Displacement and Motion Measurement

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MECE 3320: Measurements & Instrumentation Lab Exercise

I. Introduction

There are several different types of sensors that can be used to measure displacement and motion. You can measure linear displacement by using a potentiometric sensor or an LVDT (linear variable differential transformer). You can measure angular displacement or rotation using an RVDT (rotary variable differential transformer) or an encoder. Potentiometric sensors are resistive and can be read by applying a current and measuring the voltage drop across the resistor. Encoders typically generate a TTL-level pulse train. An LVDT is more complicated and requires AC excitation. The output is AC and can be measured by changes in peak-to-peak voltage and phase shift. Some of the types are discussed below.

- Resistive (potentiometric)
  - Current excitation
  - Linear

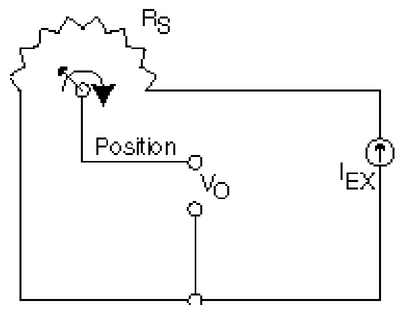


Figure 1. Resistive Option

- Encoders
  - Pulsed output
  - Quadrature The most common type of incremental encoder uses two output channels (A and B) to sense position. Using two code tracks with sectors positioned 90 degrees out of phase, the two output channels of the quadrature encoder indicate both position and direction of rotation. If A leads B, for example, the disk is rotating in a clockwise direction. If B leads A, then the disk is rotating in a counter-clockwise direction.

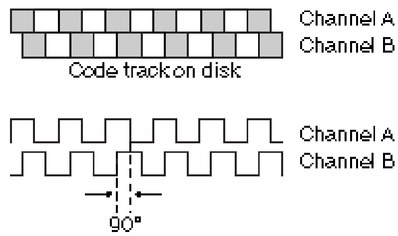


Figure 2. Encoder Option

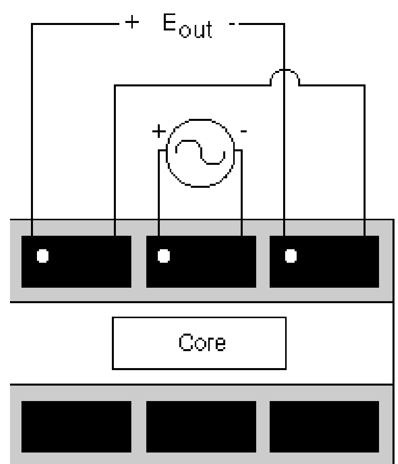
By monitoring both the number of pulses and the relative phase of signals A and B, you can track both the position and direction of rotation.

Some quadrature encoders also include a third output channel, called a zero or index or reference signal, which supplies a single pulse per revolution. This single pulse is used for precise determination of a reference position.

- ⇨ LVDT (linear variable differential transformer)
  - ⇛ Core movement through transformer
  - ⇛ AC excitation
  - ⇛ Phase voltage output change

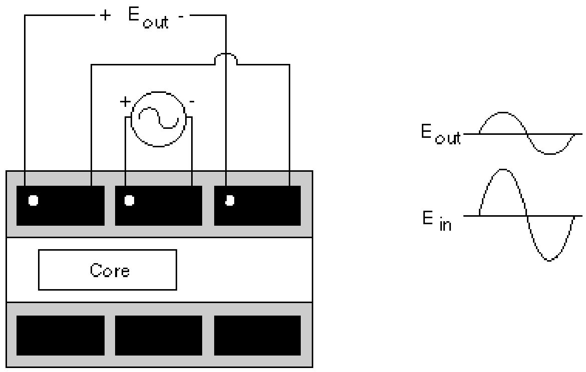
II. LVDT Fundamentals

The figure below shows a cross-sectional view of an LVDT. Two secondary windings are located on either side of the primary winding. The core causes the magnetic field generated by the primary to be coupled to the secondaries. When the core is at center as shown, the voltage induced in each secondary is equal and the LVDT output (for the series-opposed connection shown in this case) is zero because both voltages cancel.

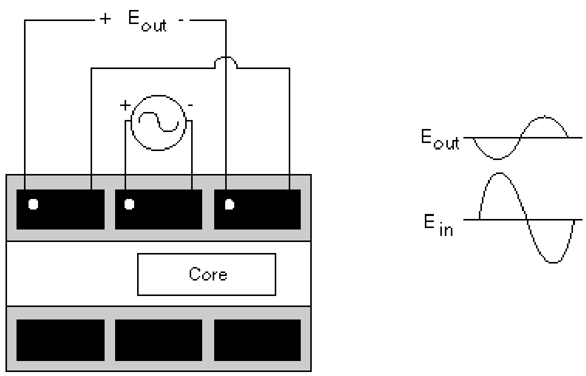


Move the core to the left and the first secondary is more strongly coupled to the primary than the second secondary. The greater voltage of the first secondary causes an output voltage which is in phase with the primary voltage.

Likewise, move the core to the right and the second secondary is more strongly coupled to the primary than the first secondary. The greater voltage of the second secondary causes an output voltage to be out-of-phase with the primary voltage.



LVDT signal conditioners generate a sine wave for the primary and synchronously demodulate the secondary output signal, so that the DC voltage that results is proportional to core displacement. The sign of the DC voltage indicates whether the displacement is to the left or right.



III. Procedure

- ⇨ Make sure that the LVDT core is fully extended.
- ⇨ Rotate the micrometer by *2mm* and record the voltage. Repeat this step for every *2mm* until the LVDT core fully contracts.
- ⇨ Plot a calibration curve of voltage versus displacement.
- ⇨ Repeat the calibration procedure, this time, let your lab partner perform the experiment.

A. Thought Questions

Document your response to these questions in your lab report.

- ⇨ What are the independent and independent variables in this calibration? Can you suggest any extraneous variables? What would be involved in a replication?
- ⇨ What would be involved in determining the repeatability of the instrument? The reproducibility? What effects are different in the two tests? Explain.

IV. Report

For this lab you will write the Results and Discussion of Results sections of a full report.

References

[1] National Instruments: http://www.ni.com/white-paper/4680/en/.