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DESIGN AND IMPLEMENTATION OF AUTOMATIC HEADLIGHT DIMMER FOR VEHICLES USING LIGHT DEPENDENT RESISTOR (LDR) SENSOR

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ABSTRACT

Headlights of vehicles pose a great danger during night driving. The drivers of most vehicles use high, bright beam while driving at night. This causes a discomfort to the person travelling from the opposite direction and therefore experiences a sudden glare for a short period of time. This is caused due to the high intense headlight beam from the other vehicle coming towards the one from the opposite direction. In this project, an automatic headlight dimmer which uses a Light Dependent Resistor (LDR) sensor has been designed to dim the headlight of on-coming vehicles to avoid human eye effects. This automatically switched the high beam into low beam, therefore reducing the glare effect by sensing the light intensity value of approaching vehicle and also eliminated the requirement of manual switching by the driver which was not done at all times. Matlab software was employed in designing the project. The Keil software was also employed to program the microcontroller. The system device was able to automatically switch the headlight to low beam when it sensed a vehicle approaching from the opposite side using LDR sensor. It was observed that the maximum spread angle of the headlight was 135^o. At the time the spread light from other sources reached the sensor, its intensity would be very much reduced below the triggering threshold level. The sensitivity of a photo detector determined the relationship between the light falling on the device and the resulting output signal. A server module could be included to this system for receiving and storing headlight rays parameters information in a database application.

Keywords

Headlights Dimmer, Light Dependent Resistor (LDR), Troxler Effects, Human Eye

1. INTRODUCTION

Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum. The word usually refers to visible light, which is visible to the human eye and it is responsible for the sense of sight. Visible light is usually defined as having wavelengths in the range of 400–700 nanometers (nm), or 400×10^{-9} m to 700×10^{-9} m, between the infrared (with longer wavelengths) and the ultraviolet (with shorter wavelengths). Light can be produced by nature or by humans. "Artificial" light is typically produced by lighting systems that transform electrical energy into light. The human eye is a very sensitive organ. It works almost an entire day without any rest. The human eyes are adaptable to a particular range of vision. There are two visions namely the scotopic and photopic vision. Human eyes actually behave differently in different conditions. During bright surroundings, our eyes can resist up to 3 cd/m^2. This is the photopic vision.

During dark and unlit conditions, our eye switches to scotopic vision which has a range of 30-45 μcd/m^2. It takes 4 seconds for our eyes to change from photopic vision to scotopic vision. This is also an example of Troxler effect [1]. As the brightness increases, the strain to focus on an object increases. This will increase the response time of that person.

The requirement of headlight is very common during night travel. The same headlight which assists the driver for better vision during night travel is also responsible for many accidents that are being caused. The driver has the control of the headlight which can be switched from high beam (bright) to low beam (dim). The headlight has to be adjusted according to the light requirement by the driver [2].

During pitch black conditions where there are no other sources of light, high beam is used. In all other cases, low beam is preferred. But in a two-way traffic, there are vehicles plying on both sides of the road. So when the bright light from the headlight of a vehicle coming from the opposite direction falls on a person, it glares him for a certain amount of time. This causes disorientation to that driver. This discomfort will result in involuntary closing of the driver's eyes momentarily. This fraction of distraction is the prime cause of many road accidents [3].

The prototype that has been designed to reduce this problem by actually dimming down the bright headlight of our vehicle to low beam automatically when it senses a vehicle at close proximity approaching from the other direction. The entire working of the dimmer is a simple electronic circuitry arrangement which senses and switches the headlight according to the conditions required [4].

2. PROBLEM STATEMENT

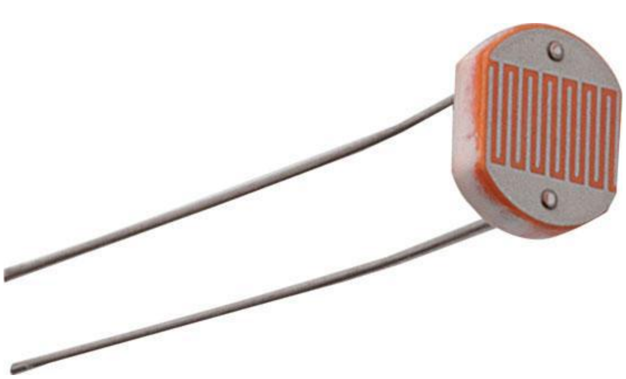
Motorists face a huge problem due to high beam light which falls directly onto their eyes when driving at night or during foggy conditions. There is medical effect associated with these phenomena. This effect includes temporary blindness, glare, fading effect of image and sometimes causing accident leading to loss of many lives. This effect contributes to a terminology known as Troxler Effect. Troxler effect is used to describe a kind of temporary blindness. It is otherwise known as the 'fading effect'. A study shows that if our eyes are exposed to a very bright light source of around 10,000 lumens, we experience a glare [5]. This glare is produced due to over exposure of the rods and cones inside our eye. Even after the source of glare is removed, an after-image remains in our eye that creates a blind spot. This phenomenon is called Troxler effect. This means that the driver's reaction time is increased by 1.4 seconds. For example, let us assume a motorist travelling at 60 miles per hour takes 0.5 seconds to react to a hazard and will stop within 41 feet. Due to Troxler effect, the same person travelling under the same conditions will take 0.9 seconds longer to react and hence will come to a complete halt only at 123 feet [6]. There is a huge difference of 82 feet. This is more than enough to cause a disaster on the road. This Troxler effect is across all ages. Any one exposed to sudden bright light experiences this Troxler effect. Hence there is a need to design and construct a prototype of this device that automatically dims the headlights for on-coming vehicles using light dependent resistor sensing technique to help solve this problem.

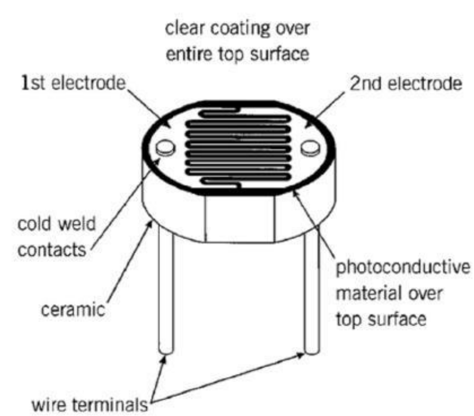
3. OVERVIEW OF LIGHT DEPENDENT RESISTOR (LDR)

Light Dependent Resistor (LDR) is a type of semiconductor and its conductivity changes with proportional change in the intensity of light. A light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity; thus , it exhibits photoconductivity. Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

A Light Dependent Resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron and its hole partner conduct electricity, thereby lowering resistance. The light sensitive part of the LDR is a wavy track of Cadmium Sulphide. Cadmium Sulphide cells rely on the materials ability to vary its resistance according to the amount of light striking the cell. The figure below shows the Construction of LDR.

Figure 1: Construction of LDR





LDR is employed in the circuit to convert the intensity of the high beam headlight of the approaching vehicle into electrical signal. The advantages of LDRs are as follows: they are cheap and are readily available in many sizes and shapes, practical LDRs are available in variety of sizes and package styles, the most popular size having a face diameter of roughly 10mm and finally they need very small power and voltage for their operations.

Table 1 : Some Properties of LDR Sensor

Property	**Value**
Nature	LDR
Current	60 µA
Voltage	4 to 30 volt
Temperature range	−55° to +150°C
Accuracy	0.5°C
Linear scale factor	+ 10.0 mV/°C

3.1 Equations Involving Illumination

This can be expressed as:

$$E = \frac{F}{A}$$

$$Intensity = \frac{P}{A}$$

Where E – Illumination, P – Power , F – Luminous Flux, A – Unit Area

4. OVERVIEW OF HEADLAMP SYSTEMS

This invention relates to vehicle headlamp systems and in particular to a system for automatically controlling the switching of the headlamps between the low beam and high beam settings. Improved automotive control systems have freed drivers from performing a number of tasks that formerly required manual operations. Such systems relieve drivers from the distractions of these auxiliary systems and often results in improved concentration as well as reduced driver fatigue. One such system which has seen limited use is an automatic headlamp dimmer system for controlling the headlamps of a vehicle. In particular, an automatic headlamp dimmer system is designed to automatically dim the headlamps (switch from high beam to low beam) in the presence of lights from other vehicles. Since a vehicle's headlamps should be dimmed for both on-coming traffic as well as traffic being approached from behind, it is necessary for an automatic headlamp dimmer system to accurately sense both the presence of another vehicle's headlamps or tail lamps [8].While numerous automatic headlamp dimmer control systems have been developed, in general, these systems have had serious drawbacks due to poor performance, complexity or cost.

These shortcomings, particularly in the area of performance, have been directly responsible for the limited use of automatic headlamp dimmer systems to date. Since these systems must sense light from headlamps as well as tail lamps from other vehicles, a key performance requirement is the system's capability to distinguish this light from extraneous in-coming light. Examples of such unwanted light include reflections from road signs, light from street lamps, or light from vehicles on other roadways. The problem of avoiding false responses to extraneous light signals is especially troublesome when it is considered that the intensity of these extraneous light signals can be many times greater than the intensity of the light signal from a tail lamp. As a result, some prior art systems simply do not attempt to detect valid tail lamp signals, but rather are designed to respond only to the light from on-coming headlamps which, of course, presents a much stronger signal. Other systems with sufficient sensitivity to detect the light from tail lamps are susceptible to false triggering which degrades performance and leads to a lack of driver confidence in the system. As a result, users frequently disable the systems entirely and revert to manual control [9].

Spurious responses in automatic headlamp dimmer systems are also encountered in the presence of overhead flashing lights. Such flashing may be produced, for instance, by blinking overhead traffic lights, or by blinking construction lights or arrows. These flashes, when detected by conventional automatic headlamp dimmer sensors, can cause the system to undesirably cycle between high and low beams in synchronization with the flashing light. A similar situation is also encountered when windshield wipers are operated if the light sensor for the automatic headlamp dimmer system is positioned behind the windshield within the sweep of the wipers. Such placement is desirable because the sensor is not exposed to exterior debris, and further because the sensor's view is likely to be as unobstructed and clear as the driver's view. However, when the windshield wipers are operated, the sensor's field of view is periodically occluded by the wiper blade. This may cause the headlamp dimmer system (when in the low beam mode) to cycle to the high beam mode while the wiper is obstructing the view, and conversely to return back to the low beam mode when the wiper is not obstructing the sensor's field of view. Obviously, cycling of the automatic headlamp dimmer in response to flashing lights and windshield wiper activity is highly annoying and contributes to the low usage of such systems [10]. It is accordingly, a primary object of the present invention to provide an improved automatic headlamp dimmer system that is responsive to both the headlamps and tail lamps of other vehicles, and yet is able to reliably distinguish between valid light signals and extraneous light signals. It is another primary object of the present invention to provide an improved automatic headlamp dimmer system that is able to disregard blinking lights from stop lights and the like and thereby avoid spurious activation of the headlamp dimmer in response thereto. It is also an object of the present invention to provide an automatic headlamp dimmer system which has its light sensor mounted behind the windshield, with the sweep of the windshield wipers in its optical field of view, and yet which is non-responsive to the operation of the windshield wipers [10].

Generally, these objects are accomplished by providing a system that is sensitive to light only in the near infrared region, and which excludes other wavelengths including light in the visible region. More particularly, it has been determined that light from headlamps and tail lamps contains a significant amount of signal information in the infrared region. On the other hand, light from extraneous light sources such as street lamps, reflections from road signs, etc., predominate in the visible region and contain very little signal information in the infrared band. Accordingly, by responding only to light in the near infrared region, the signal to noise ratio of the present system is greatly enhanced, thereby enabling the system to accurately recognize a tail lamp signal in the presence of extraneous light signals several orders of magnitude greater in intensity.

Additionally, the automatic headlamp dimmer, according to the present invention, is able to detect the presence of a spurious periodically varying light signal and temporarily disable its switching capabilities to effectively ignore the spurious signal. In one embodiment of the present invention, the automatic headlamp dimmer system is provided with the capability of determining if periodic variations in the input light signal are characteristic of variations expected by operation of the vehicle's windshield wipers. If the received signal exhibits a predefined repetitive pattern, the system will respond by not allowing switching from low beam to high beam to occur during the time that the wipers block the field of view of the sensor. Benefits and advantages of the present invention will become apparent to those skilled in the art to which this invention relates from the subsequent description of the preferred embodiments and the appended claims, taken in conjunction with the accompanying drawings.

5. METHODOLOGY

5.1 Block Diagram Design

The block diagram was designed using Matlab software. In designing the block diagram, the software had menu that contains various figures. Rectangular and square boxes were chosen to represent the various components used for the prototype.

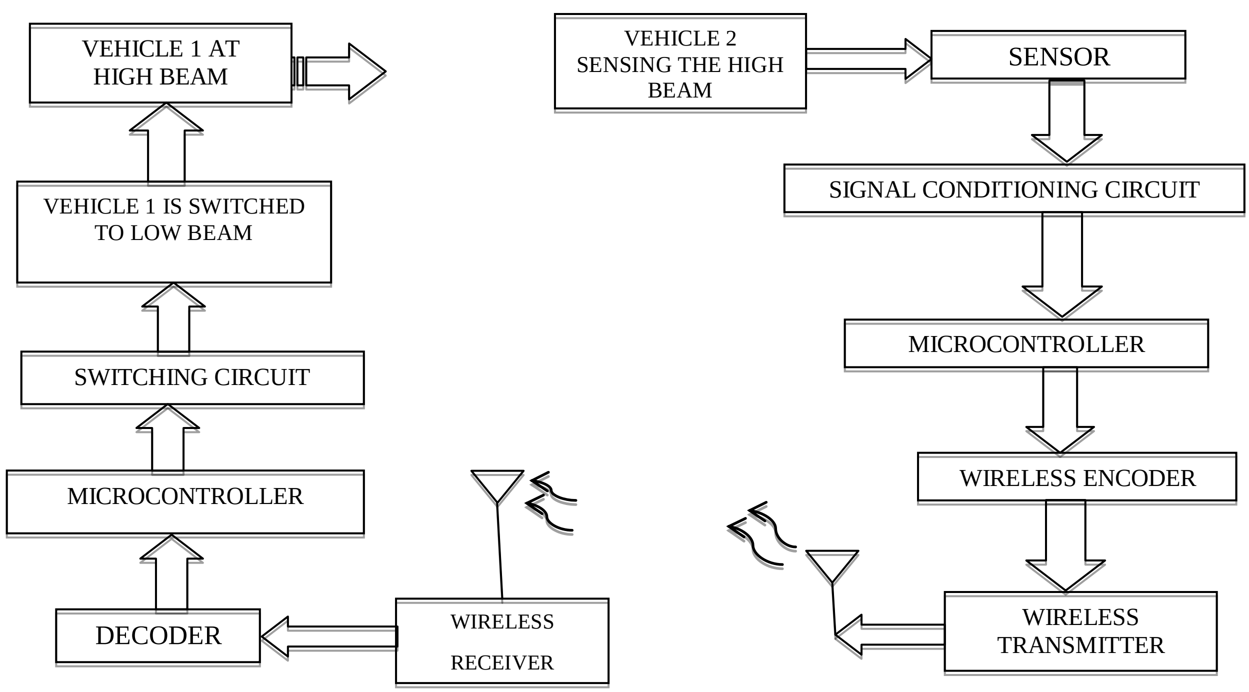


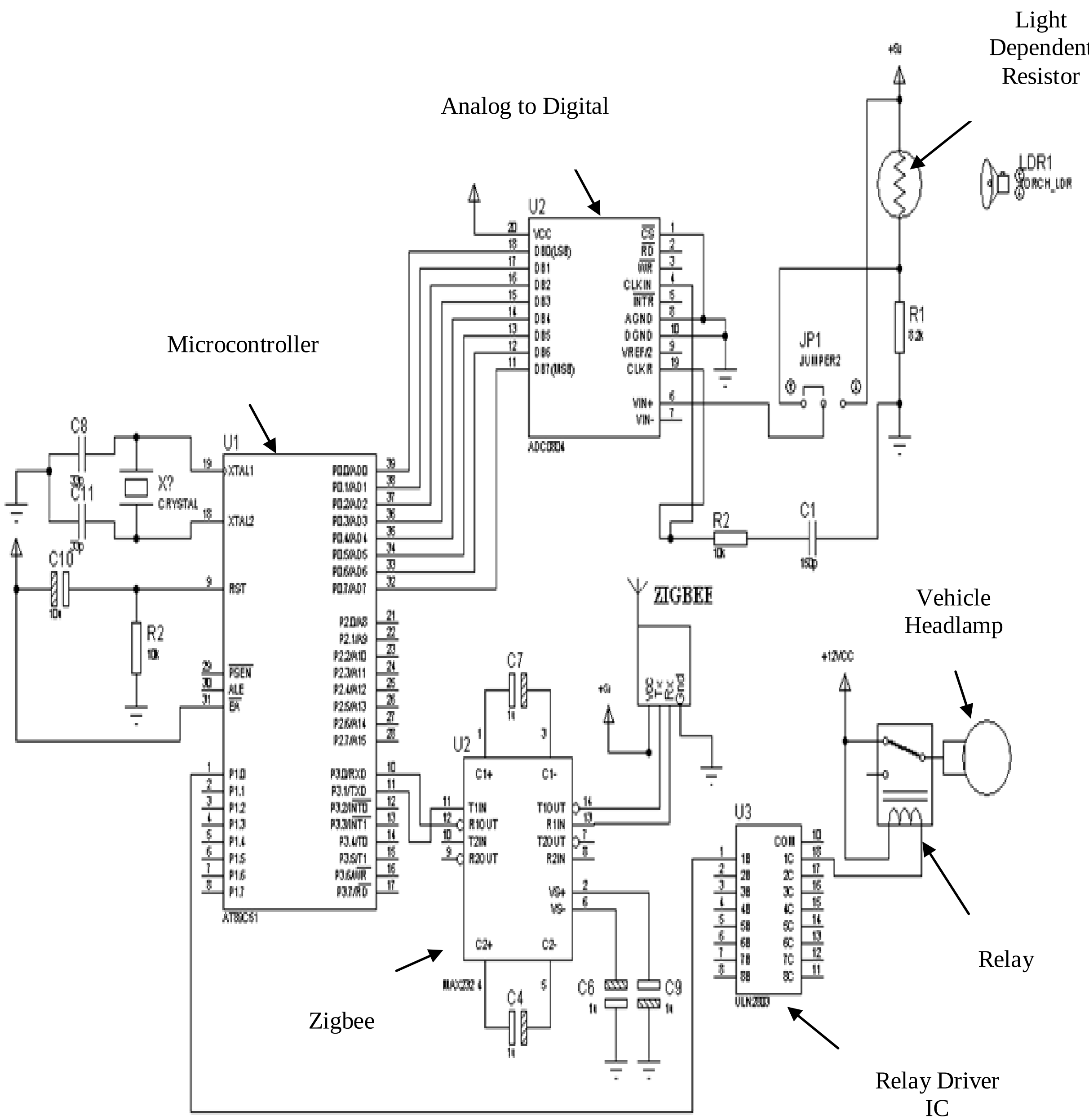
Figure 2: Block Diagram for System Device

1. The vehicle 2 senses the high beam of vehicle 1 with the help of the Light Dependent Resistor (LDR) sensors and converts the light intensity into electrical signal and send it to the signal conditioner or Analog to Digital Converter (ADC).

2. The ADC converts the analog signal at it input into digital signal for the microcontroller to work with.

3. The Microcontroller block functions as the main control unit which will monito the data from ADC and operates the Zigbee Transceiver & relay when the sensing values go beyond the set point.

5.2 Circuit Diagram for Design



5.3 Design of System Device

The design of this device was done on a vero board of dimensions 310.5 mm x 160 mm x 2 mm. Vero board is called strip board. It is a widely-used type of electronics prototyping board characterized by a 0.1 inch (2.54 mm) regular (rectangular) grid of holes, with wide parallel strips of copper cladding running in one direction all the way across one side of the board. In using the board, breaks are made in the tracks, usually around holes, to divide the strips into multiple electrical nodes. With care, it is possible to break between holes to allow for components that have two pin rows only one position apart such as twin row headers for ICs. Components were placed on the plain side of the board, with their leads protruding through the holes. The leads are then soldered to the copper tracks on the other side of the board to make the desired connections, and any excess wire is cut off. The continuous tracks were easily and neatly cut as desired to form breaks between conductors using a 5mm twist drill, a hand cutter made for the purpose, or a knife. Tracks were linked up on either side of the board using wire. The soldering process was carried out using a lead and soldering iron. This was done by joining the supposed terminals together before soldering. And after soldering each unit, test was carried out using a meter to ensure good contact.

The AT89S52 microcontroller of dimensions 50 mm x 20 mm x 2.5 mm was interfaced with a 12 V power supply, LDR sensor, RF, ADC and serial cable. The individual circuit boards were interconnected with data and power cables to form one circuit.

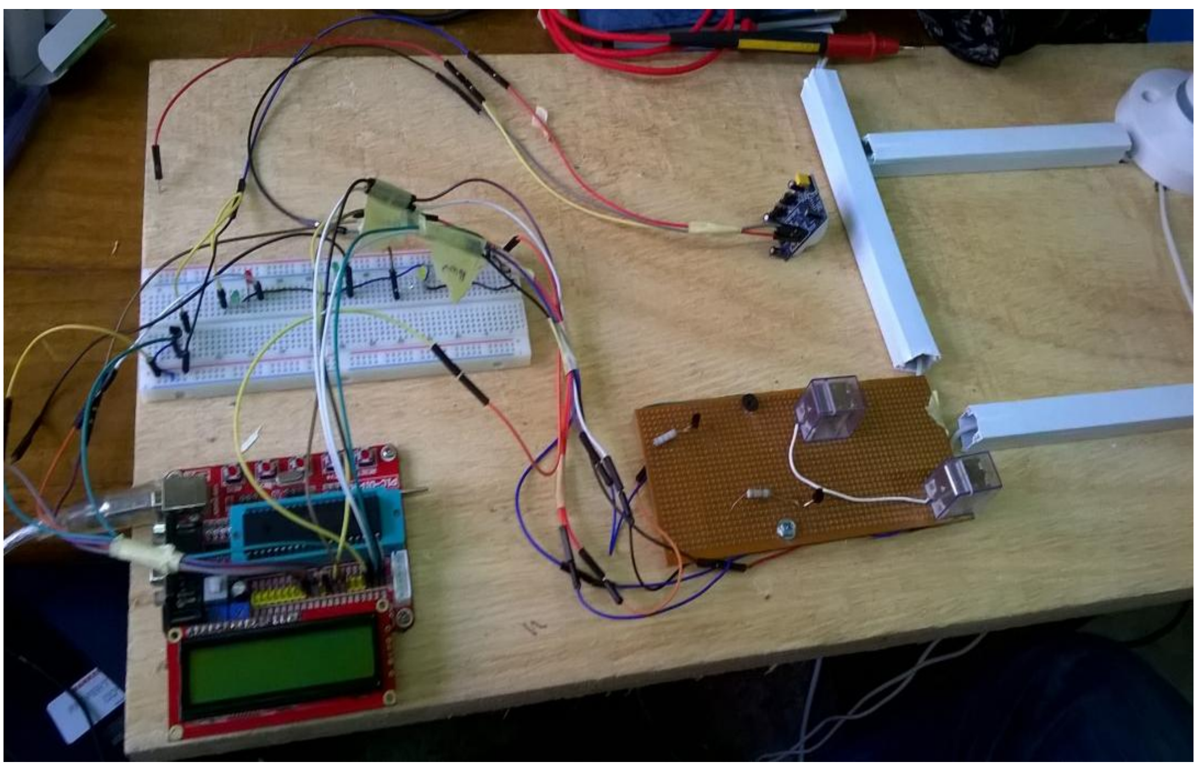


Figure 4: A Picture of Synergistic Integrated System Device

5.4 Mode of Operation of System Device

The LDR acts as a variable resistor. Therefore, the LDR and the two resistors form a potential divider network which will decide the current in the circuit. Thus, this balanced network gives a trigger to the gate/base of the transistor. The design of this particular circuit gets a trigger if there is a voltage imbalance in the circuit due to change in resistance of the LDR from the light source.

The source required for the operation is 12 V DC supply and the DC source is then taken from battery. However, in real-time application, this can be substituted from the car's own battery pack. The headlights, LDR and transistor are all connected to the same DC supply.

5.5 Software Development

5.5.1 Cross Compilers

The execution of code in the microcontroller takes place in a hexadecimal code format. The cross compilers act as a bridge between the programming software and microcontrollers. In programming the microcontroller using 'C' the code written in 'C' language cannot be directly executed by microcontroller. Hence this code written in 'C' is fed to a cross compiler which converts into hexadecimal code which is understood and executed by microcontroller. The advantage of using cross compilers is that in case of some applications programming, the microcontroller using assembly language will become bulk and tedious. When cross compilers are used, the microcontroller can be programmed in any other language which is easy to program and debug.

In this study the Keil cross compiler was used to program the microcontroller. In writing program for any microcontroller using cross compiler it cannot directly write the converted code on to the microcontroller. This means there is the need to use a special technique to load the program into the microcontroller. One of the methods is to use a microcontroller with a flash memory. Flash memory is similar to Erasable Programmable Read Only Memory (EPROM) and once the program is written and debugged using cross compiler, the program on the flash memory is flashed. Once the program is flashed, the microcontroller is loaded with the hexadecimal code and ready for execution.

5.5.2 Features of AT89S52 Microcontroller (Target Processor)

AT89S52 is a slightly more powerful microcontroller which provides highly flexible and cost effective solutions to many embedded control applications. Its features include the following:

1. It has 128 bytes of internal RAM.

2. It has low power; high performance CMOS 8-bit microcomputers with 8K bytes of flash programmable and erasable read only memory (PEROM).

3. Fully static operation: 0 Hz to 24 M Hz.

4. It has 8 programmable I/O lines i.e. it has 4 ports (port0 to port3) with 8 lines each.

5. A third 16-bit Timer/counter is present inside this microcontroller to strengthen its operation, compared to only 2 timers in standard 8051.

6. It has eight interrupted sources.

7. One more additional feature of AT89C52 is that it has 26 special function registers, 5 more than the standard 8051.

8. The device is manufactured using ATMEL's high-density nonvolatile memory technology and it is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out.

5.5.3 Description of AT89S52 Microcontroller

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out.

The AT89C51 provides the following standard features: 8K bytes of flash, 256 bytes of RAM, 32 I/O lines three 16-bit timer/counters, a six-vector two level interrupt architecture, a full serial-duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset.

5.5.4 Pin Configurations

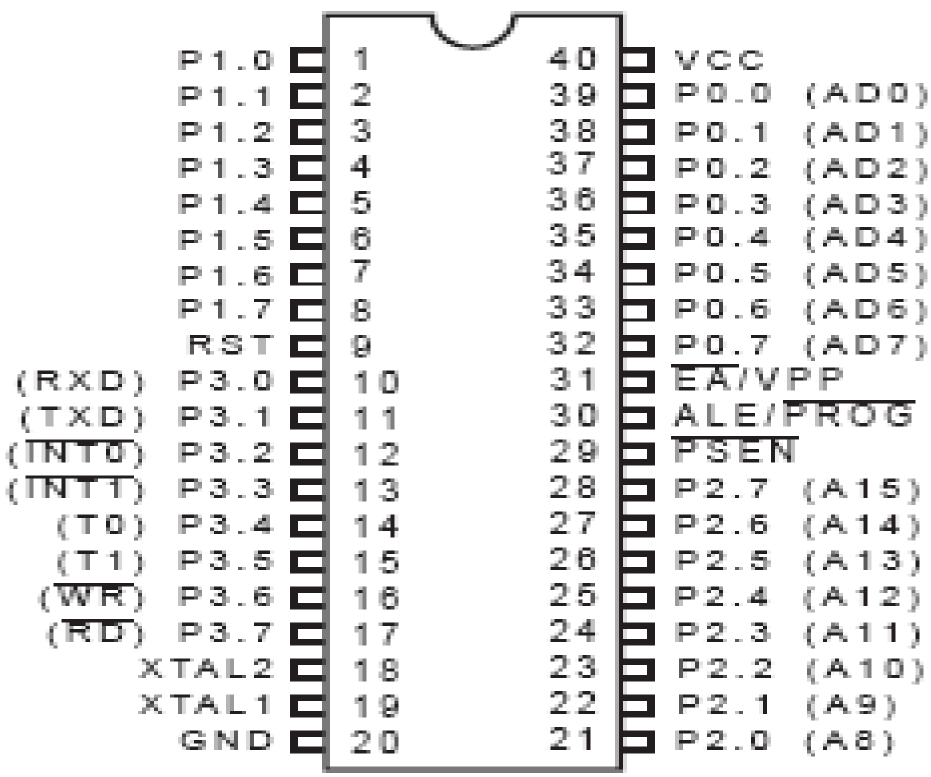


Figure 5: Pin connection of AT89C51 Microcontroller

The AT89S52 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 8 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

Block Diagram

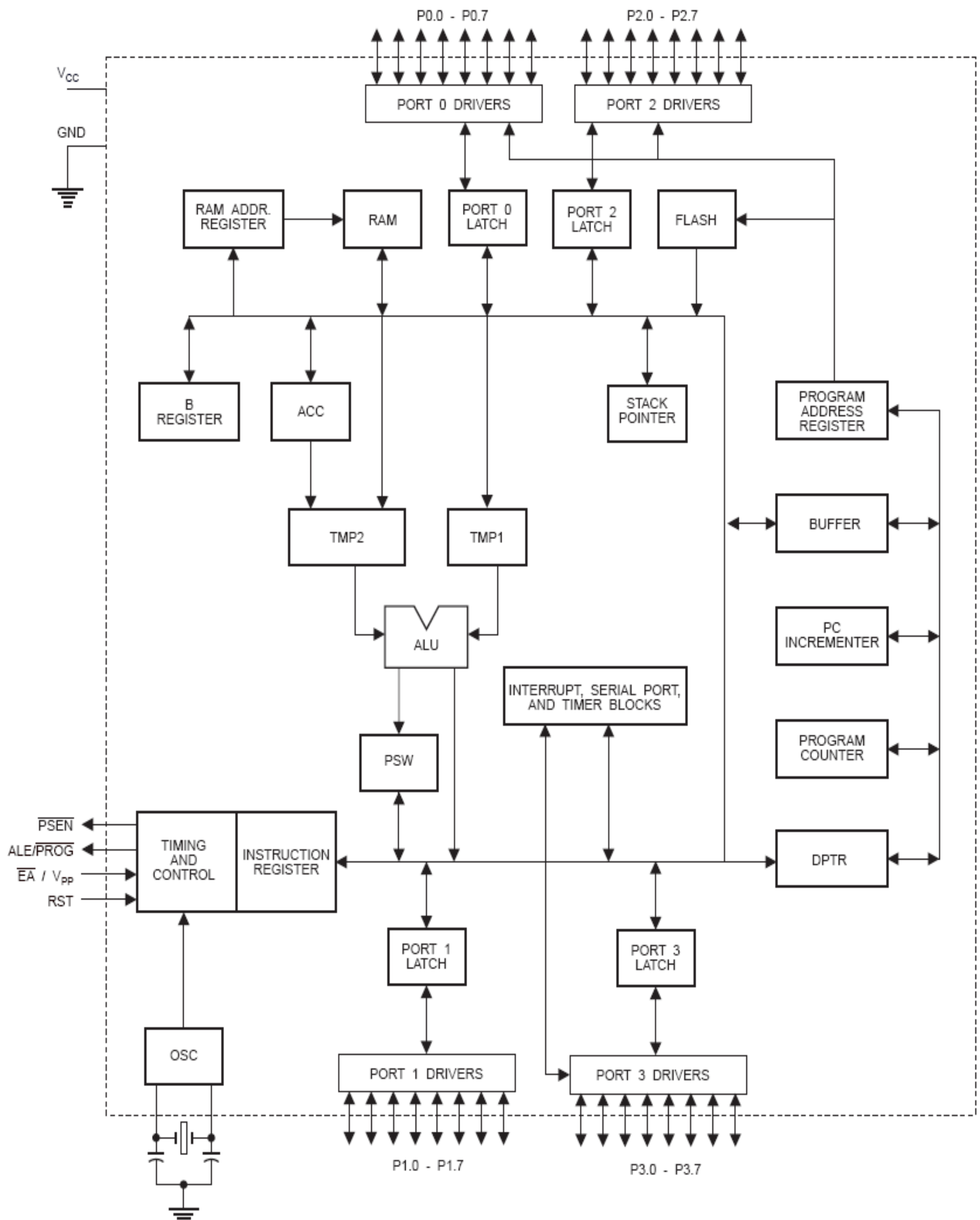


Figure 5 : Block Diagram of AT89S52 Microcontroller

5.5.5 System Implementation

The following criteria must be considered when placing the device in a real vehicle:

1. It should be kept at a safe place, protected from external environment like rain, and dust.

2. The placement of this circuit should be in line with the eye of the driver, so that it responds exactly in the same way how a driver would react to the bright light.

3. The circuit should have a constant supply whenever the headlights are turned ON.

4. It should be compact and easy to install.

This device should be place in all the vehicles. By installing this device, each vehicle can independently operate on its own. From the above discussions, it has been concluded that the device can be concealed in front of the car, near the wipers, at the base of the windscreen as shown in the figure below. The device is denoted as a red dot. This is the ideal place as it mimics the driver's line of sight and also safe from environmental factors and accidents.

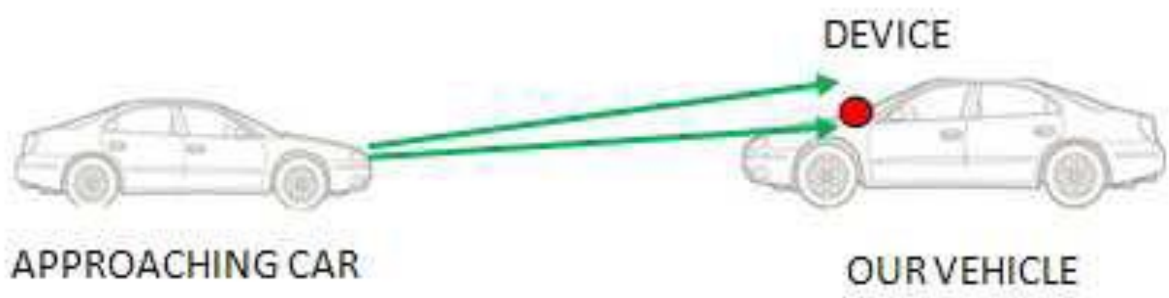


Figure 6 : Detection of an approaching car headlight

In the circuit, by using suitable adjustable resistors, the circuit's sensitivity can be tuned to the appropriate requirement. It can be made sensitive for a wide range of light beam by just varying the balance condition of the potential divider network. Therefore, the driver can manually adjust the sensitivity level so that it can be customized for his personal driving comfort.

6. RESULTS AND DISCUSSION

The circuit had been designed to be a working model. Until the vehicle is encountered by an opposite vehicle, it can travel with high beam. Once it encounters an opposite vehicle, each of the two vehicles senses the opposite vehicle's light. Thus if either of the vehicles are using high beam, it switches to low beam. If the headlight is already in low beam, then no change occurs. As the vehicles cross each other, the intensity of light falling on the sensor decreases and the headlights switch back to their original mode. There might be a question of other sources of light in the road like sign boards, street lights and buildings. But as LDR is used as the source and the placement of the device is highly directional, it is not affected by any other light sources which might be present in the vicinity. Moreover, the light from the vehicle's headlamp is of a distinct nature. The maximum spread angle of the headlight is 135^{o}. The other sources will be located far away from the road and hence their spread angle will be very high.

Hence by the time the spread light from other sources reach the sensor its intensity will be very much reduced below the triggering threshold level. The sensitivity of a photo detector is considered to be the relationship between the light falling on the device and the resulting output signal. However, for the photocell, the relationship between the incident light and the corresponding resistance of the cell is considered. Therefore, a graph of Resistance versus Lux is plotted which shows a negative slope.

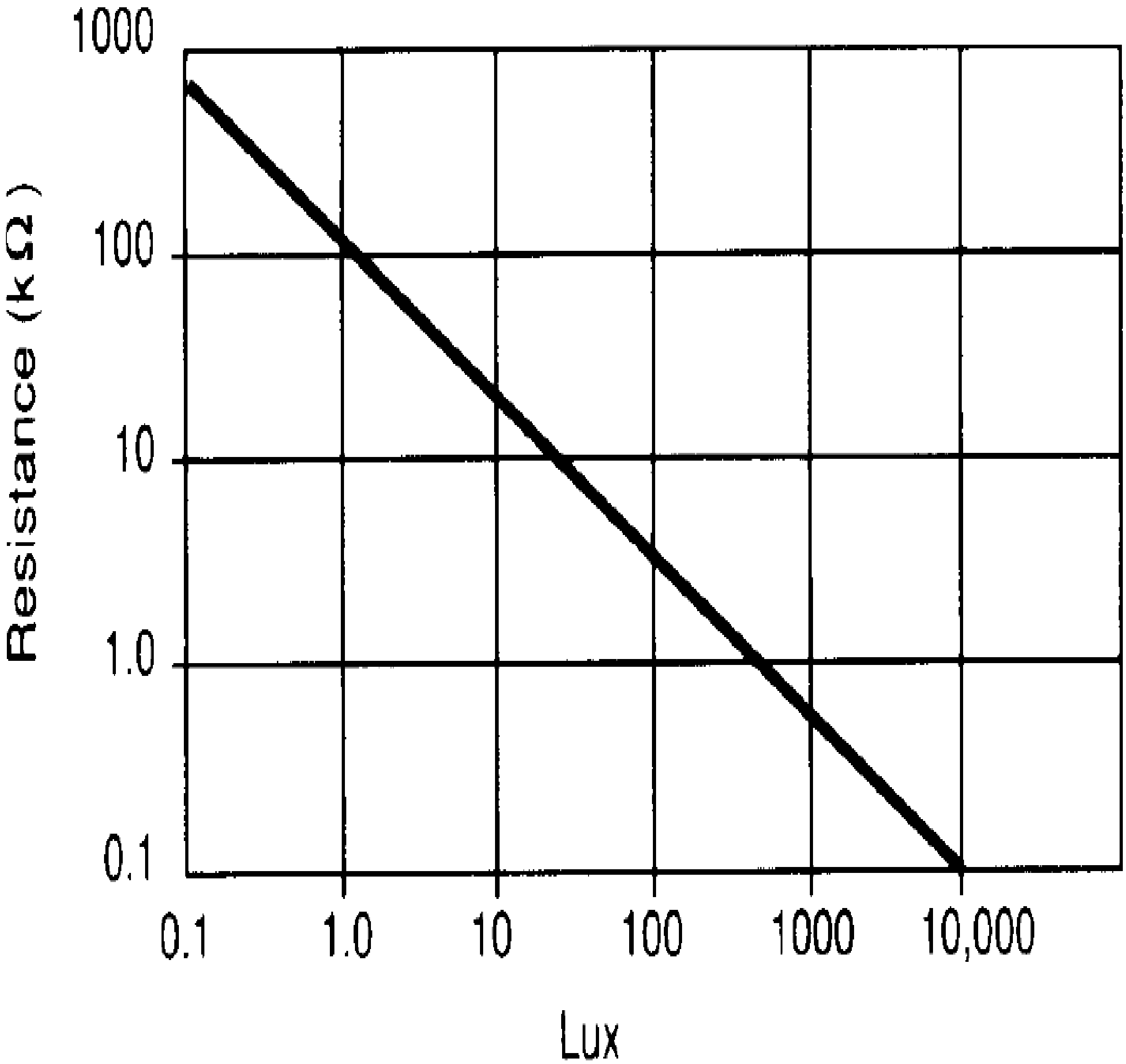


Figure 7: A graph of Resistance against Lux

Spectral Response

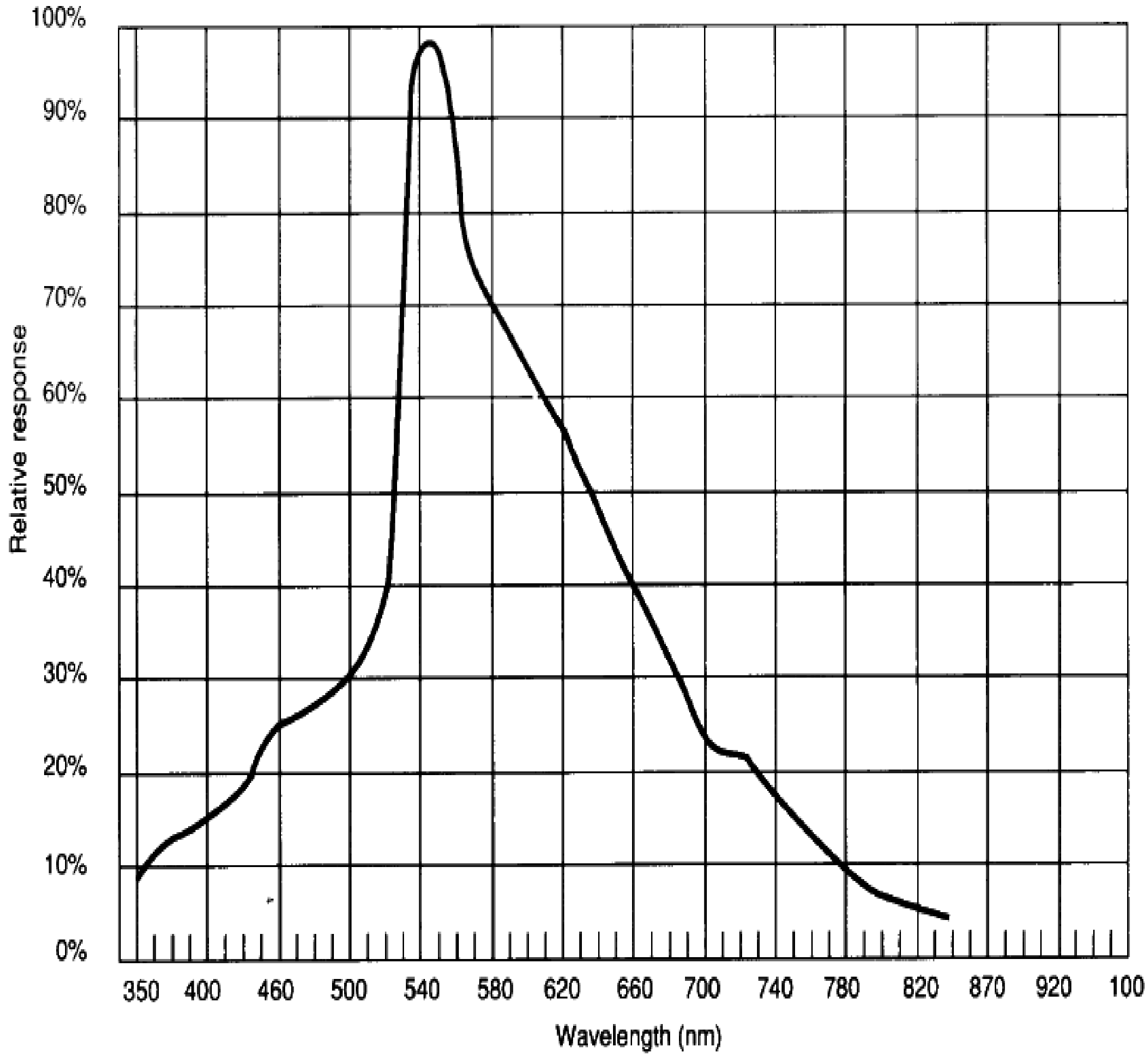


Figure 8: Spectral Response (Relative Response against wavelength)

Like the human eye, the relative sensitivity of a photoconductive cell is dependent on the wavelength (color) of the incident light. Each photoconductor material type has its own unique spectral response curve or plot of the relative response of the photocell versus wavelength of light.

Mathematically, Spectral Response can be interpreted using the equation below

$$\lambda \doteq \frac{hc}{E_g}$$

Where

h – Planck's Constant (6.626 x 10^{-34} J/s)

C – Speed of light (3 x 10^{8} m/s)

Eg - 1.12 eV

λ - **Wavelength**

7. ADVANTAGES

1.Provide safe driving during bad weather conditions

2.Economical to be installed

3.Maintenance cost is low

8. CONCLUSION

An automatic headlamp dimmer of on-coming vehicles had been designed using LDR sensing technique. Thus, the system device automatically switches the headlight to low beam when it senses a vehicle approaching from the opposite side using Light Dependent Resistor (LDR) sensor.

Glare during driving is a serious problem for drivers and therefore caused by the sudden exposure of our eyes to a very bright light of the headlights of vehicles. This causes a temporary blindness called the Troxler effect. Eventually this has become the major reason for accidents occurring at night and also during bad conditions such as rainy and foggy conditions. The driver should have turned down the bright lights immediately to avoid glare to the other person, however they find it difficult to do. Hence, the idea for the design and development of a prototype circuit called the automatic headlight dimmer. It enables the driver to use high beam light when required and also automatically switches the headlight to low beam when it senses a vehicle approaching from the opposite side. Thus, the implementation of this device in every vehicle does not only avoid accidents but also provide a safe and a comfortable driving. A server module could be included to this system for receiving and storing headlight rays parameters information in a database application.

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