Adaptive Headlamps

A Project Report

By Vikram Venkat and Sidharth Sankar

Introduction

Aim

The aim of this project is to solve two of the most persistent issues with regards to vehicle headlamps and their handling, by automating their utilization with a specific embedded control solution that can be calibrated and customized as and when required.

Background

The automotive industry is growing at an accelerating pace, thanks to an ever-increasing global requirement for vehicular mobility. This alone has led to a significant increase in automobile activity across the board and around the clock, without taking into consideration other positive economic factors; an increase in vehicular activity includes an increase in vehicular activity during dimly-lit and night-time conditions.

All motor/electric vehicles of all kinds have specific factors in common. Braking systems, horns, and external lighting arrangements are some examples of such common factors. The focus of the problem is found to often lie on the lattermost example; while the chances of you dying due to non-functioning brakes can be as high as one in every twenty rides in the US, the probability that frequent high-beam headlamp usage can get you killed on a scale of one in every ten rides in the US to three in every four rides in India!

Localizing to India, the Ministry of Road and Transport, India, mandated the integration of Always Headlights On (abbreviated to AHO and often mistaken to be “Automatic Headlights On”) headlamps, less commonly known as Daytime Running Lights (or DRL), in all vehicles that have been manufactured since April 1, 2017. The mandate states that the headlamps of all vehicles are required to stay ON throughout the duration of the vehicle’s runtime, irrespective of time of day. This takes a constant and considerable toll on vehicle batteries and the components involved - especially the lifetime of the lamps. The reason for the passing of this mandate is popularly theorized to be the absence of headlamps during night-time travel leading to accidents - an irony that will be discussed shortly.

In short, the paragraphs above can be condensed down to two simple problem statements that require immediate addressing -

- The level of ignorance with respect to manual rider control of high-beam headlamps is very high, leading to a significant increase of probability of any vehicle traveling in the opposite direction to meet with an accident.
- The AHO/DRL feature introduced by the Ministry can be replaced with a more efficient and effective solution, at both industrial and domestic levels.

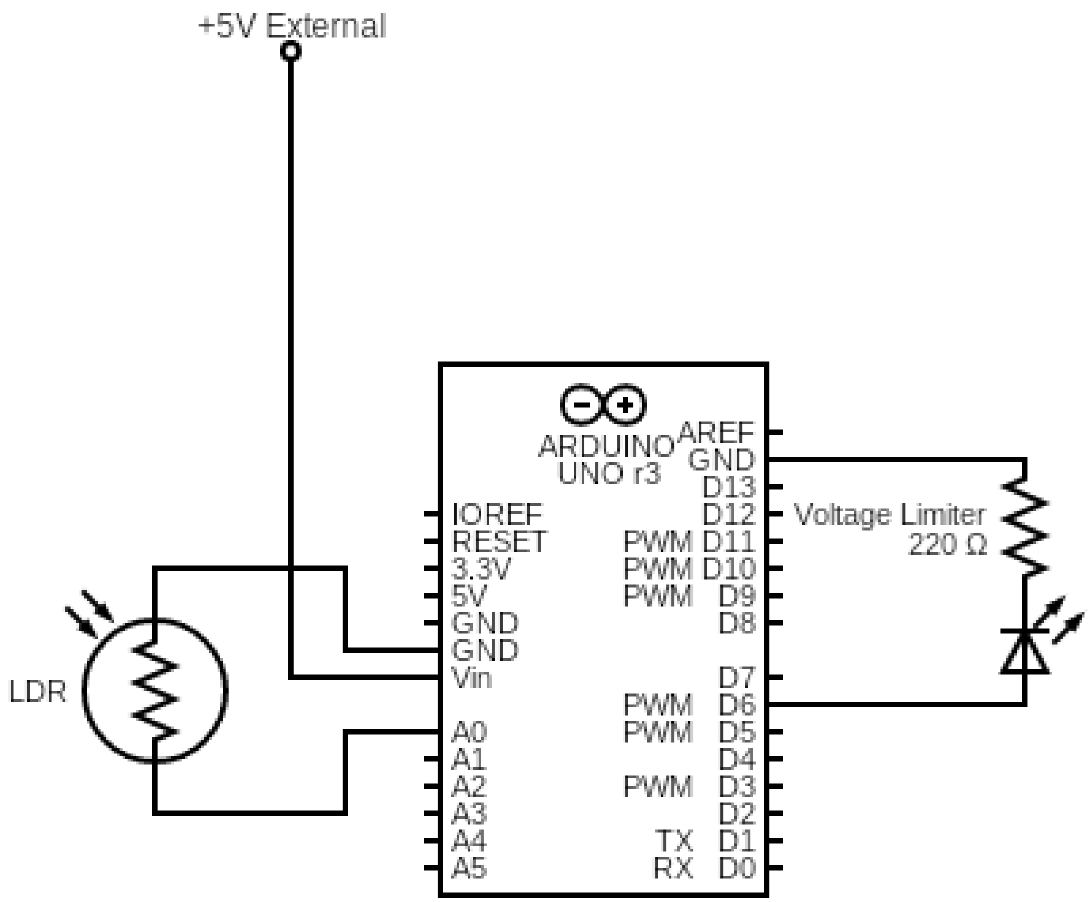
Scope

The scope of this project involves several parameters, all of which are defined below:

- The **primary beneficiaries** of this project are limited to the global automotive industry, vehicle manufacturers, retailers, and buyers. This may extend to transport and road safety ministries of governments in any country, should this project be integrated into an upcoming safety standard norm.
- The **outcome** of this project is to design an effective automatic/adaptive headlamp controller that is compatible as an internal and/or external peripheral module with any vehicle that may require this device, and consequently enable the project to be able to integrate any third-party modules or drivers that may be required in order for it to be integrated into any given system.
- The **limitations** of this project are strictly within the context of unpredictable weather and/or environmental conditions - specifically, heavy onset of fog and ground-level, high-density smoke. The project may unintentionally combat these situations in erratic and/or unpredictable ways, as it has been untested in such circumstances.
- The **legal considerations** that have been taken into consideration for this project are extremely liberal, and allow the integration of such peripherals into vehicles with or without due permission from region-specific ministries, agencies, and/or governments.

Specifications

Circuit Setup



Circuit Diagram of Adaptive Headlamp Controller

Components

- 1x Arduino Uno
- 1x Light Dependent Resistor
- 1x Light Emitting Diode
- 1x 220 Ω Limiting Resistor
- 1x External Power Supply (of any kind, stepped down to 5V DC

Implementation

The hardware components are connected as follows:

- The LDR is connected to an analog pin that is set to INPUT mode, and is grounded.
- The LED is connected to a digital pin with PWM capability that is set to OUTPUT mode. The LED is grounded separately through a 220 Ω limiting resistor.
- The controller board is powered up using a 5-volt external supply - this is either done directly, or through a buck-boost converter in order to step up or step down any external DC voltage provided to the board.

The software part of this project can be implemented using the Arduino IDE, which can be found here.

To the extent of this report, there are a very few number of issues that required addressing from our side:

- The LDR is required to be calibrated at differing environments where the ambient environmental lighting changes, and the conditions for the if-else statements change accordingly.
- There are differing requirements for LED output intensities across the board, due to personal/commercial/industrial/governmental requirements; this means that the LED output has to be calibrated accordingly as well.
- The code-size efficiency of the project is significant, due to the presence of a large number of situational conditions that need to be fulfilled.
- An unshielded LDR is often victim to critical damage due to its fragile nature, and hence the shielding of both the LDR and LED are a physical requirement.
- The LDR and LED are required to be kept mutually shielded, as light from the LED is detected by the LDR as ambient light, leading to a constant flickering of the LED.

Results and Conclusions

The embedded control system for adaptive headlamps works successfully. Under bright to very bright lighting conditions, the LED is turned OFF completely. As the ambient brightness is reduced artificially - at the LDR level or the environment level - the LED can be observed to output light that increases linearly in intensity with respect to decrease in ambient light.

Several tests had to be performed in order to ensure that the LDR-LED function mapping works as intended, and we concluded that five divisions for the analog output (between 0 and 1024) worked as intended for the proof-of-concept. As the project increases in scope and grade, the resolution of the controller can be scaled up to increase in precision.

In conclusion, an embedded control system has been developed, designed, implemented, and verified to adapt a vehicular headlamp to ambient lighting conditions.