MCE380: Measurements and Instrumentation Lab

Chapter 5: Electromechanical Transducers

Part II

Topics:
Resistive Electromechanical Coupling
Capacitive Electromechanical Coupling Voltage Dividers
Bridge Circuits

Reference: Holman, CH 4.

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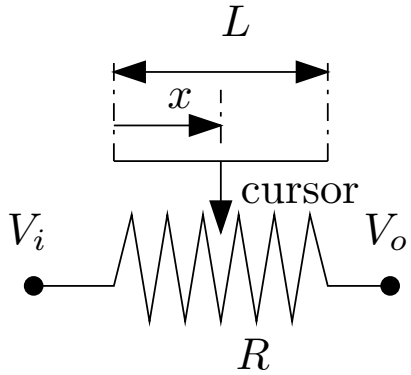
The Potentiometer

The potentiometer is a transducer capable of converting displacement to voltage (one way only!!) through changes in resistance.



The resistance between either end and the pointer changes linearly with x. Now we obtain the appropriate relationships.

Potentiometers....

Sometimes a wide range of resistance values needs to be accommodated in a small space. Rotary potentiometers (volume knobs) are built for this purpose. Some potentiometers have a logarithmic rather than linear variation.

A *rheostat* is a large potentiometer intended for high power applications. Old streetcars had rheostats which worked as electric brakes by converting kinetic energy into electricity (using a generator) and then into heat dissipated in the rheostats.

Trimpots are small potentiometers for printed circuit board (PCB) mounting. The adjustment is made with a tightly-fitting screw. Trimpots are not meant for frequent re-adjustment.

Capacitive Position Transducers

- The capacitance of a parallel-plate capacitor with variable air gap is given by the formula

$$C = \frac{0.225A}{x}$$

  where A is the area in sq.in., x is the separation in inches and C is the capacitance in pF.

- The capacitive sensor offers a large sensitivity. For example when $x = 0.01$ inches and $A = 1$ in^2:

$$\frac{dC}{dx} = -\frac{0.225A}{x^2} = 2250 \text{ pF/in}$$

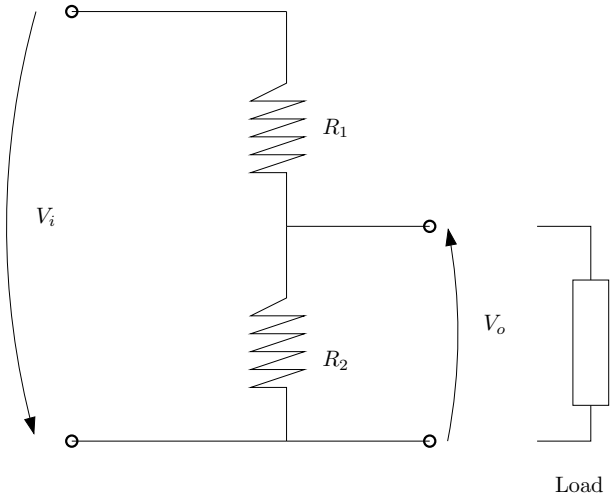
  Note that the sensitivity is nonlinear and larger for small x.

- The capacitive element presents the difficulty of having an extremely large output impedance. For example, at 10kHz the impedance is 708 kΩ. Worsens at lower frequencies.

- Special electronics are required to interface capacitance sensors.

Voltage Divider

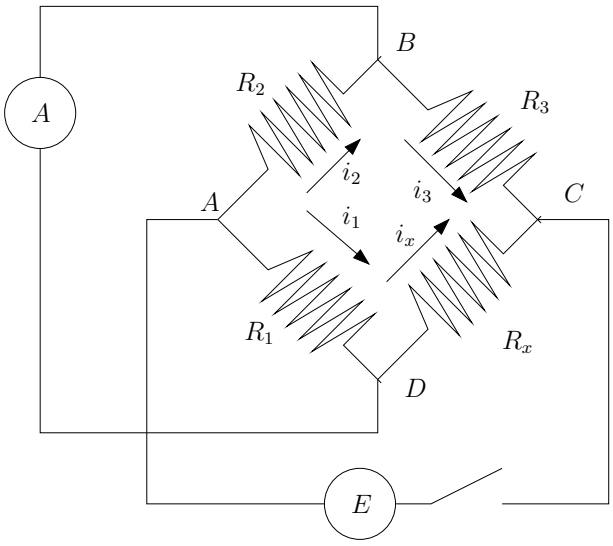
The voltage divider can be used to convert one voltage level to another. Its operation depends on the load connected to the output terminals.



We now obtain the output voltage with and without load.

Wheatstone Bridge

The Wheatstone bridge circuit is a widely-used circuit. It is used for the indirect measurement of resistance.
Many transducers operate based on resistance changes. For example: strain gages, RTD's (resistance temperature detectors) and hot-wire anenometers.



Wheatstone Bridge Principle of Operation

A voltage E is applied between points A and C. R_2 and R_3 are precision resistors of known value and high thermal stability. R_1 is adjustable. Under unbalanced conditions, a current will be registered in ammeter A. The bridge can be balanced by adjusting R_1 until no current flows through A. As we derive next, R_x can be found as a function of the known resistors when the bridge is balanced.

This mode of operation corresponds to a *null method* of measurement.