Electrical and Electronic Measurements, Part 2

Lecture 4: Sensors and Transducers

Displacement, Position and Proximity Sensors, 2

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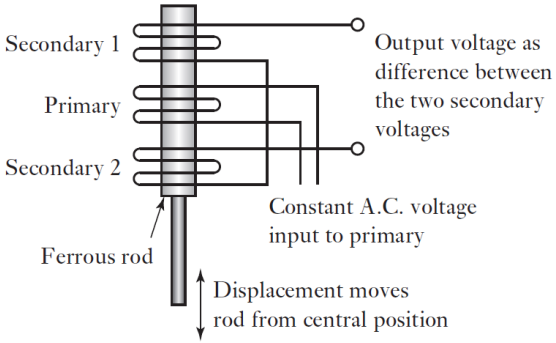
Displacement, Position and Proximity Sensors:

[5] Linear Variable Differential Transformer (LVDT):

- The LVDT consists of three coils symmetrically spaced along an insulated tube.
- The central coil is the primary coil which is connected to an AC current source.
- AC E.M.Fs, E_{s1} and E_{s2}, are generated in the two secondary coils. The two secondary coils are identical and are connected in series in such a way that their outputs oppose each other.
- A magnetic core is moved through the central tube which is connected to the displacement being monitored.



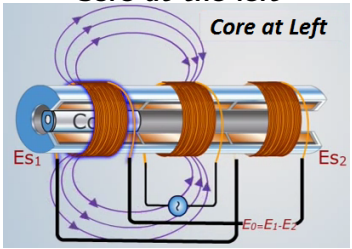
Displacement, Position and Proximity Sensors:

[5] Differential Transformers:

- The net E.M.F, E_o is depending on the position of the core inside the insulator:

$$E_o = E_{s1} - E_{s2}$$

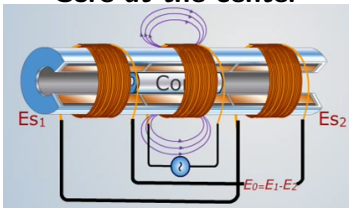
Core at the left



$E_{s1} > E_{s2}$

$E_o = +ve$

Core at the center

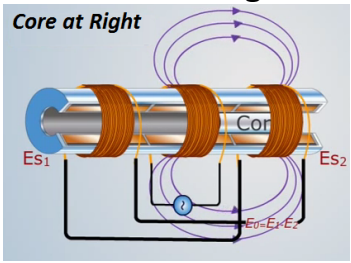


$E_{s1} = E_{s2}$

$E_o = 0$

Null Position

Core at the right



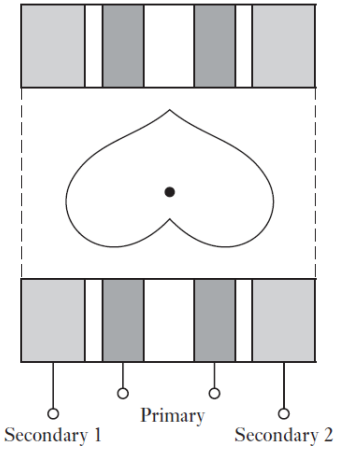
$E_{s1} < E_{s2}$

$E_o = -ve$

Displacement, Position and Proximity Sensors:

[5] Differential Transformers:

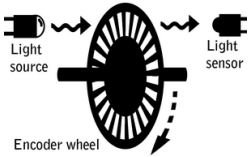
- A Rotary Variable Differential Transformer (RVDT) can be used for the measurement of rotation. It operates on the same principle as the LVDT.
- The core is a cardioid-shaped piece of magnetic material and rotation causes more of it to pass into one secondary coil than the other.



Displacement, Position and Proximity Sensors:

[6] Optical Encoders:

- An optical encoder is a device that provides a digital output as a result of a linear or angular displacement.
- Position encoders can be grouped into two categories: **incremental encoders** and **absolute encoders**.
- **Incremental Encoder**: detects changes in rotation from some datum position.
- **Absolute Encoder** Gives the actual angular position.
- A beam of light passes through slots in a disc and is detected by a suitable light sensor.
- When the disc is rotated, a pulsed output is produced by the sensor.
- The **number of pulses** is proportional to the **angle** being measured.

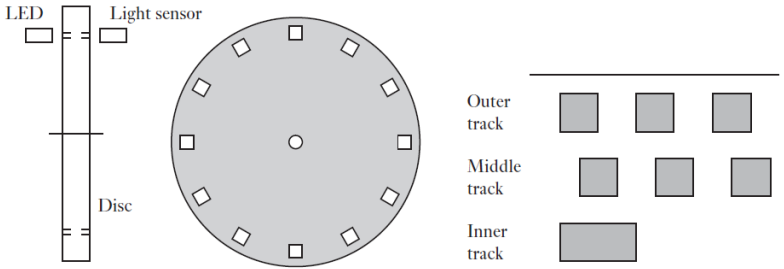


Displacement, Position and Proximity Sensors:

[6] Optical Encoders:

Incremental Encoder:

- In practice three concentric tracks with three sensors are used.
- The inner track has just one hole as the home position.
- The other two tracks have a series of equally spaced holes with offset to enable the detection of direction of rotation.
- Resolution $= 360\,\text{deg}\,/\text{No of slots}$.



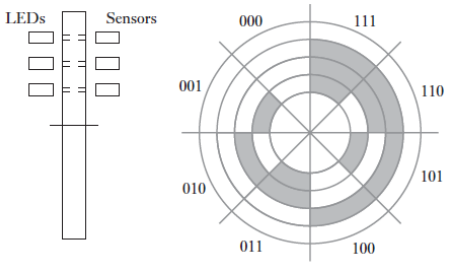
The disc with slots through which the light can pass

Displacement, Position and Proximity Sensors:

[6] Optical Encoders:

Absolute Encoder:

- The absolute encoder gives an output in the form of a binary number of several digits, each such number representing a particular angular position.
- The rotating disc has three concentric circles of slots and three sensors to detect the light pulses. The slots are arranged in such a way that the sequential output from the sensors is a number in the binary code.
- Resolution $= 360/2^n$ (n is the number of bits = number of tracks)

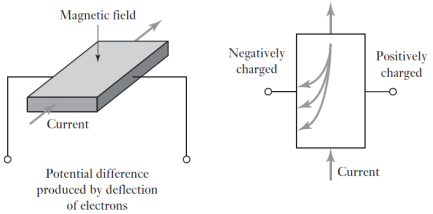


Displacement, Position and Proximity Sensors:

[7] Hall Effect Sensor:

- A current flowing in a conducting plate will create moving charges (electrons).
- These electrons are deflected by a magnetic field applied at right angles to the plate.
- Electrons are deflected to one side of the plate forming a negative charge, and the other side is positively charged.
- This separation of electrons will produce an electrical potential V in the material:

$$V = K_H \frac{BI}{t}$$



Displacement, Position and Proximity Sensors:

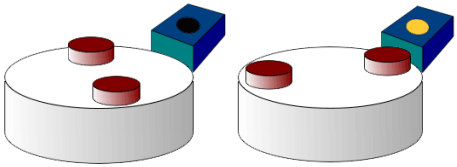
[7] Hall Effect Sensor:

- This separation of electrons will produce an electrical potential V in the material:

$$V = K_H \frac{BI}{t}$$

V: Electrical voltage.
B: Magnetic flux.
I: Input current.
t: Plate thickness.
K_H: Hall coefficient constant.

- The sensor output voltage is an indication of the magnetic flux B.
- Such sensors can be used as position, displacement and proximity sensors if the object being sensed is fitted with a small permanent magnet.

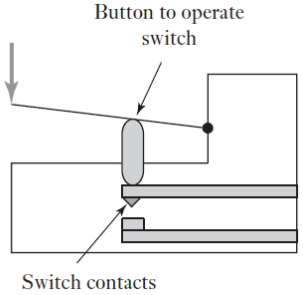


Fluid-level detector

Displacement, Position and Proximity Sensors:

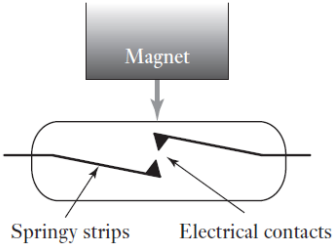
[8] Proximity switches:

There are many forms of proximity switch that can give either ON or OFF according to the presence of a certain object.



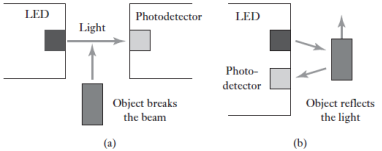
Micro Switch

Requires physical contact



Reed Switch (Magnet)

No physical contact



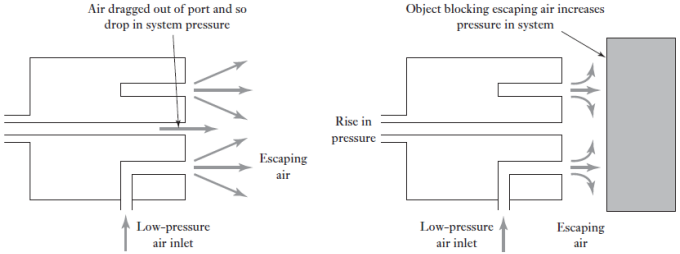
Photosensitive Switch

No physical contact

Displacement, Position and Proximity Sensors:

[9] Pneumatic sensors:

- Pneumatic sensors involve the use of compressed air, displacement or the proximity of an object being transformed into a change in air pressure.
- In the absence of any close-by object, the air escapes doing reduction in the air pressure in the nearby sensor output port.
- If there is a close-by object, the air cannot so readily escape and the result is that the pressure increases in the sensor output port.
- The output pressure from the sensor depends on the proximity of objects.



End of Lecture

Best Wishes

Reference videos:

Absolute Encoder.

Hall Effect Sensor.