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Solar Lights for Highways with Zone-Wise Speed Control System for Vehicle

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ABSTRACT

The challenge of providing adequate lighting along highways, particularly at critical points such as sharp turns and speed breakers, poses significant safety concerns. Traditional energy sources often fail to meet the demands of continuous lighting, especially in remote areas. To tackle this challenge, we present an automatic lighting system aimed at selectively activating lights during nighttime while also reducing vehicle speed near or at danger zones.

Entire system is designed as automatic, human involvement is not required; lights are controlled automatically by sensing the vehicles. Whenever the vehicle enters into the danger zone, lights will be energized and they remain in ON state until the vehicle leaves that area. The system will be activated automatically during dark. In this method precious energy acquired from the solar panel can be saved. During the day time the battery will be charged and this stored energy is utilized in the nights[10]. It is a novel approach to vehicle navigation and safety implementation, and also aimed at automatically sensing the areas/zones like Schools, Hospital Accident, etc and automatically reducing the speed of the vehicle for safety purposes.

Key words: 555 Timer, LDR, 89C2051 & 89C52 ATMEL Microcontrollers, TSOP 1738, LM 567 Tone Decoder, Relays, BC547 NPN Transistor, 7805 & 7815 Voltage Regulators

1. INTRODUCTION

The research can be delineated into two distinct sections: the implementation of a solar highway lighting system and the development of zone-wise speed control for vehicles. The "Solar Lights for Highways" is aimed at clearing the traffic on highway roads where there is no conventional power supply available and reducing energy consumption. The whole system works based on solar energy as a power supply, so it can be charged in the daytime and work at night. No exterior power supply is needed. It works safely and efficiently. Whenever a vehicle comes near the infrared transmitter microcontroller turns on the lamp, it turns on automatically based on the natural light at night and turns off in daytime; no operator is required and it works steadily and reliably with long-term use.

"Solar Lights for Highways," focuses on mitigating traffic congestion on highway roads, especially in areas lacking conventional power supply infrastructure. This innovative system operates solely on solar energy, enabling charging during daylight hours for nighttime illumination without the need for external power sources. By harnessing solar power[6], the system reduces energy consumption and environmental impact while ensuring safe and efficient highway operations[7]. The system's autonomous operation is facilitated by infrared sensors, which detect vehicle presence and trigger the activation of lamps. Additionally, a microcontroller governs the lighting system, automatically adjusting lamp functionality based on natural light conditions, thus enhancing reliability and longevity without requiring manual intervention.

"Zone-Wise Speed Control," the focus shifts to enhancing vehicle safety through dynamic speed regulation in designated zones[5]. This adaptive control mechanism aims to reduce the risk of accidents by automatically adjusting vehicle speed near or at danger zones[1]. By leveraging advanced sensing technology, the system ensures seamless integration with existing infrastructure while promoting safe driving practices.

2. PRELIMINARIES AND RELATED WORKS

2.1 Enhance Road Safety

To reduce accidents and increase safety for the vehicle drivers at night times four infrared sensors associated with infrared signal generator and detection are incorporated at sharp curve and speed breaker simulation. Accordingly, two lamp posts are designed to provide lighting effects for the following pathways (a) Lamp Post 1 is designed with high-glow LEDs and it is arranged at the speed breaker[7] (b) Lamp Post 2 is designed with high-glow LEDs arranged at the sharp curve. For making fast decisions, the presence of the vehicle is monitored through infrared detection, and for providing lights, a microcontroller-based circuit is designed.

To ensure continuous operation under varying weather and atmospheric conditions, a battery-based solar panel generating a 12V DC voltage is incorporated into the design. During periods of low light or at night, the 12V battery sustains circuit operation[8]. Provisions are made for solar panel charging during sunlight hours, ensuring uninterrupted functionality by replenishing the battery when sunlight is available[10].

This can be further enhanced by using a number of infrared sensors at various vulnerable locations so that it can take care of the entire stretch of lengthy roads such as national corridors, coastal corridors, national highways, and subways, across the length and breadth of the country with associated circuitry. However, it involves huge investment/Infrastructure and dedicated continuous maintenance.

2.2 Automated Lighting

For demonstration purposes, a small-scale model comprising four infrared sensors/detection circuits is selected to illustrate the design concept. Since the infrared signal is free from noise, pollution, dust, humidity, temperature, and lighting conditions, sensors are based on infrared radiation. The sensors are mounted on either side of the road such that normally when there is no traffic flow the generator emanates infrared radiation and the detector detects the infrared emanated from the generator and gives a suitable signal to the Microcontroller saying that there is no traffic flow on the road. Whenever a vehicle crosses the first set of sensors controller energizes the relay–1 to light the lamp post1 to give an advanced cautious indication to the vehicle driver before coming to the speed breaker such that the driver will reduce the speed of the vehicle so that accidents can be avoided. As we know way roads especially single-lane roads generally pass through small towns and villages. It’s pretty hard or complicated to provide the lights throughout the highway road. So, to overcome this problem we preferred the non-conventional source of energy to provide the lighting system. Moreover, the lights are pretty much essential at the speed breakers and sharp turnings where the speed of the vehicles should be decreased at such points.

During day time that’s not a big problem as the visibility will be very much clear. But during night time as the vision will not be that much clear, the lights should be operated at such critical places sensing the presence of the vehicle. One more important feature is designed based on power saving. As the energy generated from the nonconventional source i.e., solar energy is stored in the battery, the same is used for operating the lights[9]. But as the energy is precious generated from the sun, the lights at the critical places need not be operated through the night. But the requirement is when the vehicles come to those particular points only. So by constructing the sensing circuits using infrared sensors the presence of the vehicle is sensed and the lights at the critical points are switched ON and switched OFF automatically. As these lights are to be operated during night time only, a natural light sensing circuit is designed for sensing the natural light using LDR (Light Dependent Resistor). So the entire circuit will be activated during the night time only and during the day time sensing the natural light the system will be switched OFF.

Here a proto-type module of the above-mentioned concept is designed with an 89C51 microcontroller unit, four pairs of IR sensors, and a triggering circuit for sensing the natural light. The sensing circuits are arranged on either side of the road at the sharp turning 3 and at the speed breaker. Two pairs of IR sensors for these two critical points (sharp curve and speed breaker). Whenever the sensor is obstructed the controller energizes the relay by which the lights at the the sharp turning will be activated. And when the sensor after turning is obstructed the controller deactivates the relay by which the lights will be switched OFF. And in the same manner the light present at the speed breaker will also be activated and deactivated by sensing the vehicle. The entire system will operate in the above-mentioned manner only during the night time and the entire lights will be OFF if no vehicle is passing through the highway. The natural light sensing circuit is designed with LDR and the triggering circuit is constructed using a 555-timer chip. Here lamp posts are designed with brilliant modern LED lights[7]; LED street lighting is the future technology – pleasing both treasurers and taxpayers as they are remarkably lighter, clearly longer lived[6], and much more energy efficient. Security also is enhanced as dark areas and long shadows belong to the past.

Similarly, where the roads are in a curved manner these types of sensor arrangements are essential so that accidents can be avoided, since the accidents will occur in a very short time which causes a lot of human loss and property loss. This loss cannot be restored/retrieved. Particularly Human loss cannot be replaced by any means. Hence, considering all the above situations gives better results and better investment and takes care of the needs of society. It also satisfies the Human living environments.

The ATMEL 89C2051 is an 8-bit controller, the internal Architecture is similar to the 8031 cores. The most popular and used architecture is Intel’s 8031. Market acceptance of this particular family has driven many semiconductor manufacturers to develop something new based on this particular architecture. The 8031 contains a variety of configurations; even after 25 years of existence, semiconductor manufacturers still come out with some kind of device using these 8031 cores. Since this mainly focuses on the ATMEL 89C51 8-bit microcontroller, it is essential to understand the basics of the microcontroller.

3. LITERATURE SURVEY

Divya Pujar, Jyothika.P, Anupama Naik, Mahant.G.Kattimani, “Solar Highway Lighting System with Auto Turn Off On Day Time with LCD Display”, 2020

This paper presents a solar highway lighting system designed with an auto turn-off feature during the day, aiming to contribute to energy efficiency and smart city initiatives. The integration of an LCD display enhances real-time information dissemination, aligning with modern trends in infrastructure development. Key Components: Solar-powered highway lighting system for energy efficiency. Auto turn-off feature during daylight hours. Integration of an LCD display for real-time information. Contribution to smart city initiatives by incorporating automation in energy management. Contributions: The paper provides a novel approach to highway lighting by introducing solar-powered systems with auto turn-off functionality. The LCD display not only contributes to energy awareness but also aligns with the broader goals of creating intelligent and sustainable urban infrastructure. Challenges and Future Work: While the solar highway lighting system presented in the paper shows promise, challenges related to reliability, cost-effectiveness, and adaptability to diverse environmental conditions are acknowledged. Future research directions may involve refining the system design, exploring advanced energy storage solutions, and conducting field trials for practical validation.

Prof. L Srinivasan, Janav S, Monisha S M, Pavan Kumar M G, "Solar-based Automatic Speed Control of Vehicles in Sensitive Zones", 2020

The paper explores the application of solar energy in traffic management, specifically focusing on the automatic speed control of vehicles within sensitive zones. The research aims to provide an eco-friendly and sustainable solution to enhance safety in areas with high pedestrian activity and residential neighborhoods. Key Components: Integration of solar power for continuous and sustainable operation. Automatic speed control mechanisms utilizing sensors and communication systems[4]. Implementation in sensitive zones such as school zones and residential areas. The inclusion of an LCD display for realtime information dissemination. Contributions: The paper contributes to the growing field of solar-based traffic management by introducing an automatic speed control system tailored for sensitive zones[3]. The integration of solar power ensures energy efficiency, and the LCD display enhances driver awareness, promoting safer driving practices. Challenges and Future Work: While the paper highlights the potential benefits of the proposed system, challenges related to reliability, cost-effectiveness, and adaptability to diverse traffic conditions are acknowledged. Future research directions may involve optimizing system efficiency, incorporating machine learning for adaptive control, and addressing scalability concerns.

4. NOVELTY

Our approach lies in the integration of solar-powered street lights with a unique activation mechanism based on natural light conditions. Unlike traditional street lighting systems that operate continuously, our system harnesses solar energy to power the street lights, ensuring sustainability and reducing dependency on conventional energy sources. What sets our system apart is its intelligent activation feature, which synchronizes the lighting operation with natural light cycles. By utilizing light sensors, our system automatically turns on the street lights only during nighttime, optimizing energy usage and minimizing light pollution. This innovative approach not only enhances efficiency and environmental sustainability but also ensures that street lighting is provided precisely when needed, thereby improving safety and reducing energy consumption. This integration of solar-powered street lights with intelligent activation represents a significant advancement in street lighting technology, offering a practical and sustainable solution for urban and rural areas alike.

Zone-wise speed control system lies in its sophisticated and context-aware approach to enhancing road safety in critical areas such as school zones and hospital zones. Unlike conventional speed control systems that typically apply static speed limits across all road segments, our system dynamically adjusts vehicle speed limits based on real-time conditions and specific zone characteristics.

Our system incorporates a comprehensive set of parameters and contextual factors to dynamically adjust speed limits within each zone. These factors may include time of day, traffic density, pedestrian activity, and proximity to school or hospital entrances. For instance, during peak school hours, the system automatically reduces speed limits in school zones to ensure the safety of students and pedestrians crossing the road. Similarly, in hospital zones, speed limits may be lowered to accommodate emergency vehicles and maintain a safe environment for patients and healthcare personnel.

5. PROPOSED MODEL

The current street lighting system efficiently turns off during the day, emphasizing energy conservation. However, the proposed model introduces a comprehensive enhancement by incorporating intelligent nighttime features. This advanced system not only ensures lights are turned off during the day but also employs vehicle detection technology at night. By dynamically adjusting street light intensity based on detected vehicle presence, the model aims to optimize energy consumption while significantly improving safety. Additionally, the introduction of speed control zones within specified areas further contributes to road safety, aligning with the broader vision of creating smarter and more secure urban environments[2].

Central to the model is a sophisticated solar energy harvesting system that utilizes high-efficiency solar panels seamlessly integrated into the vehicle's design. These panels cover suitable surfaces, such as the roof, to maximize solar energy capture. Advanced solar energy conversion technology efficiently transforms sunlight into electrical power, which can be utilized to power various onboard systems and auxiliary functions. Additionally, the model incorporates energy storage solutions, such as high-capacity batteries or supercapacitors, to store surplus energy generated during daylight hours for use during periods of low sunlight or high demand.

6. BLOCK DIAGRAM

6.1 Solar Lighting for Vehicles

Figure 1 shows the block diagram for Solar lighting for vehicles.

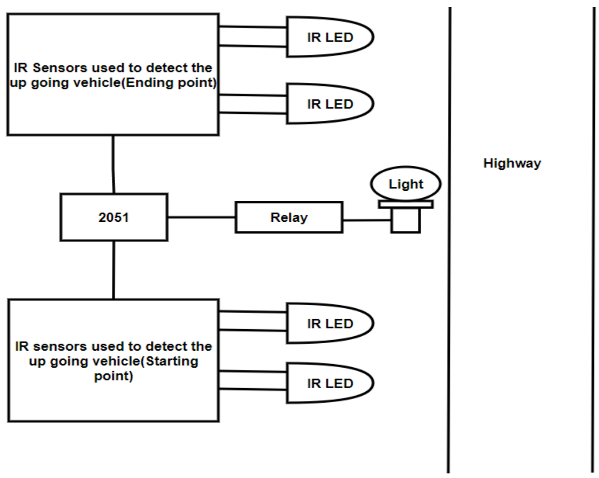

Figure 1: Block Diagram of solar lights on highway

6.2 Zone-wise Speed Control

Figure 2 shows the block diagram for zone-wise speed control for vehicles.

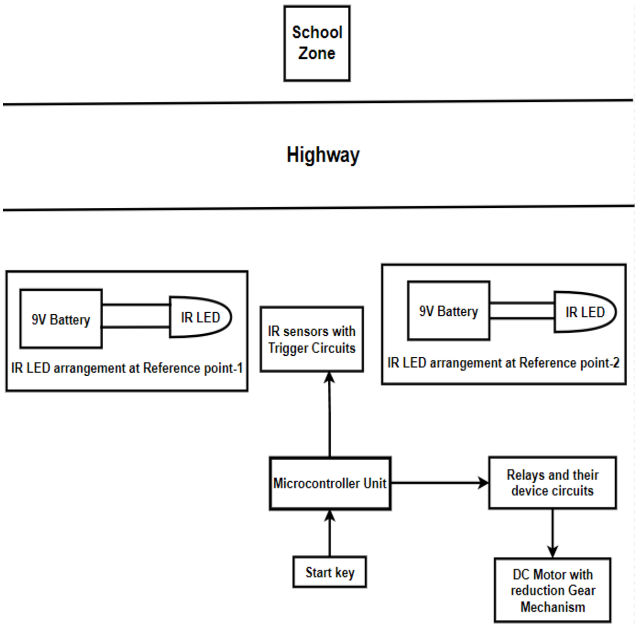

Figure 2: Block Diagram of zone-wise speed control of vehicle

7. RESULTS AND DISCUSSION

7.1 Solar Light Integration:

The integration of solar light systems into vehicles yielded promising results in terms of energy efficiency and sustainability. The solar panels installed on the vehicle's roof effectively harness solar energy during daylight hours, converting it into electrical energy to power various vehicle functions, including lighting, air conditioning, and auxiliary systems. The following are the key findings and discussions regarding solar light integration[9]. The figure 3 gives the connections of solar lighting for highways and working of the same.

Energy Efficiency: The solar panels demonstrated significant potential in improving energy efficiency by reducing the reliance on traditional fuel sources. By harnessing solar energy, vehicles can reduce their carbon footprint and decrease dependency on fossil fuels, contributing to environmental preservation and sustainability.

Cost-effectiveness: While the initial investment in solar panel installation may be relatively high, the long-term cost-effectiveness of solar-powered vehicles is evident. The savings accrued from reduced fuel consumption and maintenance costs, coupled with potential government incentives for adopting eco-friendly transportation solutions, make solar-powered vehicles a financially viable option.

Technological Advancements: Continuous advancements in solar panel technology, such as improvements in efficiency and durability, further enhance the feasibility and performance of solar-powered vehicles. Innovations such as lightweight and flexible solar panels expand integration possibilities and improve the overall aesthetics and functionality of solar-powered vehicles.

Challenges and Limitations: Despite the numerous benefits, challenges such as limited energy storage capacity and variability in solar irradiance pose obstacles to widespread adoption. Research and development efforts are crucial to address these challenges and optimize the performance of solar-powered vehicles under various environmental conditions.

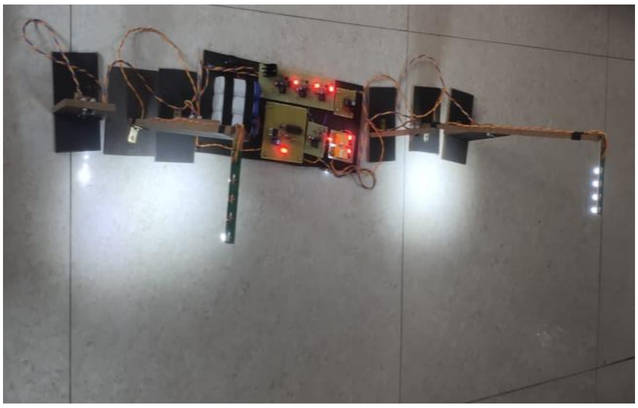

Figure 3: Solar lighting

7.2 Zone-wise Speed Control:

Implementing zone-wise speed control mechanisms in vehicles has demonstrated positive outcomes in terms of safety, traffic management, and efficiency. By dynamically adjusting vehicle speed based on designated zones, such as residential areas, school zones, and highways, the following results and discussions emerge. The figure 4 gives the connections of zone-wise speed control for the vehicles and working of the same[2].

Enhanced Safety: Zone-wise speed control systems contribute to enhanced road safety by enforcing appropriate speed limits in specific areas prone to accidents or pedestrian activity. By adhering to designated speed limits, drivers reduce the risk of collisions and mitigate the severity of accidents, thereby safeguarding lives and minimizing property damage.

Traffic Management: Efficient traffic flow is crucial for minimizing congestion and optimizing roadway utilization. Zone-wise speed control facilitates smoother traffic management by regulating vehicle speeds according to the characteristics of each zone, thereby reducing traffic bottlenecks and improving overall traffic flow.

Environmental Impact: By promoting optimal vehicle speeds, zone-wise speed control systems contribute to reduced fuel consumption and emissions, thereby mitigating environmental pollution and carbon footprint. Conserving fuel through efficient driving practices aligns with sustainability goals and promotes eco-friendly transportation solutions.

Driver Compliance and Awareness: Effective implementation of zone-wise speed control relies on driver compliance and awareness of speed regulations in different zones. Educational campaigns and enforcement measures play a vital role in fostering a culture of responsible driving behaviour and promoting adherence to designated speed limits.

Integration with Smart Infrastructure: Integration of zone-wise speed control systems with smart infrastructure, such as traffic lights and road signage, enhances system effectiveness and responsiveness. Real-time data exchange and communication enable dynamic adjustment of speed limits based on changing traffic conditions and emerging safety hazards.

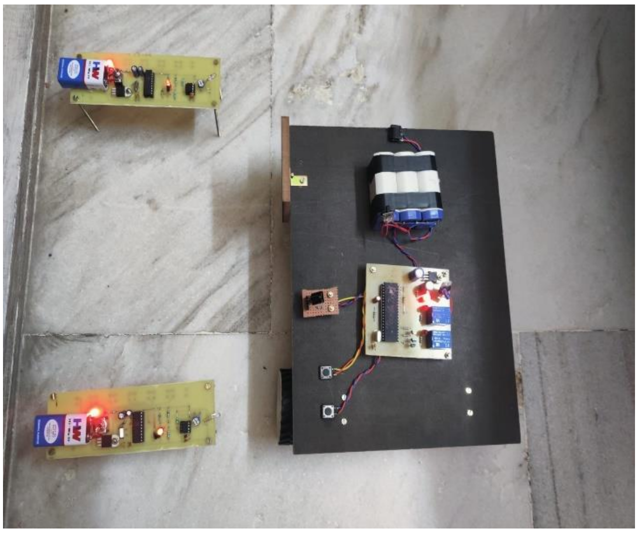

Figure 4: Zone-wise speed control of vehicle

8. CONCLUSION

The implementation of solar-powered lighting systems and zone-wise speed control mechanisms for vehicles offers promising solutions to address contemporary challenges in energy efficiency and road safety. Solar lighting not only provides sustainable and environmentally friendly illumination but also reduces dependence on conventional energy sources, contributing to mitigating climate change[9]. Additionally, zone-wise speed control systems enhance road safety by adapting vehicle speeds to specific road conditions and traffic densities, thereby reducing the likelihood of accidents and improving overall traffic flow.

By integrating these technologies into urban and rural infrastructure, communities can enjoy safer roads, reduced energy costs, and decreased environmental impact. However, successful implementation requires comprehensive planning, investment, and collaboration between governments, industries, and communities. Continued research and development efforts are also essential to optimize the efficiency and effectiveness of these solutions, ensuring their widespread adoption and long-term benefits for society. Overall, solar lighting and zone-wise speed control represent significant steps towards building more sustainable and safer transportation systems for the future.

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