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IMPROVEMENT OF A NEW DESIGN FOR THE LIGHTING SYSTEM (AFS) AUTOMOBILE USING LED MATRIX AND DIGITAL TECHNOLOGY (PWM)

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ABSTRACT

AFS (Adaptive Front-Lighting System) automatic lighting system is a new technique added to modern vehicles. It helps to improve front lighting, which contributes to the improvement of motor vehicle safety. Given the importance of this system, a new architecture of this system is propose in this article. This architecture replaces the old architecture, which is based on the lighting system of conventional headlamps by a new lighting system based on LEDs. The new system features are efficient, intelligent, economical in terms of energy consumption, and offers total and continuous coverage of the lighting level on the entire road during driving.

Keywords: AFS, PWM, LED, Arduino, FPGA.

1. INTRODUCTION

Current luxury vehicles contain lighting systems that benefit from an adaptive lighting technique known as the Automotive Front Lighting System (AFS) [1-5, 17]. In fact, the AFS represents a lighting system offering an optimized vision for the driver under the particular conditions of driving, namely the poor visibility of the road or the turn. The AFS system works by adjusting the angle of the dipped or beam headlamps and their intensity according to several variables such as vehicle speed, angle of turn or climatic conditions.

The patent [6] presents an illumination control system for vehicles comprising a motor drive controlled by a control circuit.

The latter is connect to the steering column of the vehicle. The engine spins vehicle lights through a transmission mechanism incorporating hydraulic cylinders, to guide the vehicle lights according to the radius of the steering wheel.

Similarly, for both patents [7-8], they present an adaptive front lighting module (AFS) which is configure for peripheral lighting and dipped beam illumination. This module comprises a plurality of LEDs capable of emitting light in response to the turning radius of the vehicle.

The Patent [9] describes an AFS lighting module of the vehicle which is bases on the control of a stepper motor directly connected to the dipped-beam headlamp and which orientates these latter according to the turning radius.

The patent [10] presents a lighting module consisting of a lamp and a reflector. The light produced by the lamp can be emitter in a direction of propagation by means of the reflector, a rotation system, and a control system.

The Patent [11] describes a fixed AFS lighting module, whereas a maximum amount of light is emit as a function of the turning radius.

The article [1] describes an AFS lighting module, based on a front lighting system of the vehicle, comprising the dipped-beam headlamp that is associated with a stepping motor, which causes the light to be guide in accordance with the Steering angle.

The article [2] describes a new AFS light module, based on front lighting system of the vehicle, which includes dipped-beam headlamps that are fixe but arranged at precise angles. The lighting of these lamps is adjusted according to the steering angle using a process based on the digital technique PWM (Pulse Width Modulation) using the FPGA board.

The article [5] presents an AFS system that gives us four modes of lighting, its principle is bases on the optics and the light produced by LED matrix.

Compared to the previous technical state [2, 3, 4, 5, 12, 16], the position of the lamps helps us to avert the use of stepper motors or any other rotation system or any optic system which, reduces electricity consumption and avoids the problems of engine failures and the mechanisms.

Moreover, the object of the system in the last article cited in [2] is a compact system assembled in a single module (the parabola).

In this article, we have designed and realized a new fixed AFS lighting module, by improving the last system in [2]. In this module, the AFS automobile lighting system includes low power LEDs compared to conventional lamps. This gives us full coverage and continuous light across the road while driving and the problems of engine failures (and mechanisms) parables on the market are avoid.

This article is organize as follows: in the first part, we will present the current architectures of the AFS system, in the second part we will present the improvement that we have made on the latter system, with an implementation on the ARDUINO board and a realized

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prototype. Finally, we will conclude by showing the advantages of the improved system compared to the old systems.

2. LITERATURE REVIEW

A. Current AFS System Architectures

In article [1], the AFS system is bases on a stepper motor that turns lights to low beam headlight, in such a way not to exceed a maximum angle of +10 ° to the right and a maximum angle of -20 ° to the left as shown in Figure-1. This system has several disadvantages as the huge energy consumption, the mechanical problems, and it does not offer a continuous light when taking a turn.

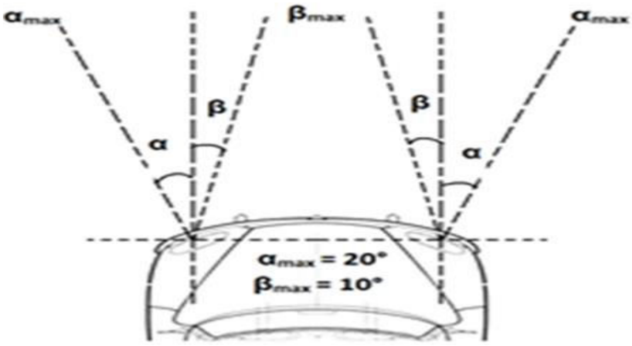

Figure-1. Architecture of the parables of light type 1.

In article [2], the architecture of the vehicle lighting system consists of four lamps. Taking the left parable as an example, the first lamp on the right corresponds to the high beam and the other three lamps correspond to the low beam headlight.

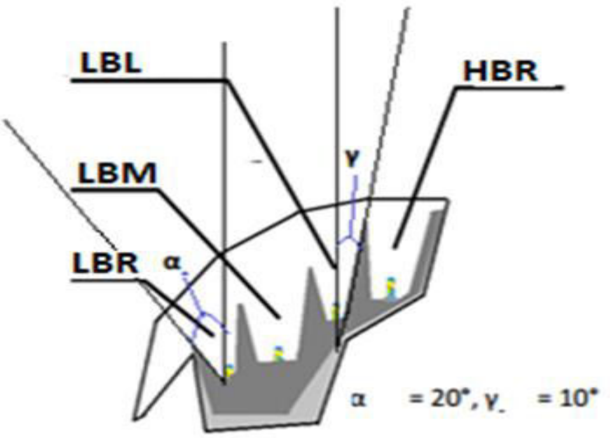

Figure-2. Architecture of the parable of light type.

So, in this architecture, the low beam headlamp is replace by three lamps that are fixe but oriented at predefined angles with respect to the horizontal axis of the car. Taking the left parabola as an example, the first lamp is oriented at an angle of + 10 ° and illuminates the right. The second lamp is oriented at an angle of -20 ° and illuminates the left side. The third lamp is in the middle and is oriented at a zero angle. The right parabola is design symmetrically compared to the left parabola. The disadvantage of this system is that it uses the traditional lamps that consume a lot of energy ranging between 20 watts and 100 watts per lamp.

3. RESEARCH METHOD AND MATERIELS

A. New Architectures of the AFS System

- **New architecture of the parabola with new improvements car lighting**

Due to the enormous power consumption, and to have a continuous light, and full coverage of the light on the road while driving, and to avoid mechanical parts,

This article will present a new module of the vehicle lighting system, in this module, the architecture rather than consist of four lamps; it consists of four LED arrays. Taking the left parabola as an example, the first matrix on the right represents the high beam headlight; the other matrices represent the low beam headlight as shown in Figure-3.

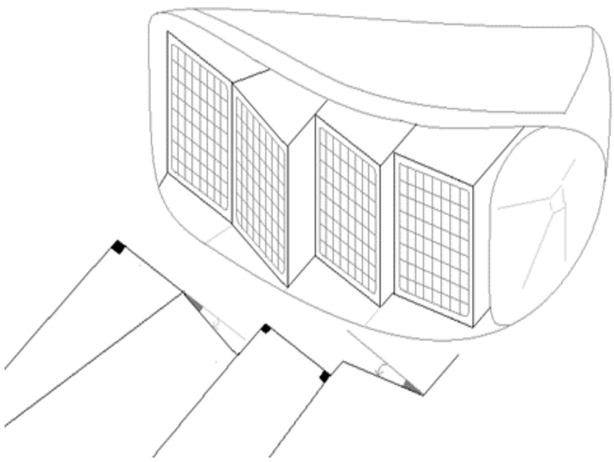

Figure-3. New architecture of the parable car with new improvements car lighting.

However, they are oriented at predetermined angles to the horizontal axis of the car. Taking the left parabola as an example, the first LED array is oriented at an angle of +10° and illuminates the right side of the car. In addition, for the second LED array it is oriented at an angle of -20° and illuminates the left side of the vehicle, at the end the third array is in the middle and oriented at an angle of zero, it illuminates the front of the car. The right parabola is design symmetrically to the left parabola.

- **The improved lighting process**

The Figure-4 shows one of the most important parts of our system, which is the digital analog conversion. The ADC digital analog converter receives the analog data from the steering wheel direction sensor and converts it into a digital value for transmission to the data processing block. The PWM circuit adjusts the brightness of the LED arrays that represent the main beam and the LED arrays that represent the dipped beam as follows:

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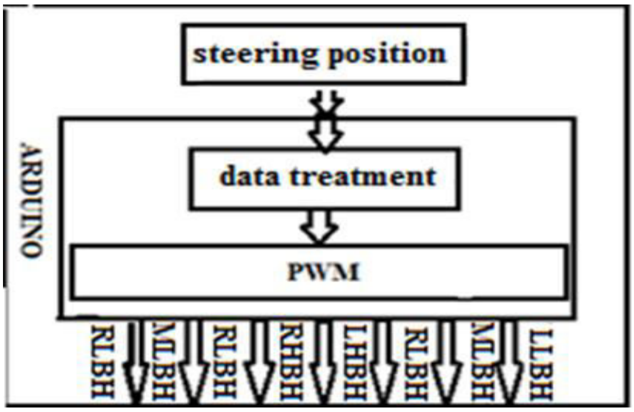

Figure-4. Overall scheme of the AFS system.

For the left parable:

- LHBH: LED Matrix representing the high beam headlight.
- LLBH: LED Matrix representing the low beam headlight on the left side.
- MLBH: LED Matrix representing the low beam headlight of the middle.
- RLBH: LED Matrix representing the low beam headlight on the right side.

The same for the right parabola, it is designed in a symmetrical way.

- **ARDUINO board in the proposed AFS lighting process**

As shown in Figures 4 and 5, the analog digital converter (ADC) is use to convert the analog data from the steering wheel rotation sensor to the ARDUINO. The latter will adjust the brightness of the LEDs using the PWM digital technique [13-14-15]. To do this, we have chosen a 10-bit converter. Figure-5 shows how the binary model is assign to the direction. The numbers determine the decimal representation of the 10-bit data provided by the digital analog converter (ADC). For example, if the cockpit is at 512, ADC will provide the binary value "1000000000".

Figure-5. Steering wheel position converted by ADC.

- **The data processing block**

In Figures 4 and 5 inside the ARDUINO, the data processing unit (state processing) receives the numerical values from the ADC. The schemes, in order to generate new states for them, transmit them to the PWM block.

- **The principle of system operation using the PWM digital technique**

The PWM circuit adjusts the brightness of the LED matrices that come from the low beam headlight according to the type of state it receives (Table-1). The brightness of the LEDs is adjust in 32 levels. In one of the realizations of the article, each level corresponds to a percentage of the maximum power consumed by LED as shown in the following table:

Table-1. Percentage power levels of power supplied to the LEDs.

Levels	%PMAX	Level	%PMAX	Level	%PMAX
Level 1	0%	Level 12	26%	Level 23	74%
Level 2	0,2%	Level 13	31,4%	Level 24	80%
Level 3	0,4%	Level 14	35%	Level 25	84%
Level 4	4%	Level 15	40%	Level 26	88%
Level 5	7,8%	Level 16	43%	Level 27	92%
Level 6	10%	Level 17	47%	Level 28	93%
Level 7	11,8%	Level 18	52%	Level 29	95%
Level 8	13%	Level 19	56%	Level 30	97%
Level 9	15,7%	Level 20	60%	Level 31	99%
Level 10	20%	Level 21	64%	level 32	100%
Level 11	23,6%	Level 22	70%		

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When the car takes a straight road (the ADC gives us a value between 505 and 515), then the ARDUINO gives a maximum power to the middle matrices MLBH, also a zero power to the LLBH and RLBH matrices. When the car takes a right turn (meaning the ADC gives us a value between 515 and 1024) the brightness of the LEDs that make up the MLBH medium matrices begins to decrease from left to right according to the following data:

- The degree of steering.
- The power levels given by ARDUINO quoted in Table-1.

At the same time, the brightness of the LEDs that make up the RLBH right side matrices begins to increase from left to right, and for the LLBH left side matrices remain off.

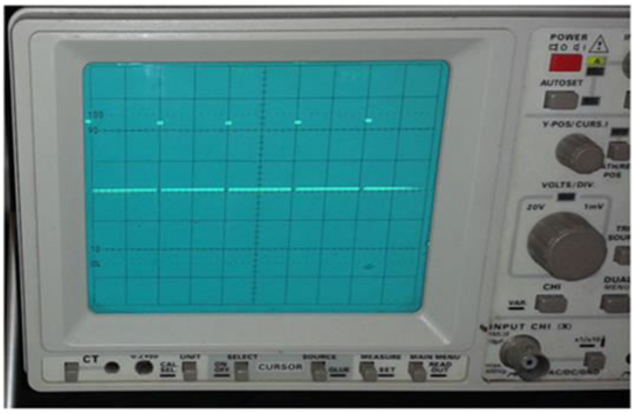

Figure-6. Example of a 7.8% cyclic ratio PWM signal generated by ARDUINO.

4. RESULTS AND DISCUSSIONS

To test our system as shown in Figure-7, we have implemented the global AFS program on ARDUINO MEGA 2650. In such a way that the rotation sensor is connected to port A0 and the PWM ports of the ARDUINO board are connected to the control of the LED columns that make up each matrix that represents the following lights: RLBH, MLBH, LLBH, LHBH, RHBH.

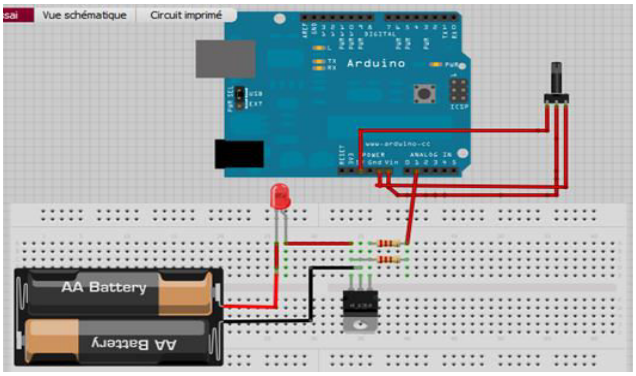

Figure-7. Schematic diagram of the LED brightness control with ARDUINO.

Figure-8 shows the simulation results, the luminaire flow follows the direction of the car (wheel rotation) while taking a continuous turn.

With the system that we have developed, we have found optimal results; we have realized a system that provides a total coverage of light road while driving.

With this system, we managed to have a continuous luminance flow that can follow the direction of the turn, taking advantage of the digital PWM technique (32 levels). It is economical in terms of energy consumption and for engine failure; problems of the parabolas present on the market are avoid.

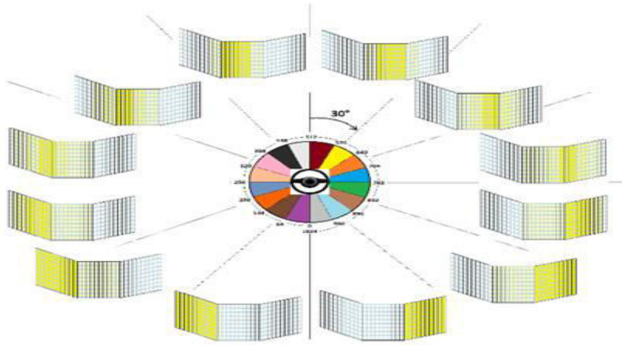

Figure-8. Simulation results obtained on ARDUINO for some examples of steering angle.

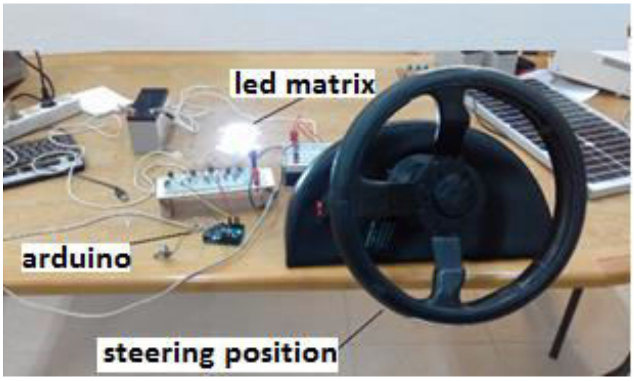

Figure-9. Prototype realized of the new AFS system.

The project is realized by using LED matrices (10 columns each column contains 10 LEDs mounted in parallel with common cathode and anode) which represent the dipped-beam headlamps that are fixed but deposited at precise angles.

The brightness of the LEDs is adjust according to the steering wheel turning angle using a procedure based on the digital method of Pulse Width Modulation using the ARDUINO board (Figure-9). The steering wheel is connect to the rotation sensor, which sends rotation data to the ARDUINO card, in order to adjust the brightness of the LEDs, and a power circuit linked to them.

We can see that the architecture of our improved system is simple, it contains no motorization system or mirrors system, it is easy to maintain, and for programming, it is adapted to the AUTOSAR standard.

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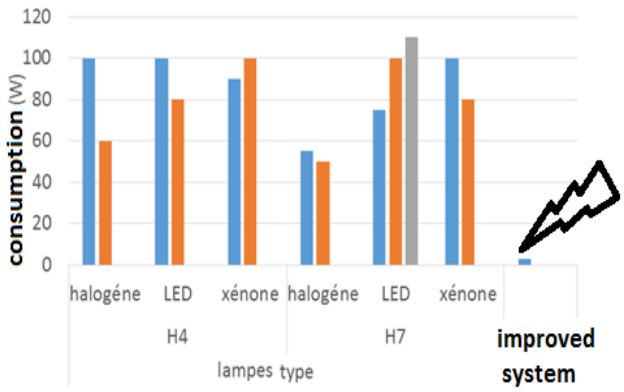

Figure-10. Consumption Energy comparison.

Figure-10 shows a comparison between the consumption of lamps used in the market which varies between 20 and 100 watts and the consumption of an LED matrix in our improved system which does not exceed 3 watts, it is clear that the consumption of a single matrix is very negligible compared to the consumption of other conventional lamps.

After this comparative study it is concluded that our system does not consume a lot of energy (3W) compared to other lighting system (20W-100W), so it is economical at the level of energy consumption, it owns all performances to introduce it in the automotive lighting field as soon as possible.

5. CONCLUSIONS

In this article, we have designed and implemented a new architecture of an intelligent AFS system on ARDUINO keeping the conventional light distribution to improve the night lighting and user safety. The system that we have developed does not allow the use of stepper motors or any other rotation system, which reduces electricity consumption as we mentioned in Figure-10 and avoids problems of motor and mechanism failures.

This system uses high-resolution PWM technology that provides better beam control and LED intensity according to the vehicle's steering angle. So that the light follows the road's turn, in order to have a total and continuous coverage at the road lighting level, and on the other hand, we have realized an intelligent, secure system, and adapted to the AUTOSAR international standard with better performances.

REFERENCES

[1] Lino Samuel M., Mrs Meena K. V., Dr Raja R., Mrs Savita Patil Y. 2014. Design of AFS system in automobiles on FPGA. International Journal of Research in Engineering & Advanced Technology. 2(2): 1-6.

[2] Dahou H., Elgouri R., Mateur K., Alareqi M., Zemmouri A., Mezouari A., Hlou L. 2017. New design of an intelligent system (afs) of automobile with digital pwm technique on fpga board. ARPN Journal of Engineering and Applied Sciences. 12(3): 680.

[3] Dong G., Hongpei W., Song G., Jing W. 2011. Study of adaptive front-lighting system of automobile based on microcontroller. Transportation, Mechanical, and Electrical Engineering (TMEE). International Conference. 23(6): 1281-1284.

[4] Lifu L., Mingjun Y., Jinyong Z. 2015. The bending mode control method of AFS system based on preview control. International journal on smart sensing and intelligent systems. 8(1): 637-657.

[5] Lee, Jun Ho, *et al*. 2017. Automotive Adaptive Front Lighting Requiring Only On/Off Modulation of Multi-array LEDs. Current Optics and Photonics 1.3: 207-213.

[6] Lin C. 1995. Steering wheel controlled car light piloting system. US5416465 A.

[7] Dikau R., 13 autres. 2012. Projection headlight for motor vehicles. US20120092884A1.

[8] Lukacs L., 5 autres. 2013. Adaptive front-lighting system with fuzzy logic control. US8433479B2.

[9] Sung Uk CHOI, 5 autres. 2011. Adaptive front lighting system for performing highway and urban district modes of front lighting. US20110125373A1.

[10] Herbers T. 2015. Supplementary Light Module for a Headlamp of a Vehicle. US2015308651A1.

[11] Uchida Y., Mizuno R. 2016. System, device and method for controlling vehicle light. US20160001696A1.

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

[13] Eftichios K., D. Apostolos, K. Kostas. 2006. Highf requency pulse width modulation implementation using FPGA and CPLD ICs. Journal of Systems Architecture. 52(issue): 332-344.

[14] Nouman Z., Klima B., Knobloch J. 2013. Generating PWM Signals with Variable Duty From 0% to 100% Based FPGA SPARTAN3AN. electrorevue. 4(4):75-79.

[15] Zemmouri A., Elgouri R., Alareqi M., Benbrahim M., Hlou L. 2017. Design and Implementation of Pulse Width Modulation Using Hardware/Software Micro Blaze Soft-Core. International Journal of Power Electronics and Drive System (IJPEDS). 8(1): 167-175.

[16] Shingate Prateek, *et al*. 2019. Design and Fabrication of Adaptive Headlight System.

[17] M. M., Latchumanan. 2019. Design and Implementation of Adaptive Automobile Headlamp System. Proceedings of the 5th International Conference on Mechatronics and Robotics Engineering.