International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

INTERNATIONAL JOURNAL OF INNOVATION AND INDUSTRIAL REVOLUTION (IJIREV)
www.gaexcellence.com/ijirev

GLOBAL ACADEMIC EXCELLENCE

AUTO MOTION SOLAR POWERED ROAD LIGHTING SYSTEM

Sufian Mohamad[1]*, Norbaiti Sidik[2], Zakariah Yusuf[3]

[1]Fakulti Kejuruteraan Elektrik, Universiti Teknologi MARA, Malaysia
sufia315@uitm.edu.my https://orcid.org/0009-0005-6917-6703
[2]Fakulti Kejuruteraan Elektrik, Universiti Teknologi MARA, Malaysia
sidiknorbaiti@uitm.edu.my https://orcid.org/0000-0002-3387-3460
[3]Fakulti Kejuruteraan Elektrik, Universiti Teknologi MARA, Malaysia
zakariahyusuf@uitm.edu.my https://orcid.org/0000-0001-5647-8474
*Corresponding Author

Article Info:

Article history:
Received date: 08.07.2026
Revised date: 28.07.2026
Accepted date: 10.08.2026
Published date: 03.09.2026

To cite this document:

Mohamad, S., Sidik, N., & Yusuf, Z. (2026). Auto Motion Solar Powered Road Lighting System. *International Journal of Innovation and Industrial Revolution, 8*(26), 97-114.

DOI: 10.35631/IJIREV.826006

Abstract:

The Auto Motion Solar Powered Road Lighting System is designed to enhance energy efficiency, safety, and environmental sustainability in urban roadways. This system integrates motion and light sensors to automatically adjust the brightness of LED lamps based on vehicle detection and ambient light levels. The lamps operate at 50% brightness under low ambient light conditions and increase to full brightness when vehicles are detected. Conventional solar-powered street lighting systems often operate at fixed illumination levels, resulting in unnecessary energy consumption during periods of low traffic. Although motion-activated lighting has been proposed, limited studies have evaluated integrated systems combining adaptive brightness control, environmental sensing, and real-time monitoring in a cost-effective solution. Powered by a solar energy system, this solution minimizes energy consumption and light pollution, contributing to a more sustainable urban environment. Additionally, an LCD display monitors and records motion counts and ambient light level, providing valuable data for further optimization. An audible alert is activated whenever motion is detected to verify sensor operation during testing. The project aims to create a cost-effective and eco-friendly lighting solution that improves road safety and reduces environmental impact.

Keyword:

Auto Motion, Energy Efficiency, Motion Detection, Smart Street Lighting, Solar-Powered.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 97-114

Introduction

In modern cities, an efficient and sustainable urban infrastructure is really needed especially in energy consumption and environmental impact which are the major concerns. Street lighting is one of the important components in urban infrastructure. It plays a crucial role in ensuring public safety and enhancing the aesthetic appeal of urban areas. However, the conventional street lighting system are often inefficient, operating at full brightness regardless of actual lighting needs. This will result in significant energy waste and contributes to environmental issues such as light pollution and increased carbon emissions.

Urban roadways require effective lighting systems to ensure the safety and visibility drivers and pedestrians, especially during nighttime or low-light conditions. Since the conventional street lighting are lack of capability to adjust their brightness based on real time conditions, leading to unnecessary energy consumption during periods of low traffic. Furthermore, continuous high-intensity lighting contributes to light pollution, which disrupts natural ecosystems, affects human health, and obscures the night sky.

By addressing these issues, there is a growing interest in making a intelligent lighting systems that can adjust their operation based on environmental and situational. A sensor technology and by using renewable energy sources present new opportunities for creating a system than enhance energy efficiency, reduce operational costs, and reduce environmental impact. This project, the Auto Motion Solar Energy Powered Road Lighting System aims to harness these technological advancements to create a smart and eco-friendly lighting system. By ensuring visibility only, when necessary, the system will not only enhance road safety but also contribute to environmental sustainability. It will also offer a cost-effective and scalable alternative that can be implemented in urban areas.

Literature Review

Most of the studies carried out related to smart street lighting systems revolve around the efficient use of energy, the reliability of a system, and how a smart control mechanism can preserve the environment. Conventional street lighting systems operate at full brightness and result in high costs and energy consumption. To overcome this problem, various solutions related to lighting have been proposed by regulating real-time traffic conditions and ambient light intensity.

This study proposes an intelligent solar-powered road lighting system that integrates motion detection, ambient light sensing, adaptive LED brightness control, and real-time monitoring within a single embedded platform.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

In this system, each streetlight works independently. Digital dimming techniques are used to reduce energy consumption when traffic flow is low. The use of LED technology can also increase efficiency with low energy consumption and a longer lifespan.

Microcontrollers like Arduino are widely used because of their low cost, flexibility, and ease of integration. The use of light-dependent resistors (LDRs) is for ambient light detection while passive infrared (PIR) or infrared (IR) sensors are for motion and vehicle detection. Energy consumption savings can be achieved when streetlights are activated only under low-light conditions and in the presence of motion.

Overall, by integrating LED technology, intelligent sensing, decentralized control, and adaptive power management in a smart street lighting system, it can provide solutions to energy and environmental issues.

Methodology

A. Introduction

This chapter describes the methodology for designing and implementing the Auto Motion Solar Powered Road Lighting System project. A systematic approach has been implemented including designing the system, hardware selection, integrating sensors, microcontroller programming in addition to functional validation. This methodology has integrated movement with ambient light sensing with LED-based illumination powered by a solar energy system to achieve energy efficiency and environmental sustainability for street lighting solutions.

This prototype was developed using an ESP32 microcontroller and integrated with a PIR motion sensor, an LDR sensor, photovoltaic panels, batteries, and LED lighting modules. The system's performance is evaluated based on simulated traffic conditions during the day and night.

B. System Block Diagram

This block diagram shows the architecture function of the Auto Motion Solar Powered Road Lighting System. This system is designed to control the brightness of streetlights based on vehicle movement and ambient light intensity, with solar energy acting as the main energy source.

To ensure continuous operation of the system, a photovoltaic panel supplies renewable energy and charges a rechargeable battery has been used. The function of the light sensor is to measure ambient illumination levels while a PIR motion sensor acts to detect the presence of vehicle movement. These sensor signals are processed by the Arduino microcontroller which acts as a central control unit. The microcontroller controls the brightness of the LED lamp through a lamp control unit based on the processed data.

A passive buzzer is activated upon motion detection to provide an audible alert, and an LCD module displays real-time system information such as ambient light levels, motion detection count, and lamp status. The LED lamps serve as the primary output, providing adaptive illumination to improve road safety and energy efficiency.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

A passive buzzer is activated when movement is detected to provide an audible alert, while an LCD module displays real-time system information such as ambient light levels, motion detection count, and lamp status. The LED lamps act as the primary output for providing adaptive illumination.

C. System Flow Description

This flowchart starts with the absorption of solar light. The energy produced from the absorption of solar light is stored in the battery. When the ambient light reaches a low level, the lights will dim to 50% brightness. While when the ambient light does not reach a low level, this system will not start.

Next, when a car is detected, the lights will dim to 100% brightness for up to 5 seconds. The buzzer is activated and this process is complete. While when the car is not detected, the system will return to 50% brightness of the dim lights.

D. Schematic Design

The schematic implementation of the system is divided into two main sections. The first section illustrates schematic diagram of Auto Motion Solar Powered Road Lighting System. The second section shows schematic diagram for Auto Motion Solar Powered Road Lighting System in Hardware Implementation.

In the schematic diagram, all components can be found such as LCD module, PIR motion sensor, and ambient light sensor with the Arduino. The PIR sensor provides motion detection signals, while the light sensor supplies ambient illumination data. The LCD module displays real-time operational information. These inputs enable the microcontroller to dynamically control the lighting system based on environmental and traffic conditions.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 97-114

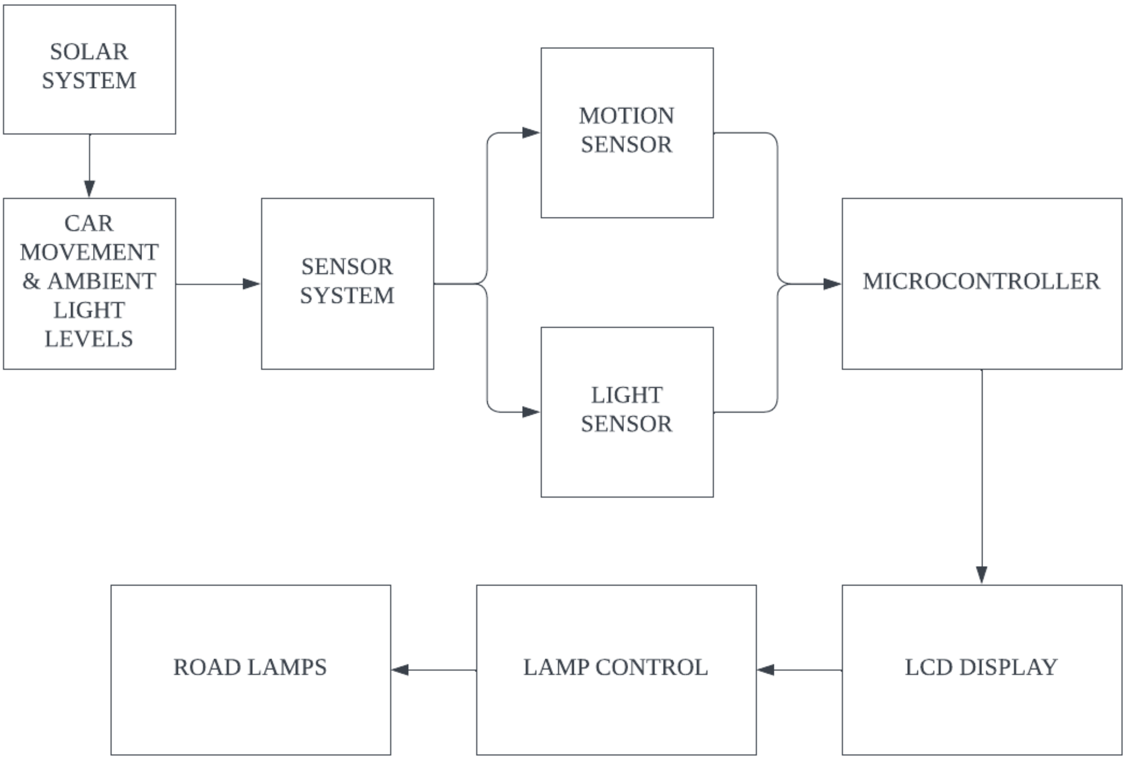

Figure 3.1 Block Diagram of the Auto Motion Solar Powered Road Lighting System

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 97-114

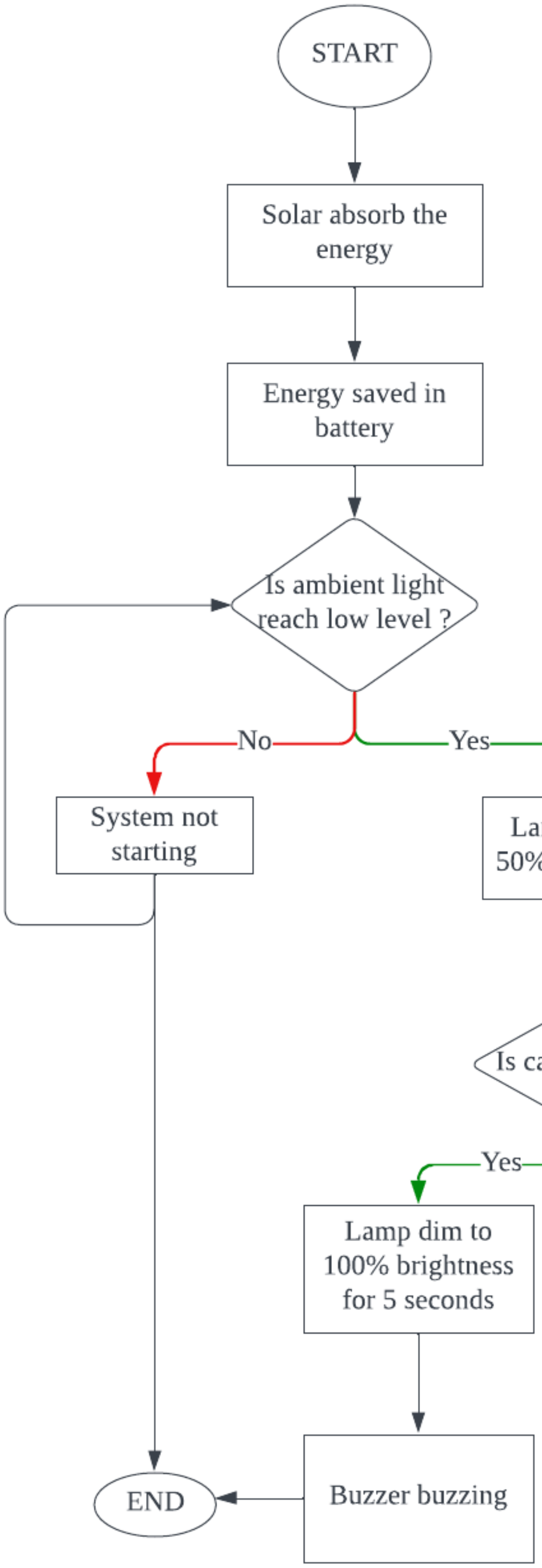

Figure 3.2 Flowchart for Auto Motion Solar Powered Road Lighting System

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

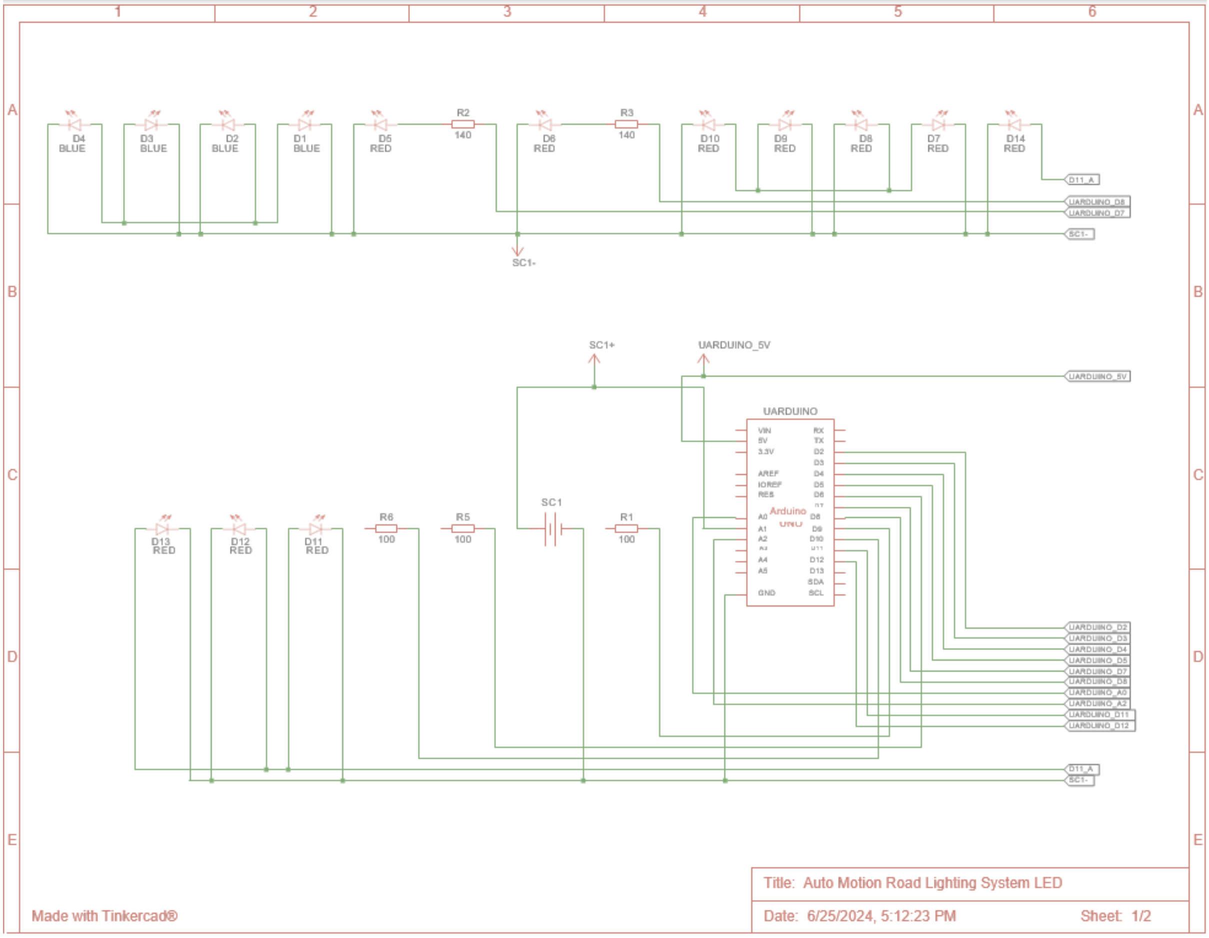

Figure 3.3 Schematic Diagram of Auto Motion Solar Powered Road Lighting System

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 97-114

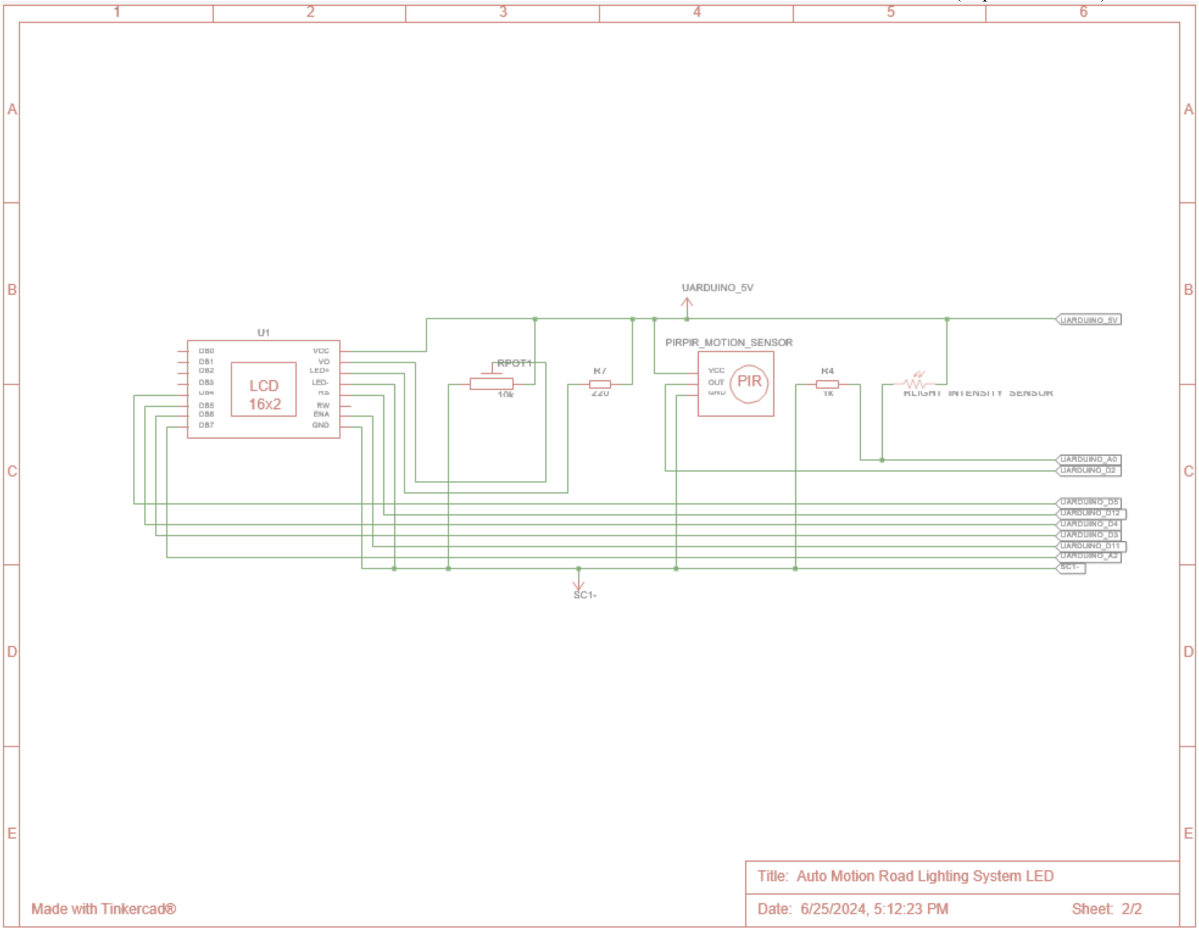

Figure 3.4 Schematic Diagram for Auto Motion Solar Powered Road Lighting System

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

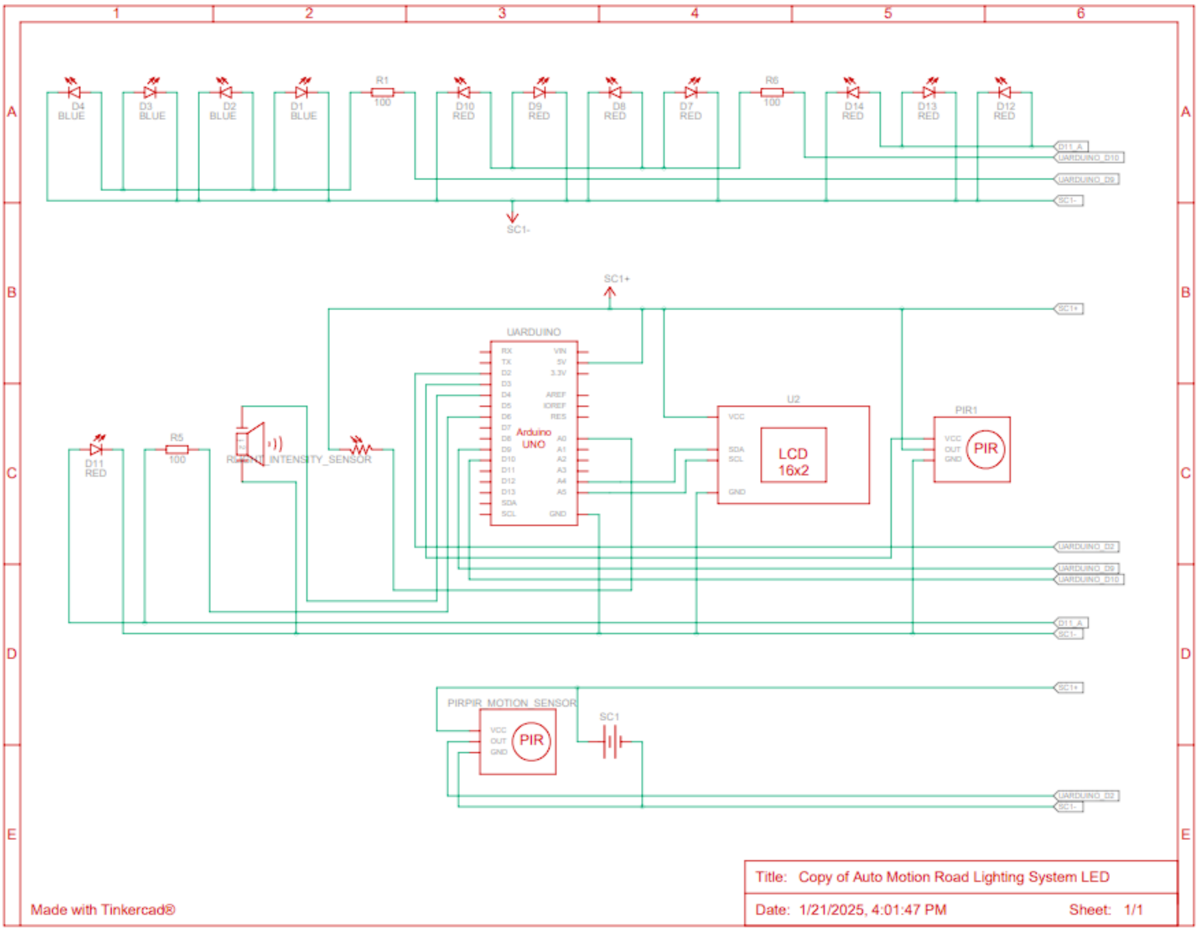

Figure 3.5 Schematic Diagram for Auto Motion Solar Powered Road Lighting System in Hardware Implementation

Results

Software Simulation

Software simulation is done to see the results produced by solar energy, ambient light, and motion detection.

Solar Monitoring

LED indicators are used to see the solar efficiency. 100% absorption will light 2 LEDs, 50% absorption will light 1 LED, while when there is no absorption at all, which is 0%, the LED will not light. This shows that the reduction in electricity consumption can be done when the absorption rate is adjusted. In this way, it can be a simple method to optimize renewable energy usage.

Ambient Light Monitoring

The light sensor signal found on the Arduino will activate the LED when the ambient light is low, to ensure sufficient lighting at night. When the ambient light is high, the LED will turn

International Journal of
Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

off, and the LCD display will display the lighting status of the lamp, so it can save energy during the day.

Motion Detection Monitoring

When there is no movement, the LED will operate at 50% brightness (10.2 mA). When there is movement, the LED brightness will continue to increase to 100%. This will be displayed on the LCD. This proves that dynamic lighting can be controlled, while also improving road safety and reducing energy consumption.

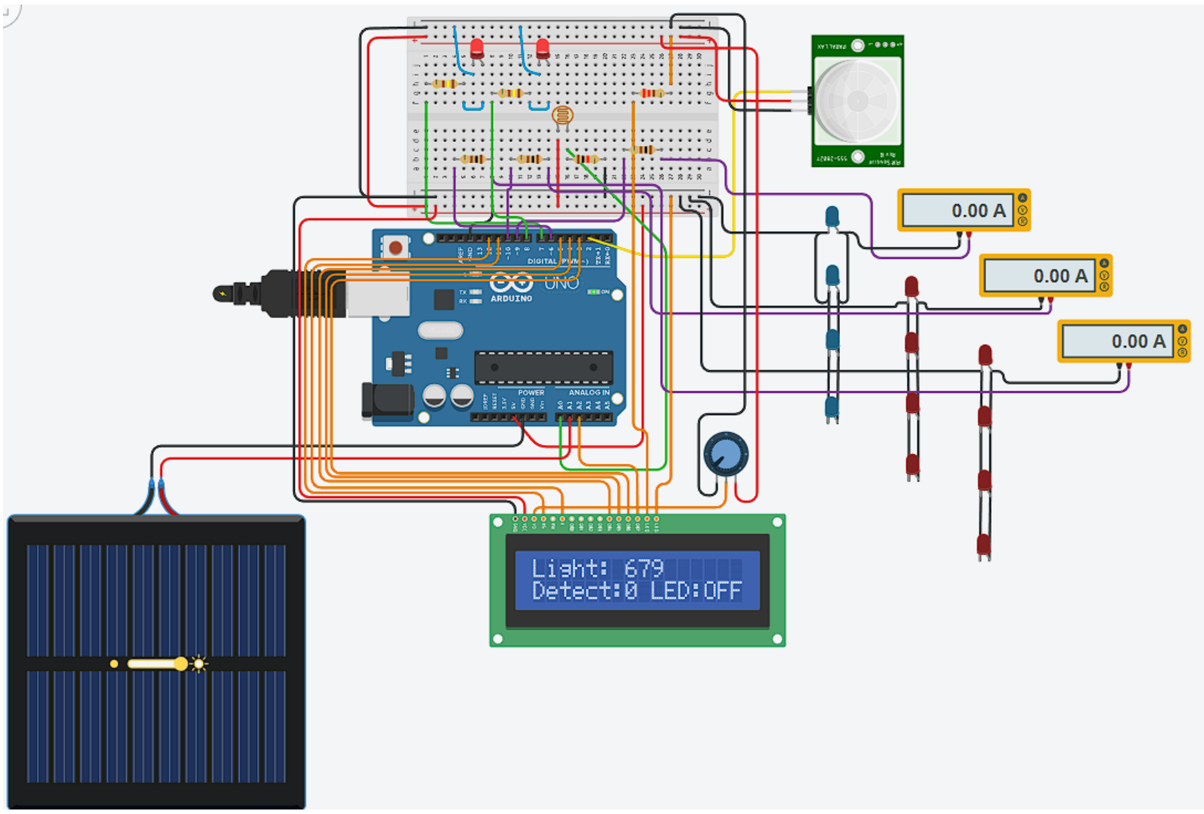

Figure 4.1 Simulation Result for Condition 1 Of Solar Monitoring

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

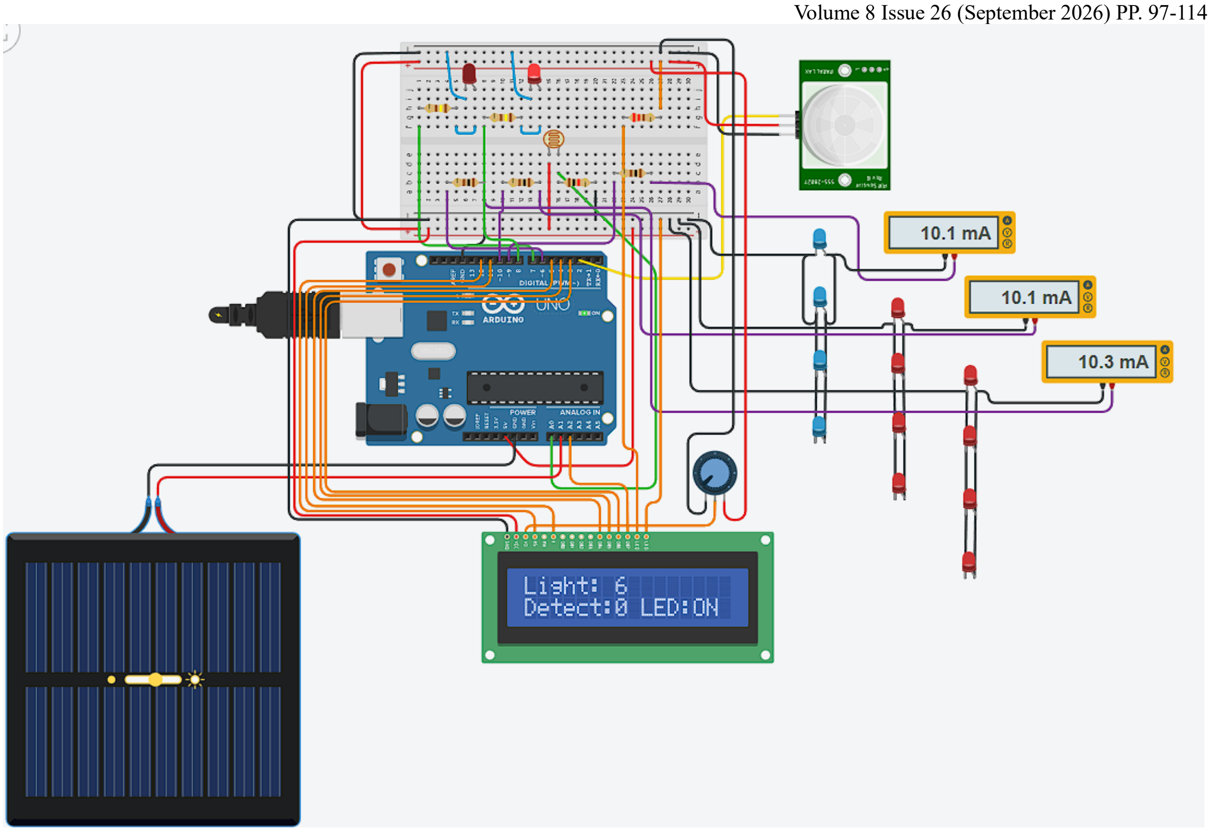

Figure 4.2 Simulation Result for Condition 2 Of Solar Monitoring

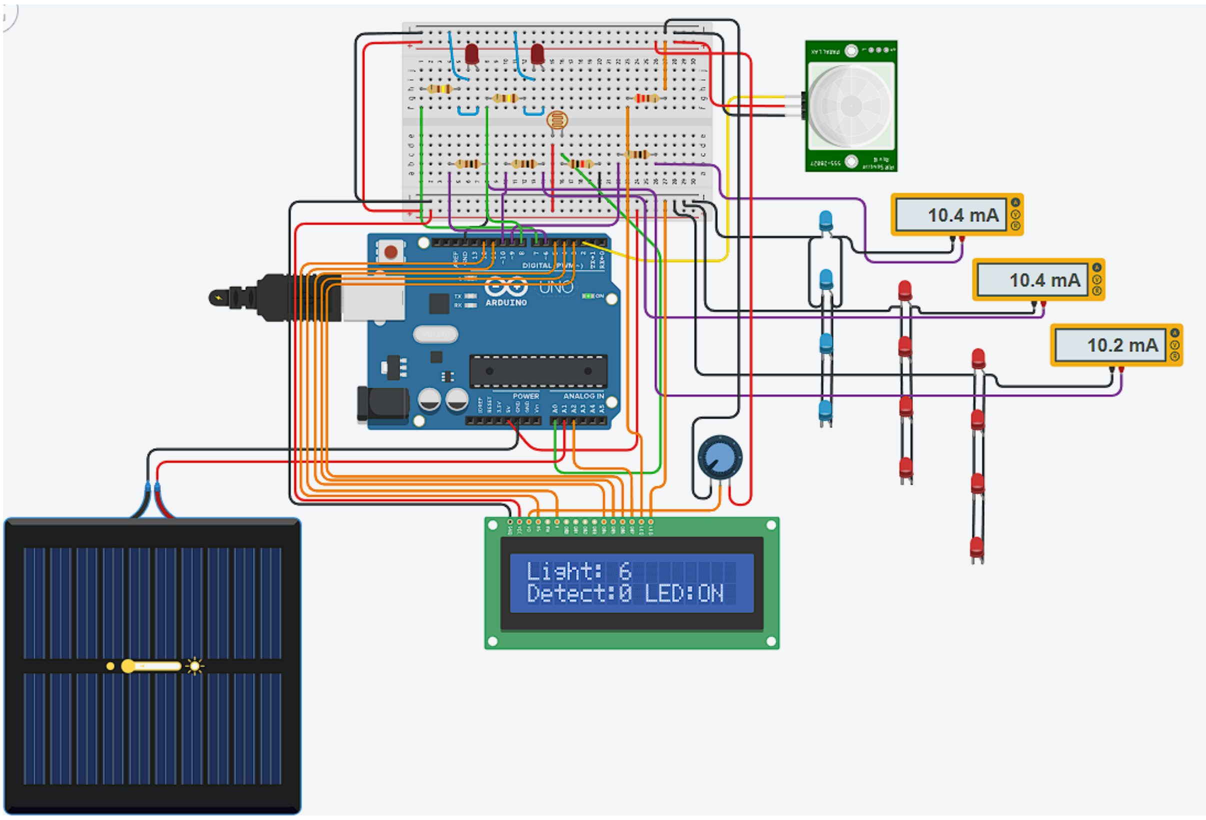

Figure 4.3 Simulation Result For Condition 3 Of Solar Monitoring

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

Ambient Light Monitoring

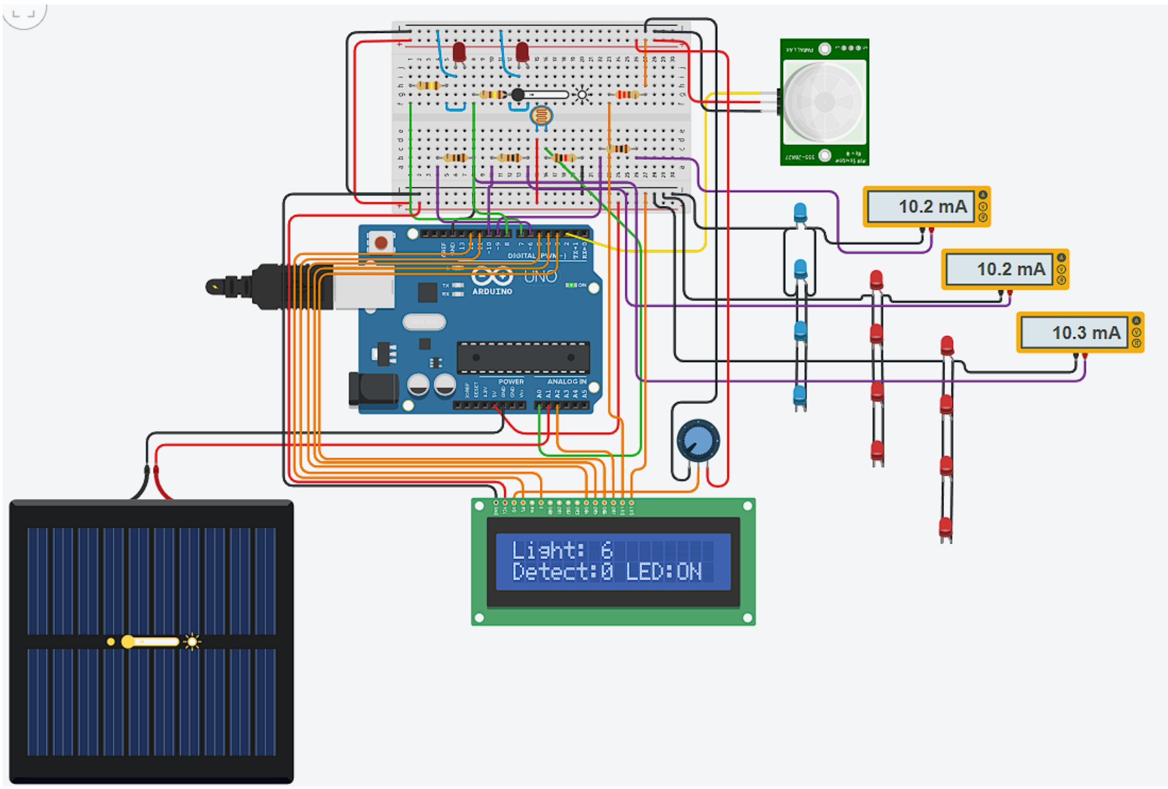

Figure 4.4 Simulation Result for Condition 1 of Ambient Light Monitoring

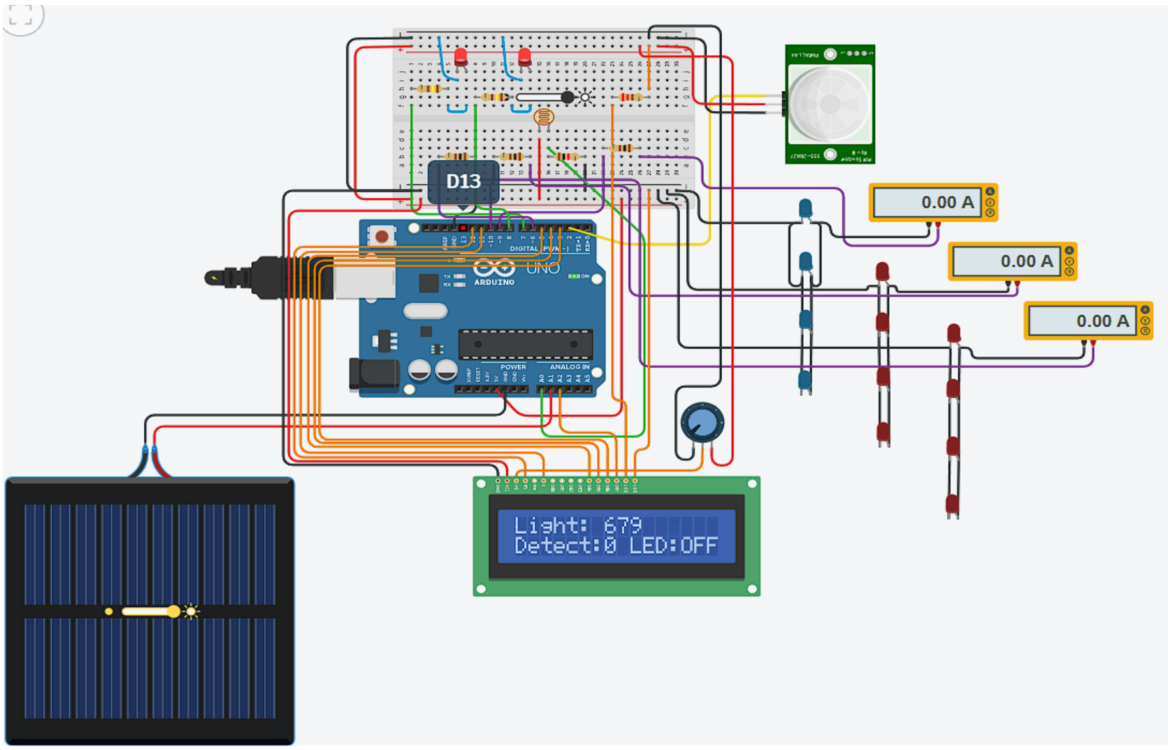

Figure 4.5 Simulation Result for Condition 2 of Ambient Light Monitoring

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 97-114

Motion Detection Monitoring

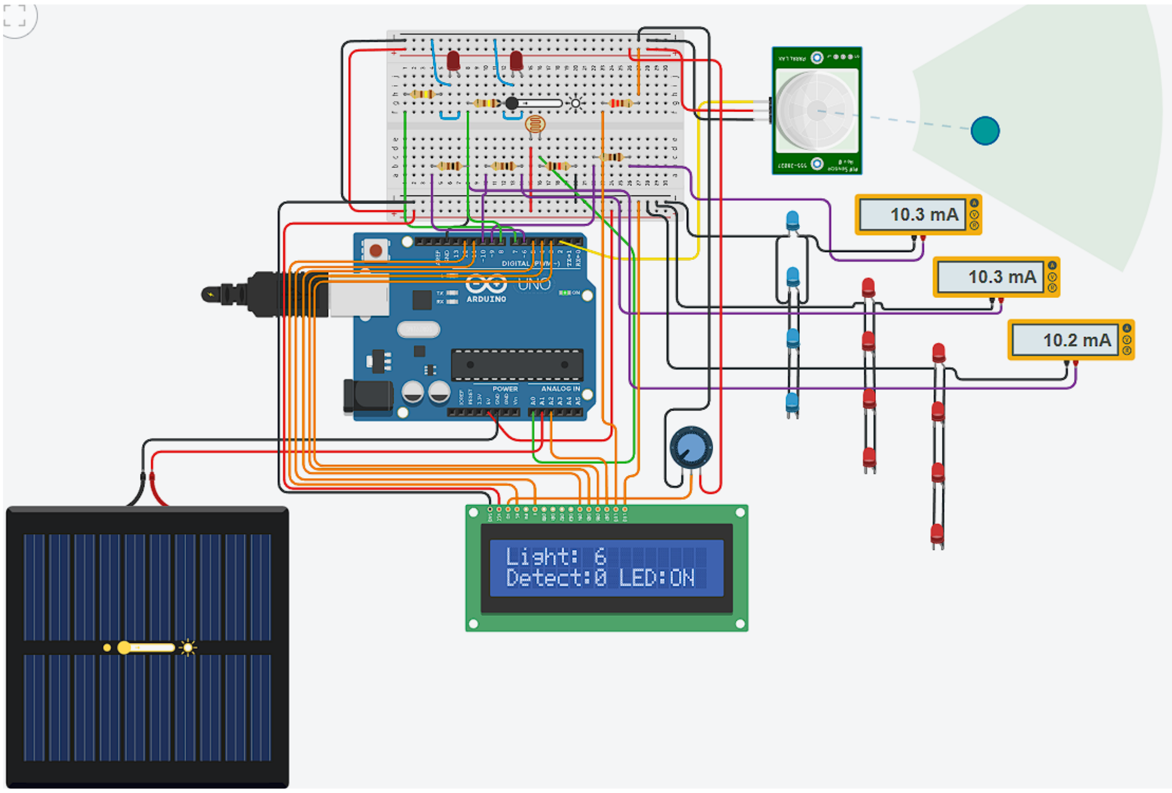

Figure 4.6 Simulation Result for Condition 1 of Motion Detection Monitoring

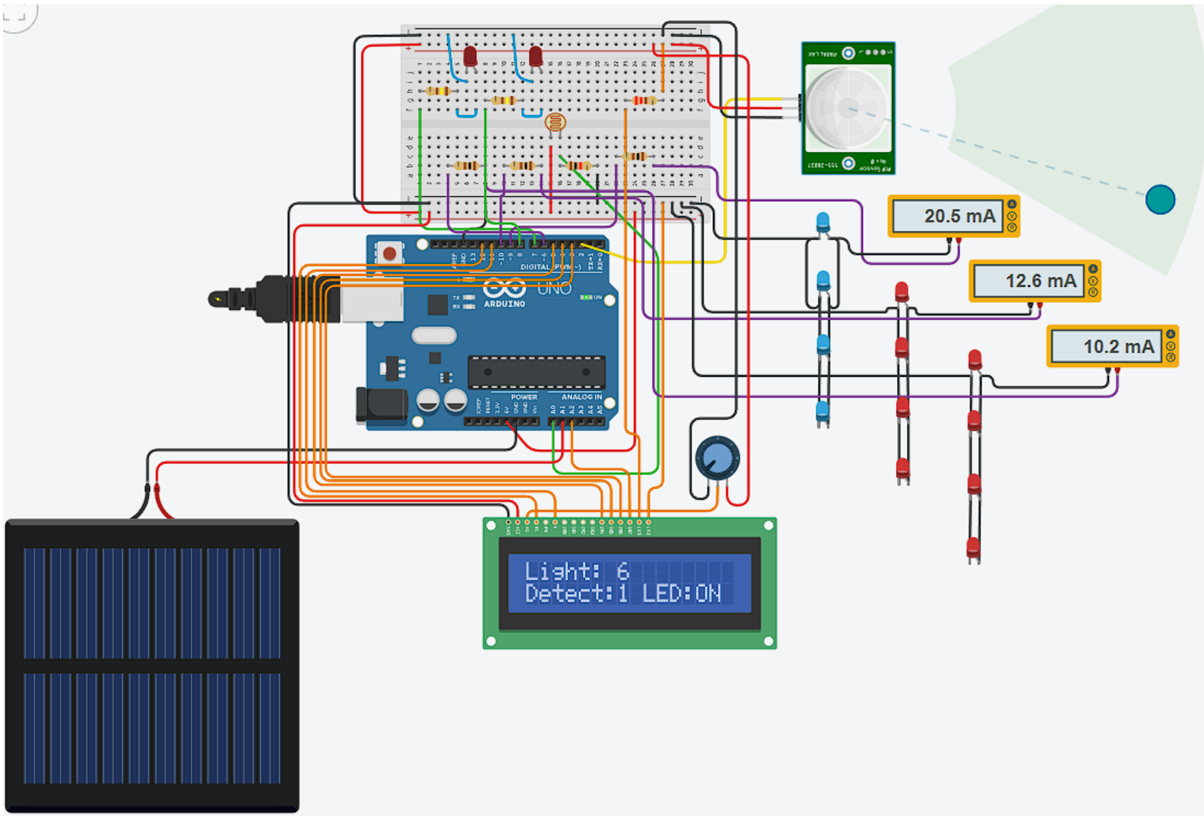

Figure 4.7 Simulation Result for Condition 2 of Motion Detection Monitoring

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

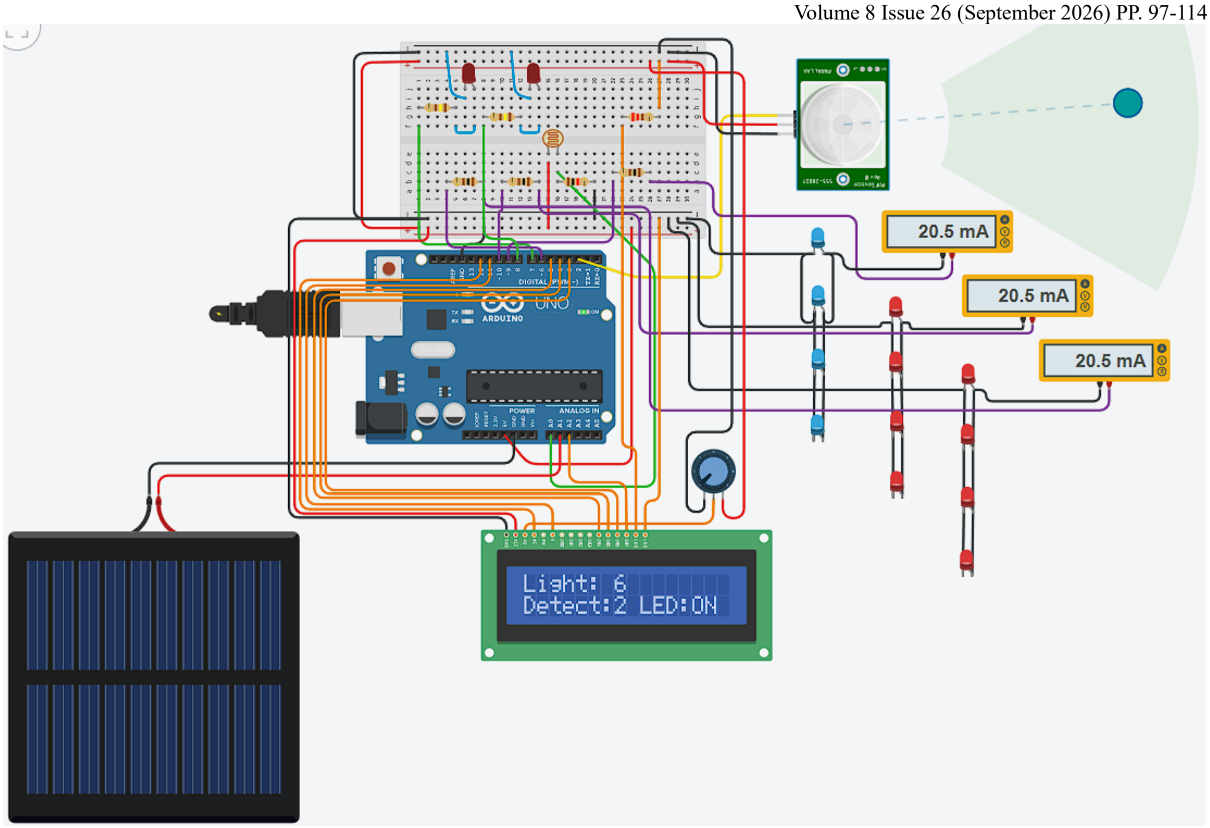

Figure 4.8 Simulation Result for Condition 3 of Motion Detection Monitoring

Proteus is used to design PCBs by integrating circuit simulation and PCB layout. Work begins with designing and simulating the circuit to ensure that the connections work properly. Once validated, the design is converted into a PCB layout. Proteus can also efficiently place components, transforming the shape from a virtual circuit to a physical board.

International Journal of
Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

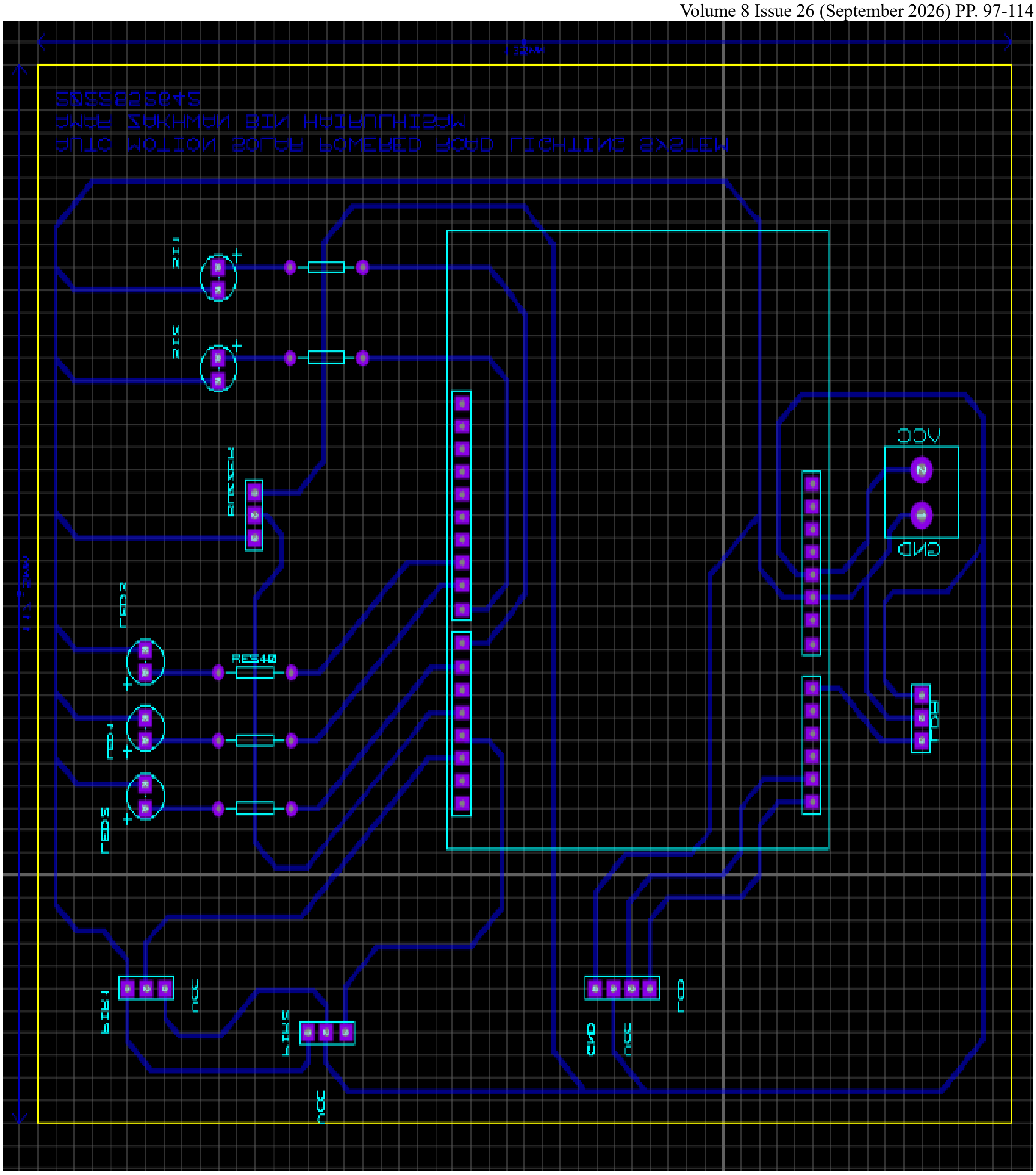

Figure 4.9 The Final Design of PCB Board using Proteus

Conclusion

The Auto Motion Solar Powered Road Lighting System is a solution to improve energy efficiency, road safety, and sustainability in street lighting systems. By integrating light and motion sensors with solar powered LEDs, the system will adapt based on current traffic and light conditions. Simulation results show that the LEDs operate by reducing brightness during periods of low traffic and increasing brightness when there is movement, ensuring optimal lighting while conserving energy. Real-time feedback is provided via an LCD display, monitoring and maintenance facilities. This approach can reduce energy consumption, operational costs, and offer a more environmentally friendly street lighting system.

Acknowledgements:	The authors would like to express their sincere gratitude to Universiti Teknologi MARA for providing the necessary resources and support throughout the course of this research. Special appreciation is extended to colleagues and peers who contributed valuable insights and constructive feedback, which greatly enhanced the quality of this paper.
Funding Statement:	No Funding
Conflict of Interest Statement:	The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Innovation and Industrial Revolution (IJIREV).
Ethics Statement:	This study did not involve any human participants, animals, or sensitive data requiring ethical approval. The authors confirm that the research was conducted in accordance with accepted academic integrity and ethical publishing standards.
Author Contribution Statement:	All authors contributed significantly to the development of this manuscript. Sufian bin Mohamad was responsible for the conceptualization, methodology, and overall supervision of the study. Norbaiti binti Sidik handled data collection, analysis, and interpretation of results. Zakariah bin Yusuf contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

References

Akanksha, M. B., Jambhulkar, D. C., Padghan, P. A., & Yawa, N. V. (2020). Hybrid power generation for highway application. *International Journal of Advances in Engineering and Management, 2*(7), 657–661. https://doi.org/10.35629/5252-0207657661

Al-Smadi, A. M., Salah, S. T., Al-Moomani, A. A., & Al-Bataineh, M. S. (2019). Street lighting energy-saving system. *2019 16th International Multi-Conference on Systems, Signals & Devices (SSD)*, 763–766. https://doi.org/10.1109/SSD.2019.8893160

Attia, H., Takruri, M., & Omar, A. (2022). Design and implementation of decentralized streetlight dimming system for different motion sensor strengths and unlimited light poles. *2022 International Conference on Electrical and Computing Technologies and Applications (ICECTA)*, 63–67. https://doi.org/10.1109/ICECTA57148.2022.9990126

Faid, M. S., Shariff, N. N. M., Hamidi, Z. S., Sabri, S. N. U., Zainol, N. H., Husien, N. H., & Ali, M. O. (2016). Monitoring the level of light pollution and its impact on astronomical bodies naked-eye visibility range in selected areas in Malaysia using Sky Quality Meter. *2016 International Conference on Industrial Engineering, Management Science and Application (ICIMSA)*, 1–6. https://doi.org/10.1109/ICIMSA.2016.7504020

Jiang, W., Wang, T., Yuan, D., Sha, A., Zhang, S., Zhang, Y., Xiao, J., & Xing, C. (2024). Available solar resources and photovoltaic system planning strategy for highway. *Renewable and Sustainable Energy Reviews, 203*, Article 114765. https://doi.org/10.1016/j.rser.2024.114765

Jung, J., Han, S. U., & Kim, B. (2019). Digital numerical map-oriented estimation of solar energy potential for site selection of photovoltaic solar panels on national highway slopes. *Applied Energy, 242*, 57–68. https://doi.org/10.1016/j.apenergy.2019.03.101

Kyuchukov, T. (2019). Light pollution—"Borders" of lighting design. *2019 Second Balkan Junior Conference on Lighting (Balkan Light Junior)*, 1–5. https://doi.org/10.1109/BLJ.2019.8883614

Nguyen, V. C., Wang, C.-T., & Hsieh, Y.-J. (2021). Electrification of highway transportation with solar and wind energy. *Sustainability, 13*(10), Article 5456. https://doi.org/10.3390/su13105456

Ntshangase, M. S., Langa, H. M., & Mathaba, T. N. D. (2024). Energy efficient control approach for street lighting. *2024 International Conference on Science, Engineering and Business for Driving Sustainable Development Goals (SEB4SDG)*, 1–7. https://doi.org/10.1109/SEB4SDG60871.2024.10629873

Petrinska, I., & Ivanov, D. (2020). Estimation of the light pollution, introduced by the architectural lighting of an educational building. *2020 Fifth Junior Conference on Lighting (Lighting)*, 1–4. https://doi.org/10.1109/Lighting47792.2020.9240557

Pinto, R. A., Roncalio, J. G., & do Prado, R. N. (2013). Street lighting system using light emitting diode (LEDs) supplied by the mains and by batteries. *2013 International Conference on New Concepts in Smart Cities: Fostering Public and Private Alliances (SmartMILE)*, 1–7. https://doi.org/10.1109/SmartMILE.2013.6708204

Sailesh, B. S. A., Madhavi, S. A., Venkata, G. P., Sravanthi, I., Kiran, K. B. S., & Venkateswara Rao, C. (2021). Arduino based smart street light system. *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)*, 657–660. https://doi.org/10.1109/ICAC3N53548.2021.9725439

Savla, D. V., Savla, H. R., & Kansara, K. B. (2018). Brainy streets: An automatic lighting system. *2018 2nd International Conference on Inventive Systems and Control (ICISC)*, 16–21. https://doi.org/10.1109/ICISC.2018.8399064

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 97-114

Sharma, P., & Harinarayana, T. (2013). Solar energy generation potential along national highways. *International Journal of Energy and Environmental Engineering, 4*(1), Article 16. https://doi.org/10.1186/2251-6832-4-16

Zahran, E.-S. M. M., Tan, S. J., Yap, Y. H., Tan, E. H., Pena, C. M. F., Yee, H. F., & Uddin, M. R. (2019). An investigation into the impact of alternate road lighting on road traffic accident hotspots using spatial analysis. *2019 4th International Conference on Intelligent Transportation Engineering (ICITE)*, 242–246. https://doi.org/10.1109/ICITE.2019.8880263

Zhang, K., Chen, M., Yang, Y., Zhong, T., Zhu, R., Zhang, F., Qian, Z., Lü, G., & Yan, J. (2022). Quantifying the photovoltaic potential of highways in China. *Applied Energy, 324*, Article 119600. https://doi.org/10.1016/j.apenergy.2022.119600