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ADVANCED HEAD LAMP LEVELING SYSTEM BY OCCUPANT DETECTION METHOD

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ABSTRACT

Head lamps are designed to light / illuminate the way ahead. Traditionally automotive designs use two beams; Main beam is normally used on unlit roads where long sight distance is needed and high speeds are allowed and Dipped beam is normally used to provide good road illumination & still offer no dazzling intensity (glare) to the oncoming traffic. The primary objective for the use of headlamp leveling systems in the vehicle is to control the increase in glare that occurs with headlamps aimed too high. Dipped beam light cut off will move up-down as per the vehicle loading conditions such as co- passenger, rear seat occupants and boot load. Due to different loading conditions, naturally beam will move up and certainly cause the glare for the oncoming traffic. To overcome this problem National and International regulations currently specifies a limited range within which the vertical aim (illumination range) of the dipped headlamps must be maintained under various vehicle load conditions either by automatically or by manual headlamp leveling system to avoid the glare for the oncoming traffic. Earlier one is cost effective and generally used in all types of lower and middle class of vehicle. Second one used in higher segment class of vehicles and more expensive. To overcome this problem Investigation and formulation of low cost semiautomatic headlamp leveling devices is developed. This proposed technology will address the lower and mid-segment vehicle in India, considering India is a still developing and lower economy country. This paper describe the study of load sensors located in different seating position and boot load to provide the signals to the headlamp actuator for maintaining the required beam pattern. Finally total system was integrated and calibrated as per the national and international norms.

KEYWORDS: Headlamp; glare, headlamp leveling, micro-controller, automotive safety.

1.0 INTRODUCTION

The motor vehicle industry is one of the major pioneer activities for social and economic progress of any country. Automotive manufacturer always depends on new technologies for vehicular accessories like lighting systems, mirrors, seat belts, interior fittings, windscreen bumpers dashboards etc. These components are defined as safety critical components in Central Motor Vehicle Rule (CMVR). In India it is reported[1] during the year 2016 the number of deaths occurred every hour were 17 due to road accidents. The occurrence of road accidents is observed to be higher during night when visibility is at its lowest. The two factors which affect visibility are insufficient illumination and glare caused by the oncoming traffic. Road accident at night is disproportionately high in numbers & severity compared to day time driving. The statistics bring out that 60% of all road accidents take place during night, when only 15% of the total traffic is plying.[8] Fig shows the statistics of the road accidents for oncoming (vehicles coming from opposite) and following traffic (self driving) due to glare. This shows the importance of the vehicle lighting system for night visibility.

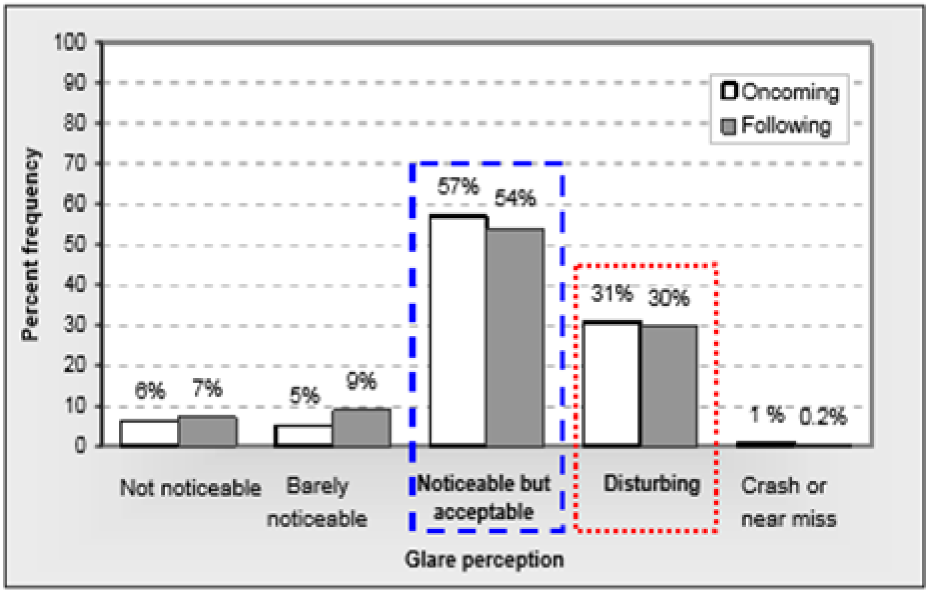


Fig. 1: Percent frequencies of respondents for oncoming and following glare.

1.1. Headlamp leveling system

National and International regulations[4,5] currently specifies a limited range within which the vertical aim (illumination range) of the dipped headlamps must be maintained under various vehicle load conditions either by automatically or by manual headlamp leveling system to avoid the glare for the oncoming traffic. The primary objective for the use of headlamp leveling systems in the vehicle is to control the increase in glare that occurs with headlamps aimed too high. Dipped beam light cut off will move up-down as per the vehicle loading conditions such as co- passenger, rear seat occupants and boot load. Due to different loading conditions, naturally beam will move up and certainly cause the glare for the oncoming traffic. The Fig. 2 demonstrate the head lamp beam movement due to different loading conditions.

Fig. 2: Head lamp beam movement due to different loading conditions.

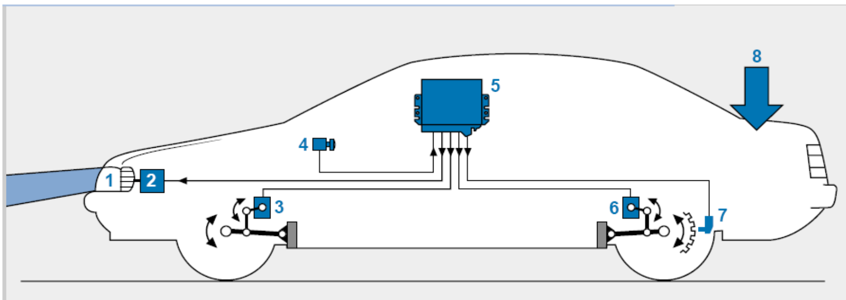
To overcome these problems, presently there are two types of leveling systems viz; manual and automatic head lamp leveling systems. The manual headlamp leveling system is controlled by the driver with a switch and having various positions 0-4 or 0-3 range. These leveling systems can take care of loading effect on vehicle where the manual switch is placed near the driver and two typical switches are shown in Fig. 3.

Fig. 3: Two types of manual switches near driver.

The automatic headlamp leveling system linked to the vehicle suspension system will keep the headlamps position correctly as per the requirement regardless of vehicle load and without driver intervention.

Automatic headlight leveling control system fall into two categories: Static and dynamic. While static system compensate for load variations in the boot and passenger compartments, dynamic systems also correct headlamp aim during acceleration both from standing starts and when under way and when breaking.

Components of a typical headlight leveling control system include in Fig 4. Sensors on the vehicle axles to precisely measure the vehicle's inclination or tilt. An ECU that uses the sensor signals as the basis for calculating the vehicle's pitch angle. The ECU compares these data with the specified values and responds to deviations by the transmitting appropriate control signals to the headlamps motor. Headlamp's motor will adjust the lamp to the correct angle.



1. Head lamp 2. Actuator 3.Front suspension travel sensor 4. Light switch (ON/OFF) 5. ECU 6. Front suspension travel sensor 7. Wheel speed sensor 8. Load.

Fig. 4: System components of automatic leveling devices.

In both the system, aiming is achieved by movement of headlamp reflector by actuator present in the headlamp. The signals either from automatic leveling or manual received by actuator depending on the loading conditions of the vehicle and actuator will rotate the reflector of the headlamp to achieve the required beam level.

2.0 SCOPE OF THE STUDY

- Second one used in higher segment class of vehicles and more expensive. Certainly second version is not viable in Indian scenario considering the segment of vehicle category present and cost of leaving. The manual leveling device is cost effective and generally used in all types of lower and middle class of vehicle. Manual leveling device is totally depends on the driver responsibility, he needs to operate dashboard control lever or knob depending the loading conditions of his vehicle and it is always a question mark in the system. The study shows that.
- Drivers not aware of the headlamp leveling function and it's relation with passenger occupancy and loading pattern.

- Drivers using the headlamp leveling function on Highways for better visibility by pulling up the beam irrespective of any load.
- Drivers using the headlamp leveling function in low lit areas by pulling down the beam
- Maximum drivers do not change the company setting for headlamp leveling device ever in the vehicle life span.
- No awareness of existence of headlamp switch or knob by 40 % of drivers.

To overcome this situation low cost adoptive headlamp leveling devices concept is developed based on the occupant and load detection in the vehicle. In this system, presence of occupant and boot load is detected by load sensors located below the each passenger seat and luggage compartment. Load sensors located in different seating position and boot load will provide the signals to the headlamp actuator to maintain the required beam pattern. Total system is to be integrated and calibrated as per the norms.

3.0 METHODOLOGY

The following methodology adopted for the study:

- Study is limited to M1 category of vehicles with 5 seating capacity
- Study is conducted on static mode without consideration of vehicle
- Regular headlamp with manual motor was used for this study for the simulation
- 5 different types of Load cell was used for the purpose of occupant detection
- Initial study was conducted with load range from 50 kg to 75 kg on each load cell.

The components (digital weighing machine, amplifier, control unit, leveling motor etc) required for the research investigation were procured, studied and integrated in the laboratory. The system will be placed inside the vehicle and integrated to the vehicle headlamp and headlamp motor. Total system is to be integrated and calibrated as per the national and international norms. Block Diagram of the circuit for automatic leveling control. The Fig 5 shows that **b**lock diagram of working principle of head lamp leveling system.

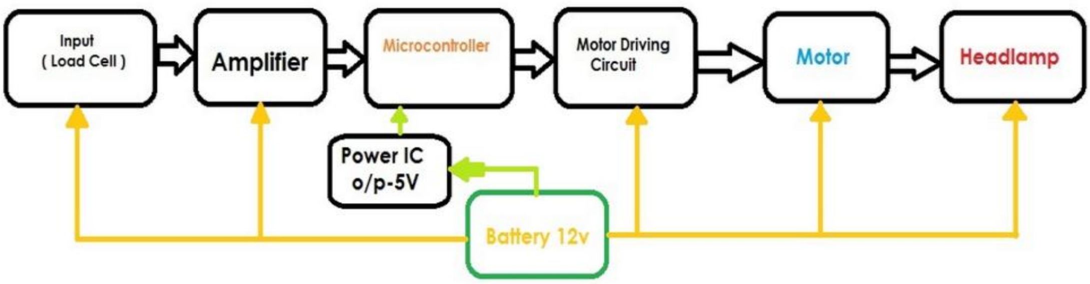


Fig. 5: Block diagram of working principle of head lamp leveling system.

The load cells generate an electrical signal in response to the substrate being stressed by the weight. The electrical signal changes as a function of the weight of the seat occupant. The system was integrated with the consideration of electrical signal output v/s load of each load cell and same is connected to the headlamp leveling motor through amplifier and micro controller. The Figure 6 shows the working principle of the headlamp leveling system.

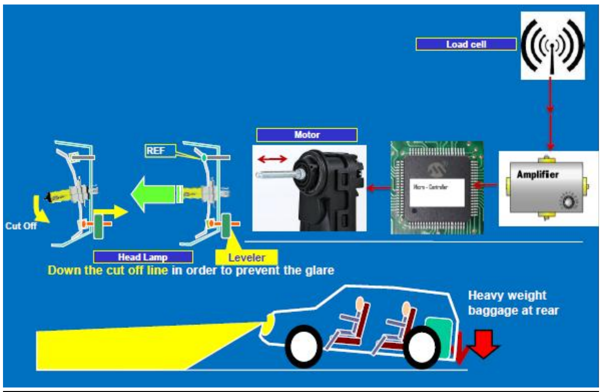
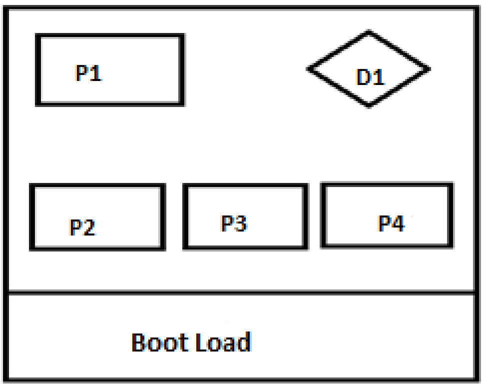


Fig. 6: Working principle of the headlamp leveling system.

The relay operates with the microcontroller and gives supply to motor according to the different load. The above electronic board is fitted to the headlamp of a vehicle and experiments were conducted.

3.1 Combination of Seat Numbers and Switching Positions

For the purpose of experimentation, M1 category (5-seater) vehicle is used, hence the seat positions are simulated same as in M1 category vehicles. With the number of seat occupants detected, the combinations for the switch positions are set and accordingly the motors are being controlled. Fig.7 depicts seat Position layout of M1 Category Vehicle.



Load cell position

- Driver Only (D1)
- Driver and Co-Passenger (D1+P1)
- All seats (5 passengers) (D1+P1+P2+P3+P4)
- All Seats (5 passengers) to Maximum Rear Axil or Gross Vehicle Mass whichever is achieved first (P1+P2+P3+P4+MRV/GVM)
- Driver + Maximum Rear Axil or Gross Vehicle Mass whichever is achieved first (D1+MRV/GVM

Fig. 7: Seat Position layout of M1 Category Vehicle.

The M1 category, 5 seater sedan vehicle was identified to conduct the experiments. The loading specification for the vehicle is as follows:

- Unladen Rang 2244Kg
- Gross Vehicle Weight (GVM) 3050Kg
- Maximum Rear Axle 1775Kg
- Maximum Front Axle 1500Kg

The table 1 shows experiment results of the Head lamp beam movement position with various loading conditions and is lies between the ranges of -0.5 to -2.5% cut-off as per the standard requirements.[4,5] The following figure 8 represents the head lamp filament reference position, test distance and range of beam movement requirements. The same is follows for all beam angle representation.

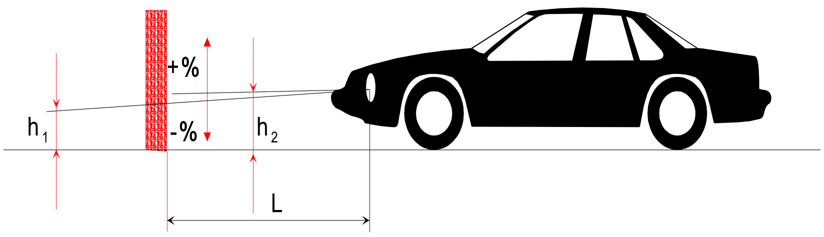


Fig. 8: Head lamp beam inclination.

Inclination is expressed in percentage inclination

Where

h1 is the height above the ground, in millimeters, of the above- mentioned characteristic point, measured on a vertical screen perpendicular to the vehicle longitudinal median plane, placed at a horizontal distance L.

h2 is the height above the ground, in millimeters, of the center of reference (which is taken to be the nominal origin of the characteristic point chosen in h1).

L is the distance, in millimeters, from the screen to the centre of reference (10 M).

4.0 EXPERIMENTATION

The system tested as per the procedure defined in ECE R 48 / AIS: 008 with each loading position. The readings were taken in the zero position, then after in each loading conditions for both Left (LH side) and right (RH side) hand side of head lamps beam position. The average beam inclination is calculated with the consideration of LH and RH side headlamp inclination. In each loading, the average beam position shows, the head lamp cut-off retain automatically within the specified range as per the standards by occupant detection using load sensors and headlamp motor activation to move the head lamp beam through reflector. Conducted repeatability and reproducibility of the test and observed that results are satisfactory. Also noted the beam movement and correlated with the manual leveling switch position. The table shows the Head lamp beam movement position with various loading conditions.

Table 1: Head lamp beam movement position with various loading conditions.

Sr. No.	Vehicle loading configuration and loading pattern	Total (Kg)	Initial Switch position	Head lamp side	h 2(mm)	h 1(mm)	Initial Average % (manual mode)	Final Average % (Semi automatic mode)	Final Average switch position-calculation	Voltage of Motor(V)
1	Driver only	2319	0	LH	1031	911	-1.20	-1.2	0	11.7
				RH	1025	905				
2	Driver + Co-driver	2394	0	LH	1028	895	-1.28	-1.28	0	11.7
				RH	1021	898				
3	Driver + Co-driver + 3 Passengers	2620	0	LH	1018	975	**-0.41**	**-2.42**	**1**	9.67
				RH	1016	978				
4	Driver + Co-driver + 3 Passengers +Boot load	2952	0	LH	1065	1040	**-0.23**	**-2.43**	**2**	7.64
				RH	1060	1040				
5	Driver + Co-driver + 3 Passengers + Boot load	2811	0	LH	1036	1100	**0.49**	**-1.16**	**1**	9.67
				RH	1036	1090				

5.0 CONCLUSION

The literature review indicates the possible prospects of further investigations in the field of automotive head lighting and night safety; hence the low cost adoptive headlamp leveling devices concept investigation is formulated using occupant detection method using load sensors. Experiments were conducted with different loading conditions in static level conditions. The experimental results shows that the headlamp leveling position is under limit as specified in the standard with different loading conditions With this system, manual leveling switch can be replaced by this system, so that malfunctioning of beam leveling is removed and will be achieved more safety during night driving. Above concept may be one of the solutions to overcome all these problems. However, more detail study need to be conduct regarding the selection of load sensor, integration in the seat, calibration of load, calibration of leveling motor with respect to different load cell electrical signals, adoption in the vehicle, vehicle level test etc.

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