



USING SENSORS TO BUILD SMART ROADS AND ENERGY CONSERVATION

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ABSTRACT: Water reduces the friction between road surface and tyres of cars or vehicles. It is seen that due to heavy rain the traction reduces, so when a vehicle moving at a higher speed suddenly brakes the tyres loses traction and skids, in turn the driver loses control of the vehicle resulting in accident and causing damage to properties and lives. The amount of friction between the tyre and road surface varies depending upon the road condition. In case of perfectly dry road the friction is high while in case of wet roads friction is less. So, in order to reduce accidents smart sensors can be implemented which will detect the road condition and in turn change the speed limit and display information on roadside display screens alerting the drivers. Even these smart sensors can be used to deploy speed breakers when it is necessary to slow down traffic at times of road repairs, accidents, natural calamities etc. These smart roads will reduce damage to human lives and properties.

KEYWORDS—Smart sensor, smart roads, speed breaker, traction

INTRODUCTION

Generally, in India road accidents occur during heavy rains, wet road condition when the driver loses control of the vehicle and the vehicle overturns, skids, causes damage to lives and properties. Hardly anyone follows any posted speed limit. In other developed nations people follow traffic rules and driving limits. But, in a road when in dry condition the speed limit given is safe, when there is rain and the surface becomes wet the traction reduces but the speed limit doesn't change. So, in wet road condition when driver drives his car at a speed safe for dry road condition, there is a huge possibility that in case of emergency and sudden

braking he/she will lose control of the vehicle as the friction between the road and the tyre will be low in wet road. There should be a system which gives driver prior warning about the road condition ahead, variable speed limit which changes depending upon the road surface condition. If the driver follows these rules then there will be less accident and less damage to human lives and properties.

DISADVANTAGES OF SOME OF THE IMPLEMENTED TECHNIQUES:

- Presently no such system is installed that will give prior warning regarding the road condition ahead.
- There is no such devices or methods installed that

can reduce speeds of the moving vehicle.

- Law enforcement is not that strong to enforce proper follow of traffic rule.

The disadvantages can be overcome by the technique discussed in details below taking each case separately.

ANALYSIS

Rain Sensors[1]

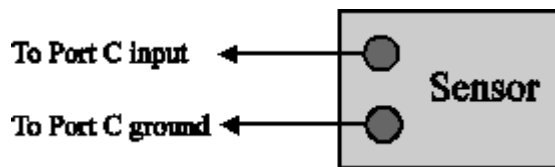
Using rain sensors i.e. the sensors that detect rain or water falling on it. The test sensor considered is HomeVision or HomeVision-Pro to the Rain/Water Sensor made by Wadsworth Electronics.

Connecting To HomeVision

You can connect the sensor directly to a digital input, or through an X-10 Powerflash module. A direct connection is the most reliable method and is recommended where practical.

Direct Connection

Run two wires from the sensor to where HomeVision is located. Connect them to HomeVision Port C and configure Port C as an input. The connections are as follows:



Connect one wire to the desired input (terminal block inputs C-1 through C-8).

Connect the other wire to ground (terminal block C-10).

When the sensor is dry, it will be electrically "open". This causes the input port to stay high (its normal state). When the sensor gets wet, its resistance decreases and the input port will go low (to ground).

Note that this sensor will usually not work properly on HomeVision Port B. Port B requires that an input be shorted to ground through less than 500 ohms resistance in order to read the input as low. This sensor's resistance may only go as low as 10,000 ohms even when soaked in water. Therefore, the input will always be read as high even when wet. Port C is a much more sensitive input and will go low even when

the sensor's resistance only drops to 100,000 ohms.

Through a Powerflash Module

The X-10 Powerflash module sends X-10 signals when the input to it closes. By connecting the sensor to in, you can avoid having to run wires to HomeVision. However, the X-10 signals may interfere with other X-10 signals. The connection process is as follows:

- Use two wires to connect the sensor to the Powerflash module.
- Set the Powerflash module to the desired house code and unit code.
- Set the Powerflash module "Mode" switch to "1".
- Set the Powerflash module "Input" switch to "B".

Note that the Powerflash module is not as sensitive as HomeVision Port C. If the sensor is only slightly wet, the Powerflash module may not trip where Port C would.

Programming

This example assumes the sensor is connected directly to an input port, not through a Powerflash module. If you're using a Powerflash module, then you would use the X-10 ON and OFF signals as inputs instead of the input ports.

There are several ways to use the sensor in your schedule. The most obvious is to check the input port with an If-Then statement whenever you need to know if it's raining. Another method is to use a flag to store the current state and set or clear it every time the input port changes. However, both of these methods have the drawback that the sensor may switch back and forth frequently if it's only slightly wet.

A better way is to use a flag to hold the current state, but only change the flag after the input port has changed for a certain period of time. For example, one might change the state only if the input remains steady for one minute. Here's an example of how to accomplish this.

1. Create a flag named "It's Raining".
2. Create a timer named "Timing Rain Sensor".
3. In the "Low Actions" for the sensor input

(which are performed whenever the port goes low (it stops raining)), enter:

4. Wait 1 minute with timer "Timing Rain Sensor", Then:
5. Set flag "It's Raining"
End wait
6. In the "High Actions" for the sensor input (which are performed whenever the port goes high), enter:
7. Wait 1 minute with timer "Timing Rain Sensor", Then:
8. Clear flag "It's Raining"
9. End wait

How This Works

Assume it's not raining and the flag is CLEAR. When the rain starts, the port goes low, the low actions are performed, and the wait timer starts running. After one minute, the timer goes off and the flag is SET, indicating it's raining. When the rain stops and the sensor dries out, the port goes high. One minute later, the wait timer times out and the flag is changed to CLEAR. Thus, the flag indicates whether or not it's raining, but with a one minute delay.

Now let's assume again that it's not raining and the flag is CLEAR. The port then goes low, but only for a few seconds. When it first goes low, the wait timer starts running, waiting to set the flag. Before the timer expires, the input goes back high and the high actions are performed. Since the same timer is used for both sets of actions, this effectively cancels the first wait timer, then restarts it waiting to clear the flag. Thus, the flag will never be set by the low actions (since its wait timer was canceled). After one minute, the second wait timer expires and clears the flag. Of course, the flag was already clear, so this has no real effect. With this schedule, changes in sensor state of less than one minute are effectively ignored.

Impedance Moisture Sensor[2]

- Impedance sensors consist of two thin, metal plates separated by a hygroscopic (water-absorbing) material like nylon. The top metal plate – usually connected to a ground – contains hundreds of tiny

holes that allow water to seep through and into the hygroscopic material. Once the hygroscopic layer gets wet, the water it absorbs forms a link between the top ground plate and the bottom positive plate. Electricity passes through the water, closing a circuit that activates the system. Impedance sensors are simple, rugged, cheap, and the heat produced during their electrical transfer causes water trapped in the hygroscopic material to evaporate. This makes the impedance sensor quick to respond if the rain should suddenly stop.

Rain Sensing Wiper Technology[3]

In the past, automakers have tried to either eliminate the wipers or to control their speed automatically. Some of the schemes involved detecting the vibrations caused by individual raindrops hitting the windshield, applying special coatings that did not allow drops to form, or even ultrasonically vibrating the windshield to break up the droplets so they don't need to be wiped at all. However, a new type of wiper system is starting to appear on cars that actually does a good job of detecting the amount of water on the windshield and controlling the wipers. One such system is made by TRW Inc.,

TRW Inc. uses optical sensors to detect the moisture. The sensor is mounted in contact with the inside of the windshield, near the rearview mirror.

The sensor projects **infrared light** into the windshield at a 45-degree angle. If the glass is dry, most of this light is reflected back into the sensor by the front of the windshield. If water droplets are on the glass, they reflect the light in different directions – the wetter the glass, the less light makes it back into the sensor.

The electronics and software in the sensor turn on the wipers when the amount of light reflected onto the sensor decreases to a preset level. The software sets the speed of the wipers based on how fast the moisture builds up between wipes. It can operate the wipers at any speed. The system adjusts the speed as

often as necessary to match with the rate of moisture accumulation.

Proposed Modification

- Using rain sensors to detect rain and to determine the road surface condition.
- Using the above techniques mentioned, rain detection sensors can be implemented to detect the onset of rains and the sensors will transmit the data to the display board which will display the runtime speed limit depending upon the road surface condition.
- Depending on the amount of rain, the water collected at the surface of the road varies, according to the water collected the friction between the tyres and road surface will vary. So, the safe speed with which the car can safely move with proper traction and control varies. The sensor will detect and matches with the pre-programmed values of safe speed according to mm of rainfall and displays that safe speed limit on the display board.
- The cost of sensor is very cheap and can be placed after 10-20km apart.

5. LIGHT SENSOR FOR AUTOMATIC STREET LIGHT IN INDIA[4]

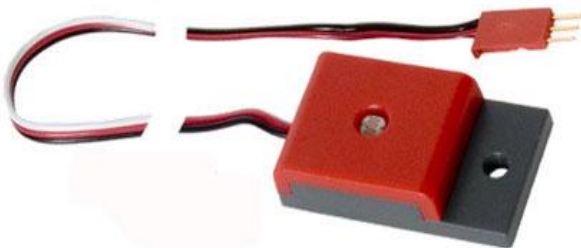


Figure 1. Light sensor kit components

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 "Infrared" to "Visible" up to "Ultraviolet" light spectrum. The light sensor is a passive device that

convert this "light energy" whether visible or in the infrared parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because they 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*. This leads to the following classification of devices.

- **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 semiconductor materials sandwiched together creating a voltage of approximately 0.5V. The most common photovoltaic material 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 [5]

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 *Photo resistor* which changes its electrical resistance in response to changes in the light intensity. Photo resistors 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**.



Typical LDR

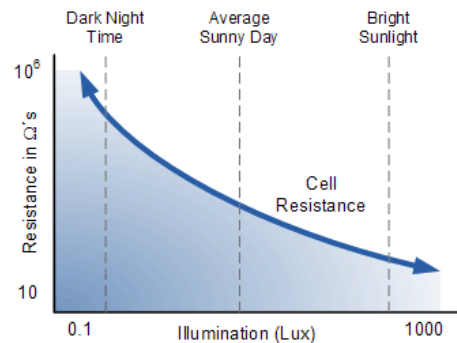
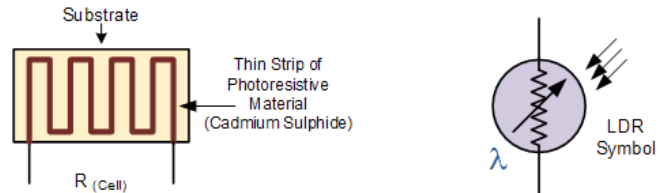
As its name implies, the **Light Dependent Resistor** (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs 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 a change in the light intensity.

Materials used as the semiconductor substrate include, lead sulphide (PbS), lead selenide (PbSe), indium antimonide (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

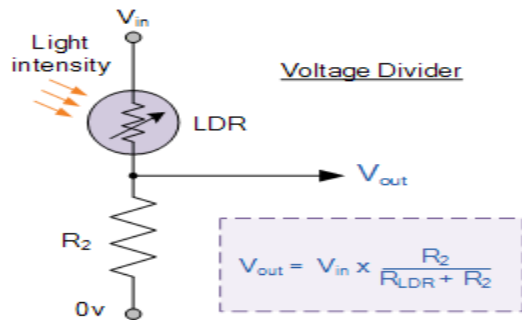
manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λ_p) of about 560nm to 600nm in the visible spectral range.

The Light Dependent Resistor Cell



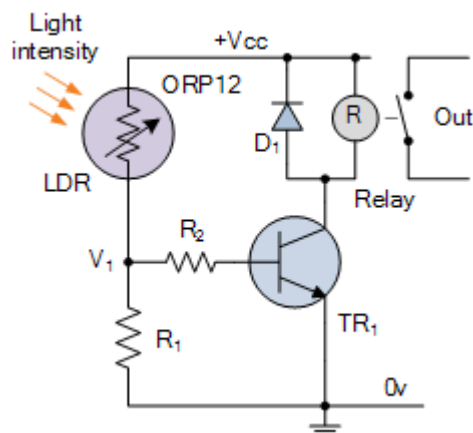
The most commonly used photoresistive light sensor is the **ORP12** Cadmium Sulphide photoconductive cell. This light dependent resistor has a spectral response of about 610nm in the yellow to orange region of light. The resistance of the cell when unilluminated (dark resistance) is very high at about 10MΩ's which falls to about 100Ω's when fully illuminated (lit resistance).

To increase the dark resistance and therefore reduce the dark current, the resistive path forms a zigzag pattern across the ceramic substrate. The CdS photocell is a very low cost device often used in auto dimming, darkness or twilight detection for turning the street lights "ON" and "OFF", and for photographic exposure meter type applications.



Connecting a light dependant resistor in series with a standard resistor like this across a single DC supply voltage has one major advantage, a different voltage will appear at their junction for different levels of light. The amount of voltage drop across series resistor, R₂ is determined by the resistive value of the light dependant resistor, R_{LDR}. This ability to generate different voltages produces a very handy circuit called a "Potential Divider" or **Voltage Divider Network**.

As we know, the current through a series circuit is common and as the LDR changes its resistive value due to the light intensity, the voltage present at V_{OUT} will be determined by the voltage divider formula. A LDR's resistance, R_{LDR} can vary from about 100Ω's in the sun light, to over 10MΩ's in absolute darkness with this variation of resistance being converted into a voltage variation at V_{OUT} as shown. One simple use of a *Light Dependent Resistor*, is as a light sensitive switch as shown below.



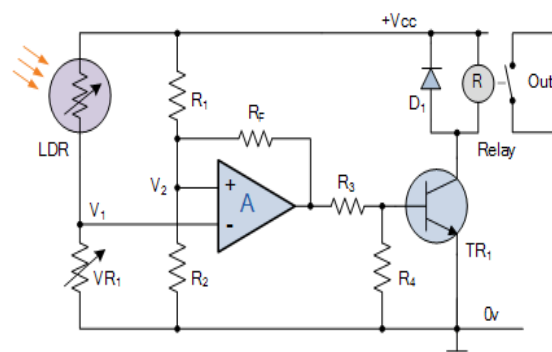
This basic light sensor circuit is of a relay output light activated switch. A potential divider circuit is formed between the photo resistor, LDR and the resistor R₁.

When no light is present ie in darkness, the resistance of the LDR is very high in the Mega ohms range so zero base bias is applied to the transistor TR₁ and the relay is de-energized or "OFF".

As the light level increases the resistance of the LDR starts to decrease causing the base bias voltage at V₁ to rise. At some point determined by the potential divider network formed with resistor R₁, the base bias voltage is high enough to turn the transistor TR₁ "ON" and thus activate the relay which inturn is used to control some external circuitry. As the light level falls back to darkness again the resistance of the LDR increases causing the base voltage of the transistor to decrease, turning the transistor and relay "OFF" at a fixed light level determined again by the potential divider network.

By replacing the fixed resistor R₁ with a potentiometer VR₁, the point at which the relay turns "ON" or "OFF" can be pre-set to a particular light level. This type of simple circuit shown above has a fairly low sensitivity and its switching point may not be consistent due to variations in either temperature or the supply voltage. A more sensitive precision light activated circuit can be easily made by incorporating the LDR into a "Wheatstone Bridge" arrangement and replacing the transistor with an **Operational Amplifier** as shown.

5.1.3 Light Level Sensing Circuit



In this basic dark sensing circuit, the light dependent resistor LDR₁ and the potentiometer VR₁ form one adjustable arm of a simple resistance bridge network, also known commonly as a *Wheatstone bridge*, while the two fixed resistors R₁ and R₂ form the other arm.

Both sides of the bridge form potential divider networks across the supply voltage whose outputs V1 and V2 are connected to the non-inverting and inverting voltage inputs respectively of the operational amplifier.

The operational amplifier is configured as a Differential Amplifier also known as a voltage comparator with feedback whose output voltage condition is determined by the difference between the two input signals or voltages, V1 and V2. The resistor combination R1 and R2 form a fixed voltage reference at input V2, set by the ratio of the two resistors. The LDR –VR1 combination provides a variable voltage input V1 proportional to the light level being detected by the photoresistor.

As with the previous circuit the output from the operational amplifier is used to control a relay, which is protected by a free wheel diode, D1. When the light level sensed by the LDR and its output voltage falls below the reference voltage set at V2 the output from the op-amp changes state activating the relay and switching the connected load. Likewise as the light level increases the output will switch back turning "OFF" the relay. The hysteresis of the two switching points is set by the feedback resistor Rf can be chosen to give any suitable voltage gain of the amplifier.

The operation of this type of light sensor circuit can also be reversed to switch the relay "ON" when the light level exceeds the reference voltage level and vice versa by reversing the positions of the light sensor LDR and the potentiometer VR1. The potentiometer can be used to "pre-set" the switching point of the differential amplifier to any particular light level making it ideal as a simple light sensor project circuit.

Proposed Modification

- In India, street lights don't come on automatically. Someone from the control station has to put on the lights and at dawn someone has to put off the light. But, it is seen that at the dawn lights remain on and it causes wastage of energy.

- So, in order to prevent wastage of energy automatic lighting sensors can be implemented.
- These light sensors will detect darkness and daylight and will turn on & off light automatically, which will save a lot of energy consumption.
- These sensors can be implemented only one for a particular zone and is very cost effective.
- The costs of light sensors are very cheap and are very robust.

CASE STUDY

Case I – Study of effect of road surface condition in vehicle stability under hard braking

Test Vehicle : Bajaj Pulsar 220cc

Test road length : 100m

Track condition : 1. Dry, 2. Wet

Test Process :The motorbike initially travelling at a speed of 40km/h on the dry patch was hard braked and the stopping distance was measured from the point of brake application to the point of stopping. Following this method in the wet patch also, readings were taken.

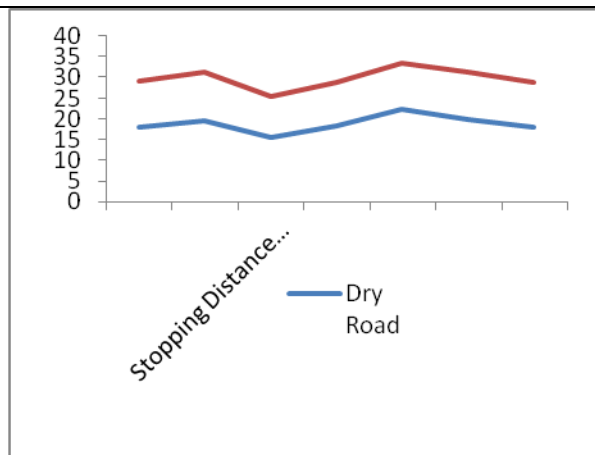
Observation –Dry Road

Obs. No	Speed (km/h)	Stopping distance(m)
1	40	18.2
2	50	19.59
3	30	15.56
4	40	18.5
5	60	22.5
6	50	20.02
7	40	18.0

Wet Road

Obs. No	Speed (Km/h)	Stopping Distance (m)
1	40	29.2
2	50	31.20
3	30	25.35
4	40	28.78
5	60	33.5

6	50	31.46
7	40	28.80



Result Analysis

From the above test performed it is seen that the stopping distance is more in case of wet road under hard braking. So, if the speed limit is same for both dry and wet condition, there is a possibility that the vehicle will lose control and requires more stopping distance, which might result in an accident. So, by using rain detection sensor and by connecting it to the digital speed limit display board, the speed limit can be varied according to the road surface condition. The results of the test are further being examined and are under more detailed analysis.

Case II- Study of effect of light sensor in electricity consumption and energy conservation

Test Specimen – Halogen Flood Lights
 Number of test specimen considered – 5
 Energy consumption –150W each

Test Process – Average operating hours were observed for 1 week (7 days), energy consumption was calculated and then light sensor was used to operate lighting condition and energy consumption was calculated for the same test lights for 1 week

Observation –

Case I – Normal operation

Daily hours of light operation – 5.30pm – 7am = 13.5 hours (Average operating hours as light was put off manually in the morning)

Total weekly working hours (Avg.) = 94.5 hours

Weekly energy consumption = 70875W = 70.875KW

Electricity per unit rate = ₹ 7/

Total Electricity bill per week = 70.875 x 7 = ₹ 496/

Yearly Electricity bill estimated = ₹ 25862/

Case II – Light Sensor used operation

Daily hours of light operation = 6pm – 5.30am = 11.5 hours

Total weekly working hours (Avg.) = 80.5 hours

Weekly energy consumption = 60375 W = 60.375kW

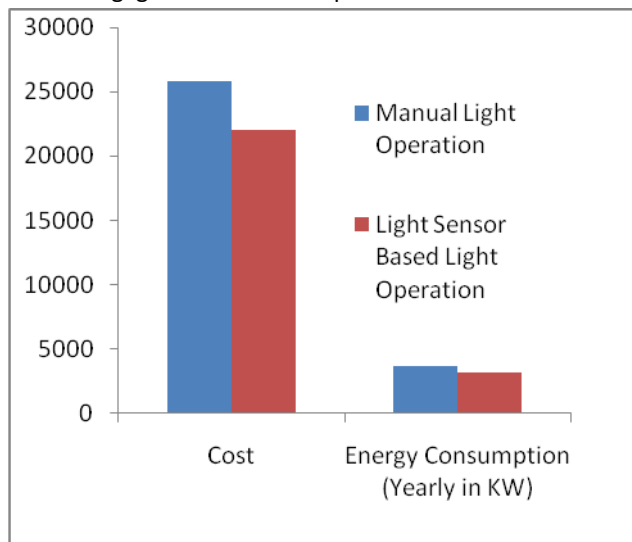
Electricity per unit rate = ₹ 7/

Total Electricity bill per week = 60.375 x 7 = ₹ 422/

Yearly Electricity bill estimated = ₹ 22004/

Result Analysis

By using light sensor to reduce effective working hours of light, there was a savings of approximate 15% for the yearly consumption of the five test lamps. This savings in energy is very effective in today’s world of energy crisis. By using light sensor we can conserve lots of energy which is wasted every day, month, year due to negligence in manual operation.



CONCLUSION

- Use of rain sensors will increase the road safety and reduce the damage to life and property.
- Proper alerting system to alert the drivers about the road condition.

- Use of light sensors to regulate the operation of street lights in India resulting in savings of energy and proper utilization of resources.
- Detailed analysis report will be given after practical testing is over.
- These proposals are still in development, testing phase. Practical Implementation needs to be done.

[14]Linear Light Sensor Type : LLSO5-A, SENBA Optical Electronics Co. Ltd.

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