**International Journal of Software Innovation**
Volume 10 • Issue 2

# Frequency Acquisition Method for Measuring Strain of Vibration Wire Sensor

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## ABSTRACT

A vibrating wire sensor is designed to monitor structural transformations at construction sites. The sensors that measure pressure and strain at construction sites are ultimately expressed by stress values. To express a stress value, the vibration frequency is measured by attaching a sensor without affecting the structure. Accurate measurement of a vibrating wire sensor is used to measure the resonance frequency of the target structure. The problem is sensor wire response time and noise. For accurate measurement, the problem was solved by using a noise reduction circuit and a method of calculating the time according to the cycle of a microcontroller unit (MCU). To calculate the frequency accurately in the MCU, the time corresponding to one cycle is measured by the clock in the MCU, and time-base sensor wire analysis is conducted. This study proposes a method to accurately measure the resonance frequency.

## KEYWORDS

Acquired Sensor Data, Frequency Sweep, Input Capture, Microcontroller Unit, Sensor Measurement, Time of Cycle, Vibrating Wire Sensor, Vibration Wire Analysis

## INTRODUCTION

Vibrating wire sensors are often used to monitor structural transformations at construction sites. A vibrating wire sensor measures the strain and resonance frequency according to the transformation of the structures. When the distance between the two support points of the part to be measured is changed, the resonance frequency of the vibrating wire sensor changes (Arutunian, 2008).

A vibrating wire sensor is composed of a wire and a spring. A vibrating wire sensor also has more than one coil. The first coil monitors the vibration of the wire, and the other coils collect resonance frequency signals (Neild, Williams, & McFadden, 2005).

Vibrating wire sensors are used to monitor structural responses, civil engineering scenarios, and hydraulic and structural conditions (Braga, Morikawa, Camerini, et al., 2011; Hyo, Hwan, Se, et al., 2013; Lee, Kim, Sho, et al., 2010; Petroff, Halling, Barr, & Scott, 2014; Sreeshylam, Ravisankar, Parivallal, et al., 2008).

Many researchers have used vibrating wire sensors in strain and crack gauges to monitor the concrete stress (Liu, Wei, & Wang, 2012).

DOI: 10.4018/IJSI.289598
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Measurement with the vibrating wire sensor is very simple and the sensor is highly sensitive, although it is small. The vibrating wire sensor is appropriate for long-term monitoring because it does not deteriorate significantly over time (Coutts, Wang, & Cai, 2001; Neild, Williams, & McFadden, 2005; Yu & Gupta, 2005).

This paper discusses a method for acquiring vibrating wire sensor data from a microcontroller unit (MCU). For accurate reading of the vibrating wire sensor, an algorithm, hardware, and software were configured to process one cycle per clock in the time base of the MCU.

The remainder of this paper is organized as follows. Section 2 introduces the mathematical model and measurement method of the vibrating wire sensor. Section 3 describes the design of the interface hardware circuit and calculation software algorithm. Section 4 presents the results of this study for the collected data. Finally, Section 5 concludes this paper.

## METHODOLOGY

The electromagnet was stimulated using the input pulse train. This stimulus is transmitted to the wire and generates an output signal that matches the resonance frequency of the target. This is called the natural vibration frequency according to the transformation of the target (Lee, Kim, Sho, et al., 2010).

A force is applied to the target to transform the natural vibration frequency. The applied force transforms the supports on both sides of the wire. Thus, the natural vibration frequency is measured differently even if the length of the wire changes only slightly, making this a sensor with high precision sensitivity.

The initial frequency of the vibrating wire sensor can be calculated using the following equation:

$$f_0 = \frac{1}{2L}\sqrt{\frac{\sigma}{\rho}} = \frac{1}{2L}\sqrt{\frac{E\varepsilon_0 \mathrm{g}}{\rho}}$$

$g : The\ gravitational\ acceleration\left(m / s^2\right)$

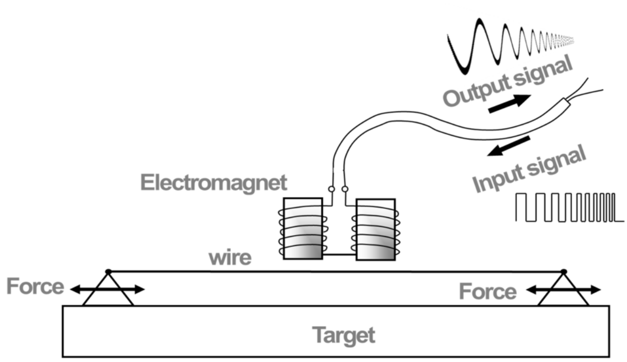
$f_0 : The\ natual\ frequency\left(Hz\right)$

$L : The\ length\left(m\right)$

$\sigma : The\ Stress\left(Pa\right)$

$\rho : The\ mass\ density(kg / m^3)$

**Figure 1. Measurement theory of vibrating wire sensor**



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