VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

NEW DESIGN OF AN INTELLIGENT SYSTEM (AFS) OF AUTOMOBILE WITH DIGITAL PWM TECHNIQUE ON FPGA BOARD

H. Dahou[1], R. El Gouri[1, 2], K. Mateur[1], M. Alareqi[1], A. Zemmouri[1], A. Mezouari[1] and L. Hlou[1]
[1]Laboratory of Electrical Engineeringand Energy Systems, Faculty of Sciences Kenitra, Ibn Tofail University, Morocco
[2]Laboratory of Electrical Engineering and Telecommunications Systems, National School of Applied Sciences, Ibn Tofail University, Morocco
Email:hamad.dahou@gmail.com

ABSTRACT

The automatic light AFS (adaptive Front-Lightning System) is a complement to the functionality of modern vehicles. It helps to improve vehicle safety. The system also helps to minimize energy consumption when compared to the existing systems.

A new architecture of the AFS was suggested in this article. This architecture replaces the old mechanical system based on stepping motors by a new lighting system by adapting digital technique PWM (Pulse Width Modulation) using the FPGA SPARTAN 3E FG 500, 320.

This system performs intelligently and is very helpful in road traffic management and work according to the steering angle of the car and depending on weather, speed and driving position.

Keywords: adaptive front-lightning system, pulse width modulation, field programmable gate array.

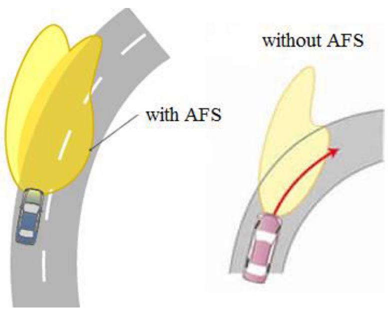
1. INTRODUCTION

With the increasing number of cars in the world and in spite of consistent development in design and manufacture of cars the number of accidents is increasing.

Therefore, automobile engineers are focusing more than ever on the safety devices to prevent these accidents, which are mainly due to human factors.

One of these systems is AFS [1] [2] [3], which is supposed to reduce driver fatigue by providing a suitable lighting for the driver in order to cover the entire road while negotiating a curve or corner.

The Figure-1showsa car with and without AFS. While taking a turn, the distribution of the light ahead and leaves off many blind corners (b): which causes a difficulty for the driver and thus increases the probability of an accident. However, in the case of a vehicle with (a) AFS, the distribution of the light leans towards the direction of the turn by reducing blind angles and covering the whole of these angles.



(a)(b)

Figure-1. (a) car with AFS system (b) car without AFS system.

Given that the driver must provide a minimum of effort to cover the visual field of its path, the curved trajectory of the light provided bya system is based on a stepper motor [1], which controls the headlights in order to follow the direction of the turn.

This system uses four lamps: two lamps fire the road while two are crossing fire lamps, which are connected to two stepper motors, of which one is vertical and it turns the lights vertically, and the other is horizontal, which turns the lamps horizontally to follow the trajectory of the car through the turn [1] [4].

Figure-2. Light view in the opposite direction.

The disadvantage of the latter is that it causes confusion for the driver coming from the other side. The Figure-2 shows the glare seen by the driver of the car from the opposite direction. This light intensity was reduced by the AFS.

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

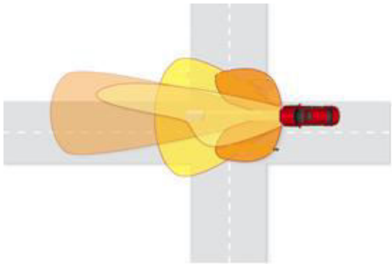


Figure-3. Light distribution for each scenario.

This article proposed a new architecture of the AFS, which will keep the same operation of the low beam lamps. However, it will replace the low beam lamps with three lamps. These lamps illuminate successively the right, the left and the middle of the car. Therefore, instead of ordering, the stepper motor to move the headlights to follow the direction of the turn [1].We will control the degree of brightness of the low beam lamps horizontally and vertically according to the rotation of the steering wheel, as well as the brightness of the low beam lamps according to the speed, using the digital PWM technique [5].The overall system implemented on FPGA board.

2. MATERIALS AND METHODS

A. New architecture of the parabola of car lighting

Figure-4 shows the architecture of parabola of the current car, the current system of AFS is based on a stepper motor that in fact turns the low beam lamps in such a way as not to exceed a maximum angle of -10 degrees to the right and a maximum angle of +20 degrees to the left.

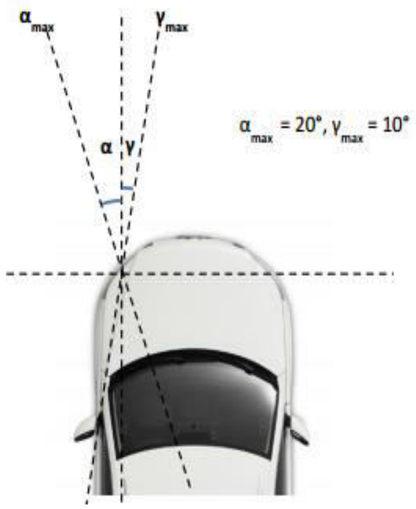


Figure-4. The architecture of parabola of the current car.

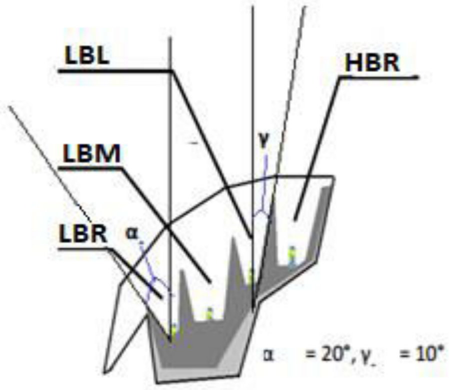


Figure-5. New architectures of parabola of proposed lighting.

Figure-5shows the architecture of the proposed parabola left containing four types of lamps:

The first on the right is the high beam lamps, the others are those of low beam lamps. The lamp tilted with an angle of +10 degrees illuminates the right side of the car, the middle is lit by a second lamp and the left side is lit by a third lamp inwhich the tilt is -20 degrees.

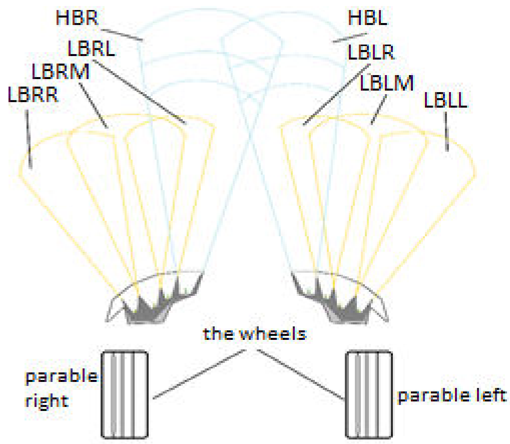


Figure-6. Trajectories of the light of various lamps.

Figure-6shows the types of lamps for the parabola left and right of the car as well as the trajectory of the lighting.

B. Proposed Architecture

One of the essential parts of our system is the analog conversion digital.

The ADC receives the analog data from the sensors to the direction of the steering wheel, with speed converts them into a digital value, wraps it up in the FPGA block and constitutes a LUT and a PWM.

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

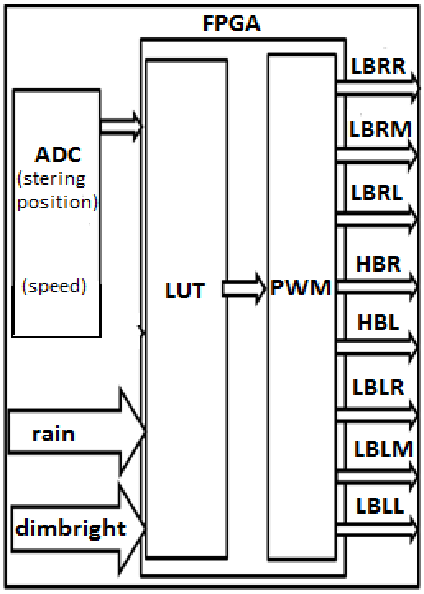


Figure-7. Global diagramof AFS.

The block (LUT) receives, in addition to the previous data, two other data selected by the operator specifying as well the existence or not of the rain mode and the lighting mode.

The block (PWM) circuit adjusts the brightness of the low beam lamps, and high beam lamps.

C. ADC in AFS architecture

In this application the ADC is used to convert the analog data from the rotation sensor link to the steering wheel, in order to transmit them to the FPGA which is going to change the brightness of lamps using the digital PWM technique, and to do this, we have chosen a converter of 8-bit.

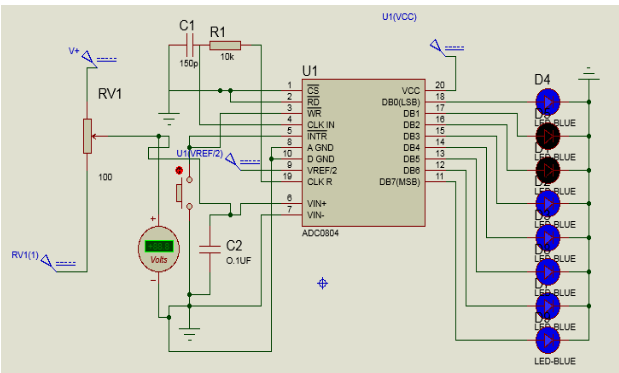


Figure-8. Simulation ADC.

Figure-9 shows how the binary model is assigned to the Steering wheel.

The numbers determine the representation in decimal of 8 bits of data provided by the ADC. For example, if the cockpit is to 128, the ADC will provide the binary value '10000000'for the FPGA.

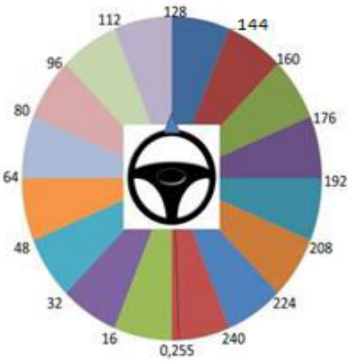


Figure-9. The position of the steering wheel converted by ADC.

D. Controller block

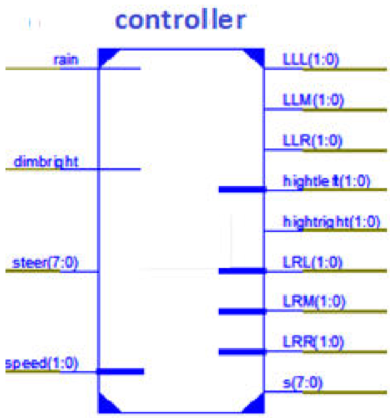


Figure-10. Synthesized blockof controller.

The PWM block receives data from the controller block (LUT) in order to generate the PWM signal for each lamp. The system takes into consideration the condition of the driving position, vehicle speed and the condition of the climate outside. It allows you to adjust the brightness of the lamps in an intelligent manner bolt-to-bolt of the conditions of the road and the speed of the vehicle as shown in Figure-3.

In different scenarios, the AFS acts differently. The lighting mode of the motorway is activated when the vehicle is moving above 80km/h, the lighting mode of the national road is activated when the vehicles speed is greater than 40 km/h, and below this speed, the lighting mode of the city is enabled.

When the vehicle is in clear mode as shown in Figure-11and Figure-14, we are going to give a PWM signal to the lighting of road to compensate for the style of conventional lighting. When the vehicle is moving above 80km/h, we enable the two lamps with a maximum capacity to improve the driver's visibility.

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

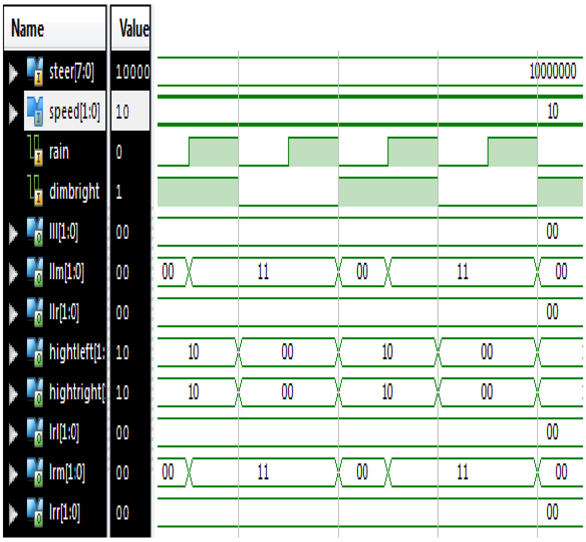


Figure-11. Simulation of the controller block in clear mode.

Figure-11andFigure-12 show how the controller block is in dark mode and in clear mode. It monitors the inputs from sensors such as rain and speed. When the speed sensor reaches its maximum value, the controller assumes that the vehicle moves with a maximum speed and will provide a maximum intensity to the high beam lamps.

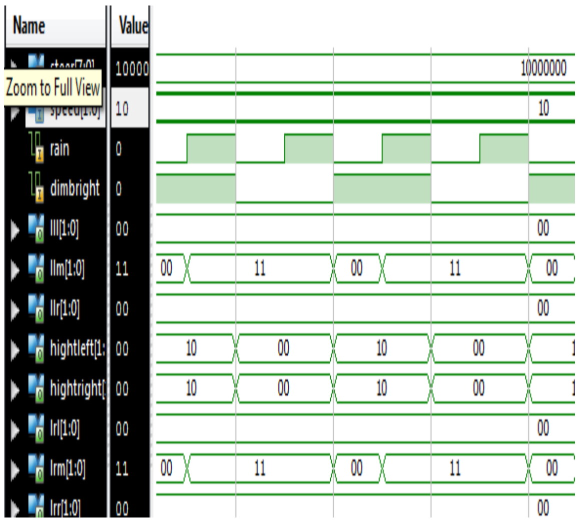


Figure-12. Simulation of controller block in dark mode.

In the Figure-12,the controller block is in dark mode therefore when the rain sensor is activated, the Lighting of road is provided with half of its maximum capacity.

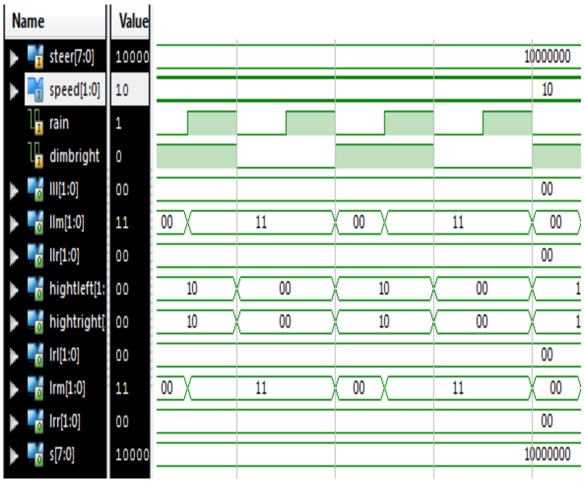


Figure-13. Simulation of block controller mode in rain and in dark mode.

In the Figure-14: the car marked with a high speed, the high beam lamps are supplied with maximum intensity.

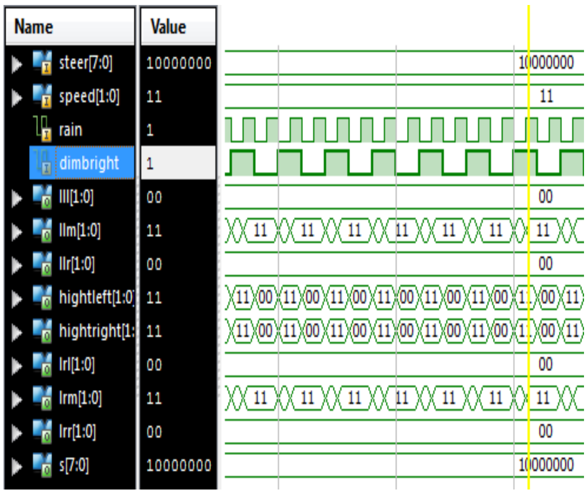


Figure-14. Simulation of block: when the car lighting mode of motorway.

When the car takes a turn to the left or right the controller block treats all cases depending on the steering angle. We will cite a few examples. This allows us to say that there is a relationship between the angle of rotation of the steering and the angle of rotation of the wheels, each brand of automobile has its own index and it is called: steering ratio.

$$AD = AR \times DD \quad (1)$$

AD: Steering Angle
AR: angle of wheels
DD: steering ratio.

And concerning the Figure-15: the wheels turns to the right with an angle between 0° and 15°, therefore the steering sensor gives us a given between 128 and 170 in decimal the block controller gives a value means to the low

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

beam lamps LBLM and LBRM and then a low value to the low beam lamps LBLR and LBLL.

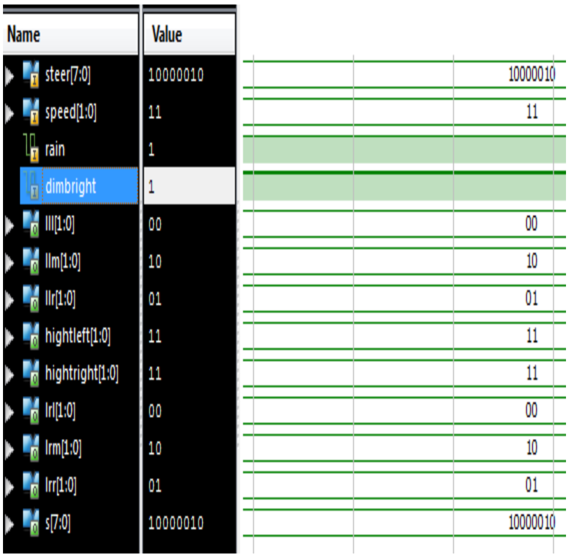


Figure-15. Simulation of controller block in case of a small rotation to right.

And for the Figure-16: the wheels will rotate to the right with an angle between 15° and 30 so the steering sensor give us a signal between 170 and 212 in decimal .

The controller block gives a low value to the low beam lamps LBLM and LBRM and then an average value to the low beam lamps LBRL and LBLL.

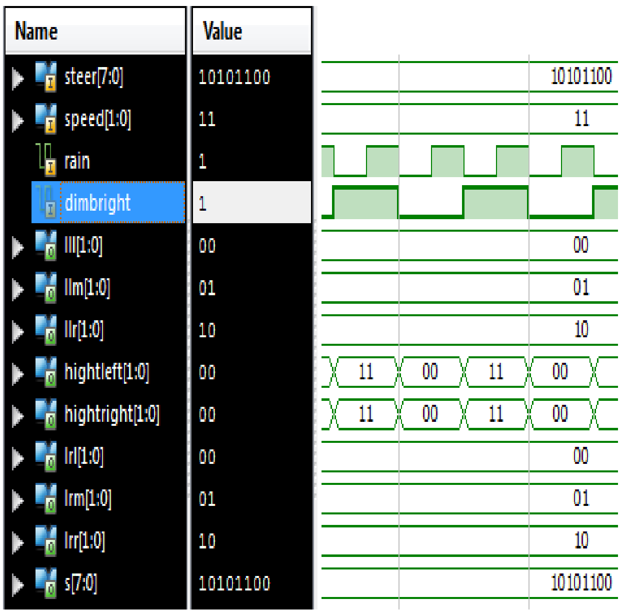


Figure-16. Simulation of controller block in case of an average rotation to right.

Regarding the figure 17: the wheels turn to the right with an angle between 30° and 45° so the steering sensor gives us a signal between 212 and 255 in decimal and the controller block gives a null value to the low beam lamps LBLM and LBRM and then a maximum value to the low beam lamps LBRL and LBLL.

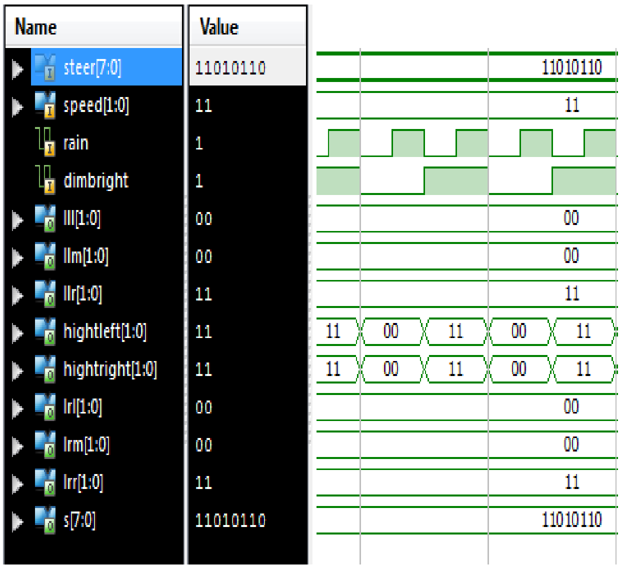


Figure-17. Simulation of block controller in the event of a maximum rotation to right.

We note that the same reasoning is valid for the left rotation.

E. PWM Technique used

The pulse width modulation (PWM) is a powerful technique for the control of analog circuits with digital outputs of a processor. PWM is used in a wide variety of applications, ranging from the measurement and the communication to the conversion and the power control. The applications of PWM are used in the control systems as the converters DC / DC [6] [7] [8], or the PWM signals have been used to convert the DC voltage stable or variable, and also in the controls of AC motor, inverters.

A PWM signal is not constant, the main parameter is a market factor D that is part of the PWM period and describes the proportion of time at regular intervals. Equation (1) describes the cyclic ratio in the following way:

$$D=\frac{\tau}{T} \quad (1)$$

When: $0 \leq D \leq 1$

The output signal is therefore calculated in equation (2):

$$output = D \times input = \frac{ton}{ts} \times input \quad (2)$$

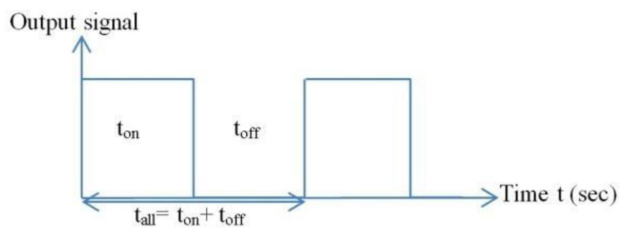


Figure-18. PWM with cyclic ratio.

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

The PWM technique allows you to control the frequency and the power given to the engine. In our system, we will use this technique to control the electrical power applied to the bulbs of the parabola lighting of the car. Using FPGA, it will generate PWM signals into four levels.

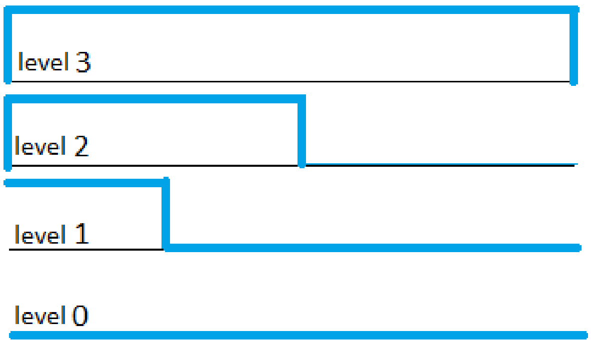


Figure-19. Different levels generate by PWM.

In our system we have designed, a program containing eight sub-programs.PWM ensures that the electrical power given to each lamp varies depending on the scenario of road and the direction.

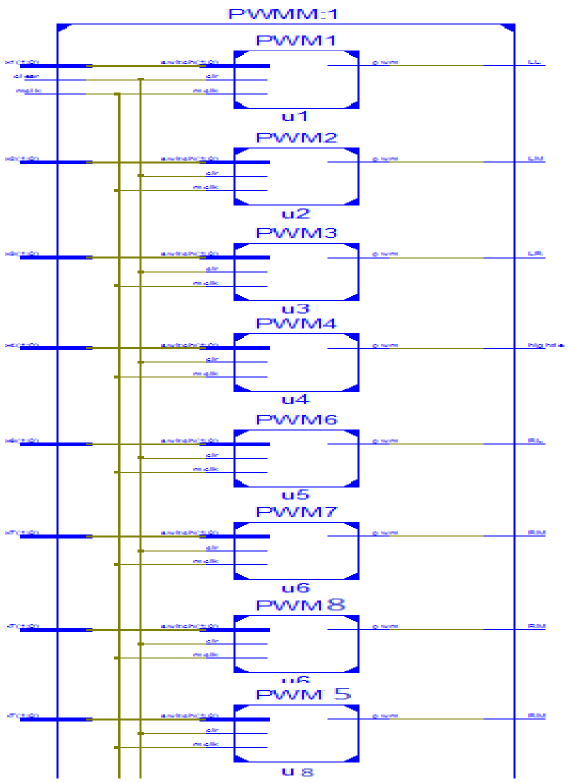


Figure-20. Synthesized block ofPWM driver.

F. Simulation and overall analysis of the AFS

In order to design all of the elements of our system we have assembled the global AFS, which is sensitive to the direction and the condition of the road as shown in Figure-19, which allows us to control lamps for lighting.

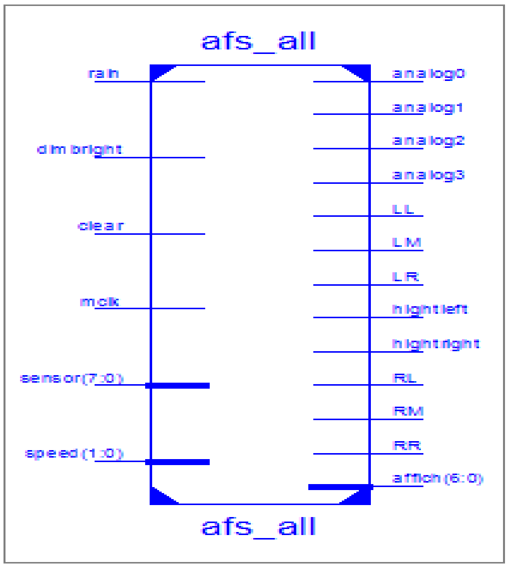


Figure-21. Block synthesized OF AFS system.

For Figure-20: the overall program includes Sub-programs in the form of components connected between them. The controller block provides its outputs to the PWM block, which passes to the end to build the global system that controls the operation of the lamps according tothe scenario of the road and the condition of cockpit ensuring all safety standards and the quality of driving.

3. RESULTS AND DISCUSSIONS

- **Implementation of AFS system in FPGA**

To test our system, we implemented the comprehensive program on FPGASPARTAN 3E 500 FG320. We have used the switches as outputs of the ADC, connected to the rotation sensor, which is linked to the steering and the push buttons, as are the digital outputs of the ADC attached to the speed sensors and humidity sensor.

In addition, the light-emitting diode (LED) as entered the actuators connected to the front light lamps of car as shown in Table-1 and in Figure-22.

Table-1. Input and outputs of FPGA used in the tested.

Between/outputs system	Between/output FPGA
Sensor connected to the direction	Switches
Speed Sensor	BTN(0) and BTN(1)
Rain Mode	BTN(2)
Dark Mode	BTN(3)
Lamps for lighting	LED

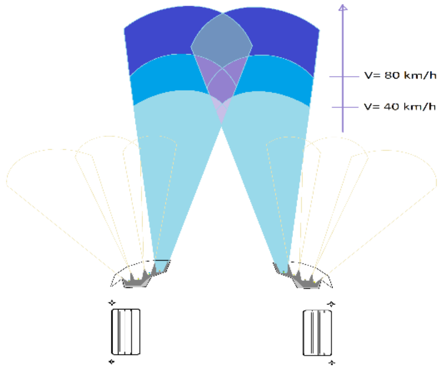
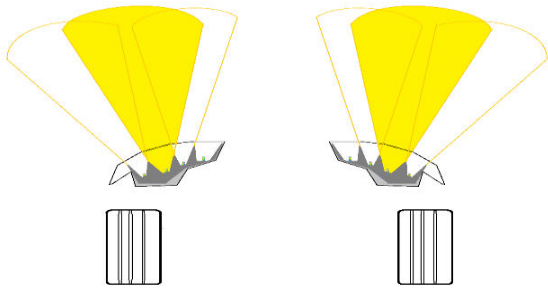
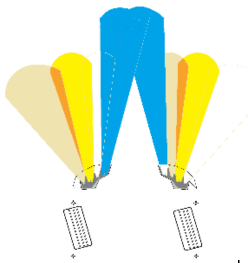
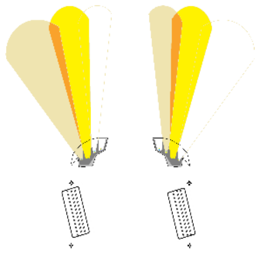
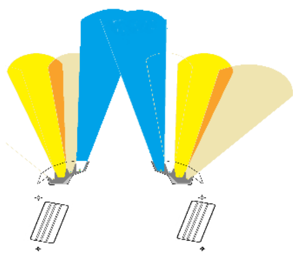
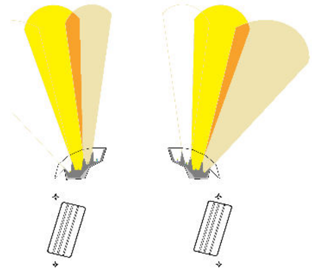
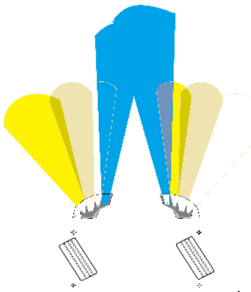
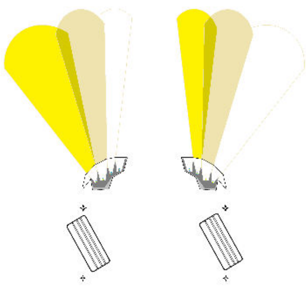
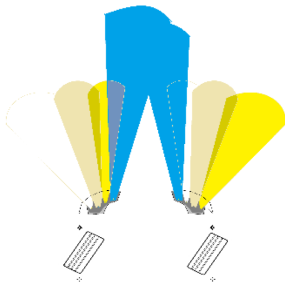
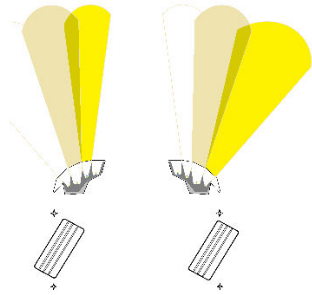
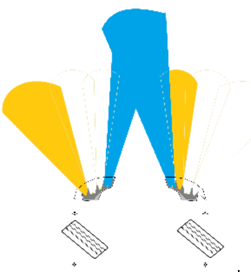
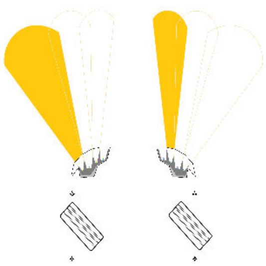
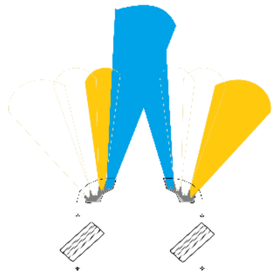
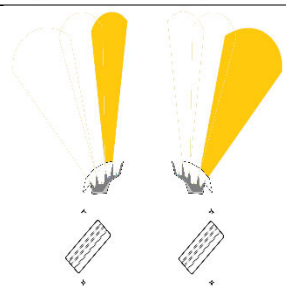
VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

In addition, we have tested all the possible cases of the scenario of the road, and we got our results. In the Table-2: We have cited a few examples, which allow us to see that the light follows the direction of the turn depending on the angle of rotation of the wheelsϴ.

Among the advantages of system, it saves energy consumed by two stepper motors horizontal and vertical: 12 volt 1A, that turned the headlights to low beam light depending on the direction of the car and the driver's requirements

Table-2. Results obtained on FPGA for a few examples.

<table>
<tr><th>Angle</th><th colspan="2">Dark mode</th><th colspan="2">Clear mode</th></tr>
<tr><td>ϴ= 0°</td><td colspan="2">
</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">left</td><td colspan="2">right</td></tr>
<tr><td></td><td>Clear mode</td><td>Dark mode</td><td>Clear mode</td><td>Dark mode</td></tr>
<tr><td>0°<ϴ≤15°</td><td></td><td></td><td></td><td></td></tr>
<tr><td>15° ≤ϴ< 30°</td><td></td><td></td><td></td><td></td></tr>
<tr><td>30° ≤ϴ< 45</td><td></td><td></td><td></td><td></td></tr>
</table>

VOL. 12, NO. 3, FEBRUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Table-3. Number of logic gates used by the system.

Device Utilization Summary (estimated values)			
Logic Utilization	Used	Available	Utilization
Number of Slices	115	4656	2%
Number of Slice Flip Flops	94	9312	1%
Number of 4 input LUTs	216	9312	2%
Number of bonded IOBs	33	232	14%
Number of GCLKs	2	24	8%

Table-3 shows the statistics of logic gate used and the flip-flop and the number of inputs and outputs the clocks which used in FPGA, it is clear that our system uses only 2% of logic gate and 1% of the flops; because of this we have a fast robust and performing system.

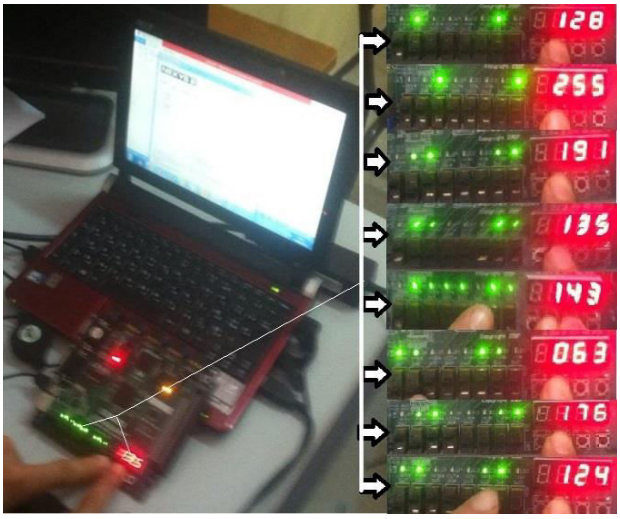


Figure-22. Implementing the AFS on FPGA.

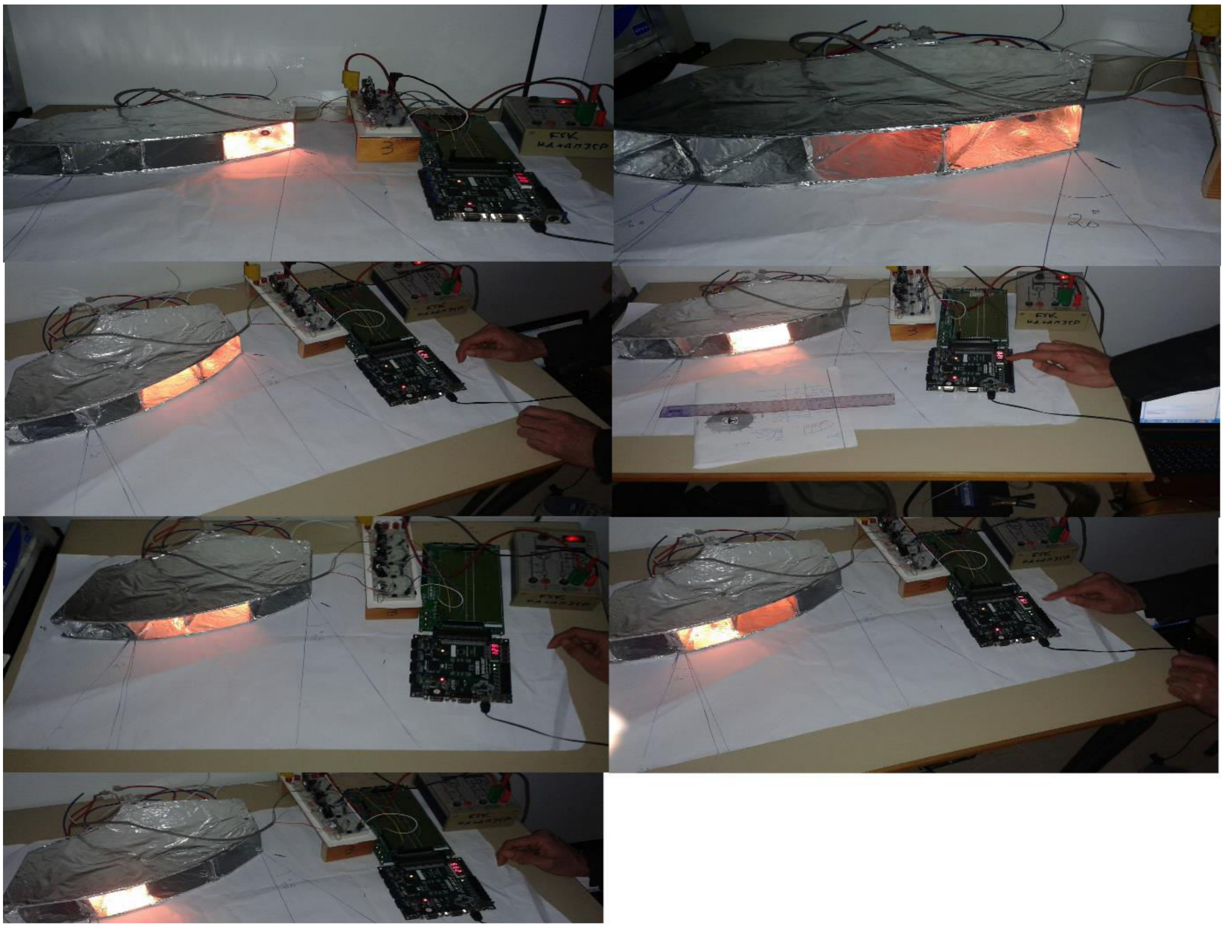


Figure-23. Prototype Realized AFSwith different case car turning.

The Figure-22 shows prototype that contains devices and lighting system, which allows for variable brightness of the car lighting lamps according to the road conditions and the position of the steering wheel by using the PWM digital technology in FPGA. Both results revealed that, there is no difference between those obtained from the prototype and the simulation. Figure-24 shows light generating by our system according to the scenario of the road and the cockpit.

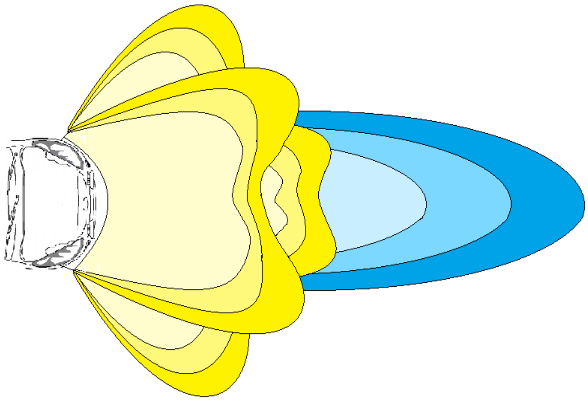


Figure-24. Diagram of illumination of the road generate by the car.

4. CONCLUSIONS

In this article we are designed an architecture for an intelligent system AFS on FPGA for keeping the distribution of conventional light to improve the lighting of night and the security of users.

This system uses the digital PWM technique with high resolution, which provides a better control of hardness and the intensity of the headlights according to the rotation of the steering wheel.

Whereas the light follows the bend in the road, so we were designed an intelligent system and device reliable, robust, secure and with economic energy levels.

REFERENCES

[1] Lino M Samuel, Mrs Meena KV, Dr. Raja R, Mrs Savita Y Patil. 2014. Design of AFS system in automobiles on FPGA. International Journal of Research in Engineering & Advanced Technology. Vol. 2, Outcome 2, Apr-May.

[2] Snehal G. Magar. 2011. Study ofadaptive front-lighting system of automobile based on microcontroller. Transportation, Mechanical, and Electrical Engineering (TMEE), 2011 International Conference. 23(6): 1281-1284.

[3] Li Lifu, Yang Mingjun and Zhang Jinyong. 2015. The bending mode control method of AFS system based on preview control. International journal on smart sensing and intelligent systems. 8(1).

[4] Ronten Ma. 2013. Automotive Adaptive Front-lighting System Reference Design. TEXAS Instruments reference design: SPRUHP3-july 2013, System Application Engineering/MCU.

[5] Z. Nouman, B. Klima, J. Knobloch. 2013. Generating PWM Signals with Variable Duty From 0% to 100% Based FPGA SPARTAN3YEAR. Electrorevue. 4(4).

[6] Muntean, N, Gavris M has Cornea O. 2011. Dualinput hybrid DC-DC converters. Eurocan International Conference on Computer as a Tool (Eurocan), 2011 IEEE: And conference calls. 27-29 April.

[7] Agnihotri, P. Kaabouch, N. Salehfar, H. Wen-Chen, HU. 2010. FPGA-based combined PWM-PFM technical tb control DC-DC converters. North American Power Symposium (NAPS), 2010 IEEE Conference.

[8] K. Eftichios D. Apostolos, K. Kostas. 2006. High frequency pulse width modulation implementation using FPGA and CPLD ICs. Journal of Systems Architecture. 52: 332- 344.