Displacement Sensor (5A)

- Displacement Sensor Type
- Displacement Sensor Characteristics

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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Displacement Sensor Type

Displacement Type	Displacement Sensor	Physical Effect
Linear	Potentiometer	R (resistance)
	LVDT	L (inductance)
	Capacitive	C (capacitance)
Angular	Potentiometer	R (resistance)
	RVDT Synchro Resolver	L (inductance)
	Capacitive	C (capacitance)
	Encoder	

Potentiometer Types

Resistive Potentiometer

Magneto-resistive Potentiometer

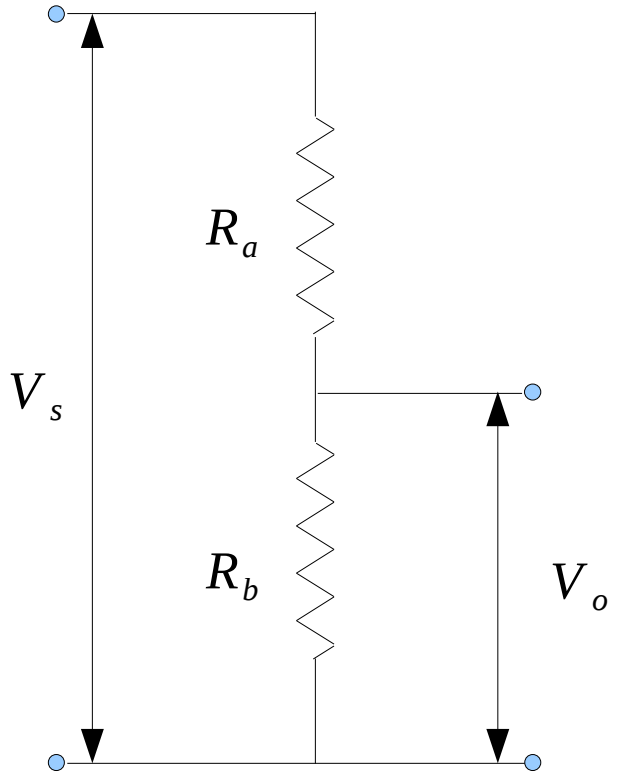
- **magnetic field => resistance**

Photo Potentiometer

- **incident light => resistance**
- **PSD (Position Sensitive Device)**
- **PIN photo-diode semiconductor**

Potentiometer (1)

Voltage Divider



$$V_o = \frac{R_b}{R_a + R_b} \cdot V_s$$

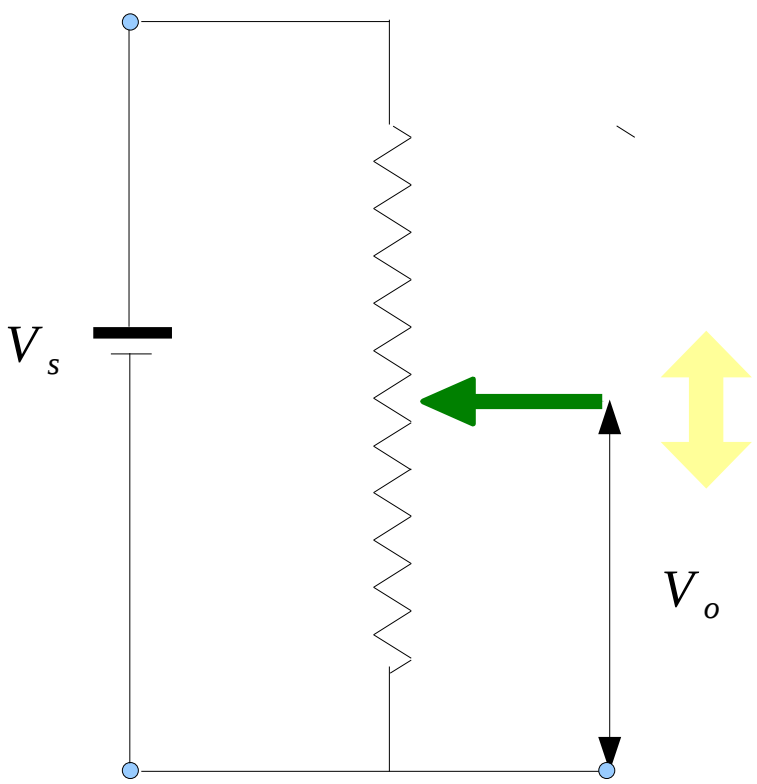
$$R_a + R_b \propto L$$

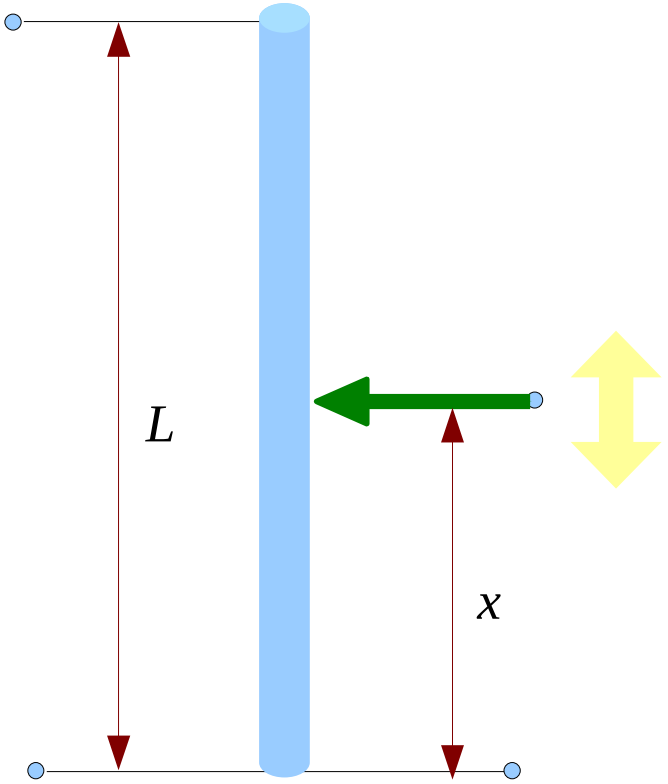
$$R_b \propto x \quad (displacement)$$

Potentiometer (2)

Voltage Divider

$$V_o = \frac{x}{L} \cdot V_s = Kx$$





Inductive Displacement Sensor Types

LVDT (Linear Variable Differential Transformer)

RVDT (Rotary Variable Differential Trnasformer)

- **primary coil**
- **secondary coil**
- **moving iron core**

Synchro

- **Rotor – primary coil**
- **Stator – 3 secondary coils (180 deg apart)**
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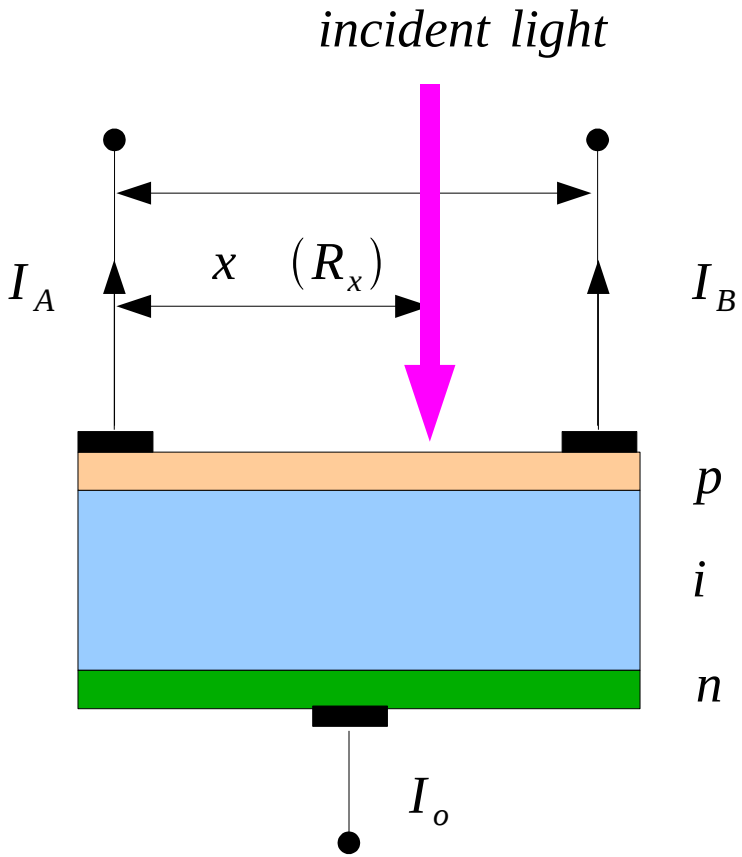
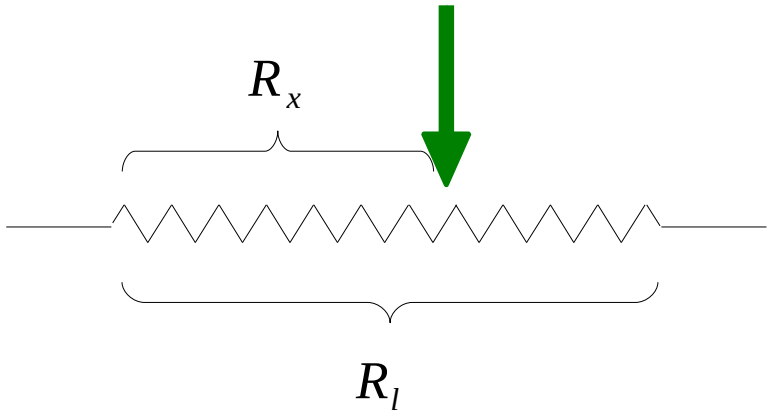
Resolver

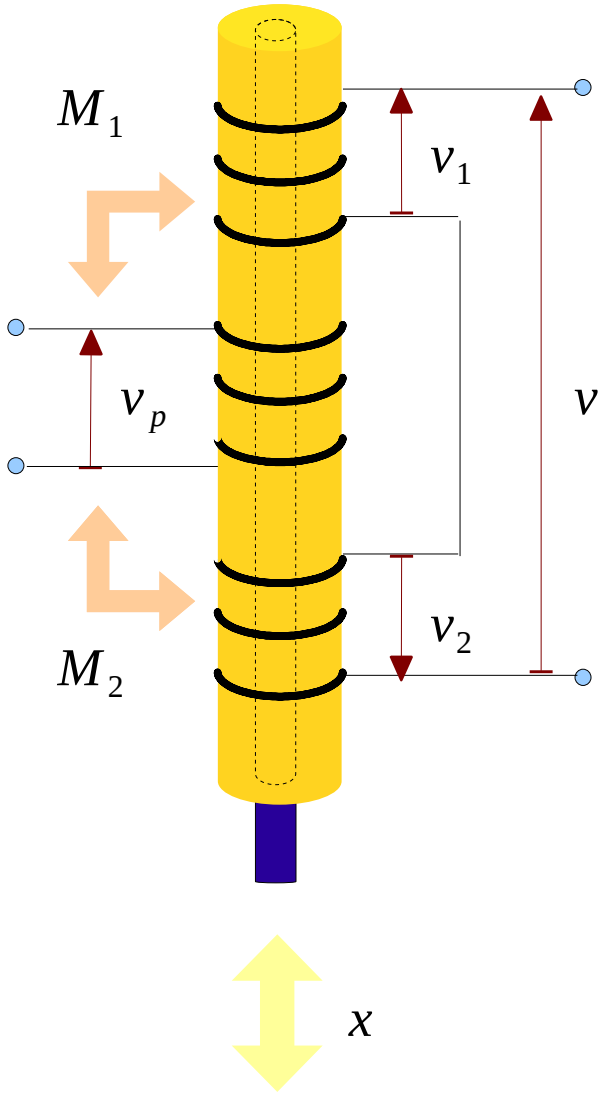
- **Rotor – primary coil**
- **Stator – 2 secondary coils (90 deg apart)**

Position Sensitive Device





Inductive Displacement Sensor – LVDT



$$v_o = v_1 - v_2$$

$$v_1 = M_1 \frac{i_p}{dt}$$

$$v_2 = M_2 \frac{i_p}{dt}$$

$$v_o = v_1 - v_2 = M_1 \frac{i_p}{dt} - M_2 \frac{i_p}{dt}$$

$$v_o = (M_1 - M_2) \frac{i_p}{dt}$$

Capacitive Displacement Sensor Types

Variable Distance Displacement Sensor

- ***x*** **is varying**

$$C(x) = \frac{\epsilon_r \epsilon_o A}{x}$$

Variable Area Displacement Sensor

- ***A*** **is varying**

Variable Dielectric Displacement Sensor

- ε_r **is varying**

Capacitive Displacement Sensor – Distance

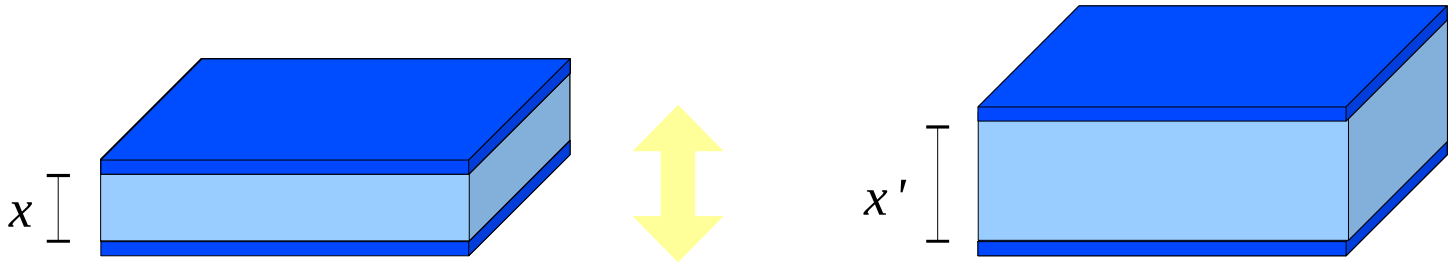
Variable Distance Displacement Sensor

- ***x*** **is varying**

$$\frac{dC(x)}{dx} = -\frac{\epsilon_r \epsilon_o A}{x^2}$$

$$C(x) = \frac{\epsilon_r \epsilon_o A}{x}$$

$$\frac{dC(x)}{C} = -\frac{dx}{x}$$

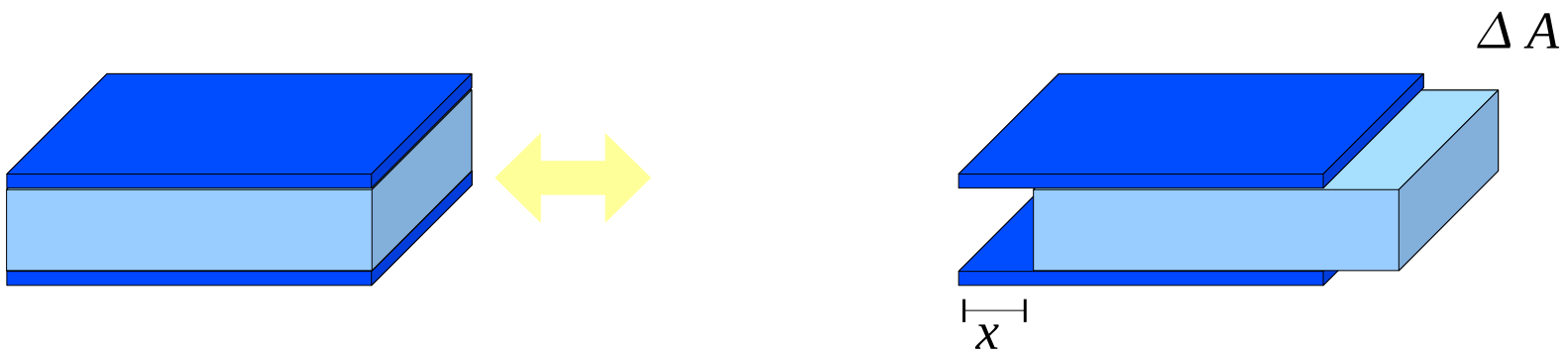


Capacitive Displacement Sensor – Area

Variable Area Displacement Sensor

- ***A*** **is varying**

$$C(x) = \frac{\epsilon_r \epsilon_o (A - wx)}{x}$$

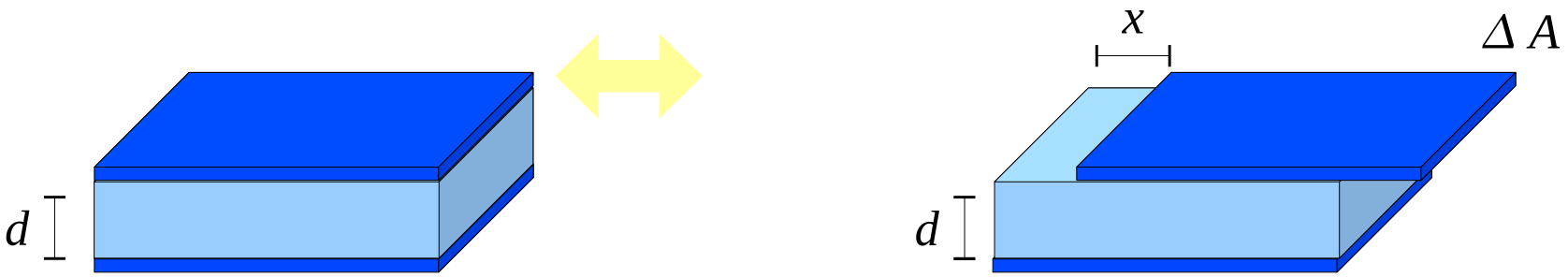


Capacitive Displacement Sensor – Dielectric

Variable Dielectric Displacement Sensor

- ***A*** **is varying**

$$C(x) = \frac{\epsilon_0 w}{d}\left[\epsilon_{r2} l - (\epsilon_{r2} - \epsilon_{r1}) x\right]$$



Capacitive Displacement Sensor

Thermo-electricity:

- **a temperature difference crates an electrical potential**
- **an electrical potential creates a temperature difference**

Pyro-electricity:

- **generates a temporary electrical potential**

  when certain materials are heated or cooled
- **the opposite effect is called electro-caloric effect**

Rotary Encoder

- **Incremental Type**
- **Absolute Type**

- **Optical Encoder**
- **Magnetic Encoder**

References

[1] http://en.wikipedia.org/
[2] Nam Ki Min, Sensor Electronics, Dong-il Press