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# Simulation of the Control Method for the Adaptive Front Lighting System

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**Abstract – Adaptive front lighting system becomes more and more popular today. Not only in combustion engine vehicles, but also in some of those new model electric vehicles. Since the new headlamp control system contains several components including drives and controls. Any error on design may affect the overall performance of the system. The simulation of The Auto-levelling control system is very important to ensure its functionality and compare the real output of the system from mock up models. Simulink is the programme which can be used for simulating the system.**

**Keywords–AFS, Adaptive front lighting, HID, Automotive**

## I. INTRODUCTION

HID lamp is now a popular lighting system for automotive application. The HID lamp is preferable than the conventional incandescent lap because of the high performance in the rendering factor, efficacy, and life time. Massive research has been conducted in the last 10 years. The ballast research on high frequency, control and soft-switching have been reported [1-6]. Recently the adaptive front-lighting has been adopted by industry. The angle of the illumination can be controlled according to the driving needs. Ref [7-9] have reported the AFS using various control method. The selection of the stepper motor has been reported in ref [10-11]. The use of the dimmable illumination has been examined in ref [12-13].

The control method for the lamp including the distance of the on-coming vehicle, illumination in the vicinity and the decision of to use high or low beam. The control method is firstly examined by using stateflow study. The simulation software "Simulink" is firstly to be used.. Through this software, a standard set of data can be created as the testing environment to compare the differences between the theory and practical results. Four criteria has been set to be the reference of the logic control which is Distance Signal, Street Lamp Sensor signal, Front Light Reflection Sensor signal and Speed Signal. These criteria will be used to calculate the logic control of the high beam and low beam of the Automatic Headlamp System. In order to show the results in a simple and clear way, assuming the pitch of the vehicle remains horizontal and velocity of vehicle remains constant.

## II. CASE 1: AUTOMATIC HIGH/LOW BEAM CONTROL

Automatic High/Low Beam is part of the headlamp control system. The result for activating the system is related to the Distance Sensor. Assuming that a half-sinusoid source is the signal generated by the ultrasonic sensor as the distance signal. From the block diagram in Figure 1, $u_x$, $u_1$ & $u_2$ represents Ultrasonic Sensor, High beam, and Low Beam respectively. In this system, the model was built according to the Finite State Machine theory to stateflow block and Simulink to make complex logic relationship clearer. The stateflow chart is described in Figure 2. The simulation result is obtained as shown in Figure 3 which clearly shows the logic operation when the system receives sampled distance signal.

The waveforms shown in Figure 3 are the signals of High beam, Low beam and distance detector respectively. Logic "1" is equivalent to "ON" state and "0" is equivalent to "OFF" state of the light. The distance transducer converts 0-50 metres to 0-5 volt. In Figure 3, high beam is switched off and low beam is switched ON as well as triggering the HID Dimming Control System while the obstacles are detected in the first 5 metres. When obstacles detected in 5-50 metres, high beam will turn off. Low beam angle signal varies within the value of 0.1-1 and the angle of Low beam will be adjusted from the lowest to highest angle. High beam & Low beam will go to ON state at the same time if there are no obstacles detected in or within 50 metres.

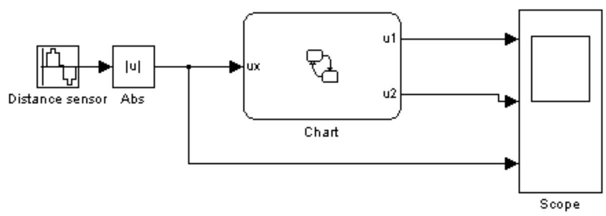


Figure 1: Automatic Hi/Lo Beam System

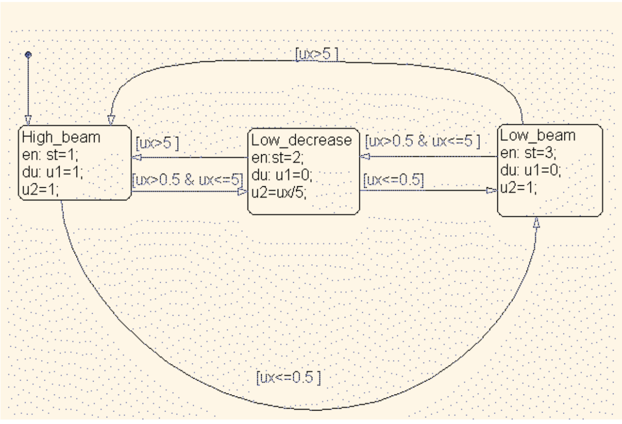


Figure 2: Stateflow of Automatic Hi/Lo Beam System

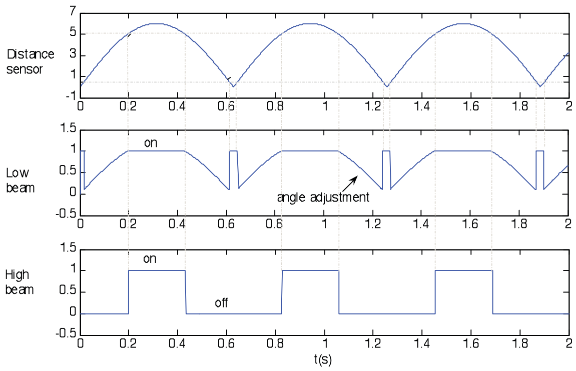


Figure 3: Waveforms of Hi/Lo Beam System
(Distance sensor scale: x10m)

## III. Case 2: Simulations with Distance & Street Lamp Detector

A revised headlamp controlling system as shown in Figure 4 can vary headlamp level and High/Low beam mode according to the distance and the light upward signal which is the Street Lamp detector. A half-sinusoidal source simulates the distance signal which is sampled by the ultrasonic sensor. A pulse trains simulates Street lamp input sampled by the light upward sensor. In this system, the stateflow chart is describing the picture of the logic in Figure 5 and the simulation result is shown in Figure 6.

Light upward signal is '1' indicates a street lamp is at ON state. As the graph shown in Figure 6, when street lamp is detected by the street lamp sensor, the signal state is "ON", The high beam is definitely off as the street lamp is present. When street light is in "OFF" state, High beam and Low beam will be working separately according to the distance signal.

According to the designed logic, at the first cycle, street lamp has been detected by the sensor. High beam will be kept at off state since it is not necessary to use High Beam in a well illuminated road. The HID dimming control system will be triggered if the obstacle detected is within 5 meters away. The low beam is at "ON" state as well. If an obstacle is over 5 meters, the low beam angle adjustment mode will be on, and the headlamp angle will be adjusted by the distance from 5 to 50 meters according to the actual distance.

When there are no obstacles detected within 50 metre as well as no street lamp illumination on the road, high beam and low beam will be at ON state simultaneously. High beam will be at "OFF" state again when the next street lamp is detected. Headlamp angle will be adjusted when the distance from an obstacle is less than 50 metres. The status repeats in another cycle. As it can be seen in Figure 1 and Figure 4, the only difference on two tests is to use the Street Lamp Detector signal to actuate the high beam.

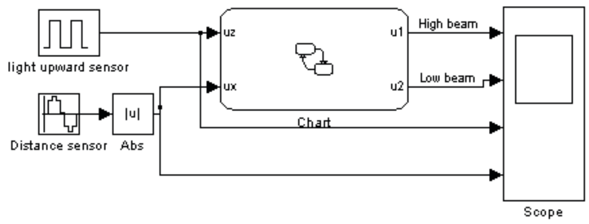


Figure 4: Low Beam level adjustment System

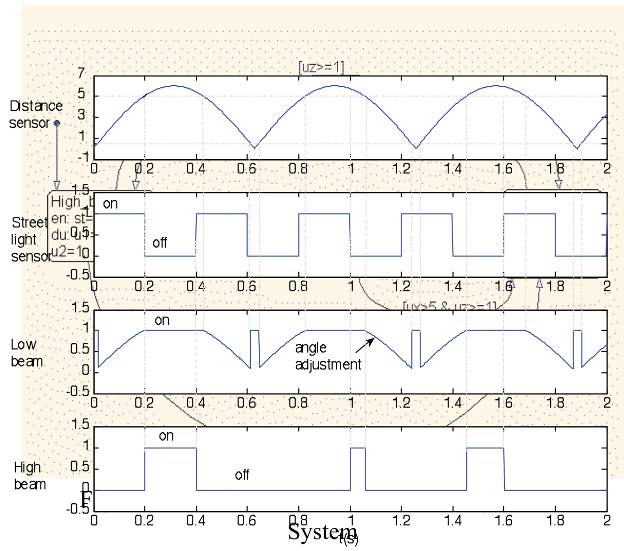


Figure 6 Waveforms of Low Beam level adjustment System. (Distance sensor scale: x10m)

## IV. Case 3: Simulation with Front Reflection Sensor Added

Assuming a light forward sensor has been installed at the dashboard facing towards the front near the level of driver's eye-sight inside the vehicle. The function for that is detecting the headlamp beams reflected by the vehicles at the front causing glare to the driver. In this new headlamp system, dimming control system is one of the major components which collects the light from the light forward sensor and sampled into light signal. It is shown in Figure 7. The stateflow chart is described and the corresponding simulation result is shown in Figure 8 and Figure 9 respectively. The high beam omitted in this case as the testing distance is not over 5 metres and the high beam is designed to be turned off. The typical distance of the obstacle is in 5 metres in our study. As shown in Figure 9, if the minimum brightness is over the designed brightness which the drivers can feel comfortably, low beam will be turned off completely until there are any increments in distance.

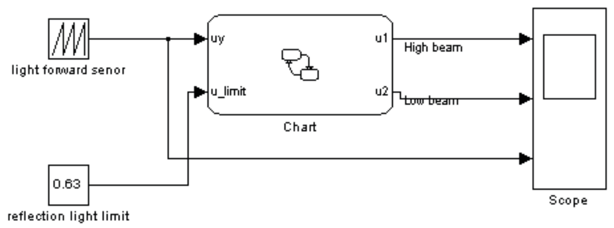


Figure 7 Headlamp Dimming Control System

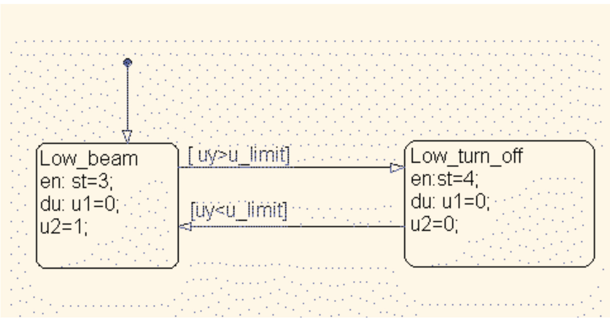


Figure 8 Stateflow of Headlamp Dimming Control System

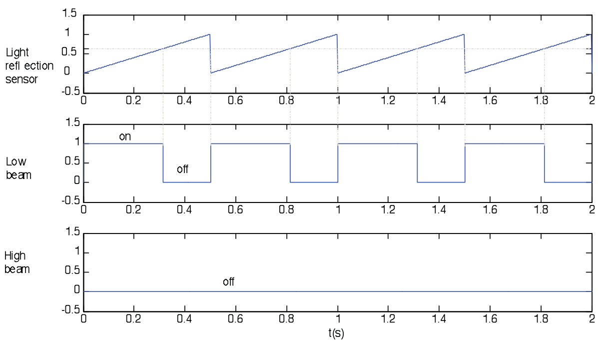


Figure 9: Waveforms of Headlamp Dimming Control System. (Distance sensor scale: x10m)

## V. CASE 4: SIMULATIONS WITH ALL CONDITIONS

Gathering all the simulated conditions mentioned above, a full headlamp controlling system consists of adjustable headlamp level, High beam/Low beam mode, is shown in Figure 10. In Figure 11, the stateflow chart has been described and the simulation results are shown in Figure 12.

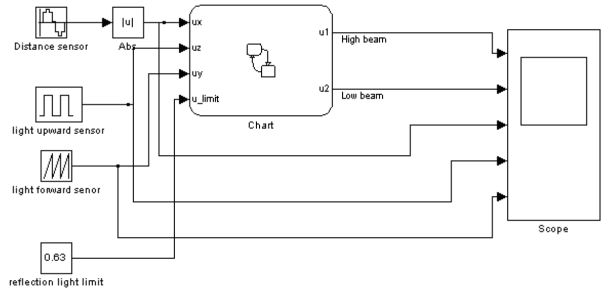


Figure 10: Headlamp Control System

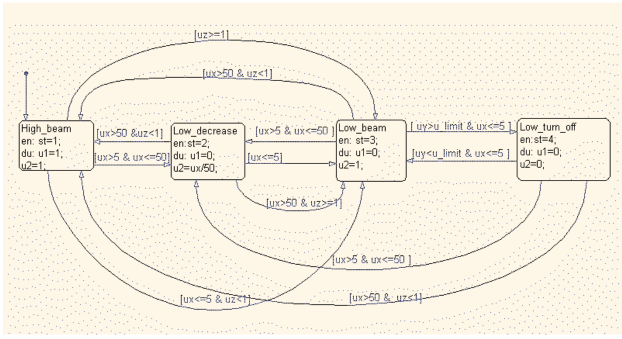


Figure 11: Stateflow of Headlamp Control System

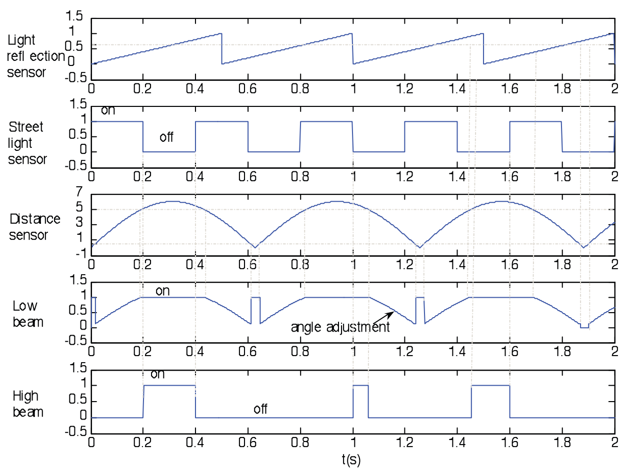


Figure 12: Waveforms of Headlamp Control System (Distance sensor scale: x10m)

As shown in Figure 12, high beam is off in the first cycle of Street lamp sensor. If an obstacle appears in 5 meters at the same cycle and the brightness is still acceptable, the low beam is on with dimming by the HID dimming control system.

If an obstacle appears at a distance from 5 to 50 metres, then headlamp angle for Low Beam is adjusted according to the distance and High Beam is complete OFF.

In the next cycle with the street lamp detector is in OFF state, then high beam is on because there are no obstacles detected within 50 metres. However, the high beam will be off again when an obstacle appears in 50 meters. This operation is repeating until the end of the second cycle.

If the distance is in 5 meters and the brightness is over limit, low beam is also off.

## VI. Conclusion

The Simulink model has been presented to examine the logic flow of different parts of the Advanced Headlamp Control System. This simulation gives a clear mind on testing the functionality of our design ideas before building a physical model. The method shows developing a new system by using simulation can reduce time and failure rate. Simulation results of 4 different cases have been provided.

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