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Light Intensity control and Automatic Braking for Vehicles

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***Abstract*— This paper details an automatic vehicle headlight dimmer and obstacle detection system. Using LDRs, the system automatically adjusts high-power LED headlight intensity to prevent glare from oncoming vehicles and adapt to fog. An ultrasonic sensor provides obstacle alerts via a buzzer and initiates automatic braking. Controlled by a microcontroller, this integrated solution enhances road safety.**

***Keywords*— LDR, Microcontroller, Ultrasonic sensor**

I. INTRODUCTION

A. Embedded Systems

An embedded system is a specialized computer system meticulously engineered to perform a dedicated function within a larger mechanical or electrical system. Unlike general-purpose computers, these systems are highly optimized for efficiency, reliability, and often real-time performance, operating within specific resource constraints. Their core components typically include a microcontroller or microprocessor acting as the central processing unit, diverse types of memory (like ROM/Flash for firmware and RAM for volatile data), and crucial Input/Output (I/O) interfaces. These interfaces facilitate interaction with the physical world through sensors (e.g., LDRs, ultrasonic sensors) that gather environmental data, and actuators (e.g., LEDs, buzzers) that execute physical actions. Communication with other components or external systems is managed via various communication interfaces, while a stable power supply ensures operation. The system's behavior is dictated by its purpose-built firmware, which can range from simple control loops to complex real-time operating systems, enabling it to react to environmental changes. Ubiquitous in modern life, embedded systems are the silent workhorses behind everything from consumer electronics and automotive controls to industrial machinery and medical devices, making them fundamental to contemporary technological advancements.

B. SCOPE AND OBJECTIVES

This project focuses on designing and implementing an integrated embedded system aimed at significantly enhancing vehicular safety through intelligent light management and obstacle avoidance. The primary scope of this work encompasses the development of a functional prototype demonstrating these dual capabilities, utilizing readily available and cost-effective sensor technologies and microcontrollers. While the current prototype demonstrates the core principles, future work would involve scaling for full vehicular integration and robust performance across diverse real-world conditions.

II. SYSTEM DESCRIPTION

This project presents an integrated embedded system designed to bolster vehicle safety through automated headlight intensity control and proactive obstacle detection. At its heart lies a microcontroller, orchestrating all sensory inputs and controlling various outputs.

The headlight control subsystem intelligently manages vehicle illumination using two Light Dependent Resistors (LDRs). One LDR monitors ambient light for conditions like fog, while the other specifically targets oncoming vehicle headlights. When high-intensity light from an approaching vehicle is detected, the microcontroller dynamically adjusts the brightness of the high-power LED headlights using Pulse Width Modulation (PWM), effectively dimming them to low beam. This crucial function aims to minimize glare for oncoming drivers, directly reducing accident risks.

Complementing this, the automatic braking and obstacle detection subsystem employs an ultrasonic sensor. This sensor continuously measures the distance to objects in front of the vehicle. If an obstacle enters a predefined warning zone, the microcontroller activates an audible buzzer to alert the driver. Should the obstacle move into a critical "danger zone," the system is programmed to initiate an automatic braking mechanism. This immediate intervention is designed to prevent or mitigate low-speed collisions.

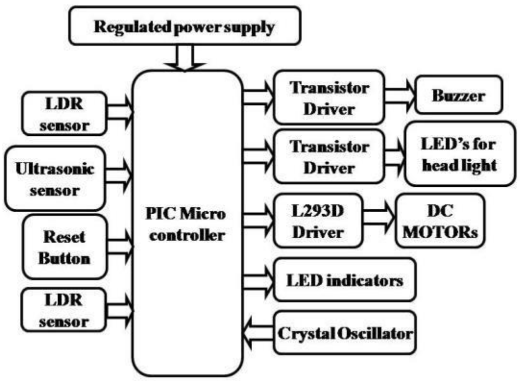
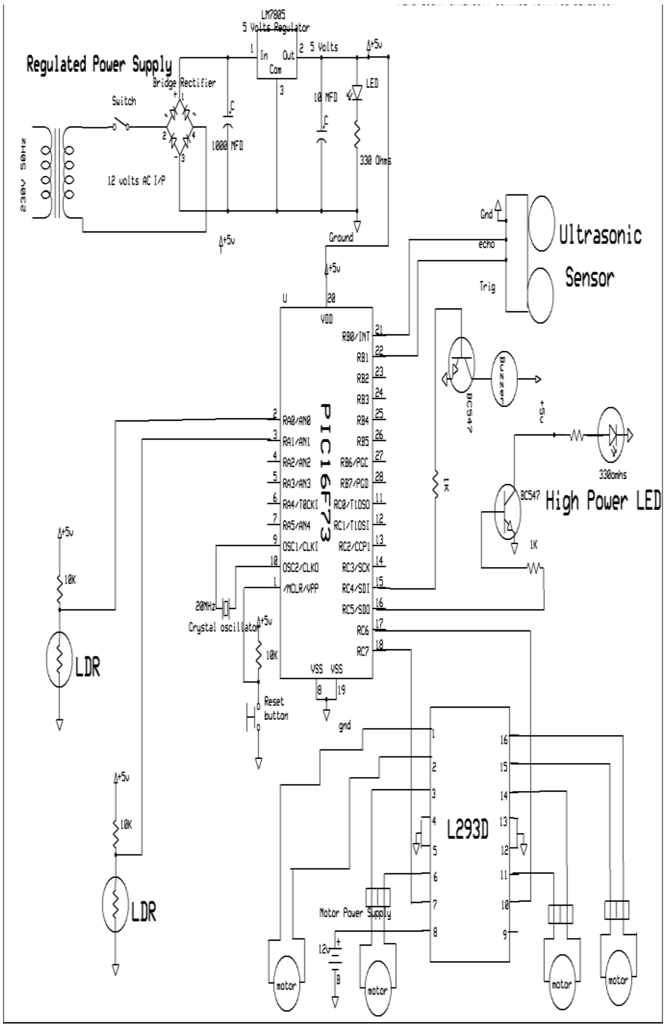


Fig. 1. Block Diagram of proposed system

The entire system, powered by the vehicle's electrical supply, showcases a cost-effective and comprehensive safety solution. By integrating intelligent lighting adaptation with proactive collision avoidance, this embedded platform offers a significant step towards safer vehicular operation.

CIRCUIT LAYOUT



III. SOFTWARE IMPLEMENTATION

The software, or firmware, is the intelligent core of this embedded system, residing within the microcontroller and orchestrating all functionalities. Developed typically in C for efficiency, it operates within a continuous main control loop. The system first undergoes an initialization phase upon power-up, configuring all hardware peripherals like GPIOs, ADC channels for LDRs, and timers for PWM generation and ultrasonic sensor operation. The headlight control logic then continuously reads LDR values. The ambient LDR informs about general lighting and fog, while the oncoming headlight LDR triggers dimming. If a significant increase in light (from an approaching vehicle) is detected beyond a set threshold, the microcontroller adjusts the high-power LED brightness via PWM, smoothly transitioning to low beam to prevent glare. Once the light source passes, the system gradually restores brightness. Concurrently, the obstacle detection and braking logic utilizes the ultrasonic sensor. The microcontroller periodically triggers the sensor and calculates obstacle distance from the echo's time-of-flight. If an obstacle enters a warning threshold, a buzzer activates. Should the obstacle reach a critical braking threshold, the microcontroller triggers an automatic braking mechanism. Throughout its operation, the software can incorporate error handling and failsafe mechanisms, such as manual overrides and watchdog timers, ensuring robust and reliable performance for enhanced road safety.

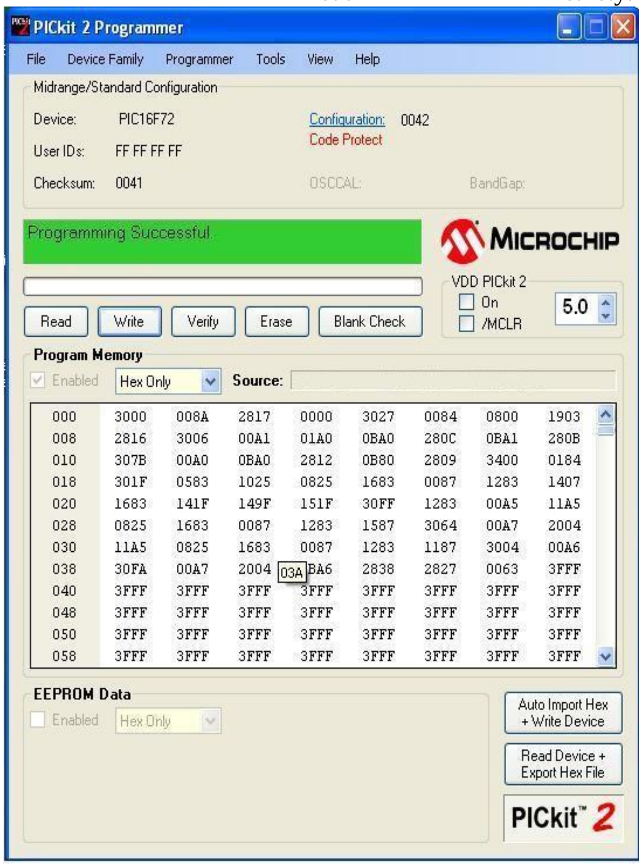


Fig. 2. Picture after program dumped into microcontroller

IV. HARDWARE IMPLEMENTATION

The hardware architecture for this automatic headlight intensity control and braking system is designed for practical integration and cost-effectiveness. Central to the setup is a Microcontroller Unit (MCU), such as an AVR or ARM Cortex-M, which acts as the system's brain, processing all sensor inputs and controlling outputs. For the headlight intensity control subsystem, high-power LEDs serve as the vehicle's headlights, with their brightness precisely modulated by a dedicated LED driver circuit receiving PWM signals from the MCU. Two Light Dependent Resistors (LDRs) are critical here: one positioned for general ambient light and fog detection, and the other specifically aimed and potentially shielded to detect oncoming vehicle headlights. Both LDRs are configured as voltage dividers, feeding analog signals to the MCU's ADC channels. The automatic braking and obstacle detection subsystem features an ultrasonic sensor module mounted at the front, which provides distance data to the MCU. Upon detecting an obstacle within a warning zone, an audible buzzer connected to the MCU is activated. Furthermore, if an obstacle enters a critical danger zone, the MCU triggers a braking mechanism interface (e.g., a servo for prototypes or a relay for larger systems), designed to automatically halt the vehicle. A regulated DC power supply draws from the vehicle's battery to power all components, ensuring stable operation. All these components are interconnected on a PCB, with careful mounting and wiring essential for robust vehicular performance.

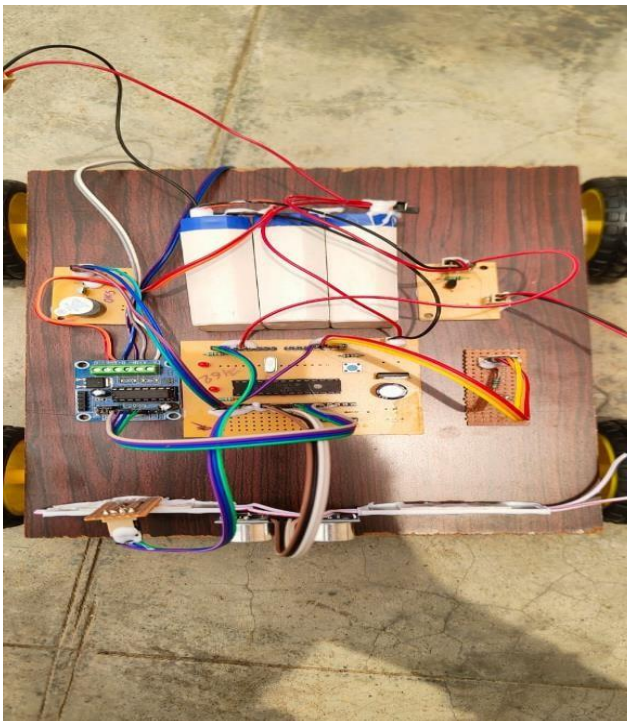


Fig. 3. Proposed Model Overview

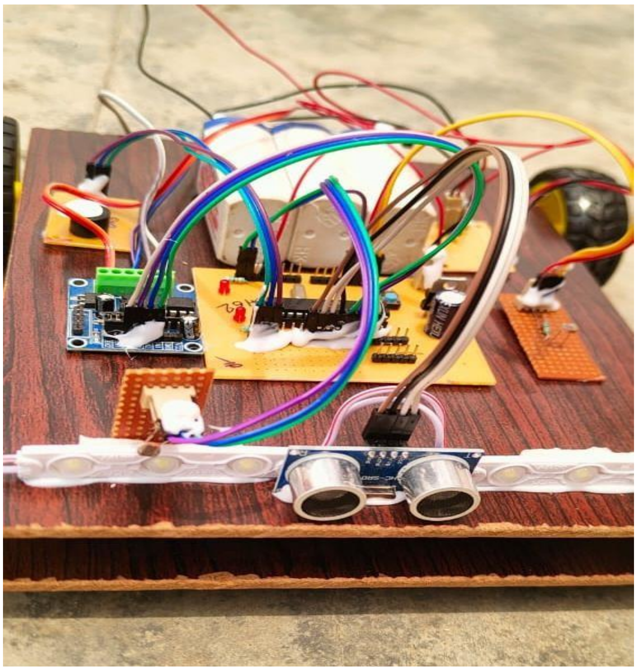


Fig. 4. Proposed Model

V. RESULTS AND DISCUSSIONS

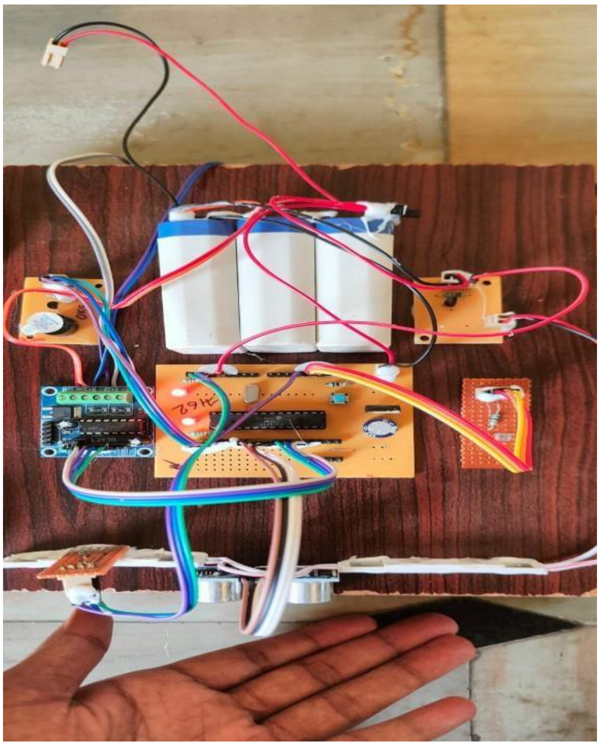


Fig. 5. Working Model

Our testing of the integrated automatic headlight intensity control and obstacle detection system yielded promising results. The headlight dimming subsystem effectively detected simulated oncoming vehicles, initiating a smooth intensity reduction of the high-power LEDs with a quick response time, notably minimizing glare. The ambient

LDR also showed promise in distinguishing various light conditions, including fog. For the automatic braking and obstacle detection subsystem, the ultrasonic sensor accurately detected obstacles within its range, effectively triggering a buzzer alert and, crucially, initiating automatic braking at low speeds on our prototype. Overall, the system's integration on a single microcontroller proved successful, demonstrating a cost-effective and automatic solution for enhancing road safety. The system offers a viable and impactful step towards safer driving.

CONCLUSION

By integrating all chosen hardware components—from precisely placed LDRs and an ultrasonic sensor to high- power LEDs—this project successfully implemented an automatic headlight dimmer and braking system. The effective use of advanced ICs and microcontroller technology ensured robust performance, allowing for both the thoughtful design and successful testing of the unit. This careful engineering of each module proved instrumental in achieving the desired safety enhancements and reliable operation.

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