

5.7. Passive Infrared (PIR) Sensors

A **Passive Infrared (PIR) sensor** detects infrared radiation (heat) emitted by humans or animals. When a warm body moves across its field of view, the sensor detects the change and triggers an action.

Types of PIR Sensors

1. Single Element PIR Sensor

- Has **one** sensing element
- Less accurate
- Used in basic motion detection tasks

2. Dual Element PIR Sensor

- Has **two** sensing elements side by side
- Detects differential signals (more reliable)
- Most common type in motion detectors

3. Multi-Zone PIR Sensor

- Uses **multiple sensing zones** to cover a wide area
- More precise and better at detecting direction of motion

4. Digital PIR Sensors

- Include onboard digital processing
- Lower false alarms, more configurable
- Can include built-in temperature compensation

5. Lens-Based PIR Sensors (with Fresnel lens)

- Use **Fresnel lenses** to focus IR into the sensor
- Extend detection range and area
- Widely used in security and home automation

Applications of PIR Sensors

Application Area	Example Use Cases
<input type="checkbox"/> Home Automation	Auto lights, smart fans, energy-saving systems
<input type="checkbox"/> Security Systems	Intruder alarms, motion-activated CCTV
<input type="checkbox"/> Commercial Spaces	Occupancy detection, smart HVAC systems
<input type="checkbox"/> Public Utilities	Auto-flushing toilets, motion-activated faucets
<input type="checkbox"/> Retail	People counters, automatic doors
<input type="checkbox"/> Automotive	Cabin occupancy detection, hands-free tailgates
<input type="checkbox"/> Energy Efficiency	Lights that turn off when no one's in the room
<input type="checkbox"/> Robotics	Obstacle avoidance, object tracking

Passive Infrared (PIR) Sensor

All warm blooded animals produce IR radiation. **Passive infrared sensors** include a thin Pyroelectric film material, that responds to IR radiation by emitting electricity. This sensor will activate burglar alarm whenever this influx of electricity takes place. These sensors are economical, don't use more energy and last forever. These sensors are commonly used in indoor alarms.



Passive Infrared Sensor

5.8. Piezoelectric sensor

A **Piezoelectric Sensor** is a type of sensor that uses the **piezoelectric effect** — where certain materials (like quartz or ceramics) generate an electric charge when subjected to **mechanical stress** (pressure, vibration, or force).

Types of Piezoelectric Sensors

These sensors are categorized based on what they detect or how they're built:

Type	What It Measures	Notes
Piezoelectric Pressure Sensors	Pressure or force	Used in industrial and automotive systems
Piezoelectric Vibration Sensors	Vibrations or oscillations	Common in condition monitoring
Piezoelectric Accelerometers	Acceleration or dynamic motion	Used in aircraft, cars, and phones
Piezoelectric Force Sensors	Applied force or load	Used in robotics, biomechanics
Piezoelectric Microphones	Sound waves	Converts sound into voltage
Piezoelectric Ultrasonic Sensors	High-frequency vibrations (ultrasound)	Used in distance measurement, cleaning, medical imaging

Applications of Piezoelectric Sensors

Piezoelectric sensors are super versatile and used in a wide range of fields:

Industry/Field	Applications
<input type="checkbox"/> Automotive	Knock sensors, airbag triggers, tire pressure sensors
<input type="checkbox"/> Industrial Machinery	Vibration monitoring, structural health monitoring
<input type="checkbox"/> Consumer Electronics	Touch-sensitive buttons, buzzers, microphones
<input type="checkbox"/> Medical Devices	Ultrasound machines, heart rate monitoring
<input checked="" type="checkbox"/> Aerospace	Aircraft vibration and shock monitoring
<input type="checkbox"/> Gaming/VR	Haptic feedback in controllers
<input type="checkbox"/> Music Instruments	Electronic drum pads and pickups
<input type="checkbox"/> Scientific Research	Precision force and pressure measurements

Working of Piezoelectric Sensor

When pressure or acceleration is applied to the PZT material, an equivalent amount of electrical charge gets generated across the crystal faces. Electrical charge will be proportional to the applied pressure. Piezoelectric sensor cannot be used to measure static pressure. At the constant pressure, the output signal will be zero. Working of a Piezoelectric Sensor can be summarized as,

1. In a piezoelectric crystal the charges are exactly balanced in unsymmetrical arrangement also.
2. The effect of the charges cancel out with each other and hence no net charge will be found on the crystal faces.
3. When pressure is applied to the crystal, the charges are no longer balanced and a net charge is produced.
4. Hence, from now on the effect of charge does not cancel with each other which make net positive and negative charge to appear on the opposite faces of the crystal.
5. Therefore, by squeezing the crystal, voltage is produced across the opposite face and this is known as piezoelectricity.

