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Digital Photo Sensor Able to Differentiate up to Three Light Intensity Bands and its Applications

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Abstract- This paper deals with the design of a module which can differentiate among three different light intensity ranges. This module uses two LDRs in such a configuration, so that they can collectively give the output which helps in differentiating among various light intensity ranges. The unique feature of the module is to differentiate among three different light intensity ranges which finds applications in the area like automatic plant irrigation system, automatic street light system, maintaining light at a particular intensity and further more.

Keywords- LDR, LED, VARIAC, COMPARATOR, OP-AMP.

I. INTRODUCTION

We need to monitor light condition at many places to improve the working conditions. Sometimes we need to differentiate between multiple colors. We can control these conditions with the use of Light Dependent Resistor (LDR). Presently, the module that industries are providing is able to differentiate only between two light intensity ranges i.e. differentiate between two colors. But the module that we have developed will be able to differentiate among three light intensities. Through our module we will be able to recognize three different intensity ranges of a light radiation.

II. CIRCUITRY

Fig.8 shows the circuitry included in the module. In the figure, two LDRs are used, one is used in such a way so that it gives high voltage (Logic '1') on increasing the light intensity above a particular reference level and low voltage (Logic '0') below that particular reference intensity level. Another one is used in the reversed manner to the first LDR i.e. it will give low voltage (Logic '0') above a particular reference light intensity level and below that reference level it will give high voltage (Logic '1'). The levels of light intensity can be changed with variable resistor called Variac. For both the LDRs, the Variacs are totally different and independent which means we are able to set two different reference levels for LDRs. So for the purpose discussed above, connection has been made as shown in the Fig.8.

III. COMPONENTS

The following components are used to make the desired module: Variable resistance (Variac), Light Dependent Resistor (LDR), comparator IC LM358 and some basic components like resistances and LEDs. The description of the major components has been given in a very precise manner while other components are discussed as required.

A. Comparator IC LM-358

The IC LM-358[1] (fig.1) consists of two internally frequency compensated, high gain operational amplifiers. This IC can be operated with single power supply over a wide range of voltages and also has split supply mode. In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage. IC is available in 8-Bump micro SMD chip sized package.

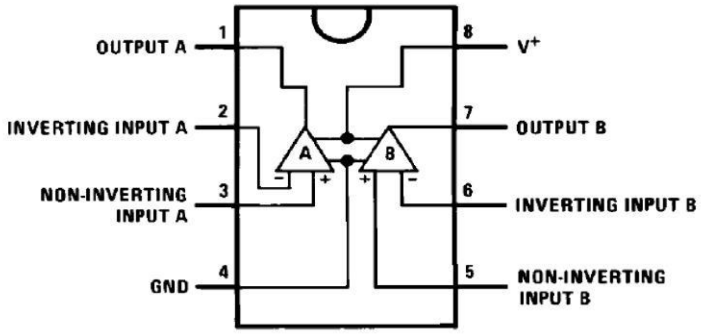


Fig. 1 IC LM358 Pin diagram

It is internally frequency compensated for unity gain. Some basic features of IC LM358 are discussed below. Wide power supply range: single supply: 3V to 32V; dual supply: ±1.5V to ±16V; very low current drain; low input offset voltage: 2mV; wide bandwidth (unity gain): 1 MHz; input common-mode voltage range includes ground; large output voltage swing; differential input voltage range is equal to the power supply voltage.

B. Light Dependent resistor (LDR)

As the name suggests, its resistance depends upon the light intensity incident on it and varies accordingly. The resistance of the photo resistor decreases on increasing the light intensity. In other words, we can say that it exhibits photoconductivity. The symbol of LDR is as shown in the fig2. The characteristics of a typical LDR are shown in the fig. 3. One can see that as the illumination increases, the resistance of the LDR decreases. The dark resistance of LDR is 1M-ohm and maximum current is 75 mA.[8] If we take the analog signal from the LDR then we can find the intensity of the incident light. This is a way to use the LDR as a light intensity meter.

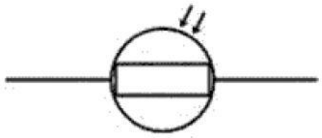


Fig. 2 LDR symbol

So let us move towards the working and construction part of the LDR. A base material of a semi insulating material is joined with a semiconductor material in the zigzag form as shown in the fig. 6.

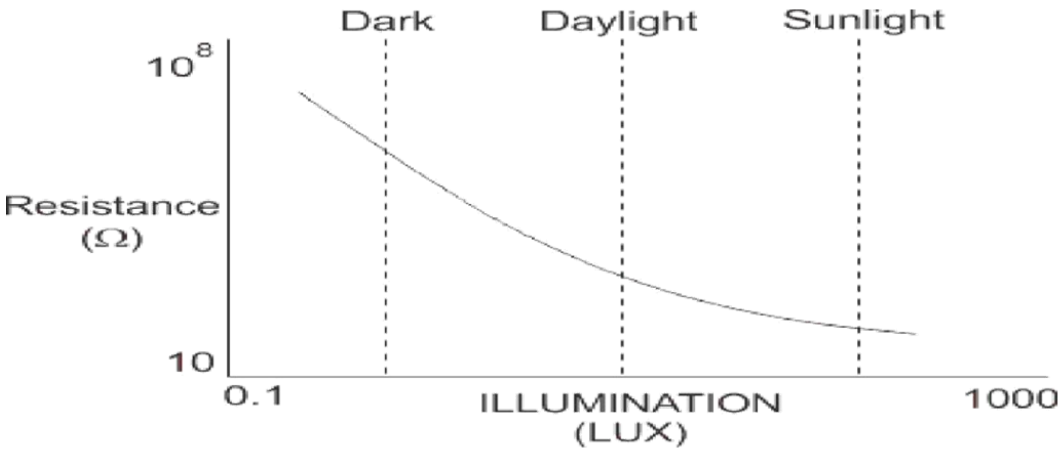
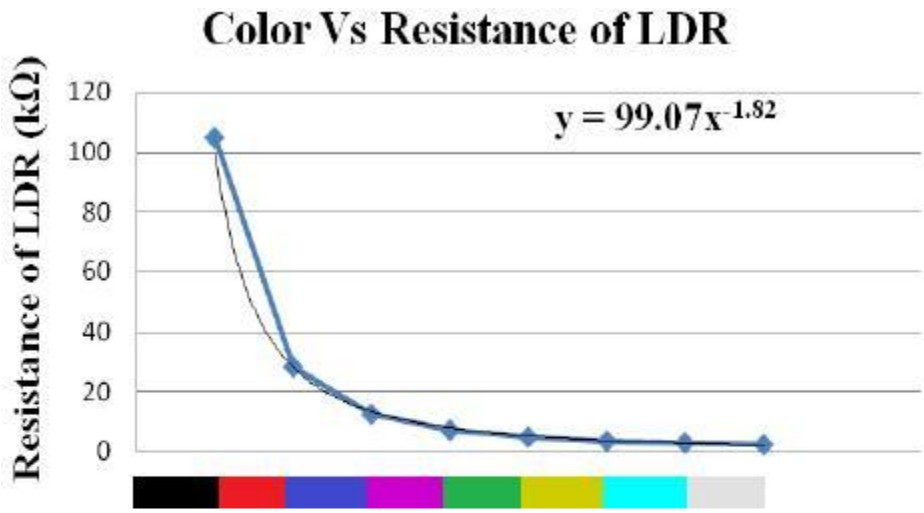


Fig. 3[2] Resistance v/s Light Intensity Curve

The purpose of making it zigzag is only to obtain the good range of the resistance so that it can be operated for some considerable voltage range. There are two types of contacts- Ohmic and metallic. Ohmic contact is between highly doped semiconductor material and very less doped semiconductor material and metallic contact is between highly doped semiconductor material and metal. When light falls on the zigzag material (very less doped semiconductor material), some electron-hole pairs get generated [3]. These newly generated electron-hole pairs increase the conductivity of the zigzag path and hence the resistance decreases.

Different colors light intensity incident on the LDR will produce different voltages at the terminal connected to LDR, and hence on the basis of the various voltage generated at that terminal will differentiate the colors. [4] Figure 4 and figure 5 shows the variation of resistance and voltage across both of the terminals of LDR with the colors.



COLOR VS VOLTAGE ACROSS LDR

Fig. 4[6] variation of resistance of LDR with different colors

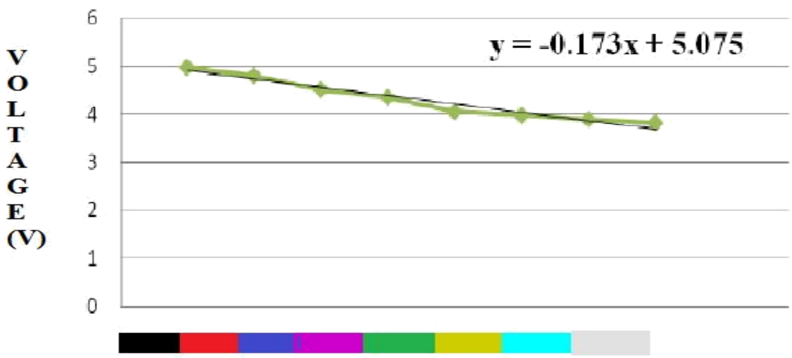


Fig. 5[6] variation of voltage across LDR with different colors

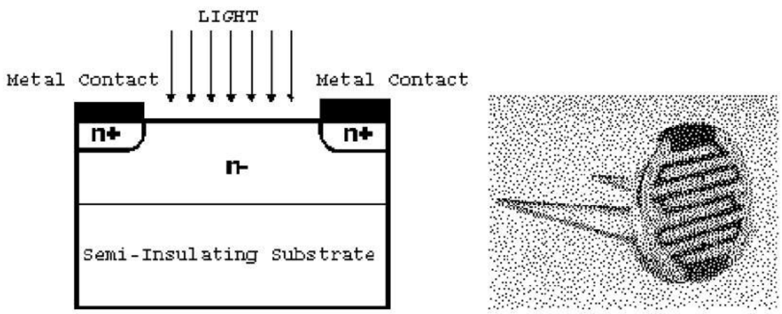


Fig. 6[2] Construction of LDR

So if we use only the LDR it will give analog signal. To operate it digitally (for the well-known purpose) we have a circuitry using the comparator IC LM358 and other basic components (refer fig. 7). So till now we can differentiate between two light intensity ranges with this digital form of LDR.

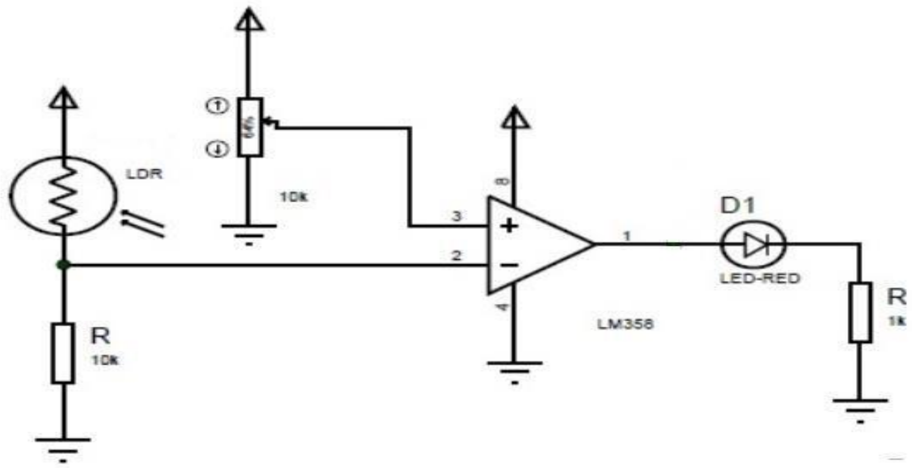


Fig. 7 LDR module with digital output

IV. CIRCUIT IMPLEMENTATION AND WORKING

When the light incident on the LDR surface, its resistance reduces and hence voltage at the comparator terminals increases accordingly. Let's assume two comparator op-amps comparators1 and comparator2. LDR1 at its one terminal it is connected with Vcc and at other terminal it is connected with negative terminal as well as resistor R1. While LDR2 is very similar to the LDR1 rather than connection to positive terminal of comparator2 and resistor R2. At any instant of time voltage at R1 and R2 will be very similar since R1=R2=R and similar lighting conditioning, let's assume it as VIN.

Now, let us discuss about the different cases of the variations of the light intensity. We have divided the light intensity in three categories:

Case 1: During the day time i.e. at the time of high light intensity, due to the incident light on the surface of the LDRs the resistance of the LDRs will decrease. Due to this decrement of the resistance the voltages across resistor R will increases. The voltage across the resistor R (Vin) is supplied as an input to inverting terminal of the comparator1, a comparator is a differential amplifier with the saturation voltages as +Vcc(5V) and -Vee(0V), it amplifies the difference of the input on the non-inverting and inverting terminals. We have supplied a reference voltage (Vref1) at the non-inverting terminal, and if the difference of the reference voltage and the input voltage (Vref1-Vin) is positive the comparator1 amplifies the input to 5V (logic 1) and if the difference is negative it amplifies it to 0V (logic 0).

The voltage across R (Vin) is supplied to the non-inverting terminal of the comparator2, we have discussed that the comparator is a differential amplifier and amplifies the difference of the inputs between its two terminals. A reference voltage (Vref2) is supplied at the inverting terminal of the comparator2. Now, if the difference of the terminals of the comparator2 (Vin-Vref2) is positive it amplifies the difference to 5V (logic 1) and if the difference is negative it amplifies it to 0V (logic 0).

Now, considering the voltage across resistor R (Vin) increases and is more the value of the reference voltages (Vref1, Vref2), The output of both the comparators will be,

1) For comparator 1, given Vin>Vref1; Non-inverting terminal = Vref1; Inverting terminal=Vin;
   Difference of the input voltages =Vref1-Vin=negative; Output= 0V= logic 0=Low;

2) For comparator 2, given Vin>Vref2 Non-inverting terminal = Vin; Inverting terminal=Vref2;
   Difference of the input voltages =Vin-Vref2=positive; Output = 5V= logic 1=High;

Case 2: During the night time, i.e. at the time of low light intensity, the resistance of LDR increases, due to which the voltages across R (Vin) decreases. Now, considering the voltage across the resistors R (Vin) decreases and is less than the reference voltage (Vref1, Vref2), The output of both the comparators will be,

1) For comparator 1, given Vin<Vref1 Non-inverting terminal = Vref1; Inverting terminal =Vin;
   Difference of the input voltages =Vref1-Vin=positive; Output =5V= logic 1=High;

2) For comparator 2, given Vin<Vref2 Non-inverting terminal = Vin;
   Inverting terminal =Vref2;
   Difference of the input voltages =Vin-Vref2=negative;
   Output = 0V= logic 0=Low;

Case 3: During the evening/morning time i.e. at the time of moderate light intensity, the voltage across resistor of R(Vin) is such that: Vin<Vref1 & Vin>Vref2, The output of both the comparators will be,

1) For comparator 1, given Vin<Vref1 Non-inverting terminal = Vref1; Inverting terminal =Vin;
   Difference of the input voltages =Vref1-Vin=positive; Output = 5V= logic 1=High;

2) For comparator 2, given Vin>Vref2 Non-inverting terminal = Vin; Inverting terminal=Vref2;
   Difference of the input voltages =Vin-Vref2=positive; Output = 5V= logic 1=High;

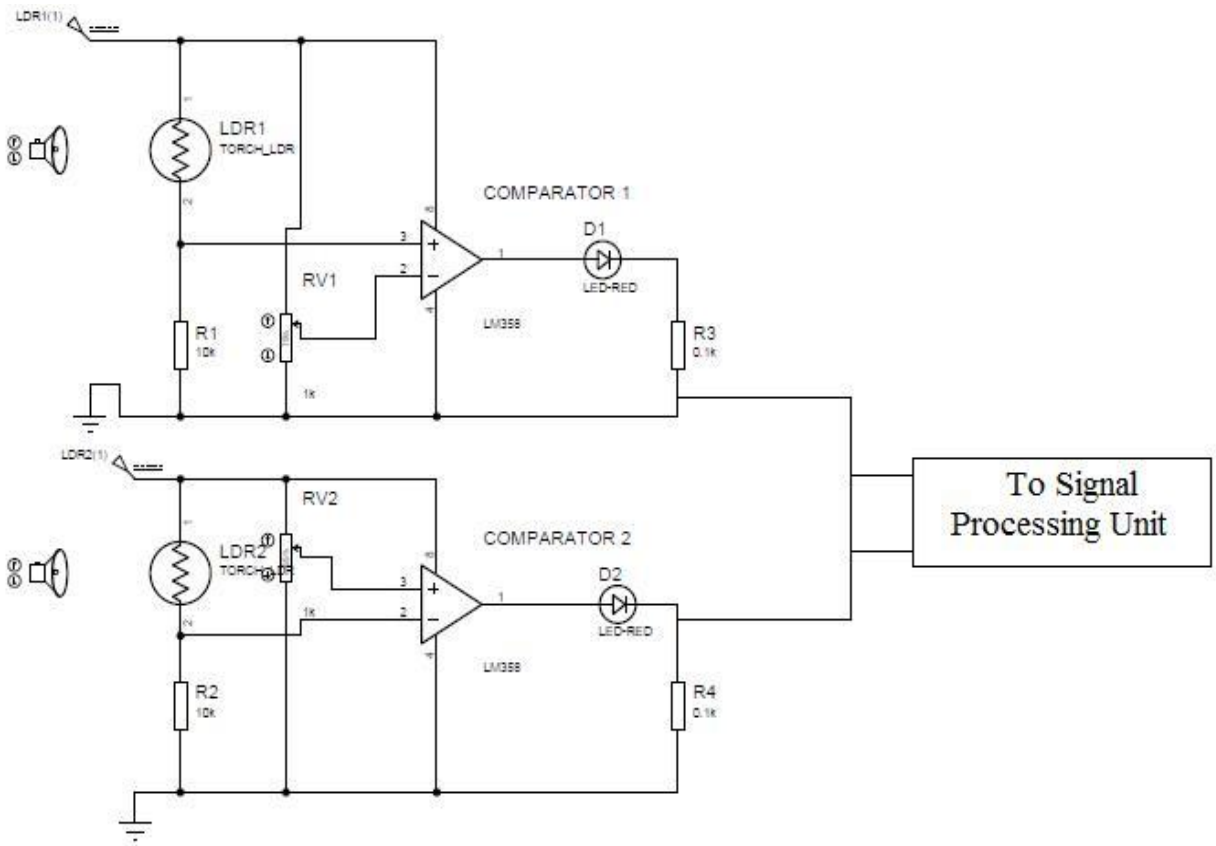


Fig. 8 Circuit Implementation

V. RESULTS

During the experiment of the module we detected the light intensity during the day, evening/morning and the night time. The experiment was successfully performed and the readings were noted as follows:

TABLE I RESULTS

Light Intensity	**Output Of Comparator 1**	**Output Of Comparator 2**
Day(High Light Intensity)	Logic 0(LOW)	Logic 1(HIGH)
Night(Low Light Intensity)	Logic 1(HIGH)	Logic 0(LOW)
Evening (Moderate Light Intensity)	Logic 1(HIGH)	Logic 1(HIGH)

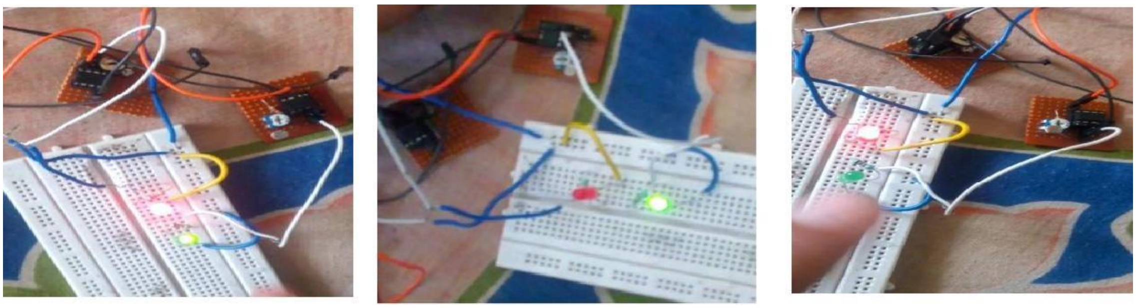


Fig. 9 Practical Implementation of circuit

CONCLUSIONS

We have successfully divided the light intensity in three different ranges. The range of the three light intensities can be varied according to the need of the applications by changing the value of the reference voltages.

Practical applications:

a. Automatic irrigation systems, Automatic garden plant watering systems- Some plants get destroyed if irrigated during mid-noon. This module can be used to detect the light intensities during the different time period of a day. So it can be used in automatic plant irrigation system [3] where plants are watered during morning and evening.

b. Lighting can account for 10–38% of the total energy bill in typical cities worldwide [7].To modify the automatic street light system to produce light of different intensities during different times of the day. That is, no light during daytime, medium light during the evening & morning time and bright light at the night time.

This reduces the overall energy consumption. as we earlier use the system that differentiate between two light intensities but this time using above module sensor we will be able to differentiate among 3 light intensities.[5]

c. For maintaining the light at a particular intensity.

d. Able to detect three colors: This application can be made more helpful in the robotics for the color differentiation. In line follower which was earlier a two color line follower but now with this we can incorporate another feature for the line follower robot that it can easily handle with three color arena. Another application is in counting two different color boxes. This can be understood by this point. Suppose there are some blocks of two different colors, blue and green, are separated by a distance and robot has to count the blue and green color boxes. Since there is no reflection in vacant space (no blocks) so any sensor we use it will count it as a color that's why in the case of proximity sensor we are able to count only on type of box (same color) but using three color sensor we are able to count two different color boxes like green and blue.

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