Adaptive Headlight System for accident prevention

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Adaptive Headlight System for Accident Prevention

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Abstract—**This paper focuses on the design and working of a microcontroller based Adaptive Headlight System (AHS) for automobiles. The main purpose of this system is to present a cost effective technique to illuminate blind spots while driving in the night and during the times when the visibility is reduced significantly so as to make the objects visible in those darkened locations and thereby prevent accidents. The system functions in accordance to the controlled input from Atmel AT89S52 microcontroller unit which drives the stepper motors connected to the headlights. The system is also designed to receive input from the indicator switch wherein a full turn is achieved by the headlight mirror when the indicator input is given. Also, the adaptive headlights are automatically switched on when the amount of light measured by a photo diode falls below a threshold, thereby eliminating the need for the driver to switch on the headlights.**

Keywords— Headlight system; Accident mitigation in vehicles; Embedded systems; Microcontroller; Blind spot elimination; Stepper motor;

I. INTRODUCTION

Accidents during night have become very common in the current scenario. Automobiles have headlights that lights up the road in front of the vehicle and fails to provide illumination at bends. Reasons like lack of visibility, inability to view objects at the corner of a turn have plagued automobile drivers during late night travel. To overcome these situations, several mechanisms have been sought after to mitigate once an accident occurs but there were not much solutions proposed to prevent an accident even before it occurs.

The main reason for accidents in roads having steep turns and curved roads in hilly areas is due to the presence of blind spots. Blind spots are the areas around the vehicle that cannot be directly observed by the driver. These areas cannot be seen directly by looking forward or by looking through either of the side mirrors. Blind spots may occur due to inappropriate positioning of the vehicles' side mirrors, thickness of the A-pillar, height and width of the vehicle, etc. Other causes of blind spots are steep curves in roads, lack of visibility due to weather conditions etc. Blind spots can occur due to the condition of the driver as well. Poor infrastructure, like improper street lights create problems for the driver, especially in the highways. These blind spots must be eliminated for safe driving.

Temporary blindness of the driver can occur due to dazzling of headlamps. Dazzling occurs when the headlights of the vehicle coming in the opposite direction falls directly into the eyes of the driver. This result in the driver being blinded for some time and in turn increase the probability of accidents. This problem is more prevalent when the road is curved. A vehicle with normal headlights sends the light rays tangential to the curve. Thus, the probability of dazzling of lights in the eyes of the driver of the vehicle coming in the opposite direction is very high. This driver, with his eyes momentarily blinded, can go off the curve and off the road and create a major accident, hence, killing him and others on the road.

There are also instances where the driver fails to switch on the head lamp during night or when the visibility is not sufficient to guarantee safe driving, accidents occur especially in highways. Hence a mechanism to ensure that the head lamps are turned on automatically is required. This mechanism again is incorporated only in high end cars like BMW, Audi, Volvo etc. In order to incorporate this mechanism in low end cars, a cost effective and efficient method is the need of the hour. This can be incorporated by mounting a photo diode on the windshield behind the internal rear view mirror.

Thus, theremust be a cost effective mechanism to address the problems of blind spots, dazzling of head lights and low visibility. In this paper, the proposed system is one such solution that helps in preventing an accident by providing proper visibility to drivers by illuminating curves and bent paths such that the driver can be cautioned before he hits any object or life.

II. RELATED STUDY

The concept of adaptive headlamps is not new in high end cars like Volvo, BMW, Audi etc. where in these mechanisms are already employed but a rather different approach have been taken in doing so. These vehicles used expensive sensorsto measure speed, steering angle and yaw, which is the degree of rotation around the vertical axis and small electric motors to turn the cars' headlights and to guide the driver along the bends of the roads [1]. Due to such

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sophisticated devices being used in these cars the cost is as high as $1000 [11].

The second approach is the use of Hardware in the loop simulations, a mathematical approach, where the headlamp orientation control system rotates the right and left low beam headlights independently and keeps the beam as parallel to the curved road as possible to provide better night time visibility. Here two hardware platforms are employed where the first platform simulates the vehicle and road models and the other platform simulates the Adaptive Headlamp System controller which obtains the necessary vehicle states from the first platform and carries out the necessary AHS computations. This second platform then sends the calculated commands to the headlight positioning electric motors [2].

Furthermore actuator based mechanisms have also been tested and developed for adaptive headlight systems where in a PIC microcontroller PIC16F877A is used. A potentiometer based sensor is attached to the steering shaft which provides the sensing input to the microcontroller unit in the form of voltage. Servomotors with built in feedback mechanisms were used as actuating blocks that receives the microcontroller output to turn the headlamps [3].

A table below has been provided which compares the cost of the adaptive headlight system which is currently used in various high end cars.

Table 1 Cost of AHS in various cars

Serial No.	Car Model	Cost estimate
1.	Mercedes Benz S550	$700 (For stand-alone option)
2.	Mercedes Benz Premium 3 Engine	$6550
3.	Volvo V60	$850
4.	Lexus RX350	$515

From the above table it is clear that the cost of the adaptive headlamp system is quite high for these sophisticated automobiles. Whereas the system proposed in this paper provides a cost efficient method to ensure safety while driving in night. The approximate cost of the proposed system comes to $250 which is marginally lower than the above mentioned vehicles. Moreover the system described below is designed specially for lower end vehicles like Tata Indica V2 which are commonly found in Indian roads.

III. PROPOSED SYSTEM

The components that are used to implement the adaptive headlight system are described below.

A. Microcontroller unit

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. This chip is compatible with the industry-standard 80C51 instruction set.The standard features of AT89S52 includes- 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry [8]. In addition, this microcontroller unit is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes.The microcontroller is interfaced with a DC generator to measure the current, a photo diode to measure the light intensity of sunlight and two stepper motors to rotate the headlamp accordingly. The microcontroller chip is shown in Figure 1.

Figure 1ATMEL 89S52 microcontroller IC in Dual-in line (DIP) package.

B. DC Generator

The DC generator is a device that converts the mechanical energy of a rotating conductor into electrical energy as shown in Figure 2. It works on the principle of Faraday's law of electromagnetic induction which states that a change in the flux linkage in a closed loop conductor causes an Electromotive Force (EMF) to be induced. The direction of current in the generator's coil is given by Fleming's right hand rule. As the steering wheel is rotated, the steering column rotates in the magnetic field and thus generates an EMF.

Figure 2 DC Generator

C. Photo diode

A photo diode is a device that is capable of converting light into current or voltage [4]. Current flows from cathode to anode when they are connected in the presence of light. For the purpose of measuring the light intensity of sunlight in the visible spectrum, a BPW21 silicon photodiode (shown in

Figure 3) is used. Its spectral range is 350 nm to 820 nm. The wavelength of maximum sensitivity is 550nm. The maximum current generated is 2nA during extreme sunlight in noon. The photo diode as mentioned earlier is mounted in the windshield behind the internal rear view mirror such that the light rays of the sun alone are incident on it and not that of the headlamps of other vehicles plying on the roads.

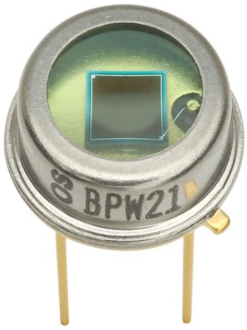

Figure 3 BPW21 Silicon photodiode

D. Stepper Motor

A stepper motor is an electromechanical device that converts electrical pulses into discrete mechanical movements. The shaft of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in proper sequence. The stepper motor is interfaced with the ATMEL 89S52 microcontroller and the angle of rotation is determined and fed to the stepper motor. The headlamp is fixed on the stepper motor and rotates according to the stepper motor rotation. Figure 4 shows a stepper motor.

Figure 4 Stepper Motor

IV. SYSTEM ARCHITECTURE AND OPERATION

The overall system architecture is as shownin Figure 5. The Adaptive headlight system consists of a photo diode, two stepper motors and a DC generator interfaced to the ATMEL 89S52 microcontroller unit. The mirror shaft is mounted on the stepper motor and it rotates along with the turns of the stepper motor. The working of the system is as follows: The adaptive headlight system works when either of the following condition is true- a) The headlight switch is on b) The current generated by the photo diode falls below a particular threshold value (i.e. the light intensity becomes less than the minimum amount required for visibility). In the case b), the headlight is automatically turned on and the adaptive headlight system starts functioning. When the steering wheel is turned, the steering column moves along with the DC generator fixed to it. When the DC generator rotates in the magnetic field, the flux linkage in the closed loop conductor varies and thereby generating an EMF according to Faraday's law of electromagnetic induction. This EMF is measured by the microcontroller unit which performs a conversion to get the degree by which the head lamp has to rotate;this is described by the algorithm given below. Once the degree of rotation is determined, discrete signals are sent to the stepper motors and it rotates. Hence, the head lamp mounted on it correspondingly rotates. Figure 6 shows the block diagram of the proposed adaptive headlight system.

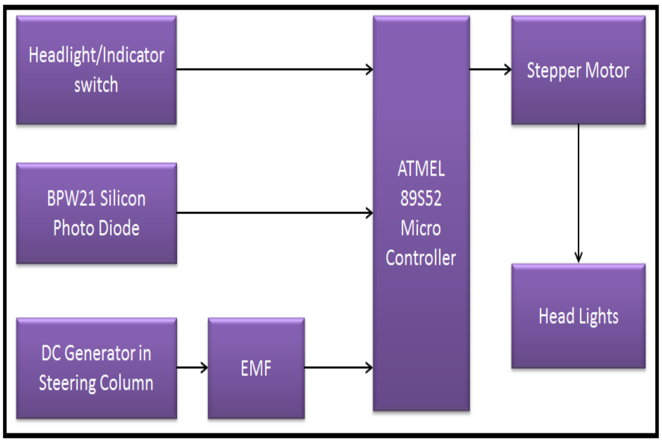

Figure 5 System architecture of Adaptive Headlight System

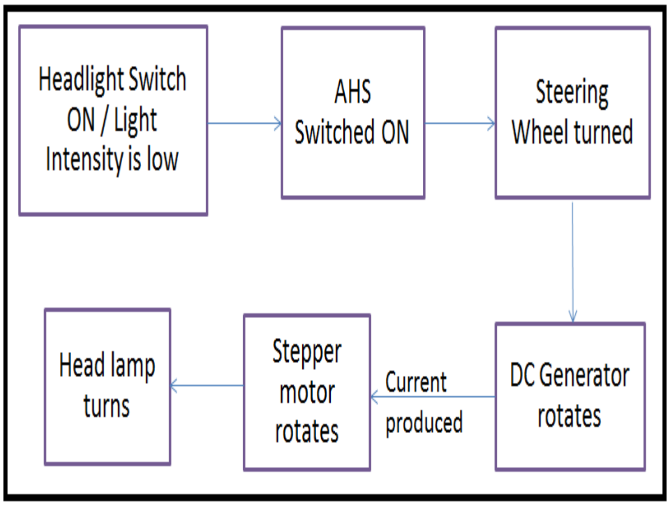

Figure 6 Block diagram of the proposed Adaptive Headlight System method

V. ALGORITHM

Table 1 presents the algorithm for adaptive headlight system method. The algorithm works as follows. The headlight and the indicator switch are continuously monitored. The photodiode also measures the light intensity. If the light intensity falls below a certain threshold value, the headlamps are automatically turned on. If the indicator switch is on and the steering wheel is rotated, the EMF generated is measured by the microcontroller unit and the stepper motor is rotated accordingly. The head lamps also rotate along with the stepper motor. Once the steering wheel and/or indicator switch is released, both the left and right stepper motors rotates in the opposite direction to bring back the headlamps to the original position.

Table 2 Algorithm of Adaptive Headlight System

1. Monitor headlight switch status (HS_{status}) and indicator switch status (IS_{status}).
2. Monitor current generated by photo diode(I_{pd}).
3. while (I_{pd}<*Threshold current value*)
4. $HS_{status} = ON$
5. while(IS_{status} = ON || HS_{status} = ON)
6. Measure Voltage (V_{dc}) from DC Generator
7. Angle $\omega_L = V_{dc} * \tau_L$
8. Angle $\omega_R = V_{dc} * \tau_R$
9. Rotate left stepper motor through ω_L in direction of rotation of steering wheel
10. Rotate right stepper motor through $\omega_R$in direction of rotation of steering wheel
11. If (IS_{status} = released)
12. Rotate left stepper motor through ω_L in the opposite direction of rotation of steering wheel
13. Rotate right stepper motor through $\omega_R$in the opposite direction of rotation of steering wheel

Figure 7 shows the experimental setup of the adaptive headlight system.

Figure 7 Experimental Setup

The specifications of the various components used in the experiments are as follows. The threshold current for the photo diode was set as 0.8 nA.The system is activated if the current falls below this threshold. A stepper motor of torque 3kg cm is used. The maximum voltage generated by the DC generator is 5V during full rotation of the steering wheel and 0V when there is to rotation. The experimental setup was designed for Tata IndicaV2 car. The maximum rotation of the headlight is 37 degrees on the left and 43 degrees on the right. Hence we derive the mathematical relation for angle of rotation from the voltage as follows. The constants τ_L and τ_R can be calculated as follows. Since 37 degrees and 43 degrees correspond to the maximum voltage of 5V,

For left headlight, we get

$$\tau_L = 37/5 = 7.4$$

Similarly, for right headlight,

$$\tau_R = 43/5 = 8.6$$

The initial programming was done in Assembly Language using KeilµVision simulator and then burnt on to the chip. The maximum limit of the turning of the headlamps was limited to 43 degrees on the right hand side turn and 37 degrees on the left hand side turn, as the maximum turning of the vehicle is 43 degrees and 37 degrees on the right hand side and left hand side, respectively. This is done by incorporating the same in Assembly Language.

VII. RESULTS

Upon testing the system the following results were obtained whose graphical representations are as illustrated below. Figure 8 shows the relation between the number of steering wheel rotations in rpm (N) and the corresponding voltage (V) generated.

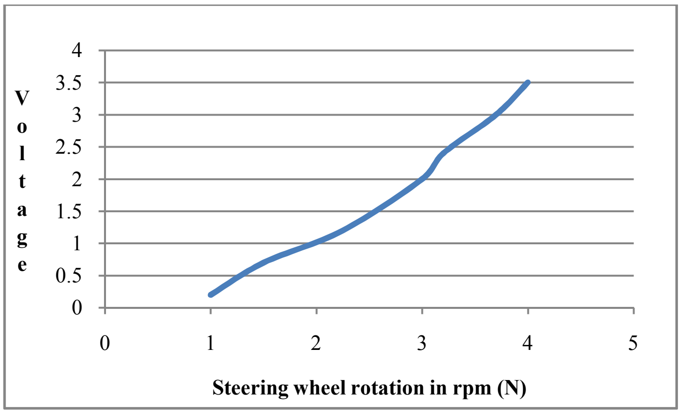

Figure 8 Relation between no of steering wheel rotations (N) and the voltage generated (V)

From Figure 8, we infer that the voltage generated increases linearly with respect to the number of steering wheel rotations made. Figure 9 shows the relation between the voltage (V) given as input to the microcontroller and the degree of rotation of the left stepper motor ω_L as per the following relation.

$$\omega_L = V_{dc} * \tau_L$$

where τ_L = 7.4. We can infer from the given relation that the angle of rotation of the left stepper motor varies linearly with the voltage V from the DC generator.

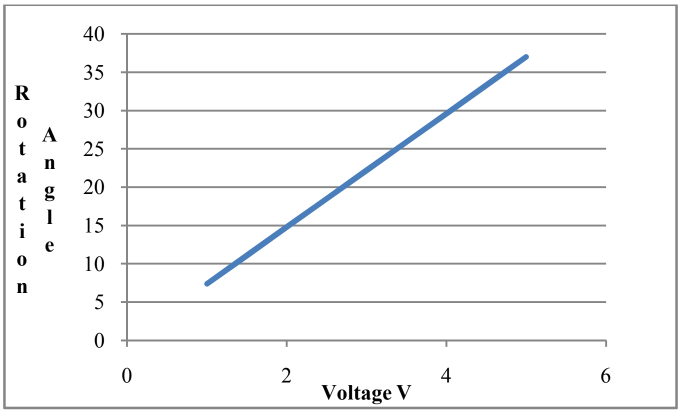

Figure 9 Relation between Voltage V and the angle of rotation of left stepper motor ω_L

Figure 10 shows the relation between the voltage (V) given as input to the microcontroller and the degree of rotation of the right stepper motor ω_R as per the following relation.

$$\omega_R = V_{dc} * \tau_R$$

where τ_R = 8.6. We can infer from the given relation that the angle of rotation of the right stepper motor varies linearly with the voltage V from the DC generator.

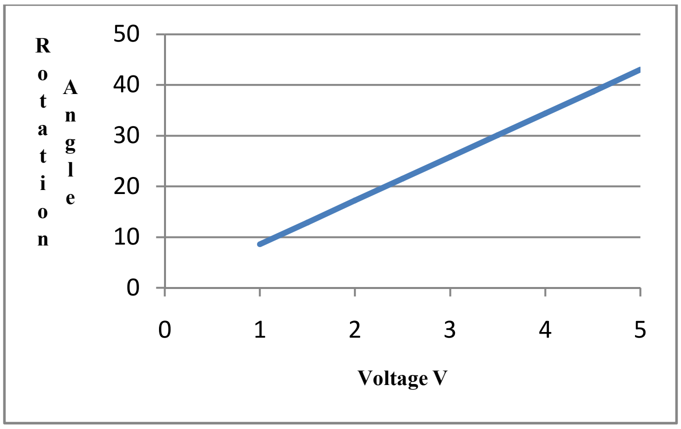

Figure 10 Relation between Voltage V and the angle of rotation of right stepper motor ω_R.

From the above graphical representations we can conclude that both the DC generator voltage and the voltage input to the microcontroller unit has a linear dependence on the rotations of the steering wheel and the stepper motor connected to the headlamps.

VII. Conclusion And Future Scope

Thus the adaptive headlight system is an optimal and cost effective solution to prevent frequent accidents in the nights. The designed system provides step wise turns of the headlamps on either side based on the controlled input given to the stepper motor attached to the lamps on either side. The maximum degree of turn achieved on the left headlamp is 37 degrees and on the right hand side is 43 degrees. The DC generator voltage input ranging from 0-5V triggers the microcontroller unit thereby it generates equivalent output voltage to the stepper motor. The stepper motor transduces this voltage value into corresponding turning angles and provides adequate turn at the bends. Hence this system is reliable and ensures efficient and safe driving. It also costs less and can be included in low end cars also.

In future, the adaptive headlight system can be made more efficient by controlling the spread of the light beam from the head lamps using an ‘automatic range extender’ depending on the vehicle speed. The beam can be made to diverge when the vehicle is travelling at high speeds and can be made to converge when the speed is low. Also automatic low beam-high beam adjuster can be incorporated to reduce accidents due to dazzling of lights.

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