

FEATURES

- Easy to use
- Low cost solution
- Higher performance than two or three op amp design
- Unity gain with no external resistor
- Optional gains with one external resistor
(Gain range: 2 to 1000)
- Wide power supply range: $\pm 2.6\text{ V}$ to $\pm 15\text{ V}$
- Available in 8-lead PDIP and 8-lead SOIC_N packages
- Low power, 1.5 mA maximum supply current
- DC performance
 - 0.15% gain accuracy: $G = 1$
 - 125 μV maximum input offset voltage
 - 1.0 $\mu\text{V}/^\circ\text{C}$ maximum input offset drift
 - 5 nA maximum input bias current
 - 66 dB minimum common-mode rejection ratio: $G = 1$
- Noise
 - 12 nV/ $\sqrt{\text{Hz}}$ @ 1 kHz input voltage noise
 - 0.60 μV p-p noise: 0.1 Hz to 10 Hz, $G = 10$
- AC characteristics
 - 800 kHz bandwidth: $G = 10$
 - 10 μs settling time to 0.1% @ $G = 1$ to 100
 - 1.2 V/ μs slew rate

APPLICATIONS

- Transducer interface
- Low cost thermocouple amplifier
- Industrial process controls
- Difference amplifier
- Low cost data acquisition

PIN CONFIGURATION

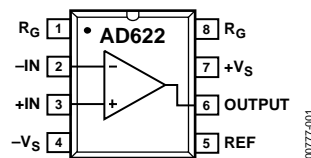


Figure 1. 8-Lead PDIP and 8-Lead SOIC_N
(N and R Suffixes)

GENERAL DESCRIPTION

The AD622 is a low cost, moderately accurate instrumentation amplifier in the traditional pin configuration that requires only one external resistor to set any gain between 2 and 1000. For a gain of 1, no external resistor is required. The AD622 is a complete difference or subtractor amplifier system that also provides superior linearity and common-mode rejection by incorporating precision laser-trimmed resistors.

The AD622 replaces low cost, discrete, two or three op amp instrumentation amplifier designs and offers good common-mode rejection, superior linearity, temperature stability, reliability, power, and board area consumption. The low cost of the AD622 eliminates the need to design discrete instrumentation amplifiers to meet stringent cost targets. While providing a lower cost solution, it also provides performance and space improvements.

Table 1. Next Generation Upgrades for AD622

| Part | Comment |
|--------|--|
| AD8221 | Better specs at lower price |
| AD8222 | Dual channel or differential out |
| AD8226 | Low power, wide input range |
| AD8220 | JFET input |
| AD8228 | Best gain accuracy |
| AD8295 | +2 precision op amps or differential out |
| AD8421 | Low noise, better specs |

Rev. E

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

TABLE OF CONTENTS

| | | | |
|---|---|---|----|
| Features | 1 | Theory of Operation | 9 |
| Applications | 1 | Make vs. Buy: A Typical Application Error Budget..... | 9 |
| Pin Configuration | 1 | Gain Selection | 11 |
| General Description | 1 | Input and Output Offset Voltage..... | 11 |
| Revision History | 2 | Reference Terminal | 11 |
| Specifications..... | 3 | Input Protection | 11 |
| Absolute Maximum Ratings..... | 5 | RF Interference | 12 |
| Thermal Resistance | 5 | Ground Returns for Input Bias Currents | 12 |
| ESD Caution..... | 5 | Outline Dimensions | 13 |
| Typical Performance Characteristics | 6 | Ordering Guide | 14 |

REVISION HISTORY

6/12—Rev. D to Rev. E

| | |
|---|----|
| Changes to General Description Section; Added Table 1 | 1 |
| Changes to Theory of Operation Section and Figure 16..... | 9 |
| Changes to Table 5..... | 10 |
| Changes to Input Selection Section; Deleted Large Input Voltages at Large Gains Section; Added Figure 18, Renumbered Sequentially | 11 |
| Changes to Ordering Guide | 14 |

8/07—Rev. C to Rev. D

| | |
|--|---|
| Updated Format..... Universal | |
| Added Thermal Resistance Section | 5 |
| Added Figure 16..... | 9 |

| | |
|---|----|
| Added Large Input Voltages at Large Gains Section | 11 |
| Replaced RF Interference Section | 11 |
| Deleted Grounding Section | 10 |
| Deleted Figure 16..... | 10 |
| Changes to Ground Returns for Input Bias Currents Section.. | 12 |
| Updated Outline Dimensions | 13 |
| Changes to Ordering Guide | 14 |

4/99—Rev. B to Rev. C

8/98—Rev. A to Rev. B

2/97—Rev. 0 to Rev. A

1/96—Revision 0: Initial Version

SPECIFICATIONS

$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{ V}$, and $R_L = 2\text{ k}\Omega$ typical, unless otherwise noted.

Table 2.

| Parameter | Conditions | Min | Typ | Max | Unit |
|--|---|---------------|----------|---------------|------------------------------|
| GAIN | $G = 1 + (50.5\text{ k}/R_G)$ | | | | |
| Gain Range | | 1 | | 1000 | |
| Gain Error ¹ | $V_{OUT} = \pm 10\text{ V}$ | | | | |
| $G = 1$ | | | 0.05 | 0.15 | % |
| $G = 10$ | | | 0.2 | 0.50 | % |
| $G = 100$ | | | 0.2 | 0.50 | % |
| $G = 1000$ | | | 0.2 | 0.50 | % |
| Nonlinearity | $V_{OUT} = \pm 10\text{ V}$ | | | | |
| $G = 1$ to 1000 | $R_L = 10\text{ k}\Omega$ | | 10 | | ppm |
| $G = 1$ to 100 | $R_L = 2\text{ k}\Omega$ | | 10 | | ppm |
| Gain vs. Temperature | Gain = 1 | | | 10 | ppm/ $^\circ\text{C}$ |
| | Gain > 1 ¹ | | | -50 | ppm/ $^\circ\text{C}$ |
| VOLTAGE OFFSET | Total RTI Error = $V_{OSI} + V_{OSO}/G$ | | | | |
| Input Offset, V_{OSI} | $V_S = \pm 5\text{ V to } \pm 15\text{ V}$ | | 60 | 125 | μV |
| Average Temperature Coefficient | $V_S = \pm 5\text{ V to } \pm 15\text{ V}$ | | | 1.0 | $\mu\text{V}/^\circ\text{C}$ |
| Output Offset, V_{OSO} | $V_S = \pm 5\text{ V to } \pm 15\text{ V}$ | | 600 | 1500 | μV |
| Average Temperature Coefficient | $V_S = \pm 5\text{ V to } \pm 15\text{ V}$ | | | 15 | $\mu\text{V}/^\circ\text{C}$ |
| Offset Referred to Input vs. Supply (PSR) | $V_S = \pm 5\text{ V to } \pm 15\text{ V}$ | | | | |
| $G = 1$ | | 80 | 100 | | dB |
| $G = 10$ | | 95 | 120 | | dB |
| $G = 100$ | | 110 | 140 | | dB |
| $G = 1000$ | | 110 | 140 | | dB |
| INPUT CURRENT | | | | | |
| Input Bias Current | | | 2.0 | 5.0 | nA |
| Average Temperature Coefficient | | | 3.0 | | pA/ $^\circ\text{C}$ |
| Input Offset Current | | | 0.7 | 2.5 | nA |
| Average Temperature Coefficient | | | 2.0 | | pA/ $^\circ\text{C}$ |
| INPUT | | | | | |
| Input Impedance | | | | | |
| Differential | | | 10 2 | | $\text{G}\Omega \text{pF}$ |
| Common Mode | | | 10 2 | | $\text{G}\Omega \text{pF}$ |
| Input Voltage Range ² | $V_S = \pm 2.6\text{ V to } \pm 5\text{ V}$ | - $V_S + 1.9$ | | + $V_S - 1.2$ | V |
| Over Temperature | | - $V_S + 2.1$ | | + $V_S - 1.3$ | V |
| | $V_S = \pm 5\text{ V to } \pm 18\text{ V}$ | - $V_S + 1.9$ | | + $V_S - 1.4$ | V |
| Over Temperature | | - $V_S + 2.1$ | | + $V_S - 1.4$ | V |
| Common-Mode Rejection Ratio | $V_{CM} = 0\text{ V to } \pm 10\text{ V}$ | | | | |
| DC to 60 Hz with 1 k Ω Source Imbalance | | | | | |
| $G = 1$ | | 66 | 78 | | dB |
| $G = 10$ | | 86 | 98 | | dB |
| $G = 100$ | | 103 | 118 | | dB |
| $G = 1000$ | | 103 | 118 | | dB |
| OUTPUT | | | | | |
| Output Swing | $R_L = 10\text{ k}\Omega$ | | | | |
| | $V_S = \pm 2.6\text{ V to } \pm 5\text{ V}$ | - $V_S + 1.1$ | | + $V_S - 1.2$ | V |
| Over Temperature | | - $V_S + 1.4$ | | + $V_S - 1.3$ | V |
| | $V_S = \pm 5\text{ V to } \pm 18\text{ V}$ | - $V_S + 1.2$ | | + $V_S - 1.4$ | V |
| Over Temperature | | - $V_S + 1.6$ | | + $V_S - 1.5$ | V |
| Short Current Circuit | | | ± 18 | | mA |

| Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--|---------------|------------|--------------|--------|
| DYNAMIC RESPONSE | | | | | |
| Small Signal –3 dB Bandwidth | | | | | |
| G = 1 | | | 1000 | | kHz |
| G = 10 | | | 800 | | kHz |
| G = 100 | | | 120 | | kHz |
| G = 1000 | | | 12 | | kHz |
| Slew Rate | | | 1.2 | | V/μs |
| Settling Time to 0.1% | 10 V step | | | | |
| G = 1 to 100 | | | 10 | | μs |
| NOISE | | | | | |
| Voltage Noise, 1 kHz | Total RTI Noise = $\sqrt{(e_{ni}^2) + (e_{no}/G)^2}$ | | | | |
| Input Voltage Noise, e_{ni} | | | 12 | | nV/√Hz |
| Output Voltage Noise, e_{no} | | | 72 | | nV/√Hz |
| RTI, 0.1 Hz to 10 Hz | | | | | |
| G = 1 | | | 4.0 | | μV p-p |
| G = 10 | | | 0.6 | | μV p-p |
| G = 100 | | | 0.3 | | μV p-p |
| Current Noise | f = 1 kHz | | 100 | | fA/√Hz |
| 0.1 Hz to 10 Hz | | | 10 | | pA p-p |
| REFERENCE INPUT | | | | | |
| R_{IN} | | | 20 | | kΩ |
| I_{IN} | $V_{IN+}, V_{REF} = 0$ | | 50 | 60 | μA |
| Voltage Range | | – $V_S + 1.6$ | | $+V_S - 1.6$ | V |
| Gain to Output | | | 1 ± 0.0015 | | |
| POWER SUPPLY | | | | | |
| Operating Range ³ | | ±2.6 | | ±18 | V |
| Quiescent Current | $V_S = \pm 2.6 \text{ V to } \pm 18 \text{ V}$ | | 0.9 | 1.3 | mA |
| Over Temperature | | | 1.1 | 1.5 | mA |
| TEMPERATURE RANGE | | | | | |
| For Specified Performance | | | –40 to +85 | | °C |

¹ Does not include effects of External Resistor R_G .

² One input grounded, G = 1.

³ Defined as the same supply range that is used to specify PSR.

ABSOLUTE MAXIMUM RATINGS

Table 3.

| Parameter | Rating |
|---|---|
| Supply Voltage | ± 18 V |
| Internal Power Dissipation ¹ | 650 mW |
| Input Voltage (Common Mode) | $\pm V_s$ |
| Differential Input Voltage ² | ± 25 V |
| Output Short Circuit Duration | Indefinite |
| Storage Temperature Range | -65°C to $+125^{\circ}\text{C}$ |
| Operating Temperature Range | -40°C to $+85^{\circ}\text{C}$ |
| Lead Temperature (Soldering, 10 sec) | 300°C |

¹ Specification is for device in free air; see Table 4.

² May be further restricted for gains greater than 14. See the Input Protection section for more information.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the device in free air.

Table 4. Thermal Resistance

| Package Type | θ_{JA} | Unit |
|---------------------|---------------|-----------------------------|
| 8-Lead PDIP (N-8) | 95 | $^{\circ}\text{C}/\text{W}$ |
| 8-Lead SOIC_N (R-8) | 155 | $^{\circ}\text{C}/\text{W}$ |

ESD CAUTION



ESD (electrostatic discharge) sensitive device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{ V}$, $R_L = 2\text{ k}\Omega$, unless otherwise noted.

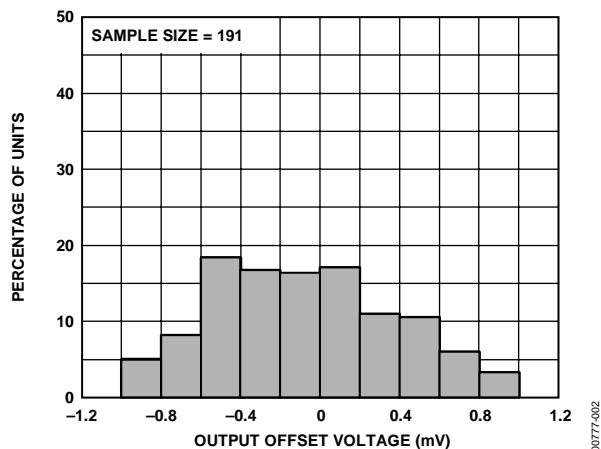


Figure 2. Typical Distribution of Output Offset Voltage

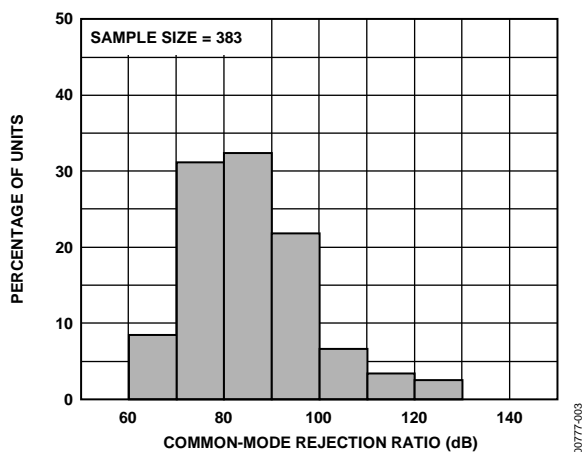


Figure 3. Typical Distribution of Common-Mode Rejection

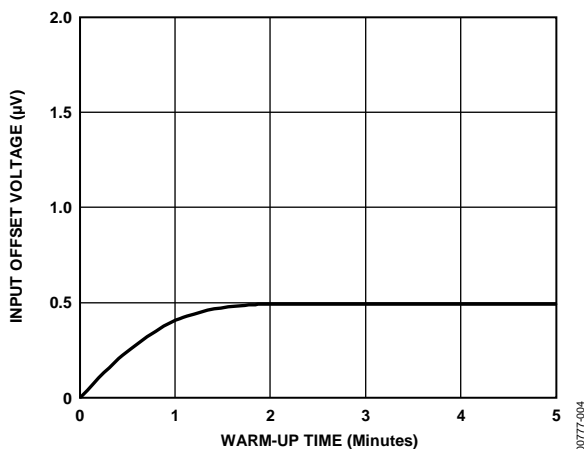


Figure 4. Change in Input Offset Voltage vs. Warm-Up Time

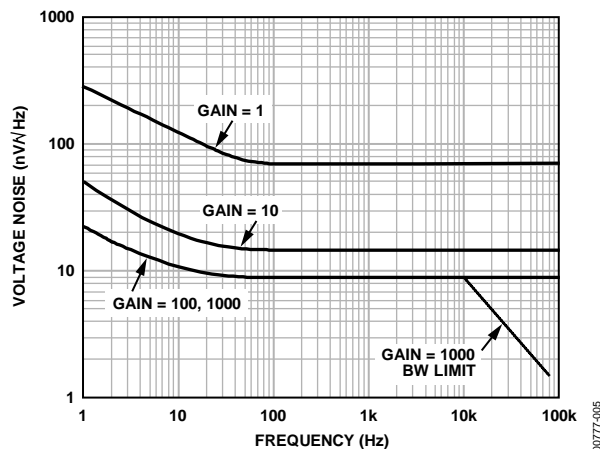


Figure 5. Voltage Noise Spectral Density vs. Frequency ($G = 1$ to 1000)

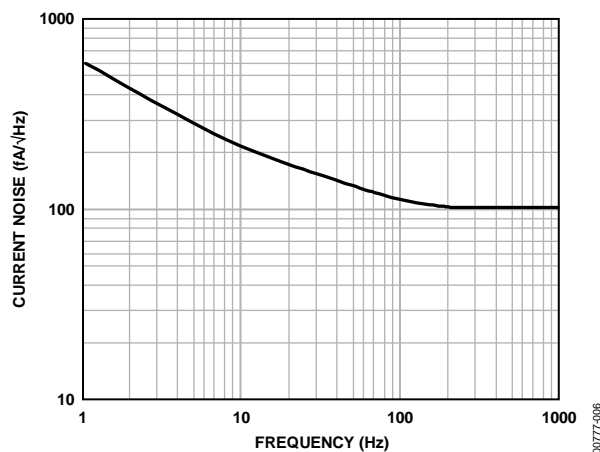


Figure 6. Current Noise Spectral Density vs. Frequency

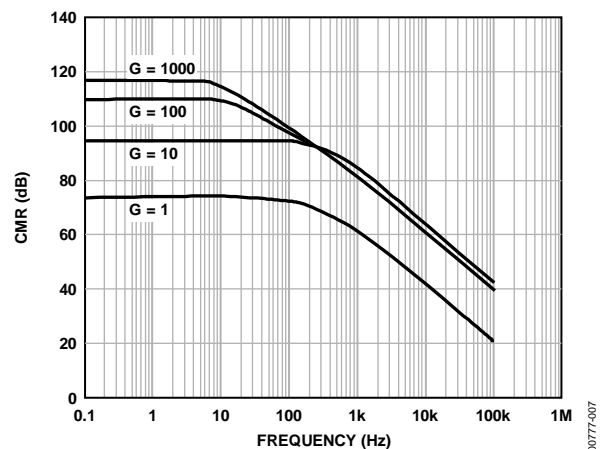


Figure 7. CMR vs. Frequency, RTI, 0 k Ω to 1 k Ω Source Imbalance

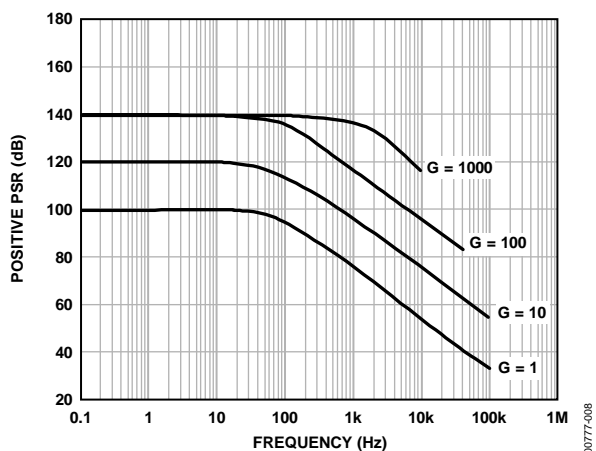


Figure 8. Positive PSR vs. Frequency, RTI (G = 1 to 1000)

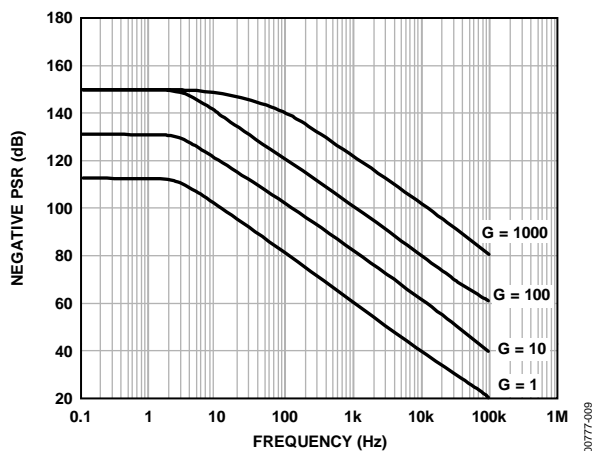


Figure 9. Negative PSR vs. Frequency, RTI (G = 1 to 1000)

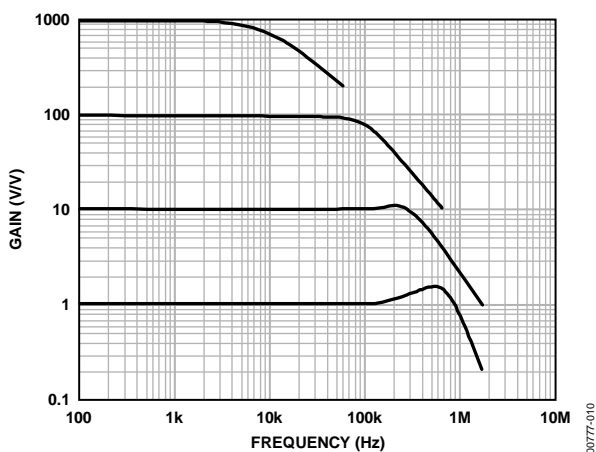


Figure 10. Gain vs. Frequency

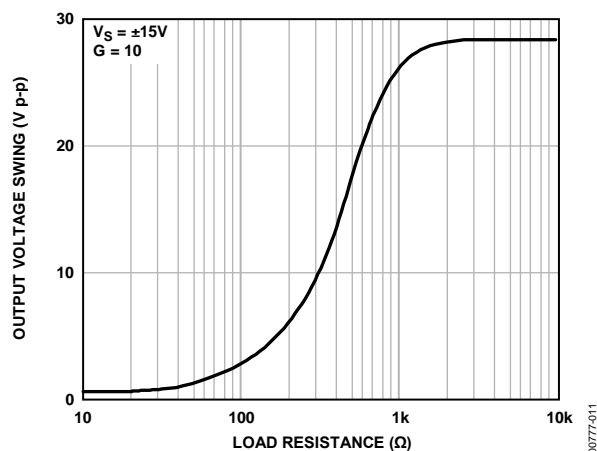


Figure 11. Output Voltage Swing vs. Load Resistance

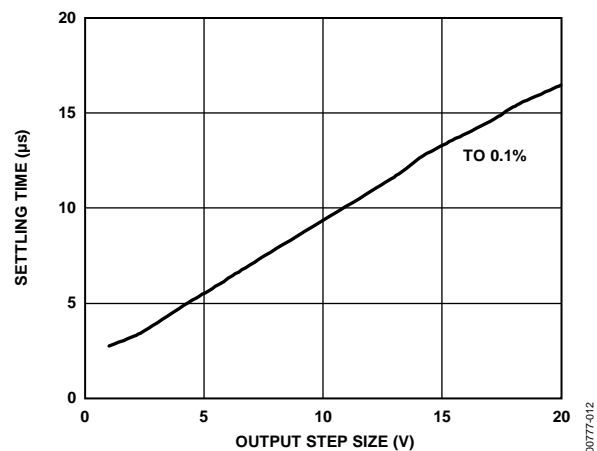


Figure 12. Settling Time vs. Step Size (G = 1)

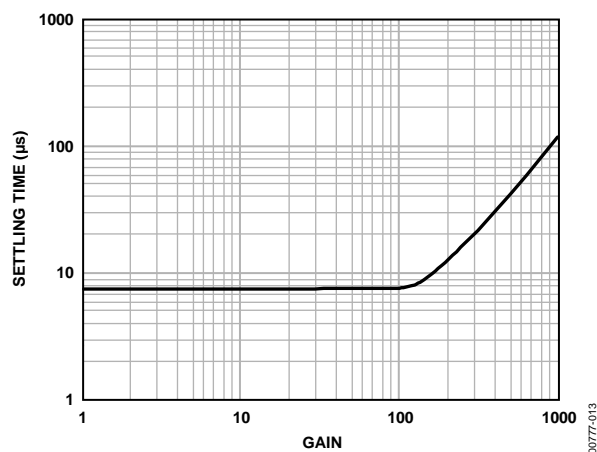


Figure 13. Settling Time to 0.1% vs. Gain, for a 10 V Step

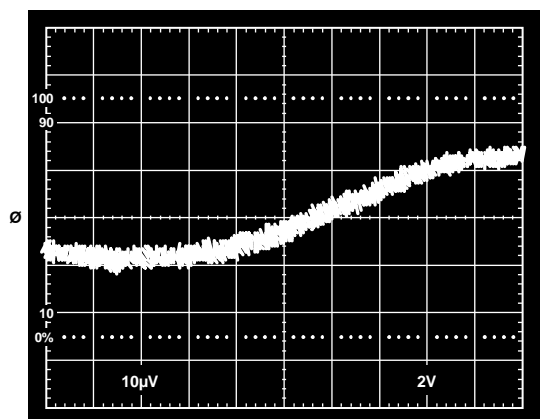


Figure 14. Gain Nonlinearity, $G = 1$, $R_L = 10 \text{ k}\Omega$ ($20 \mu\text{V} = 2 \text{ ppm}$)

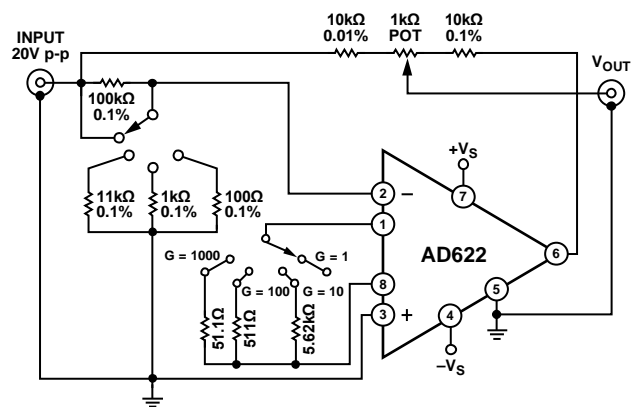


Figure 15. Settling Time Test Circuit

THEORY OF OPERATION

The AD622 is a monolithic instrumentation amplifier based on a modification of the classic three op amp approach. Absolute value trimming allows the user to program gain accurately (to 0.5% at $G = 1000$) with only one resistor. Monolithic construction and laser wafer trimming allow the tight matching and tracking of circuit components, thus insuring AD622 performance.

Input Transistor Q1 and Input Transistor Q2 provide a single differential-pair bipolar input for high precision (see Figure 16). Feedback through the Q1-A1-R1 loop and the Q2-A2-R2 loop maintains constant collector current of the Q1 and Q2 input devices, thereby impressing the input voltage across External Gain-Setting Resistor R_G . This creates a differential gain from the inputs to the A1 and A2 outputs given by $G = (R_1 + R_2)/R_G + 1$. Unity-Gain Subtractor A3 removes any common-mode signal, yielding a single-ended output referred to the REF pin potential.

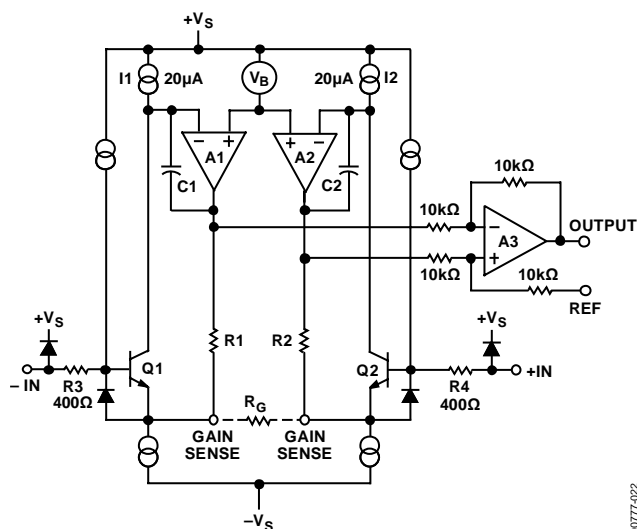
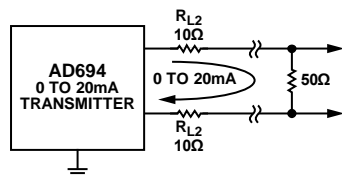
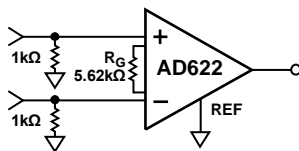


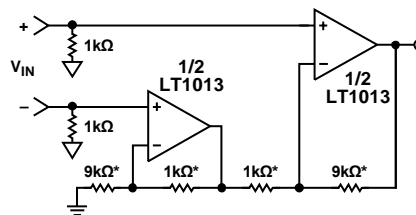
Figure 16. Simplified Schematic of the AD622



0 TO 20mA CURRENT LOOP
WITH 50Ω SHUNT IMPEDANCE



AD622 MONOLITHIC INSTRUMENTATION
AMPLIFIER, $G = 9.986$



*0.1% RESISTOR MATCH, 50ppm/°C TRACKING

HOMEBREW IN-AMP, $G = 10$

Figure 17. Make vs. Buy

The value of R_G also determines the transconductance of the preamp stage. As R_G is reduced for larger gains, the transconductance increases asymptotically to that of the input transistors. This has the following three important advantages:

- Open-loop gain is boosted for increasing programmed gain, thus reducing gain-related errors.
- The gain-bandwidth product (determined by C_1 , C_2 , and the preamp transconductance) increases with programmed gain, thus optimizing frequency response.
- The input voltage noise is reduced to a value of 12 nV/√Hz, determined mainly by the collector current and base resistance of the input devices.

The internal gain resistors, R_1 and R_2 , are trimmed to an absolute value of 25.25 kΩ, allowing the gain to be programmed accurately with a single external resistor.

MAKE vs. BUY: A TYPICAL APPLICATION ERROR BUDGET

The AD622 offers cost and performance advantages over discrete two op amp instrumentation amplifier designs along with smaller size and fewer components. In a typical application shown in Figure 17, a gain of 10 is required to receive and amplify a 0 to 20 mA signal from the AD694 current transmitter. The current is converted to a voltage in a 50 Ω shunt. In applications where transmission is over long distances, line impedance can be significant so that differential voltage measurement is essential. Where there is no connection between the ground returns of transmitter and receiver, there must be a dc path from each input to ground, implemented in this case using two 1 kΩ resistors. The error budget detailed in Table 5 shows how to calculate the effect of various error sources on circuit accuracy.

The AD622 provides greater accuracy at lower cost. The higher cost of the homebrew circuit is dominated in this case by the matched resistor network. One could also realize a homebrew design using cheaper discrete resistors that are either trimmed or hand selected to give high common-mode rejection. This level of common-mode rejection, however, degrades significantly

over temperature due to the drift mismatch of the discrete resistors.

Note that for the homebrew circuit, the LT1013 specification for noise has been multiplied by $\sqrt{2}$. This is because a two op amp type instrumentation amplifier has two op amps at its inputs, both contributing to the overall noise.

Table 5. Make vs. Buy Error Budget

| Error Source | AD622 Circuit Calculation | Homebrew Circuit Calculation | Total Error in ppm Relative to 1 V FS | |
|--|---|--|--|----------|
| | | | AD622 | Homebrew |
| ABSOLUTE ACCURACY at $T_A = 25^\circ\text{C}$ | | | | |
| Total RTI Offset Voltage, μV | $125 \mu\text{V} + 1500 \mu\text{V}/10$ | $800 \mu\text{V} \times 2$ | 275 | 1600 |
| Input Offset Current, nA | $2.5 \text{ nA} \times 1 \text{ k}\Omega$ | $15 \text{ nA} \times 1 \text{ k}\Omega$ | 2.5 | 15 |
| CMR, dB | $86 \text{ dB} \rightarrow 50 \text{ ppm} \times 0.5 \text{ V}$ | $(0.1\% \text{ Match} \times 0.5 \text{ V})/10 \text{ V}$ | 25 | 50 |
| | | Total Absolute Error | 302.5 | 1665 |
| DRIFT TO 85°C | | | | |
| Gain Drift, ppm/ $^\circ\text{C}$ | $(50 \text{ ppm} + 5 \text{ ppm}) \times 60^\circ\text{C}$ | $(50 \text{ ppm})/^\circ\text{C} \times 60^\circ\text{C}$ | 3300 | 3000 |
| Total RTI Offset Voltage, $\mu\text{V}/^\circ\text{C}$ | $(1 \mu\text{V}/^\circ\text{C} + 15 \mu\text{V}/^\circ\text{C}/10) \times 60^\circ\text{C}$ | $9 \mu\text{V}/^\circ\text{C} \times 2 \times 60^\circ\text{C}$ | 150 | 1080 |
| Input Offset Current, pA/ $^\circ\text{C}$ | $2 \text{ pA}/^\circ\text{C} \times 1 \text{ k}\Omega \times 60^\circ\text{C}$ | $155 \text{ pA}/^\circ\text{C} \times 1 \text{ k}\Omega \times 60^\circ\text{C}$ | 0.12 | 9.3 |
| | | Total Drift Error | 3450.12 | 4089.3 |
| RESOLUTION | | | | |
| Gain Nonlinearity, ppm of Full Scale | 10 ppm | 20 ppm | 10 | 20 |
| Typ 0.1 Hz to 10 Hz Voltage Noise, $\mu\text{V p-p}$ | 0.6 $\mu\text{V p-p}$ | $0.55 \mu\text{V p-p} \times \sqrt{2}$ | 0.6 | 0.778 |
| | | Total Resolution Error | 10.6 | 20.778 |
| | | Grand Total Error | 3763 | 5775 |

GAIN SELECTION

The AD622 gain is resistor programmed by R_G or, more precisely, by whatever impedance appears between Pin 1 and Pin 8. The AD622 is designed to offer gains as close as possible to popular integer values using standard 1% resistors. Table 6 shows required values of R_G for various gains. Note that for $G = 1$, the R_G pins are unconnected ($R_G = \infty$). For any arbitrary gain, R_G can be calculated by using the formula

$$R_G = \frac{50.5 \text{ k}\Omega}{G - 1}$$

To minimize gain error, avoid high parasitic resistance in series with R_G . To minimize gain drift, R_G should have a low temperature coefficient less than 10 ppm/°C for the best performance.

Table 6. Required Values of Gain Resistors

| Desired Gain | 1% Std Table Value of R_G , Ω | Calculated Gain |
|--------------|--|-----------------|
| 2 | 51.1 k | 1.988 |
| 5 | 12.7 k | 4.976 |
| 10 | 5.62 k | 9.986 |
| 20 | 2.67 k | 19.91 |
| 33 | 1.58 k | 32.96 |
| 40 | 1.3 k | 39.85 |
| 50 | 1.02 k | 50.50 |
| 65 | 787 | 65.17 |
| 100 | 511 | 99.83 |
| 200 | 255 | 199.0 |
| 500 | 102 | 496.1 |
| 1000 | 51.1 | 989.3 |

INPUT AND OUTPUT OFFSET VOLTAGE

The low errors of the AD622 are attributable to two sources: input and output errors. The output error is divided by G when referred to the input. In practice, the input errors dominate at high gains and the output errors dominate at low gains. The total V_{OS} for a given gain is calculated as follows:

$$\text{Total Error RTI} = \text{input error} + (\text{output error}/G)$$

$$\text{Total Error RTO} = (\text{input error} \times G) + \text{output error}$$

REFERENCE TERMINAL

The reference terminal potential defines the zero output voltage and is especially useful when the load does not share a precise ground with the rest of the system. The reference terminal provides a direct means of injecting a precise offset to the output, with an allowable range of 2 V within the supply voltages. Parasitic resistance should be kept to a minimum for optimum CMR.

INPUT PROTECTION

The AD622 safely withstands an input current of ± 60 mA for several hours at room temperature. This is true for all gains and power on and off, which is useful if the signal source and amplifier are powered separately. For longer time periods, the input current should not exceed 6 mA.

For input voltages beyond the supplies, a protection resistor should be placed in series with each input to limit the current to 6 mA. These can be the same resistors as those used in the RFI filter. High values of resistance can impact the noise and AC CMRR performance of the system. Low leakage diodes (such as the BAV199) can be placed at the inputs to reduce the required protection resistance.

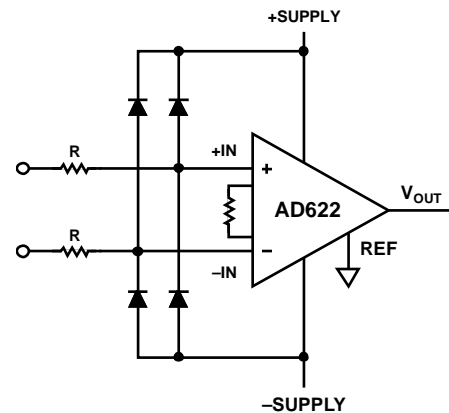


Figure 18. Diode Protection for Voltages Beyond Supply

RF INTERFERENCE

RF rectification is often a problem when amplifiers are used in applications where there are strong RF signals. The disturbance may appear as a small dc offset voltage. High frequency signals can be filtered with a low-pass, RC network placed at the input of the instrumentation amplifier, as shown in Figure 19. In addition, this RC input network also provides additional input overload protection (see the Input Protection section).

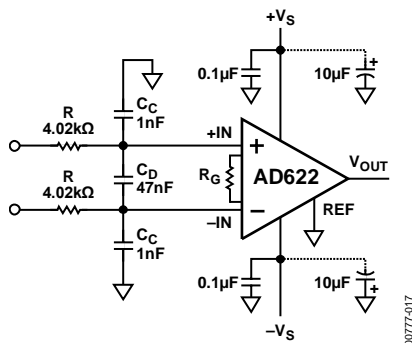


Figure 19. RFI Suppression Circuit for AD622 Series In-Amps

The filter limits the input signal bandwidth to the following cutoff frequencies:

$$FilterFreq_{DIFF} = \frac{1}{2\pi R(2C_D + C_C)}$$

$$FilterFreq_{CM} = \frac{1}{2\pi RC_C}$$

where $C_D \geq 10C_C$.

Figure 19 shows an example where the differential filter frequency is approximately 400 Hz, and the common-mode filter frequency is approximately 40 kHz. With this differential filter in place and operating at gain of 1000, the typical dc offset shift over a frequency range of 1 Hz to 20 MHz is less than 1.5 μV RTI, and the RF signal rejection of the circuit is better than 71 dB. At a gain of 100, the dc offset shift is well below 1 mV RTI, and RF rejection is greater than 70 dB.

The input resistors should be selected to be high enough to isolate the sensor from the C_C and C_D capacitors but low enough not to influence system noise. Mismatch between $R \times C_C$ at the positive input and $R \times C_C$ at the negative input degrades the CMRR of the AD622. Therefore, the C_C capacitors should be high precision types such as NPO/COG ceramics. The tolerance of the C_D capacitor is less critical.

GROUND RETURNS FOR INPUT BIAS CURRENTS

Input bias currents are those currents necessary to bias the input transistors of an amplifier. There must be a direct return path for these currents; therefore, when amplifying floating input sources such as transformers or ac-coupled sources, there must be a dc path from each input to ground as shown in Figure 20, Figure 21, and Figure 22. Refer to the [Designer's Guide to Instrumentation Amplifiers](#) (free from Analog Devices, Inc.) for more information regarding in-amp applications.

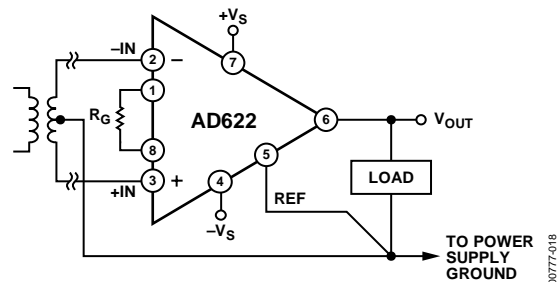


Figure 20. Ground Returns for Bias Currents with Transformer Coupled Inputs

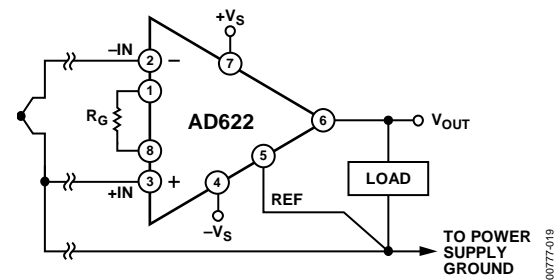


Figure 21. Ground Returns for Bias Currents with Thermocouple Inputs

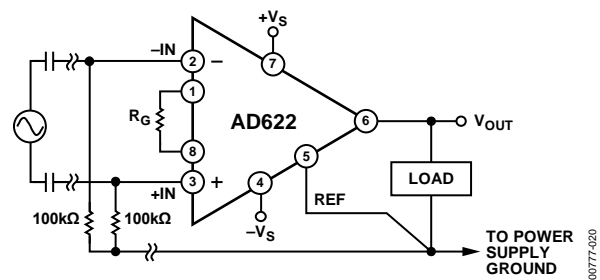
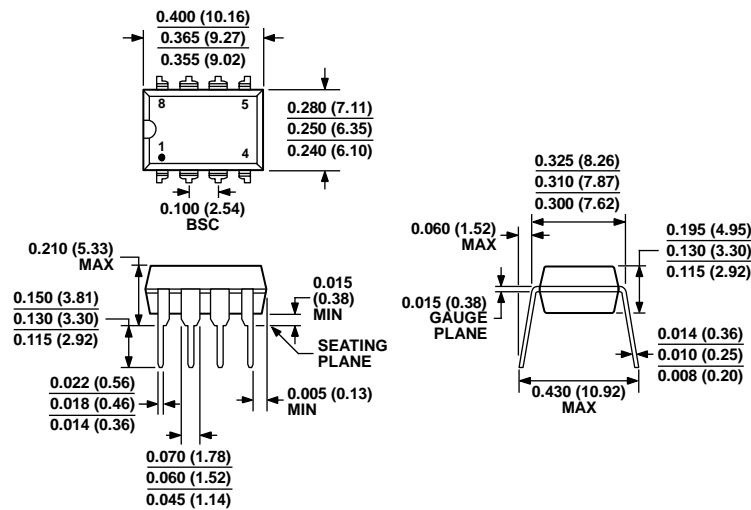


Figure 22. Ground Returns for Bias Currents with AC-Coupled Inputs

OUTLINE DIMENSIONS

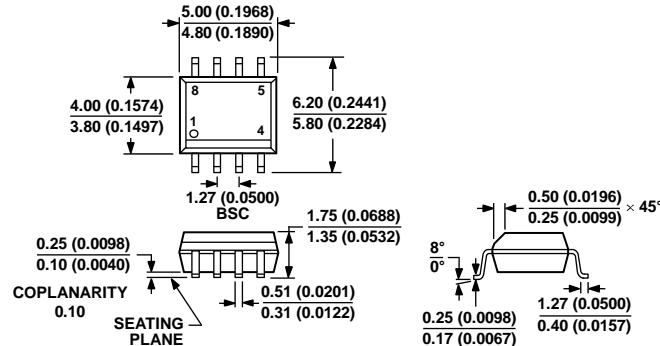


COMPLIANT TO JEDEC STANDARDS MS-001
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

Figure 23. 8-Lead Plastic Dual In-Line Package [PDIP]
Narrow Body
(N-8)

Dimensions shown in inches and (millimeters)

070606-A



COMPLIANT TO JEDEC STANDARDS MS-012-AA
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 24. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-8)

Dimensions shown in millimeters and (inches)

012407-A

ORDERING GUIDE

| Model ¹ | Temperature Range | Package Description | Package Option |
|--------------------|-------------------|---------------------|----------------|
| AD622ANZ | –40°C to +85°C | 8-Lead PDIP | N-8 |
| AD622AR | –40°C to +85°C | 8-Lead SOIC_N | R-8 |
| AD622AR-REEL | –40°C to +85°C | 8-Lead SOIC_N | R-8 |
| AD622AR-REEL7 | –40°C to +85°C | 8-Lead SOIC_N | R-8 |
| AD622ARZ | –40°C to +85°C | 8-Lead SOIC_N | R-8 |
| AD622ARZ-RL | –40°C to +85°C | 8-Lead SOIC_N | R-8 |
| AD622ARZ-R7 | –40°C to +85°C | 8-Lead SOIC_N | R-8 |

¹ Z = RoHS Compliant Part.

NOTES

NOTES

SPECIFICATIONS

USB-6218

Isolated 32 AI (16-Bit, 250 kS/s), 2 AO (250 kS/s), 8 DI, 8 DIO USB Multifunction I/O Device

These specifications apply to the USB-218 BNC and USB-6218 Spring Terminal.

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

The following characteristic specifications describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the performance met by a majority of models.
- *Nominal* specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are *Typical* unless otherwise noted.

Conditions

Specifications are valid at 25 °C unless otherwise noted.

Analog Input

| | |
|----------------------------------|---|
| Number of channels | 16 differential or 32 single ended |
| ADC resolution | 16 bits |
| DNL | No missing codes guaranteed |
| INL | Refer to the AI Absolute Accuracy section |
| Sample rate | |
| Single channel maximum | 250 kS/s |
| Multichannel maximum (aggregate) | 250 kS/s |
| Minimum | 0 S/s |
| Timing resolution | 50 ns |

| | |
|--|---|
| Timing accuracy | 50 ppm of sample rate |
| Input coupling | DC |
| Input range | ± 0.2 V, ± 1 V, ± 5 V, ± 10 V |
| Maximum working voltage for analog inputs (signal + common mode) | ± 10.4 V of AI GND |
| CMRR (DC to 60 Hz) | 100 dB |
| Input impedance | |
| Device on | |
| AI+ to AI GND | >10 G Ω in parallel with 100 pF |
| AI- to AI GND | >10 G Ω in parallel with 100 pF |
| Device off | |
| AI+ to AI GND | 1,200 Ω |
| AI- to AI GND | 1,200 Ω |
| Input bias current | ± 100 pA |
| Crosstalk (at 100 kHz) | |
| Adjacent channels | -75 dB |
| Non-adjacent channels | -90 dB |
| Small signal bandwidth (-3 dB) | 450 kHz |
| Input FIFO size | 4,095 samples |
| Scan list memory | 4,095 entries |
| USB | USB Signal Stream, programmed I/O |
| Overvoltage protection for all analog input and sense channels | |
| Device on | ± 30 V for up to two AI pins |
| Device off | ± 20 V for up to two AI pins |
| Input current during overvoltage condition | ± 20 mA maximum/AI pin |

Settling Time for Multichannel Measurements

| | |
|---------------------------------------|----------------------------|
| Accuracy, full-scale step, all ranges | |
| ± 90 ppm of step (± 6 LSB) | 4 μ s convert interval |
| ± 30 ppm of step (± 2 LSB) | 5 μ s convert interval |
| ± 15 ppm of step (± 1 LSB) | 7 μ s convert interval |

Typical Performance Graphs

Figure 1. Settling Error versus Time for Different Source Impedances

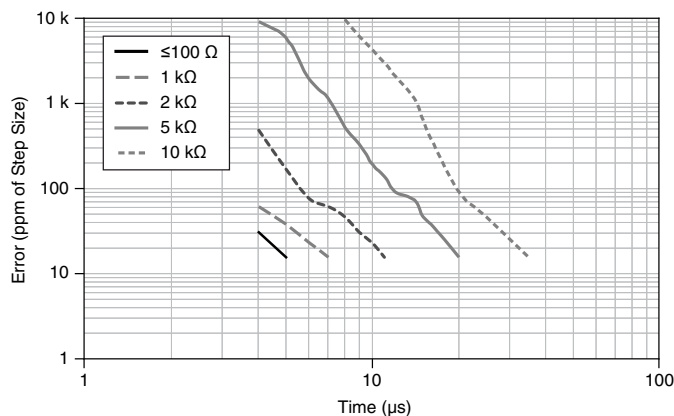
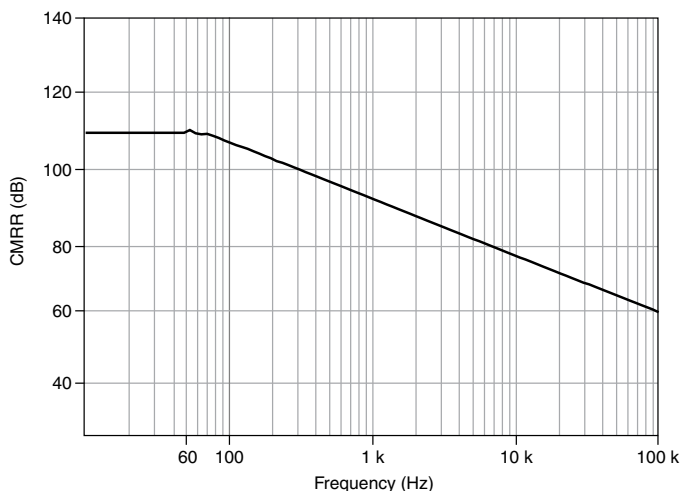


Figure 2. AI CMRR



Absolute Accuracy (Warranted)



Note Accuracies listed are valid for up to one year from the device external calibration.



Note The input/output channels of this device are not protected for electromagnetic interference due to functional reasons. As a result, this device may experience

reduced measurement accuracy or other temporary performance degradation when connected cables are routed in an environment with radiated or conducted radio frequency electromagnetic interference. To ensure that this device functions within specifications in its operational electromagnetic environment and to limit radiated emissions, care should be taken in the selection, design, and installation of measurement probes and cables.

Table 1. AI Absolute Accuracy

| Nominal Range Positive Full Scale (V) | Nominal Range Negative Full Scale (V) | Residual Gain Error (ppm of Reading) | Residual Offset Error (ppm of Range) | Offset Tempco (ppm of Range/°C) | Random Noise, σ (μ Vrms) | Absolute Accuracy at Full Scale (μ V) | Sensitivity (μ V) |
|---------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|---------------------------------|--------------------------------------|--|------------------------|
| 10 | -10 | 75 | 20 | 34 | 229 | 2,690 | 91.6 |
| 5 | -5 | 85 | 20 | 36 | 118 | 1,410 | 47.2 |
| 1 | -1 | 95 | 25 | 49 | 26 | 310 | 10.4 |
| 0.2 | -0.2 | 135 | 40 | 116 | 12 | 88 | 4.8 |



Note Sensitivity is the smallest voltage change that can be detected. It is a function of noise.

Gain tempco 7.3 ppm/°C

Reference tempco 5 ppm/°C

INL error 76 ppm of range

AI Absolute Accuracy Equation

$$\text{AbsoluteAccuracy} = \text{Reading} \cdot (\text{GainError}) + \text{Range} \cdot (\text{OffsetError}) + \text{NoiseUncertainty}$$

$$\text{GainError} = \text{ResidualAIGainError} + \text{GainTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \cdot (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualAIOffsetError} + \text{OffsetTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{INLError}$$

$$\text{NoiseUncertainty} = \frac{\text{Random Noise} \cdot 3}{\sqrt{100}} \text{ for a coverage factor of } 3 \sigma \text{ and averaging } 100 \text{ points.}$$

AI Absolute Accuracy Example

Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

- TempChangeFromLastExternalCal = 10 °C
- TempChangeFromLastInternalCal = 1 °C
- number_of_readings = 100
- CoverageFactor = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

GainError = 75 ppm + 7.3 ppm · 1 + 5 ppm · 10 = 132 ppm

OffsetError = 20 ppm + 34 ppm · 1 + 76 ppm = 130 ppm

NoiseUncertainty = $\frac{229 \mu V \cdot 3}{\sqrt{100}}$ = 68.7 μV

AbsoluteAccuracy = 10 V · (GainError) + 10 V · (OffsetError) + NoiseUncertainty = 2,690 μV

Analog Output

| | |
|----------------------|--|
| Number of channels | 2 |
| DAC resolution | 16 bits |
| DNL | ±1 LSB |
| Monotonicity | 16 bit guaranteed |
| Maximum update rate | |
| 1 channel | 250 kS/s |
| 2 channels | 250 kS/s per channel |
| Timing accuracy | 50 ppm of sample rate |
| Timing resolution | 50 ns |
| Output range | ±10 V |
| Output coupling | DC |
| Output impedance | 0.2 Ω |
| Output current drive | ±2 mA |
| Overdrive protection | ±30 V |
| Overdrive current | 2.4 mA |
| Power-on state | ±20 mV |
| Power-on glitch | ±1 V for 200 ms |
| Output FIFO size | 8,191 samples shared among channels used |

| | |
|--|--|
| Data transfers | USB Signal Stream, programmed I/O |
| AO waveform modes | Non-periodic waveform, periodic waveform regeneration mode from onboard FIFO, periodic waveform regeneration from host buffer including dynamic update |
| Settling time, full-scale step, 15 ppm (1 LSB) | 32 μ s |
| Slew rate | 5 V/ μ s |
| Glitch energy | |
| Magnitude | 100 mV |
| Duration | 2.6 μ s |

AO Absolute Accuracy (Warranted)

Absolute accuracy at full-scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration.



Note Accuracies listed are valid for up to one year from the device external calibration.



Note The input/output channels of this device are not protected for electromagnetic interference due to functional reasons. As a result, this device may experience reduced measurement accuracy or other temporary performance degradation when connected cables are routed in an environment with radiated or conducted radio frequency electromagnetic interference. To ensure that this device functions within specifications in its operational electromagnetic environment and to limit radiated emissions, care should be taken in the selection, design, and installation of measurement probes and cables.

Table 2. AO Absolute Accuracy

| Nominal Range Positive Full Scale (V) | Nominal Range Negative Full Scale (V) | Residual Gain Error (ppm of Reading) | Gain Tempco (ppm/°C) | Residual Offset Error (ppm of Range) | Offset Tempco (ppm of Range/°C) | Absolute Accuracy at Full Scale (μ V) |
|---------------------------------------|---------------------------------------|--------------------------------------|----------------------|--------------------------------------|---------------------------------|--|
| 10 | -10 | 90 | 11 | 60 | 12 | 3,512 |

| | |
|------------------|------------------|
| Reference tempco | 5 ppm/°C |
| INL error | 128 ppm of range |

AO Absolute Accuracy Equation

$$\text{AbsoluteAccuracy} = \text{OutputValue} \cdot (\text{GainError}) + \text{Range} \cdot (\text{OffsetError})$$
$$\text{GainError} = \text{ResidualGainError} + \text{GainTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \cdot (\text{TempChangeFromLastExternalCal})$$
$$\text{OffsetError} = \text{ResidualOffsetError} + \text{AOOffsetTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{INLError}$$

Digital I/O and PFI

Static Digital I/O Characteristics

| | |
|-----------------------------------|--|
| Number of digital input channels | 8 (PFI <0..3>/P0.<0..3>, PFI <8..11>/P0.<4..7>) |
| Number of digital output channels | 8 (PFI <4..7>/P1.<0..3>, PFI <12..15>/P1.<4..7>) |
| Ground reference | D GND |
| Pull-down resistor | 47 kΩ ±1% |
| Input voltage protection | ±20 V on up to 8 pins ¹ |

PFI Functionality

| | |
|---------------------------------|--|
| PFI <0..3>, PFI <8..11>/Port 0 | |
| Functionality | Static digital input, timing input |
| Debounce filter settings | 125 ns, 6.425 μs, 2.56 ms, disable; high and low transitions; selectable per input |
| PFI <4..7>, PFI <12..15>/Port 1 | |
| Functionality | Static digital output, timing output |
| Timing output sources | Many AI, AO, counter timing signals |

Maximum Operating Conditions

| | |
|-------------------------------------|----------------|
| I _{OL} output low current | 16 mA maximum |
| I _{OH} output high current | -16 mA maximum |

¹ Stresses beyond those listed under *Input voltage protection* may cause permanent damage to the device.

Digital Input Characteristics

| Level | Minimum | Maximum |
|--|---------|---------|
| V _{IL} input low voltage | 0 V | 0.8 V |
| V _{IH} input high voltage | 2 V | 5.25 V |
| I _{IL} input low current (V _{in} = 0 V) | - | -10 µA |
| I _{IH} input high current (V _{in} = 5 V) | - | 120 µA |

Digital Output Characteristics

| Parameter | Voltage Level | Current Level |
|-----------------|---------------|---------------|
| V _{OL} | 0.6 V | 6 mA |
| V _{OH} | 2.7 V | -16 mA |
| V _{OH} | 3.8 V | -6 mA |

General-Purpose Counters/Timers

| | |
|-------------------------------|---|
| Number of counter/timers | 2 |
| Resolution | 32 bits |
| Counter measurements | Edge counting, pulse, semi-period, period, two-edge separation |
| Position measurements | X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding |
| Output applications | Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling |
| Internal base clocks | 80 MHz, 20 MHz, 0.1 MHz |
| External base clock frequency | 0 MHz to 20 MHz |
| Base clock accuracy | 50 ppm |
| Inputs | Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down |
| Routing options for inputs | PFI <0..3>, PFI <8..11>, many internal signals |
| FIFO | 1,023 samples |
| Data transfers | USB Signal Stream, programmed I/O |

Frequency Generator

| | |
|---------------------|-----------------|
| Number of channels | 1 |
| Base clocks | 10 MHz, 100 kHz |
| Divisors | 1 to 16 |
| Base clock accuracy | 50 ppm |

Output can be available on any output PFI terminal.

External Digital Triggers

| | |
|------------------------|---|
| Source | PFI <0..3>, PFI <8..11> |
| Polarity | Software-selectable for most signals |
| Analog input function | Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase |
| Analog output function | Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase |
| Counter/timer function | Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down |

Bus Interface

| | |
|-------------------|---|
| USB | USB 2.0 Hi-Speed or full-speed ² |
| USB Signal Stream | 4, can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1 |

Current Limits

| | |
|--------------------------------------|--|
| +5 V terminal as output ³ | |
| Voltage | 4.6 V to 5.2 V |
| Current (internally limited) | 50 mA maximum, shared with digital outputs |

² If you are using an USB M Series device in full-speed mode, device performance will be lower and you will not be able to achieve maximum sample/update rates.

³ These devices have a self-resetting fuse that opens when current exceeds this specification.

+5 V terminal as input³

| | |
|---------|-------------------------------------|
| Voltage | 4.75 V to 5.35 V |
| Current | 350 mA maximum, self-resetting fuse |



Caution Do *not* exceed 16 mA per DIO pin.

| | |
|------------|-------|
| Protection | ±10 V |
|------------|-------|

Power Requirements

| | |
|---------------------------|-------------------------------------|
| Input voltage on USB port | 4.5 V to 5.25 V in configured state |
| Maximum inrush current | 500 mA |
| No load typical current | 320 mA at 4.5 V |
| Maximum load | |
| Typical current | 400 mA at 4.5 V |
| Suspend current | 260 µA typical |

Physical Characteristics

| | |
|----------------------------------|--|
| Dimensions (includes connectors) | |
| BNC | 23.5 cm × 11.2 cm × 6.4 cm (9.25 in. × 4.40 in. × 2.50 in.) |
| Screw Terminal | 16.9 cm × 9.4 cm × 3.1 cm (6.65 in. × 3.70 in. × 1.20 in.) |
| Weight | |
| BNC | 950 g (33.5 oz) |
| Screw Terminal | 206 g (7.2 oz) |
| I/O connectors | |
| BNC | 19 BNCs and 26 screw terminals |
| Screw Terminal | 4 16-position combicon |
| Screw terminal wiring | 16 AWG to 28 AWG |
| Torque for screw terminals | 0.22 N · m to 0.25 N · m (2.0 lb · in. to 2.2 lb · in.) |
| USB connector | Series B receptacle |

To clean the device, wipe with a dry towel.

Calibration

| | |
|--------------------------|------------|
| Recommended warm-up time | 15 minutes |
| Calibration interval | 1 year |

Environmental

| | |
|-----------------------|---------------------------------|
| Operating temperature | 0 °C to 45 °C |
| Storage temperature | -20 °C to 70 °C |
| Humidity | 10% RH to 90% RH, noncondensing |
| Maximum altitude | 2,000 m |
| Pollution Degree | 2 |

Indoor use only.

Safety Voltages

Connect only voltages that are below these limits.

| | |
|--|--|
| Channel-to-earth ground ⁴ | |
| Continuous | ≤60 VDC Measurement Category I |
| Withstand | ≤1,000 Vrms, verified by a 5 s dielectric withstand test |
| Analog channel-to-AI GND or AO GND (in the following figure, $ V_a - V_c $) | ≤11 V, Measurement Category I |
| Digital channel-to-D GND (in the following figure, $ V_b - V_c $) | ≤5.25 V, Measurement Category I |

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.



Caution This device is rated for Measurement Category I and the voltage across the isolation barrier is limited to no greater than 30 Vrms/60 VDC/42.4 V_{pk}

⁴ In the figure, $|V_a - V_d|$, $|V_b - V_d|$, and $|V_c - V_d|$.

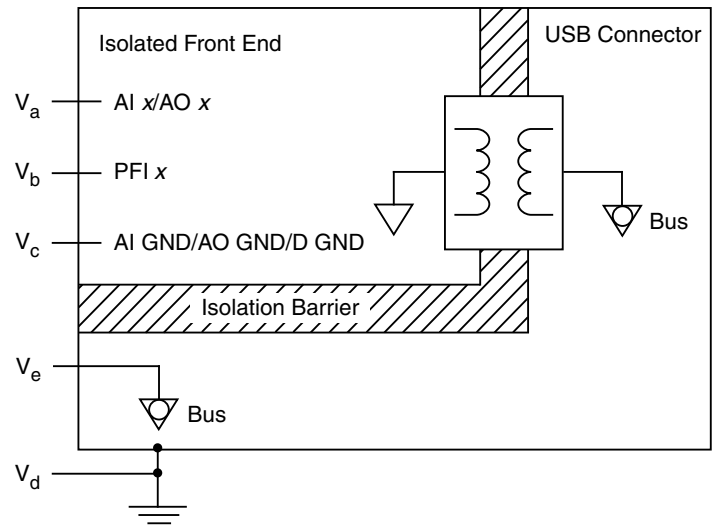
continuous. Do not use for measurements within Measurement Categories CAT II, CAT III, or CAT IV.



Note Measurement Categories CAT I and CAT O (Other) are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

The following figure illustrates the safety voltages specifications.

Figure 3. USB-6218 Safety Voltages



Safety

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1



Note For UL and other safety certifications, refer to the product label or the [Online Product Certification](#) section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use; for radio equipment; and for telecommunication terminal equipment:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions



Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.



Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.



Note For EMC declarations and certifications, and additional information, refer to the [Online Product Certification](#) section.

CE Compliance

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2011/65/EU; Restriction of Hazardous Substances (RoHS)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)



EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit ni.com/environment/weee.

电子信息产品污染控制管理办法（中国 RoHS）



中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Information is subject to change without notice. Refer to the *NI Trademarks and Logo Guidelines* at ni.com/trademarks for information on NI trademarks. Other product and company names mentioned herein are trademarks or trade names of their respective companies. For patents covering NI products/technology, refer to the appropriate location: **Help»Patents** in your software, the `patents.txt` file on your media, or the *National Instruments Patent Notice* at ni.com/patents. You can find information about end-user license agreements (EULAs) and third-party legal notices in the `readme` file for your NI product. Refer to the *Export Compliance Information* at ni.com/legal/export-compliance for the NI global trade compliance policy and how to obtain relevant HTS codes, ECCNs, and other import/export data. NI MAKES NO EXPRESS OR IMPLIED WARRANTIES AS TO THE ACCURACY OF THE INFORMATION CONTAINED HEREIN AND SHALL NOT BE LIABLE FOR ANY ERRORS. U.S. Government Customers: The data contained in this manual was developed at private expense and is subject to the applicable limited rights and restricted data rights as set forth in FAR 52.227-14, DFAR 252.227-7014, and DFAR 252.227-7015.

19 mm (0.75") DIAMETER STAINLESS STEEL COMPRESSION LOAD CELL

STANDARD AND METRIC MODELS

Compression

0-25 lb to 0-1000 lb

0-100 to 0-5000 N

1 Newton = 0.2248 lb

1 daNewton = 10 Newtons

1 lb = 454 g

1 t = 1000 kg = 2204 lb

LC302/LCM302 Series



- ✓ Small 19 mm (0.75") Dia.
- ✓ Low 13 mm (0.5") Profile
- ✓ Robotic and Test Bench Applications
- ✓ Built-In Load Button for Easy Installation
- ✓ 5-Point Traceable Calibration Provided

The LC302/LCM302 Series load cells are only 19 mm (¾") in diameter and fit in the smallest places. Their high $\pm 0.5\%$ accuracy and small package solve many industrial force measurement applications. The all stainless steel construction and high-quality strain gage ensure long-term reliability.

SPECIFICATIONS

Excitation: 5 Vdc, 15 Vdc max

Output: 1 mV/V (nominal)

Accuracy: $\pm 0.5\%$ FSO linearity, hysteresis, repeatability combined

5-Point Calibration:

0%, 50%, 100%, 50%, 0%

Zero Balance: $\pm 2\%$ FSO

Operating Temp Range:

-54 to 125°C (-65 to 250°F)

Compensated Temp Range:

16 to 71°C (60 to 160°F)

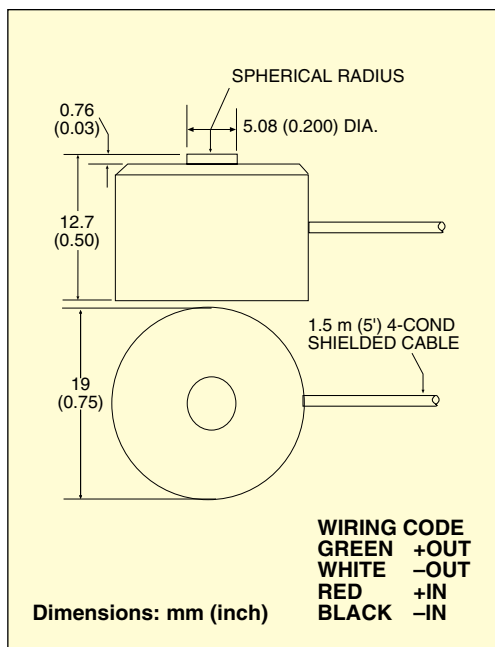
Thermal Effects:

Zero: 0.009% FSO/°F

Span: 0.036% FSO/°F

Safe Overload: 150% of capacity

Protection Class: IP54



Deflection: 0.03 to 0.08 mm (0.001 to 0.003")

Ultimate Overload: 300% of capacity

Bridge Resistance: 350 Ω minimum

Construction: Stainless steel

Electrical Connection: 1.5 m (5')

4-conductor insulated cable with temperature compensation board

LC302-1K, shown actual size.

STANDARD MODELS

To Order

| CAPACITY | | MODEL NO. | COMPATIBLE METERS |
|----------|------|-----------|-----------------------|
| lb | N | | |
| 25 | 111 | LC302-25 | DPiS, DP41-S, DP25B-S |
| 50 | 222 | LC302-50 | DPiS, DP41-S, DP25B-S |
| 100 | 445 | LC302-100 | DPiS, DP41-S, DP25B-S |
| 250 | 1112 | LC302-250 | DPiS, DP41-S, DP25B-S |
| 500 | 2224 | LC302-500 | DPiS, DP41-S, DP25B-S |
| 1000 | 4448 | LC302-1K | DPiS, DP41-S, DP25B-S |

METRIC MODEL

| CAPACITY | | MODEL NO. | COMPATIBLE METERS |
|----------|------|-------------|--------------------------|
| N | lb | | |
| 100 | 22.5 | LCM302-100N | iSeries, DP41-S, DP25B-S |
| 200 | 45 | LCM302-200N | iSeries, DP41-S, DP25B-S |
| 500 | 112 | LCM302-500N | iSeries, DP41-S, DP25B-S |
| 1000 | 225 | LCM302-1KN | iSeries, DP41-S, DP25B-S |
| 2000 | 450 | LCM302-2KN | iSeries, DP41-S, DP25B-S |
| 5000 | 1124 | LCM302-5KN | iSeries, DP41-S, DP25B-S |

Comes complete with 5-point NIST-traceable calibration and 59 k Ω shunt data.

* Visit us online for compatible meters.

Ordering Examples: LC302-25, 25 lb capacity load cell.

LC302-100, 100 lb capacity load cell.

LCM302-100N, 100 Newton capacity load cell.

LCM302-2KN, 2000 N capacity load cell.

Tekpower TP3005T Variable Linear DC Power Supply



Details

The Tekpower TP3005T variable DC power supply is a compact and affordable instrument that is suitable for both Lab and industrial use. This digital DC power supply has maximum output voltage of up to 30 volts and current up to 5 amps. It comes with rotary switches for setting up the voltage and current. With its reliability and versatility, it's an invaluable and indispensable tool for testing, science project and etc., ideal for labs, research institutes, R & D facilities. You can set CV and CC by pushing the Buttons, easy and stable.

Specifications

Output DC Voltage: 0.0V – 30.0V

Output DC Current: 0.00V – 5.00 A

Input Voltage: 110V/AC, 60Hz

Voltage and Current adjustment

Voltage regulation: CV < 0.01% + 3mV, CC < 0.2% + 6 mA

Load regulation: CV < 0.01% + 3mV, CC < 0.02% + 3mA

Ripple and noises: CV < 1 mV rms, CC < 3 mA, rms

Protection: High current limiting and cooling fan.

Operating Temperature: 0 - 102 F (0 - 40 C), Relative Humidity: < 80%

LCD Accuracy is within +/- 2.5%

Size: 10 x 5 x 7 ¾ inches

Weight: approx. 12 lbs

Included

TP3005T power supply

Power cord

Test leads with alligator clips (28 inches long)

User manual

User manual



Wood chips moisture transmitter for the determination of water content of wood chips

Version 4.1

© Schaller GmbH
2016

Table of contents

| | |
|---|----|
| 1. General | 3 |
| 2. Installation instructions | 3 |
| 3. Mounting the sensor | 4 |
| 3.1. View upper side | 4 |
| 3.2. Side view | 4 |
| 4. Electrical connection..... | 5 |
| 5. Scaling analogue output | 5 |
| 6. Calibration curves and measuring range | 5 |
| 7. Interpolation point table for control system | 6 |
| 7.1 interpolation point table for “Coarse wood chips”: | 6 |
| 7.2 interpolation point table for “Industrial wood chips”: | 7 |
| 7.3 interpolation point table for “Fine wood chips”: | 7 |
| 8. Exemption from liability..... | 7 |
| 9. Technical data | 7 |
| 10. Example pictures for selection of right calibration curve | 8 |
| 11. Device maintenance instructions..... | 10 |
| 12. Most common reasons for miss readings | 10 |
| 13. Test block | 10 |

1. General

The wood chips moisture transmitter allows an online measurement of water content (optionally water content and temperature) of wood chips. Therefore a sensor is embedded in the material stream. This is a ready calibrated system; the measuring values are calculated by the transmitter unit. The water content (and optional also the temperature) are transmitted by a 4 to 20mA analogue output.

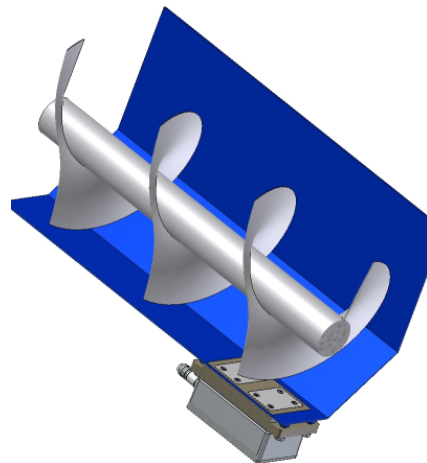
2. Installation instructions

Requirements:

During the measurement, the two stainless metal sheets have to have constant contact with the product (wood chips). To ensure correct measuring results, the wood chips have to exert a minimum pressure of 20 N/dm² on the sensor surface. The sensor measures the material that directly touches the sensor field. It must be ensured that no electrically conductive material affects the sensor surface.

Possible installation positions:

- Screw conveyor:
installation at the bottom of the trough
- In-feed chute with hydraulic ram:
installation at the side wall
- Bunker:
installation at the side wall (to ensure the minimum pressure, the sensor possibly has to be mounted at an angle)



Measuring principle:

The wood chips moisture transmitter uses a conductance measurement specially developed by Schaller GmbH. This principle is based on the fact that electrical conductivity changes according to the moisture content of a porous material. Electrical conductivity in dry material is lower than in wet material. The evaluation electronics converts the measured conductance value into weight percent and shows the water content on the display.

Information for installation after dryer:

After the drying process the material surface of the wood chips is much dryer than its core. Therefore an installation directly after the dryer will lead to too low measuring values. The specified minimum measuring range of 10% water content (for wood chips) will not be possible; in fact the measuring range limit is higher.

3. Mounting the sensor

3.1. View upper side

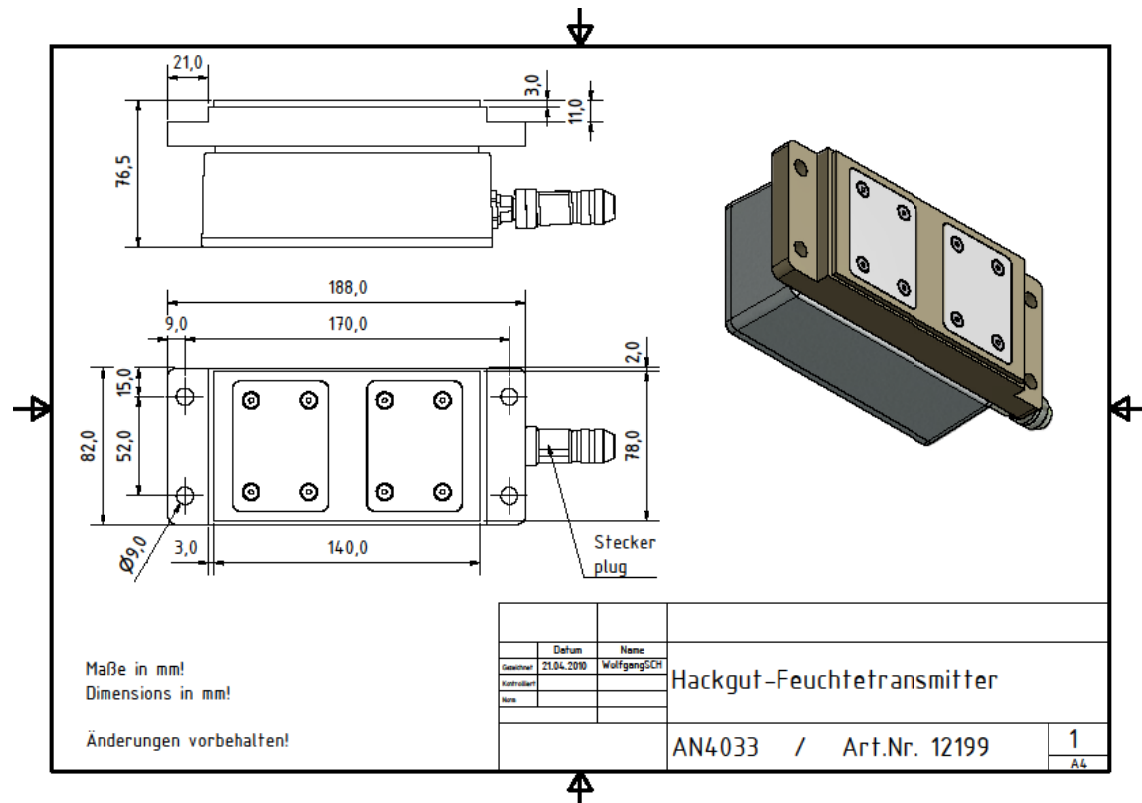
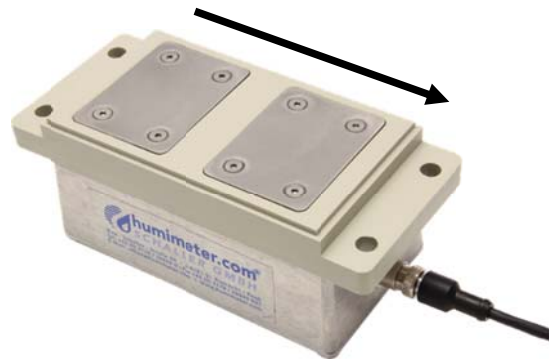
Fix the sensor using the four holes ($\varnothing 9.0$ mm). Note the correct flow direction of the wood chips as shown on the picture. Take care that the two metal sheets have constant contact with the material.



Flow direction of material

3.2. Side view

Put the sensor plug of the cable into the bush of the moisture transmitter and screw it tightly. Please note that the sensor may be destroyed when screwing too strongly.



4. Electrical connection

The wood chips moisture transmitter has to be powered with 24 VDC (15 to 29 VDC). The output of the measuring results is effected via an analogue 4-20mA output. The delivery includes a plug with open cable ends for power supply and analogue output.

Connector pin assignment

| | |
|--------------|---|
| white | 24 VDC power supply (15 to 29VDC) |
| brown | ground power supply & analogue output |
| yellow/green | shield of cable |
| blue | analogue output water content 4 to 20mA |
| grey | <i>optional analogue output for temperature 4 to 20mA</i> |

For connecting with the analysing unit (PLC), a shielded cable with minimum wire of 0.25mm² has to be used.

The cable shield has to be grounded at the analysing unit (PLC)!



5. Scaling analogue output

The water content is transmitted continuously via the 4 to 20 mA analogue output.

The determination of temperature is available optionally!

| signal | type | minimum value | maximum value |
|-------------|---------|-----------------|-----------------|
| moisture | 4..20mA | 4mA \pm 0% | 20mA \pm 80% |
| temperature | 4..20mA | 4mA \pm -10°C | 20mA \pm 70°C |

6. Calibration curves and measuring range

| name | description | measuring range |
|------------|----------------------|-----------------|
| wood chips | wood chips P31 - P45 | 10 – 50 % |

The system is calibrated for standard wood chips according to class P16 up to class P45. In practice it may occur that the shown value differs from the real value. That indicates that the present material has a different “moisture calibration curve” than the type of material taken for calibration.

- **Wood chips:** wood chips of class **P31** and **P45** (forest wood chips) according to norm EN ISO 17225-1
- **Coarse wood chips:** coarse wood chips of class **P31** or **P45** with few fines according to norm EN ISO 17225-1
- **Industrial wood chips:** industrial wood chips **without barks and fines**
- **Fine wood chips:** wood chips with a lot of fines (class P16)

Definition of wood chips classes (norm EN ISO 17225-1)

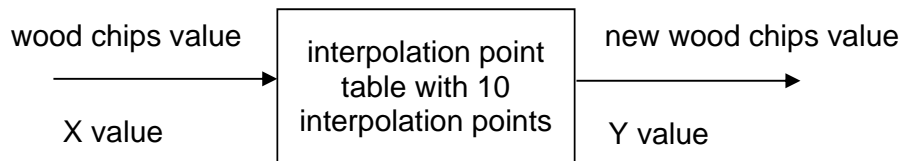
The stated numbers refer to the particle size that goes through round gaps of the corresponding diameters (ONORM M 7133).

- **P16 (G30)** minimum 75% of the bulk is between 3.15 and 16 mm
- **P31 (G50)** minimum 75% of the bulk is between 8 and 31.5 mm
- **P45 (G50)** minimum 75% of the bulk is between 8 and 45 mm
- **P63 (G100)** minimum 75% of the bulk is between 8 and 63 mm

7. Interpolation point table for control system

For measuring coarse wood chips resp. industrial wood chips, in the programming of the control system a special curve for these sorts has to be stored. This is affected via so-called interpolation point tables. The curves are created via fix points, intermediate values are calculated by linear interpolation.

The input value for calculating the interpolation point table is the water content of the transmitter. This value is the value for standard wood chips and corresponds to 4..20mA and 0 to 80% water content.



7.1 interpolation point table for “Coarse wood chips”:

| interpolation point no. | analogue output [mA] (X-Wert) | wood chip [%WC] (X value) | coarse wood chips [%WC] (Y value) |
|-------------------------|-------------------------------|---------------------------|-----------------------------------|
| 0 | 4.00 | 0.0 | 0.0 |
| 1 | 5.20 | 6.0 | 6.0 |
| 2 | 5.80 | 9.0 | 9.0 |
| 3 | 7.20 | 16.0 | 16.0 |
| 4 | 8.70 | 23.5 | 24.9 |
| 5 | 10.40 | 32.0 | 37.2 |
| 6 | 11.20 | 36.0 | 43.0 |
| 7 | 12.16 | 40.8 | 50.0 |
| 8 | 14.10 | 50.5 | 55.0 |
| 9 | 20.00 | 80.0 | 55.0 |

7.2 interpolation point table for “Industrial wood chips”:

| interpolation point no. | analogue output [mA] (X-Wert) | wood chip [%WC] (X value) | industrial wood chips [%WC] (Y value) |
|-------------------------|-------------------------------|---------------------------|---------------------------------------|
| 0 | 4.00 | 0.0 | 0.0 |
| 1 | 5.20 | 6.0 | 6.0 |
| 2 | 5.80 | 9.0 | 9.0 |
| 3 | 7.20 | 16.0 | 16.0 |
| 4 | 8.70 | 23.5 | 26.3 |
| 5 | 10.40 | 32.0 | 42.3 |
| 6 | 11.20 | 36.0 | 50.0 |
| 7 | 13.24 | 46.2 | 55.0 |
| 8 | 17.00 | 65.0 | 55.0 |
| 9 | 20.00 | 80.0 | 55.0 |

7.3 interpolation point table for “Fine wood chips”:

| interpolation point no. | analogue output [mA] (X-Wert) | wood chip [%WC] (X value) | industrial wood chips [%WC] (Y value) |
|-------------------------|-------------------------------|---------------------------|---------------------------------------|
| 0 | 4.00 | 0.0 | 0.0 |
| 1 | 5.20 | 6.0 | 6.0 |
| 2 | 5.80 | 9.0 | 9.0 |
| 3 | 7.20 | 16.0 | 16.0 |
| 4 | 8.70 | 23.5 | 22.8 |
| 5 | 10.40 | 32.0 | 29.4 |
| 6 | 11.20 | 36.0 | 32.5 |
| 7 | 14.00 | 50.0 | 43.5 |
| 8 | 14.56 | 52.8 | 50.0 |
| 9 | 20.00 | 80.0 | 55.0 |

8. Exemption from liability

For misreading's and wrong measurements and of this resulting damage we refuse any liability. This is a device for quick determination of moisture. The moisture depends on multiple conditions and multiple materials. Therefore we recommend a plausibility check of the measuring results. Each device includes a serial number and the guarantee stamp. If those are broken, no claims for guarantee can be made. In case of a faulty device, please contact Schaller GmbH (www.humimeter.com) or your dealer.

9. Technical data

| | |
|-------------------------|------------------------------------|
| Measuring range | 10 to 50 % water content |
| Material temperature | +5 to +70 °C |
| Surrounding temperature | -10 to +60 °C |
| Protection class | IP 65 |
| Power supply | 24 VDC (15 to 29 VDC) |
| Current consumption | 90mA & analogue output (4 to 20mA) |

10. Example pictures for selection of right calibration curve

Wood chips



Coarse wood chips



Industrial wood chips



Fine wood chips



11. Device maintenance instructions

- Please always keep in mind that the moisture sensors are sensitive measuring instruments and handle them **WITH CAUTION**.
- If the measuring system doesn't work properly, please first of all reboot the system (disconnection of power supply).
- The sensor has to be cleaned from pollution or something similar periodically.
- Do not bend the cable of sensor. We recommend the installation of a protection as the sensor may be damaged if the cable is bended too often.
- Wrong pin allocation may destroy the sensor and the control unit! This is no case of warranty.

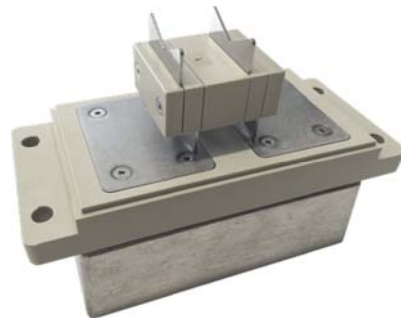
12. Most common reasons for miss readings

- When there is no material above the sensor, the air value is displayed (5.5%)
- Also when there is dust on the sensor, a measuring value is displayed
- Water drops due to condensation on the measuring surface of the sensor
- Temperature (of material or surroundings) out of specified range. In general the accuracy decreases with rising temperatures due to a higher compensation factor
- The pressure between sensor and material is too low
- The cables must not lie in the area of electro-magnetic interference fields
- The sensors have to be cleaned periodically
- The sensor connector is not connected properly
- Do not open sensor unit! Get in contact with Schaller GmbH or your local dealer in order to clarify possible errors

13. Test block

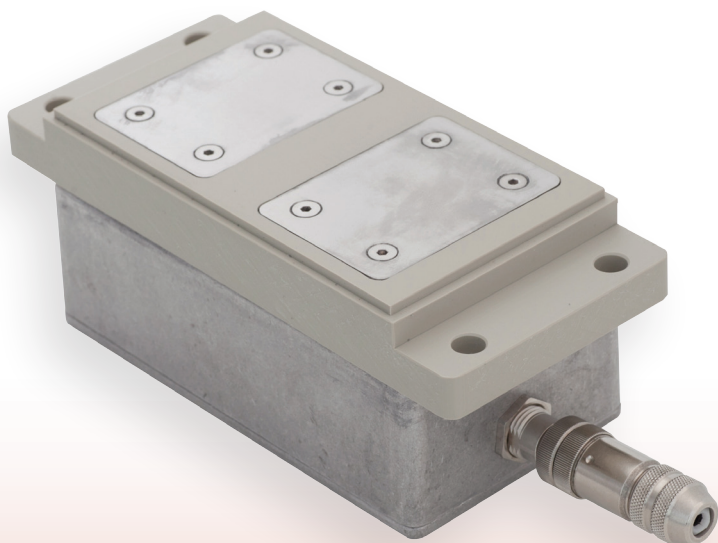
Via the optionally available test block (article no. 12308) the operation and calibration of the wood chips moisture transmitter can be checked easily.

By pressing the test block on the stainless metal sensor sheets a fixed water content is simulated. Turning the test block, another fixed value is simulated.





***humimeter* wood chips moisture transmitter**
***humimeter* universal moisture transmitter**
for determination of water content of wood chips and further materials



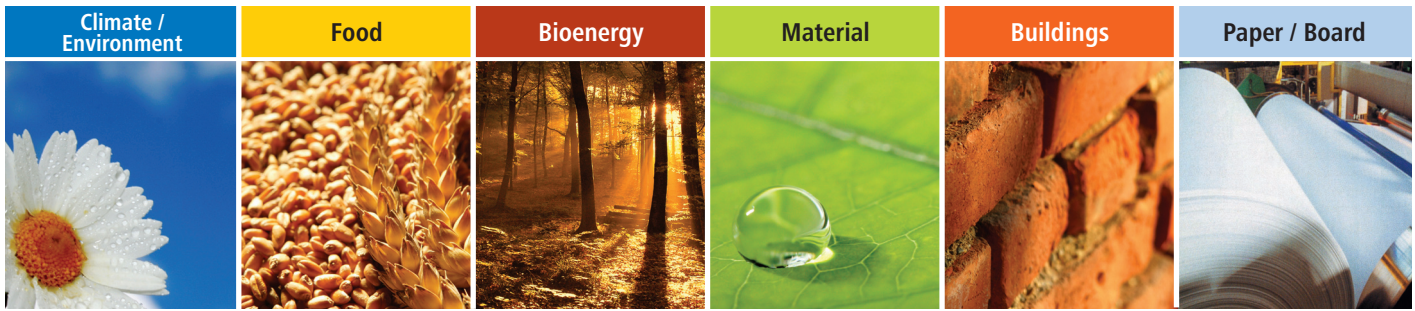
Wood chips moisture transmitter

- Ready calibrated system (standard sensor)
- For wood chips class P16 up to P45
- Increase in efficiency of incineration plants of 3 - 5% by regulation and monitoring of water content
- Saving of costs by process optimisation
- Also in high temperature implementation +5 to +85°C
- Analogue output water content 4-20mA
- Optional: analogue output temperature 4-20mA, display and keypad



Universal moisture transmitter

- Simple determination of water content and temperature of your material
- Raising efficiency of your plant by monitoring the water content
- Can be extended up to 32 material types in the desired language
- Simple adaption to existing mechanical conditions
- Assuring your quality



www.humimeter.com

technical data

humimeter transmitters enable the facile **online determination of water content of wood chips** or further materials.

They can easily be integrated also in existing plants and are therefore ideal for optimizing your dryer, oven or plant relating to the water content.

This enables an efficiency improvement of your oven, a reduction of the energy consumption for drying and in general raising efficiency of your plant, which means the fabrication of a product of higher quality.

The connection to a control system can be realised by the **4-20mA analogue output**. As the transmitters are already completely calibrated, the installation can be realised with a modicum of effort.

To avoid very costly mistakes due to incorrect moisture levels it is necessary to check the moisture of a material in the manufacturing and treatment process in order to be able to take suitable measures in time.

Due to its longstanding experience in this field and constant research, **Schaller GmbH** has attained the highest quality in the development and production of air humidity and material moisture meters for **professional applications**.

Our main areas are: **climate, environment, food, bioenergy, buildings, paper, board** and **various other materials**.

More than **40,000** customer-specific solutions have been designed and produced for **industry, universities** and **research institutions** all over the world.

Our technicians provide reliable support and are available to answer your questions.

humimeter wood chips moisture transmitter

for determination of water content of wood chips class P16 up to P45

article no. 12199

article no. 12234 high temperature implementation +5 to +85°C

- Power supply 24VDC (15 to 29VDC)
- Measuring range 10 - 50% water content (represents 100% wood moisture)
- Requires close contact of material to the measuring surface of the sensor
- Analogue output water content 4-20mA
- Optional: analogue output temperature 4-20mA, display and keypad

humimeter universal moisture transmitter

for determination of water content of materials (with adapted sensor)

article no. 12849

- Power supply 24VDC (15 to 29VDC)
- Automatic temperature compensation
- Large, well-lit LC display
- Analogue outputs 4-20mA for water content and temperature

Know-how obtained through decades of research and development!



Any technical changes reserved. Pictures do not show possible changes that have been made on different models.

A wide range of other instruments and external sensors can be found at www.humimeter.com

humimeter.com
SCHALLER GMBH

Schaller GmbH | Max-Schaller-Straße 99 | A-8181 St. Ruprecht / Raab | T. +43 (0)3178 - 28899 | F. DW - 901 | info@humimeter.com