Displacement Sensors

Potentiometer

by
Dr. Sotiris Omirou
AMEM 211

- A resistance with a movable contact (a potentiometer) may be used to measure linear or rotational displacements
A known voltage is applied to the resistor ends. The contact is attached to the moving object of interest. The output voltage at the contact is proportional to the displacement.

\[ V_o = V_s \frac{x - x_{\text{MIN}}}{x_{\text{MAX}} - x_{\text{MIN}}} \]

Potentiometers are one of the most widely used forms of position sensor. They can be angular or linear. They consist of a length of resistive material with a sliding contact onto the resistive track. When used as a position transducer, a potential is placed across the two end terminals, the voltage on the sliding contact is then proportional to its position. They are an inexpensive and easy to use sensor.
CONSTRUCTION PRINCIPLES OF POTENTIOMETERS

Linear

Rotary

POTENTIOMETERS TYPES

Linear

Rotary
Three styles of potentiometers are shown below. The center lead in each style is referred to as the “wiper.”

**Uses of potentiometers:** Potentiometers have two key uses:

1) **Adjustable resistors (or rheostats)**
   - In this case, only two leads are required. Use the center lead (wiper) and either end lead.
   - **Symbol:**

2) **Voltage dividers (or potentiometers)**
   - In this case, all three leads are used as the potentiometer acts like a voltage divider. A 10k potentiometer can be thought of as two series resistors, where the sum of the two resistors is always 10k. Adjusting the wiper changes the value of $R_1$ and $R_2$ ($R_2 = 10k - R_1$).
   - **Symbol:**
   
$R_1 + R_2 = 10k$
(for a 10k Potentiometer)
Connecting a potentiometer as a potential divider

Example:
if $R_1 = R_0$ (say 10 ohms each)

Voltage at divider should be?

Potential divider (continued)
EXERCISE 11

Problem
Consider the linear displacement potentiometer circuit diagram shown. The input voltage $V_i$ is 5 volts, and the output voltage $V_o$ is 2.5 volts. The total resistance element length is 100 mm, so when the sliding contact is at the centre, the distance $AB = BC = 50$ mm.

The linear displacement of an object causes the sliding contact to move such that the output voltage changes to 2.65 volts. Determine the displacement of the object and the direction in which it moves.

1. Data:
   - Voltage across AC = 5 Volts
   - Distance AC = 100 mm
   - Output Voltage changes to 2.65 Volts

2. Asked:
   a. Displacement of the object $\Delta L$
   b. Direction of its movement
Relation between volts and mm: Volts / mm = 5 / 100 = 0.05 V/mm

If the output voltage changes from 2.5 volts to 2.65 this is a change of
2.65 – 2.5 = 0.15 Volts.

Thus the displacement of the object is 0.15 / 0.05 = 3 mm

Since the output voltage has become more positive, the displacement is towards A
1. Data:
   Input Voltage $V_i = 5$ Volts
   $R_0 = 8 \text{ k}\Omega$
   $R_1 = 2 \text{ k}\Omega$

2. Asked:
   a. Output Voltage $V_0$
   b. Scaling factor of the potentiometer

3. Solution:

   $$V_0 = V_i \left( \frac{R_0}{R_1 + R_0} \right) =$$

   $$= 12 \left( \frac{8}{2 + 8} \right) = 12 \times 0.8 = 9.6V$$

   $V_0 = 9.6$ Volts

   Scaling factor = \frac{output\ voltage}{input\ voltage} = \frac{V_0}{V_i} = \frac{9.6}{12} = 0.8

   Scaling factor = 0.8 or 80%