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Adaptive Matrix Headlight Control System in Two-Wheeler

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Abstract: *Night driving presents significant safety challenges due to limited visibility, glare from oncoming headlights, and varying environmental conditions. Traditional headlight systems require manual control, often leading to improper use of high beams, driver fatigue, and increased risk of accidents. This paper proposes the design and development of an intelligent Adaptive Matrix Headlight Control System using an ESP32 microcontroller, ultrasonic sensors, and light-dependent resistors (LDRs) to automatically adjust headlight brightness in real-time. The system independently controls left and right LED matrix headlights based on obstacle proximity and incoming vehicle light intensity, effectively minimizing glare for oncoming drivers and improving pedestrian safety. PWM drivers, relay modules, and MOSFET circuits are implemented for efficient LED brightness regulation, while a DC-DC step- down converter ensures stable power supply from a 12V vehicle battery. The system incorporates a buzzer for immediate driver alerts under hazardous conditions. Experimental results demonstrate reliable performance under various lighting and weather scenarios, offering enhanced road safety, improved driver comfort, and energy-efficient operation. This scalable solution contributes to the advancement of smart vehicle technologies and aligns with future trends in autonomous and connected vehicles.*

Keywords: Adaptive Headlights, ESP32, Ultrasonic Sensor, LDR, LED Matrix

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