

# Design and Implementation of Adaptive Front Lighting System

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**Abstract** - Major road mishaps occur at night on account of curve roads and glare caused from the headlights of incoming vehicles. Night time driving with conventional headlamps is particularly unsafe: only 25% of the driving is done at night but 55% of the driving accidents occur during this period [4]. The existing conventional light system does not provide illumination in the right direction and at the precise angle. Due to this constrain, a need to understand an alternative technology solution. Adaptive front lighting system (AFS) helps improve driver's visibility at night time hence achieving enhance safety. The objective of this work is to design and build an AFS Prototype. From the results, it is concluded that the headlamp swings in horizontal direction by sensing steering angle and vertical by sensing distance between subject vehicle and next vehicle. Accuracy, reliability and availability of the components were few considerations during the conceptualization stage.

## 1. INTRODUCTION

Road accidents are human tragedy. They involve high human suffering and monetary cost in terms of untimely deaths, injuries and loss of potential income. The loss of main bread winner can be catastrophic. Road safety is an issue of national concern, considering its magnitude and gravity and the consequent negative impacts on the economy, public health and the general welfare of the people

For framing strategies and technology solutions for prevention of accident, understanding timing of accidents is a prerequisite. The US National Highway Traffic Safety Administration states that nearly half of all traffic-related fatalities occur in the dark, despite only 25% of traffic travelling during darkness [6]. Within India, the distribution of the total accidents during night time (6 PM to 6 AM) and day time (6 AM to 6 PM) is approximately in the ratio of 2:3 i.e. about 40 per cent during night time and 60 per cent during daytime. However distance covered during night time is only 20%. A task force under the EUREKA organization, composed primarily of European automakers, lighting companies and regulators began working to develop design and performance specifications for Adaptive Front-Lighting Systems [7].

The current static headlamp provides illumination in direction of the headlamp without any consideration towards the steering angle and the incoming vehicle. The driver is therefore subjected to insufficient illumination and unreliable or incomplete view of the road. To add, the driver is also exposed to the light from the headlamp of incoming vehicle and thus subjected to glare. Glare results in an

instinctive desire to look away from a bright light source resulting in difficulty in seeing the road ahead. It is therefore imperative to study new technology. Adaptive front light system (AFS) is an innovative technology and is being studied by researchers across the globe [1-4]. The AFS controls the aiming direction and lighting distribution of the low beams according to the amount of turn applied to the steering wheel during cornering or turning. AFS therefore improves driver's visibility during night driving by automatically turning the headlamp in the direction of travel according to steering wheel angle

Highway Loss Data Institute looked at adaptive headlights offered by Acura, Mazda, Mercedes and Volvo. PDL (Property Damage Liability) claims fell as much as 10 % with adaptive headlights. This was the new insight, since only about 7 % of police-reported crashes occur between 9 p.m. and 6 a.m. and involve more than one vehicle. An even smaller percentage are multiple-vehicle, night time crashes occurring on a curve, where adaptive headlights would be expected to have an effect. It's possible that other differences between the adaptive headlights and conventional ones besides steerability — for example, in brightness or range — may have played a role in reducing crashes with other vehicles. [8]

Automatic high/low beam system firstly existed in 1952 by general motor called "Autroic Eye" [5]. It was a device on automobiles which used a photo resistor to automatically adjust the headlight beams from "high beam" to "low beam" when encountering oncoming vehicles during night time driving and to switch back to high beam after vehicles had passed. With the advancement in light sources (Halogen lamps being replaced by Hid lamps) the light has become brighter causing increase in glare. Glaring is the discomfort or blindness caused by showering of unwanted lights temporarily.

Valeo, the world leader in automotive lighting technology and first made intelligent head light system. Valeo developed a technology for lamps, which is called bending lights. Various types of adaptive headlights have been around throughout nearly the entire history of automobiles, but a resurgence of interest in the technology has occurred in recent years.

## 2. THE DEVELOPED SYSTEM ARCHITECTURE

This is a feedback system working from sensor to controller and controller to actuators

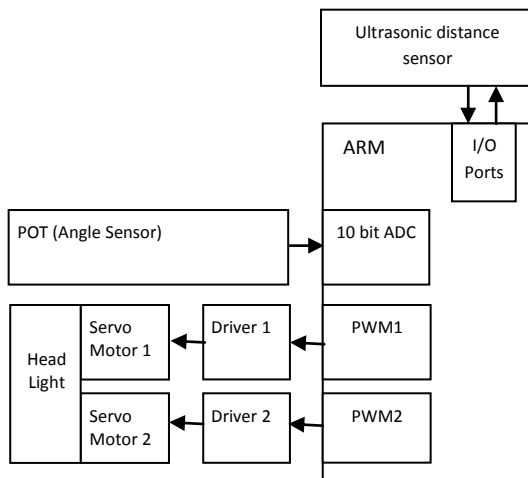


Figure 1: The block diagram of an AFS system.



Figure 2: Actual Hardware of AFS

Ultrasonic module needs trigger pulse of  $10\mu\text{s}$  to initiate its operation. In response to the pulse an echo pulse will be generated with width proportional to the distance between the vehicles. The output if feed to the controller and the controller will update PWM width to rotate headlight vertically.

### 2.1 Sensor Block

The sensors used are ultrasonic distance sensor and potentiometer as steering angle sensor. It is expected that the position of the headlight will change in accordance with the steering shaft. Therefore the potentiometer, attached with the steering shaft, takes input from steering shaft sends analog signal to the ADC. This helps in horizontal movement of the headlamp. Correspondingly the vertical movement of the headlight is achieved through ultrasonic distance sensor.

### 2.2 Microcontroller

LPC2148 an ARM7 series microcontroller is used to control the motor. The LPC2148 uses 16/32-Bit and has 512KB of internal flash and 32+8K RAM. It has inbuilt 14 channel 10 bit ADC, 6 channel 10 bit PWM and high speed of 60 MHz. The choice of controller is determined by easy availability, affordable price, reliability and the fact that it permits the use of C language for its programing.

### 2.3 Actuators

To facilitate movement of the headlamp based on steering shaft, the headlamp is mounted on motors. The actuators used are two servo motors, one for horizontal motion and one for vertical motion. The rotating angle for servo motor is 0-180 degree for horizontal and vertical movement of headlamp. The motor works on 4.5– 6 volts.

### 3. Principle of operation

A 10K potentiometer is coupled to steering shaft. Potentiometer will generate varying analog voltage according to turning of steering. This voltage is fed to ADC and then is read by controller. The controller unit processes the input and updates the PWM width. The output is feed to the servo motor. This in turn helps to rotate headlight horizontally.

### 3.1 Software Flowchart

Philips flash utility software allows uploading and execution of code. Keil tool by ARM (For ARM7 (LPC2148)  $\mu\text{Vision4}$  software is used for compilation purpose.

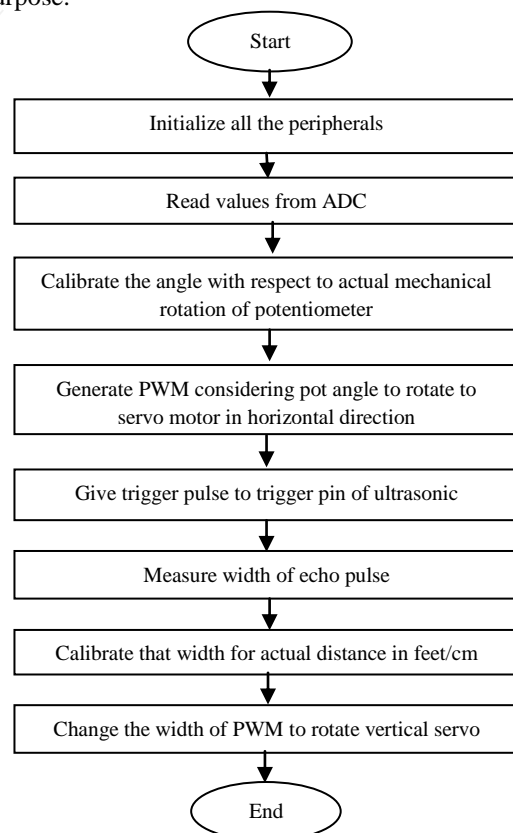


Figure 3: System Flowchart

### 3.2 Formula used in program for calculating required PWM width

$$\text{vertical\_servo\_pwm} = 18000 + (150 - (\text{ultrasonic\_cnt} - 50)) * 60;$$

PWM waveform for vertical servo motor depends upon ultrasonic count. Ultrasonic sensor gives minimum width of 50 and maximum of 200. We have shifted down the lower limit to 0 by subtracting 50 from all the values. Now the range becomes 0 to 150. To preserve the relation that when object is at far distance headlight angle is up and if the object is nearer then headlight should be lowered, obtained count is subtracted from 150. Multiplication of 60 brings this count in the range of thousands and ensures full vertical span of motor is covered. 18000 count brings motor to lowermost point and any addition of remaining factor brings it to upper angle by some proportional amount.

$$\text{horizontal\_servo\_pwm} = (1024 - \text{adc\_read}(0,3)) * (1024/280);$$

ADC being of 10 bit gives number 1024 corresponding to 3.3v input. Potentiometer is used for angle measurement and potentiometer rotates from 0 degree to 280 degrees. The factor (1024/280) converts maximum range of 1024 to 280. Here potentiometer is interfaced to channel 3 of ADC0. ADC value subtracted from 1024 ensures correct direction of rotation of servo motor with respect to direction of turning of steering.

### 4. PWM WAVEFORM RESULTS.



Figure 4: PWM waveform with 1ms + width

The signal period is always 20ms. PWM waveform with 1ms + width (ON time) shows that servo motor is rotating at 0 degree. In this case off time is 19ms.



Figure 5: PWM waveform with 2ms + width

In Figure 5, PWM waveform with 2ms + width shows that servo motor is rotating at 90 degree. Off time in this case is 18ms.

### 5. CONCLUSION

The horizontal headlight movement through movement of steering shaft and vertical movement of headlamp due to distance between the two vehicles is achieved by the means of AFS system architecture and its corresponding program. Few critical design factors considered during inception stage were ease of availability, affordability and reliability of the components use. It is also observed that the system can be accommodated in the current low cost models without major changes. Finally every technology has a human side and therefore it is assuring and fulfilling that desired objective of safety and accuracy during night driving is achieved.

### 6. FUTURE WORK

This system relies on information obtained from various sensors and considers only a next vehicle. A step forward can be achieved by adding computer vision based image processing algorithms. Instead of only fixed ultrasonic module we can add radar type mechanism to scan the vehicle coming from all directions. With this consideration, a neighbouring and backside vehicle can also be traced. A second dimension which can be introduced and realized is shape of the road. This can be achieved through navigation data.

### 7. REFERENCES

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