Designing of an Electric Light Sensor Circuit using Light Dependent Resistor for Auto Lighting Systems at Home. An experimental design.

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Abstract

Background:
Due to the increasing wastage of electricity resulting from failure to switch off bulbs during day time, this research aimed at designing an electric light sensor circuit using a light-dependent resistor that helps to switch on and off lights at night and during the day respectively. The specific objectives was to generate an electric light sensor circuit using a light-dependent resistor and to determine the performance of an electric light sensor circuit in terms of resistance due to light exposure.

Methodology:
The research design was experimental; an electric light sensor circuit was designed and tested for its effectiveness. It was designed using resistors, a BC547 transistor, an LDR (Light dependent resistor), an led (bulb), and two resistors. Testing for the effectiveness of the electric light sensor was carried out based on Increasing the voltage on the DC power supply (from 2volts to 9volts) while reading the respective values of the resistance of the electric light sensor circuit using the multimeter and at the same time covering an LDR to create darkness on it.

Results:
A detailed analysis concerning the performance of the Electric light sensor system has been performed and presented. The device performed well using a light-dependent resistor as the light sensor. It was proven that the increase in the intensity of light falling on the light-dependent resistor as a light sensor makes the bulb (led) go off. This meant that during the day when the intensity of light was very high, the bulb (led) was off.

Conclusion:
A detailed analysis concerning the performance of the Electric light sensor system has been performed and presented. The device performed well using a light-dependent resistor as the light sensor.

Recommendation:
The system should next time be operated using the photocell instead of the LDR to improve its effectiveness.

Keywords: Electric Light Sensor Circuit, Dependent Resistor, Auto Lighting Systems, Submitted: 11th/09/2022 Accepted: 15th/11/2022

1. Background of the Study

The background of the study is divided into; historical, theoretical, conceptual, and contextual perspectives.

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1.1. ***Historical Perspective***

The first electric light sensor circuits were selenium cells. Selenium was used for resistances at the receiving station on the transatlantic telegraph cable in the 1860s, and it was noticed that it gave erratic results in daylight. Selenium can generate a small photovoltaic current so it was used in pre-war light meters. It was in 1873 when Willoughby Smith discovered that the electrical resistance of grey selenium was dependent on ambient light. The first commercial products were developed by Werner Siemens in the mid-1870s. The idea of a Photo resistor was developed when photoconductivity in Selenium was discovered by Willoughby Smith in 1873. Since then many electric light sensor circuits had been designed to control lights at home or in other places and among them include An infrared door sensor based on electrical and electronics combinational circuit technology that was used to develop the automatic light switching system.

Samuel Pierpont Langley (1878) invented the first infrared door electric light sensor. This radiant-heat detector was sensitive to differences in temperature of one hundred-thousandth of a degree Celsius, which enabled the study of the solar irradiance far into the infrared spectrum.

1.2. ***Conceptual Perspective***

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light. It is often used as a light sensor, light meter, Automatic street light, and in an area where we need to have light sensitivity.

The weakness of the LDR is that they require a few milliseconds or more to respond fully to the changes in light intensity. The LDR takes a few seconds to return to its normal dark resistance once the light is removed. The sensitivity and resistance range of the LDR varies from one device to another.

A BC547 transistor is a negative–positive–negative (NPN) transistor. It has an emitter terminal, a base or control terminal, and a collector. The BC547 has a gain value of 110 to 800; this value determines the amplification capacity of the transistor. The maximum amount of current that could flow through the Collector pin is 100mA; hence the BC547 cannot connect loads that consume more than 100mA (Ashok, 2021).

A light-emitting diode (LED) is a semiconductor device, which can emit light when an electric current passes through it. To this, holes from p-type semiconductors recombine with electrons from n-type semiconductors to produce light (Held, 2016).

A Zener Diode, also known as a breakdown diode, is a heavily doped semiconductor device that is designed to operate in the reverse direction. When the voltage across the terminals of a Zener diode is reversed and the potential reaches the Zener Voltage (knee voltage), the junction breaks down and the current flows in the reverse direction.

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1.2.1. *Theoretical Perspective*

The light-dependent resistor works on the principle of photoconductivity whenever the light on its photoconductive material falls on its surface, it absorbs its energy, and the electrons of that photoconductive material that is in the valence band get excited and go to the conduction band and thus increases the conductivity as per the increase in light intensity. Also, the energy in incident light should be greater than the band gap energy so that the electrons from the valence band get excited and go to the conduction band. The LDR has the highest resistance in dark around 1012Ohm and this resistance decreases with the increase in Light as shown in figure 1.0

The light-dependent resistor is an optical phenomenon in which the conductivity of the material is increased when light is absorbed by the ma-

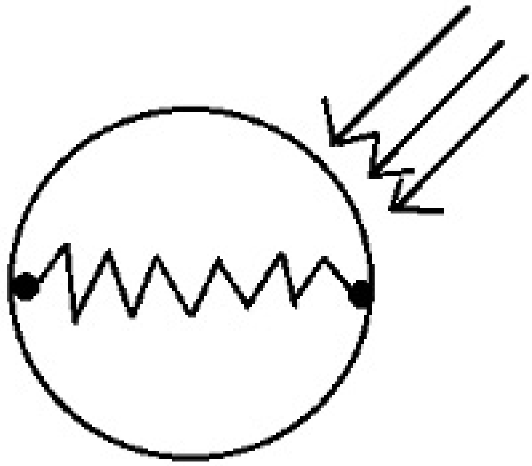

Figure 1: surface of light dependent resistor

terial. When the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence, when light having enough energy strikes the device, more and more electrons are excited to the conduction band which results in a large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR (Vikas, 2016).

Contextual Perspective

The electric light sensor circuit is very important when it comes to overcoming power wastage. It is a device that detects light and helps to switch on and off lights. For years, homes, institutions, hospitals, families, and other bodies have incurred costs of paying electricity bills when they have not used the units of power maximally because of electricity being wasted. People experience these problems especially when they are busy or rushing to go to work, and they forget to switch off their home bulbs. Electricity is wasted daily simply because people do not think to turn off lights when they not using them. According to the Energy Saving Trust, the UK squanders £170 million a year simply by leaving lights on and £30 to an average annual household bill. If one installs the electric light sensor circuit, it will help to reduce the wastage of power. The electric light sensor circuit can prevent some of the consequences of leaving lights on. The longer you leave the lights on, the higher the electricity bills.

The research was conducted in Uganda, university of kisubi, and aimed at designing an electric light sensor circuit to switch on and off during the night and the day respectively. In today's world, lights are very much required in homes. Due to the busy lifestyle of humans, switching operations on home or workplace lights is not carried out on time, and a huge amount of electricity is wasted. In the present system, it is observed that lights are not turned OFF even when there is an ample amount of light after the sun rises and are turned ON even before sunset (vigas, 2021). Electricity is wasted daily simply because people do not think to turn off lights when they not using them. According to the Energy Saving Trust, the UK squanders £170 million a year simply by leaving lights on and £30 to an average annual household bill. To overcome these problems, an automatic electric light sensor circuit is to be designed. The project aimed to eliminate manual operations and to design an automatic electric light sensor circuit using a light dependent resistor (LDR). This automatic electric light sensor circuit system requires less maintenance and is highly reliable.

2. Methodology

Research Design

The experimental design was used to design an electric light sensor circuit using a light dependent resistor.

*2.1. **Procedures:***

A wire was connected from the negative terminal of the battery to the Zener diode. The Zener diode was connected in parallel with the transistor.

A wire was also got from the base of the transistor to the 2.2k ohm resistor connected in parallel with the 1k ohm resistor. After this, a wire from the 1k ohm resistor was connected to the LDR, and the LDR was also connected in series with the led and the buzzer. To complete the circuit, the wire from the buzzer was then connected to the positive terminal of the battery.

The block Diagram for the Electric Light Sensor Circuit

Operations of the Electric Light Sensor Circuit were as follows:

1. 9V battery supplied the source DC biasing voltage needed to bias the transistor.

2. With the battery connected, when light falls on the LDR its resistance is reduced. The supply voltage was connected to the ground through a 2.2k ohms resistor. No voltage got to the transistors, and they remain at the cut-off region.

3. Consequently, no output voltage to the bulb, and the light remained off

4. During the dark, the resistance of the LDR was very high and the current then took the path of low resistance (1k ohm).

2.2. BC547 Transistor

A BC547 transistor is a negative-positive-negative (NPN) transistor that is used for many purposes. This type has an emitter terminal, a base or control terminal, and a collector terminal (Nischal, 2018).In this research, BC547 was used because it amplifies current.

Resistors

The resistors fit snugly into a breadboard with very little movement.

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Led (bulb)

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it (luo, 2010).

2.3. Zener diode

A Zener Diode, also known as a breakdown diode, is a heavily doped semiconductor device that is designed to operate in the reverse direction. When the voltage across the terminals of a Zener diode is reversed and the potential reaches the Zener Voltage (knee voltage), the junction breaks down and the current flows in the reverse direction.

3. Results:

Presentation of Electric Light Sensor Circuit

The electric light sensor circuit was designed and presented. The electric light sensor circuit

The materials used in the designing of the electric light sensor circuit basically include:

COMPONENT	QUANTITY
Light dependent resistor	1
Transistor (BC547)	1
Resistor (1k ohm, 2.2kohm)	2
Zener Diode (IN4001)	1
Buzzer	1

Figure 2: List of the components used in designing of anelectric light sensor circuit.

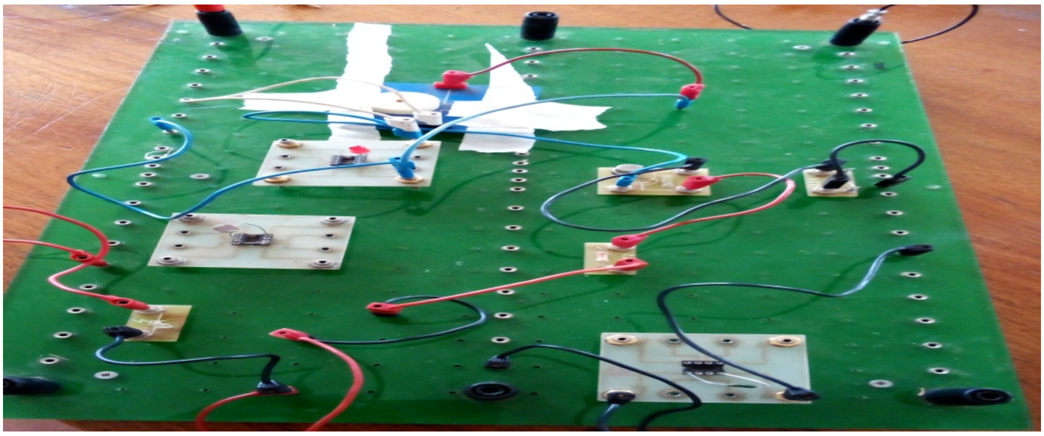

Figure 3: The block Diagram forthe Electric Light Sensor Circuit

was completed and then tested for its performance and effectiveness.

The specific objective number one of the study was achieved when the electric light sensor was completed and worked.

Performance of electric light sensor circuit

When the voltage was zero (0), the whole resistance of the electric light sensor circuit was very low since there was no current flowing through the circuit but the resistance for light dependent resistor was high. The led was not giving light and the buzzer was not giving sound. The performance of the electric light sensor circuit looked at how the voltage varied with the resistance of the electric light sensor circuit.

At 2.00 volts, the resistance of the electric light sensor circuit was 4.75 mega ohms and from ohm's law, the current flowing through the electric light sensor was 0.421 x10-6 A. When the bulb was not covered, there was no light and the buzzer was not giving sound. This was because the resistance of the electric light sensor circuit was high and the voltage was very low. The current flowing was too

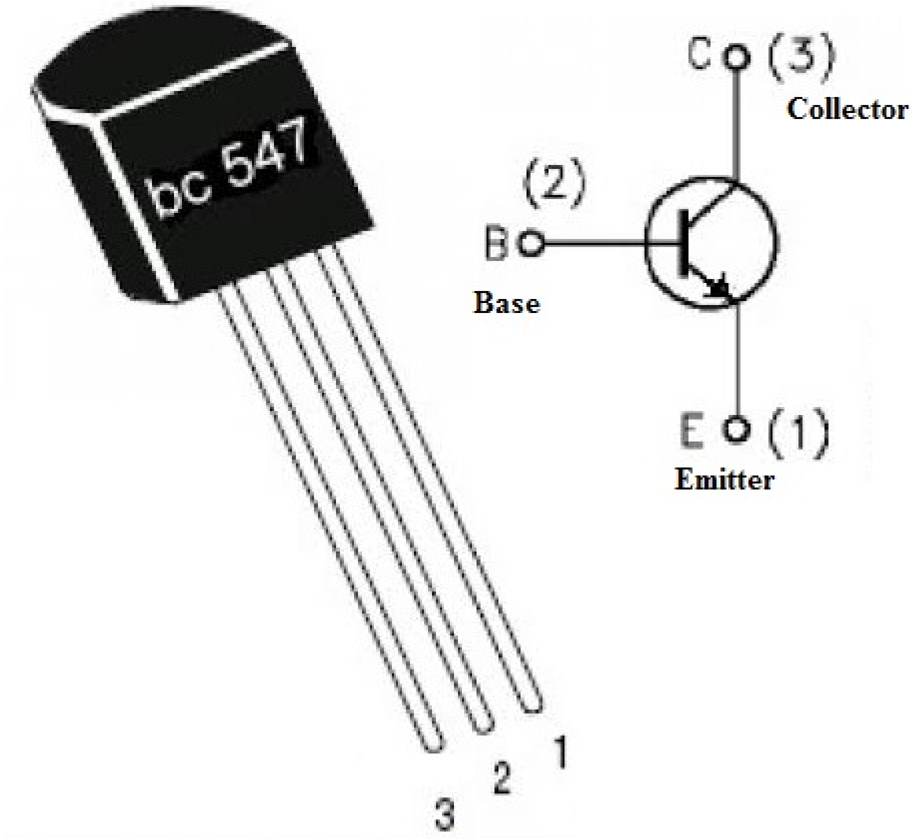

Figure 4: BC547 Transistor

Figure 5: 1kohm resistor (Tanveer, 2015)

Figure 6: 2.2 k ohm resistor(Hrovat, 2012).

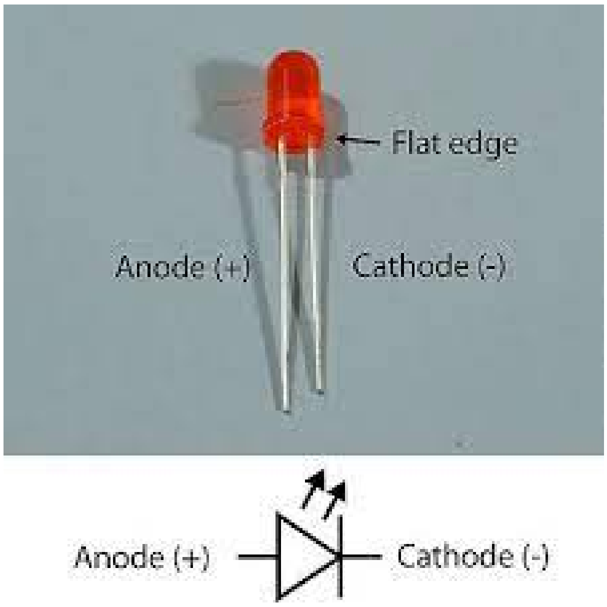

Figure 7: led (Joshi et al 2013)

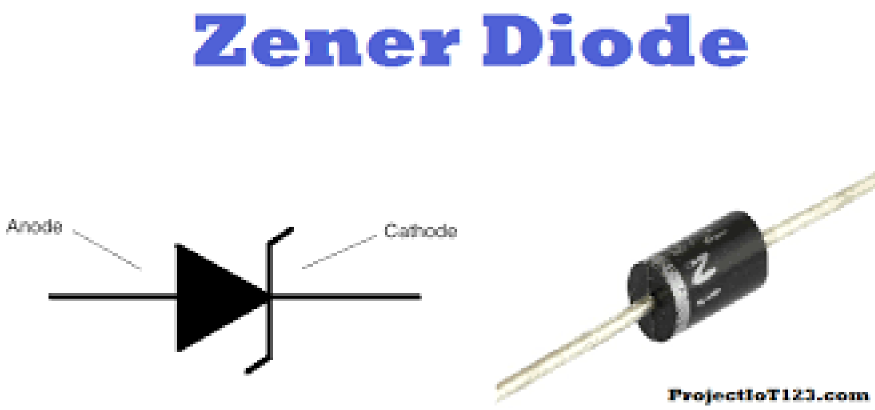

Figure 8: **zener diode**

low.

The resistance of electric light increased as the voltage was increased and at 4.5v, there was very dim light and the moderate sound produced by the buzzer. The resistance of the electric light sensor circuit was maximum when the voltage was 8.00 volts and the current flowing was 0.422x10-6

Figure 10 gave an overview of what happened when voltage from DC supply was increasing. The figure 10 showed that as the voltage was increasing, the resistance of the electric light sensor circuit was increasing so much.

V(v)	R(Ω) X10^6	I(A) X10^{-6}	Bulb	Buzzer
2.00	4.75	0.421	No light	No sound
2.50	7.95	0.314	No light	No sound
3.00	12.65	0.237	No light	No sound
3.50	14.75	0.237	No light	Very low sound
4.00	17.65	0.227	No light	Very low sound
4.50	18.50	0.243	Very dim light	Moderate low sound
5.00	18.85	0.265	Very dim light	Moderate sound
5.50	18.90	0.291	Dim light	High sound
6.00	18.95	0.317	Bright light	Moderate high sound
6.50	19.00	0.342	Bright light	Moderate high sound
7.00	19.10	0.366	Very bright light	Moderate high sound
7.50	18.85	0.398	Dim light	Very high sound
8.00	19.15	0.418	Very dim light very	Very high sound
8.50	18.95	0.449	dim light	Very high sound
9.00	18.90	0.476	Very dim light	Very high sound

Figure 9: gave an overview of the variation of the voltage with theresistance of the electric light sensor circuit and at what voltage was thebulb and buzzer able to give light and sound respectively: **variation of voltage with resistance of electric light sensor circuit, data findings 2022**

4. Discussions, Conclusions and Recommendation

4.1. Discussion of the Results

Results from the measurements carried out on the electric light sensor circuit showed that the system was able to detect between light and dark via the Light Dependent Resistor (LDR). Similarly, tests carried out on the system also showed the system was able to switch OFF or switch ON led (bulb) when light rays were incident or shaded from the LDR respectively. The control of the unit is automatic and needs no manual intervention. The advantages of the model design were: It is easy to set up, It is easy to maintain, It has faster response, The light detector automatically controls the switch OFF/ON, LDRs are small enough to fit into virtually any electronic device and LDRs are sensitive, inexpensive and readily available

devices that have good power and voltage handling capabilities similar to those of a conventional resistor.

The designed electric light sensor was unique compared to the one in the literature review "automatic door infrared electric light sensor circuit" since it cannot be switched on and off manually during the day and night.

The specific objective number 2(two) of the study was achieved since the electric light sensor was completed and its performance was tested and analyzed well. The system was able to detect between light and dark. The data given in table 1.0 gave an overview of the voltage variation with the resistance of the electric light sensor circuit. The voltage was increasing as the resistance of the electric light sensor was increasing.

However, the system needed to be installed at the corner of the building to avoid stray lights from other bulbs since stray lights would disturb its resistance to decrease

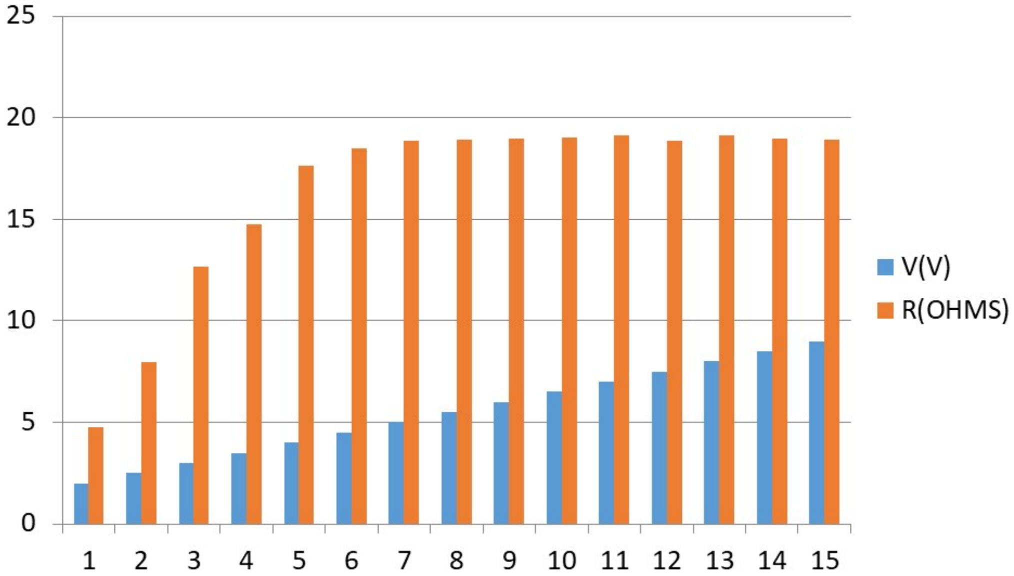

Figure 10: circuit comparison of voltage and the resistance of the electric light sensor circuit.

5. Conclusions

A detailed analysis concerning the performance of the Electric light sensor system has been performed and presented. The device performed well using a light-dependent resistor as the light sensor.

It was proven that the increase in the intensity of light falling on the light-dependent resistor as a light sensor makes the bulb (led) go off. This meant that during the day when the intensity of light was very high, the bulb (led) was off.

It was also proven that when the resistance of the light-dependent resistor sensor was very high, the bulb (led) gave maximum light since no current was flowing through the light-dependent resistor instead it was flowing through the bulb (led). This meant that at night the bulb (led) gave maximum lights since the resistance of the light-dependent resistor was high at night.

Therefore, an electrical light sensor system will be useful in both homes and other places like offices and institutions where bulbs are usually forgotten to be switched off since the system will automatically switch on and off the bulbs. The device when properly installed in a place where it cannot be affected by stray lights at night can help the user(s) to automatically switch on the bulbs.

However, the electric light sensor should be installed in a place some distance away from the bulbs (in the corners) to avoid stray lights from bulbs reaching it. The stray lights can decrease its resistance and the bulbs may dim, or may not give lights at all.

6. Recommendations:

Based on the results obtained from the design and testing of the electric light sensor system, the use of a DC (direct current) power supply has been proven most effective and will help people in different areas, since one can use a dry cell like 9 volts Duracell as well.

The following recommendations have been passed on for further research to improve and effectiveness of this system.

The system should next time be operated using dry cells and not the DC power supply. This means that people can simply use the dry cells as an alternative source of power to operate it.

The system should next time be operated using the photocell instead of the LDR to improve its effectiveness.

The system should next time be designed while including the microcontroller so that it can be programmed to perform automatic tasks

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9. References:

1) Chen, L. (2013). Sensor performance of advanced photocontrol systems.

2) Atkinson, P. (2017). The Design Journal and the meaning of designhttps://doi.org/10.1080/14606925.2017.1253247

3) Wszołek, M. (2020). When there is meaning in design? Two dimensions of the practice of designing (communication). ActaUniversitatisLodziensis. Folia LitterariaPolonica, 58(3), 237-248.https://doi.org/10.18778/1505-9057.58.13

4) Hafezi, M., Hsseinalipour, M., &Ghafoori, S. P. (2019). Design Errors in Construction Projects: The Meaning, Reasons, Consequences and Solutions. Soffeh, 29(1), 21-34.https://doi.org/10.29252/soffeh.29.1.21

5) Knudsen, L. S., &Haase, L. M. (2018). The construction of meaning in design-driven projects. In The Fifth International Conference on Design Creativity (ICDC2018) (pp. 207-214). Design Society.

6) Faroqi, A., Ramdhani, M. A., Kamelia, L., Hidayat, C., &Rofiq, A. (2018, July). Automatic water clarity monitoring and filtration system using light dependent resistor based on arduinouno. In 2018 4th International Conference on Wireless and Telematics (ICWT) (pp. 1-4). IEEE.https://doi.org/10.1109/ICWT.2018.8527786

7) Indonesia, A. M. I. M. A. M. I. N. (2020). ENHANCE DESIGNING SECURITY TOOLS USING SENSOR LIGHT DEPENDENT RESISTOR (LDR) THROUGH MOBILE PHONE Yusnidah. Journal Homepage: http://ijmr. net. in, 7(1).

8) Putri, M., &Lubis, S. A. (2018). Design of Security Tools Using Sensor Light Dependent Resistor (LDR) Through Mobile Phone. Int. J. Innov. Res. in Comp. and Comm. Eng, 4(10), 168-173.

9) Ahmmed, M. S., Chowdhury, T. Z., & Ghosh, S. K. (2018). Automatic Street Light Control System using Light Dependent Resistor and Motion Sensor. Global Journal of Research In Engineering.

10) Shaikh, V. K. V. V. F., &Viegas, J. K. M. A. E. Intelligent Automatic Street Light Control System.

11) Kunaraj, A., Mathavan, J. J., &Jayasekara, K. G. D. R. (2021). Portable Multifunction Tester Design to Check the Continuity of Wires and to Measure the Electrical Parameters. In Proceedings of International Conference on Intelligent Computing, Information and Control Systems (pp. 863-878). Springer, Singapore.https://doi.org/10.1007/978-981-15-8443-5_73

12) Darlis, A. R., Widura, A., &Andrian, M. R. (2018). Bidirectional Underwater Visible Light Communication. International Journal of Electrical and Computer Engineering (IJECE), 8(6), 5203-5214.https://doi.org/10.11591/ijece.v8i6.pp5203-5214

13) Fisher, E. M. (2018). Principles and early historical development of silicon avalanche and Geiger-mode photodiodes. Photon Counting-Fundamentals and Applications.https://doi.org/10.5772/intechopen.72148

14) Luo, X., Mao, Z., & Liu, S. (2010, June). Thermal design of a 16W LED bulb based on thermal analysis of a 4W LED bulb. In 2010 Proceedings 60th Electronic Components and Technology Conference (ECTC) (pp. 1906-1911). IEEE.https://doi.org/10.1109/ECTC.2010.5490694

15) Hrovat, M., Kielbasinski, K., Makarovič, K., Belavič, D., &Jakubowska, M. (2012). The characterisation of lead-free thick-film resistors on different low temperature Co-fired ceramics substrates. Materials Research Bulletin, 47(12), 4131-4136.https://doi.org/10.1016/j.materresbull.2012.08.066

16) Tanveer, A., Choudhary, A., Pal, D., Gupta, R., & Husain, F. (2015). Automated farming using microcontroller and sensors. International Journal of Scientific Research and Management Studies (IJSRMS), 2(1), 21-30.

17) Papalias, T. A., & Wong, M. (2006). Making sense of light sensors. Electronic Engineering Times, 10-14.

18) Ashok, M. G. S. (2021). FIRE ALARM WITH SIREN SOUND (Doctoral dissertation, SAVITRIBAI PHULE PUNE UNIVERSITY).

19) Held, G. (2016). Introduction to light emitting diode technology and applications. Auerbach publications.https://doi.org/10.1201/9781420076639

20) Alsharif, K. I., Pesch, A. H., Borra, V., Li, F. X., Cortes, P., MacDonald, E., & Choo, K. (2022). A Novel Modal Representation of Battery Dynamics. IEEE Access.https://doi.org/10.1109/ACCESS.2022.3149617

21) Ranjit, S. S. S., Ibrahim, A. F. T., Salim, S. I., & Wong, Y. C. (2009, November). Door sensors for automatic light switching system. In 2009 Third UKSim European Symposium on Computer Modeling and Simulation (pp. 574-578). IEEE.https://doi.org/10.1109/EMS.2009.75 22) Indonesia, A. M. I. M. A. M. I. N. (2020). ENHANCE DESIGNING SECURITY TOOLS USING SENSOR LIGHT DEPENDENT RESISTOR (LDR) THROUGH MOBILE PHONE Yusnidah. Journal Homepage: http://ijmr. net. in, 7(1).

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