Basic Mechatronics Workshop

Module 2: Sensors

Lecture-3

Proximity Sensor Introduction.

Principle of operation, Reed and Inductive, Capacitive, Optical, Ultrasonic

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Proximity Sensor Introduction.

Principle of operation, Reed and Inductive, Capacitive, Optical, Ultrasonic

Objectives

Upon completion of this chapter, Student should be able to

- ✓ List the different types of proximity sensors.
- ✓ Define the function of Eddy current proximity sensor and its applications.
- ✓ Explain the function of Inductive proximity switch and its applications.
- ✓ Describe the functions of Optical encoders and its applications
- ✓ Explain the Pneumatic Sensors and its applications.
- ✓ Describe the functions of Proximity Switches and its applications.
- ✓ Explain the hall effect sensor and its applications.

What Is a Proximity Sensor?

a Proximity Sensor?

Three Common Types of Sensors

https://www.youtube.com/watch?v=f15uUSdVkKQ

What Is a Proximity Sensor?

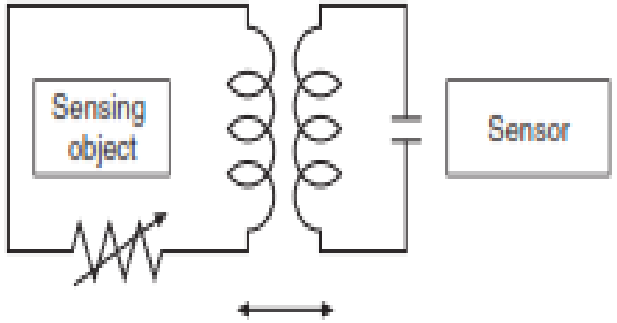
"Proximity Sensor" **includes all sensors that perform non-contact detection** in comparison to sensors, such as limit switches, that detect objects by physically contacting them. Proximity Sensors convert information on the movement or presence of an object into an electrical signal.

There are three types of detection systems that do this conversion:

- ✓ Systems that **use the eddy currents** that are generated in metallic sensing objects by electromagnetic induction,
- ✓ Systems that **detect changes in electrical capacity** when approaching the sensing object,
- ✓ Systems that use **magnets** and **reed switches**

Operating Principles

Detection Principle of Inductive Proximity Sensors



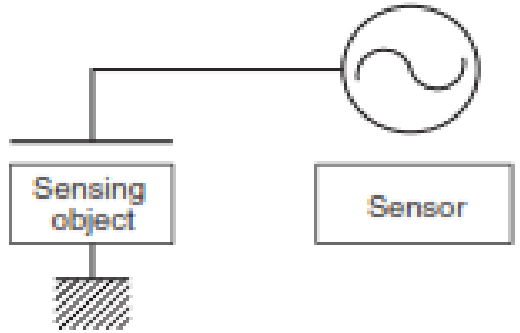
Inductive Proximity Sensors detect magnetic loss due to eddy currents that are generated on a conductive surface by an external magnetic field. An AC magnetic field is generated on the detection coil, and changes in the impedance due to eddy currents generated on a metallic object are detected.

Other methods include Aluminum-detecting Sensors, which detect the phase component of the frequency, and All-metal Sensors, which use a working coil to detect only the changed component of the impedance. There are also Pulse response Sensors, which generate an eddy current in pulses and detect the time change in the eddy current with the voltage induced in the coil.

The sensing object and Sensor form what appears to be a transformer-like relationship.

Operating Principles

Detection Principle of Capacitive Proximity Sensors

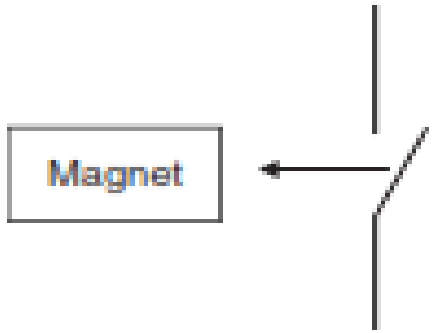


Capacitive Proximity Sensors detect changes in the capacitance between the sensing object and the Sensor. The amount of capacitance varies depending on the size and distance of the sensing object. An ordinary Capacitive Proximity Sensor is similar to a capacitor with two parallel plates, where the capacity of the two plates is detected. One of the plates is the object being measured (with an imaginary ground), and the other is the Sensor's sensing surface. The changes in the capacity generated between these two poles are detected.

The objects that can be detected depend on their dielectric constant, but they include resin and water in addition to metals.

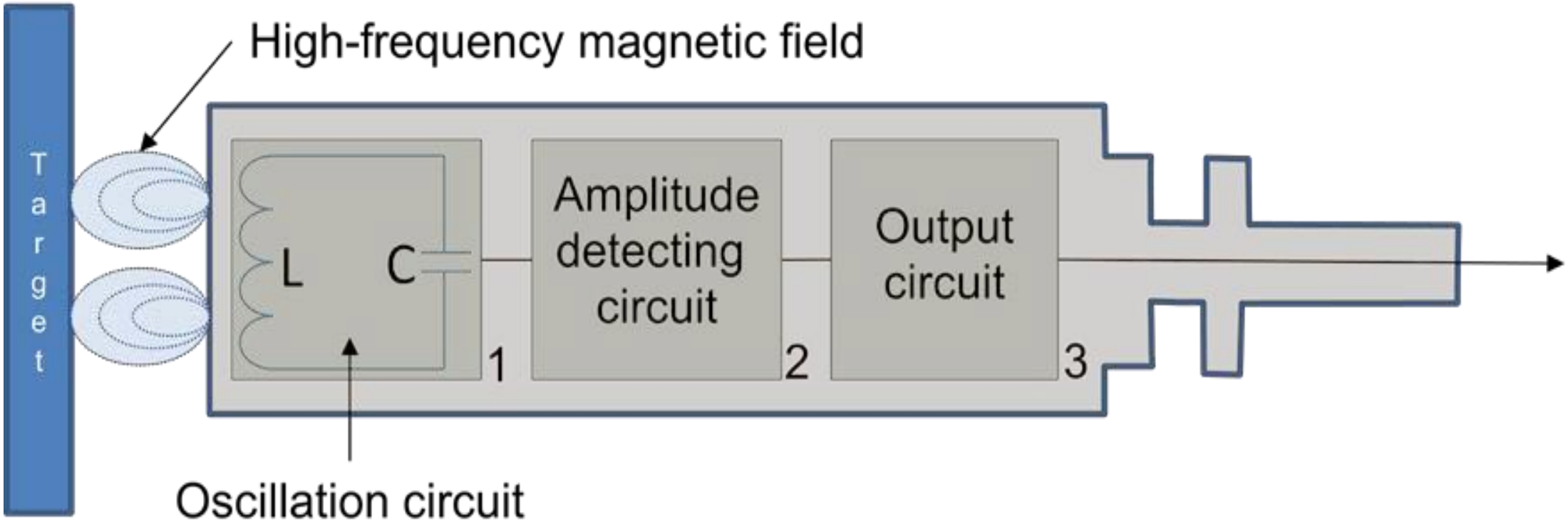
Operating Principles

Detection Principle of Magnetic Proximity Sensors



The reed end of the switch is operated by a magnet. When the reed switch is turned ON, the Sensor is turned ON.

Eddy current proximity sensors



Eddy current proximity sensors are used to detect non-magnetic but conductive materials.

Eddy current proximity sensors

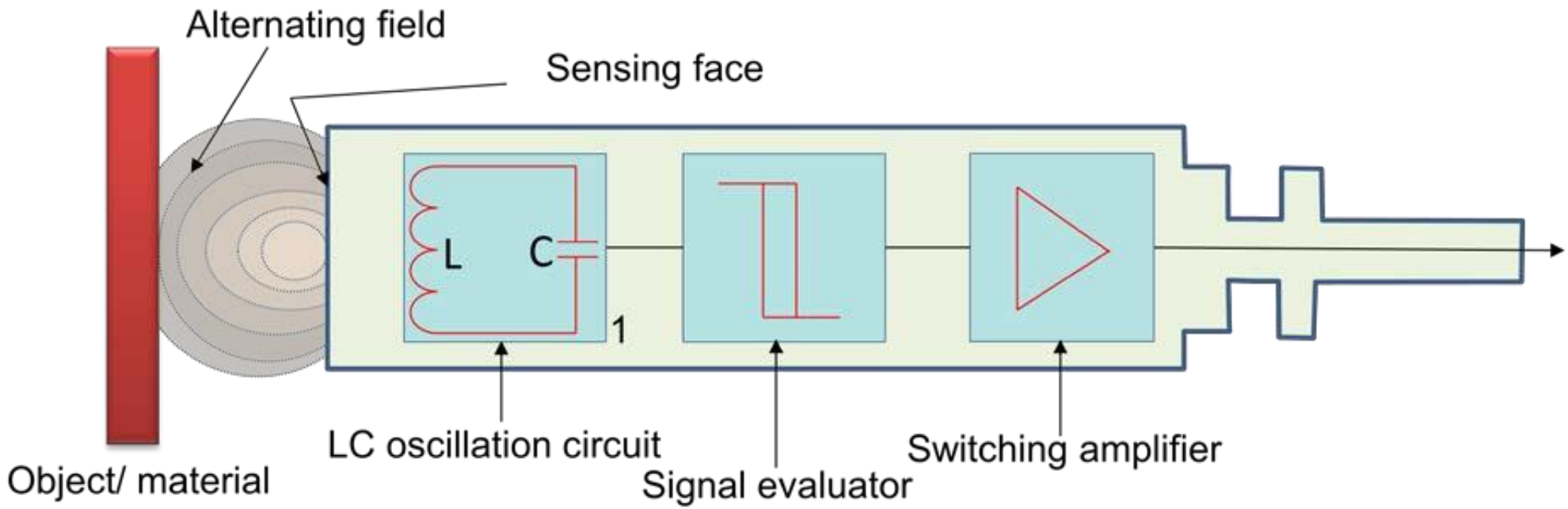
operation theory of eddy current proximity switch.

When an alternating current is passed thru this coil, an alternative magnetic field is generated. If a metal object comes in the close proximity of the coil, then eddy currents are induced in the object due to the magnetic field. These eddy currents create their own magnetic field which distorts the magnetic field responsible for their generation. As a result, impedance of the coil changes and so the amplitude of alternating current. This can be used to trigger a switch at some pre-determined level of change in current.

Applications of eddy current proximity sensors

- ✓Automation requiring precise location
- ✓Machine tool monitoring
- ✓Final assembly of precision equipment such as disk drives
- ✓Measuring the dynamics of a continuously moving target, such as a vibrating element,
- ✓Drive shaft monitoring
- ✓Vibration measurements

Inductive proximity switch



Inductive proximity switches are basically used for detection of metallic objects.

Inductive proximity switch

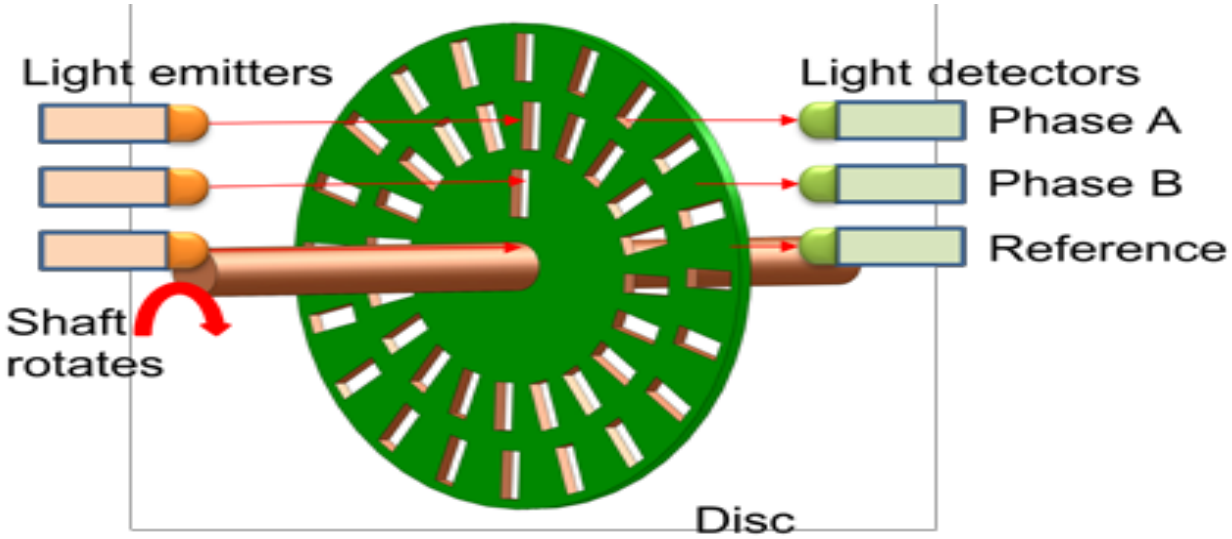
operation theory of inductive proximity switch.

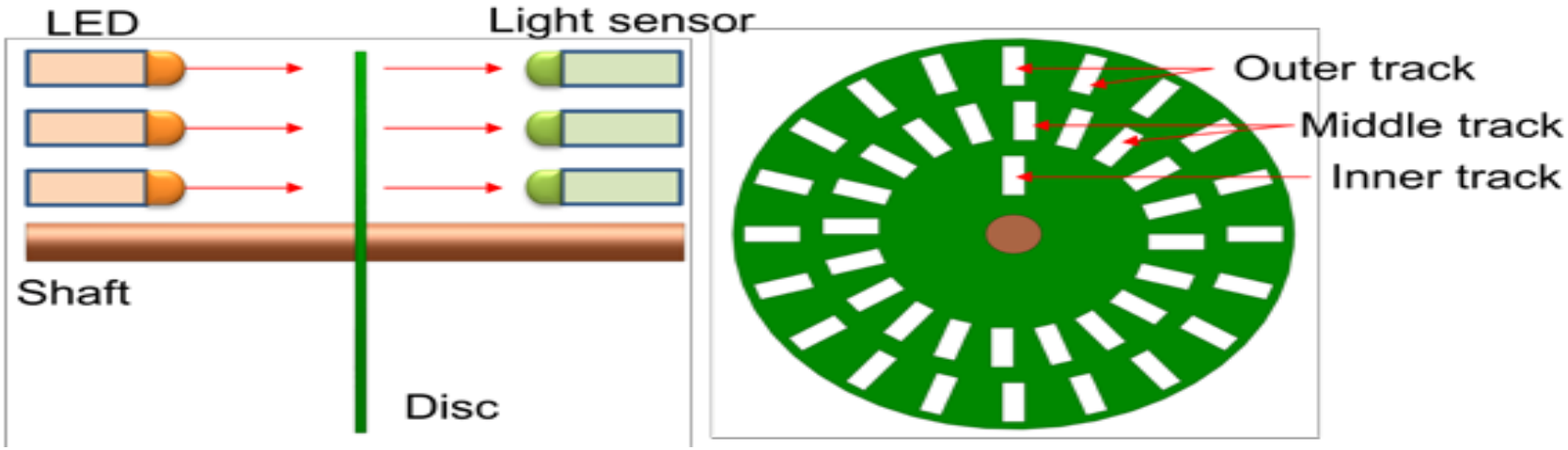
An inductive proximity sensor has four components; the coil, oscillator, detection circuit and output circuit. An alternating current is supplied to the coil which generates a magnetic field. When, a metal object comes closer to the end of the coil, inductance of the coil changes. This is continuously monitored by a circuit which triggers a switch when a preset value of inductance change is occurred.

Applications of inductive proximity switches

- ✓Industrial automation: counting of products during production or transfer
- ✓Security: detection of metal objects, arms, land mines

Optical encoders





Optical encoders provide digital output as a result of linear / angular displacement. These are widely used in the Servo motors to measure the rotation of shafts.

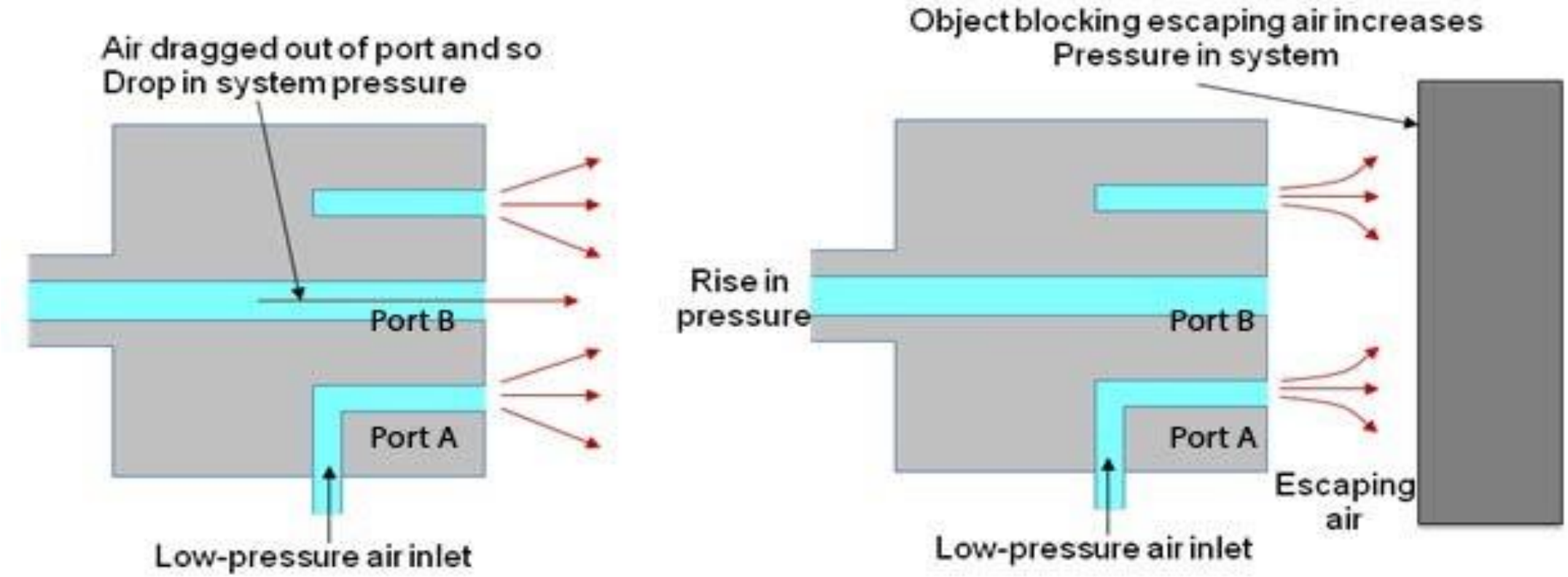
Optical encoders

operation theory of Optical encoders.

It comprises of a disc with three concentric tracks of equally spaced holes. Three light sensors are employed to detect the light passing thru the holes. These sensors produce electric pulses which give the angular displacement of the mechanical element e.g. shaft on which the Optical encoder is mounted. The inner track has just one hole which is used locate the 'home' position of the disc. The holes on the middle track offset from the holes of the outer track by one-half of the width of the hole. This arrangement provides the direction of rotation to be determined. When the disc rotates in clockwise direction, the pulses in the outer track lead those in the inner; in counterclockwise direction they lag behind. The resolution can be determined by the number of holes on disc. With 100 holes in one revolution, the resolution would be,

$$360^0/100 = 3.6^0.$$

Pneumatic Sensors



Pneumatic sensors are used to measure the displacement as well as to sense the proximity of an object close to it. The displacement and proximity are transformed into change in air pressure.

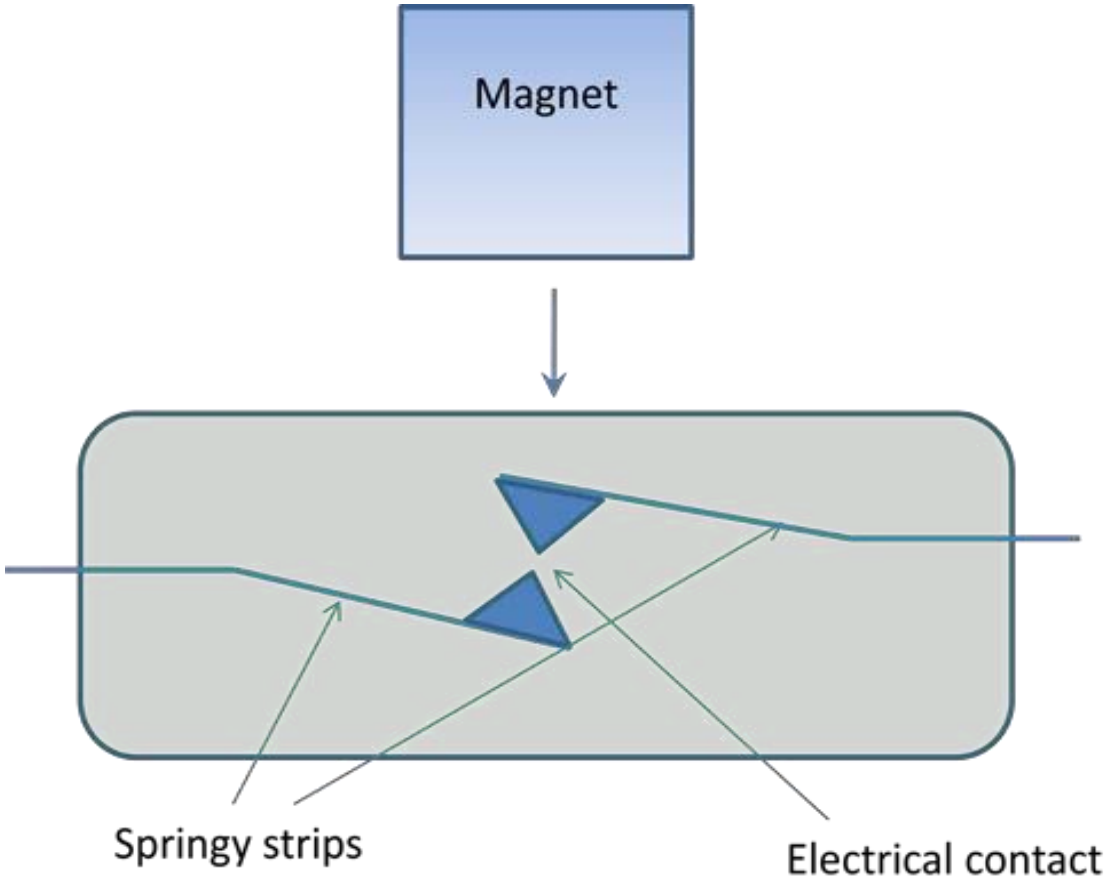
Pneumatic Sensors

operation theory of Optical encoders.

It comprises of three ports. Low pressure air is allowed to escape through port A. In the absence of any obstacle / object, this low-pressure air escapes and in doing so, reduces the pressure in the port B. However, when an object obstructs the low-pressure air (Port A), there is rise in pressure in output port B. This rise in pressure is calibrated to measure the displacement or to trigger a switch.

These sensors are used in robotics, pneumatics and for tooling in CNC machine tool

Reed Switch



Magnet based Reed switches are used as proximity switches. When a magnet attached to an object brought close to the switch, the magnetic reeds attract to each other and close the switch contacts.

Reed Switch

What is a Reed Relay? from Pickering Electronics

https://www.youtube.com/watch?v=zTbv5szQNoA

LED based proximity sensors

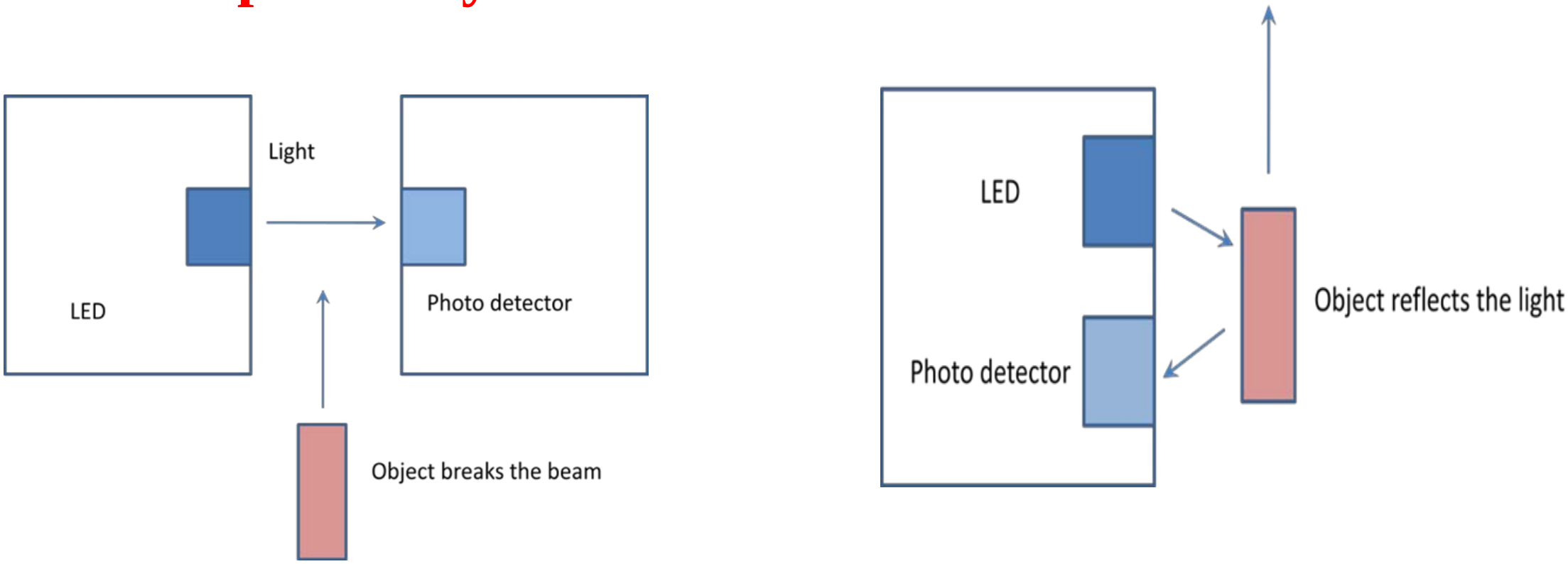
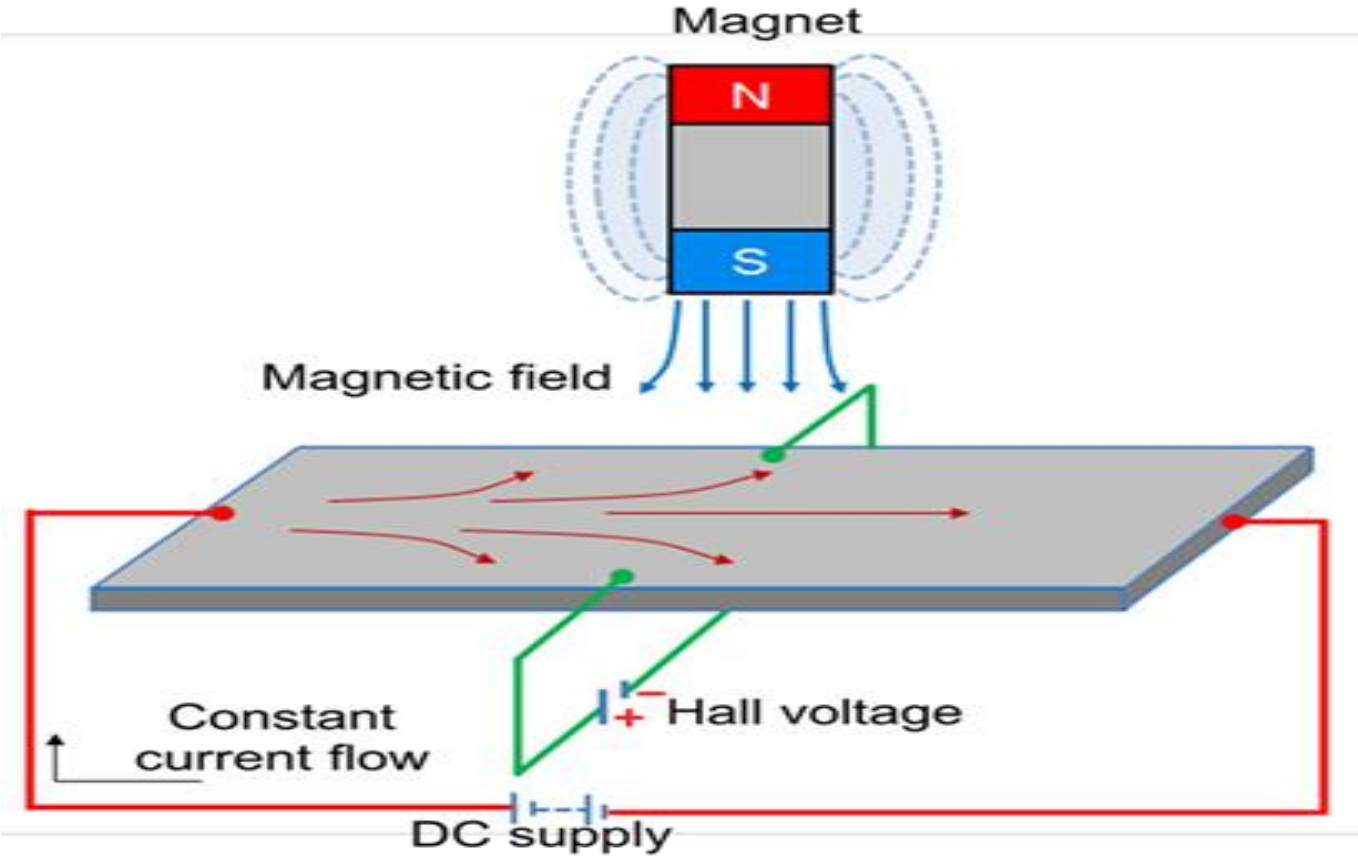


Photo emitting devices such as Light emitting diodes (LEDs) and photosensitive devices such as photo diodes and photo transistors are used in combination to work as proximity sensing devices. Figure shows two typical arrangements of LEDs and photo diodes to detect the objects breaking the beam and reflecting light

Hall effect sensor



Hall effect sensors work on the principle that when a beam of charge particles passes through a magnetic field, forces act on the particles and the current beam is deflected from its straight-line path. Thus, one side of the disc will become negatively charged and the other side will be of positive charge. This charge separation generates a potential difference which is the measure of distance of magnetic field from the disc carrying current.

Hall effect sensor

What is Hall Effect and How Hall Effect Sensors Work

https://www.youtube.com/watch?v=wpAA3qeOYiI

Applications of Hall effect sensor

The typical application of Hall effect sensor is the measurement of fluid level in a container. The container comprises of a float with a permanent magnet attached at its top. An electric circuit with a current carrying disc is mounted in the casing. When the fluid level increases, the magnet will come close to the disc and a potential difference generates. This voltage triggers a switch to stop the fluid to come inside the container.