MEE303 Sensor Systems

W01
Sensor Characteristics

Proximity Sensing

Introduction A critical distance is measured by proximity sensors

A proximity sensor is a threshold version of a position sensor which generates the output signal when a certain distance to the object becomes essential for an indication

Threshold value

Digital signal

Position Sensor → Comparator Circuit →

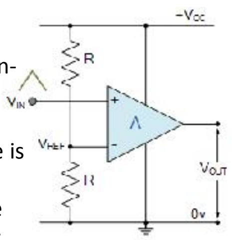
Analog value

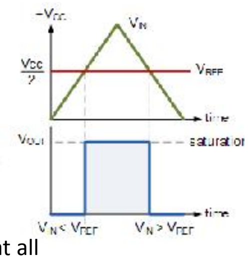
The analog value from sensor output is compared to a reference value to have one bit knowledge about the realisatiion of given condiiton

Non-inverting Comparator Circuit

with the input signal connected to the non-inverting input.

the reference voltage is connected to the inverting input of the operational amplifier



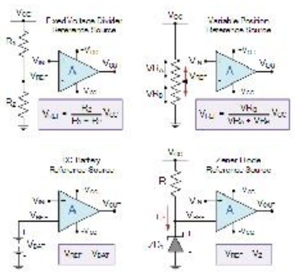


no feedback at all

two resistors forming the potential divider network are equal and: R1 = R2 = R. This will produce a fixed reference voltage which is one half that of the supply voltage, that is Vcc/2,

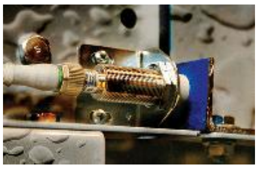
When VIN is greater than VREF, the op-amp comparators output will saturate towards the positive supply rail, Vcc. as shown.

When VIN is less than VREF the op-amp comparators output will change state and saturate at the negative supply rail, 0v

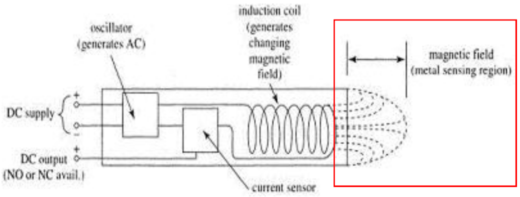


Proximity Sensing **Inductive Proximity Switches**

Inductive proximity sensors are used for non-contact detection of metallic objects.

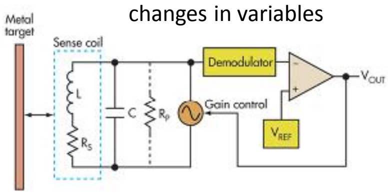


Their structure is similar to inductive displacement sensors



And sensors for observing electrical variables

And circuits to detect changes in variables

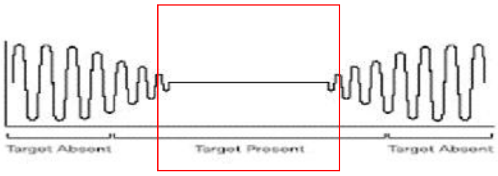


They have an LC (inductor-capacitor) oscillator circuit

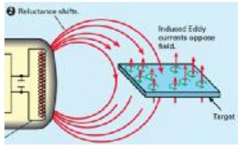
The oscillator driven coil creates an electromagnetic field in the close surroundings of the sensing surface

When the field lines are interrupted by a metal object, the oscillator voltage is reduced, proportional to the size and distance of the object from the coil.

The reduction in the oscillator voltage is caused by eddy currents induced in the metal interrupting the field lines.



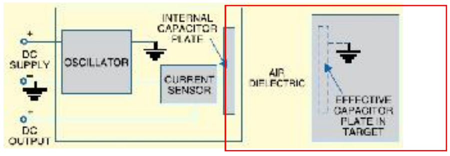
Objects that do not conduct electricity, such as wood and plastic, cannot be detected by inductive proximity sensor

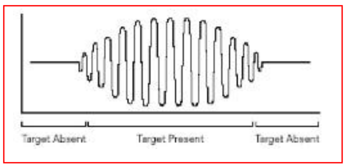


Proximity Sensing **Capacitive Proximity Switches**

Capacitive proximity sensors are used for almost every type of objects

Their structure is similar to capactive displacement sensors



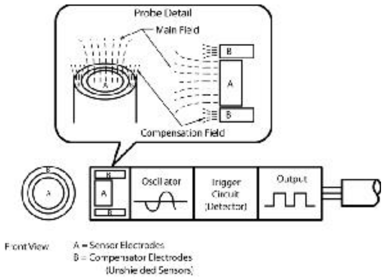


Sensing probe: LC oscillator circuit with capacitor part which has only one plate.

The object to be detected actually forms the second plate of the capacitor.

If this object is near enough to the face of the capacitive sensor, the sensor will then be able to move significant current in and out

Another configuration of sensor utilizes two metallic electrodes or plates to create the sensing element in a capacitive proximity detector.



If this object is near enough to the face of the capacitive sensor to be affected by the charge in the sensor's internal capacitor plate, it will respond by becoming oppositely charged near the sensor. The sensor will then be able to move significant current

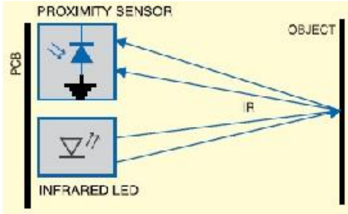
A target approaching the face of the sensor changes the dielectric constant between the plates and raises the capacitance. The higher capacitance boosts the amplitude of the oscillations being measured by a level-detection circuit.

Proximity Sensing **Optical Proximity Switches**

A complete optical proximity sensor includes a light source, and a sensor that detects the light.

They are widely used in automated systems because they have been available longer and because some can fit into small locations.

The light source generates light of a frequency that the light sensor is best able to detect, and that is not likely to be generated by other nearby sources.

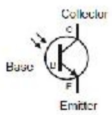


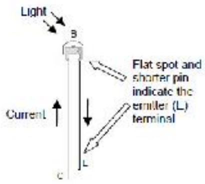
Infra-red light is used in most optical sensors

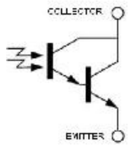
The light sensor circuit is designed so that light that is not pulsing at this frequency is rejected.

To make the light sensing system more robust, most optical proximity sensor light sources pulse the infra-red light on and off at a fixed frequency

The light sensor in the optical proximity sensor is typically a semiconductor device such as a photodiode, which generates a small current when light energy strikes it



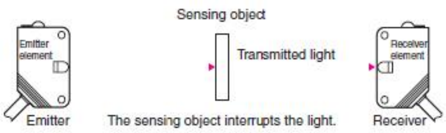


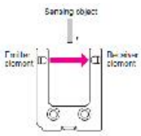


more commonly a phototransistor or a photo-darlington that allows current to flow if light strikes it.

Proximity Sensing **Optical Proximity Switches**

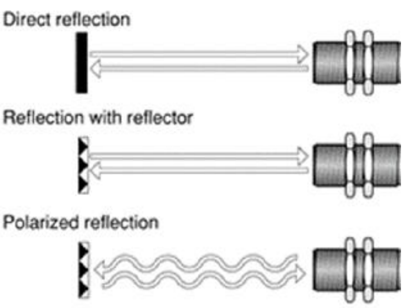
Through beam type sensors are usually used to signal the presence of an object that blocks light.





Reflective type light sensors

The Emitter and Receiver are installed in the same housing and light from the Emitter is normally reflected back to the Receiver by a Reflector installed on the opposite side.



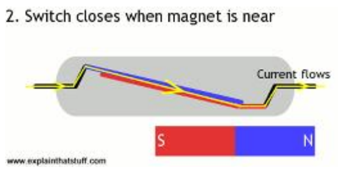
Direct Reflection (Diffused) - emitter and receiver are housed together and use the light reflected directly off the object for detection.

Reflection with Reflector:The Emitter and Receiver are installed in the same housing and light from the Emitter is normally reflected back to the Receiver by a Reflector installed on the opposite side. When the sensing object interrupts the light, it reduces the amount of light received. This reduction in light intensity is used to detect the object.

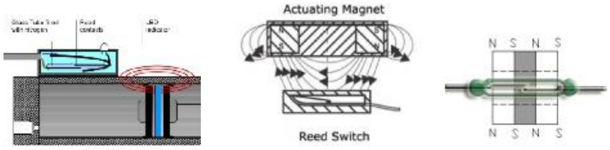
Polarized Reflection with Reflector - similar to Reflection with Reflector, these photocells use an anti-reflex device. The use of such a device, which bases its functioning on a polarized band of light, offers considerable advantages and secure readings

Proximity Sensing **Magnetic Proximity (Reed) Switches**

Magnetically-operated proximity switches are known which respond to changes in distribution of flux resulting from the presence of a ferromagnetic mass



The basic reed switch consists of two ferromagnetic nickel-iron wires and a glass capsule.
The two wires are formed into "reeds" by flattening one end.
The reed ends are carefully aligned with a small overlap and then permanently sealed inside the glass capsule.



The two reeds act as magnetic flux conductors when exposed to an external magnetic field from either a permanent magnet or an electromagnetic coil.

Poles of opposite polarity are created at the contact gap and the contacts close when the magnetic force exceeds the spring force of the reeds.

The contacts open when the external magnetic field is reduced so that the magnetic attractive force between the reeds is less than the restoring spring force of the reeds.

Motion Sensing **Microwave and Ultrasonic Motion Detectors**

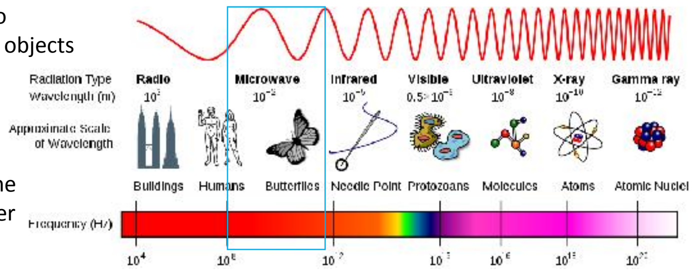
Motion detectors respond only to moving objects. The applications of these sensors include security, surveillance, energy management, (electric lights control), personal safety, friendly home appliances, interactive toys,

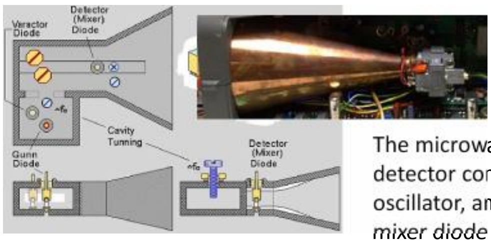
Microwave detectors *Ultrasonic detectors* *Infrared detectors*

Microwave detectors: active sensors responsive to microwave electromagnetic signals reflected from objects

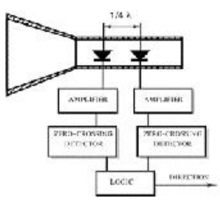
common frequencies are 10.525 GHz and 24.125 GHz

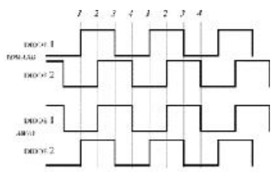
wavelengths are long enough (λ =3 cm) to pass freely through most contaminants, such as airborne dust, and short enough for being reflected by larger objects





The microwave part of the detector consists of a Gunn oscillator, an antenna, and a *mixer diode*





Motion Sensing

Microwave and Ultrasonic Motion Detectors

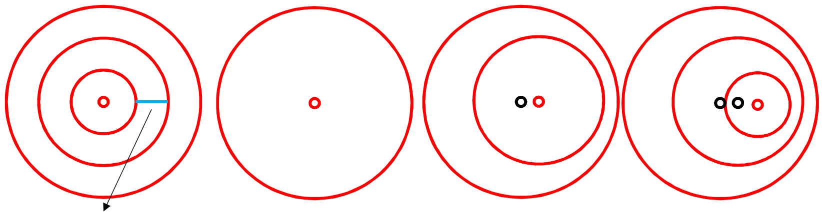
Ultrasonic detectors: similar to microwaves except that instead of electromagnetic radiation, ultrasonic waves are used. The Doppler effect is the basis for the operation of microwave and ultrasonic detectors.

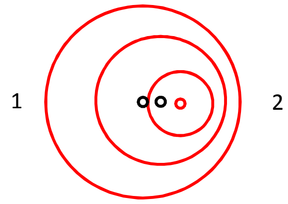
Doppler Effect

Stationary Source *Source is moving ì direction with constant speed*

Observer 1 observes a longer wavelength

$$\lambda_1 = (v_w + v_s)T_w$$





wavelength t= t-2T_w t= t-T_w t

$$\lambda_2 = (v_w - v_s)T_w$$

Observer 2 observes a shorter wavelength

$$\lambda = v_w T_w$$

The Doppler effect is the change in the frequency of a wave motion when there is relative motion between the source and the observer.

As a wave source approaches, an observer encounters waves with a higher frequency. As the wave source moves away, an observer encounters waves with a lower frequency

The apparent change in frequency is known as the Doppler Shift.

The Doppler shift increases as the relative velocity between the source and the observer increases

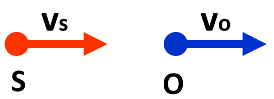
Mathematically,

$$f' = \left(\frac{c \pm v_o}{c \mp v_s}\right)f$$

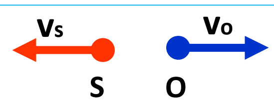
Motion Sensing

Microwave and Ultrasonic Motion Detectors

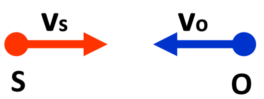
Doppler Effect



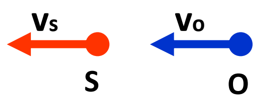
$$f' = \left(\frac{c - v_O}{c - v_S}\right)f$$



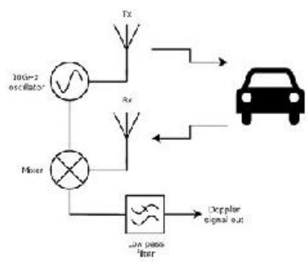
$$f' = \left(\frac{c - v_O}{c + v_S}\right)f$$



$$f' = \left(\frac{c + v_O}{c - v_S}\right)f$$



$$f' = \left(\frac{c + v_O}{c + v_S}\right)f$$



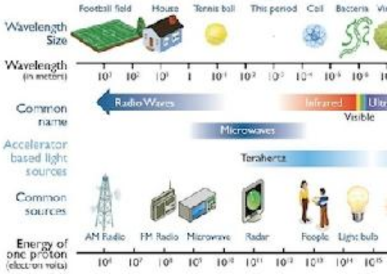
Motion Sensing **Infrared Motion Detectors**

Infrared motion detectors: devices sensitive to heat waves emanated from warm or cold moving objects

operates in the optical range of thermal radiation

the optical range of thermal radiation

the optical range of thermal radiation is subdivided into ultraviolet radiation (UV), the spectrum of light visible for man (VIS) and infrared radiation (IR).

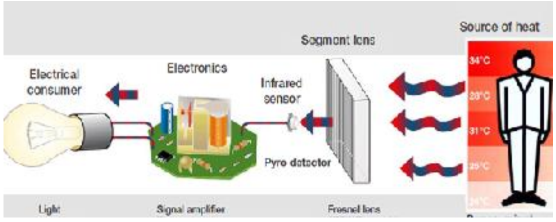


It ranges between wavelengths of 100 nm to 1 mm.

Electromagnetic waves in this range obey the laws of optics--they can be focused and refracted with lenses

PIR Motion Detectors

A PIR is a passive infrared motion sensor. It detects infrared energy, which is in a form of a temperature that is radiated from body of humans, animals and other objects



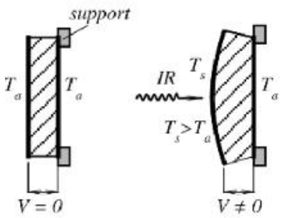
The PIR sensing element must be responsive to far-infrared radiation within a spectral range from 4 to 20 µm, where most of the thermal power emanated by humans is concentrated

The magnitude of infrared energy can be quantified by a pyroelectric sensor. This sensor is placed behind an infrared-transparent cover, so that it may monitor objects with varying infrared energy

Motion Sensing **Infrared Motion Detectors**

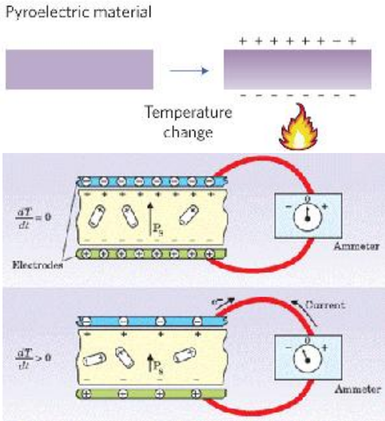
PIR Motion Detectors

A pyroelectric material generates an electric charge in response to thermal energy flow through its body.



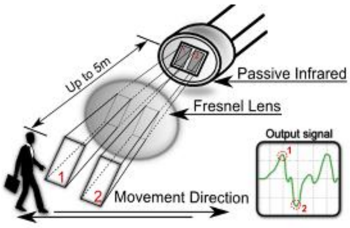
In a very simplified way, it may be described as a secondary effect of a thermal expansion

Because all pyroelectrics are also piezoelectrics, the absorbed heat causes the front side of the sensing element to expand.



The resulting thermally induced stress leads to the development of a piezoelectric charge on the element electrodes.

This charge is manifested as voltage across the electrodes deposited on the opposite sides of the material



when a human walks into the sensors detection range, the temperature in that range changes from a temperature of room objects (if used indoors), which is lower, to a temperature of a human body, which is higher and when a human walks out of the detection range the temperature changes back to the temperature of room objects.

A PIR sensor detects these changes in temperature and transfers them into electrical signals