

TIME RESPONSE MEASUREMENTS OF PRESSURE SENSORS USING PINK NOISE TECHNIQUE

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ABSTRACT

This work presents an experimental setup for Pink Noise method application on pressure transmitters' response times. The Pink Noise method consists on injecting artificial pressure noise into the pressure transmitter. The artificial pressure noise is generated using a current-to-pressure (I-to-P) converter, which is driven by a random noise signal generator. The output pressure transmitter noise is then analyzed using conventional Noise Analysis Technique. Noise signals may be interpreted using spectral techniques or empirical time series models. The frequency domain method consists of evaluating the Power Spectral Density (PSD) function. The information needed for time constant estimation can be obtained by fitting an all-pole transfer function to this power spectral density.

1. INTRODUCTION

Estimation of pressure sensor response characteristics is necessary to satisfy requirements on allowable response time for nuclear power plants. One method consists in doing the analysis of the noise from the sensors, and the information about the dynamic behavior of the sensor is obtained with a minimal interference during normal operation of the nuclear power plant [2].

The Noise Analysis Technique is based on analyzing the natural fluctuations that exist at the output of pressure transmitters while the plant is operating. These fluctuations (noise) are caused by turbulence that is induced by the flow of water in the system, by vibration, and by other naturally occurring phenomena.

The Noise Analysis Technique provides a passive method for the dynamic testing of pressure transmitter and its sensing lines at the same test. The tests can be performed remotely while the plant is operating, do not require transmitters to be removed from service, do not interfere with plant operation, and can be performed on several transmitters simultaneously.

Testing the response time of pressure sensing systems in nuclear power plants requires wideband process fluctuations or "white noise". Although, the term white noise is commonly used, process fluctuations do not normally have white noise characteristics. However, this does not pose a problem as long as the bandwidth of the process fluctuations is sufficiently greater than the expected bandwidth of the pressure sensing system being tested.

For some pressure transmitters in nuclear power plants, such as containment pressure transmitters and water storage tank level transmitters, process fluctuations do not normally exist or they are inadequate for using the Noise Analysis Technique to test response time. As such, these transmitters' response times are tested using either the conventional ramp test method [3], or by injecting artificial pressure

noise into the transmitter. The artificial pressure noise is generated using a current-to-pressure (I-to-P) converter, which is driven by a random noise signal generator.

The resulting signal is referred to as pink noise, and the test method is thus called the Pink Noise Technique. This work presents an experimental setup for the Pink Noise method to be applied for pressure transmitters' response times.

2. EXPERIMENTAL SETUP

The experimental setup consists in a random noise generator, the pressure sensor and a noise data acquisition system (Fig. 1). The artificial pressure noise is generated using a current-to-pressure (I-to-P) converter, which is driven by a random noise signal generator.

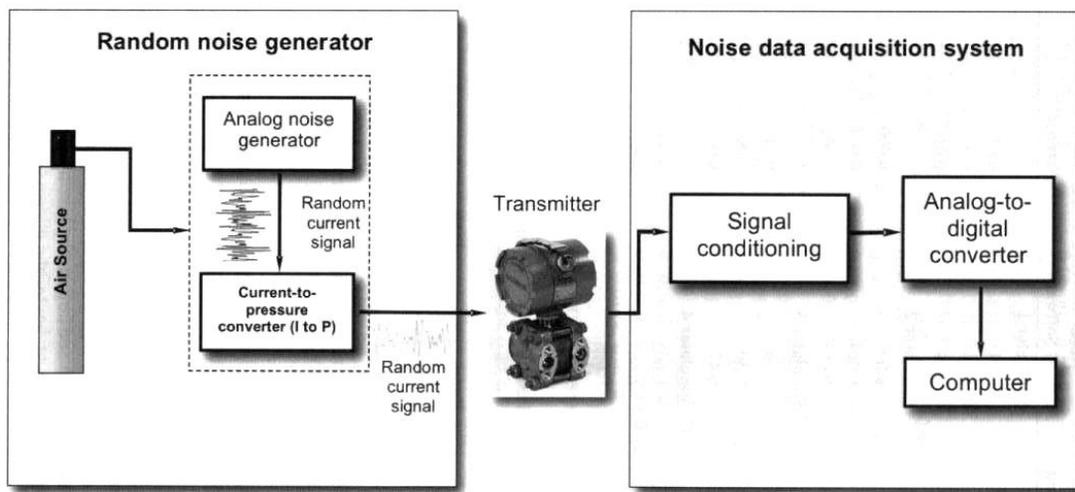


Figure 1. Equipment setup for response time testing of containment pressure transmitters using the Pink Noise technique [2].

2.1. Current-to-pressure (I to P) Converter

The current-to-pressure (I to P) converter used in this experiment is the Electropneumatic Valve Positioners Series 8012-3-C, Precise Reliable Valve Positioning, from Masoneilan [1]. This equipment is a force-balance electropneumatic device which, by directly comparing valve stem position with controller DC output signal, provides dynamic response and positioning accuracy not obtainable with transducer and pneumatic positioner combination (Fig. 2). In this work it is used as a current-to-pressure converter.

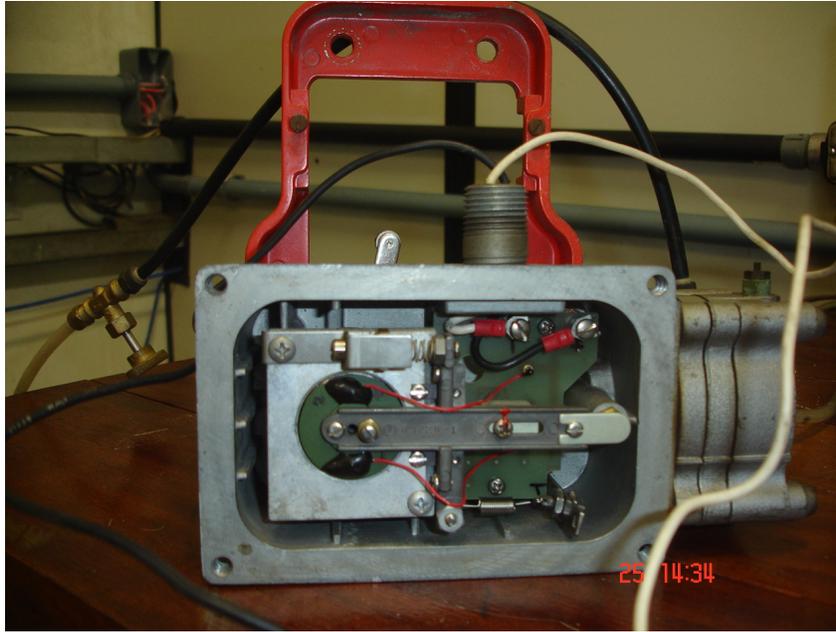


Figure 2. Current-to-Pressure (I-P) Converter.

2.2. Random Noise Signal Generator

A white noise signal current is generated using a Hewlett Packard function/arbitrary waveform generator 33120A. The 33120A features sine, triangle, square, ramp, and noise waveforms, a 12-bit, 40 MSa/s, 16k-deep arbitrary waveform generator, and both internal sweep and modulation capabilities. Noise signals can be generated at different amplitudes in a bandwidth up to 10 MHz.

2.3. Isolating Amplifier

Isolation amplifiers provide electrical isolation and an electrical safety barrier. They protect data acquisition components from common mode voltages, which are potential differences between instrument ground and signal ground. This action serves to protect the amplifier and the instrument connected to it, while still allowing a reasonably accurate measurement. The isolation amplifier has different adjustable gain from 1 to 10000.

2.4. Noise Data Acquisition System

The data acquisition system used in this experiment consists by a notebook Pentium IV with Windows XP and data acquisition program developed using LabView. The data acquisition card for laptop-based measurements is from National Instruments - DAQCard-6024E, and the SCB-68 shielded I/O connector block for interfacing I/O signals to plug-in DAQ devices with 68-pin connectors.

2.5. Pressure Transmitter and Sensor

The pressure sensor used in this experiment is the Smar LD 200 D04 differential pressure transmitter. The sensor is a capacity cell type sensor and operates in a range from 0 to 400 kPa.

The complete experimental setup is shown in Fig. 3. An additional air supply is used in the experiment in order to feed the I-P converter and the pressure sensor.

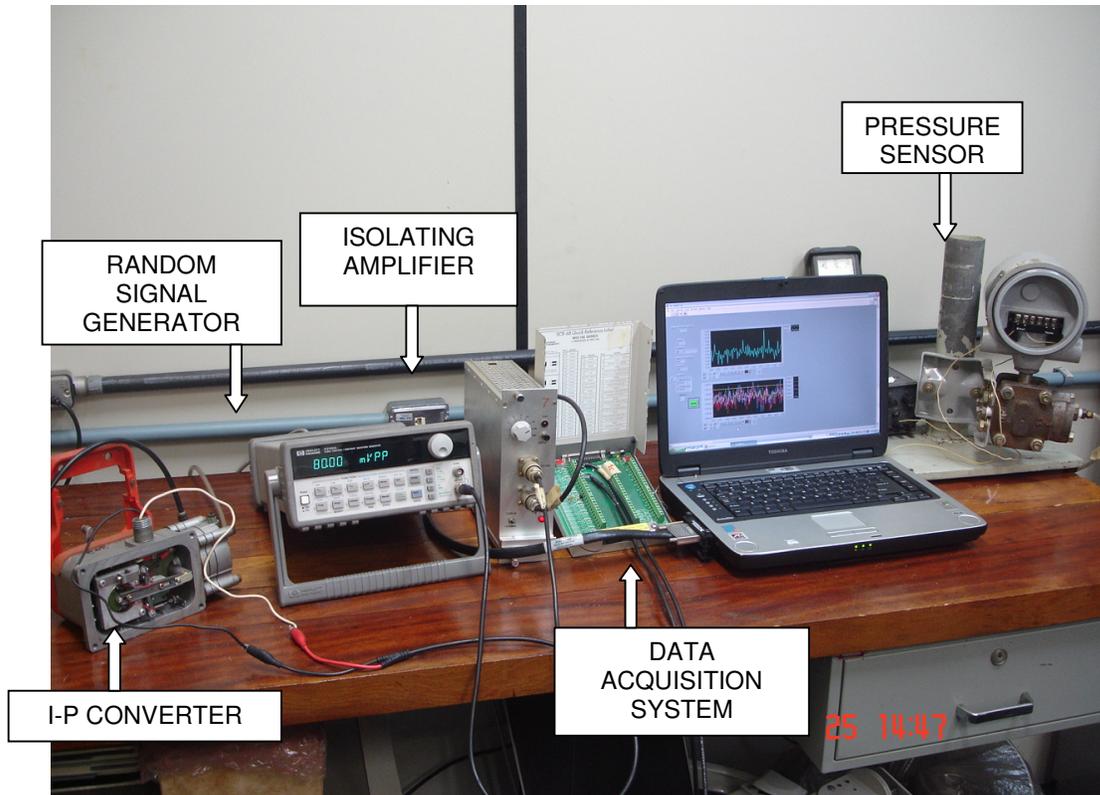


Figure 3. Experimental setup for Pink Noise methodology measurements.

The experiment can be briefly explained as follows:

- a random signal current is produced by the **random signal generator**
- this current signal is the **I-P converter** input, and the I-P output is a random pressure signal
- this random pressure signal excites the **pressure sensor**, which produces a random signal output
- the pressure sensor output passes through a **isolating amplifier**, the signal is filtered and amplified
- the resulting noise signal is analyzed using the traditional Noise Analysis Technique.

Noise signals may be interpreted using spectral techniques or empirical time series models. The frequency domain method consists of evaluating the Power Spectral Density (PSD) function. The

information needed for time constant estimation can be obtained by fitting an all-pole transfer function to this power spectral density. If the system has only one dominant pole, then the time constant of interest can be obtained from the break frequency of the PSD curve. Figure 4 shows the pressure sensor output with noise pressure input condition.

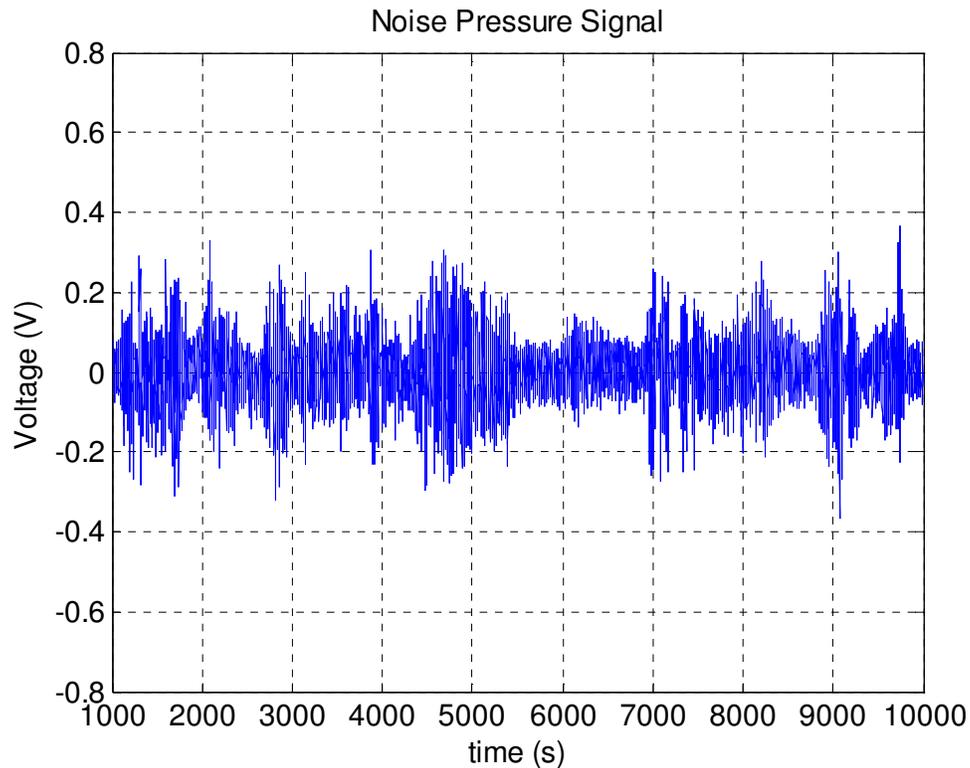


Figure 4. Noise pressure signal.

3. CONCLUSIONS AND FUTURE WORKS

For some pressure transmitters in nuclear power plants, such as containment pressure transmitters and water storage tank level transmitters, process fluctuations do not normally exist or they are inadequate for using the Noise Analysis Technique to test response time. As such, these transmitters' response times can be tested by injecting artificial pressure noise into the transmitter. The artificial pressure noise is generated using a current-to-pressure (I-to-P) converter, which is driven by a random noise signal generator. This work presents an experimental setup to perform the Pink Noise Technique applied for pressure transmitters' response times, and is a first step towards the methodology implementation for a future application in nuclear power plants pressure sensors' time response measurements.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to Mr. Arivaldo Vicente Gomes for his help in this work.

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