Working Of Inductive and Capacitive Proximity Sensors

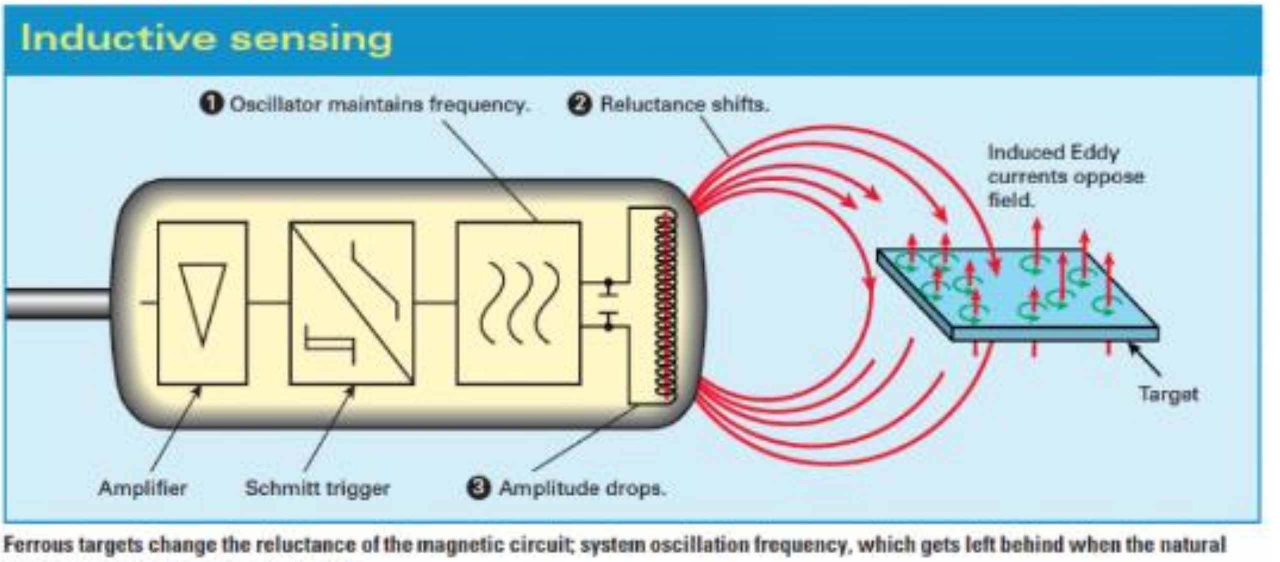
Proximity sensors detect the presence or absence of objects using electromagnetic fields, light, and sound. There are many types, each suited to specific applications and environments.

Inductive sensors

These non-contact proximity sensors detect ferrous targets, ideally mild steel thicker than one millimeter. They consist of four major components: a ferrite core with coils, an oscillator, a Schmitt trigger, and an output amplifier. The oscillator creates a symmetrical, oscillating magnetic field that radiates from the ferrite core and coil array at the sensing face. When a ferrous target enters this magnetic field, small independent electrical currents called eddy currents are induced on the metal's surface. This changes the reluctance (natural frequency) of the magnetic circuit, which in turn reduces the oscillation amplitude. As more metal enters the sensing field the oscillation amplitude shrinks, and eventually collapses. (This is the "Eddy Current Killed Oscillator" or ECKO principle.) The Schmitt trigger responds to these amplitude changes, and adjusts sensor output. When the target finally moves from the sensor's range, the circuit begins to oscillate again, and the Schmitt trigger returns the sensor to its previous output.

If the sensor has a normally open configuration, its output is an on signal when the target enters the sensing zone. With normally closed, its output is an off signal with the target present. Output is then read by an external control unit (e.g. PLC, motion controller, smart drive) that converts the sensor on and off states into useable information. Inductive sensors are typically rated by frequency, or on/off cycles per second. Their speeds range from 10 to 20 Hz in ac, or 500 Hz to 5 kHz in dc. Because of magnetic field limitations, inductive sensors have a relatively narrow sensing range — from fractions of millimeters to 60 mm on average — though longer-range specialty products are available.

To accommodate close ranges in the tight confines of industrial machinery, geometric and mounting styles available include shielded (flush), unshielded (non-flush), tubular, and rectangular “flat-pack”. Tubular sensors, by far the most popular, are available with diameters from 3 to 40 mm.



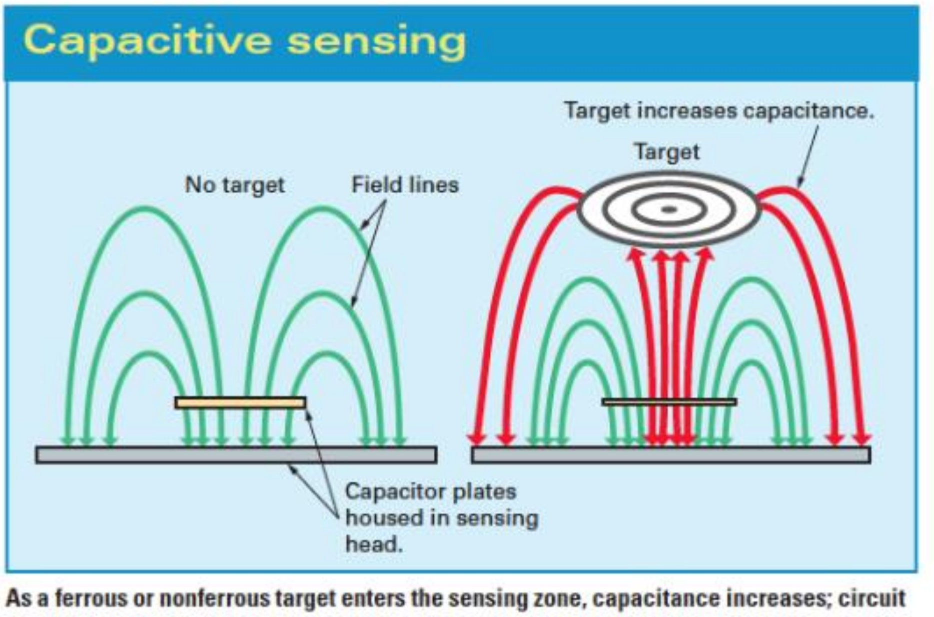
Ferrous targets change the reluctance of the magnetic circuit; system oscillation frequency, which gets left behind when the natural frequency shifts, then loses amplitude.

But what inductive sensors lack in range, they make up in environment adaptability and metal-sensing versatility. With no moving parts to wear, proper setup guarantees long life. Special designs with IP ratings of 67 and higher are capable of withstanding the buildup of contaminants such as cutting fluids, grease, and non-metallic dust, both in the air and on the sensor itself. It should be noted that metallic contaminants (e.g. filings from cutting applications) sometimes affect the sensor’s performance. Inductive sensor housing is typically nickel-plated brass, stainless steel, or PBT plastic.

Capacitive sensors

Capacitive proximity sensors can detect both metallic and non-metallic targets in powder, granulate, liquid, and solid form. This, along with their ability to sense through nonferrous materials, makes them ideal for sight glass monitoring, tank liquid level detection, and hopper powder level recognition.

In capacitive sensors, the two conduction plates (at different potentials) are housed in the sensing head and positioned to operate like an open capacitor. Air acts as an insulator; at rest there is little capacitance between the two plates. Like inductive sensors, these plates are linked to an oscillator, a Schmitt trigger, and an output amplifier. As a target enters the sensing zone the capacitance of the two plates increases, causing oscillator amplitude change, in turn changing the Schmitt trigger state, and creating an output signal. Note the difference between the inductive and capacitive sensors: inductive sensors oscillate until the target is present and capacitive sensors oscillate when the target is present.



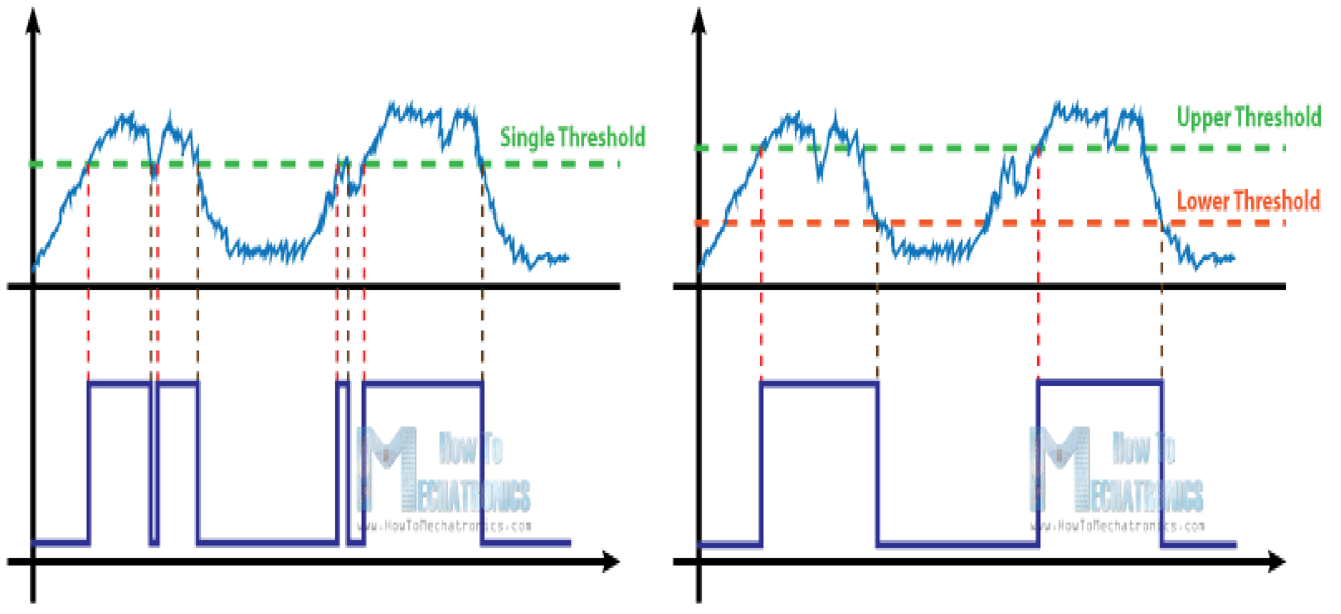
As a ferrous or nonferrous target enters the sensing zone, capacitance increases; circuit natural frequency shifts towards the oscillation frequency, causing amplitude gain.

Because capacitive sensing involves charging plates, it is somewhat slower than inductive sensing ... ranging from 10 to 50 Hz, with a sensing scope from 3 to 60 mm. Many housing styles are available; common diameters range from 12 to 60 mm in shielded and unshielded mounting versions. Housing (usually metal or PBT plastic) is rugged to allow mounting very close to the monitored process. If the sensor has normally-open and normally-closed options, it is said to have a complimentary output. Due to their ability to detect most types of materials, capacitive sensors must be kept away from non-target materials to avoid false triggering. For this reason, if the intended target contains a ferrous material, an inductive sensor is a more reliable option.

Schmitt Trigger

The Schmitt Trigger is a logic input type that provides hysteresis or two different threshold voltage levels for rising and falling edge. This is useful because it can avoid the errors when we have noisy input signals from which we want to get square wave signals.

So for example, if we have a noisy input signal like this, that is meant to have 2 pulses, a device that has only one set point, or threshold, could get incorrect input and it could register more than two pulses as shown in this illustration. And if we use the Schmitt Trigger for the same input signal we will get a correct input of two pulses because of the two different thresholds. So that’s the primal function of the Schmitt Trigger, to convert noisy square waves, sine waves or slow edges inputs into clean square waves.


Single Threshold
Upper Threshold
Lower Threshold