# Low Power Instrumentation Amplifie

The HT8620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of and DIP packaging that is smaller than discrete designs and offers lower power (only 1.3 mA max supply current), making
The HT8620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50 μV max, and offset drift of 0.6 μV/℃ max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Furthermore, the low noise, low input bias current, and low power of the HT8620 make it well suited for medical applications, such as ECG and noninvasive blood pressure monitors.

The low input bias current of 1.0 nA max is made possible with the use of Superбeta processing in the input stage. The HT8620 works well as a preamplifier due to its low input voltage noise of 9 nV/√Hz at 1 kHz, 0.28 μV p-p in the 0.1 Hz to 10 Hz band, and 0.1 pA/√Hz input current noise. Also, the HT8620 is well suited for multiplexed applications with its settling time of 15 μs to 0.01%, and its cost is

## FEATURES

Easy to use
- Gain set with one external resistor
  (Gain range 1 to 10,000)
- Wide power supply range (±2.3 V to ±18 V)±10)
- Higher performance than 3 op amp IA designs
- Available in 8-lead DIP and SOIC packaging
- Low power, 1.3 mA max supply current

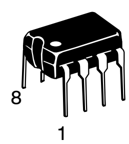
Excellent dc performance (B grade)
- 50 μV max, input offset voltage
- 0.6 μV/°C max, input offset drift
- 1.0 nA max, input bias current
- 100 dB min common-mode rejection ratio (G

Low noise
- 9 nV/√Hz @ 1 kHz, input voltage noise
- 0.28 μV p-p noise (0.1 Hz to 10 Hz)

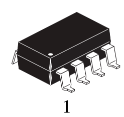
Excellent ac specifications
- 120 kHz bandwidth (G = 100)
- 15 μs settling time to 0.01%

## APPLICATIONS

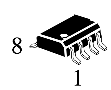
Weigh scales
ECG and medical instrumentation
Transducer interface
Data acquisition systems
Industrial process controls
Battery-powered and portable equipment



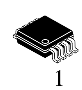

**DIP8 N SUFFIX HT8620ANZ**




**DUB8 U SUFFIX HT8620ARUZ**



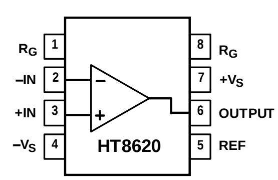

**SOP8 R SUFFIX HT8620ARZ**




**MSOP8 M SUFFIX HT8620ARMZ**

**NOTE: If you need to customize the packaging shape, please contact the manufacturer.**

## CONNECTION DIAGRAM



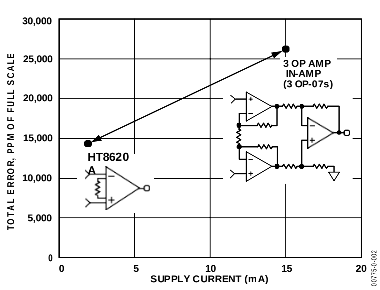




*Figure 2. Three Op Amp IA Designs vs. HT8620*

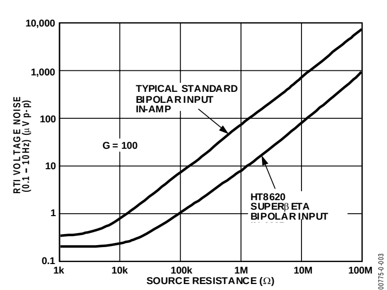



*Figure 3. Total Voltage Noise vs. Source Resistance*

# SPECIFICATIONS

Typical @ 25 ℃, $V_S$ = ±15 V, and $R_L$ = 2 kΩ, unless otherwise noted.

**Table 1.**

| Parameter | Conditions | HT8620A Min | HT8620A Typ | HT8620A Max | HT8620B Min | HT8620B Typ | HT8620B Max | HT8620S Min | HT8620S Typ | HT8620S Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GAIN | G = 1 + (49.4 kΩ/$R_G$) | | | | | | | | | | |
| Gain Range | | 1 | | 10,000 | 1 | | 10,000 | 1 | | 10,000 | |
| Gain Error[2] | $V_{OUT}$ = ±10 V | | | | | | | | | | |
| G = 1 | | | 0.03 | 0.10 | | 0.01 | 0.02 | | 0.03 | 0.10 | % |
| G = 10 | | | 0.15 | 0.30 | | 0.10 | 0.15 | | 0.15 | 0.30 | % |
| G = 100 | | | 0.15 | 0.30 | | 0.10 | 0.15 | | 0.15 | 0.30 | % |
| G = 1000 | | | 0.40 | 0.70 | | 0.35 | 0.50 | | 0.40 | 0.70 | % |
| Nonlinearity | $V_{OUT}$ = −10 V to +10 V | | | | | | | | | | |
| G = 1–1000 | $R_L$ = 10 kΩ | | 10 | 40 | | 10 | 40 | | 10 | 40 | ppm |
| G = 1–100 | $R_L$ = 2 kΩ | | 10 | 95 | | 10 | 95 | | 10 | 95 | ppm |
| Gain vs. Temperature | | | | | | | | | | | |
| | G = 1 | | | 10 | | | 10 | | | 10 | ppm/°C |
| | Gain >1[2] | | | −50 | | | −50 | | | −50 | ppm/°C |
| VOLTAGE OFFSET | (Total RTI Error = $V_{OSI}$ + $V_{OSO}$/G) | | | | | | | | | | |
| Input Offset, $V_{OSI}$ | $V_S$ = ±5 V to ± 15 V | | 30 | 125 | | 15 | 50 | | 30 | 125 | µV |
| Overtemperature | $V_S$ = ±5 V to ± 15 V | | | 185 | | | 85 | | | 225 | µV |
| Average TC | $V_S$ = ±5 V to ± 15 V | | 0.3 | 1.0 | | 0.1 | 0.6 | | 0.3 | 1.0 | µV/°C |
| Output Offset, $V_{OSO}$ | $V_S$ = ±15 V | | 400 | 1000 | | 200 | 500 | | 400 | 1000 | µV |
| | $V_S$ = ± 5 V | | | 1500 | | | 750 | | | 1500 | µV |
| Overtemperature | $V_S$ = ±5 V to ± 15 V | | | 2000 | | | 1000 | | | 2000 | µV |
| Average TC | $V_S$ = ±5 V to ± 15 V | | 5.0 | 15 | | 2.5 | 7.0 | | 5.0 | 15 | µV/°C |
| Offset Referred to the Input vs. Supply (PSR) | $V_S$ = ±2.3 V to ±18 V | | | | | | | | | | |
| G = 1 | | 80 | 100 | | 80 | 100 | | 80 | 100 | | dB |
| G = 10 | | 95 | 120 | | 100 | 120 | | 95 | 120 | | dB |
| G = 100 | | 110 | 140 | | 120 | 140 | | 110 | 140 | | dB |
| G = 1000 | | 110 | 140 | | 120 | 140 | | 110 | 140 | | dB |
| INPUT CURRENT | | | | | | | | | | | |
| Input Bias Current | | | 0.5 | 2.0 | | 0.5 | 1.0 | | 0.5 | 2 | nA |
| Overtemperature | | | | 2.5 | | | 1.5 | | | 4 | nA |
| Average TC | | | 3.0 | | | 3.0 | | | 8.0 | | pA/°C |
| Input Offset Current | | | 0.3 | 1.0 | | 0.3 | 0.5 | | 0.3 | 1.0 | nA |
| Overtemperature | | | | 1.5 | | | 0.75 | | | 2.0 | nA |
| Average TC | | | 1.5 | | | 1.5 | | | 8.0 | | pA/°C |
| INPUT | | | | | | | | | | | |
| Input Impedance | | | | | | | | | | | |
| Differential | | | 10\|\|2 | | | 10\|\|2 | | | 10\|\|2 | | GΩ_pF |
| Common-Mode | | | 10\|\|2 | | | 10\|\|2 | | | 10\|\|2 | | GΩ_pF |
| Input Voltage Range[3] | $V_S$ = ±2.3 V to ±5 V | $-V_S + 1.9$ | | $+V_S - 1.2$ | $-V_S + 1.9$ | | $+V_S - 1.2$ | $-V_S + 1.9$ | | $+V_S - 1.2$ | V |
| Overtemperature | | $-V_S + 2.1$ | | $+V_S - 1.3$ | $-V_S + 2.1$ | | $+V_S - 1.3$ | $-V_S + 2.1$ | | $+V_S - 1.3$ | V |
| | $V_S$ = ± 5 V to ±18 V | $-V_S + 1.9$ | | $+V_S - 1.4$ | $-V_S + 1.9$ | | $+V_S - 1.4$ | $-V_S + 1.9$ | | $+V_S - 1.4$ | V |
| Overtemperature | | $-V_S + 2.1$ | | $+V_S - 1.4$ | $-V_S + 2.1$ | | $+V_S + 2.1$ | $-V_S + 2.3$ | | $+V_S - 1.4$ | V |

| Parameter | Conditions | HT8620A Min | HT8620A Typ | HT8620A Max | HT8620B Min | HT8620B Typ | HT8620B Max | HT8620S Min | HT8620S Typ | HT8620S Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common-Mode Rejection Ratio DC to 60 Hz with 1 kΩ Source Imbalance | $V_{CM}$ = 0 V to ± 10 V | | | | | | | | | | |
| G = 1 | | 73 | 90 | | 80 | 90 | | 73 | 90 | | dB |
| G = 10 | | 93 | 110 | | 100 | 110 | | 93 | 110 | | dB |
| G = 100 | | 110 | 130 | | 120 | 130 | | 110 | 130 | | dB |
| G = 1000 | | 110 | 130 | | 120 | 130 | | 110 | 130 | | dB |
| OUTPUT | | | | | | | | | | | |
| Output Swing | $R_L$ = 10 kΩ | | | | | | | | | | |
| | $V_S$ = ±2.3 V to ± 5 V | $-V_S$ + 1.1 | | $+V_S$ − 1.2 | $-V_S$ + 1.1 | | $+V_S$ − 1.2 | $-V_S$ + 1.1 | | $+V_S$ − 1.2 | V |
| Overtemperature | | $-V_S$ + 1.4 | | $+V_S$ − 1.3 | $-V_S$ + 1.4 | | $+V_S$ − 1.3 | $-V_S$ + 1.6 | | $+V_S$ − 1.3 | V |
| | $V_S$ = ±5 V to ± 18 V | $-V_S$ + 1.2 | | $+V_S$ − 1.4 | $-V_S$ + 1.2 | | $+V_S$ − 1.4 | $-V_S$ + 1.2 | | $+V_S$ − 1.4 | V |
| Overtemperature | | $-V_S$ + 1.6 | | $+V_S$ − 1.5 | $-V_S$ + 1.6 | | $+V_S$ − 1.5 | $-V_S$ + 2.3 | | $+V_S$ − 1.5 | V |
| Short Circuit Current | | | ±18 | | | ±18 | | | ±18 | | mA |
| DYNAMIC RESPONSE | | | | | | | | | | | |
| Small Signal −3 dB Bandwidth | | | | | | | | | | | |
| G = 1 | | | 1000 | | | 1000 | | | 1000 | | kHz |
| G = 10 | | | 800 | | | 800 | | | 800 | | kHz |
| G = 100 | | | 120 | | | 120 | | | 120 | | kHz |
| G = 1000 | | | 12 | | | 12 | | | 12 | | kHz |
| Slew Rate | | 0.75 | 1.2 | | 0.75 | 1.2 | | 0.75 | 1.2 | | V/µs |
| Settling Time to 0.01% | 10 V Step | | | | | | | | | | |
| G = 1–100 | | | 15 | | | 15 | | | 15 | | µs |
| G = 1000 | | | 150 | | | 150 | | | 150 | | µs |
| NOISE | | | | | | | | | | | |
| Voltage Noise, 1 kHz | $Total\ RTI\ Noise = \sqrt{(e^2_{ni}) + (e_{no}/G)^2}$ | | | | | | | | | | |
| Input, Voltage Noise, $e_{ni}$ | | | 9 | 13 | | 9 | 13 | | 9 | 13 | nV/√Hz |
| Output, Voltage Noise, $e_{no}$ | | | 72 | 100 | | 72 | 100 | | 72 | 100 | nV/√Hz |
| RTI, 0.1 Hz to 10 Hz | | | | | | | | | | | |
| G = 1 | | | 3.0 | | | 3.0 | 6.0 | | 3.0 | 6.0 | µV p-p |
| G = 10 | | | 0.55 | | | 0.55 | 0.8 | | 0.55 | 0.8 | µV p-p |
| G = 100–1000 | | | 0.28 | | | 0.28 | 0.4 | | 0.28 | 0.4 | µV p-p |
| Current Noise | f = 1 kHz | | 100 | | | 100 | | | 100 | | fA/√Hz |
| 0.1 Hz to 10 Hz | | | 10 | | | 10 | | | 10 | | pA p-p |
| REFERENCE INPUT | | | | | | | | | | | |
| $R_{IN}$ | | | 20 | | | 20 | | | 20 | | kΩ |
| $I_{IN}$ | $V_{IN+}$, $V_{REF}$ = 0 | | 50 | 60 | | 50 | 60 | | 50 | 60 | µA |
| Voltage Range | | $-V_S$ + 1.6 | | $+V_S$ − 1.6 | $-V_S$ + 1.6 | | $+V_S$ − 1.6 | $-V_S$ + 1.6 | | $+V_S$ − 1.6 | V |
| Gain to Output | | 1 ± 0.0001 | | | 1 ± 0.0001 | | | 1 ± 0.0001 | | | |
| POWER SUPPLY | | | | | | | | | | | |
| Operating Range[4] | | ±2.3 | | ±18 | ±2.3 | | ±18 | ±2.3 | | ±18 | V |
| Quiescent Current | $V_S$ = ±2.3 V to ±18 V | | 0.9 | 1.3 | | 0.9 | 1.3 | | 0.9 | 1.3 | mA |
| Overtemperature | | | 1.1 | 1.6 | | 1.1 | 1.6 | | 1.1 | 1.6 | mA |
| TEMPERATURE RANGE | | | | | | | | | | | |
| For Specified Performance | | −40 to +85 | | | −40 to +85 | | | −55 to +125 | | | °C |

[1] See Analog Devices military data sheet for 883B tested specifications.
[2] Does not include effects of external resistor $R_G$.
[3] One input grounded. G = 1.
[4] This is defined as the same supply range that is used to specify PSR.

## TYPICAL PERFORMANCE CHARACTERISTICS

(@ 25 ℃, $V_S$ = ±15 V, $R_L$ = 2 kΩ, unless otherwise noted.)

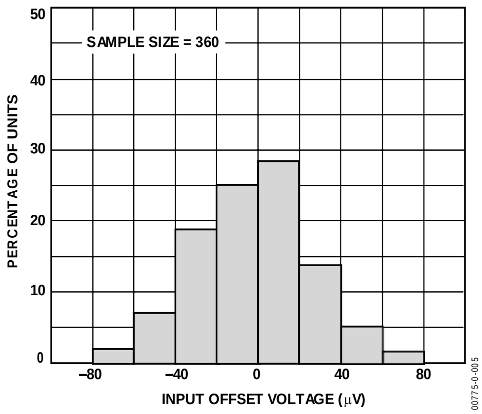



*Figure 5. Typical Distribution of Input Offset Voltage*

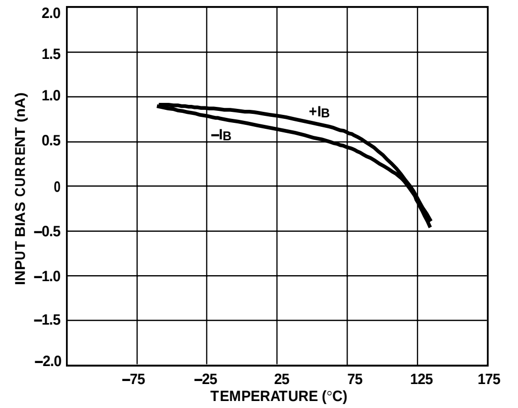



*Figure 8. Input Bias Current vs. Temperature*

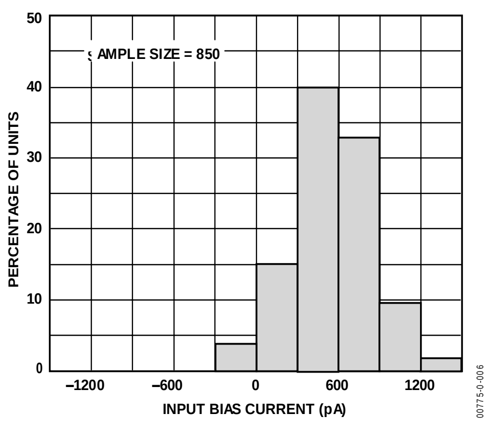



*Figure 6. Typical Distribution of Input Bias Current*

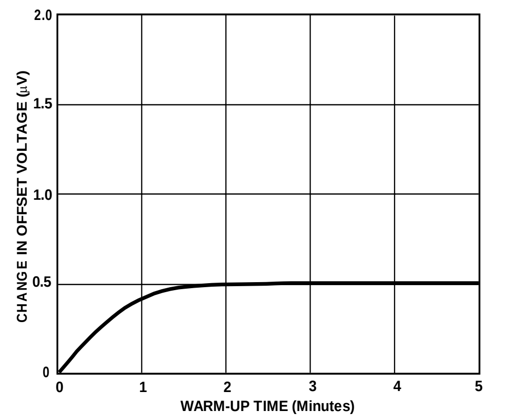



*Figure 9. Change in Input Offset Voltage vs. Warm-Up Time*

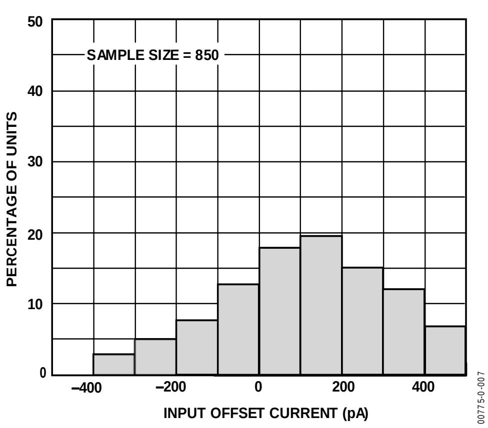



*Figure 7. Typical Distribution of Input Offset Current*

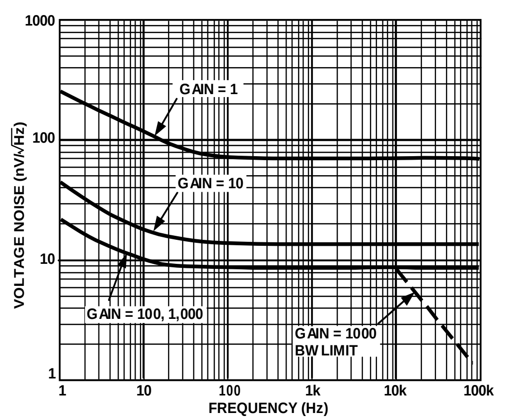



*Figure 10. Voltage Noise Spectral Density vs. Frequency (G = 1−1000)*

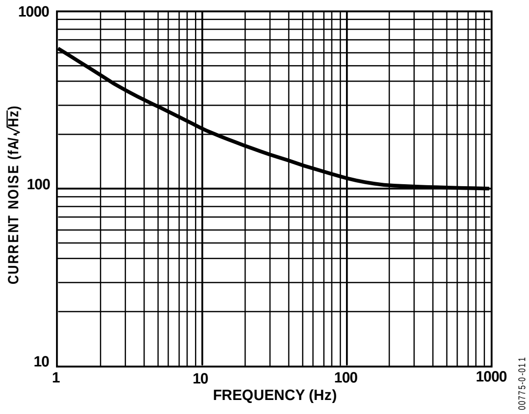



Figure 11. Current Noise Spectral Density vs. Frequency

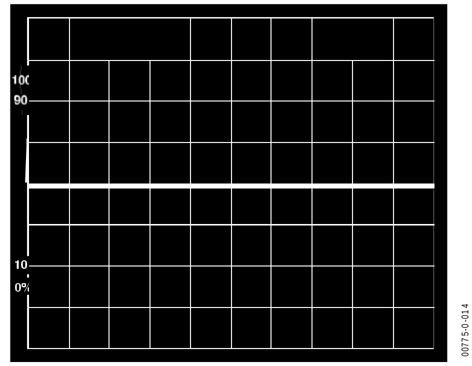



Figure 14. 0.1 Hz to 10 Hz Current Noise, 5 pA/Div

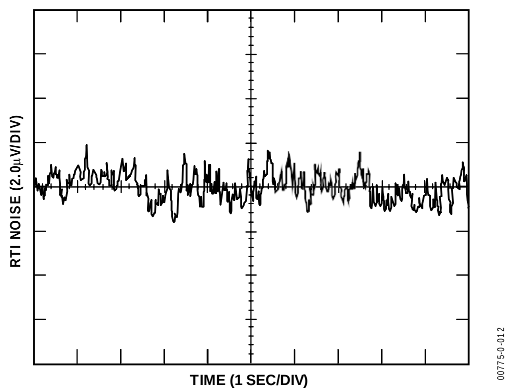



Figure 12. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1)

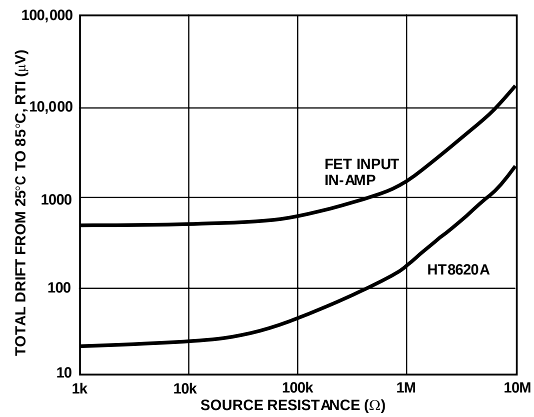



Figure 15. Total Drift vs. Source Resistance

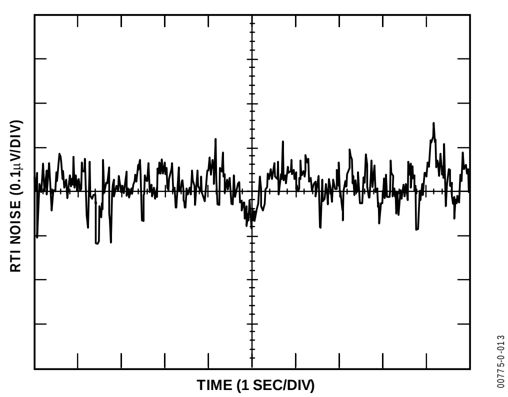



Figure 13. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1000)

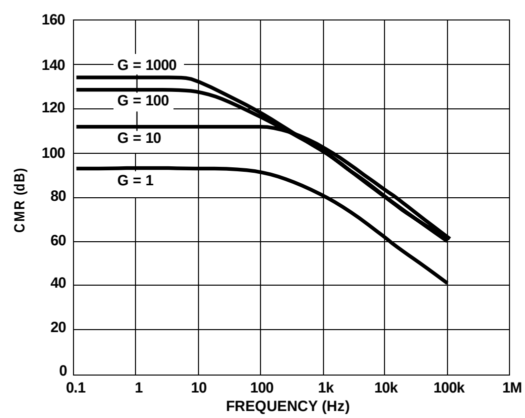



Figure 16. Typical CMR vs. Frequency, RTI, Zero to 1 kΩ Source Imbalance

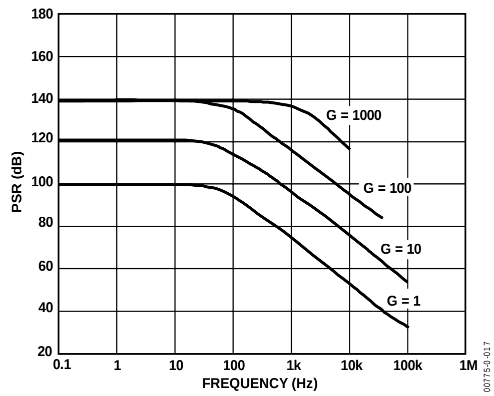



*Figure 17. Positive PSR vs. Frequency, RTI (G = 1−1000)*

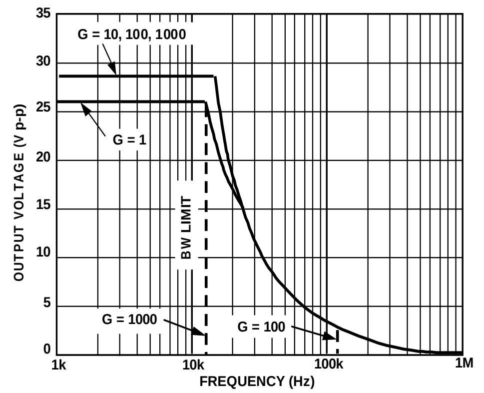



*Figure 20. Large Signal Frequency Response*

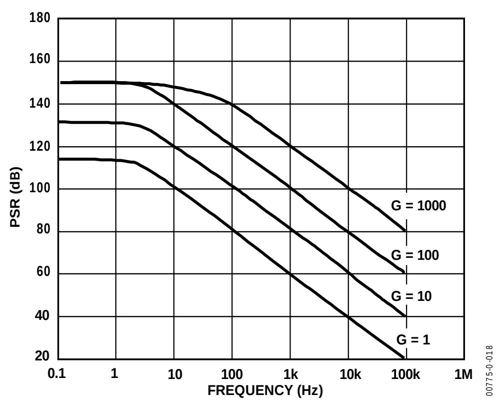



*Figure 18. Negative PSR vs. Frequency, RTI (G = 1−1000)*

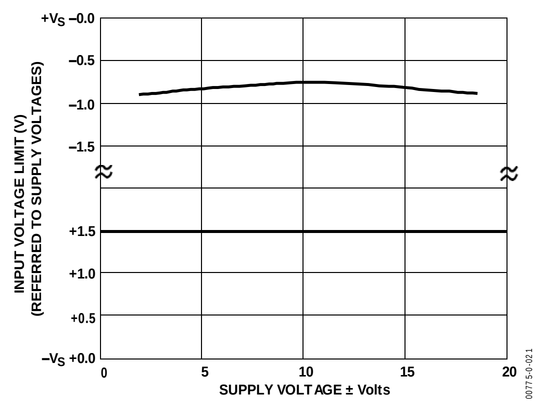



*Figure 21. Input Voltage Range vs. Supply Voltage, G = 1*

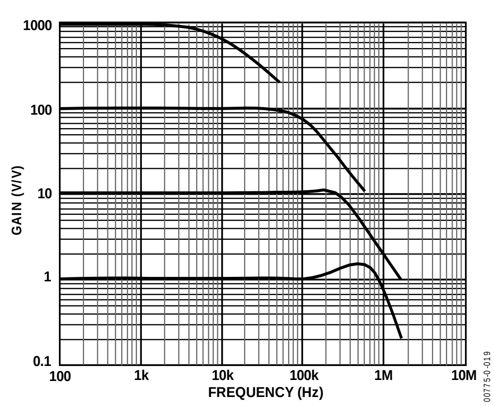



*Figure 19. Gain vs. Frequency*

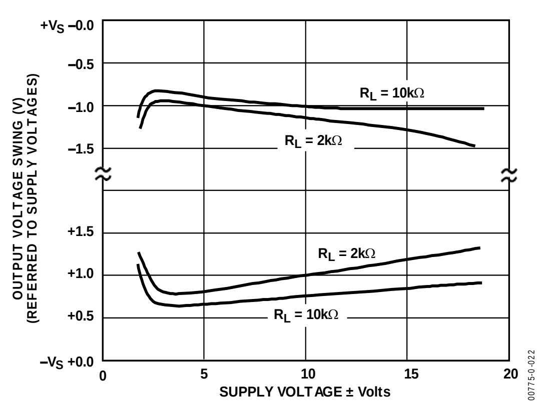



*Figure 22. Output Voltage Swing vs. Supply Voltage, G = 10*

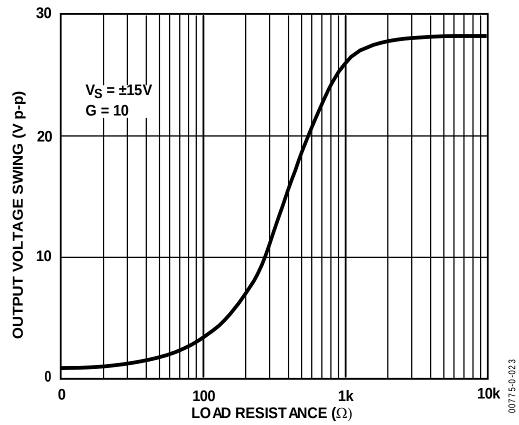



*Figure 23. Output Voltage Swing vs. Load Resistance*

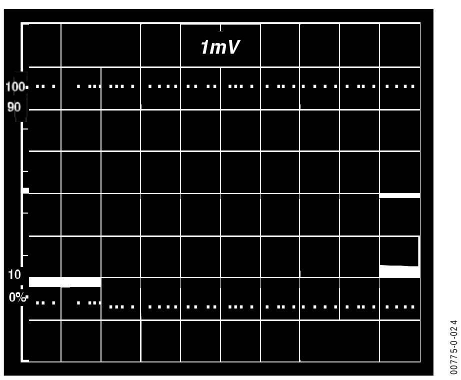



*Figure 24. Large Signal Pulse Response and Settling Time G = 1 (0.5 mV = 0.01%)*

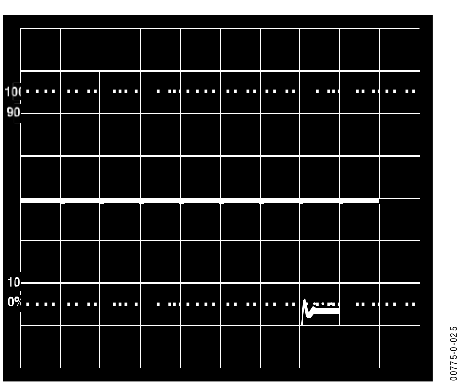



*Figure 25. Small Signal Response, G = 1, $R_L$ = 2 kΩ, $C_L$ = 100 pF*

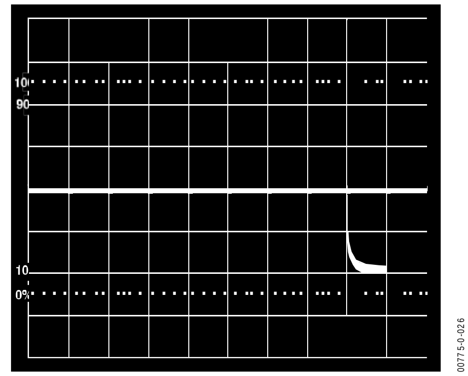



*Figure 26. Large Signal Response and Settling Time, G = 10 (0.5 mV = 0.01%)*

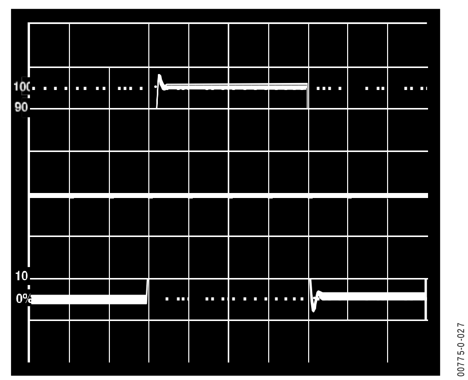



*Figure 27. Small Signal Response, G = 10, $R_L$ = 2 kΩ, $C_L$ = 100 pF*

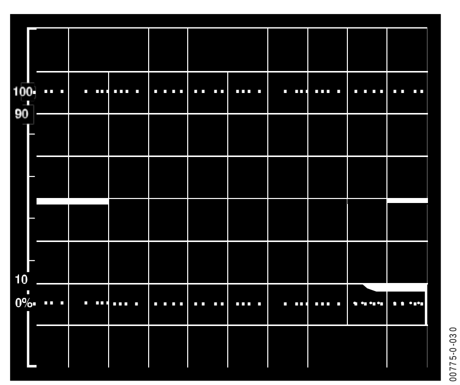



*Figure 28. Large Signal Response and Settling Time, G = 100 (0.5 mV = 0.01%)*

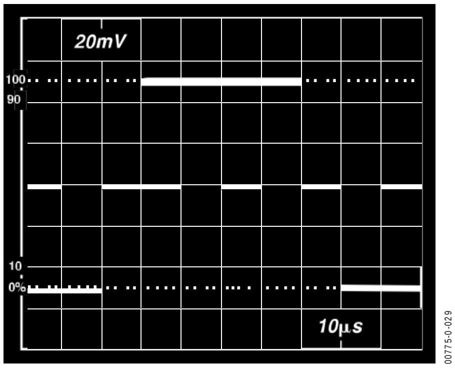



Figure 29. Small Signal Pulse Response, G = 100, $R_L$ = 2 kΩ, $C_L$ = 100 pF

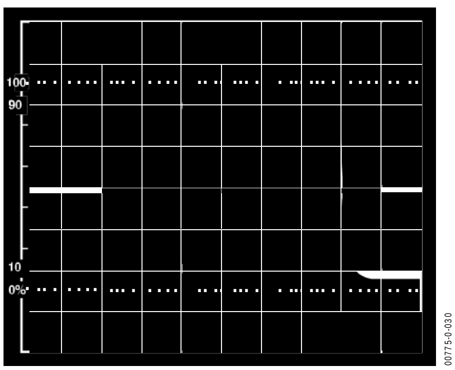



Figure 30. Large Signal Response and Settling Time, G = 1000 (0.5 mV = 0.01% )

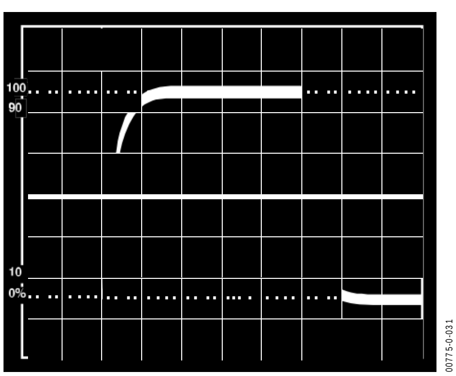



Figure 31. Small Signal Pulse Response, G = 1000, $R_L$ = 2 kΩ, $C_L$ = 100 pF

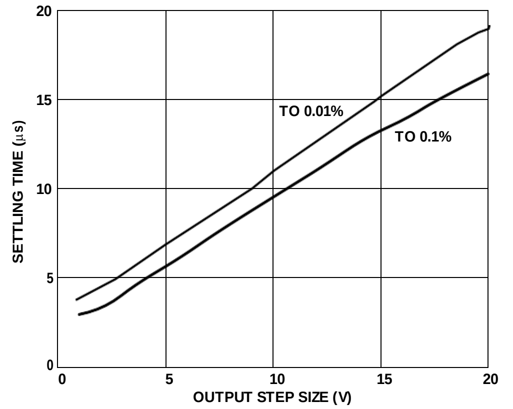



Figure 32. Settling Time vs. Step Size (G = 1)

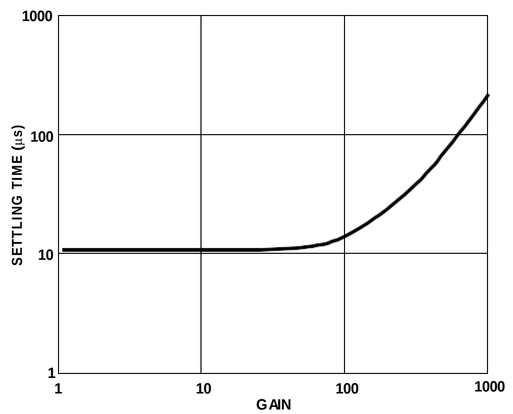



Figure 33. Settling Time to 0.01% vs. Gain, for a 10 V Step

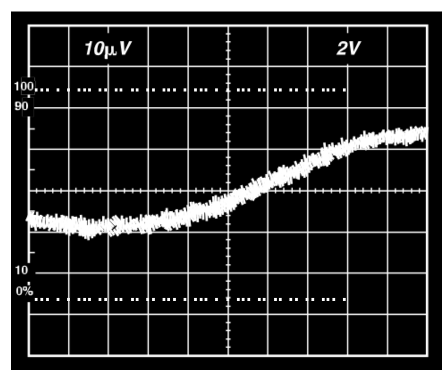



Figure 34. Gain Nonlinearity, G = 1, $R_L$ = 10 kΩ (10 µV = 1 ppm)

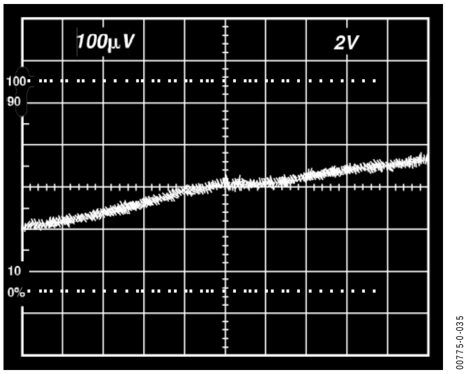



*Figure 35. Gain Nonlinearity, G = 100, $R_L$ = 10 kΩ (100 µV = 10 ppm)*

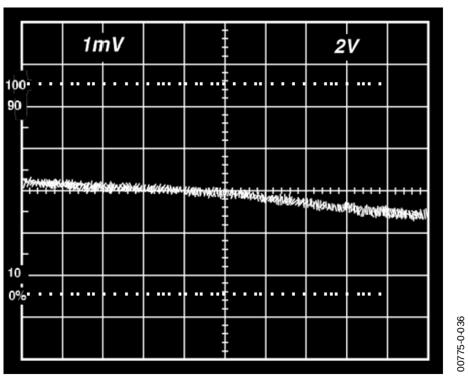



*Figure 36. Gain Nonlinearity, G = 1000, $R_L$ = 10 kΩ (1 mV = 100 ppm)*

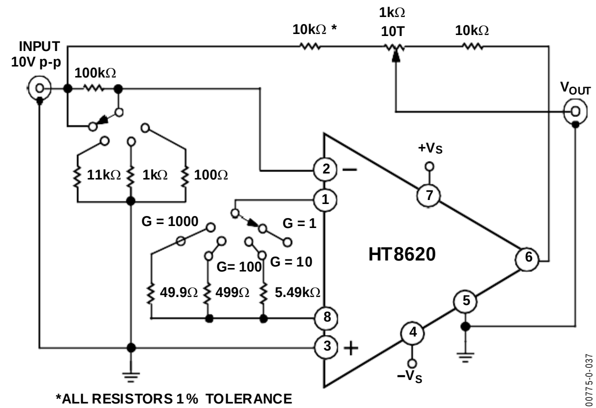



*Figure 37. Settling Time Test Circuit*

# THEORY OF OPERATION

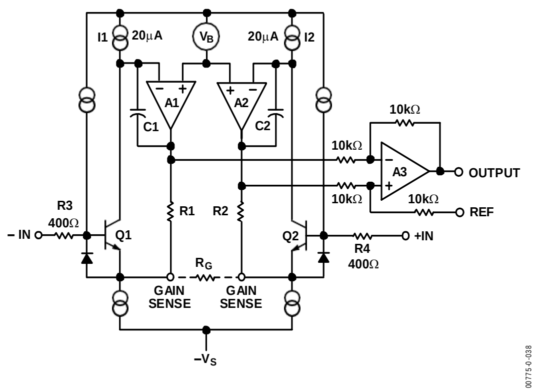



*Figure 38. Simplified Schematic of HT8620*

The HT8620 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 0.15% at G = 100) with only one resistor. Monolithic construction and laser wafer trimming allow the tight matching and tracking of circuit components, thus ensuring the high level of performance inherent in this circuit.

The input transistors Q1 and Q2 provide a single differential-pair bipolar input for high precision (Figure 38), yet offer 10× lower input bias current thanks to Superδeta processing. Feedback through the Q1-A1-R1 loop and the Q2-A2-R2 loop maintains constant collector current of the input devices Q1 and Q2, thereby impressing the input voltage across the external gain setting resistor $R_G$. This creates a differential gain from the inputs to the A1/A2 outputs given by $G = (R1 + R2)/R_G + 1$. The unity-gain subtractor, A3, removes any common-mode signal, yielding a single-ended output referred to the REF pin potential.

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 three important advantages: (a) Open-loop gain is boosted for increasing programmed gain, thus reducing gain related errors. (b) The gain-bandwidth product (determined by C1 and C2 and the preamp transconductance) increases with programmed gain, thus optimizing frequency response. (c) The input voltage noise is reduced to a value of 9 nV/√Hz, determined mainly by the collector current and base resistance of the input devices.

The internal gain resistors, R1 and R2, are trimmed to an absolute value of 24.7 kΩ, allowing the gain to be programmed accurately with a single external resistor.

The gain equation is then

$$G = \frac{49.4k\Omega}{R_G} + 1$$

$$R_G = \frac{49.4k\Omega}{G - 1}$$

### *Make vs. Buy: a Typical Bridge Application Error Budget*

The HT8620 offers improved performance over “homebrew” three op amp IA designs, along with smaller size, fewer components, and 10× lower supply current. In the typical application, shown in Figure 39, a gain of 100 is required to amplify a bridge output of 20 mV full-scale over the industrial temperature range of −40°C to +85°C. Table 3 shows how to calculate the effect various error sources have on circuit accuracy.

Regardless of the system in which it is being used, the HT8620 provides greater accuracy at low power and price. In simple systems, absolute accuracy and drift errors are by far the most significant contributors to error. In more complex systems with an intelligent processor, an autogain/autozero cycle will remove all absolute accuracy and drift errors, leaving only the resolution errors of gain, nonlinearity, and noise, thus allowing full 14-bit accuracy.

Note that for the homebrew circuit, the OP07 specifications for input voltage offset and noise have been multiplied by √2. This is because a three op amp type in-amp has two op amps at its inputs, both contributing to the overall input error.

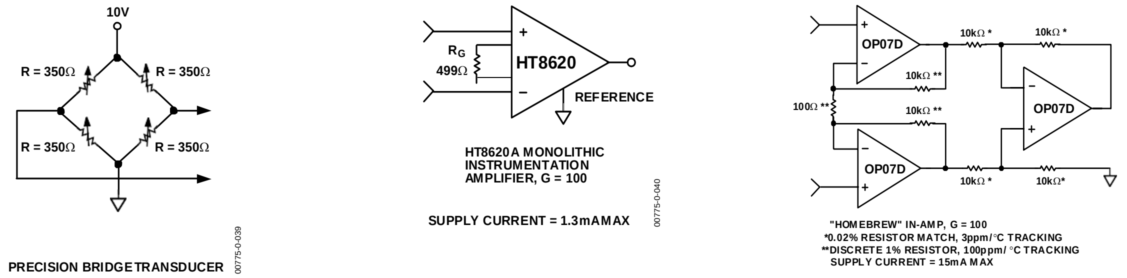



*Figure 39. Make vs. Buy*

**Table 3. Make vs. Buy Error Budget**

| Error Source | HT8620 Circuit Calculation | "Homebrew" Circuit Calculation | Error, ppm of Full Scale HT8620 | Error, ppm of Full Scale Homebrew |
|---|---|---|---|---|
| ABSOLUTE ACCURACY at $T_A$ = 25°C | | | | |
| Input Offset Voltage, µV | 125 µV/20 mV | (150 µV × √2)/20 mV | 6,250 | 10,607 |
| Output Offset Voltage, µV | 1000 µV/100 mV/20 mV | ((150 µV × 2)/100)/20 mV | 500 | 150 |
| Input Offset Current, nA | 2 nA ×350 Ω/20 mV | (6 nA ×350 Ω)/20 mV | 18 | 53 |
| CMR, dB | 110 dB(3.16 ppm) ×5 V/20 mV | (0.02% Match × 5 V)/20 mV/100 | 791 | 500 |
| | | Total Absolute Error | 7,559 | 11,310 |
| DRIFT TO 85°C | | | | |
| Gain Drift, ppm/°C | (50 ppm + 10 ppm) ×60°C | 100 ppm/°C Track × 60°C | 3,600 | 6,000 |
| Input Offset Voltage Drift, µV/°C | 1 µV/°C × 60°C/20 mV | (2.5 µV/°C × √2 × 60°C)/20 mV | 3,000 | 10,607 |
| Output Offset Voltage Drift, µV/°C | 15 µV/°C × 60°C/100 mV/20 mV | (2.5 µV/°C × 2 × 60°C)/100 mV/20 mV | 450 | 150 |
| | | Total Drift Error | 7,050 | 16,757 |
| RESOLUTION | | | | |
| Gain Nonlinearity, ppm of Full Scale | 40 ppm | 40 ppm | 40 | 40 |
| Typ 0.1 Hz to 10 Hz Voltage Noise, µV p-p | 0.28 µV p-p/20 mV | (0.38 µV p-p × √2)/20 mV | 14 | 27 |
| | | Total Resolution Error | 54 | 67 |
| | | Grand Total Error | 14,663 | 28,134 |

G = 100, $V_S$ = ±15 V.
(All errors are min/max and referred to input.)

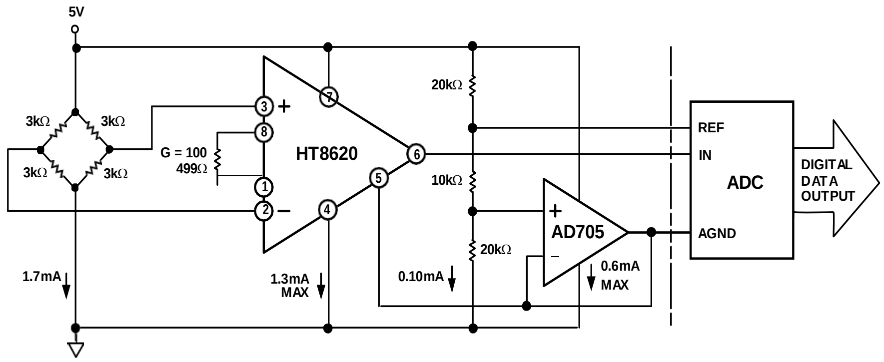



*Figure 40. A Pressure Monitor Circuit that Operates on a 5 V Single Supply*

### *Pressure Measurement*

Although useful in many bridge applications, such as weigh scales, the HT8620 is especially suitable for higher resistance pressure sensors powered at lower voltages where small size and low power become more significant.

Figure 40 shows a 3 kΩ pressure transducer bridge powered from 5 V. In such a circuit, the bridge consumes only 1.7 mA. Adding the HT8620 and a buffered voltage divider allows the signal to be conditioned for only 3.8 mA of total supply current.

Small size and low cost make the HT8620 especially attractive for voltage output pressure transducers. Since it delivers low noise and drift, it will also serve applications such as diagnostic noninvasive blood pressure measurement.

### *Medical ECG*

The low current noise of the HT8620 allows its use in ECG monitors (Figure 41) where high source resistances of 1 MΩ or higher are not uncommon. The HT8620's low power, low supply voltage requirements, and space-saving 8-lead mini-DIP and SOIC package offerings make it an excellent choice for battery- powered data recorders.

Furthermore, the low bias currents and low current noise, coupled with the low voltage noise of the HT8620, improve the dynamic range for better performance.

The value of capacitor C1 is chosen to maintain stability of the right leg drive loop. Proper safeguards, such as isolation, must be added to this circuit to protect the patient from possible harm.

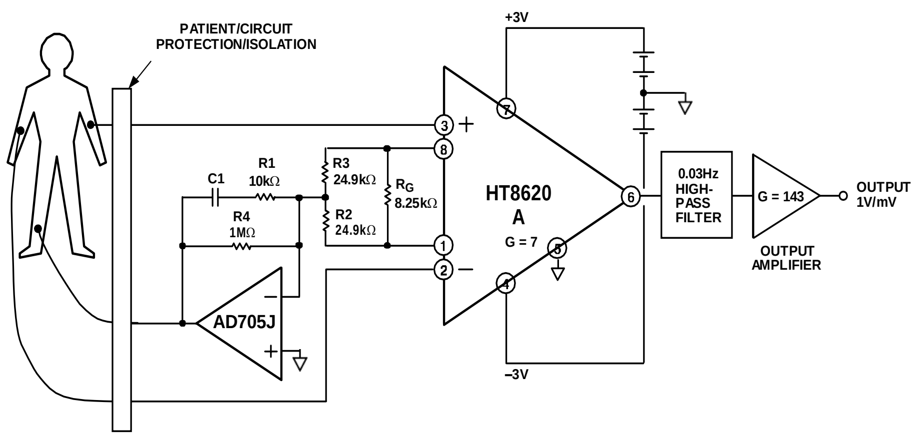



*Figure 41. A Medical ECG Monitor Circuit*

### *Precision V-I Converter*

The HT8620, along with another op amp and two resistors, makes a precision current source (Figure 42). The op amp buffers the reference terminal to maintain good CMR. The output voltage, $V_X$, of the HT8620 appears across R1, which converts it to a current. This current, less only the input bias current of the op amp, then flows out to the load.

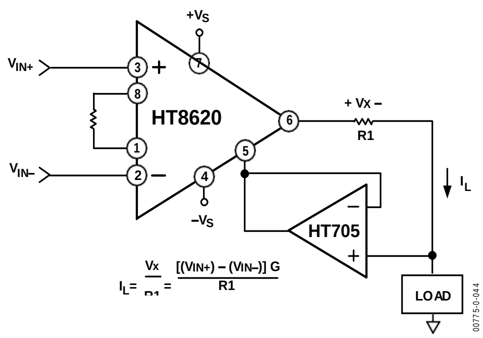



*Figure 42. Precision Voltage-to-Current Converter (Operates on 1.8 mA, ±3 V)*

## GAIN SELECTION

The HT8620's gain is resistor-programmed by $R_G$, or more precisely, by whatever impedance appears between Pins 1 and 8. The HT8620 is designed to offer accurate gains using 0.1% to 1% resistors. Table 4 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:

$$R_G = \frac{49.4\ k\Omega}{G-1}$$

To minimize gain error, avoid high parasitic resistance in series with $R_G$; to minimize gain drift, $R_G$ should have a low TC—less than 10 ppm/ ℃—for the best performance.

**Table 4. Required Values of Gain Resistors**

| 1% Std Table Value of $R_G$(Ω) | Calculated Gain | 0.1% Std Table Value of $R_G$(Ω ) | Calculated Gain |
|---|---|---|---|
| 49.9 k | 1.990 | 49.3 k | 2.002 |
| 12.4 k | 4.984 | 12.4 k | 4.984 |
| 5.49 k | 9.998 | 5.49 k | 9.998 |
| 2.61 k | 19.93 | 2.61 k | 19.93 |
| 1.00 k | 50.40 | 1.01 k | 49.91 |
| 499 | 100.0 | 499 | 100.0 |
| 249 | 199.4 | 249 | 199.4 |
| 100 | 495.0 | 98.8 | 501.0 |
| 49.9 | 991.0 | 49.3 | 1,003.0 |

## INPUT AND OUTPUT OFFSET VOLTAGE

The low errors of the HT8620 are attributed 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

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

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

## 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. It 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 HT8620 features 400 Ω of series thin film resistance at its inputs and will safely withstand input overloads of up to ±15 V or ±60 mA for several hours. This is true for all gains and power on and off, which is particularly important since the signal source and amplifier may be powered separately. For longer time periods, the current should not exceed 6 mA ($I_{IN} \leq V_{IN}/400\ \Omega$). For input overloads beyond the supplies, clamping the inputs to the supplies (using a low leakage diode such as an FD333) will reduce the required resistance, yielding lower noise.

## RF INTERFERENCE

All instrumentation amplifiers rectify small out of band signals. The disturbance may appear as a small dc voltage offset. High frequency signals can be filtered with a low pass R-C network placed at the input of the instrumentation amplifier. Figure 43 demonstrates such a configuration. The filter limits the input signal according to the following relationship:

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

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

where $C_D \geq 10C_C$.

$C_D$ affects the difference signal. $C_C$ affects the common-mode signal. Any mismatch in $R \times C_C$ will degrade the HT8620's CMRR. To avoid inadvertently reducing CMRR-bandwidth performance, make sure that $C_C$ is at least one magnitude smaller than $C_D$. The effect of mismatched $C_C$s is reduced with a larger $C_D$:$C_C$ ratio.

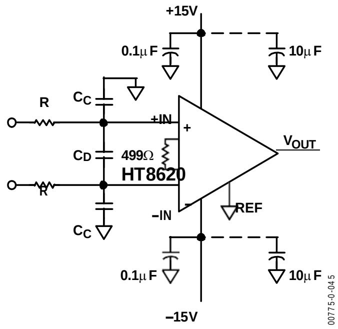



Figure 43. Circuit to Attenuate RF Interference

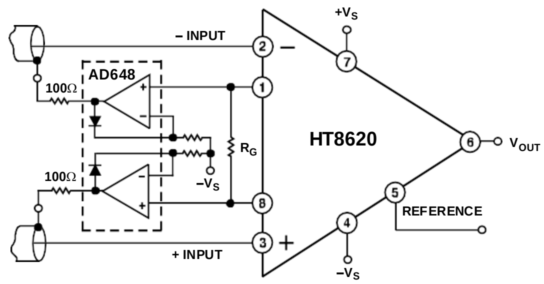



Figure 44. Differential Shield Driver

## COMMON-MODE REJECTION

Instrumentation amplifiers, such as the HT8620, offer high CMR, which is a measure of the change in output voltage when both inputs are changed by equal amounts. These specifications are usually given for a full-range input voltage change and a specifiedsource imbalance.

For optimal CMR, the reference terminal should be tied to a low impedance point, and differences in capacitance and resistance should be kept to a minimum between the two inputs. In many applications, shielded cables are used to minimize noise; for best CMR over frequency, the shield should be properly driven. Figure 44 and Figure 45 show active data guards that are configured to improve ac common-mode rejections by “bootstrapping” the capacitances of input cable shields, thus minimizing the capacitance mismatch between the inputs.

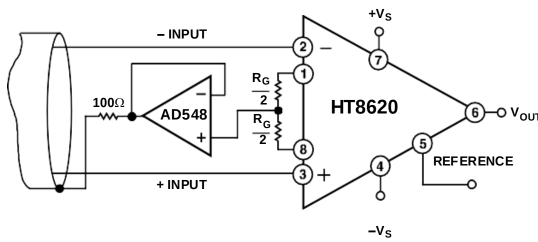



Figure 45. Common-Mode Shield Driver

## GROUNDING

Since the HT8620 output voltage is developed with respect to the potential on the reference terminal, it can solve many grounding problems by simply tying the REF pin to the appropriate “local ground.”

To isolate low level analog signals from a noisy digital environment, many data-acquisition components have separate analog and digital ground pins (Figure 46). It would be convenient to use a single ground line; however, current through ground wires and PC runs of the circuit card can cause hundreds of millivolts of error. Therefore, separate ground returns should be provided to minimize the current flow from the sensitive points to the system ground. These ground returns must be tied together at some point, usually best at the ADC package shown in Figure 46.

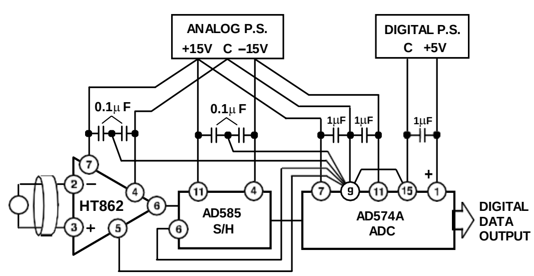



Figure 46. Basic Grounding Practice

## 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 47, Figure 48, and Figure 49. Refer to *A Designer's Guide to Instrumentation Amplifiers* (free from Analog Devices) for more information regarding in-amp applications.

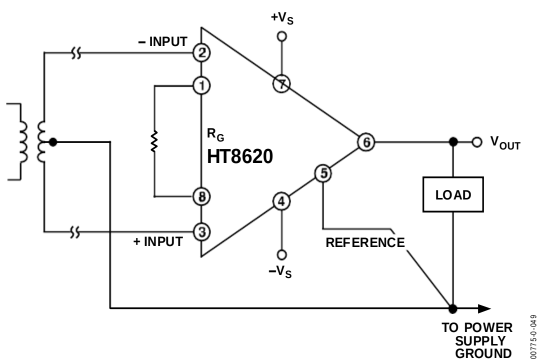



*Figure 47. Ground Returns for Bias Currents with Transformer-Coupled Inputs*

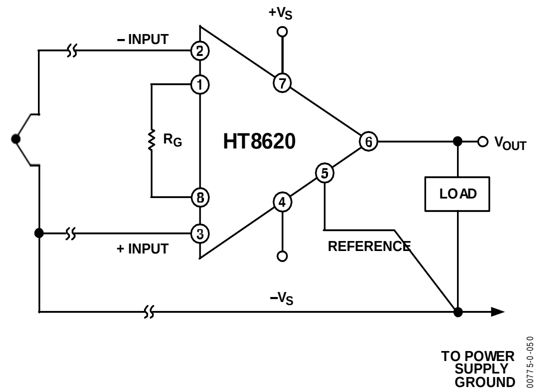



*Figure 48. Ground Returns for Bias Currents with Thermocouple Inputs*

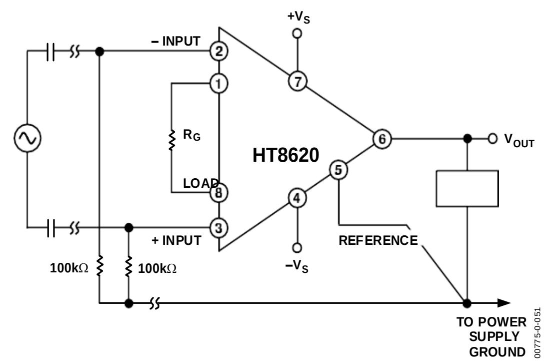
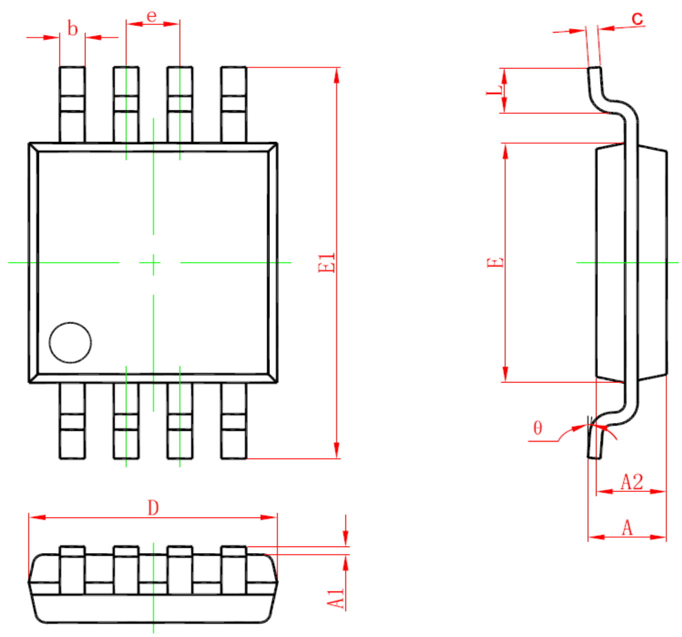



*Figure 49. Ground Returns for Bias Currents with AC-Coupled Inputs*

## Package Outline Dimensions

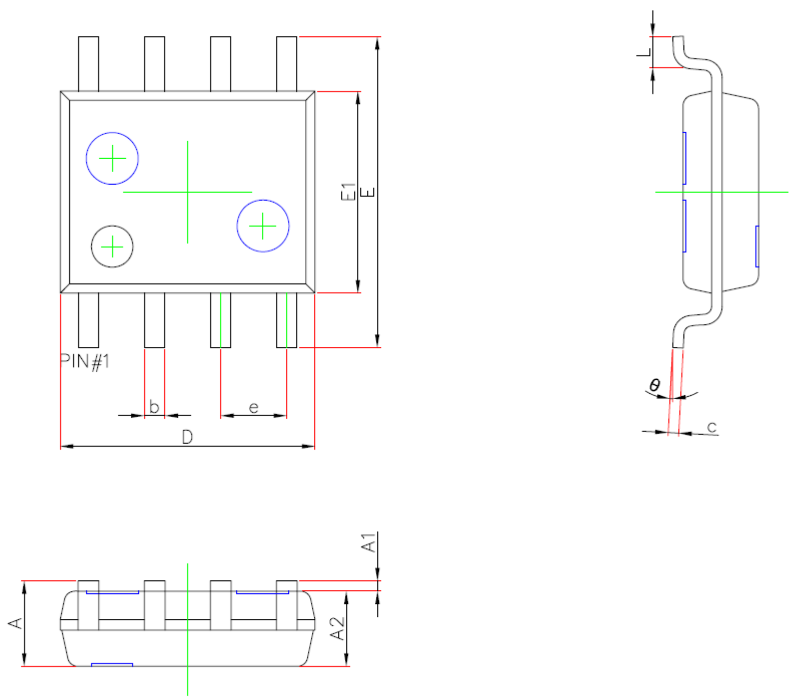
MSOP-8




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| e | 0.650(BSC) | | 0.026(BSC) | |
| E | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 4.750 | 5.050 | 0.187 | 0.199 |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 6° | 0° | 6° |

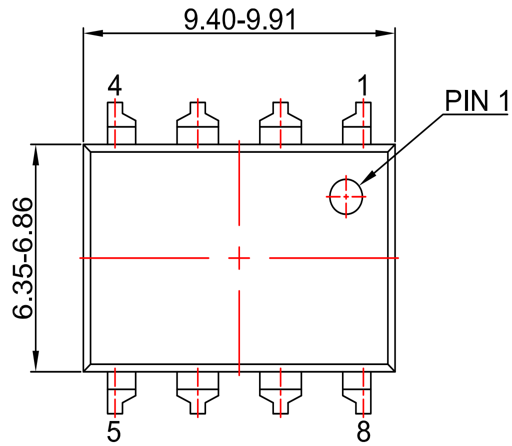
## Package Outline Dimensions

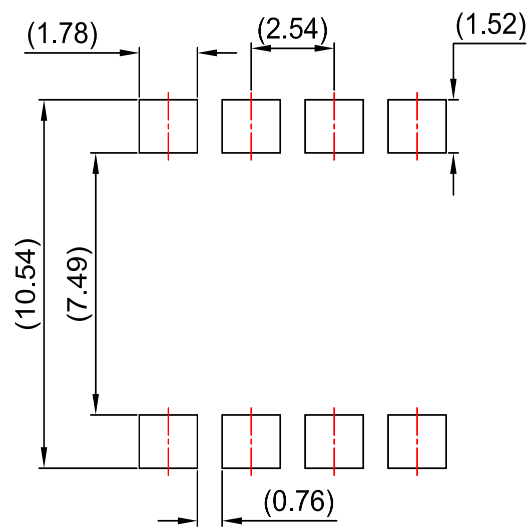
SOP-8 (SOIC-8)



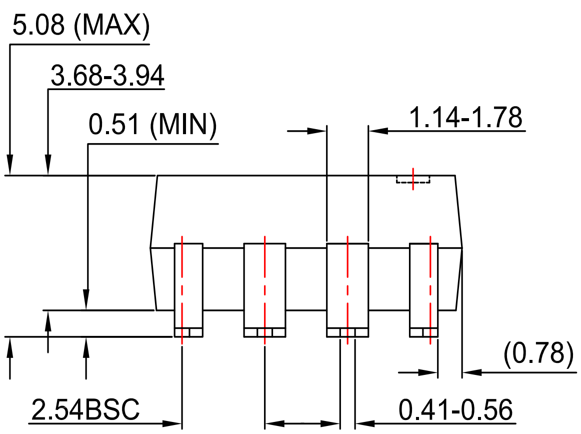

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min. | Max. | Min. | Max. |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.201 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270(BSC) | | 0.050(BSC) | |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 8° | 0° | 8° |

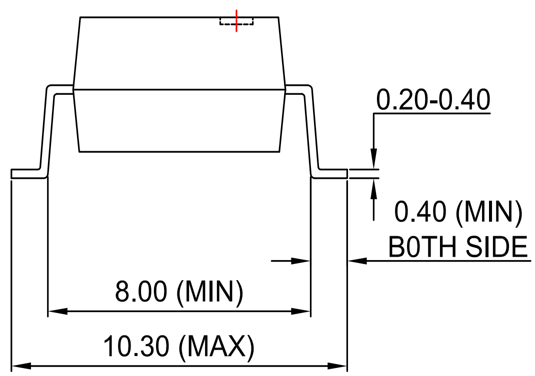
## DUB8 (7.5*6.5) package information



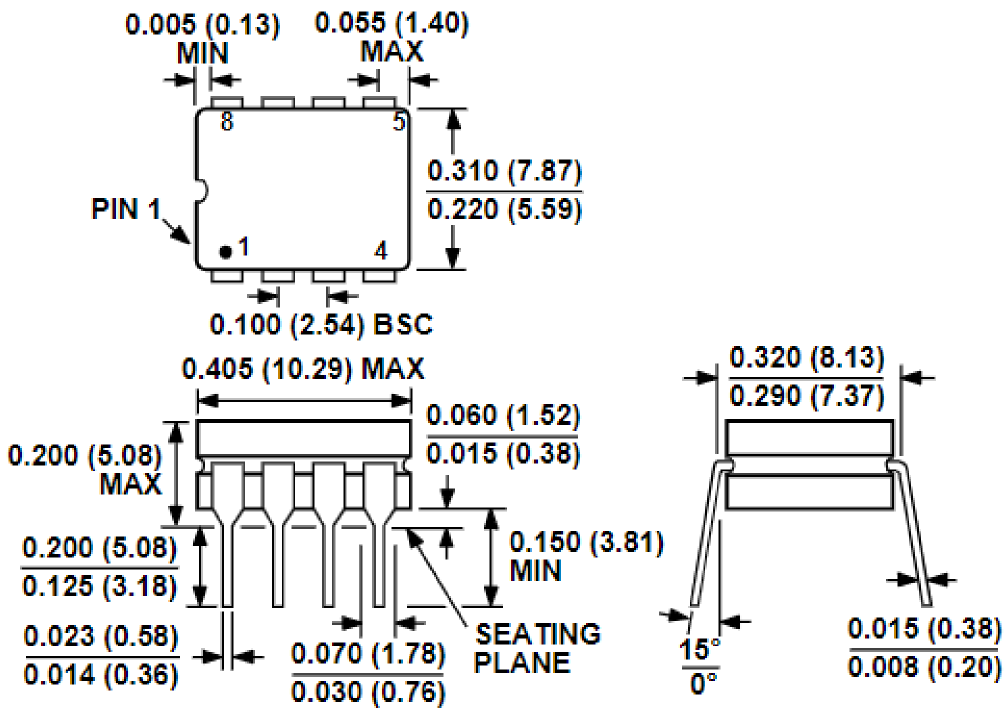




LAND PATTERN RECOMMENDATION




NOTES:
A) NO STANDARD APPLIES TO THIS PACKAGE
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DIMENSIONS ARE EXCLUSIVE OF BURRS,
MOLD FLASH, AND TIE BAR EXTRUSION
D) DRAWING FILENAME AND REVSION: MKT-N08Hrev7.




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

*Figure 51. 8-Lead Ceramic Dual In-Line Package [CERDIP] (Q-8)*
*Dimensions shown in inches and (millimeters)*