Research\Sensors in Automotive Industry

Under the supervision of professor\

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1. Introduction

The modern automotive industry has seen significant advancements in technology over the past few decades, with the integration of sensors and other electronic components playing a major role in the development of safer and more efficient vehicles. Sensors are used in various systems throughout the vehicle, including the engine, transmission, brakes, and lighting systems, among others.

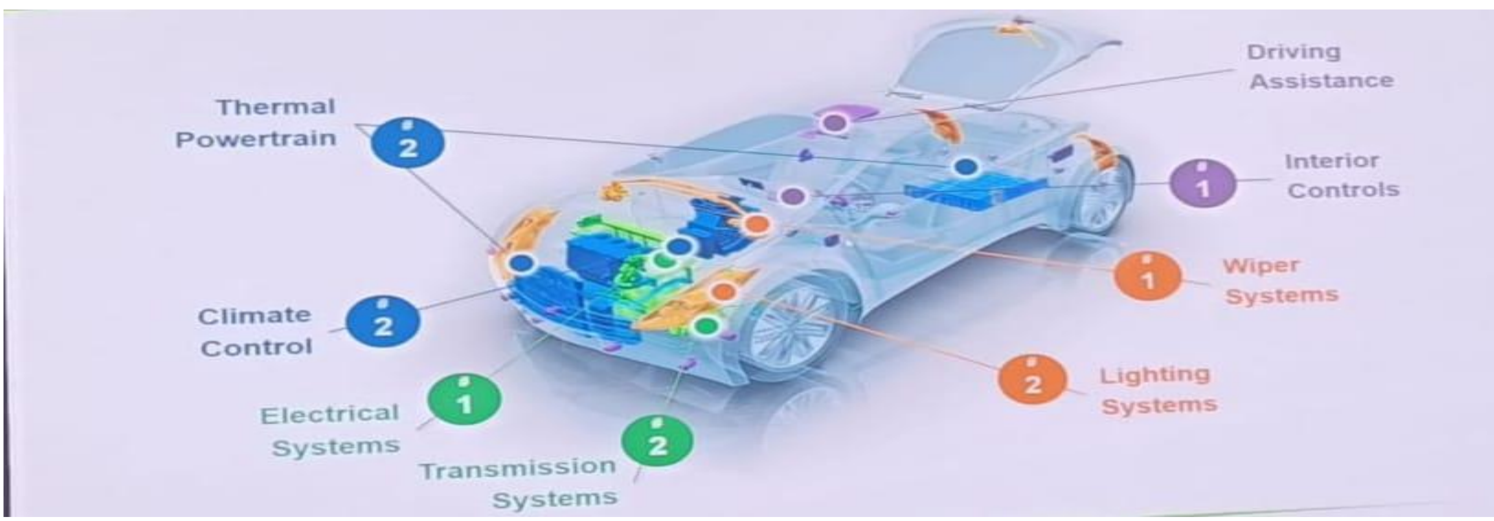
One of the primary benefits of using sensors in modern automobiles is improved safety.

In addition to improving safety, sensors can also help improve the efficiency of modern automobiles. For instance, many vehicles now come equipped with sensors that monitor the engine's performance

Overall, the integration of sensors in modern automobiles has revolutionized the automotive industry, allowing for safer, more efficient, and more technologically advanced vehicles. As technology continues to evolve, we can expect to see even more advancements in the automotive industry in the years to come.

In the modern automotive industry, vehicles are more advanced and complex than ever before, and this is largely due to the integration of numerous systems that work together to ensure optimal vehicle performance. A system in an automotive context refers to a group of interconnected components that work together to achieve a specific function or goal.

We will mention to some of automotive systems



2. Transmission System

The transmission system in an automobile is responsible for transferring power from the engine to the wheels, allowing the vehicle to accelerate and maintain speed. There are several types of transmission systems, but the most common types are manual and automatic.

➢ engine sensors

Combustion engines are so complicated due to the present of a lot of parts, especially the moving parts. Its main concept is gasoline ignition in the present of oxygen. In the correct timing a spark should be produced, that make a strong enough explosion. This explosion pushes the piston down. The piston rotates the crankshaft. This angular velocity will be transferred through the transmission system to the wheels.

So, to control this system we need to know in which stage is each piston (Intake, Compression, Power or Exhaust), to calculate the best time to inject the air & fuel mixture and activate the spark.

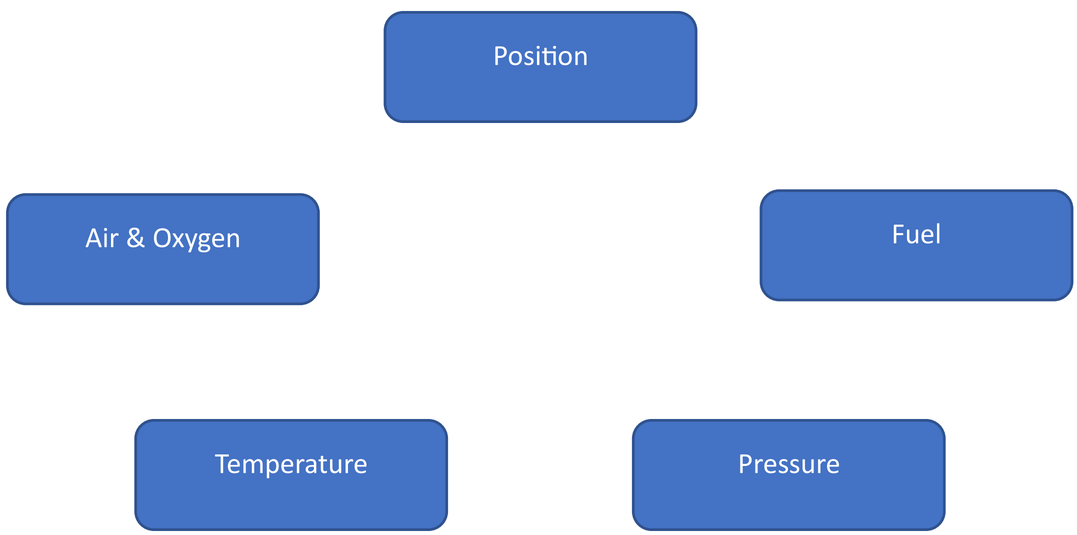


Fig.2.1: Classification of Combustion engine sensors

2.1. Position sensor

2.1.1. Crankshaft position sensor (CKP)

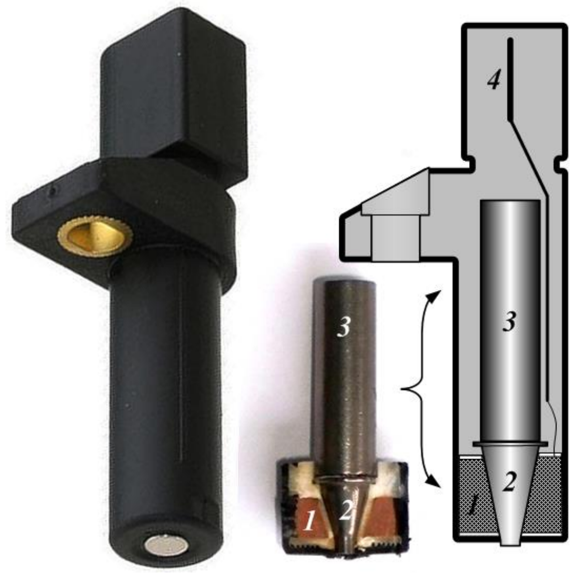


Fig.2.2: Crankshaft sensor

CKP is used to inform the ECU about the crankshaft position. So, it can know the position of each piston. By this way, the ECU could detect the best timing to inject the air & fuel mixture. Now it can know exactly what is happening inside the combustion chambers.

CKP is the essential sensor to measure the engine speed.

- CKP consists of: (*as shown at Fig.2.2)*

  1 - Coil.

  2 - Soft iron.

  3 - Magnet.

  4 - Electrical connector.

- CKP has two types:
  - Hall effect (3-wires)
  - Variable reluctance (2-wires)

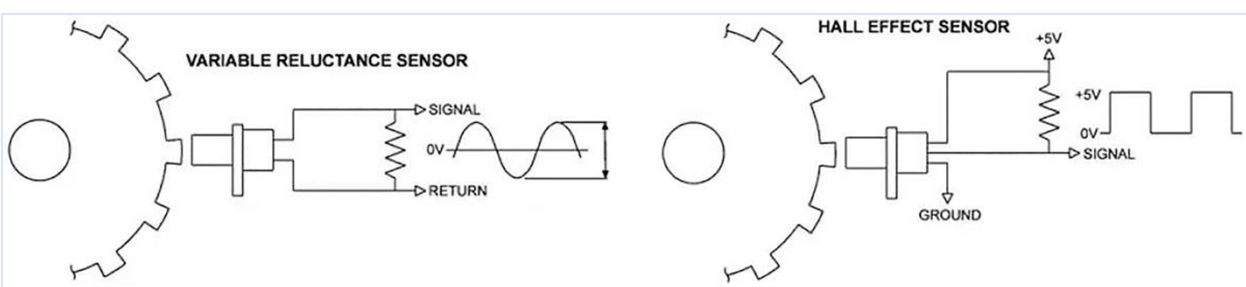


Fig.2.3: Hall effect & Variable reluctance CKP

➢ CKP basic concept

Both of them depends on the same concept "Electromagnetism". It reads a trigger wheel made from a ferrous metal. Which contain a missing tooth that make the sensor send a different signal than usual teeth.

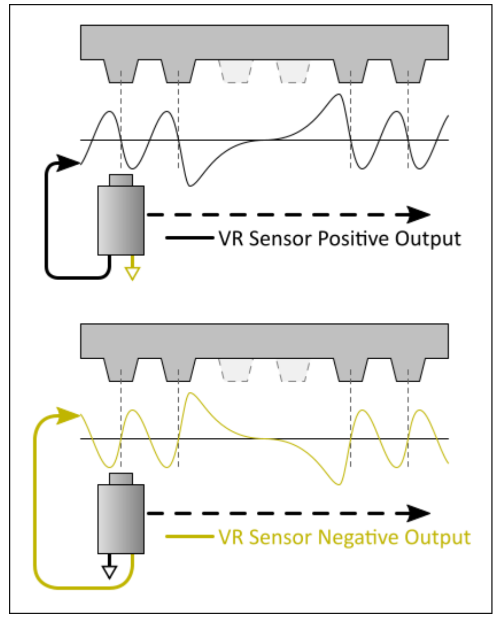


Fig.2.4: CKP basic concept

Simplified video:

https://youtu.be/pXISJ0xjrKs

It became much important when used with any type of variable valve timing systems. Then it will find the perfect timing to switch the cams.

➢ CKP can be located on:

- Crank pully
- Timing gear
- Flywheel
- Engine block

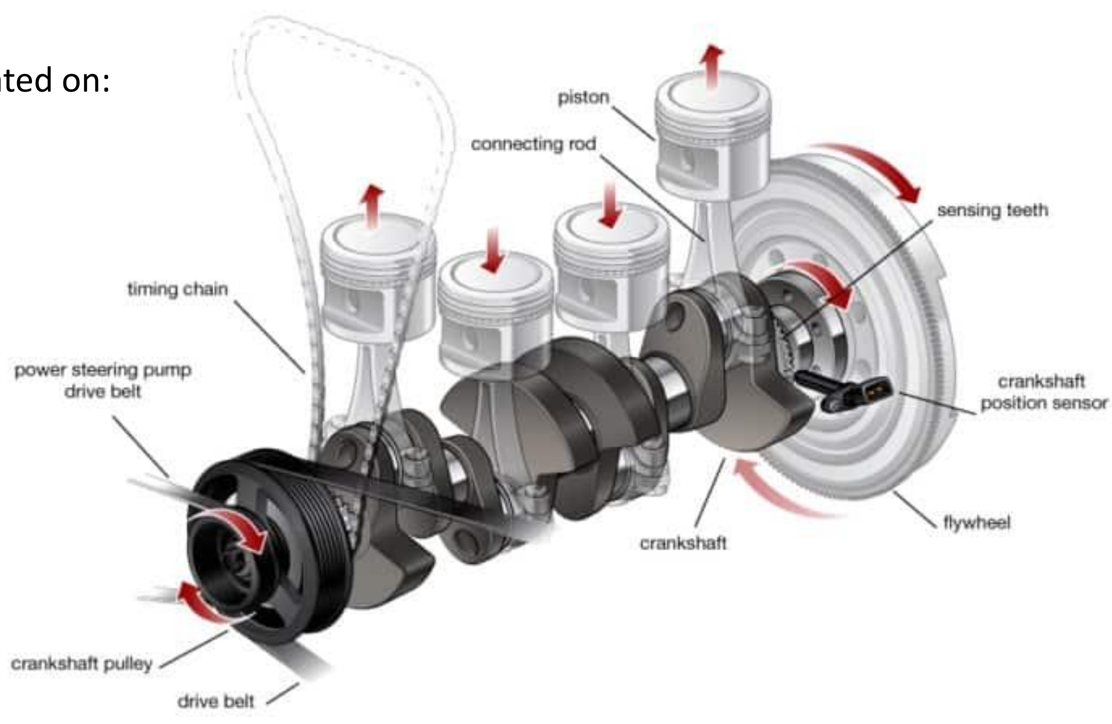


Fig.2.5: CKP location

2.1.2. Cam position sensor (CMP)

CMP dose the same thing as CKP but for cam shafts. It informs the ECU about the position of each cam shaft. The engine can run with the CKP alone, but CMP is used to conform the situation.

Infineon Technologies Sensor TLE4980, is an active chopped mono cell Hall sensor ideally suited to back-bias reduced camshaft applications. The basic operational mode of the TLE4980 map a "high" magnetic field (tooth) to a "low" electrical output signal and a "low" magnetic field (notch) to a "high" electrical output. A magnetic field is considered as "high" if the North Pole of a magnet shows towards the rear side of the-IC housing.

TLE4980 has three different operation modes

- Initial mode - pre-calibrated mode - Calibrated mode.

The block diagram is shown in Fig.2.5. The IC consists of a spinning-Hall-probe (mono-cell in the center of the chip) with a chopped preamplifier. Next there is a summing node for threshold level adjustment. The threshold switching is actually done in the main comparator at a signal level of “0". This means, that the whole signal is shifted by this summing node in such a way, that the desired switching level occurs at zero. This adjusted signal is fed into an ND-converter. The converter feeds a digital calibration logic. This logic monitors the digitized signal by looking for minimum and maximum values and also calculates correction values for threshold adjustment. The static switching level is simply done by fetching a digital value out of a PROM. The dynamic switching level is done by calculating a weighted average of min and max value. For accurate phase stability at different air gaps the dynamic switching level can be programmed with a weighting factor (ko).

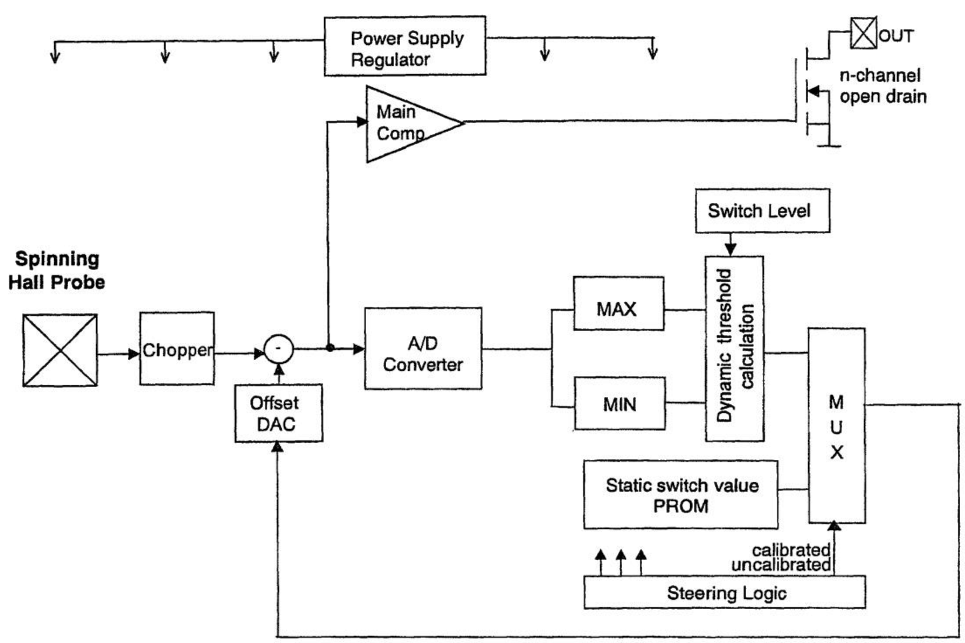


Fig.2.6: spinning-Hall-probe IC consists

2.1.3. Throttle position sensor (TPS)

In the most cases the throttle position sensor is located on the throttle body. It informs the ECU about the position of the throttle blade. So, the ECU can control the throttle opening by stepping on the accelerator pedal. By this way the amount of air entering the engine is controlled by the amount of pressure on the accelerator pedal. The ECU then can determine the amount of fuel injected in the combustion chamber to match the air fuel ratio.

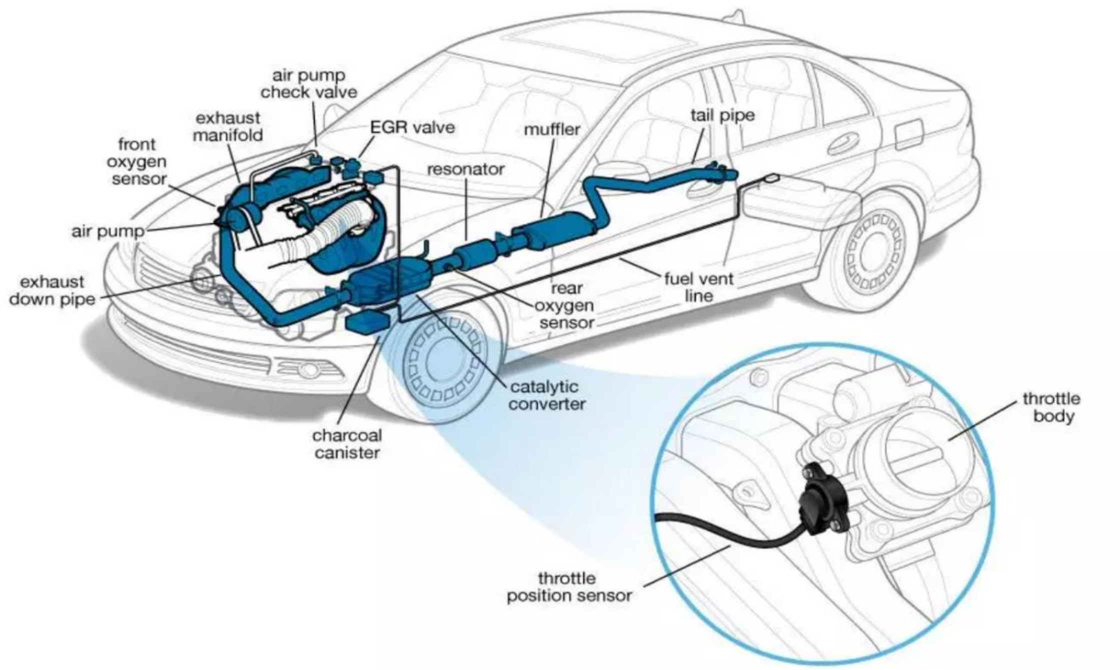


Fig.2.7: Throttle position sensor location

- The TPS can sense the throttle blade position by different ways such as:
  1. Contact method. “resistor”
  2. Non-contact method. “magnetic”

Fig.2.9: contact TPS in real-life

2.1.3.1. Contact throttle position sensor

Contact TPS’s main concept depends on variable resistors. The resistance will change depend on the position of the throttle blade position.

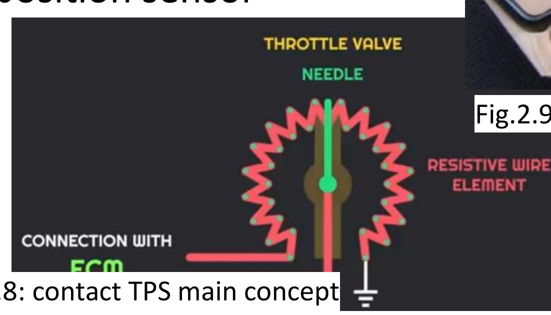


Fig.2.8: contact TPS main concept

2.1.3.2. Non-Contact throttle position sensor

It is the modern method of knowing throttle valve position without any thing touching the throttle plate itself.

- It also has two different types:
    - Hall Effect throttle position sensor
    - Inductive throttle position sensor

First -> Hall Effect throttle position sensor:

These sensors consist of magnets and Hall IC circuits. When the throttle valve position changes, it changes the magnetic flux in the Hall Effect sensor. So, it can sense this change and send it as a signal to the ECU.

Fig.2.10: Hall Effect throttle position sensor

Second -> Inductive throttle position sensor:

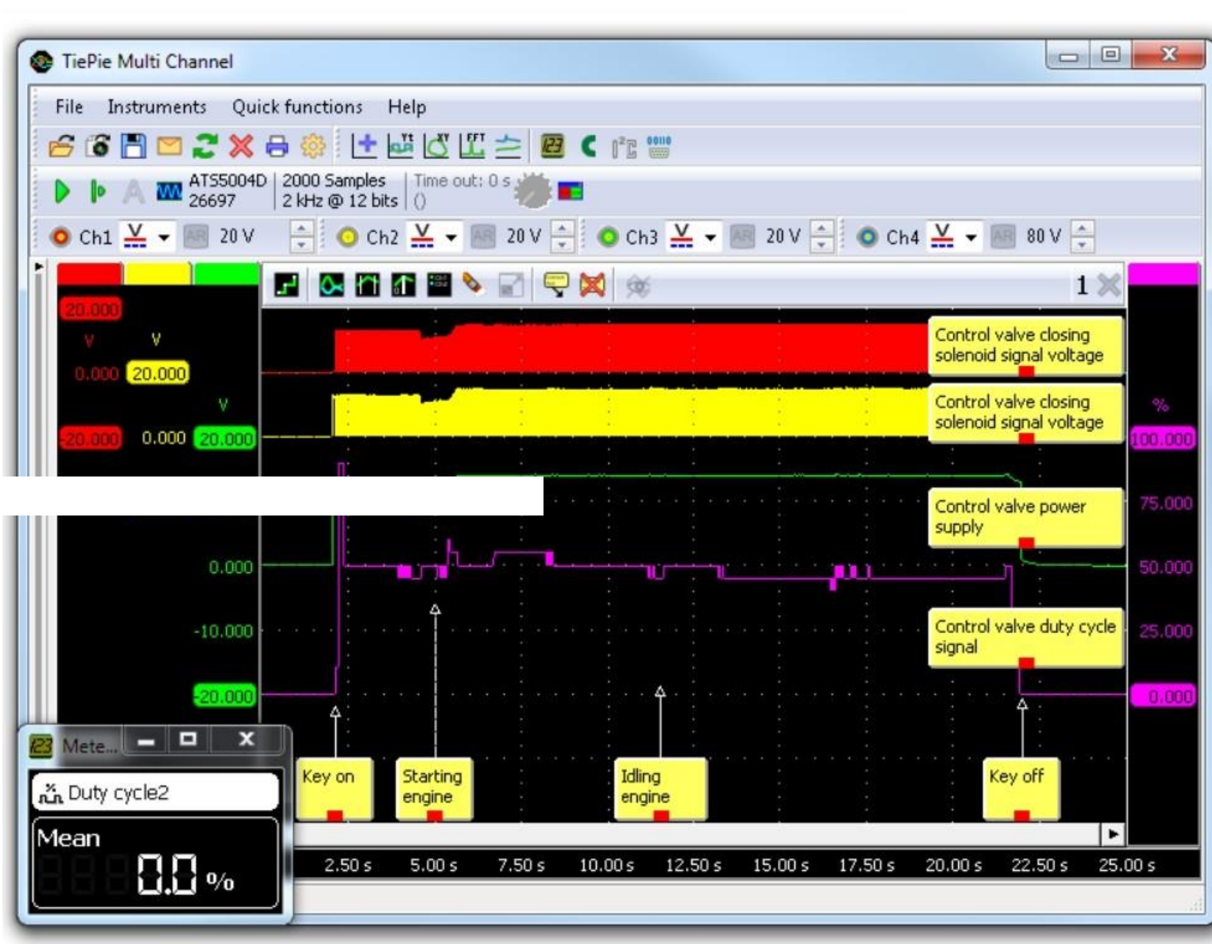
It consists of a rotor and stator. When the throttle valve position changes, it produces voltage, which is sent to the computer to inform it about the throttle valve position. They are usually integrated into the electronic throttle control system.

Fig.2.11: Inductive throttle position sensor

2.2. Air &fuel sensors

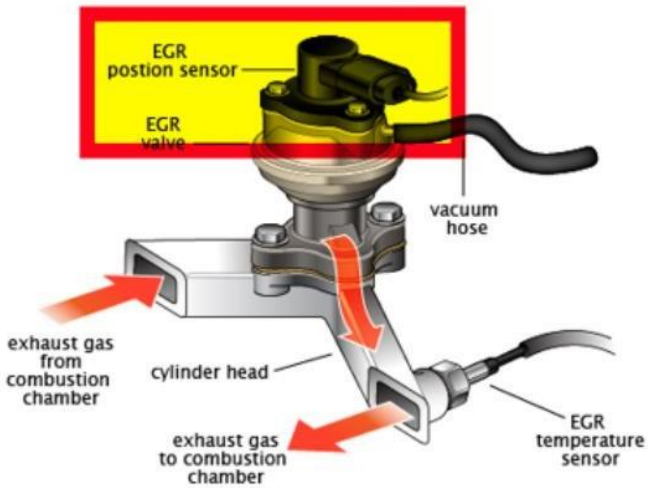
2.2.1. Idle Air Sensor (IAC):

This is not really a sensor, but a stepper motor. The IAC controls the idle of the engine. For example, when you step on the brake, the RPM drops, but the vehicle does not get enough fueland air to keep it running. The IAC increases the RPM of the engine, which in turn requests more fuel to keep the engine running. Since the computer sends fuel based on the amount of air going through the engine and there is no air moving at a stop, the engine would stall withoutthe IAC.

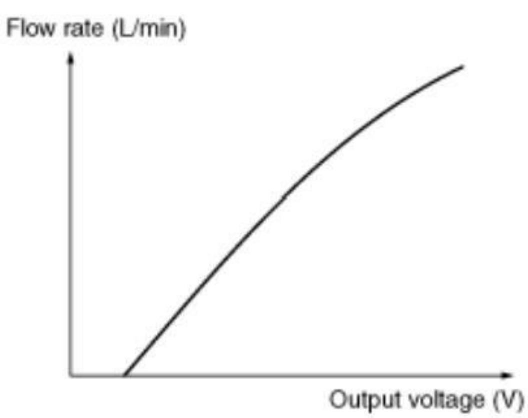


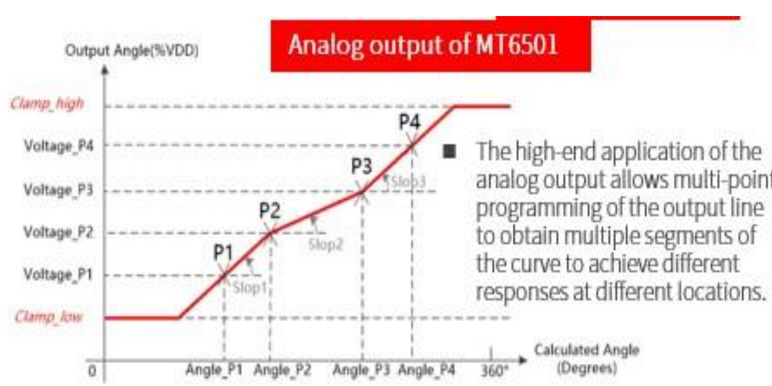
2.2.2. EGR sensor:

The EGR system in newer vehicles is complicated. The EGR sensor tells the computer when the EGR valve opens and how much-unburned oxygen is flowing into the cylinders. The computer uses these parameters to change the injector on time for more or less fuel. The exhaust gas being recirculated cools the cylinders, plus burns any oxygen that was unburned in the first go-around through the engine. This affects fuel delivery system because it changes the engine temperature and amount of air in the engine.



working principle:The EGR valve stem rises and pushes the sliding contact arm connected to it to change its position, causing the sliding contact to slide on the sliding resistor, generating different voltage signals. The signal is transmitted to the ECU, and the ECU monitors the position of the EGR valve to ensure that the valve responds correctly to the ECU's commands. In this way, the opening time and duty ratio of the EGR valve can be adjusted and corrected, and the amount of recirculation can be precisely controlled to reduce emissions and improve performance.



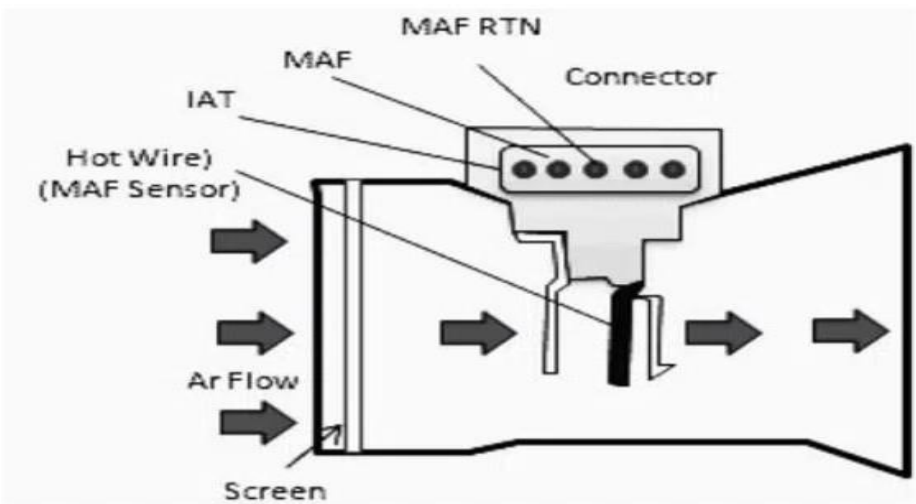


2.2.3. MAF Sensor:

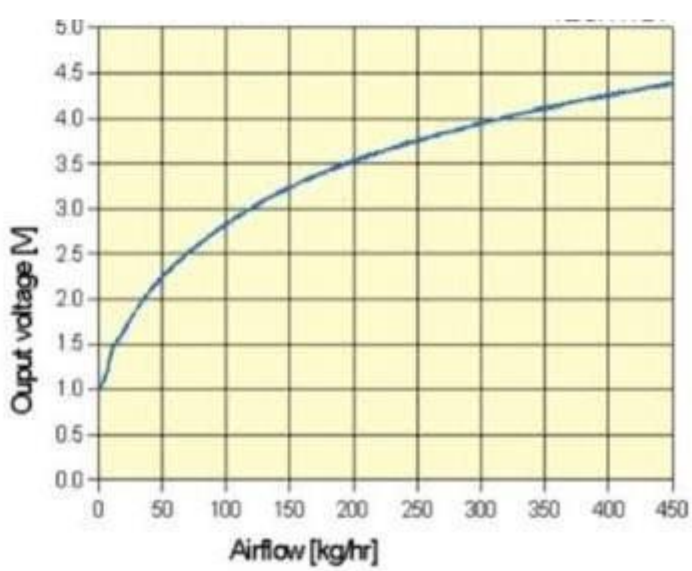
The MAF sensor (MASS AIRFLOW SENSOR) tells the control module how much air enters the engine as you are driving. The control module varies the amount of fuel based on the amount of air in the engine to keep the fuel to air ratio at the proper mixture for the best fuel mileage and emissions. It also measures the density of the air, e.g., how much water (humidity) is in theair and adjusts the fuel accordingly.

Air Flow Sensor Working Principle:

the air mass sensor is located directly in the intake air stream between the air filter and the throttle body to measure the intake air. the airflow sensor working principle is explained from the block diagram as shown below.

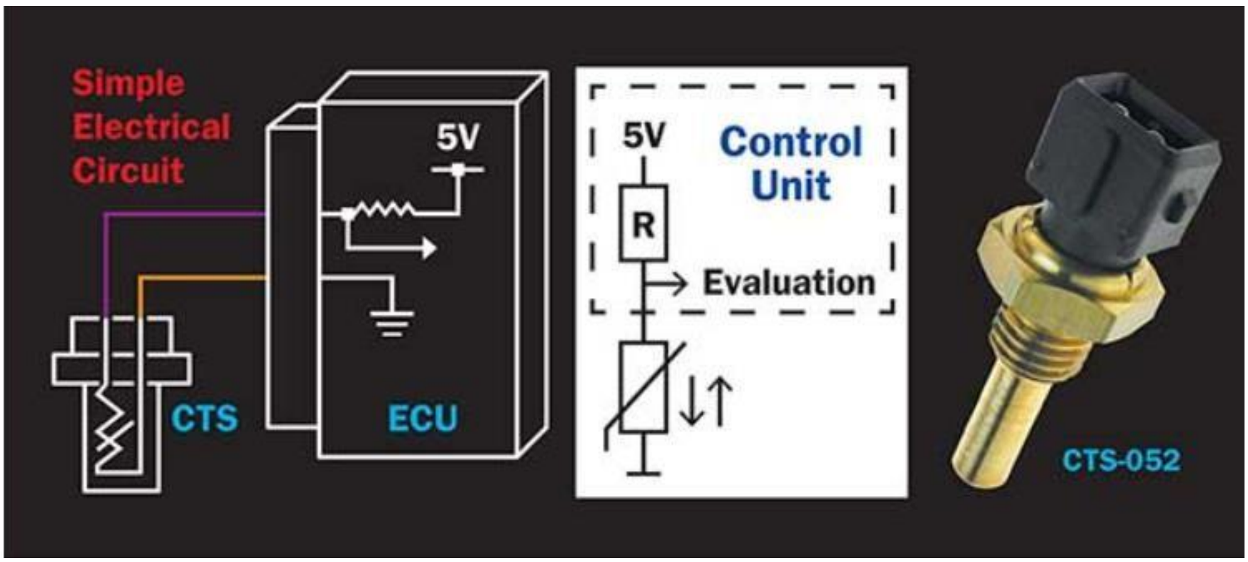


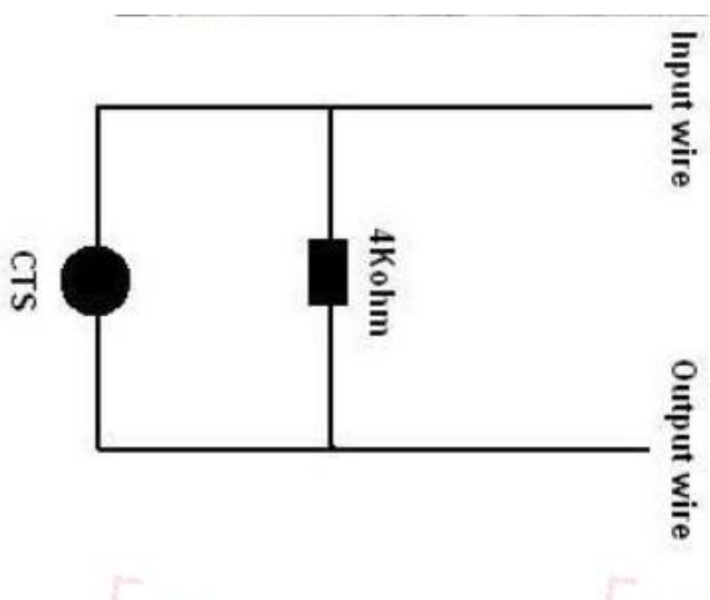
Mass Air Flow Type Sensor



2.3. Coolant Temperature Sensor (CTS):

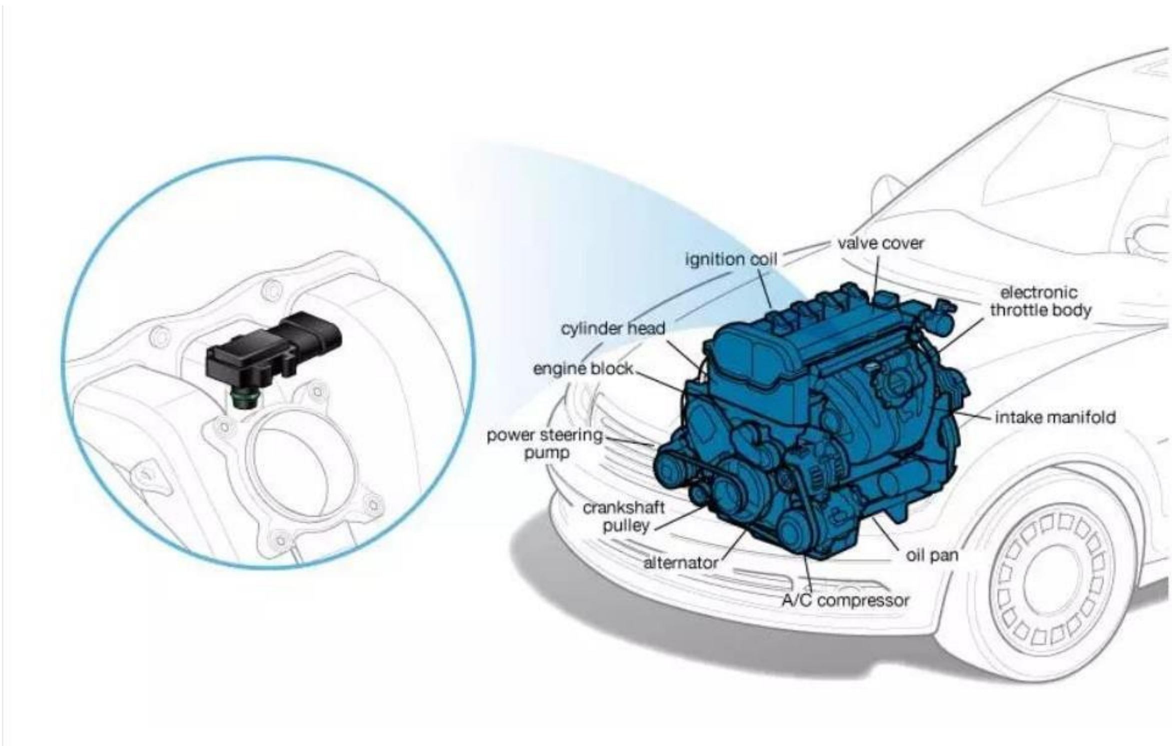
This sensor tells the computer about the temperature of the engine so that it can adjust the fuel mixture, but it also uses the information to turn the fan on via the control module when the engine reaches a certain temperature. Once the fan is on, the engine cools down, and the CTS lets the computer know to adjust the fuel-to-air ratio for the cooler temperature.





2.4. MAP Sensor:

The MAP sensor measures how much vacuum is in the engine and sends the signal to the controlmodule, which in turn used this parameter to determine how much load is on the engine. Whilethis sensor's main function is to tell the computer how to adjust the timing, it does affect fuel delivery. If the engine is idling, the control module changes the timing and the fuel ratio. As yougive the vehicle more gas, the control module richens the fuel mixture for the power that the driver is requesting.



3. ADAS System

ADAS (Advanced Driver Assistance Systems) are passive and active safety systems designed to remove the human error component when operating vehicles of many types. ADAS systems use advanced technologies to assist the driver during driving, and thereby improve drivers’ performance. ADAS uses a combination of sensor technologies to perceive the world around the vehicle, and then either provide information to the driver or take action when necessary.

This video will explain more about ADAS System: https://youtu.be/EiWl5PAtfYA

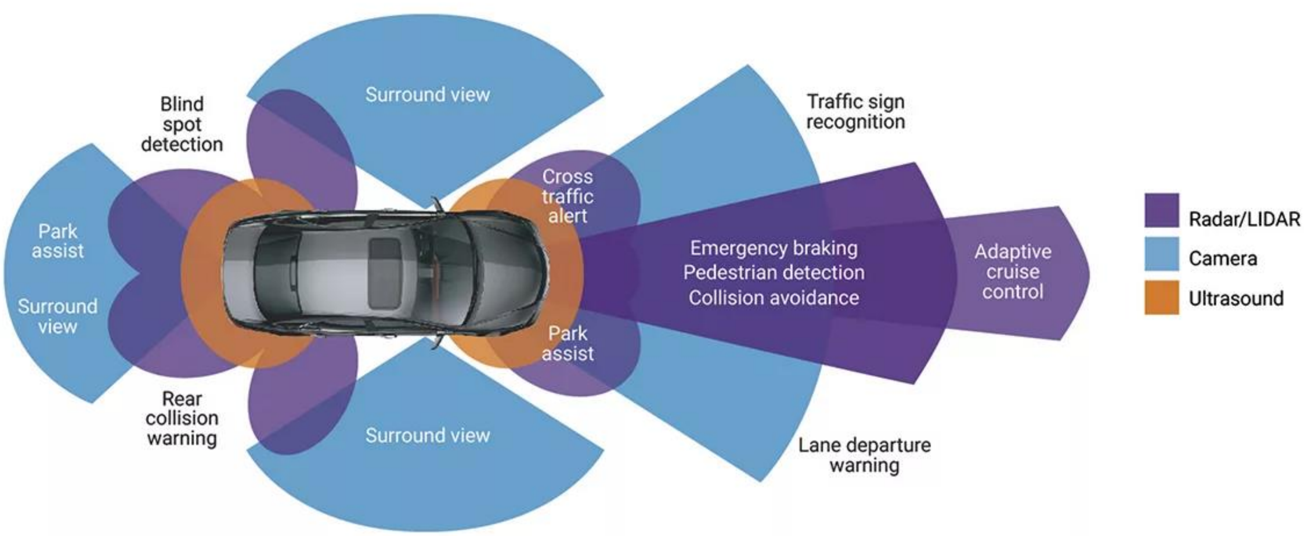
- Sensors used in ADAS:

1-Radar

2-Lidar

3-Camera

4-Ultrasonic



3.1. Radar Sensor

➢ Function in Adas System:

Radar sensors are an essential component of many ADAS systems, as they provide critical information about the vehicle's surroundings and enable the system to make decisions in real-time. Here are some of the functions of radar sensors in ADAS systems:

1. Adaptive Cruise Control (ACC): Radar sensors are used in ACC to detect the distance between the vehicle and the car in front and adjust the vehicle's speed accordingly. The radar sensor continuously measures the distance and relative speed of the car in front and sends this information to the ACC system, which can then adjust the vehicle's speed to maintain a safe following distance.
2. Blind Spot Detection (BSD): Radar sensors are used in BSD to detect the presence of other vehicles in the driver's blind spot. The radar sensor can detect the distance and speed of other vehicles in adjacent lanes and alert the driver if it's not safe to change lanes.
3. Forward Collision Warning (FCW): Radar sensors are used in FCW to detect the distance and speed of the vehicle in front and alert the driver if a potential collision is detected. The radar sensor can detect if the vehicle in front is slowing down or stopping, and warn the driver if they need to take action.
4. Collision Mitigation Braking System (CMBS): Radar sensors are used in CMBS to detect a potential collision and automatically apply the brakes to avoid or reduce the severity of the impact. The radar sensor can detect if the vehicle in front is too close and if a collision is imminent, and then apply the brakes to prevent or reduce the impact.

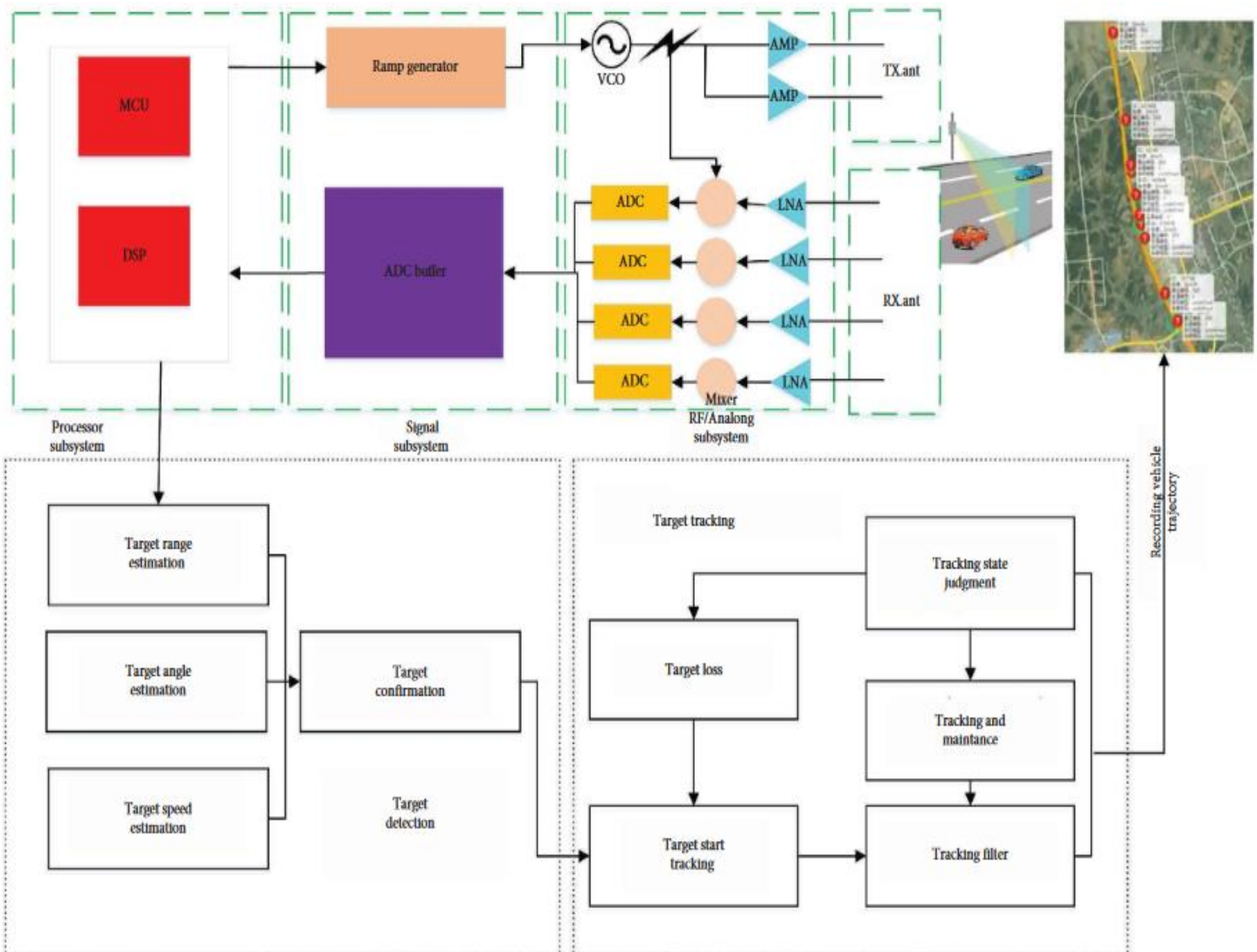
➢ Methodology

The scientific basis of radar sensors lies in the principles of electromagnetic wave propagation and reflection. Radar stands for "radio detection and ranging," and it works by emitting radio waves at a specific frequency and wavelength and then detecting the waves that bounce back after hitting an object. Radar sensors use the properties of electromagnetic waves to calculate the distance, speed, and direction of the object.

When a radar signal hits an object, some of the energy is reflected back towards the radar sensor. The time it takes for the signal to travel to the object and back is used to calculate the distance to the target. The frequency shift of the reflected signal, known as the Doppler effect, is used to calculate the speed and direction of the target.

The scientific principles behind radar sensors are based on the laws of electromagnetism, including Maxwell's equations, which describe the behavior of electromagnetic waves. The radar sensor emits electromagnetic waves, which propagate through space at the speed of light and interact with objects in their path. The properties of the reflected waves are then analyzed to provide information about the objects detected by the radar sensor.

- Architecture of the vehicle tracking method based on radar



3.2. Lidar Sensor

➢ Function in Adas System:

Lidar, which stands for Light Detection and Ranging, is a sensing technology that uses laser light to detect and measure distance to objects. Lidar is a key technology used in Advanced Driver Assistance Systems (ADAS) to improve the safety and performance of vehicles.

Lidar sensors emit laser beams that bounce off nearby objects and provide information about their location, shape, and distance. By measuring the time it takes for the laser light to reflect back to the sensor, lidar can calculate the distance to the object with high accuracy. Lidar can also provide information about the object's shape and orientation, making it useful for detecting and identifying objects such as pedestrians, vehicles, and obstacles in the road.

In ADAS, lidar sensors are typically used for collision detection and avoidance, autonomous emergency braking, and pedestrian detection systems.

Lidar technology offers several advantages over other sensing technologies. It provides high-resolution 3D images of the environment, which can help to identify objects and hazards more accurately. It is also less affected by weather conditions, such as rain, fog, or snow, than other sensing technologies. However, lidar sensors can be more expensive and require more power than other sensing technologies, which can be a consideration in the design of ADAS systems.

➢ Methodology

The methodology of lidar sensing involves emitting laser pulses and measuring the time it takes for the pulses to reflect back to the sensor. Lidar stands for Light Detection and Ranging and is a sensing technology that uses laser light to detect and measure the distance to objects.

- The lidar methodology involves several steps:

1. Emitting laser pulses: Lidar sensors emit short pulses of laser light at a specific wavelength. The light travels through the air until it hits an object.

2. Measuring the time-of-flight: When the laser light hits an object, it reflects back towards the lidar sensor. The sensor measures the time it takes for the light to travel to the object and back. This time-of-flight measurement is used to calculate the distance to the object.

3. Creating a point cloud: By repeating this process many times, lidar sensors can create a point cloud, which is a collection of 3D points that represent the surface of the objects in the sensor's field of view.

4. Processing the data: The point cloud data is processed to identify objects and extract information such as their location, size, and shape. This information can be used to create 3D maps of the environment or to detect and avoid obstacles.

Lidar sensors can also use different types of laser pulses, such as continuous wave or frequency-modulated pulses, to achieve different measurement capabilities. For example, frequency-modulated lidar can provide high-resolution 3D images of the environment, while continuous wave lidar can provide accurate distance measurements over long distances.

This fig shows the framework of the proposed change detection method. The proposed change detection network requires a 3D model and a set of real LiDAR scans to generate sufficient training data. In the training phase, a set of real LiDAR scans are captured in the real environments and the pose of the mobile LiDAR sensor is estimated with respect to the 3D model. Based on the estimated real LiDAR poses, we generate a set of synthetic LiDAR scans in the modified 3D model. The pairs of real LiDAR scans and synthetic LiDAR scans are converted into range images and then used to train the built two-branch change detection network with ground truth labels of each point of real LiDAR scans. The loss between ground truth labels and predicted labels is calculated to learn the weight of the two encoders and decoders. The ground truth labels are generated using MATLAB LiDAR Labeler. During the inference phase, the pose of the current LiDAR scan is estimated and a synthetic LiDAR scan is generated with the estimated pose. The real LiDAR scan and synthetic LiDAR scan are converted into range images and then input into the trained encoders and decoders respectively to perform the segmentation task. Each point of the real LiDAR scan will be classified into one of the four categories: unchanged, structural change, moving object and temporary change.

The developed network consists of two branches of an encoder and a decoder for synthetic LiDAR scans and real LiDAR scans respectively. The real LiDAR scans and synthetic LiDAR scans are converted into range images and then input into the two branches separately. Both branches consist of an encoder and a decoder. The output feature maps from two decoders are fused using a concatenation layer and the fused feature map is then used to perform a segmentation task.

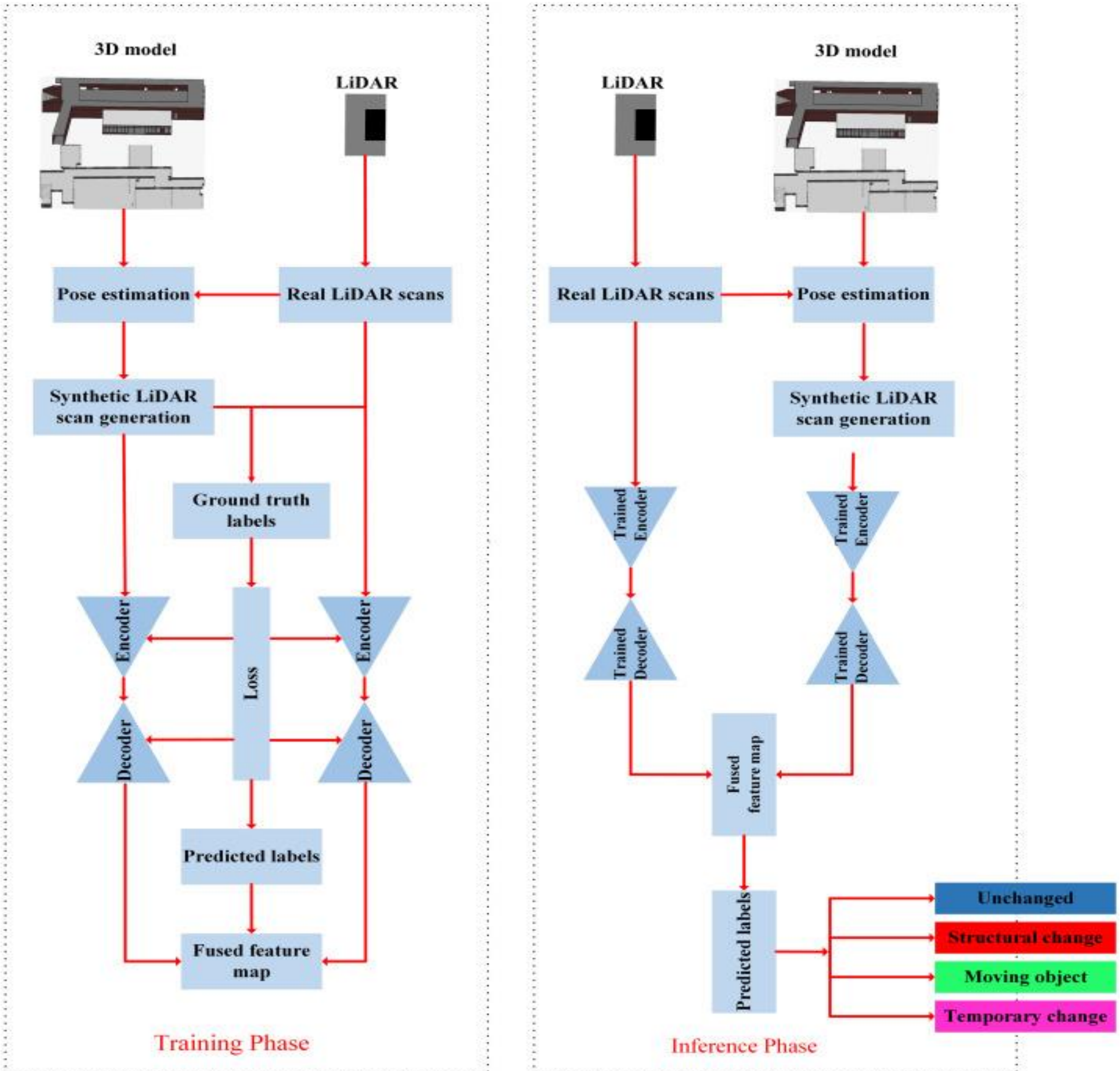


Fig. 1. Framework of proposed change detection method based on LiDAR segmentation.

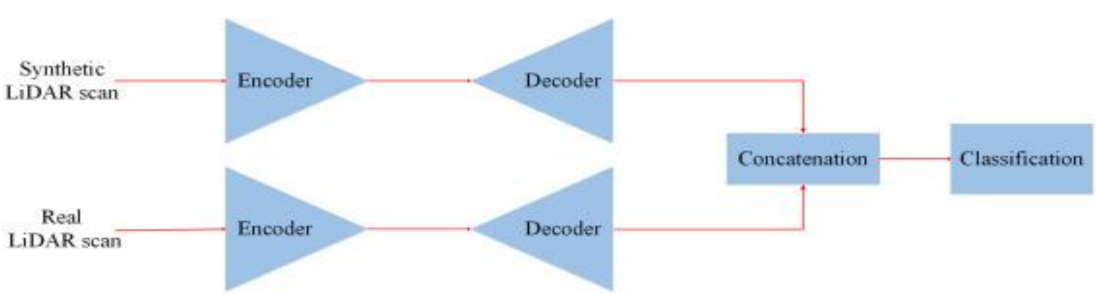


Fig. 2. Structure of the change detection network.

3.3. Camera

Function in Adas System:

Camera technology is a key component of Advanced Driver Assistance Systems (ADAS) that is used for a wide range of applications, including lane departure warning, traffic sign recognition, forward collision warning, and pedestrian detection. Cameras capture images of the environment in front of the vehicle and use image processing algorithms to identify objects and hazards.

In ADAS, cameras are typically mounted on the front, rear, and sides of the vehicle to provide a 360-degree view of the surroundings. Cameras can provide high-resolution images of the environment, which can be used to identify objects, lanes, signs, and pedestrians more accurately. They can also be used in conjunction with other sensors, such as radar and lidar, to provide a comprehensive view of the vehicle's surroundings.

Camera technology is based on the principles of optics and image processing. Cameras use lenses to focus light onto a sensor, which converts the light into digital signals that can be processed by computer algorithms. The algorithms analyze the images to identify objects, estimate their distance and speed, and predict their future movements.

Advanced camera-based ADAS systems use deep learning algorithms, which are trained on large datasets of images to recognize patterns and objects more accurately. These algorithms can detect and track multiple objects simultaneously and make predictions based on the objects' behavior.

➢ Methodology

The camera methodology involves several steps:

1. Capturing images: Cameras capture images of the environment in front of the vehicle. These images are typically captured at a high frame rate to provide a continuous stream of images.

2. Processing the images: The images are processed using computer algorithms, which analyze the images to identify objects and hazards. Image processing algorithms can detect lines, shapes, colors, and patterns in the images to identify objects such as vehicles, pedestrians, and signs.

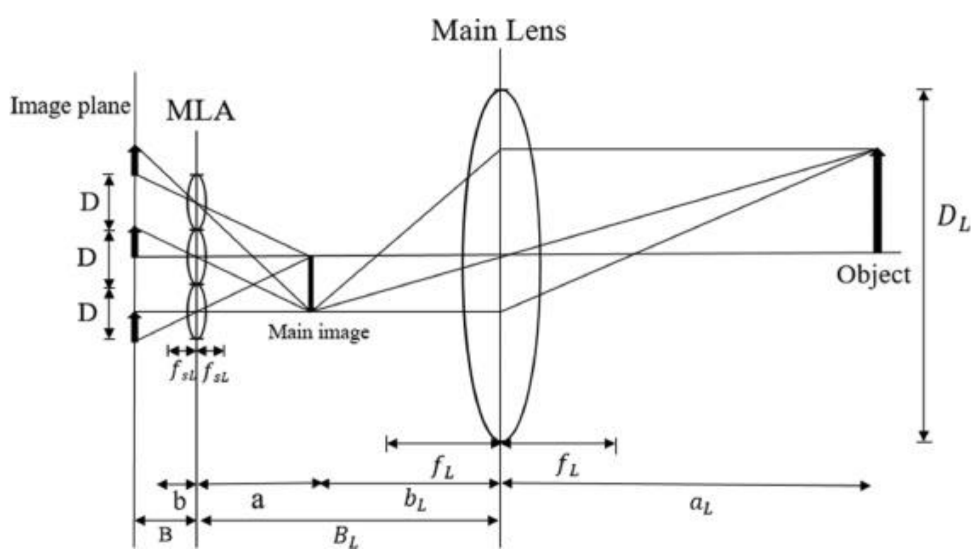
3. Estimating the distance and speed of objects: Image processing algorithms can estimate the distance and speed of objects based on their size and position in the image. This information can be used to predict the future movements of objects and to provide warnings to the driver.

4. Making decisions: Based on the information obtained from the images, the ADAS system can make decisions such as triggering a warning to the driver, braking the vehicle, or adjusting the speed to maintain a safe distance from other vehicles.

Advanced camera-based ADAS systems use deep learning algorithms, which are trained on large datasets of images to recognize patterns and objects more accurately. These algorithms can detect and track multiple objects simultaneously and make predictions based on the objects' behavior.

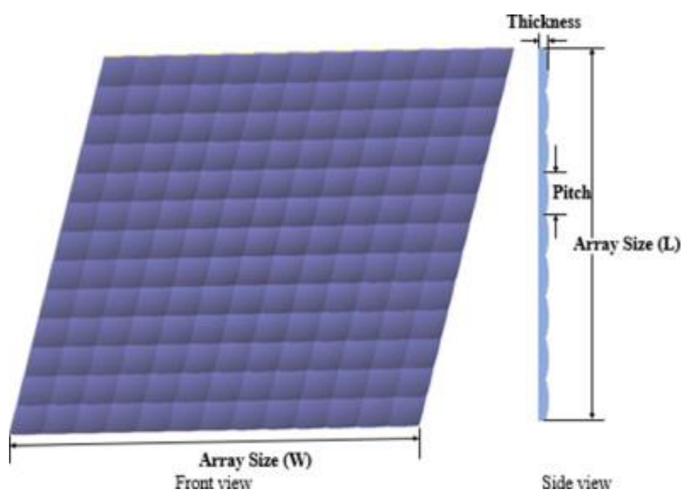
Overall, the camera methodology involves capturing images of the environment, processing these images using computer algorithms, estimating the distance and speed of objects, and making decisions based on the information obtained from the images. Camera technology is a critical component of ADAS systems, providing high-resolution images of the environment and using advanced image processing algorithms to improve the safety and performance of vehicles.

Traditional cameras have significant limitations in calculating the scene depth and thus generally obtain 2D images of the targets. Light field camera (plenoptic camera) greatly solves this problem with depth information. The image focus can be switched and rebuilt computationally after optical information is taken by the camera. The micro-lens array (MLA) between the main lens and the photoreceptor plays a key role in the light field camera as shown in figure . Each small lens in this array receives the light from the main lens and transmits the light to the photoreceptor. The photoreceptor records the light information digitally after light focusing and converting. The camera's built-in software operates an expanded depth light field that tracks where each ray of light falls on the image from different distances and digitally refocuses the target depth to recreate the information from the real world. Thus, the light field camera has obvious advantages in angular resolution. The 3D image acquisition of the observed object can be achieved conveniently and quickly, and refocus to form a series of focal stack images by the software selection and calculation



- MIA

The main function of the micro-lens array is to discretize and decouple the light emitted from the same point on the surface of the object in various directions within a certain angle range. The degree of discretization is determined by the amount, focal lengths, and apertures of the micro-lenses and the distance between the micro-lens and the imaging plane. The thickness of the micro-lens array is determined by the curvature and form factor of the sub-lens. As shown in Fig. 4, the geometry of the sub-lens is a plano-convex square. The curvatures of the sub-lenses can be divided into several groups to convert the light to different depths. The material of the lens array is fused silica. To ensure its accuracy, the micro-lens array must be able to tolerate various external forces or vibrations without deforming or altering its shape and should be able to reach a tolerance of 1/10 of a millimetre or better. Aside from the tolerance and external forces, other important parameters to consider when evaluating a micro-lens array include the number of lenses, their focal length, the size of the lenses, and the size of the image sensor. Additionally, the quality of the lenses themselves will also play an important role in the accuracy and performance of the micro-lens array



3.4. Ultrasonic

➢ Function in Adas System:

Ultrasonic sensors are a key component of Advanced Driver Assistance Systems (ADAS) that are used for parking assist, blind spot detection, and obstacle detection. Ultrasonic sensors emit high-frequency sound waves that bounce off nearby objects and provide information about their distance and location.

In ADAS, ultrasonic sensors are typically mounted on the front, rear, and sides of the vehicle to provide a 360-degree view of the surroundings. Ultrasonic sensors can detect objects that are close to the vehicle and provide warnings to the driver or trigger automatic braking to avoid collisions.

Ultrasonic sensors can provide accurate distance measurements for objects that are within a few meters of the vehicle. However, ultrasonic sensors have limitations, such as limited range and difficulty in detecting the shape and orientation of objects. Ultrasonic sensors are also affected by environmental factors, such as temperature, humidity, and wind, which can affect the speed of sound waves.

➢ Methodology

The ultrasonic methodology involves several steps:

1. Emitting sound waves: Ultrasonic sensors emit high-frequency sound waves that travel through the air and bounce off nearby objects.

2. Measuring the time-of-flight: When the sound waves hit an object, they bounce back towards the ultrasonic sensor. The sensor measures the time it takes for the sound waves to travel to the object and back. This time-of-flight measurement is used to calculate the distance to the object.

3. Processing the data: The distance measurements obtained by the ultrasonic sensor are processed to identify objects and hazards. The sensors can detect objects that are close to the vehicle and provide warnings to the driver or trigger automatic braking to avoid collisions.

4. Limitations: Ultrasonic sensors have limitations such as limited range and difficulty in detecting the shape and orientation of objects. Ultrasonic sensors are also affected by environmental factors, such as temperature, humidity, and wind, which can affect the speed of sound waves.

Scheme of the detection algorithm the scheme for moving objects detection is shown in Fig. 1. Following the original data module as the foundation of the proposed algorithm, three phases are organized sequentially:

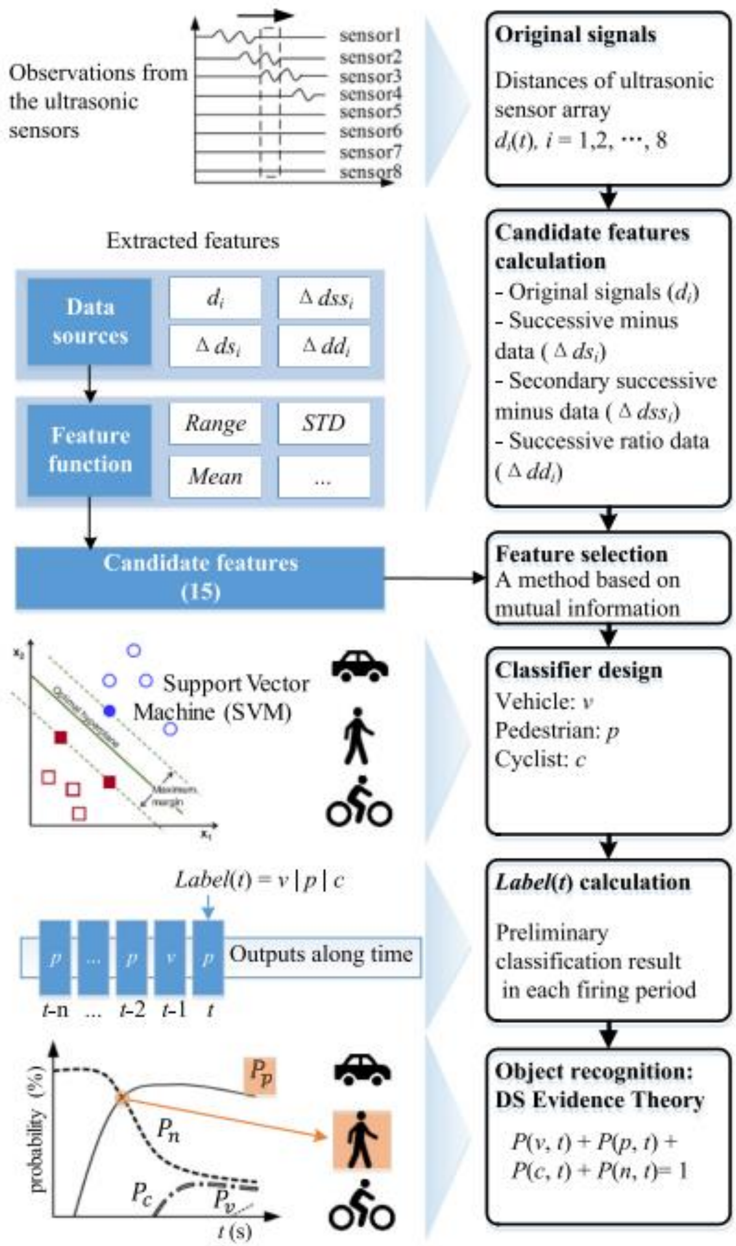


Fig. 1. Scheme of the detection algorithm.

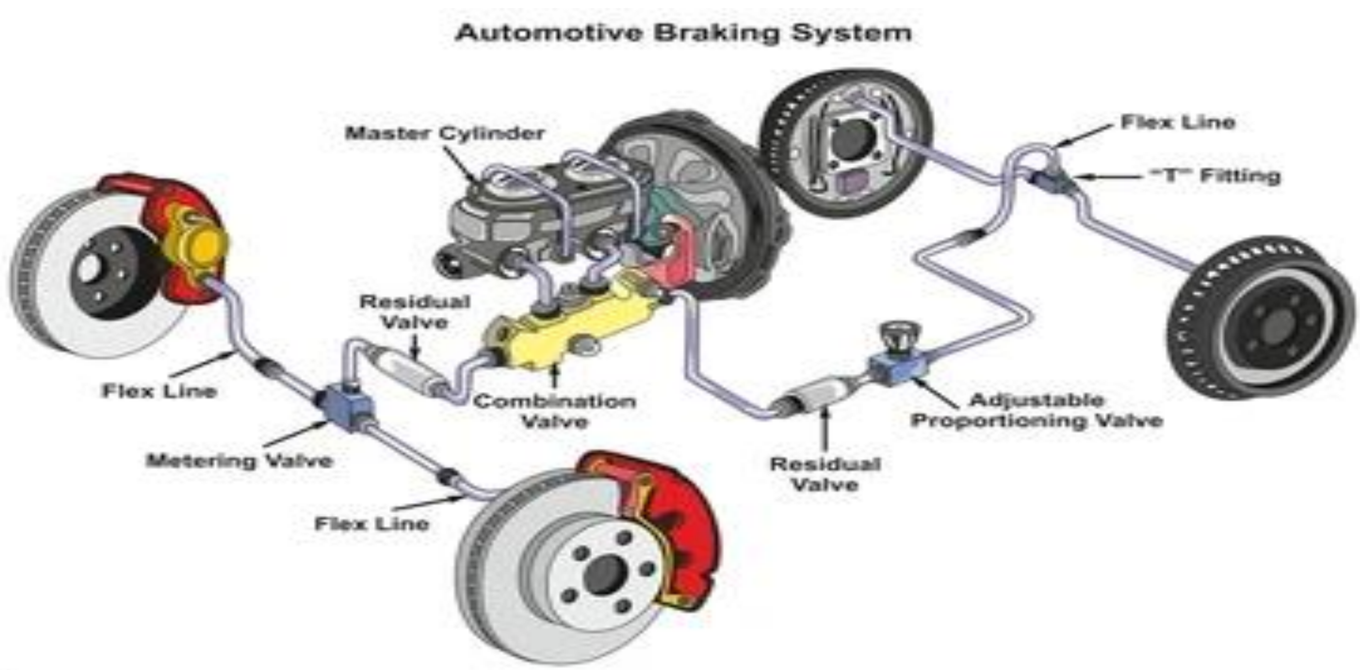
4. Braking system

The transmission system in an automobile is responsible for transferring power from the engine to the wheels, allowing the vehicle to accelerate and maintain speed. There are several types of transmission systems, but the most common types are manual and automatic.

In a manual transmission system, the driver uses a clutch pedal to disengage the engine from the transmission, allowing the driver to manually shift gears using a gear stick. This type of transmission is often preferred by driving enthusiasts because it allows for more control over the vehicle's performance.

In an automatic transmission system, the transmission automatically shifts gears based on the vehicle's speed and other factors, without the need for the driver to manually shift gears. This type of transmission is typically easier to operate and is preferred by many drivers for its convenience.

Modern automotive transmission systems often include additional features such as paddle shifters, which allow the driver to manually shift gears without a clutch pedal, and continuously variable transmissions (CVTs), which use a belt and pulley system to provide a smoother and more efficient driving experience.



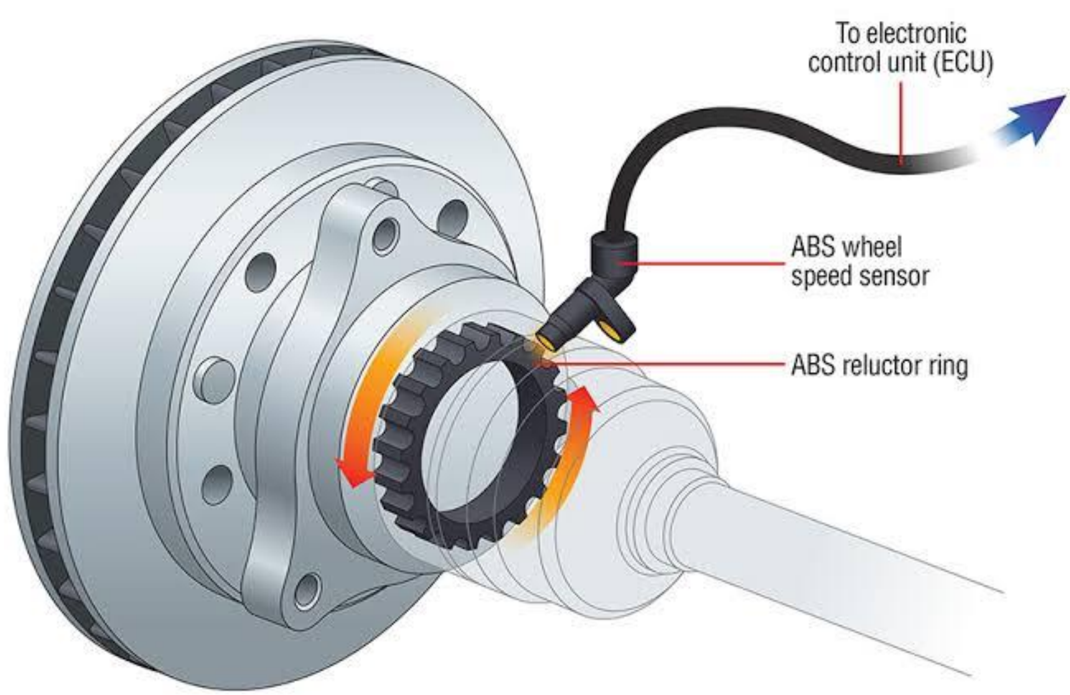
4.1. ABS SENSOR

In essence, the primary function of the anti-lock braking system (ABS) is to prevent skidding and loss of control when braking forcefully. To achieve this, the ABS employs ABS Sensors, also known as wheel speed sensors, which detect conditions within the wheel that may lead to skidding or loss of traction. However, these ABS sensors are utilized by various vehicle systems apart from ABS, which encompass:

Stability control
Traction control
Hill descent control
Collision avoidance.

The ABS sensor plays a crucial role in ensuring the effectiveness of the anti-lock braking system and other safety systems by providing prompt and accurate feedback.

To operate, the ABS sensor functions in conjunction with an ABS ring, also referred to as a tone or pulse wheel. The ABS ring is affixed to a component that rotates at the same speed as the wheel, typically the wheel hub but occasionally the brake disc, CV joint, or drive shaft. Positioned adjacent to the ABS ring, the ABS sensor detects the rotational speed and transmits this information back to the ECU (Electronic Control Unit). The method employed to measure rotation depends on the specific type of sensor and ring being utilized. The most common types of sensors are either passive or active.



➢ *PASSIVE ABS SENSOR*

A passive ABS sensors operate without the need for a power source. They utilize a coil winding surrounding a pole pin connected to a permanent magnet to generate a magnetic field that interacts with a toothed ABS ring. As the ring rotates, each tooth passing by the sensor induces a change in the magnetic field. This change is detected by the sensor, resulting in a measurable voltage. The ABS system control unit then converts this AC signal into a digital format.

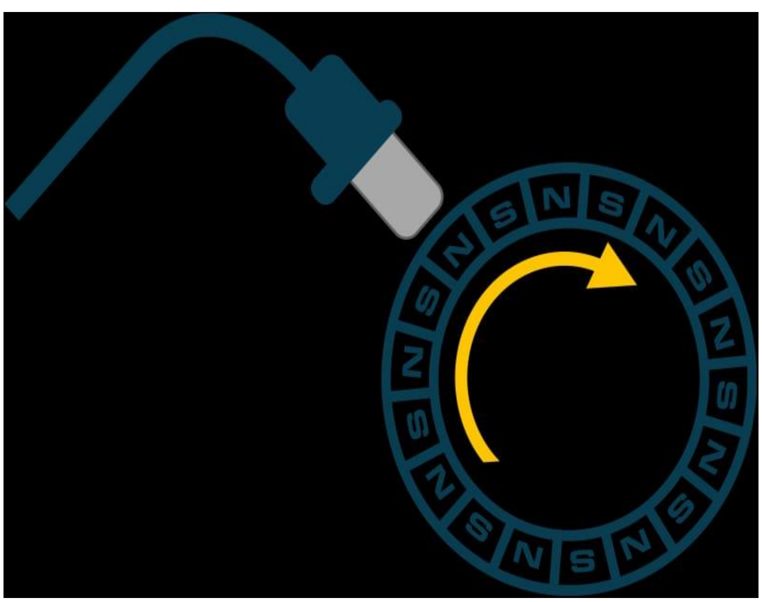
➢ *ACTIVE ABS SENSORS*

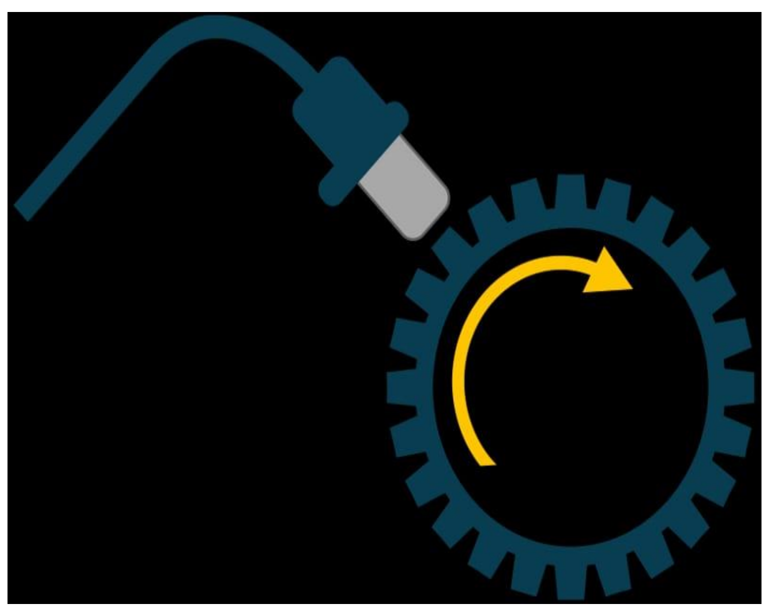
Active ABS sensors, unlike their passive counterparts, require their own power source. These sensors offer improved accuracy and overcome some of the limitations of passive sensors. They can measure lower speeds and, in some cases, determine wheel rotation direction.

Active sensors employ the Hall effect, which was discovered by Edwin Hall in 1879. The Hall effect refers to the generation of a voltage difference (known as the Hall voltage) across an electrical conductor. This voltage is produced transversely to the electric current in the conductor and the applied magnetic field perpendicular to the current.

The active sensor incorporates a semiconductor chip hall sensor that utilizes changes in the magnetic field to measure rotation. It then communicates a digital signal to the control system.

While active sensors can use a toothed ABS ring similar to passive sensors, they often utilize a magnetic or encoder ABS ring. The latter type of ring does not require a permanent magnet in the sensor and is much flatter. This allows for integration into the wheel bearing, resulting in a more compact system that is well-suited for smaller spaces.





➢ *INDICATIONS OF ABS SENSOR MALFUNCTION*

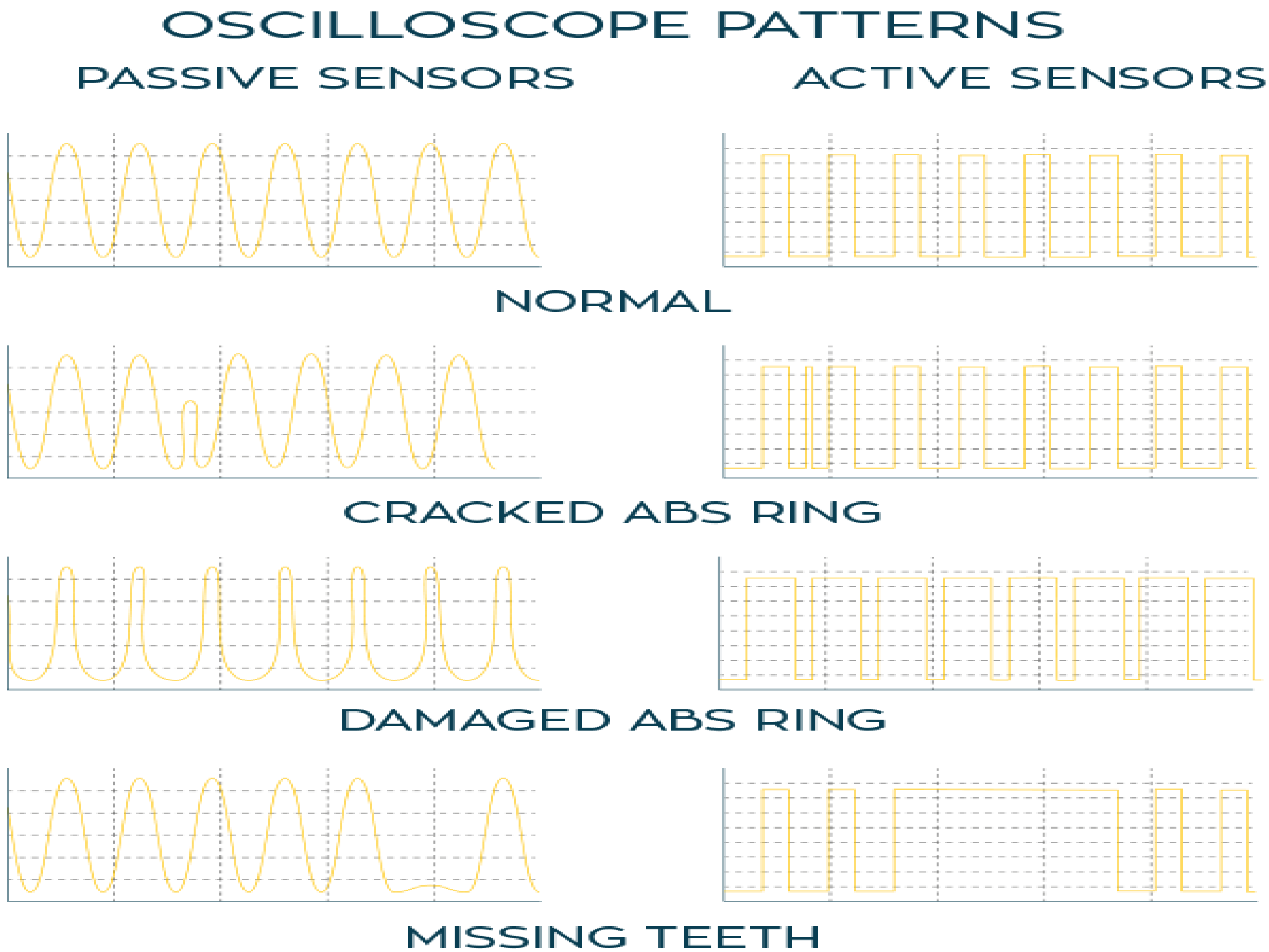
When an ABS sensor malfunctions, the following signs and symptoms are frequently observed:

Illumination of the ABS warning light (Possibly accompanied by the stability control and/or hand brake light)
Storage of a fault code
Experience of brake judder at low speeds
Wheels tending to lock up

➢ *FACTORS CONTRIBUTING TO ABS SENSOR FAILURE*

Although ABS sensors are generally simple and durable components, their placement on the vehicle exposes them to harsh conditions. As a result, the following factors are common causes of ABS sensor failure:

Physical damage caused by road debris
Sensor misalignment or increased distance from the wheel bearing
Breaks in the wiring connected to the sensor
Internal short circuits within the sensor
Heavy contamination affecting the sensor's performance
Corrosion, cracks, or swelling in the ABS ring
Blockage, damage, missing teeth, or windows in the ABS ring
An oscilloscope can be used to analyze patterns and identify problems with the ABS ring as follows:



- ***INSTALLING A NEW ABS SENSOR***

When replacing an ABS sensor, it is crucial to determine whether the sensor is passive or active. For passive sensors, a resistance test can be performed, but this should NOT be done on active sensors as it can cause damage to the component.

Before installing the new sensor, it is advisable to thoroughly clean the area where it will be placed.

Make sure the new sensor is fully seated into its designated position, as even slight misalignment can lead to signal issues.

Ensure that all wiring connected to and from the sensor is securely fastened and properly routed.

Additionally, ensure that the fasteners used to secure the sensor are tightened to the specified torque. Over-tightening can potentially damage the new sensor.

Similar to any sensor replacement, it may be necessary to reset the Electronic Control Unit (ECU) to clear any faults after the ABS sensor has been replaced.

5. Wiper System

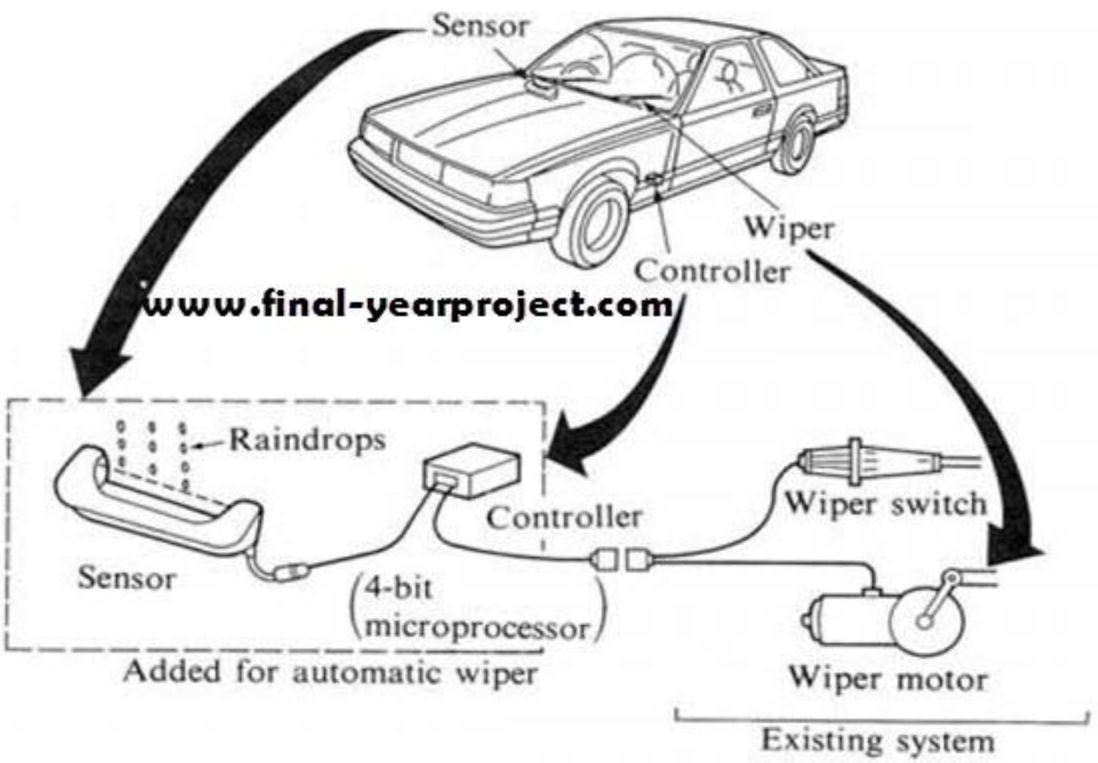
The wiper system of a vehicle is an **integrated system that is used to remove rain, snow, ice, and debris from a windscreen or windshield**. It greatly influences the visibility and affects the safety of passengers and the vehicle. It is a mandatory requirement in each motor vehicle.

This video will explain more about Wiper system https://www.youtube.com/watch?v=UnD1N7BrCsI

- Type the Sensor used in Wiper System:

1-The Rain Sensor

2-The Rain light sensor



5.1. The Rain sensor

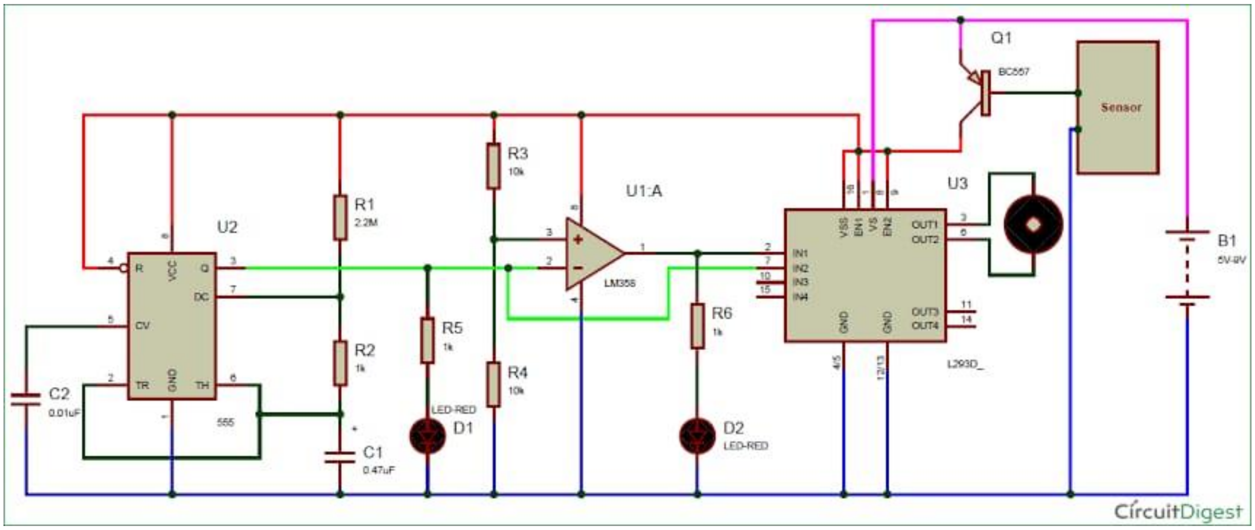
The function in Wiper system:

1- A rain sensor detects any rainfall or moisture that makes contact with the windscreen and automatically adjusts their wiper movement accordingly.

2- The rain sensors assist in the ongoing battle against driver distraction. The rain sensor appears to be attached to the car glass behind the windscreen and behind the rearview mirror.

➢ The Work Principle

When it rains, the rain sensor has a water column or a water column, and the resistance changes. Therefore, the sensor acts as a variable resistance board. The relationship between rain intensity and resistance has been found to be inversely proportional to each other. As the number of raindrops increases, the resistance of the sensor decreases. The sensor then sends a signal and the signal is received by the microcontroller. The microcontroller determines the intensity and transfers the signal to the servomotor in the form of pulse width modulation. After that, the wiper operation mode is turned on according to the rain strength.



5.2. The Rain light sensor

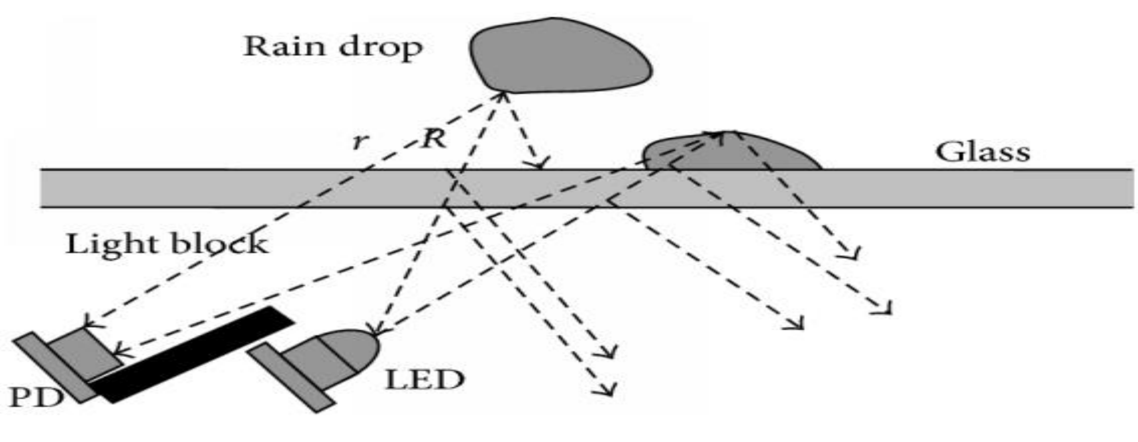
The function in Wiper system:

1- The rain light sensor basically detects the light rays. When the rain drops fall on the windshield, the sensor detects the shattering of the infrared light rays in different angles. In this way, the rain sensor sends the signal to the car computer which automatically operates the car windshield wiper blades.

➢ The work principle

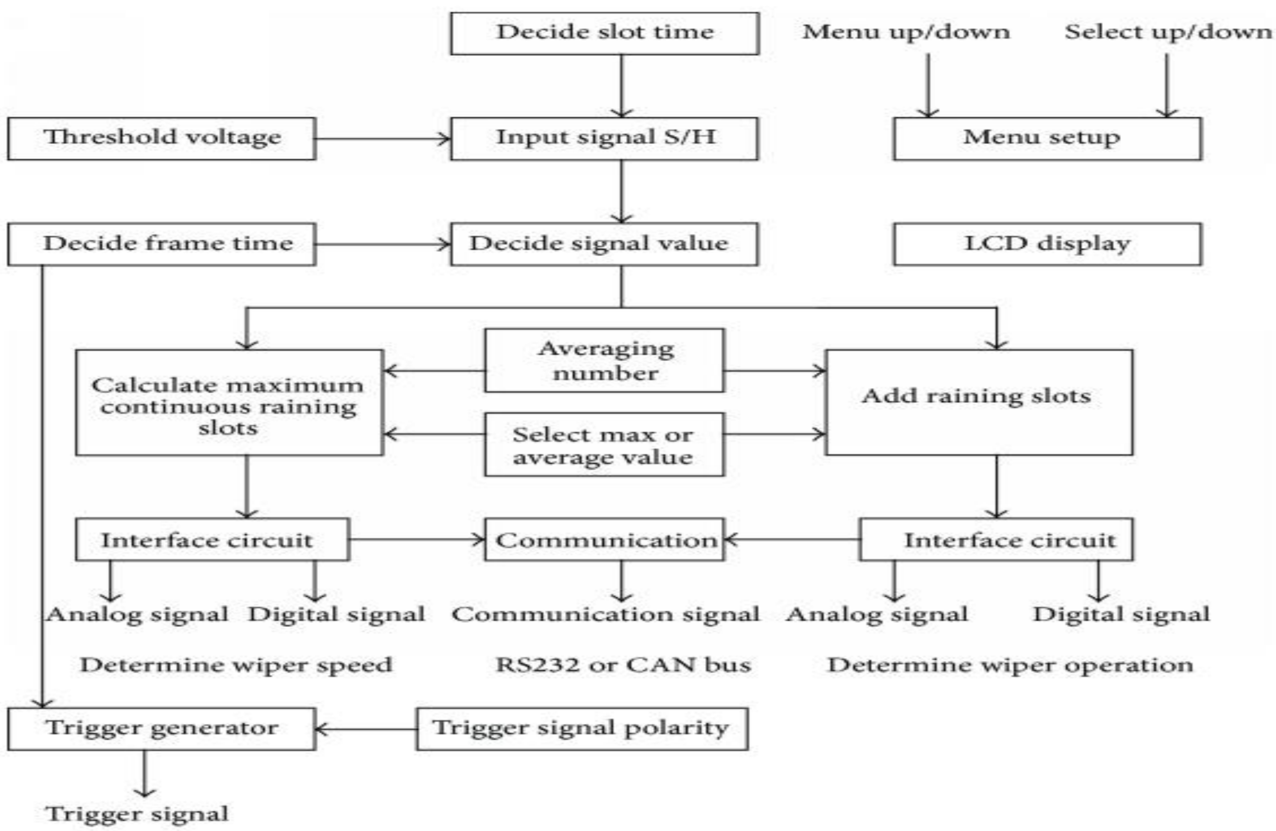
Conventional optoelectronic rain sensing method used collimated light beam to minimize optical power loss from infrared light source. Two kinds of rain sensing structures have been used. The concept of reflection type rain sensor, which detects the degree of light leaking on reflecting spot using collimating optical fixture beneath windshield glass, is shown in Figure 1(a). And the concept of optical waveguide type rain sensor utilizing light channel formed inside windshield glass connecting between light source and photodetector is shown in Figure 1(b). Vehicle rain sensor, utilizing scattered light, places light source and photodetector underneath windshield glass. Light shield is essential to block directly transmitted light from light source. In this case, transmitted light is reflected at the interface of two transparent materials, if the refractive indices are different. And the reflected optical power is proportionally related to index difference.The concept of rain Rain drop LED PD Lens (a) Rain drop LED PD Prism Lens Optical rain sensors: (a) reflection type and (b) waveguide type. r R Rain drop LED Light block PD Glass Concept of rain sensor using scattered light detection. sensor using scattered light detection is shown in Figure 2. Actual light paths are various rather than the typical one . The scattered light by rain drops which are close to windshield glass is the major signal source for detection. It is necessary to avoid direct light emission and reflection other than by rain drops on or above windshield glass to avoid interference by stray light. Transmitted light from light source travels the distance "R" to rain drop. And it reflects back to photodiode after traveling the distance "r." The received light optical power at photodetector location can be expressed as shown in (1) [40], and this received power has relationship with the rain drop morphology and the distance between rain drop and LED. $\Phi(r, \theta, \phi, t)$ is morphology of rain drop, SPD is photosen-sitive area of photodetector, $Pi(t)$ is received intensity, $Po(t)$ is emitted intensity, $PR1(t)$ is reflection probability by rain drop, and $PR2(t)$ is signal reception probability at photodetector:

$$Pi\ (t) = Po\ (t) \cdot PR1\ (t) \cdot PR2\ (t)$$
$$PR1\ (t) = \pi r2\ (4\pi R2\ 1) \cdot \Phi R1\ (r, \theta, \phi, t)$$
$$PR2\ (t) = S\text{PD}\ (4\pi R2\ 2) \cdot PR1\ (t)$$



➢ Algorithm

It is needed in automobile to have multiple operating steps by monitoring rain intensity. Rain detection algorithm based on time-to-intensity transformation process is used to have rain data such as rain drop size and rain drop count and further to closely match sensor output to actual raining condition.The flow chart of the above rain detection algorithm is shown. And actual LCD window viewing the result of rain detection algorithm instantaneous rain count is 50% in one frame time, average rain count is 45%, instantaneous rain drop size is 30% in one frame time, and average rain drop size is 30%. Further it shows that wiper starts to operate because preset threshold is 20%.



6. Lighting System

The lighting system in an automobile is responsible for providing visibility to the driver, as well as making the vehicle visible to other drivers on the road. The lighting system includes headlights, taillights, turn signals, brake lights, and interior lighting.

Headlights are the primary source of illumination for the driver and are typically located at the front of the vehicle. They provide visibility for the driver in low-light conditions and allow the driver to see the road ahead.

Taillights are located at the rear of the vehicle and provide visibility to other drivers on the road. They are typically red in color and are illuminated whenever the headlights are turned on.

Turn signals are used to indicate the driver's intention to turn or change lanes. They are typically located at the front and rear of the vehicle and are activated by the driver using a lever or button on the steering wheel.

Brake lights are located at the rear of the vehicle and are illuminated whenever the driver applies the brakes. They indicate to other drivers that the vehicle is slowing down or coming to a stop.

Interior lighting includes dome lights and dashboard lights. Dome lights provide illumination to the interior of the vehicle, while dashboard lights provide information to the driver such as speed, fuel level, and engine temperature.

Modern automotive lighting systems often include additional features such as adaptive headlights, which adjust the direction of the headlights based on the vehicle's speed and steering angle, and LED lights, which provide brighter and more energy-efficient illumination.

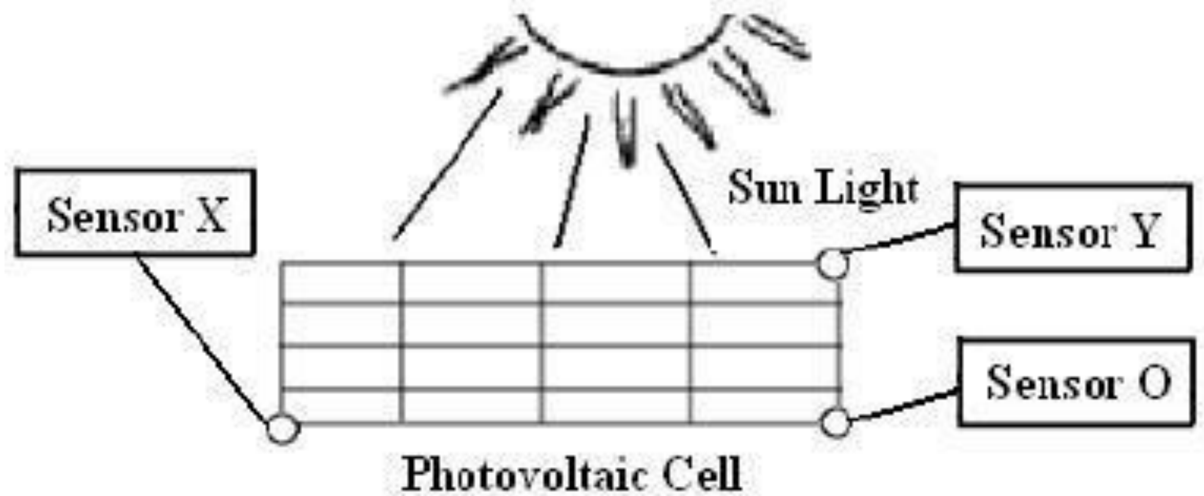
A light sensor is a photoelectric device that converts light energy (photons) detected to electrical energy (electrons). Seems simple? There is more to a light sensor than just its definition. It comes in different types and is used in various applications! Hence, in today's light sensor guide, we'll be exploring all you need

know about light sensors:

Different types of light sensors are available, mainly Photoresistors, Photodiodes, and Phototransistors. Sounds technical? I'll break it down with the explanations below!

6.1. Photoresistors

The most common light sensor type used in a light sensor circuit are photoresistors, also known as Light-
Dependent Resistors (LDR). Photoresistors detect whether a light is on or off and compare the relative light levels throughout the day.



➢ Construction of Photoresistors

Since the discovery of photoconductivity in selenium, many other materials have been found that are

light dependent. In the 1930s and 1940s, PbS, PbSe and PbTe were studied following the development of photoconductors made of silicon and germanium. Modern light dependent resistors are made of lead sulfide, lead selenide, indium antimonide, and most commonly cadmium sulfide and cadmium selenide.

The popular cadmium sulfide types are often indicated as CdS photoresistors. To manufacture a cadmium sulfide LDR, highly purified cadmium sulfide powder and inert binding materials are mixed.

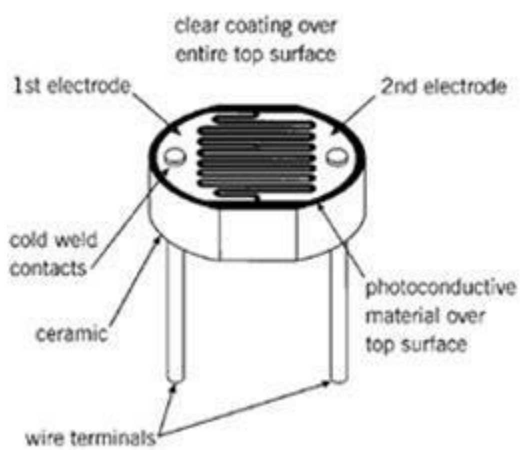
This mixture is then pressed and sintered. Electrodes are vacuum evaporated onto the surface of one

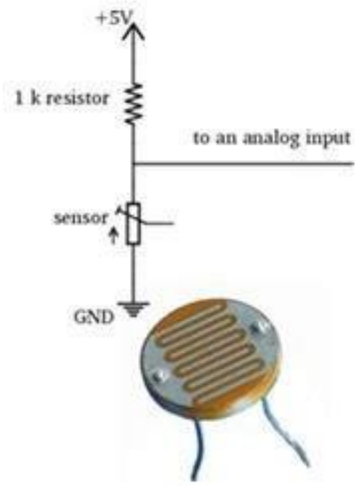
side to form interleaving combs and connection leads are connected. The disc is then mounted in a glass envelope or encapsulated in transparent plastic to prevent surface contamination. The spectral response curve of cadmium sulfide matches that of the human eye. The peak sensitivity wavelength is about 560- 600 nm which is in the visible part of the spectrum. It should be noted that devices containing lead or cadmium are not RoHS compliant and are banned for use in countries that adhere to RoHS laws

➢ Typical Applications for Photoresistors

Photoresistors are most often used as light sensors. They are often utilized when it is required to detect

the presence and absence of light or measure the light intensity. Examples are night lights and photography light meters. An interesting hobbyist application for light dependent resistors is the linefollowing robot, which uses a light source and two or more LDRs to determine the needed change of course. Sometimes, they are used in other sensing applications, for example in audio compressors, because their reaction to light is not instantaneous, and so the function of the LDR is to introduce a delayed response

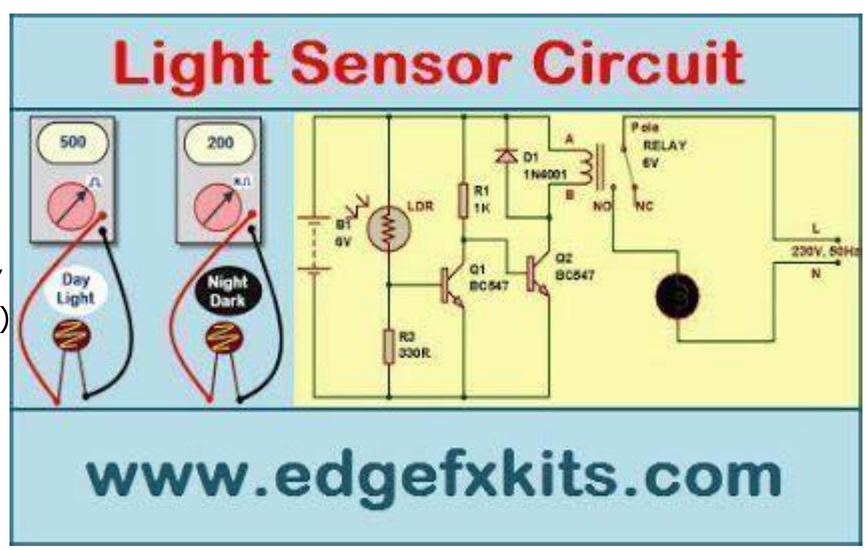


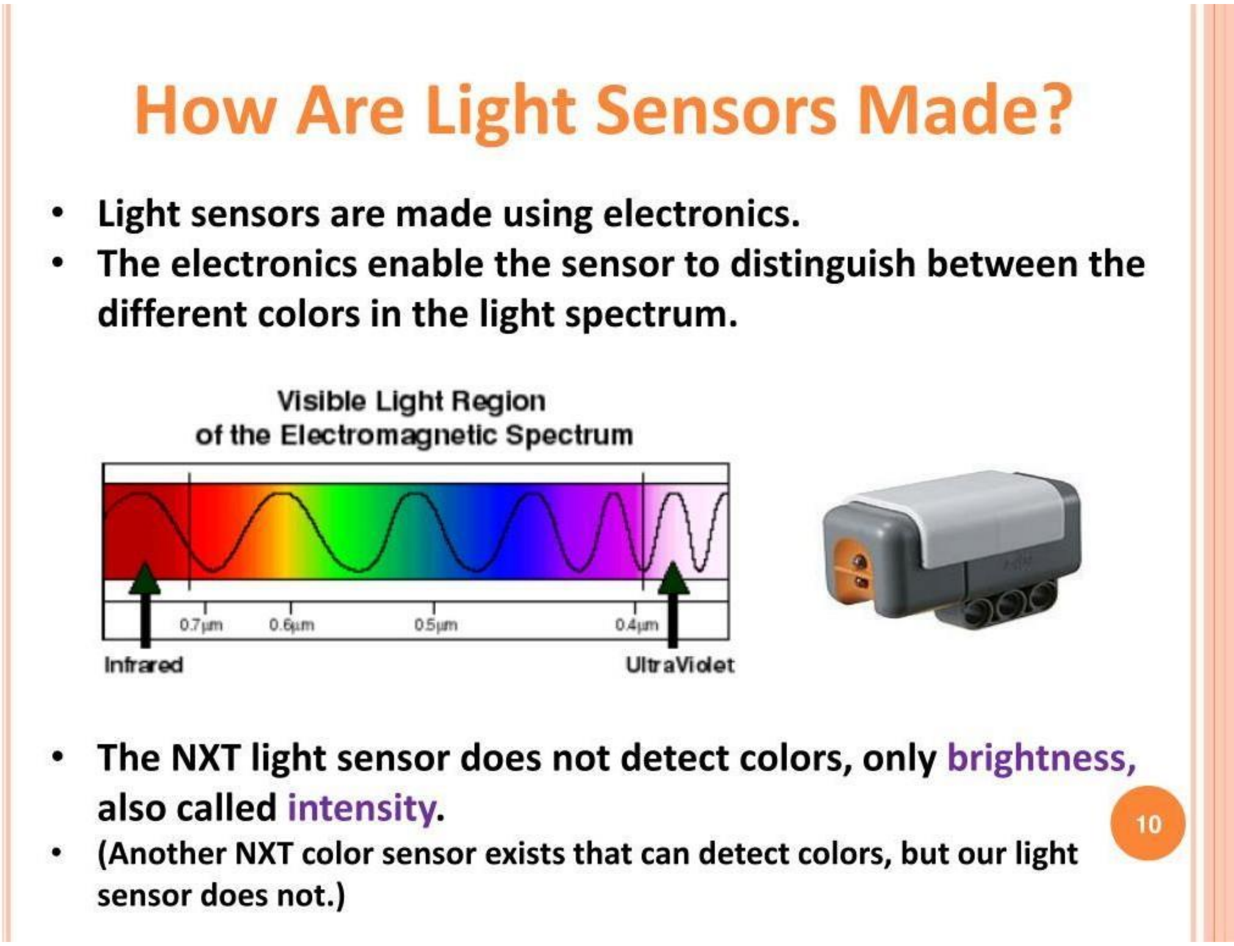


➢ Advertisement

A Light Sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light", and which ranges in frequency from "Infra-red" to "Visible" up to "Ultraviolet" light spectrum.

The light sensor is a passive device that convert this "light energy" whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because the convert light energy (photons) into electricity (electrons).





Photoelectric devices can be grouped into two main categories, those which generate electricity when illuminated, such as Photo-voltaics or Photo-emissives etc, and those which change their electrical properties in some way such as Photo-resistors or Photo-conductors.

➢ Classification of Light Sensor

• Photo-emissive Cells – These are photodevices which release free electrons from a light sensitive material such as caesium when struck by a photon of sufficient energy. The amount of energy the photons have depends on the frequency of the light and the higher the frequency, the more energy the photons have converting light energy into electrical energy.

• Photo-conductive Cells – These photodevices vary their electrical resistance when subjected to light. Photoconductivity results from light hitting a semiconductor material which controls the current flow through it. Thus, more light increases the current for a given applied voltage. The most common photoconductive material is Cadmium Sulphide used in LDR photocells.

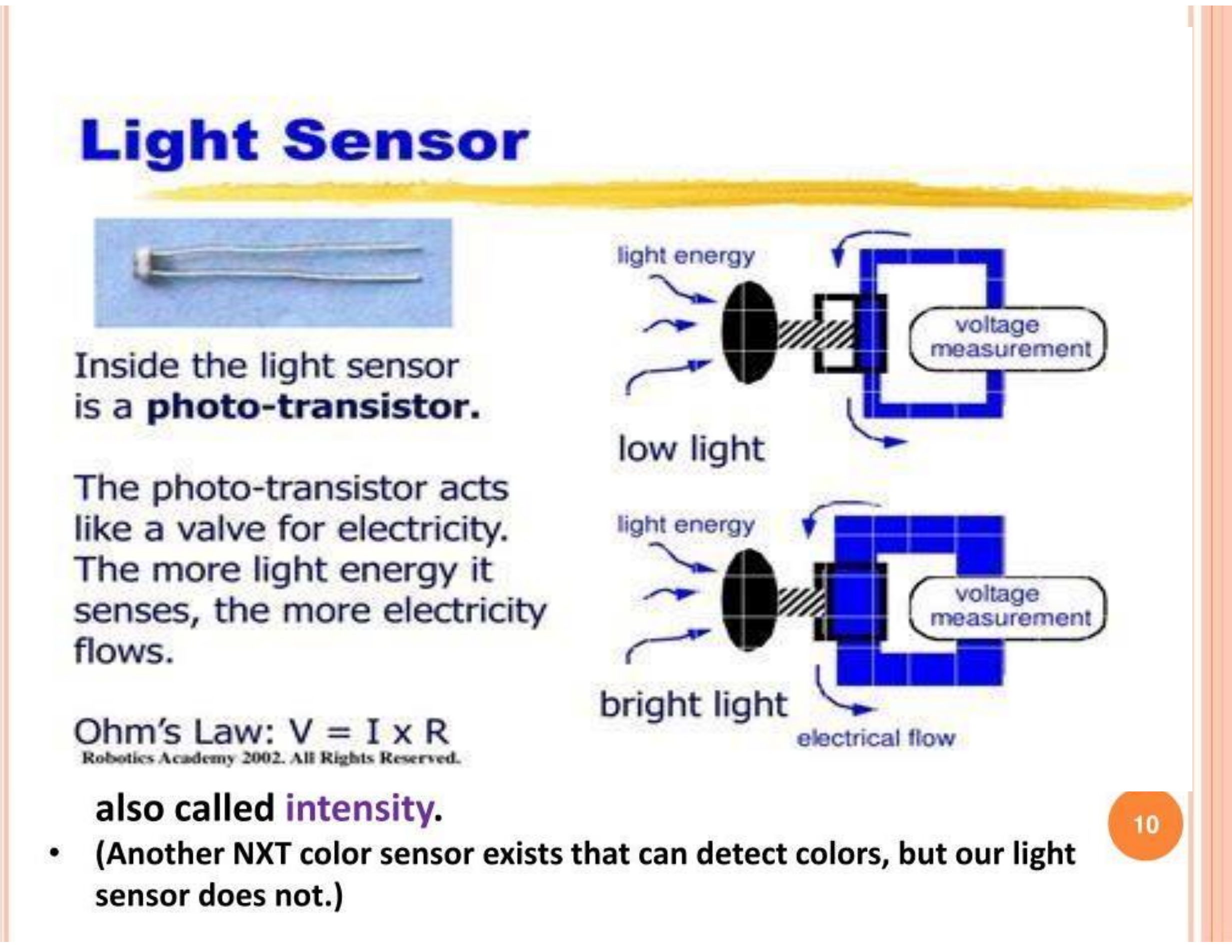
• Photo-voltaic Cells – These photodevices generate an emf in proportion to the radiant light energy received and is similar in effect to photoconductivity. Light energy falls on to two semiconductors materials sandwiched together creating a voltage of approximately 0.5V. The most common photovoltaicmaterial is Selenium used in solar cells.

• Photo-junction Devices – These photodevices are mainly true semiconductor devices such as the photodiode or phototransistor which use light to control the flow of electrons and holes across their PN-junction. Photojunction devices are specifically designed for detector application and light penetration with their spectral response tuned to the wavelength of incident light.

The Photoconductive Cell as a Light Sensor

A Photoconductive light sensor does not produce electricity but simply changes its physical properties when subjected to light energy. The most common type of photoconductive device is the Photoresistorwhich changes its electrical resistance in response to changes in the light intensity.

Photoresistors are Semiconductor devices that use light energy to control the flow of electrons, and hence the current flowing through them. The commonly used Photoconductive Cell is called the Light



Dependent Resistor or LDR.

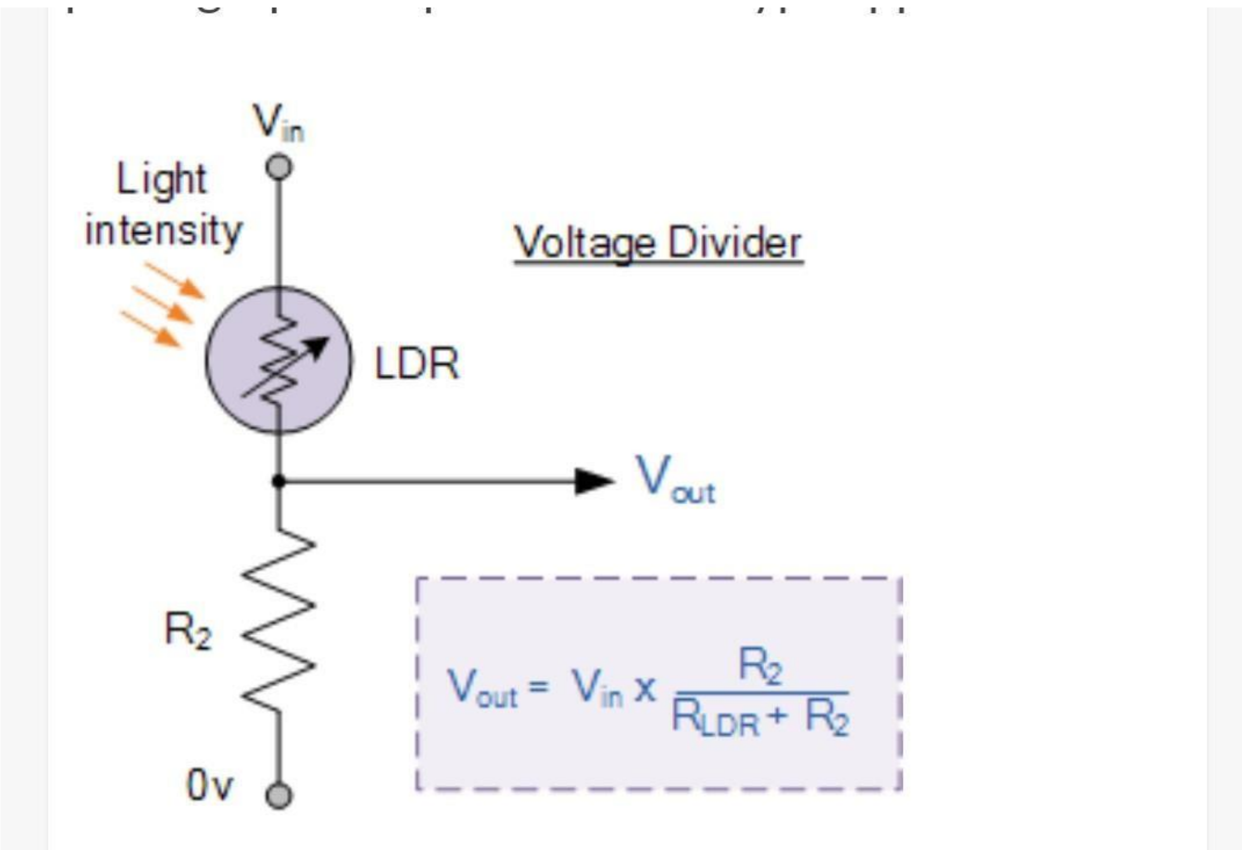
The Light Dependent Resistor (LDR)

a light dependant

resistorTypical LDR

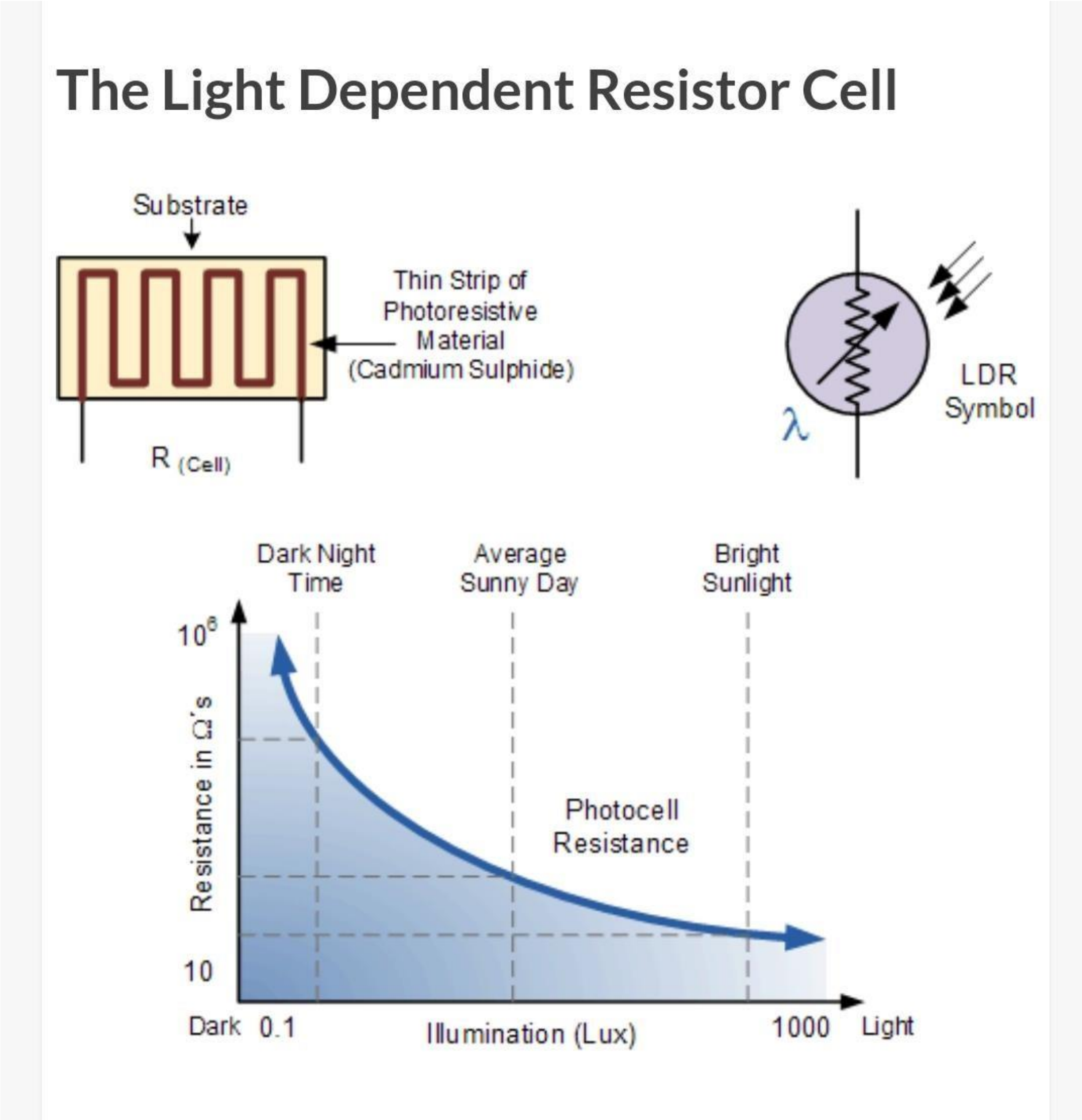
As its name implies, the Light Dependent Resistor (LDR)

is made from a piece of exposed semiconductor material such as cadmium sulphide that changes itselectrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when lightfalls upon it by creating hole-electron pairs in the material.

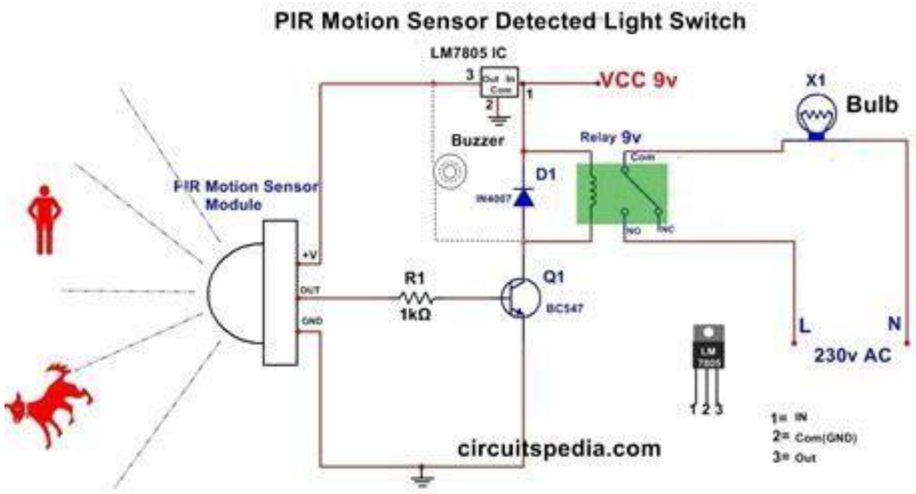


The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photoresistive cells have a long response time requiring many seconds to respond to achange in the light intensity.

Materials used as the semiconductor substrate include, lead sulphide (PbS), lead selenide (PbSe), indiumantimonide (InSb) which detect light in the infra-red range with the most commonly used of all
photoresistive light sensors being Cadmium Sulphide (Cds).



Cadmium sulphide is used in the manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λp) of about 560nm to 600nm in the visiblespectral range.Photoelectric devices can be grouped into two main categories, those which generate
electricity when illuminated, such as Photo-voltaics or Photo-emissives etc, and those which changetheir electrical properties in some way such as Photo-resistors or Photo-conductors.



Application #1 where light sensors are used: Consumer Electronics

The most common consumer electronic devices that use light sensors are Mobile Phones, and Tablets.

The light sensor is used in these devices to help with the auto-brightness function for the display. This isan essential function because the light sensor detects the light levels of the environment the user is
using the device in and can adjust the brightness automatically.

References:

- Science Direct
- Sci/hub
- Research Gate
- Springer
- Archival Research Catalogue