Noise Considerations when Using Piezoresistive Pressure Sensors

Technical Note

INTRODUCTION

The one source of error found in all systems is noise. Obviously, the higher the noise, the lower the accuracy and resolution become. In some systems, such as those used for monitoring very low pressures, noise can be a significant problem. Such low-level measurement designs require a familiarity with noise, its characteristics and its sources. This application note discusses the low frequency noise that is present in a variety of Honeywell's pressure sensors and transducers and comparative results are given.

GENERAL — HOW TO MEASURE NOISE

Since all electronic components generate noise, a noise measurement system was designed that has an order of magnitude less noise than the sensors to be measured. The signal-to-noise ratio (or, in this case, noise-to-noise ratio,) determine the minimum sensor noise that can be measured. The following is a list of items that have a direct effect on the measurement system.

- Power Supplies
- Amplifiers
- Filters
- Ground Loops
- Lead Lengths
- Component Values

To minimize noise from the power source, batteries were used in our test system to power the sensor and amplifiers. Since all semiconductor amplifiers also have low frequency 1/F noise as well as popcorn type noise, these sources represent the background noise for the ideal sensor. To minimize amplifier noise, a very low noise amplifier must be used. A general purpose amplifier could easily generate much more noise than the sensor and this noise would not be distinguishable from the sensor noise. For our test system, shown in Figure 2, a low noise LT1007CH amplifier from Linear Technology Corp. was selected. (See Figure 1)

Also, to minimize stray noise pick-up all lead lengths to the inputs of the amplifiers must be kept as short as possible in any noise measurement system. Because resistors also generate noise proportional to the resistor value, the resistor values must also be kept as low as practical.

MEASUREMENTS

Noise measurements were made with the system shown in Figure 2. The HP7015B recorder has a 10 Hz Bandwidth with the internal filters switched out; Figure 3 shows the frequency response on the 5mV/cm range. The following sensors were tested and graphs of the results are shown in the accompanying figures.

SCX01G	Figure 5
SX01G	Figure 6
SPX50D	Figure 7

Each sensor was allowed to warm up for 5 minutes and a 10 second trace was run on each. The "Base Line" noise of the amplifier is shown in Figure 4. Since the amplifier has a gain of 1000 V/V, 1mV represents 1µV of noise when referred to the input.

RESULTS

The graphs for the four sensors can be misleading. At first glance, they all seem to have about the same noise voltage. However, they are quite different in signal-to-noise ratio when the sensitivity of the sensor is taken into consideration.

Table 1 compares the peak-to-peak noise voltage of each sensor and the signal-to-noise ratio for that particular sensor. The noise voltage of the sensors was independent of the pressure range for each family of unamplified sensors. This was not true, however, of the signal-conditioned transducers; since the amplifier was the major noise source, the pressure range that has the lowest amplifier gain had the least noise voltage.

CONCLUSION

These tests show that the noise generated by the sensor was very small when compared to other noise sources. However, for particularly noise-critical applications, the SX or SCX Series should be the preferred sensors. Also, in applications where a small percentage of the total span is used or the pressure to be measured is very small (less than 1psi), amplifier selection and circuit layout is as important as the sensor selection.

TABLE 1
Typical DC to 10 Hz Noise 0.1 psi

Device Type	Vs	Sensitivity (mV/psi)	Noise Voltage (P/P)	Noise (psi)	Signal-to-Noise (Ratio)
SX01D	12 Vdc	38	1 µV	$2.6x10^{-5}$	90 dB
SPX50D	3 Vdc	5.7	1 µV	$1.7x10^{-4}$	75 dB
SCX01DN	12 Vdc	18	2 µV	$1.1x10^{-4}$	79 dB

FIGURE 1
Low Noise Amplifier

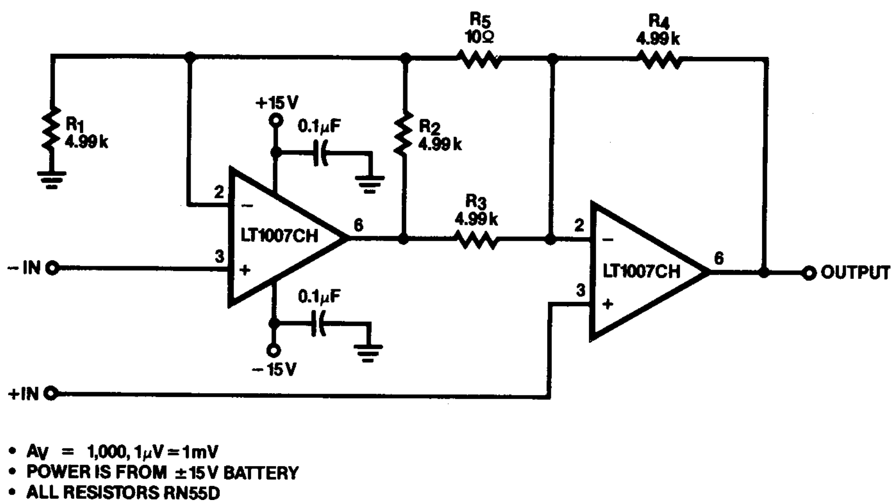

FIGURE 2
Noise Test System

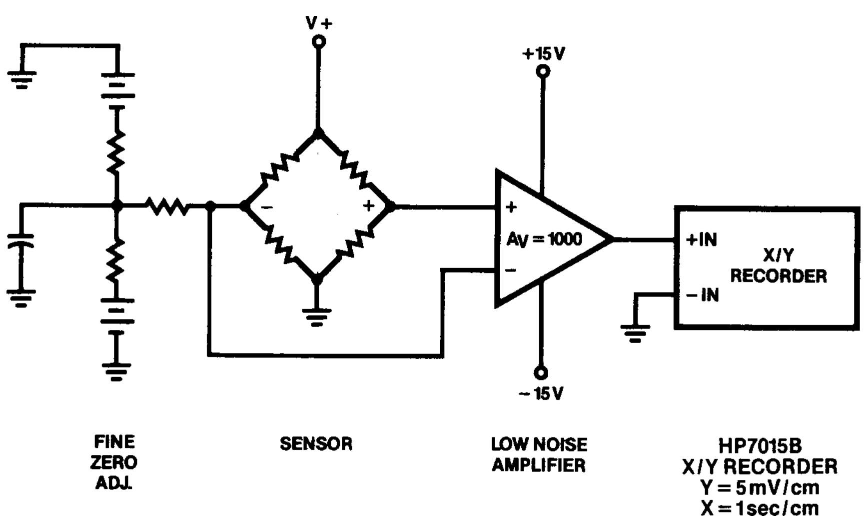

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FIGURE 3
x \ y Recorder vs. Frequency

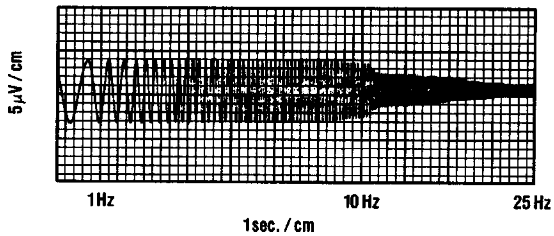


FIGURE 4
Low Noise Amplifier

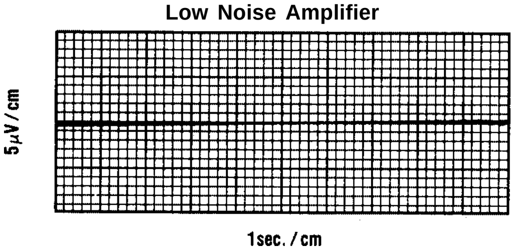


FIGURE 5
SCX01G Sensor

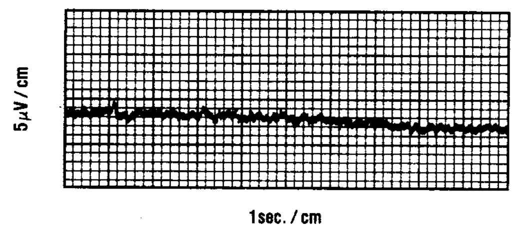


FIGURE 6
SX01D Sensor

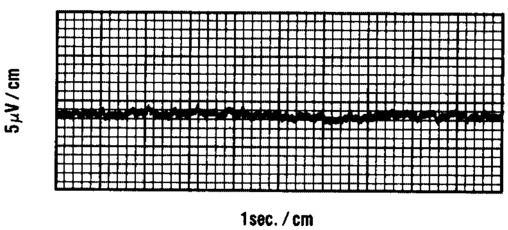
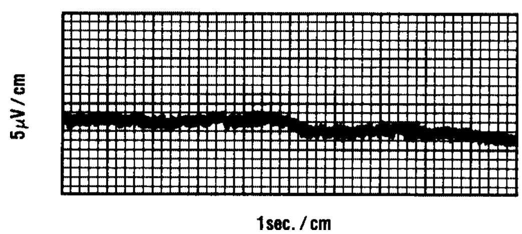


FIGURE 7
SPX50D Sensor



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