



High Accuracy Data Acquisition Instrumentation Amplifier

AD522

FEATURES

Performance

Low Drift: $2.0\mu\text{V}/^\circ\text{C}$ (AD522B)

Low Nonlinearity: 0.005% ($G = 100$)

High CMRR: $>110\text{dB}$ ($G = 1000$)

Low Noise: $1.5\mu\text{V p-p}$ (0.1 to 100Hz)

Low Initial VOS : $100\mu\text{V}$ (AD522B)

Versatility

Single-Resistor Gain Programmable: $1 \leq G \leq 1000$

Output Reference and Sense Terminals

Data Guard for Improving ac CMR

Value

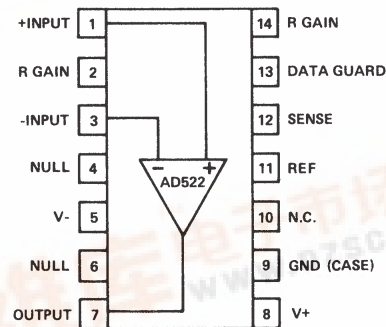
Internally Compensated

No External Components except Gain Resistor

Active Trimmed Offset, Gain, and CMR

FUNCTIONAL BLOCK DIAGRAM

14-Pin DIP



PRODUCT DESCRIPTION

The AD522 is a precision IC instrumentation amplifier designed for data acquisition applications requiring high accuracy under worst-case operating conditions. An outstanding combination of high linearity, high common mode rejection, low voltage drift, and low noise makes the AD522 suitable for use in many 12-bit data acquisition systems.

An instrumentation amplifier is usually employed as a bridge amplifier for resistance transducers (thermistors, strain gages, etc.) found in process control, instrumentation, data processing, and medical testing. The operating environment is frequently characterized by low signal-to-noise levels, fluctuating temperatures, unbalanced input impedances, and remote location which hinders recalibration.

The AD522 was designed to provide highly accurate signal conditioning under these severe conditions. It provides output offset voltage drift of less than $10\mu\text{V}/^\circ\text{C}$, input offset voltage drift of less than $2.0\mu\text{V}/^\circ\text{C}$, CMR above 80dB at unity gain (110dB at $G = 1000$), maximum gain nonlinearity of 0.001% at $G = 1$, and typical input impedance of $10^9\Omega$.

This excellent performance is achieved by combining a proven circuit configuration with state-of-the-art manufacturing technology which utilizes active laser trimming of tight-tolerance thin-film resistors to achieve low cost, small size and high reliability. This combination of high value with no-compromise performance gives the AD522 the best features of both monolithic and modular instrumentation amplifiers, thus providing extremely cost-effective precision low-level amplification.

The AD522 is available in three versions with differing accuracies and operating temperature ranges; the "A", and "B" are specified from -25°C to $+85^\circ\text{C}$, and the "S" is guaranteed over the extended aerospace temperature range of -55°C to $+125^\circ\text{C}$. All versions are packaged in a 14-pin DIP and are supplied in a pin configuration similar to that of the popular AD521 instrumentation amplifier.

AD522—SPECIFICATIONS (typical @ $V_S = \pm 15V$, $R_L = 2k\Omega$ & $T_A = +25^\circ C$ unless otherwise specified)

MODEL	AD522AD	AD522BD	AD522SD
GAIN			
Gain Equation	$1 + \frac{2(10^5)}{R_g}$	*	*
Gain Range	1 to 1000	*	*
Equation Error			
G = 1	0.2% max	0.05% max	**
G = 1000	1.0% max	0.2% max	**
Nonlinearity, max (see Fig. 4)			
G = 1	0.005%	0.001%	**
G = 1000	0.01%	0.005%	**
vs. Temp, max			
G = 1	2ppm/ $^\circ C$ (1ppm/ $^\circ C$ typ)	*	*
G = 1000	50ppm/ $^\circ C$ (25ppm/ $^\circ C$ typ)	*	*
OUTPUT CHARACTERISTICS			
Output Rating	$\pm 10V$ @ 5mA	*	*
DYNAMIC RESPONSE (see Fig. 6)			
Small Signal (-3dB)			
G = 1	300kHz	*	*
G = 100	3kHz	*	*
Full Power GBW	1.5kHz	*	*
Slew Rate	0.1V/ μs	*	*
Settling Time to 0.1%, G = 100	0.5ms	*	*
to 0.01%, G = 100	5ms	*	*
to 0.01%, G = 10	2ms	*	*
to 0.01%, G = 1	0.5ms	*	*
VOLTAGE OFFSET			
Offsets Referred to Input			
Initial Offset Voltage (adjustable to zero)			
G = 1	$\pm 400\mu V$ max ($\pm 200\mu V$ typ)	$\pm 200\mu V$ max ($\pm 100\mu V$ typ)	$\pm 200\mu V$ max ($\pm 100\mu V$ typ)
vs. Temperature, max (see Fig. 3)			
G = 1	$\pm 50\mu V/^\circ C$ ($\pm 10\mu V/^\circ C$ typ)	$\pm 25\mu V/^\circ C$ ($\pm 5\mu V/^\circ C$ typ)	$\pm 100\mu V/^\circ C$ ($\pm 10\mu V/^\circ C$ typ)
G = 1000	$\pm 6\mu V/^\circ C$	$\pm 2\mu V/^\circ C$	$\pm 6\mu V/^\circ C$
1 < G < 1000	$\pm (\frac{50}{G} + 6)\mu V/^\circ C$	$\pm (\frac{25}{G} + 2)\mu V/^\circ C$	$\pm (\frac{100}{G} + 6)\mu V/^\circ C$
vs. Supply, max			
G = 1	$\pm 20\mu V/\%$	*	*
G = 1000	$1.0\mu V/^\circ C$	$0.5\mu V/^\circ C$	**
INPUT CURRENTS			
Input Bias Current			
Initial max, $+25^\circ C$	$\pm 25nA$	*	*
vs. Temperature	$\pm 100pA/^\circ C$	*	*
Input Offset Current			
Initial max, $+25^\circ C$	$\pm 20nA$	*	*
vs. Temperature	$\pm 100pA/^\circ C$	*	*
INPUT			
Input Impedance			
Differential	$10^9\Omega$	*	*
Common Mode	$10^9\Omega$	*	*
Input Voltage Range			
Maximum Differential Input, Linear	$\pm 10V$	*	*
Maximum Differential Input, Safe	$\pm 20V$	*	*
Maximum Common Mode, Linear	$\pm 10V$	*	*
Maximum Common Mode Input, Safe	$\pm 15V$	*	*
Common Mode Rejection Ratio, Min @ $\pm 10V$, $1k\Omega$ Source			
Imbalance (see Fig. 5)			
G = 1 (dc to 30Hz)	75dB (90dB typ)	80dB (100dB typ)	75dB (90dB typ)
G = 10 (dc to 10Hz)	90dB (100dB typ)	95dB (110dB typ)	90dB (110dB typ)
G = 100 (dc to 3Hz)	100dB (110dB typ)	100dB (120dB typ)	100dB (120dB typ)
G = 1000 (dc to 1Hz)	100dB (120dB typ)	110dB (>120dB typ)	100dB (>120dB typ)
G = 1 to 1000 (dc to 60Hz)	75dB (88dB typ)	80dB (88dB typ)	*
NOISE			
Voltage Noise, RTI (see Fig. 4)			
0.1Hz to 100Hz (p-p)			
G = 1	15 μV	*	*
G = 1000	1.5 μV	*	*
10Hz to 10kHz (rms)			
G = 1	15 μV	*	*
TEMPERATURE RANGE			
Specified Performance	$-25^\circ C$ to $+85^\circ C$	*	$-55^\circ C$ to $+125^\circ C$
Operating	$-55^\circ C$ to $+125^\circ C$	*	*
Storage	$-65^\circ C$ to $+150^\circ C$	*	*
POWER SUPPLY			
Power Supply Range	$\pm (5$ to $18)V$	*	*
Quiescent Current, max @ $\pm 15V$	$\pm 10mA$	$\pm 8mA$	**
PACKAGE OPTIONS²			
Ceramic (DH-14B)	AD522AD	AD522BD	AD522SD

NOTES

¹Specifications guaranteed after 10 minute warm-up.

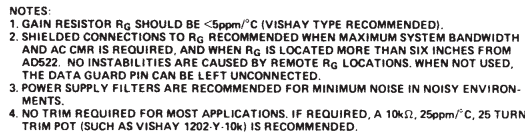
²For output information see Package Information section.

**Specifications same as AD522B.

Specifications subject to change without notice.

Applying the AD522

GENERAL APPLICATION CONSIDERATIONS
Figure 1 illustrates the AD522 wiring configuration when used in a typical bridge amplifier application. In any low-level, high impedance, noise-dominated environment, proper shielding and grounding are requisite for optimum performance; a recommended technique is shown.



Direct coupling of the AD522 inputs makes it necessary to provide a signal ground return for input amplifier bias currents. This can be achieved by direct connection as shown, or through an indirect path of less than $1\text{M}\Omega$ resistance such as other system interconnections.

Balanced design eliminates the need for external bypass capacitors for most applications. If, however, the power supplies are remotely located (farther than 10 feet or so) or if they are likely to carry more than a few millivolts of noise, local filtering will enable the user to retain optimal performance.

CMR and Noise Errors: Common mode rejection and noise performance of instrumentation amplifiers are critical because

Pin diagram of the AD522 precision centrabuck converter. The diagram shows a central triangular symbol labeled 'AD522' with a '-' sign at the top and a '+' sign at the bottom. It has 14 pins. Pin 1 is labeled '+INPUT', Pin 2 is 'R GAIN', Pin 3 is '-INPUT', Pin 4 is 'NULL', Pin 5 is 'V-', Pin 6 is 'NULL', Pin 7 is 'OUTPUT', Pin 8 is 'V+', Pin 9 is 'GND', Pin 10 is 'N.C.', Pin 11 is 'REF', Pin 12 is 'SENSE', Pin 13 is 'DATA GUARD', and Pin 14 is 'R GAIN'. The text 'TOP VIEW' is at the bottom.

Table 1. Error Sources

AD522

these errors can not be corrected by calibration. Common mode rejection of the AD522 is active laser-trimmed to the limits of thin-film resistor stability. Further trimming could improve CMR on a short term basis, but regular readjustment would be necessary to maintain this improvement (see Figure 2). In this example, untrimmed CMR and noise cause a total error of $\pm 0.0065\%$ of full scale and are the major contributors to resolution error.

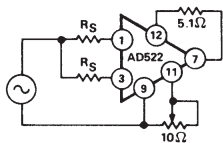


Figure 2. Optional CMR Trim

PERFORMANCE CHARACTERISTICS

Offset Voltage and Current Drift: The AD522 is available in three drift selections. Figure 3 is a graph of maximum RTO offset voltage drift vs. gain for all versions. Errors caused by offset voltage drift can thus be determined for any gain. Offset current drift will cause a voltage error equal to the product of the offset current drift and the source impedance unbalance.

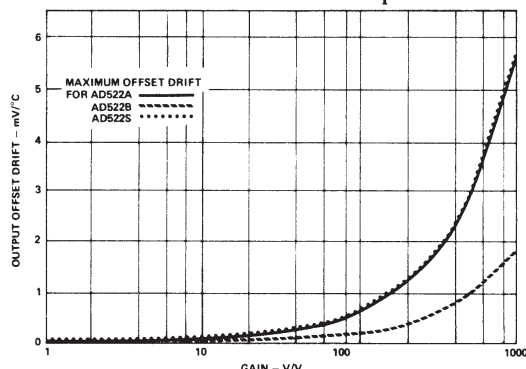


Figure 3. Output Offset Drift (RTO) vs. Gain

Gain Nonlinearity and Noise: Gain nonlinearity increases with gain as the device loop-gain decreases. Figure 4 is a plot of typical nonlinearity vs. gain. The shape of the curve can be safely used to predict worst-case nonlinearity at gains below 100. Noise vs. gain is shown on the same graph.

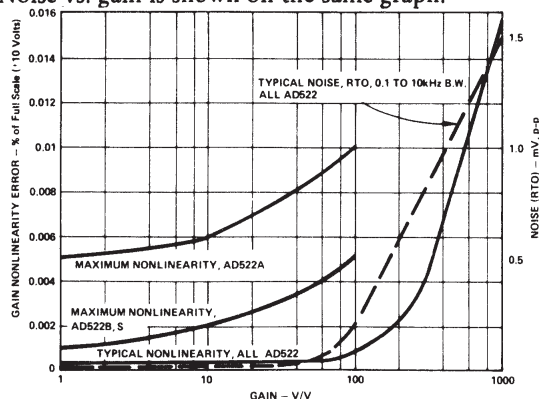


Figure 4. Gain Nonlinearity and Noise (RTO) vs. Gain

Common Mode Rejection: CMR is rated at $\pm 10V$ and $1k\Omega$ source imbalance. At lower gains, CMR depends mainly on thin-film resistor stability but due to gain-bandwidth considerations, is relatively constant with frequency to beyond 60Hz. The dc CMR improves with increasing gain and is increasingly subject to phase shifts in limited bandwidth high-gain amplifiers. Figure 5 illustrates CMR vs. Gain and Frequency.

Dynamic Performance: Settling time and unity gain bandwidth are directly proportional to gain. As a result, dynamic performance can be predicted from the well-behaved curves of Figure 6.

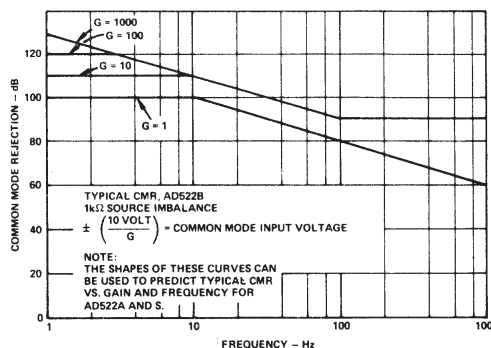


Figure 5. Common Mode Rejection vs. Frequency and Gain

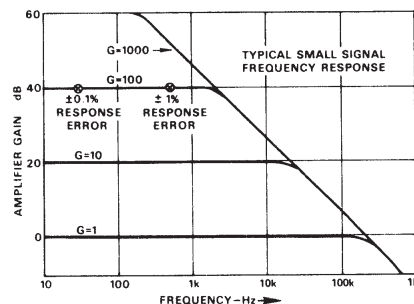


Figure 6. Small Signal Frequency Response (-3dB)

SPECIAL APPLICATIONS

Offset and Gain Trim: Gain accuracy depends largely on the quality of R_G . A precision resistor with a $10\text{ppm}/^\circ\text{C}$ temperature coefficient is advised. Offset, like gain, is laser-trimmed to a level suitable for most applications. If further adjustment is required, the circuit shown in Figure 1 is recommended. Note that good quality (25ppm) pots are necessary to maintain voltage drift specifications.

CMR Trim: A short-term CMR improvement of up to 10dB at low gains can be realized with the circuit of Figure 2. Apply a low-frequency 20/G volt peak-to-peak input signal to *both* inputs through their equivalent source resistances and trim the pot for an ac output null.

Sense Output: A sense output is provided to enable remote load sensing or use of an output current booster. Figure 7 illustrates these applications. Being "inside the loop", booster drift errors are minimized. When not used, the sense output should be tied to the output.

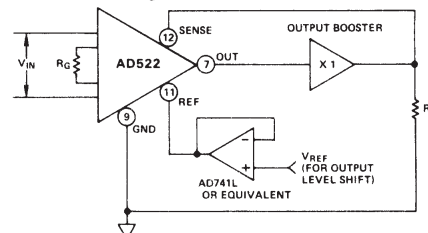


Figure 7. Output Current Booster and Buffered Output Level Shifter

Reference Output: The reference terminal is provided to permit the user to offset or "level shift" the output level to a datum compatible with his load. It must be remembered that the total output swing is ± 10 volts to be shared between signal and reference offset. Furthermore, any reference source resistance will unbalance the CMR trim by the ratio $10k/R_{ref}$. For example, if the reference source impedance is 1Ω , CMR will be reduced to 80dB ($10k\Omega/1\Omega = 10,000 = 80\text{dB}$). A buffer amplifier can be used to eliminate this error, as shown in Figure 7, but the drift of the buffer will add to output offset drift. When not used, the reference terminal should be grounded.