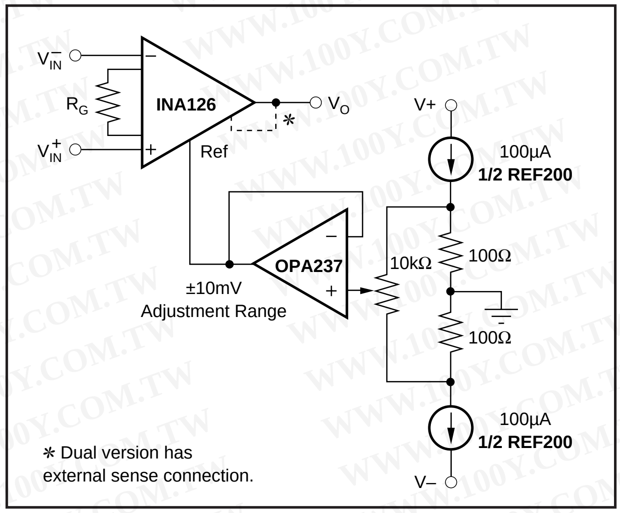
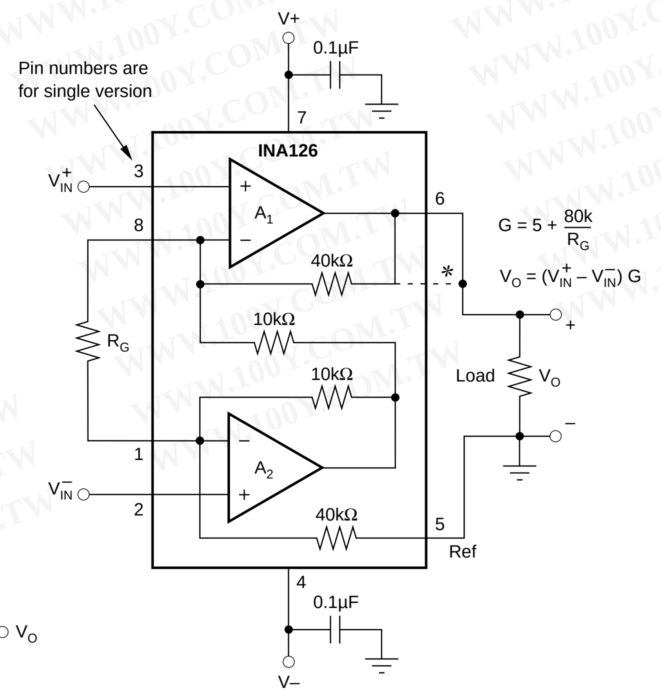


FIGURE 2. Optional Trimming of Output Offset Voltage.

DESIRED GAIN (V/V)	R_G (Ω)	NEAREST 1% R_G VALUE
5	NC	NC
10	16k	15.8k
20	5333	5360
50	1779	1780
100	842	845
200	410	412
500	162	162
1000	80.4	80.6
2000	40.1	40.2
5000	16.0	15.8
10000	8.0	7.87

NC: No Connection.



Also drawn in simplified form:

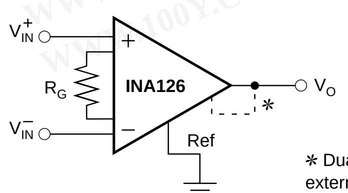


FIGURE 1. Basic Connections.

INPUT BIAS CURRENT RETURN

The input impedance of the INA126/2126 is extremely high—approximately $10^9\Omega$. However, a path must be provided for the input bias current of both inputs. This input bias current is typically –10nA (current flows out of the input terminals). 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 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 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 advantages of lower input offset voltage due to bias current and better high-frequency common-mode rejection.

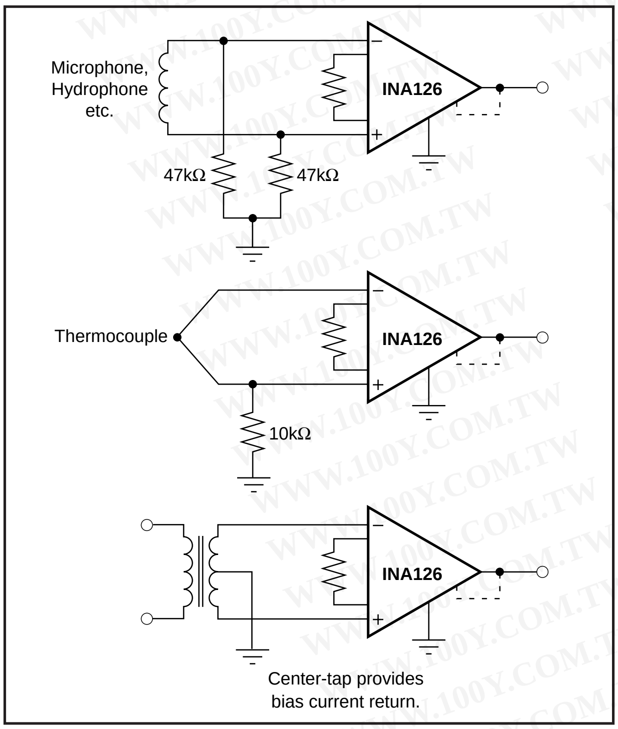


FIGURE 3. Providing an Input Common-Mode Current Path.

INPUT COMMON-MODE RANGE

The input common-mode range of the INA126/2126 is shown in typical performance curves. The common-mode range is limited on the negative side by the output voltage swing of A_2, an internal circuit node that cannot be measured on an external pin. The output voltage of A_2 can be expressed as:

$$V_{O2} = 1.25\, V_{IN}^{-} - (V_{IN}^{+} - V_{IN}^{-})\,(10k\Omega/R_G) \qquad (2)$$

(Voltages referred to Ref terminal, pin 5)

The internal op amp A_2 is identical to A_1 and its output swing is limited to typically 0.7V from the supply rails. When the input common-mode range is exceeded (A_2's output is saturated), A_1 can still be in linear operation and respond to changes in the non-inverting input voltage. The output voltage, however, will be invalid.

LOW VOLTAGE OPERATION

The INA126/2126 can be operated on power supplies as low as ±1.35V. Performance remains excellent with power supplies ranging from ±1.35V to ±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. See "Input Common-Mode Voltage Range."

The INA126/2126 can be operated from a single power supply with careful attention to input common-mode range, output voltage swing of both op amps and the voltage applied to the Ref terminal. Figure 4 shows a bridge amplifier circuit operated from a single +5V power supply. The bridge provides an input common-mode voltage near 2.5V, with a relatively small differential voltage.

INPUT PROTECTION

The inputs are protected with internal diodes connected to the power supply rails. These diodes will clamp the applied signal to prevent it from exceeding the power supplies by more than approximately 0.7V. If the signal source voltage can exceed the power supplies, the source current should be limited to less than 10mA. This can generally be done with a series resistor. Some signal sources are inherently current-limited and do not require limiting resistors.

CHANNEL CROSSTALK—DUAL VERSION

The two channels of the INA2126 are completely independent, including all bias circuitry. At DC and low frequency there is virtually no signal coupling between channels. Crosstalk increases with frequency and is dependent on circuit gain, source impedance and signal characteristics.

As source impedance increases, careful circuit layout will help achieve lowest channel crosstalk. Most crosstalk is produced by capacitive coupling of signals from one channel to the input section of the other channel. To minimize coupling, separate the input traces as far as practical from any signals associated with the opposite channel. A grounded guard trace surrounding the inputs helps reduce stray coupling between channels. Carefully balance the stray capacitance of each input to ground, and run the differential inputs of each channel parallel to each other, or directly adjacent on top and bottom side of a circuit board. Stray coupling then tends to produce a common-mode signal that is rejected by the IA's input.

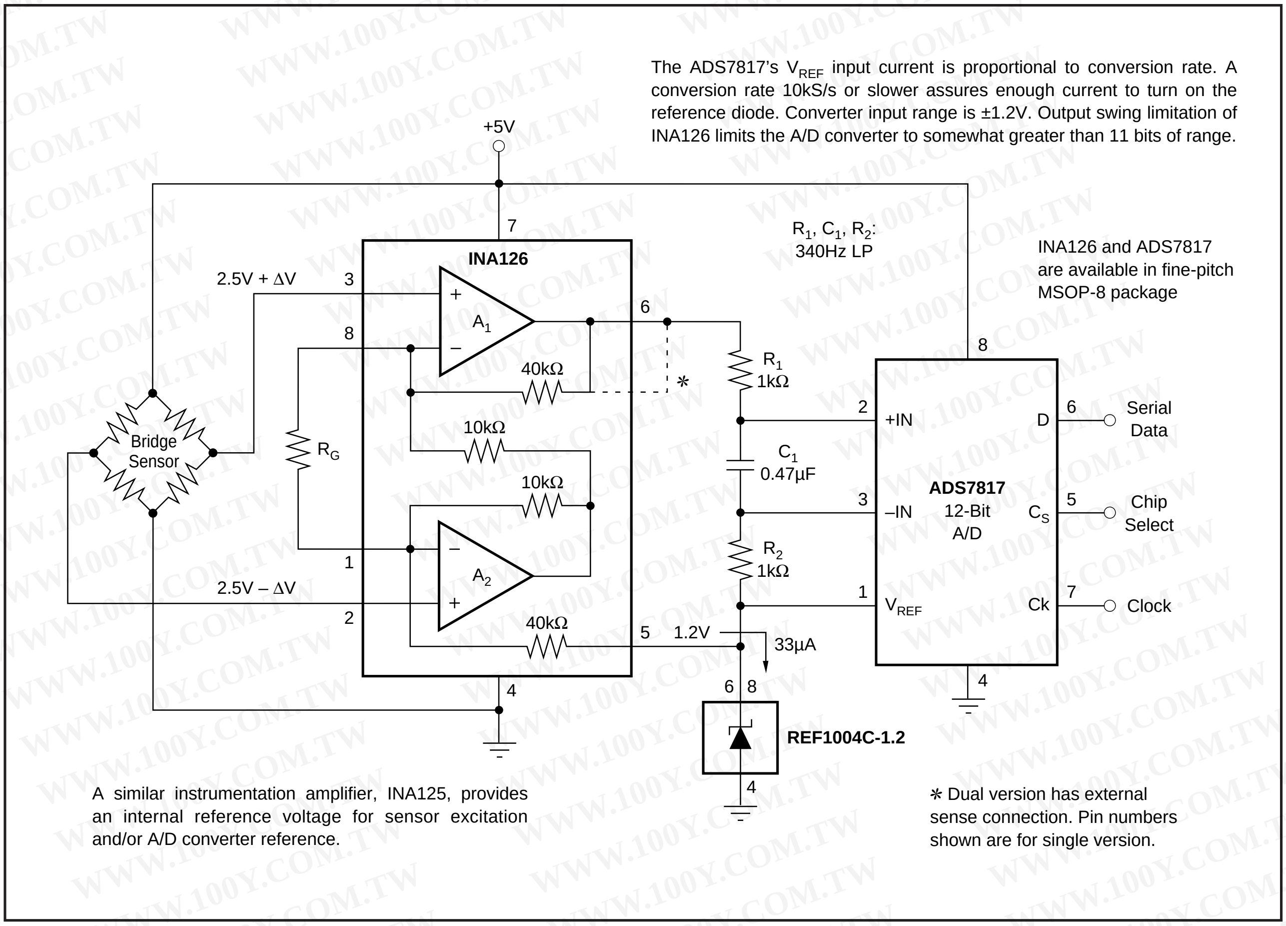
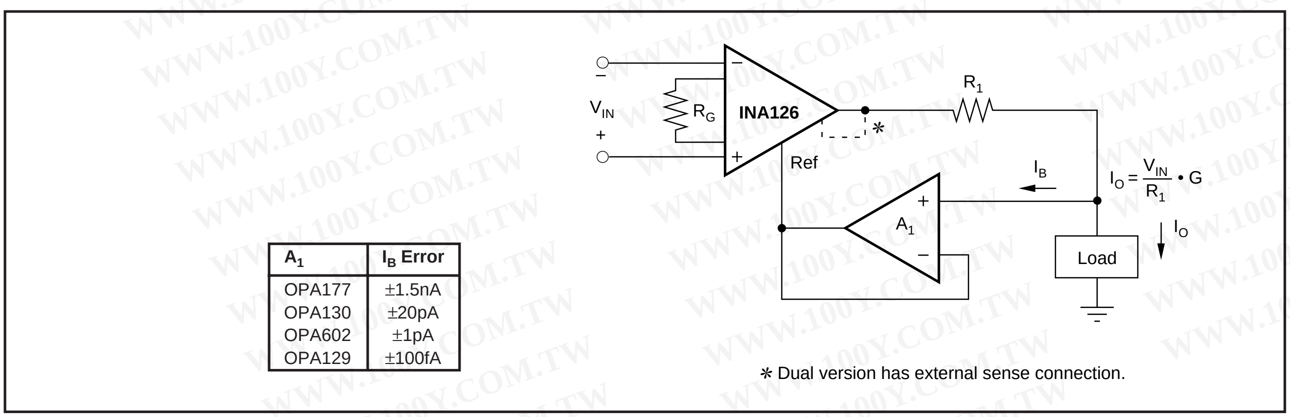


FIGURE 4. Bridge Signal Acquisition—Single 5V Supply.



A_1	I_B Error
OPA177	±1.5nA
OPA130	±20pA
OPA602	±1pA
OPA129	±100fA

FIGURE 5. Differential Voltage-to-Current Converter.