ADAPTIVE FRONT-LIGHTING SYSTEM

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Abstract—*The Adaptive Front-lighting System (AFS) is one part of the active safety system of a middle-high end passenger car, providing an optimized vision to the driver during night time and other poor-sight conditions of the road by adapting the headlight angle and intensity, and judging the speed of the car, the steering wheel angle, the weather condition, and yaw and tilt rate of the car. To facilitate a user's development of such a system and to demonstrate the performance of TI's automotive MCU family, a reference design of AFS is developed. This article describes the functions of the reference design, as well as the implementation. Furthermore, it states the guidelines for manipulating the demonstration of the reference design.*

Keywords—optimized vision,headlight angle,steering wheel angle

1. INTRODUCTION

The oldest headlamps were fueled by acetylene and oil and were introduced in the late 1880s. The first electric headlamps were introduced in 1898 on the Columbia Electric Car from the Electric Vehicle Company, and were not mandatory. The concept of swiveling headlamps is actually old one. An old innovation in lighting was to vertically tilt the beams high-beam-to-low-beam (dipped) switching dating back to 1917. Automatic high/low beam system firstly existed in 1952 by general motor called "Autroic Eye". More recently, automatic self-leveling has become an increasingly common requirement as the light sources have become more bright and glare has increased. Horizontal swiveling is important in the automotive industry. The current static headlamp provides illumination in tangent direction of the headlamp without any consideration towards the steering shaft angle and the distance between incoming vehicle and subject vehicle. 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 and distance between the incoming and subject vehicle. AFS therefore improves driver‟s visibility during night driving by automatically turning the headlamp in the direction of travel according to steering wheel angle and the distance between two vehicles. The aim of this project is to build a cost effective „Adaptive Front Light System‟ that will help achieve increases safety, comfortless and reliability. The new design and build should modify and fit into an existing fixed headlamp with a very close eye on cost and reliability. Use of existing headlamps will also allow the AFS addition to maintain the vehicle‟s conformity to existing vehicle aesthetics as well as government regulation.The objectives to achieve of this project are Achieve horizontal movement of the headlamp in related to angle of steering shaft, thereby focusing in the right direction andAchieve vertical movement of the headlamp in accordance to the distance between the subject vehicle and the incoming vehicle, thereby enhances drivers‟ visibility and reduce glare to oncoming vehicles in various traffic scenarios.

2. FUNCTION OF ADAPTIVE FRONT LIGHTING SYSTEM

An adaptive front-lighting system is defined as in ECE324-R123 as "a lighting device, providing beams with differing characteristics for automatic adaptation to varying conditions of use of the dipped-beam (passing beam) and, if it applies, the main-beam (driving-beam) with a minimum functional content; such systems consist of the "system control", one or more "supply and operating device(s)", if any, and the "installation units" of the right and of the left side of the vehicle"

A. Major functions

Basically the afs provides the following functions.

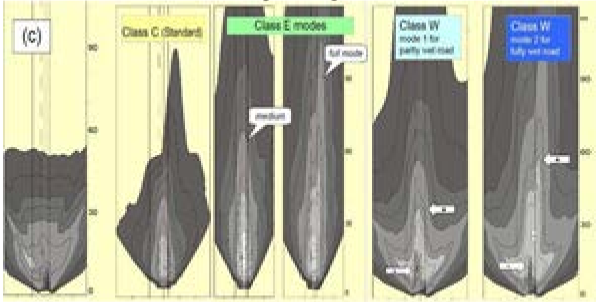
- Town passing beam (Class V)
- Basic/Country passing beam (Class C)
- Motorway passing beam (Class E)
- Wet-road passing beam (Class W)
- Static cornering light
- Dynamic swivel/level lighting

Town passing beam (Class V): At speeds below 50 km/h, town light provides a wider light distribution at reduced range, helping drivers to more clearly see pedestrians on the edge of the road.

Basic/Country passing beam (Class C): The basic light illuminates the left- and right-hand edges of the road more brightly and widely than the conventional low beam. It is usually activated at speeds between 50 and 100 km/h.

Motorway passing beam (Class E):Motorway light improves vision on highways and expressways. From 100 km/h, this beam illuminates the roadway significantly further ahead and focuses more on the left-hand edge of the road. The motorway light switches on automatically at speeds greater than 100 km/h.

Wet-road passing beam (Class W): This beam is activated when the rain sensor detects precipitation or the windshield wipers are on for 2 minutes or more. The edges of the road are more strongly illuminated for better orientation to the guiding lines.



Class V Class C Class Class W

Fig1. Light Modes

B. Function of reference design

The reference design of the AFS provides the light mode switching functions as mentioned previously. This is done by judging the vehicle speed sent through the CAN bus. All four classes of light modes are supported by the reference design. By checking the light mode, vehicle speed as well as the steering wheel position, the reference design provides the static cornering light function. With the information of the steering wheel and the tilt level of the car through the CAN bus, the reference design can also perform leveling and swiveling of the passing beam.

This design considers the general automotive operation conditions like electrical disturbances (ISO7637), environmental conditions (ISO16750), and other existing industrial standards.To better demonstrate the functions of the reference design, a demonstration set is also built with an automotive headlight product as the target load. To generate command signals as car speed, steering angle, and so on, a control panel is built for this demonstration set.

2.3. System Architecture

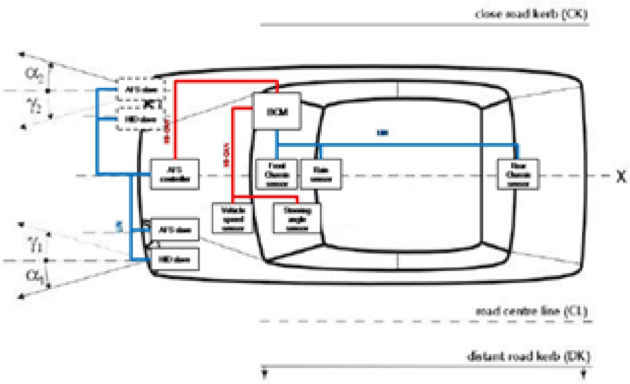


Fig 2. Automotive Network Structure

The following three modules are implemented:

- Control panel (for demo)
- Afs slave

Control Panel: For better demonstration, a control panel with buttons and switches as well as display is built with the reference design. The functions of the control panel are explained in the operation guide section.

AFS Slave: ECE324-R123 mentions that anycombination of moving the lamp or light source array can be implemented to achieve an adaptive front light. In this reference design, movement of the HID projector is used to perform the passing beam adaption.

The movement of the lamp is performed by the AFS slave in the system by controlling two stepper motors equipped in the headlight. In a practical automotive system, there is one such control unit on both the right and left headlight units.

An MSP430F2272 device is implemented on the AFS slave to control the stepper motors. This device is equipped with a 16-bit high-performance CPU core with 32KB of flash, which is sufficient for controlling the motor and communication with the LIN master.

The MSP430F2272 device is also chosen because it is a very small 40-pin, QFN package UART module with LIN support and ultra-low power consumption.

3. HORIZONTAL AND VERTICAL LIGHTING RANGES

The basic light illuminates the left- and right-hand edges of the road more brightly and widely than does the conventional low beam. The basic light is activated at speeds between 50 and 100 km/h. To activate the light mode, vehicle speed must be kept in this range for at least 5 seconds.

The headlight keeps a straight position of the neutral position axis ($\Delta\varphi$ = 0°) and swivels according to the steering angle of the vehicle within the range of αmax and γmax.

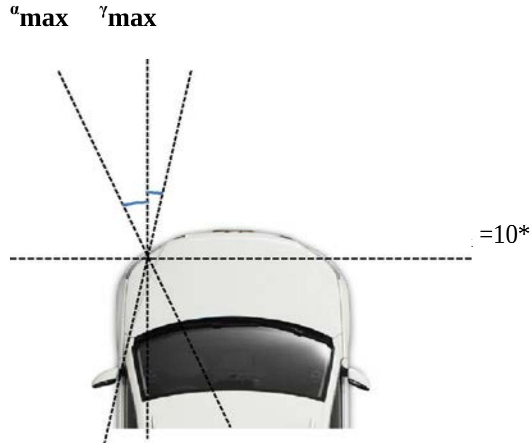


Fig3. Horizontal lighting range

The neutral position axis of the headlight is swiveled for an angle of $\Delta\varphi$ (5 degrees) toward each side, as shown in Figure 4. Horizontal swivel range is also changed based on the axis shift by

$\Delta\varphi$ (5 degrees).

Leveling is performed in this lighting mode.An additional 2 degrees downward of the headlight is applied in this mode.

Fig4. Vertical Lighting Range

4. LIN Communication

The AFS slave communicates with the AFS controller through a LIN bus as a slave node with a 20-Kbps baud rate following the LIN2.0 protocol specification.

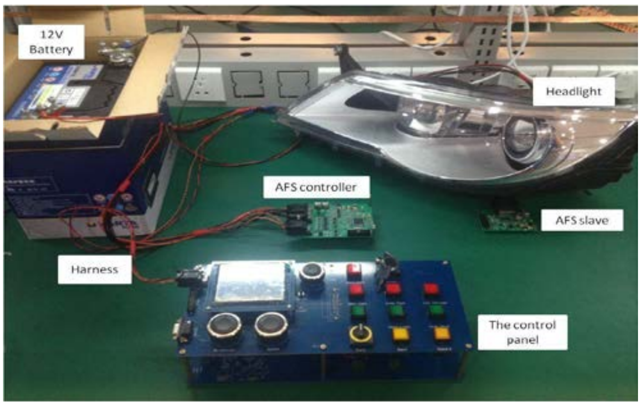


Fig5. AFS demo set

5. Operation of Demoset

Connections: To set up the demonstration system, each component of the system must be connected properly with the harness. Figure shows the terminals of the harness.

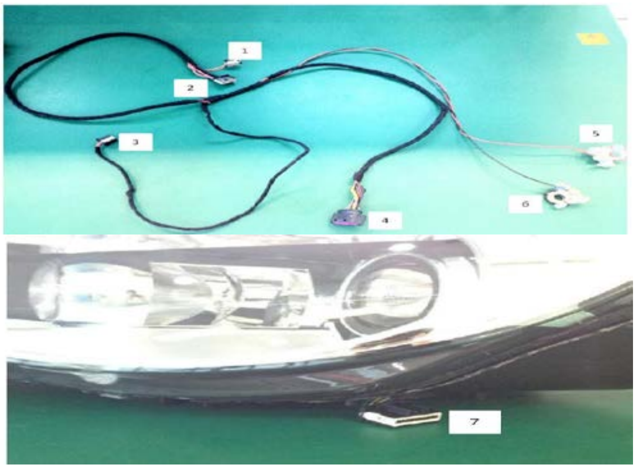


Fig6. Harness

- 8-pin terminal; communication connector for the AFS controller
- 20-pin terminal; power and control signal of the AFS controller
- 8-pin terminal; communication and power of the control panel
- 14-pin terminal; communication, power, and control signals of the headlight unit
- Power clipper to 12-V battery positive
- Ground clipper to 12-V battery negative
- 20-pin terminal; connection between headlight unit and the AFS slave.

Perform the following the steps to set up the system:

- Connect terminal 4 to the headlight unit. The receptacle of terminal 4 is at the back side of the light near the bottom. This is an antireverse connector. The user can plug the terminal into the receptacle until a click is heard.
- Place terminals 1 and 2 to the receptacles on the AFS controller, terminal 3 to the receptacle on the control panel, and terminal 7 to the receptacle on the AFS slave. These connectors are also designed with an antireverse feature. The user can plug these connectors into the receptacles until a click is heard.
- Connect terminal 5 to the positive pole of a 12-V battery, and connect terminal 6 to the negative pole.

5. Conclusion

The Adaptive Front Lighting System is a system which regulates automatically the light distribution of a vehicle. A specific control algorithm is developed for different driving conditions – curve roads and incoming vehicle‟s. AFS can be formally defined as maintaining a presumptively desired light distribution adapted to the above road environment. The system tested does so by way of input from in-vehicle parameters like steering wheel angle and distance between incoming vehicle and subject vehicle etc.

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. 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.

AFS appears to offer potential for a favorable night driving behavior potentially reducing accident risk, compared to standard headlights. 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 neighboring and backside vehicle can also be traced. A second dimension may also use external input from satellite positioning (GPS or Galileo) to determine current road environment in order to control desired light distribution.

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