Powerless Vibration Sensor Probe using DHFLCs (AS01a-23)

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Overview

Problem

Vibration sensing plays a crucial role in various fields such as in earthquake monitoring and structural health monitoring. However, the power supply for vibration sensors presents a crucial issue as the maintenance of batteries pose a significant and challenging task particularly in remote deployment.

Solution

In this project, our group aims to develop a powerless passive vibration sensing system by using a deformed helix ferroelectric liquid crystal (DHFLC) cell, optical detector, and piezoelectric film.

Objectives

1. Develop and build a passive vibration sensor system with DHFLC cell and piezoelectric film.
2. Reach vibration sensor sensitivity of 0.3784 V/(m/s²)
3. Linearity in the electro-optical response <1% full detection range

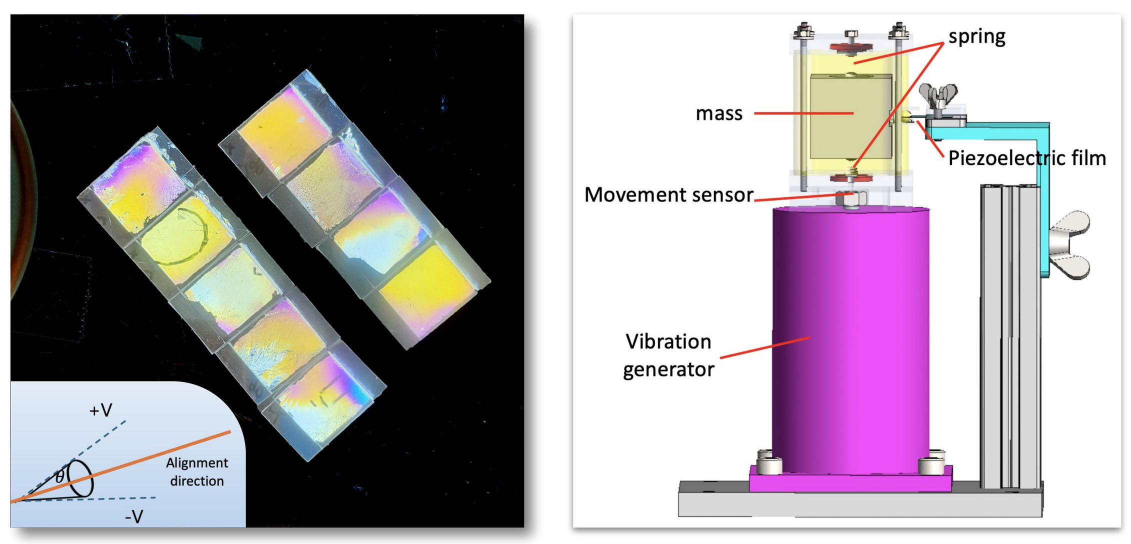

Figure 1: DHFLC cell (left) and passive vibration sensor system design (right)

Methodology

Implementation

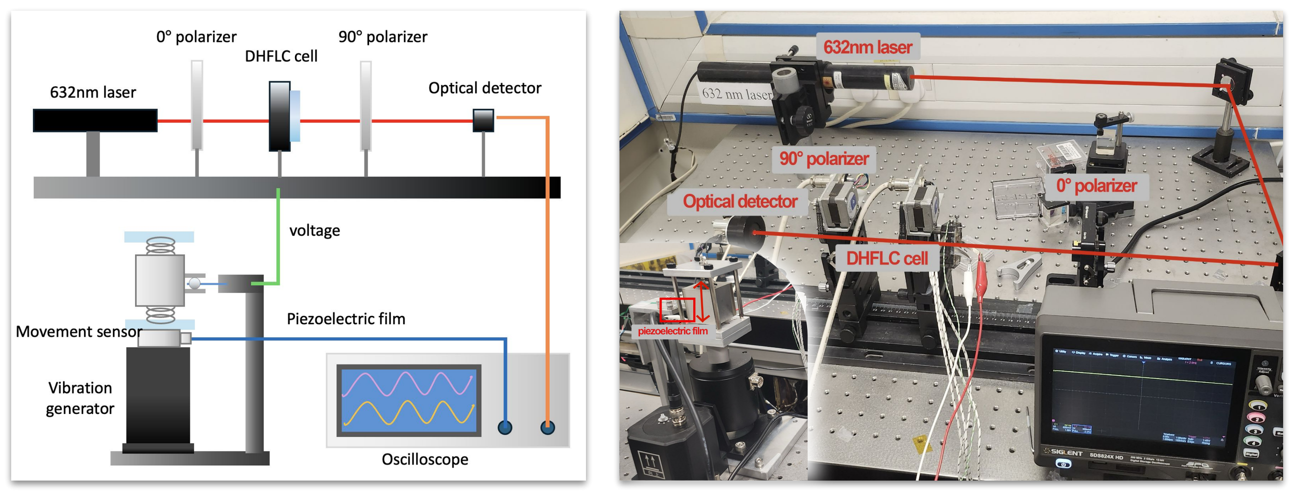

Figure 2: Overall system diagram (left) and system setup (right)

Mechanical Signal Sensing:
Vibrations originate from a vibration generator captured by a movement sensor.

Optical Signal Sensing:
The optical signal from a laser beam output, along with the voltage produced by the piezoelectric film, passes through a DHFLC cell.

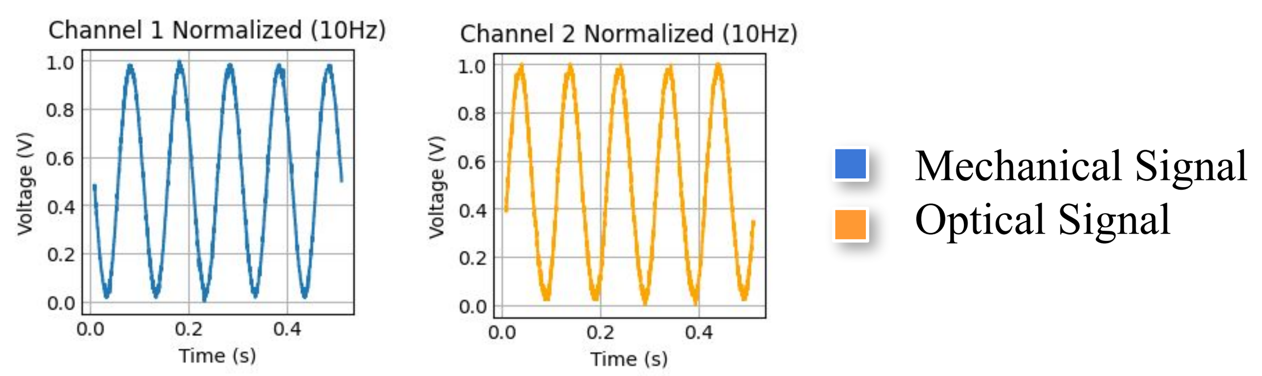

Figure 3: Voltage - Time graph of Mechanical and Optical signal

Signal Comparison:
The system is linked to an oscilloscope for data processing and signal comparison for sensitivity and linearity.

Results

Experiment Results

Experiment 1: Modelling the relationship of the movement sensor and data from the optical detector with a linear regression as shown in Figure 4a to obtain a linearity of 0.28% full range output.

Experiment 2: Using data from experiments as shown in Figure 4b, we find that our system has a sensitivity of 0.4204 V/(m/s²).

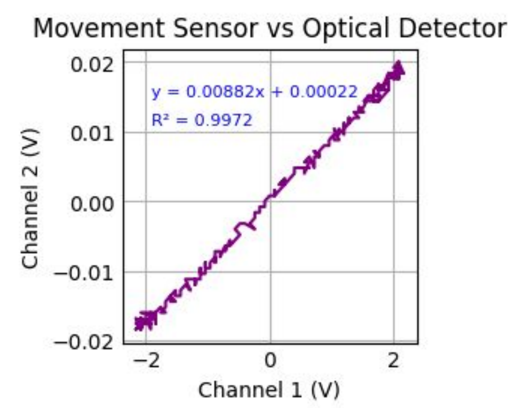

Figure 4a: Linearity graph of mechanical and optical signal

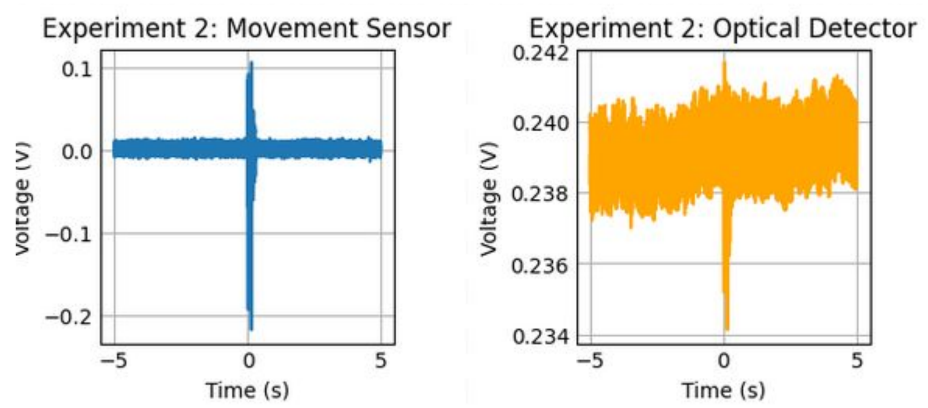

Figure 4b: Vibration and light intensity data

Conclusion

Our group created a passive vibration sensing system that has a sensitivity of 0.4204 V/(m/s²) and a linearity of 0.28% in the electro-optical response. Future works include improving the system's design, such as isolation of piezoelectric film from the ground as shown in Figure 5.

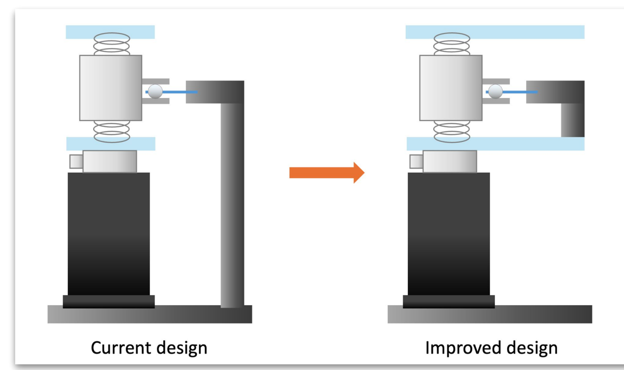

Figure 5: Improved design of the system