Intelligent lighting system for automotive

Abstract

This article specifically discusses the important role of automotive intelligent lighting in future automotive driving safety. From the history of the development of vehicle lights to explore new areas, automotive lamps have gradually evolved from simply providing lighting functions to drivers to important parts to ensure driving safety. Automotive lamps are no longer simple components such as light sources and switches. With the addition of digital control systems, automotive lamps are already a complete set of electromechanical systems, including sensors, data buses and power drivers. The system and the MCU of the car form a complete and safe driving system. In the future, the biggest challenge for unmanned systems is driving safety. In the process, lamps will add more key functions, integrate more sensors, not only act as lighting actuators, but also act as information collection sensors. Continuously enhanced automation functions not only help drivers reduce the safety risks caused by emergency response to emergencies, but also reduce the driver's operation of environmental changes in the daily driving experience, resulting in driving fatigue, further reduce driving safety risks. In order to better introduce the principle of intelligent car lights, the basic control principle will be explained through detailed analysis and examples of the Aiming system in the lamp AFS system. It is derived from the design principle of ADB system, and makes predictions for the development of future advanced ADB systems, and proposes corresponding challenges that may be faced.

Content List

Intelligent Lighting system introduction

What is intelligent lighting system

With the development of current electronic technology, electronic sensors and electronic actuators have been applied to all aspects of life, and all devices with automatic functions have been named "smart". In this era where the world is fully turning to intelligence, the automobile, as the intelligent crystal of human industrial production, is definitely the first to become the most suitable platform for the integration of various intelligent technologies. In fact, modern car have already started the automation process of its various functions very early. An ordinary modern car has about 200 electronic actuators and about 300 sensors to help the entire car realize its automation.

This article is mainly aimed at automotive lighting. I will introduce the next fully intelligent automotive application scenario. How can automotive lighting be called "smart"? Before discussing intelligence, we must first distinguish the difference between intelligence and automation.

The best example of automotive lighting automation can be said to be the development and application of AFS systems. The AFS system is no longer a new technology. When people recognized the major traffic, hazards caused by the glare problem of car headlights, it has been researched and mass-produced by various automotive lamp manufacturers around 2010. It was first applied to various types Luxury cars. By 2019, the technology has begun to be applied to all types of home cars. The new Volkswagen POLO in 2019 has begun to be equipped with the basic AFS system as standard, and the basic ADB system has been integrated as a subsystem of the AFS system. This system automatically adjusts the vertical and horizontal illumination angles of the lights, so as to avoid the potential safety hazard caused by glare. However, the adjustment of this system is based on the driving state of the car itself and a series of sensors to obtain the information of the vehicle itself, including vehicle speed, vehicle inclination, vehicle roll angle, steering angle, etc. After a preliminary system design, it is deduced that the lights should be The angle at which the adjustment is made. We will introduce the design details of this system in the following content. In the future smart headlight system, the biggest difference is the collection of non-owner information through more sensors, including vehicle information, GPS signals, and city surroundings. Environment, close-range environmental vehicles, and in the era of artificial intelligence, it is also possible to integrate historical driving data to estimate the adjustment angle of the lamp, and has reached a more accurate adjustment strategy, with higher controllability, to further reduce safety risks.

Specifically, it has appeared in models that have been mass-produced in the first stage, the ADB system (adaptive high-beam lighting system). The ADB system is a preliminary manifestation of the intelligence of the headlights. The front road information is obtained through the front image sensor, which includes the light source of the headlights of the vehicle when meeting, the position lights of the front vehicle when following, and the light reflected by the retro-reflector The image signal is converted into a digital signal to replace the driver's control of the high beam switch, which not only reduces the probability of driver misoperation, but also reduces driver fatigue through automatic control, and other types of safety risk caused by distraction during operation.

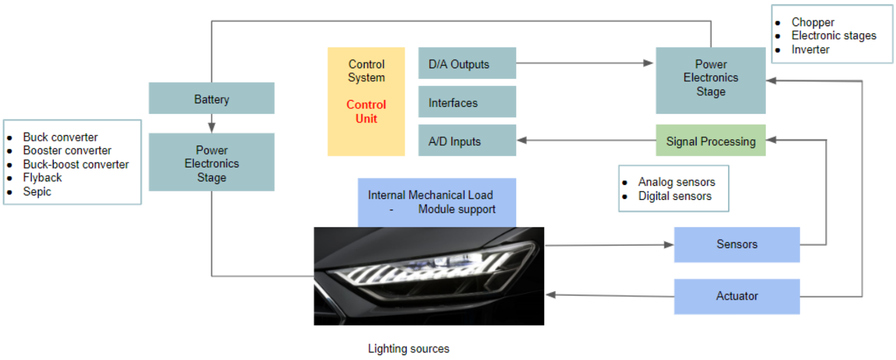
The birth of the ADB system poses unprecedented challenges to the automotive headlight manufacturing industry. Looking back at the development history of automotive lighting systems, optical performance has always been the most important technical parameter. The automotive lighting industry has been pursuing higher lumen values for a better night driving experience. The emergence of technologies such as LEDs not only helps the lamps to increase brightness, but also improves the conversion efficiency of electric energy, reduces carbon dioxide emissions, and is more friendly to the ecological environment. At the same time, LED technology has added more possibilities to the development process of automotive intelligence. The characteristics of high response rate, low heat generation, and small light-emitting area of LEDs, coupled with the extensive application of electronic circuits in automotive lamps, are increasingly Similar to the matrix ADB system, the non-mechanical structure AFS system, and the headlight information projection system are helping the car's headlights become more intelligent.

In the following chapters, I fully expand to introduce the application technology and principle of smart car lights. In the process of intelligence, because the automotive lighting is no longer a product that implements basic functions completely in accordance with engineering settings, it will face the changing road environment, weather environment, and driving scene changes all over the world. Adaptation. This can be called truly intelligent lights. While various new technologies and new functions have been added to automotive lamps, the corresponding review mechanism of automotive lamps and the update of global automotive lamp regulations have not progressed as expected, because optical performance is not the only detection indicator.

The automobile's perception of the surrounding environment and the requirements for sensors have risen to an unprecedented level. When the era of unmanned driving comes, the conversion of accident responsibility is also a severe challenge for all automotive OEMs. In order to avoid the added ticket, they are careful to verify every step of the new technology to ensure foolproof ness. International automotive law-making agencies, GBT, ECE, SAE, CCC, etc., are comprehensively advancing the formulation and verification of new laws and regulations to ensure that when new technologies are introduced to the market, they can truly be more convenient and safer.

Actuator and sensors

In the previous chapter, we introduced what smart headlights are. Before we fully understand the working principle of smart headlights, we first introduce some important components that will appear in the system. Understanding these important components will help us quickly understand The working principle and control logic of the smart headlight system. The following figure is a simplified system structure diagram.



In this schematic we can find that the sensors and actuators are directly related to the mechanical load of the lights. The actuator assumes the important responsibility of converting electrical signals into mechanical movements, but this does not mean that the processing of electrical signals and electronic control units are not important. It is precisely because electrical self-control plays an increasingly important role in intelligent lighting systems Has become an independent research direction. This research direction is more focused on electronics engineering and software engineering. Traditional automotive engineering and mechanical engineering majors will continue to conduct in-depth research in the field of mecha-electrical engineering. Therefore, in the following chapters, we will focus on the types of low-power actuators and related application areas, as well as the types of sensors, and establish a bridge between physical loads and electronic signals.

Low Power Actuators

What is an actuator?
Definition:
An actuator is a device (equivalent to a muscle) of a mechatronic system submitted to a control which is most of the time a control signal noted UC (provided by the ECU). The application of a control signal to an actuator in a mechatronic system produces a change creating a force or a torque with a linear or a rotational motion. Actuators are always linked to a power stage and a coupling mechanism.

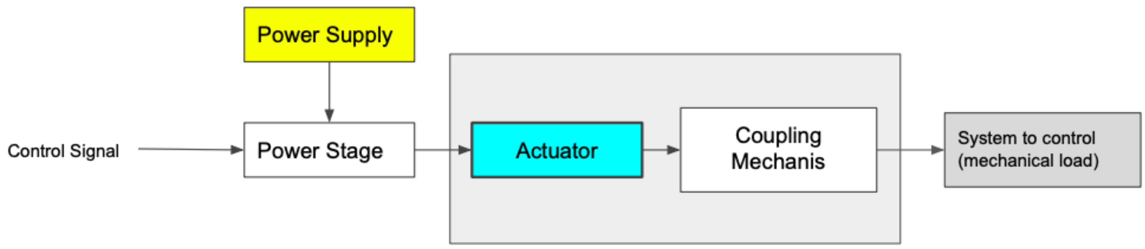


Figure 2 : Actuator in a mechatronic lighting system

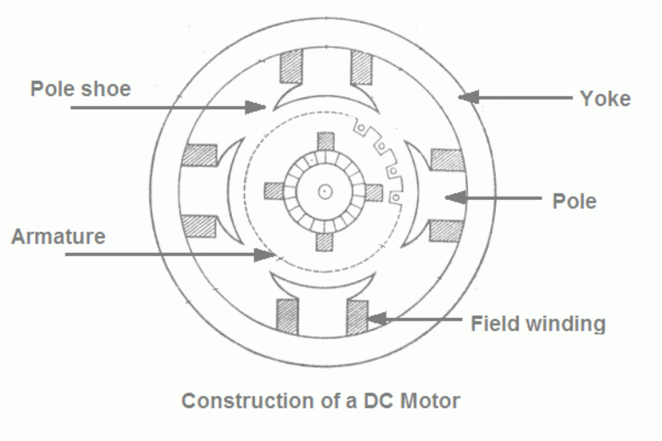
Power stage: Power electronic converter (inverter, chopper (half bridge or full bridge converter))
Power supply: continuous voltage source (rectifier or a battery)
Coupling mechanism: an interface between the actuator and the mechanical load.(pignon, gears, endless screw, linkage, ...)

Type of actuators
The actuators used in mechatronic lighting systems are mainly rotational actuators; geared motors actuators could be useful for this application. This is the case for example of piezoelectric motors or linear actuators, The main advantage of these technologies is that we do not need coupling mechanism between the motor shaft and the support of the headlight or the luminous sources.

1. In the kinematic chain of the quasi-static correction of the headlight levelling system, we use geared motors with control loops which are designed in order to control the angular position of the headlight support.
2. Also, in the kinematic chain of the dynamic correction of the headlight leveling system, we use micro stepper motors in open loop.
3. For the other technologies of actuators, the position control is carried out in closed loop.

Rotational Actuators

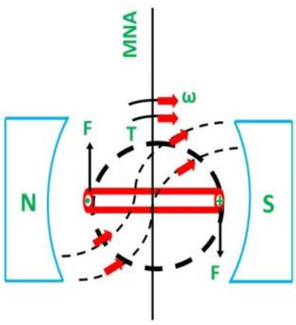
DC machine: technology

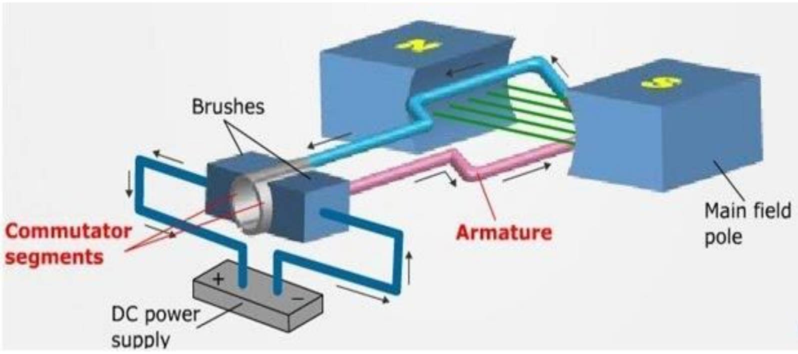


DC machine: operating principle

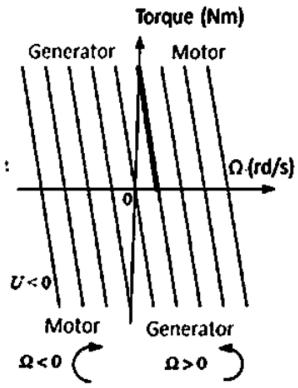
Stator: creates, with the supply of the excitation coil, a magnetic field which crosses the rotor.

Rotor: has slot in which there are wires in the form of turns, in each turn, a current run through. Applying laplace Principle, two forces are created in the two extremities of one turn. Therefore a rotation of the shaft is occurred by the produced torque. If all the turns are supplied, torque and power increase.

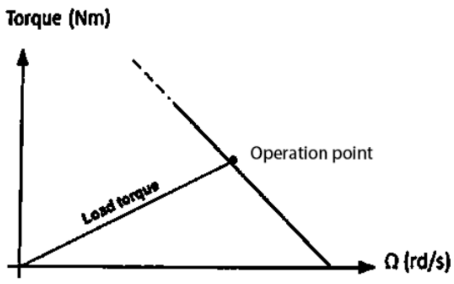




DC machine: torque/velocity characteristics



Operation Modes



Torque/velocity characteristics

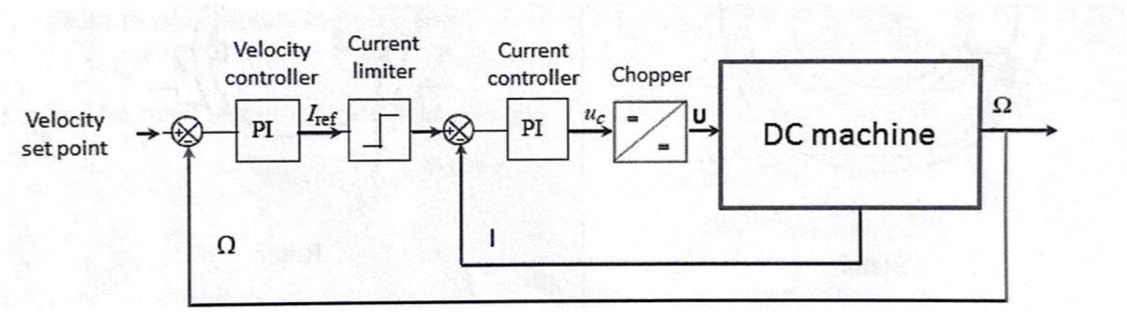
DC machine: power supply: continuous voltage source (example battery)

In case of no control

Examples: window handle, windscreen wiper.

Indirect power supply: continuous voltage source associated to a power converter stage (a chopper or a rectifier)

Type of control: position, velocity or torque
Control strategy: cascade control loop where most of the time PID controllers are used.



DC machine : Dynamic Modelling

$$U(t) = R\,I(t) + L\frac{d\,I(t)}{dt} + E \qquad (1)$$

$$C_{em} = K_m \cdot I_{induit} \qquad (2)$$

$$E = K_m\,\Omega \qquad (3)$$

$$C_{em} - C_r = Jeq\frac{d\Omega}{dt} \qquad (4)$$

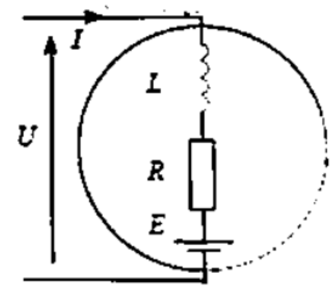
$$C_r = C_{r\_vf} + C_{r\_df} + C_{r\_Load}$$

C_{r_vf} : Resistive torque due to viscous friction

C_{r_df} : Resistive torque due to dry friction

C_{r_Load} : Resistive torque load

R, L : are respectively armature resisitance and armature inductance
K_m: torque constant



Equivalent electric circuit of the rotor

DC machine: advantages and drawbacks of a DC machine (DC motor)
Advantages:

1. Low cost for low power Example~ 2 EUR for a machine of 50W
2. Simple control
3. Torque to weight ratio and torque to volume are weak.

Disadvantages:

1. Mechanical friction (brush on collector)
2. High cost of high power

Notice the DC machine (geared motor) is often used in the automotive industry
Example: Megane Scenic (Renault) has around 200 DC machines.

In automotive, the DC machine remains the first electric machine to be used because of the following reasons:

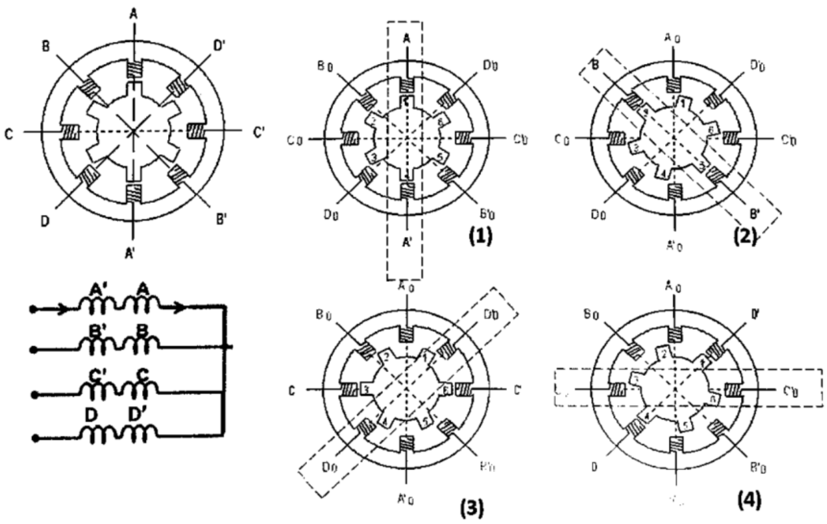
- Available DV voltage source (low voltage battery)
- The use is most of the time in on/off operation (switch); no need for control
- The price is interesting
- The need is mostly in low power.

In aeronautics, the DC machine is disappearing because of its weight, currently other technologies are used such as piezoelectric motors, synchronous machines.

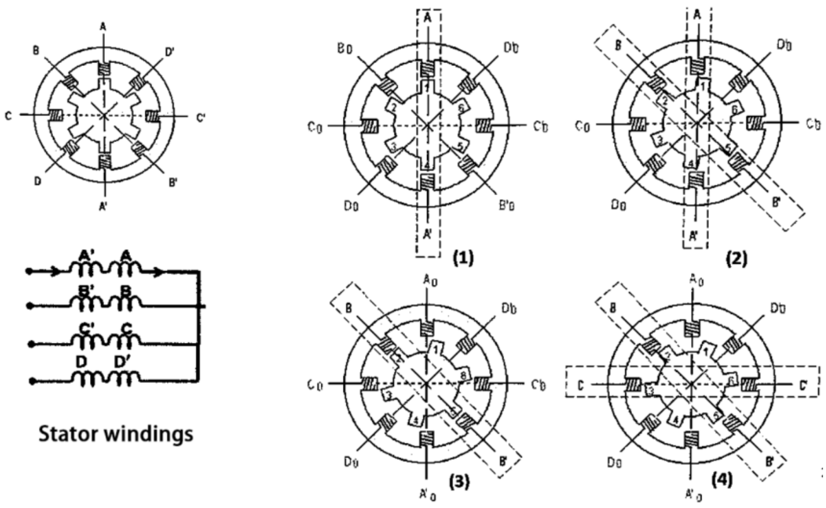
Stepper motor: technology
A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movement. The shaft of the stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The speed of the motor shaft is related to the frequency of the input pulses and the length of rotation is directly related to the number of the applied input pulses. These are three types of stepper motor technology:

Stepper motor: variable-reluctance (VR)
This type of motor has been around for a long time. It’s probably the easiest to understand from a structural point of view. Figure 1 shows a cross section of this type of motor with a soft iron multi-toothed rotor and a wound stator. When the stator windings are supplied with a DC current, the poles become magnetized. Therefore rotation occurs when the rotor teeth are attracted to the supplied stator poles.

Stepper motors with variable reluctance are characterized by their operations. For example in case of a rotor of six teeth, the teeth of the rotor are separated geometrically by an angle of 60 degrees while the teeth of the stator are separated by an angle of 45 degrees. Therefore when stator winding is supplied, motion occurs with a step angle of 15 degrees which corresponds to (60-45 degrees). Also the step angle can be computed from (formula)
Case 1

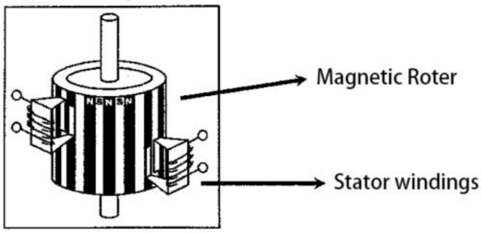


Case 2



Stepper motor: permanent-magnet (PM)

The permanent magnet step motor is a low cost and low-resolution type of motor with typical step angles of 7.5 Degrees to 15 Degrees which correspond to 48-24 steps/revolution. The PM motors name implies that they have a permanent magnet added to the motor structure. The rotor no longer has teeth unlike the VR motor. Indeed, the rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft. In this technology, the magnetized rotor poles provide an increased magnetic flux intensity which improves the torque characteristics when compared to the VR type.



Step angle of a PM stepper motor:

Step angle = $360 \div (N_{Ph} \times PH)$

N_{Ph} = Number of equivalent poles per phase = number of rotor poles

Ph = Number of phase

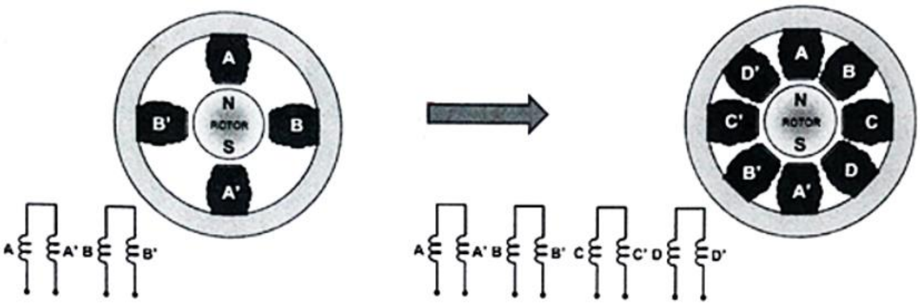
Supply modes:

Notices:

1. If we inverse the power supply, we inverse the rotor rotation.
2. If we combine the two modes of full step, we get half step motor
3. Also, the bipolar stepper motor is similar to the unipolar except it has two windings with two phases. The supply is applied separately to stator windings.

Case 1: To increase pole pairs (N-S) in the design of the magnetic rotor:

Case 2: to increase the number of stator phases.



Step Angle = 90°

Step Angle = 45°

Comment : Micro stepping motors are designed according to case 1 or 2 depending on the desired step angle and the cost

Comments:

1. If we inverse the power supply, we inverse the rotor rotation.
2. If we combine the two modes of full step, we get a half stepper motor.

3. Also, the bipolar stepper motor is similar to the unipolar except it has two windings with two phases. The supply is applied separately to stator windings.

Stepper motor: Hybrid
The hybrid stepper motor is more expensive than the PM stepper motor but provides better performances with respect to step resolution, torque and speed. Typical step angle for HP stepper motor range from 3.6 degree to 0.9 degree which corresponds to 100-400 steps/revolution. The hybrid stepper motor combines the best advantages of VR and PM stepper motors. The motor contains an axially magnetized concentric magnet around its shaft.

Stepper motor: Comparison

<table>
<tr><th>Characteristic</th><th>Permanent Magnet</th><th>Variable Reluctance</th><th>Hybrid</th></tr>
<tr><td rowspan="2">Cost</td><td rowspan="2">Cheapest</td><td>Moderate</td><td>Most Expensive</td></tr>
<tr><td colspan="2">More expensive due to manufacturing process</td></tr>
<tr><td>Design</td><td>Moderately Complex</td><td>Simple</td><td>Complex</td></tr>
<tr><td>Resolution</td><td>30D - 3D / step</td><td colspan="2">1.8D step and smaller</td></tr>
<tr><td>Torque vs. Speed</td><td></td><td>Less pronounced torque drop at higher speeds</td><td></td></tr>
<tr><td>Noise</td><td>QUIET</td><td>Noisy no matter what type of excitation</td><td>QUIET</td></tr>
<tr><td>Stepping</td><td>Full, Half and Microstamping</td><td>Typically run in Full-Step only</td><td>Full, Half and microstamping</td></tr>
</table>

Stepper motor: Characteristics

- Relatively inexpensive
- Ideal for open loop positioning control
  - Can be implemented without feedback
  - Minimizes sensing devices
  - Just count the steps!
- Torque
  - Holds its position firmly when not turning
  - Eliminates mechanical brakes
  - Produces better torque than DC motors at lower speeds.
- Positioning applications

Examples: Printers, fax, robots, headlight leveling system for dynamic correction using a micro stepper motor with a step angle of 0.25.

Particular case: Automotive application using a micro stepping motor Dynamic correction of the leveling headlight system.

Comments:
Electromagnetic machines (motors) are widely used in many applications with high or low powers. Even if they present good performances, they also have disadvantages:

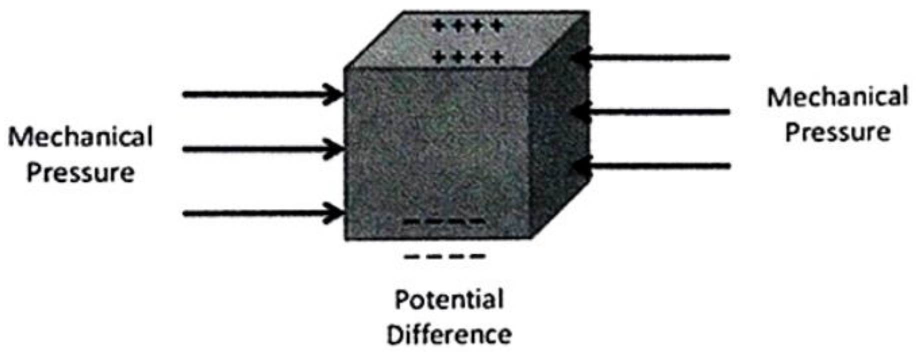
- Noisy operation
- Electromagnetic interference
- Magnetic losses (Eddy currents and Hysteresis)
- Low power factor
- Comparatively less efficiency

Because of these disadvantages, other technologies have today emerged particularly for low power actuators. Also the need of these technologies concern many applications of low powers in different domains of positioning.

Examples: Robotics, Aerospace, Medicine
Some applications: back seat adjustment (aircraft and urban vehicles), Autofocus and Optical zooming in digital cameras and surveillance cameras.

Piezoelectric motor is a also a device which converts electrical energy into mechanical energy. In comparison to electromagnetic motors electrical energy is converted to Magnetic energy and Magnetic energy is converted to mechanical energy.
This type of motor named ultrasonic motors (USM) is based on piezoelectric effect:

A pressure across a pair of opposite faces of a crystal, results in potential difference developed across the other pair as shown in the figure below



In the piezoelectric motor (USM), the working principle is based on the Converse

Piezoelectric Effect:

- When an alternative current is applied across a pair of opposite faces, alternating compressions and elongations (mechanical vibration) are obtained across the other pair of opposite faces.
- As a result, a surface wave is formed over the crystal driving force of the USM. During motion, the rotor is levitated from the stator in the perpendicular direction with less wear and tear. Therefore, motor torque is created on the rotor.

Piezoelectric motor: Construction
Actuator

- A piezoelectric material (Quartz, Barium Titan, Tourmaline, Rochelle salt) is used as an actuator
- The actuator is fixed on the stator using thin metal sheets and bearings
- The actuator is directly connected to the supply mains

Stator
- Stator is made of any malleable material such as steel
- Ring Cylindrical or rod shaped

Rotor
- Same material as that of the stator
- Same shape as that of the stator (Ring, Cylindrical or Rod)
- Frictional coupling

Casing
- Cylindrical, Disc or Box shaped
- Non-corrosive alloys or Fiber
- To provide protection against abrasion and external interference

Advantages:
- High torque and efficiency
- High power to weight ratio
- Good positioning accuracy
- Capable of working in extreme environmental conditions
- No magnetic interference
- Small size, light weight, less noise
- Holding torque without power supply
- Useful for short time applications

Disadvantages
- Require high frequency power supply (kHz range)
- Piezoelectric material is expensive
- Short lifecycle; around 2000 hours.

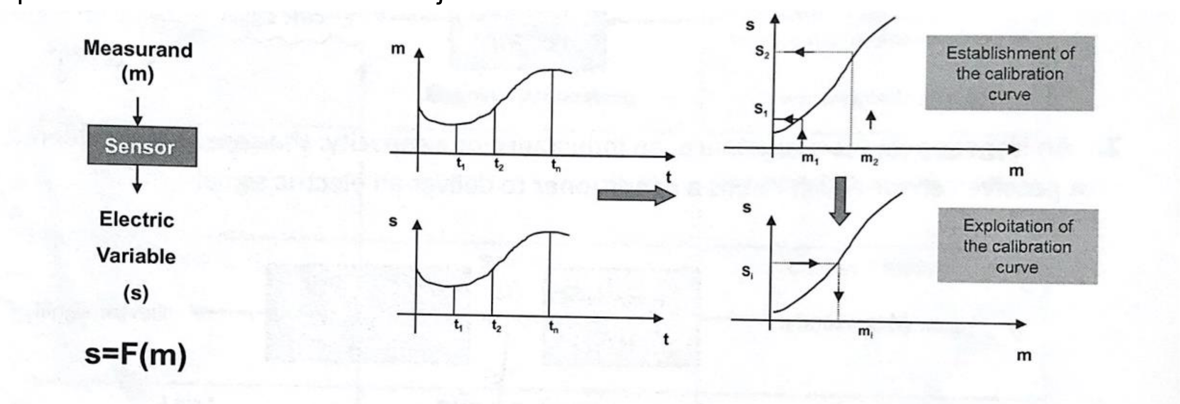
Comment:
- The above-mentioned advantages and applications conclude the scope of USMs in day-to-day life.
- The disadvantages bring up the need for further research in the field.

Torque motors:
This type of motor is useful for a direct coupling of the load. Indeed the coupling mechanism between the motor and the load namely gears, endless screw, gear of one ratio is eliminated. Therefore mechanical wear is strongly reduced and consequently the lifecycle is extended with a good reliability. Also reduction of mechanical components between the motor and the load minimizes the maintenance and the cost of the system.
Some applications in the domain of transportation
- Butterfly valves for air conditioning in aircraft
- Butterfly valves for air admission system of ICE (Internal Combustion Engine)

5, Linear actuators
1. Electric jack actuator is a linear actuator composed of a geared motor using most of time a DC machine and a coupling mechanism which converts rotational motion in linear motion.
2. Piezoelectric linear motor is similar to piezoelectric motor in the operation mode except the travelling wave creates, by friction, a linear motion of the rotor.

Analog and Digital sensors

Problem Position
We should measure all types of physical variables in order to deal with and to exploit them for different applications such as dynamic identification of systems, diagnostic, supervision or control. To achieve this objective, we need to transform the measured variable in an electric signal; image of this variable which is easily exploitable; voltage or current hence the need to use a sensor.
Definition
Sensor is a device submitted at its input to a measured action or to an excitation non electric provides an electric variable at its output. This response; noted S represents as accurately as possible the variable which is object of this measure.



For easy exploitation reasons, we realized sensors or at least we use them in order to establish a linear relationship between the variations of the output signal and the variations of the physical variable toe measure. This relationship is given by:

s= S * m where S is the sensor sensitivity

In the design or in the use of a sensor, the major problem is related to the constancy of its sensitivity which should depend as little as possible on:

1. The value of the measurand (linearity) and its frequency variation (bandwidth)
2. Ageing time
3. Other physical variables and their environment which are not the object of the measurement, called disturbances such radio-activity, magnetic field, temperature, humidity, vibrations, shocks, power voltage, etc...

Type of sensors: as an element of an electric circuit, the sensor is considered according to its output as:

1. A generator where s is electrical charges, voltage or current. In this case the sensor is considered as an active sensor because it delivers immediately an electric signal
2. An impedance, s is a resistance, an inductance or a capacity: the sensor is considered a passive sensor which needs a conditioner to deliver an electric signal.

Passive sensors
In the passive sensors, the variation of the impedance is due to the measurand action on:

1. Geometry: The sensor has either a mobile element or a deformable element. Example: Displacement or position sensors: potentiometer, inductance with movable core, capacitor with movable armature.

2. Dimensions: the sensor is submitted to a force or a pressure which causes a deformation Example: capacitor armature submitted to a differential pressure, extensometer gauges rigidly linked to a structure subjected to a constraint.
3. Electrical properties of materials: resistivity p, magnetic permeability u, dielectric constant e which are sensitive to temperature, luminance, pressure, humidity.

Materials of passive sensors:

Physical variable to measure	**Sensitive electrical properties**	**Type of used materials**
Temperature (very low temperature)	Resistivity Dielectric constant	Metal: Platine, Nickel, Copper semiconductor
Optical radiation flux	Resistivity	Semiconductors
Deformation	Resistivity Magnetic permeability.	Alloyed nickel, doped silicon Ferromagnetic alloys
Position	Resistivity	Magneto-resistive materials: Bismuth, indium antimonide
Humidity	Resistivity Dielectric constant	Lithium Chloride Alumina; polymers
Level	Dielectric constant	Insulating liquids

Conditioners for passive sensors

The impedance of a passive sensor and its variations are not directly measurable. Therefore, a conditioner supplied by a current or voltage source is necessary to use it in order to get the value of the measured variable. Four types of conditioners are used with passive sensors.

Active sensors

This type of sensor operates as a generator which provides an electric signal. The operation is based on physical effect which ensures the conversion of any type of energy related to the variable to measure to an electric energy:

(Table of active sensor)

$$\Delta v_m = e_s \frac{(R_s + R_1).\Delta R_c}{(R_{c0} + R_1 + R_s)^2}$$

$$\frac{\Delta v_m}{\Delta R_c} = e_s \frac{(R_s + R_1).}{(R_{c0} + R_1 + R_s)^2}$$

1. Thermoelectric effect: a circuit composed of two conductors of different chemical natures whose junctions are at temperatures T1 and T2 delivers an electromotive force which depends on T1 and T2 (figure thermocouple)
2. Piezoelectric effect: the piezoelectric effect concerns certain materials called piezoelectric material (quartz, tourmaline, etc) if this type of material are submitted to a mechanical constraint or a force, it will appear, on their opposite faces, equal electric charges of opposite signs. For example, this piezoelectric effect is used to design force sensors or other physical variables to measure such as pressure,

acceleration, vibration or acoustic wave from the voltage measured across opposite faces of the piezoelectric material under a constraint.

3. Electromagnetic induction effect: when a conductor moves in a fixed induction electromagnetic field, it appears an e.m.f which is proportional to its displacement velocity. Finally, the induction creates a relationship between three variables; electric current, motion and magnetic field. For instance, Dynamo tachymeter: it's a velocity sensor for DC machines. If a coil si on the DC machine shaft and if we put in the front of the coil a permanent magnet which develops a magnetic field noted B, the rotation of the shaft moves alternatively (North-south) the coil creating a voltage with a period equal to the revolution duration of the shaft. The measurement of the frequency is the frequency is the DC motor velocity.
4. Hall effect: the hall effect concerns the semiconductor materials usually is in the form of a small plate running an electric current i and submitted to an induction B creating a phase shift Y with the current i. Therefore, its appears in the perpendicular direction to the induction and the current, a voltage V whose the expression is : v=K.i.B.sin(Y), K is a constant which depends on the material properties and plate dimensions. It often uses like, a magnet linked to a mobile object which we want to know its position, determines with respect to the current the values of B and Y at the plate. However, the voltage V created by the current and the magnet depends on the position of the mobile object. The voltage to measure is image of the object position.

Metrological characteristics of sensors

1. Measurement range
2. Sensitivity
3. Dynamic characteristics
4. Precision
5. Finesse
6. Influencing factors(disturbances)
7. Use limitations of a sensor

	Nominal domain (between the extreme values)	**Non-deterioration domain (above the extreme values of the nominal domain)**	**Non-destruction domain (above the extreme values of the non-deterioration domain)**
Limit values: Measurand, influencing factors (disturbances)	No modification in the specifications which characterize the sensor	- Risk of being modified the metrological characteristics - Reversible if we come back to a nominal operation	- Modification of metrological characteristics in an irreversible way. - Possibility to reuse the sensor after a new calibration for a nominal operation.

Digital sensors

Digital sensors (optical sensors)
Analog sensors provide analog signals (voltage or current) which are deal with control units in order to use them for control, diagnostics or supervision. This is possible with the analog digital conversion which provide digital information to the control units.

In case of displacement sensors, it's however possible to conceive sensors which provide immediately the position (linear or angular) as binary byte, Two types of digital sensors are available:

1. Absolute encoders.
2. Incremental encoder

Absolute encoders

These types of digital sensors are in disc or rule shapes divided in N surfaces: band for rule shape and sector for disc shape. Both are used for the measurement of angular and linear displacements. On each surface, the binary byte is materialized according to a position using determined code and technology, the number of N surfaces determines the resolution of the absolute encoders:

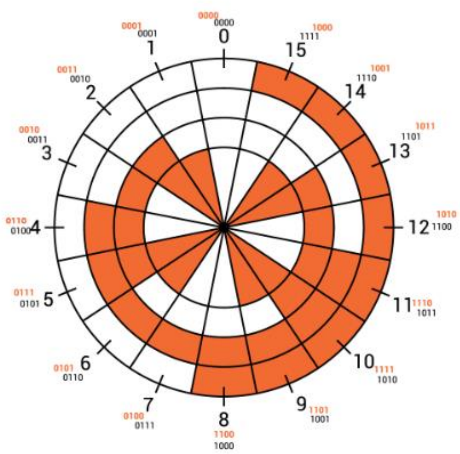
- L/N for un ruler of length L
- 360 Degrees/N for disc

Binary codes used in absolute encoders
The binary codes used in absolute encoders are often natural binary code and reflected codes namely Gray and BCD.

Code 1: Natural binary code.

ASCII BINARY ALPHABET

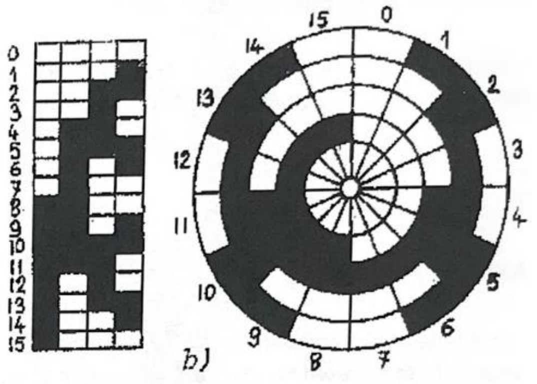
A	1000001	N	1001110
B	1000010	O	1001111
C	1000011	P	1010000
D	1000100	Q	1010001
E	1000101	R	1010010
F	1000110	S	1010011
G	1000111	T	1010100
H	1001000	U	1010101
I	1001001	V	1010110
J	1001010	W	1010111
K	1001011	X	1010111
L	1001100	Y	1011001
M	1001101	Z	1011010



Binary code in a disc

Code 2: Code Gray et BCD

Binary Base-2	Decimal Base-10	Hexa-Decimal Base-16	Octal Base-8	BCD Code	Gray Code
0000	0	0	0	0	0000
0001	1	1	1	1	0001
0010	2	2	2	2	0011
0011	3	3	3	3	0010
0100	4	4	4	4	0110
0101	5	5	5	5	0111
0110	6	6	6	6	0101
0111	7	7	7	7	0100
1000	8	8	10	8	1100
1001	9	9	11	9	1101
1010	10	A	12	---	1111
1011	11	B	13	---	1110
1100	12	C	14	---	1010
1101	13	D	15	---	1011
1110	14	E	16	---	1001
1111	15	F	17	---	1000

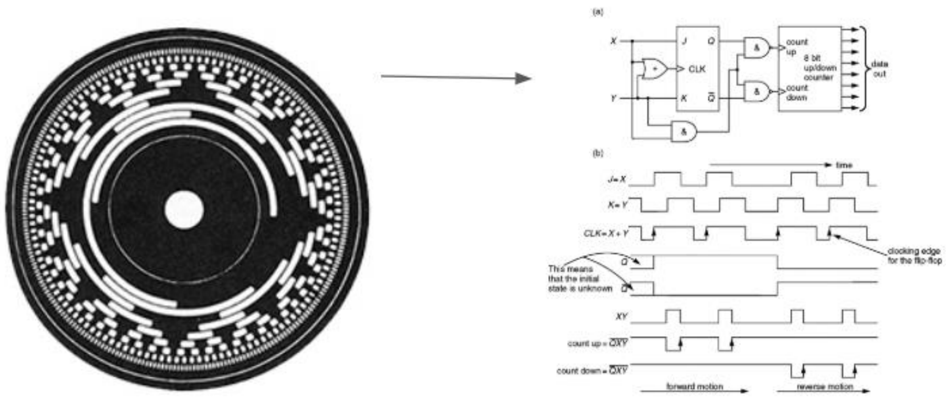


Gray code materialized as tracks in a ruler and as sectors in a dics

Methods of reading the codes: Different ways to read the code on a rule or a disc:

1. Isolate or conductor surface (current reading)
2. Diamagnetic or ferromagnetic (magnetic reading)
3. Opaque or translucent surface (optical reading)

Optical reading is the most used process to read codes of the absolute encoders; For each track or sector, a LED and a phototransistor are used. The output signal is a binary sequence with two levels: 0 or 1.



Absolute encoder with the electronic circuite of code reading

Illustration:

1, For an angular position encoder

Resolution = 360 Degrees /N

N: number of equal surfaces (sectors for a disc)

$N=2^n$, n is the number of bits (number of tracks)

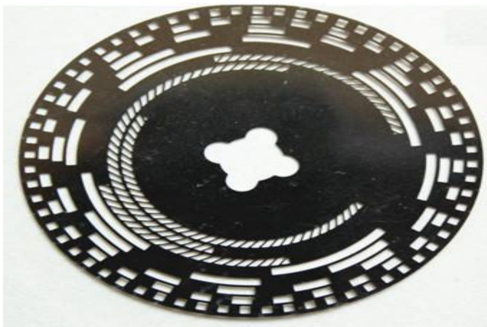
2, For a linear position encoder

Position=L/N avec L : rule length.

N: number of equal surfaces (bands for rules)

$N=2^n$, n is the number of bits (number of tracks)

Incremental encoder



This sensor has only two or three tracks with a simple device of reading. It provides pulse for each elementary displacement with the motion direction. Tracks are concentric for disc (sectors) and parallel for rules (bands). Surfaces of each track are geometrically shifted of 90 degrees in order to distinguish the direction of rotation. The third track noted TOP ZERO is used only to compute the numbers of revolutions.

Reading the pulses device:
The reading device allows by derivation of signals S1 of the track 1 to distinguish the rising edges (formula) from the falling edges (formula) and to associate them, at the same time, to the state of the signal S2 of track 2 (0 or 1). According to figure 1, a), we have:

$$\frac{dS_1}{dt} > 0 \quad \text{et} \quad S_2 = 0 \quad \text{soit} \quad \uparrow \cdot \overline{S_2} = 1$$

$$\frac{dS_1}{dt} < 0 \quad \text{et} \quad S_2 = 1 \quad \text{soit} \quad \downarrow \cdot S_2 = 1$$

Thus the logic equation for a direct rotation noted Dd

$$D_d = \uparrow \cdot \overline{S_2} + \downarrow \cdot S_2$$

And according to figure 1,b) the equation of the reverse direction D:

$$\frac{dS_1}{dt} > 0 \quad \text{et} \quad S_2 = 1 \quad \text{soit} \quad \uparrow \cdot S_2 = 1$$

$$\frac{dS_1}{dt} < 0 \quad \text{et} \quad S_2 = 0 \quad \text{soit} \quad \downarrow \cdot \overline{S_2} = 1$$

Thus, the logic equation for a direct rotation noted Di

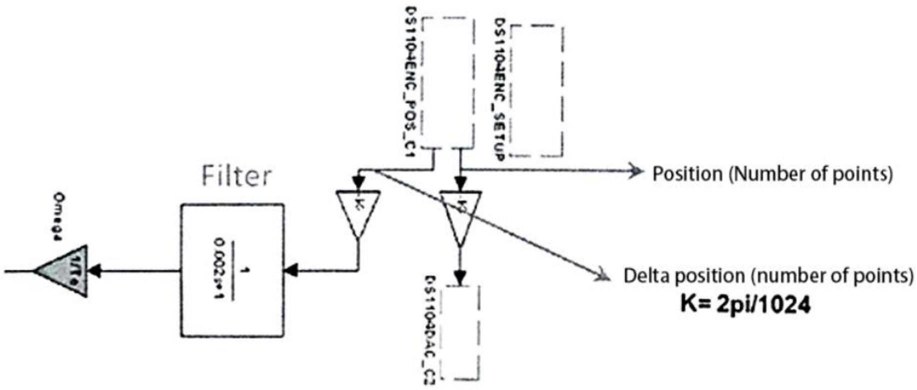
Finally, the rotation direction is carried out comparing edges of S1 and the state of S2.
The advantage of incremental encoder is in their simple design and their precision with a low price in comparison to absolute encoder. Resolution depends on the number of surfaces per sector which corresponds to the number of pulses per revolution. The disadvantage of the incremental encoder is the relative measurement because it does not have a reference position to measure.

Example of an incremental encoder: GIO90B (MCB manufacturer)

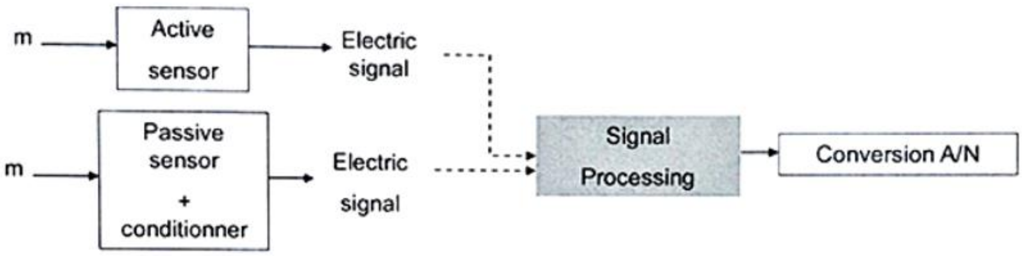
Metrological characteristics:

- Number of points: 5000
- Resolution: 4’19”
- Mass: 340g
- Rotation torque: 2.10^{-3}Nm
- Precision: ±2’
- Inertia: $200g.cm^{-2}$
- Maximum velocity: 1500 rev/m

Comment: Rotary velocity of electric machines using an incremental encoder is computed from the measured angular position
Example: use of dSPACE platform.



Signal processing



Signal processing consists to:
- Demodulate: to get back information sensors (ex: la telemetry)
- Filter: reduce noise measurement.
- Amplify: id the electric signal is low.
- Re-calibrate: calibrate the sensor in its real environment because of the influencing factors
- Calibrate: to get and to keep a constant sensitivity over the measurement range
- Adapt: electric signal to limit voltages of the analog/digital inputs.

Comment: several functions of signal processing could be in one integrated circuit with the sensor.
Example: micro sensors (smart sensors)

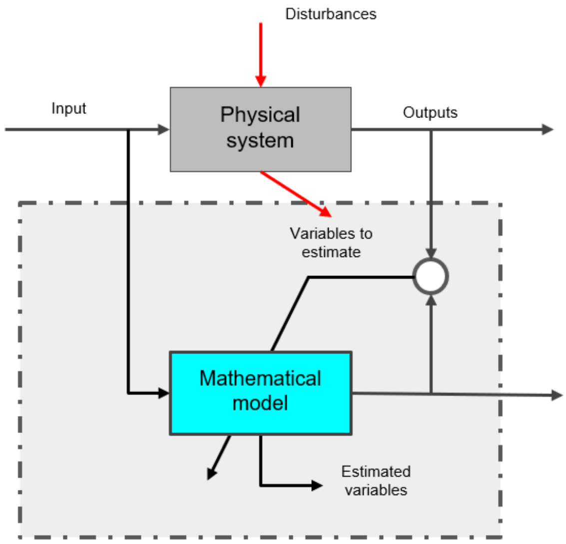
- Measurement range: minimum and maximum values of the physical variable to measure.
- Resolution: high resolution means sensor with a high precision.
- Precision: minimum error between the measured value and real value.
- Sensitivity: constant and maximum for all the measurement range.
- Zero-offset: No output signal when no input signal
- Response time: depends on the variable to measure or
- Bandwidth: to choose in terms of the frequency of the variable to measure
- Operation temperature: environment temperature for a nominal operation (no deviation)

It's hard to combine all these criteria in the selection of a sensor. However the choice depends on the application and its environment. Also other criteria have to be considered.
- Sensor dimensions
- Signal conditioning

- Reliability
- Robustness
- Maintenance
- Price

Software Sensors:

Definition: Software sensor (Virtual sensor) is an observer (estimator) which estimates online some variables non measurable using a mathematical model and available measurement



When can we use a software sensor?
1, Diagnostics and supervision
If a default occurs on an analog sensor, software sensor can ensure the operation providing estimated variables of the analog sensor. The advantage of this solution that that the process continues to operate.

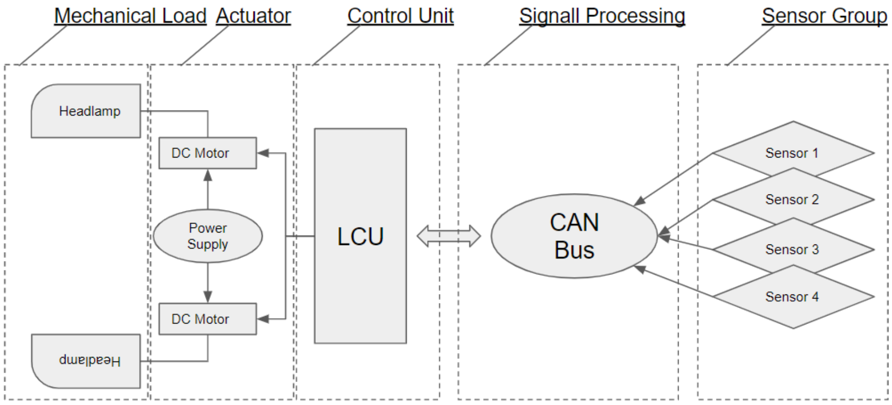
2, No possibility to measure some physical variables
If the sensors do not exist to measure some physical variables, software sensors can be used to estimate the unmeasured variable using a mathematical model and other measurable variables on the process.

3, Environment and material constraints
- Sensors emplacement difficulties due mainly to mechanical reasons or electrical wiring in the process.
- Influencing factors of the sensor environment.

Advantages:
1, Improvement of the predictive maintenance of equipments.
2, A significant saving in time.
3, Reduction of maintenance fees.
4, High cost of some sensors.
5, Limited lifetime of sensors.

Intelligent light layout

Intelligent light is a system composed of sensor group, transmission path, processor and actuator. Due to the need to make comprehensive judgments on the driving conditions of various vehicles, it is objectively determined that is a complex system with multiple inputs and multiple outputs.



To achieve different functions, ILS (Intelligent lighting system) must obtain different vehicle driving information from different sensors. For example, in order to realize the function of turning and lighting the curve, in addition to obtaining the vehicle speed from the vehicle speed sensor, the steering wheel angle sensor to obtain the steering wheel angle, and the vehicle height sensor to obtain the vehicle tilt angle, some special sensors must also be used to obtain the vehicle's actual steering angle ; In order to realize the function of lighting in very complex user environment.

Because under normal circumstances, some of the information required by ILS is also used by other control systems, that is, ILS actually needs to share some sensors with other systems. Therefore, the sensor information must be realized through the bus.

The information received by ILS, except for a small amount of information such as vehicle speed, vehicle body rotation angle, and vehicle body tilt angle, can be quantified, and most of the information sent back by other sensors can only be qualitative. For example, environmental information outside the vehicle body, such as uneven ground, heavy rain, etc., cannot be accurately quantified. This enables the lighting control Unit(LCU) of ILS to make vague judgments. And a lot of information is interrelated. For example, in the case of rainy weather and road surface water, the corners of the vehicle are significantly different from sunny days ... The LCU of ILS must not only make vague judgments, but also continuously change as the environment changes. The system parameters are modified, which makes ILS eventually become an adaptive fuzzy system.

ILS's actuator is composed of a series of motors and optical mechanisms. Generally there are projection headlamps, a height-adjusting motor that adjusts the vertical angle of the headlights, a rotary motor that adjusts the horizontal angle of the headlights, a movable light grid that adjusts the basic light type, and some additional lights such as cornering light (or front bending light FBL) and so on.

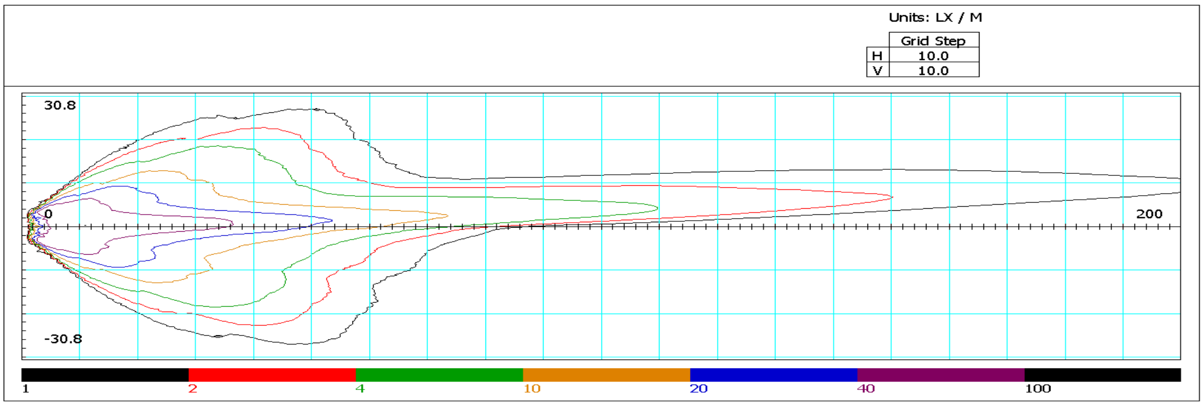
Adaptive Front lighting System

AFS research background and fundamental technology

The traditional headlight system is composed of a combination of low beam, high beam, running lights and front fog lights. When driving on urban roads and speed limits, low light is mainly used. When driving at high speed on rural roads or highways, high light is mainly used. When driving in fog, you should turn on the fog lights. During daytime, you should turn on. Lamp (this requirement is mandatory in ECE regulations).
However, in actual use, there are many problems with the traditional headlamp system. For example, the existing dipped headlights have a poor lighting effect at short distances, especially in urban areas with more complicated traffic conditions. Many drivers often turn on the dipped headlights, high beam headlights and front fog lights at night; There is also a dark area of illumination when the vehicle is turning, which seriously affects the driver's judgment of obstacles on the curve; when the vehicle is driving on a rainy day, the ground area reflects the light of the headlights, generating reflective glare and so on.
European automotive lighting research institutions have conducted a special survey on this. The results show that the most hopeful for European drivers is to improve the lighting of flooded roads in rainy weather. The second place is the lighting of rural roads, followed by curved roads. Lighting, highway lighting and urban lighting.
The existence of these problems makes it necessary to develop a headlamp with multiple lighting functions, and the switching of these functions must be realized automatically for safety reasons. Therefore, Europe and Japan have successively developed this type of headlamp system that automatically adapts to the driving state of the vehicle-AFS (Adaptive Headlamp System).

Basically, an 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)
• Dynamic swivel/level lighting
• Static cornering light

Lighting for rainy weather (Class W)
As shown in Figure 1 and Figure 2, in rainy weather, the accumulated water on the ground will reflect the light of the driving vehicle on the ground and reflect it into the eyes of the driving driver on the opposite side, making it dizzy, which may cause a traffic accident.
The effective solution of AFS is: the headlight emits a special light pattern as shown in the figure, which reduces the light intensity of the area where the ground may cause glare to the car.



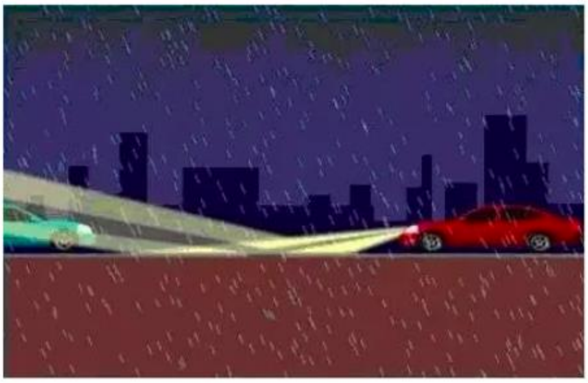


Figure 1 AFS light reflected by rainwater (side view)

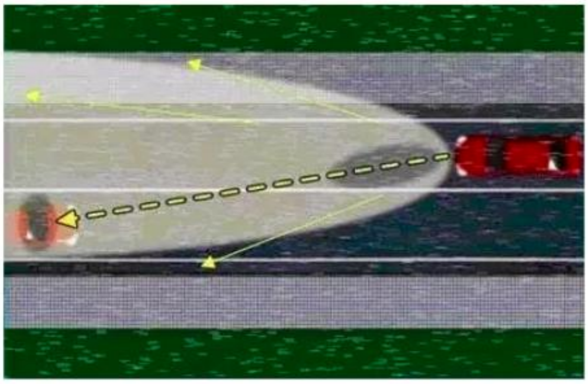
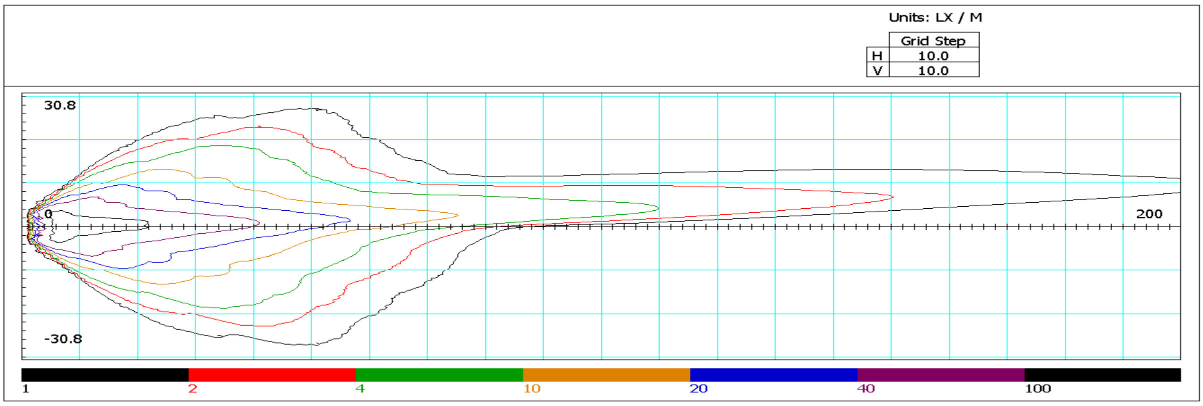


Figure 2 Reflection of AFS Light in Rainy Water (Looking Down)

Lighting of country roads

Vehicles traveling at high speed on rural roads with poor ambient lighting need headlights that are illuminated far and wide. At the same time, AFS can't produce dazzling light to the driver of the meeting car.



Lighting for turning roads

As shown in Figure 3, because the light of the traditional headlights is consistent with the direction of the vehicle, there is inevitably a dark area of illumination. Once there are obstacles on the curve, it is easy to cause a traffic accident because the driver is not prepared for them.

The method that AFS solves is: When the vehicle enters the curve, it generates a light pattern that rotates as shown in Fig. 4 to give sufficient lighting to the curve.

Figure 3 Curve lighting problem of traditional headlights

Figure 4 AFS Curved Lighting

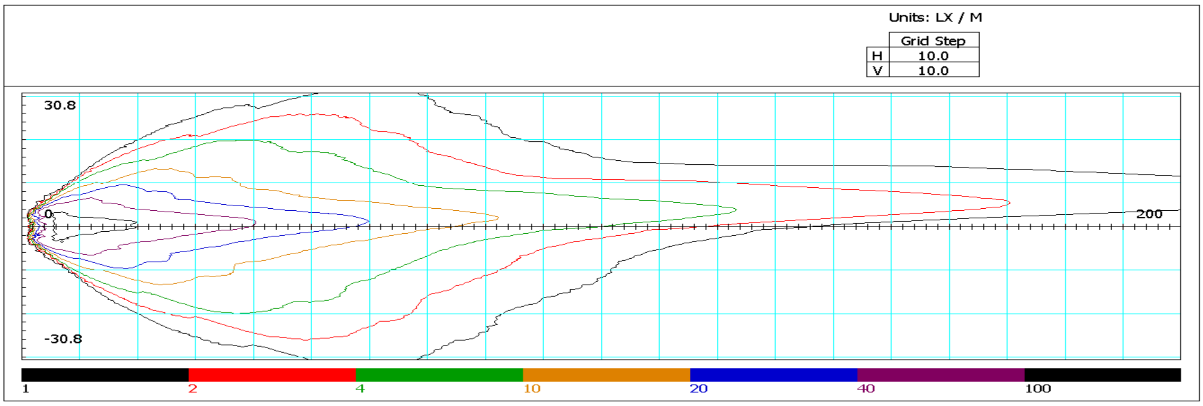
Highway lighting

As shown in FIG. 5, the vehicle runs on the highway, and because of its extremely high speed, the headlights need to be illuminated farther and wider than country roads. However, the traditional headlights have the problem of insufficient lighting on the highway.

AFS uses a wider light type as shown in Figure 6 to solve this problem.

Figure 5 Problems with existing headlights on highway lighting

Figure 6 AFS lighting on the highway



Lighting of city roads

The roads in cities are complex and narrow. The traditional low-beam headlamp is shown in Figure 7. Because the light type is relatively narrow and long, it cannot meet the requirements of urban road lighting.

Taking into account the restrictions on vehicle speed in urban areas, AFS can produce a relatively broad light pattern as shown in Figure 8, which effectively avoids possible traffic accidents with pedestrians and vehicles that suddenly appear in fork roads.

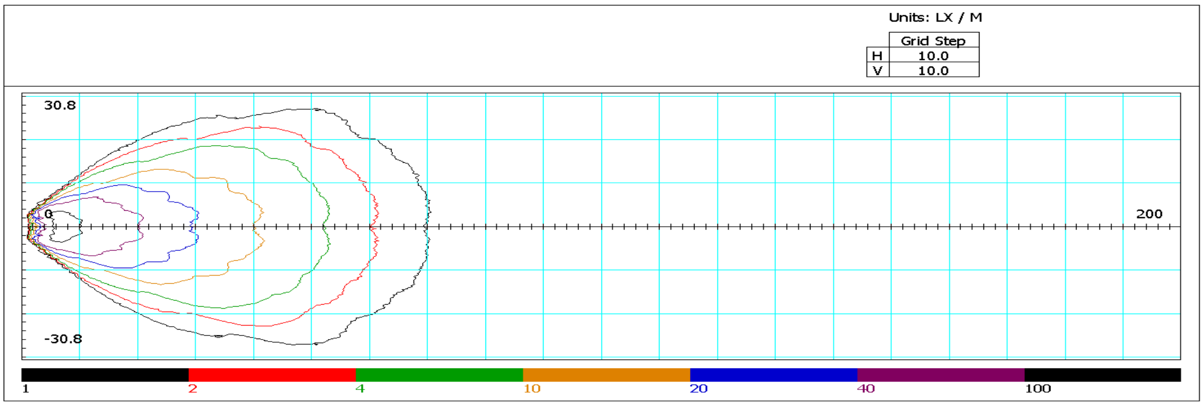
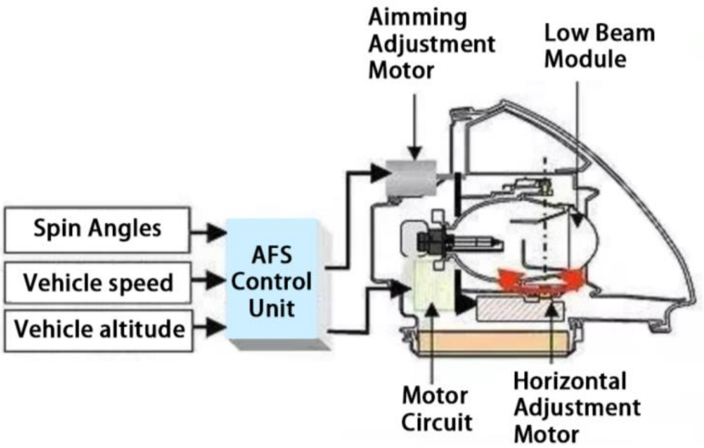


Fig. 7 The problem of low headlight illumination of traditional headlights

Figure 8 Lighting of AFS urban roads



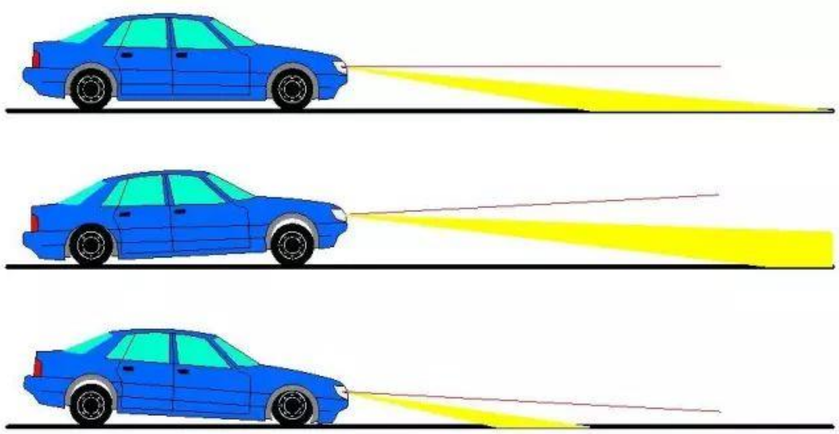
Technical foundation of AFS system function realization

The difficulty of the currently developed AFS system is the lack of effective and cheap sensors that can judge the basic road conditions. To complete the comprehensive recognition of road area water, turning roads, highways, rural roads and urban roads, even the adoption of the next generation of CCD-based image recognition technology is still a challenge.
Therefore, the AFS system in mass production now uses indirect judgment to achieve limited functions. For example, the vehicle body height sensor is used to sense the pitch angle of the vehicle body to keep the headlights and the road level; the steering wheel angle sensor

is used to sense the front wheel rotation angle, and the road speed is judged based on the vehicle speed to realize the function of turning the curve; the automatic wiper humidity sensor Sensing the rainfall and realizing the function of reflective light blocking of the headlights.

Body trim dimming function

The body will change the trim angle due to the difference of the front and rear loads, and the angle of light emitted by the headlights mounted on the body will also change, which will adversely affect the night driving safety.



As shown in the figure, the upper part is the normal headlight exit angle and lighting range, and the middle and lower parts are the headlight angle and lighting range in the case of backward tilt and forward tilt respectively. The difference is very obvious. In addition, vehicle acceleration and deceleration can also change the pitch angle of the vehicle body.
The vehicle body height sensors installed on the suspension and the vehicle body are used to obtain the height variation of the front and rear axles, and the vehicle body pitch angle is calculated based on the wheelbase. The amount of change in the trim angle of the vehicle body is the change in the angle of the headlight axis. Through the operation of the dimming motor, adjusting this angle change in the reverse direction can restore the optical axis to the original state and maintain the level.

Corner rotation function

The traditional national standard has very strict requirements for headlight lighting. The iso-luminance curve (0.5 ~ 31lux) of the headlight (single headlight) was measured on a 25m test screen. The light network generated in space was obtained by calculating the light of various energy. The space area surrounded by the red line in the figure below Is the headlight (single headlight) 1 lux optical network, then the dual lights can illuminate the area surrounded by blue lines on the road.

There is no doubt that this low beam completely meets the national standard light distribution requirements, but this does not guarantee that the driver can find the danger close to the curve, because the traditional headlights that horizontally fix the optical axis have blind spots. If the front dipped beam can be rotated an angle in advance, the left lamp is rotated by 15 degrees, and the right lamp is rotated by 9 degrees, the visible area can cover more than half of the curve with a turning radius of about 37m, so that dangers on the road can be detected early, and it should be handled .

The most extreme response to the crisis found on the curve is braking, and the angle at which the headlights need to rotate is to ensure this effective braking distance. Generally speaking, it takes 1.5 seconds from the moment when the crisis is detected, the brake is applied, and the brake is activated. During this time, the vehicle is traveling at the initial speed. After the brake is operated, the braking distance is roughly linear if there is no tail flick or lockup. The braking is the same. Adding the two together, the required distance must be within the illuminated area after the headlights are rotated.

Rain and light blocking function

Lighting in rainy and bad weather has always been the main factor affecting driving safety at night. I am afraid that many people will experience the reflection of the headlights. The reason why vehicle headlights are divided into high beam and low beam is that low beam lamps can effectively prevent direct light from reaching the driver's eyes on the opposite side. However, under the condition of water on the road area, this careful design completely fails.

Swiveling is simply understood as the lateral movement of the dipped beam module in the AFS system is only one-sided. From the perspective of the design of the luminaire, I prefer to include all the functions of the auxiliary lighting of the luminaire in this system because their purpose is to increase the horizontal visibility range during the rider process. We can divide the lateral adjustment function into dynamic and static.

Dynamic system: Use the sensor to obtain the steering angle of the car to predict the driving direction of the vehicle, and turn the low-beam system of the lamp horizontally by the corresponding angle to achieve real-time enhancement of the visible area lighting brightness in the driving direction, thereby reducing the risk of driving purpose.

Static system: also known as Fixed bending Light. Corner lights are lamps that provide auxiliary lighting at corners of roads near the front of the vehicle or auxiliary lighting for the side or rear of the vehicle. The corner lights play a certain auxiliary lighting role when road environment lighting conditions are not sufficient, which provides guarantee for driving safety. This kind of luminaire plays a certain auxiliary lighting role especially in areas where road environment lighting conditions are insufficient. There are two types of angle lights: one is to provide auxiliary lighting for the corner of the road near the front of the vehicle to turn, and it is installed on both sides of the longitudinal symmetry plane of the vehicle. The other is when the vehicle is about to reverse or slow (less than 40 Km/h), to provide auxiliary lighting for the side or rear of the vehicle, installed on the side, rear or downward of the vehicle.

AFS system modeling and simulation

Modelling Example with Aiming System:

The objective of this part is to make a deep study on a headlight levelling system from modeling to an experimental validation using a test bench. The work is focused on the quasi-static headlight levelling system used by Renault (figure 1). At the time being two technologies are used by automotive industries to make this correction.
A quasi-static correction, which is carried out using a kinematic chain with a geared motor.

A dynamic correction, which is carried out using a micro stepping motor.

Figure 1

In any vehicle, the vehicle trim is modified under the embedded load, the road profile and driving conditions (braking or acceleration phases). For an illustration, figure 2 shows the effect of the embedded load on the vehicle trim inclination and on the light beam:

1. For a normal operation, the light beam has an inclination of -1.2% and a visibility range of 60m (figure 2, a)

2. For an inclination higher than -0.5 %, the light beam glades the drivers in the opposite direction of driving (figure 2, b)

3. For an inclination lower than -2.5 %, the driver has a bad visibility of the road when driving (figure 2, c).

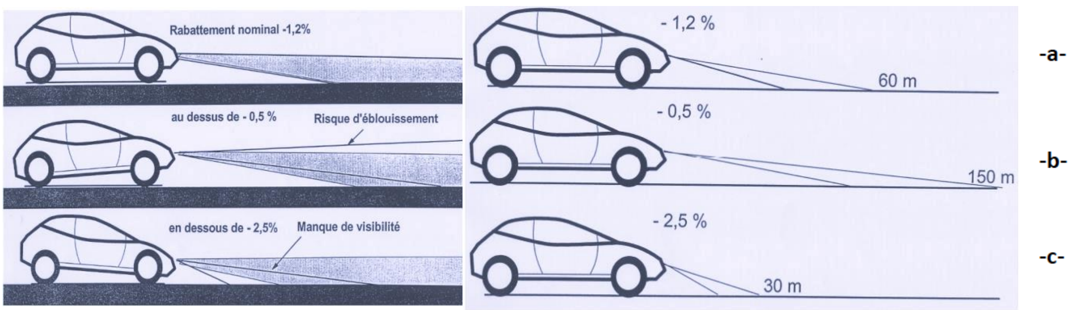
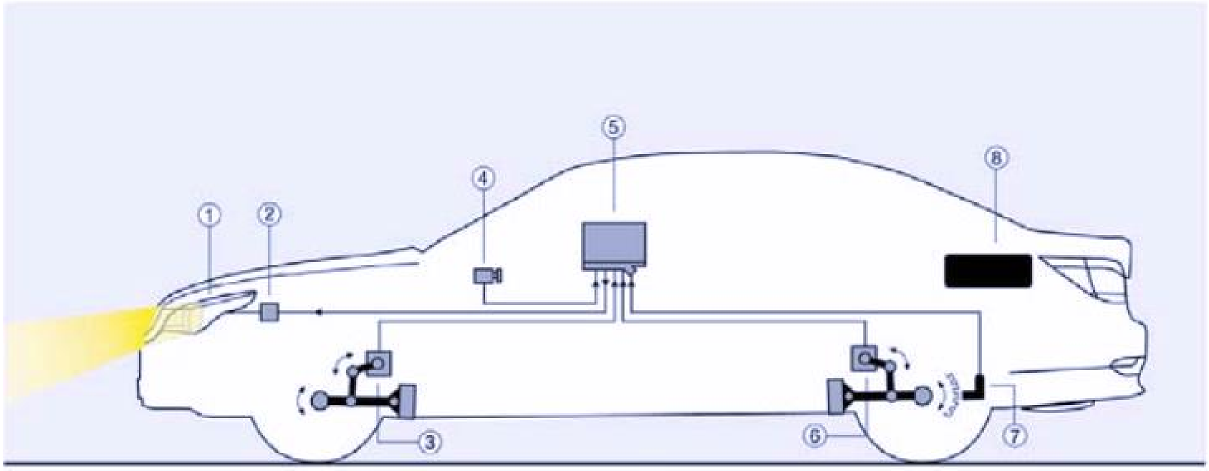


Figure 2: Effect of the embedded the load on the light beam

For abnormal positions of the headlight, the visibility range should be corrected continuously in order to ensure safety. However, the headlight levelling system can correct the visibility range whatever the embedded load, road profile and driving conditions.

Description of the headlight levelling system

Figure 3, gives a general description of the levelling system. The luminous sources are integrated in the projector (1). Both are supplied by the low voltage battery in order to give a visibility range to the driver. Under the effect of the embedded load (8), the actuator (2) adjusts the projector support (1) to its set point inclination imposed by the safety norms (-1.2%). According to the information provided by the front and rear axle sensors (3) and (6), wheel velocity sensors (7) and eventually other information, the control unit determines the appropriate correction computing the set point angular position from the control laws and the data provided by the sensors (h1 and h2).



1. Projector	5. Control Unit
2. Actuator	6. Rear axle sensor (h2)
3. Front axle sensor (h1)	7. Revolution sensor
4. Lighting switch	8. Loading (embedded load)

Figure 3: Structure of the headlight adjustment system

For the quasi-static correction system, only the embedded load is considered. According to Renault which uses this technology, the trim inclination is more significant under the effect of the embedded load. However, the vertical correction is updated, in closed loop, after any stop thus the name of quasi-static correction. In addition, most of the inclination variation is due to embedded load in the rear vehicle trim.

For the dynamic correction system, vertical correction is carried out, in open loop, in terms of driving conditions (acceleration and deceleration) and embedded load. However, the control unit deals with data provided by sensors taking into account traffic conditions and control laws in order to continuously provide the set point angular position. Indeed, the dynamic correction maintains permanently the visibility road at 60m.

Description of the kinematic chain

In this project, our study is focused on quasi-static correction used by Renault for some vehicles such as Renault Space IV or others. Figure 4, shows the devices of the kinematic chain of the headlight vertical adjustment system. The orientation block contains luminous sources which are supplied by a power electronics stage linked to the battery.

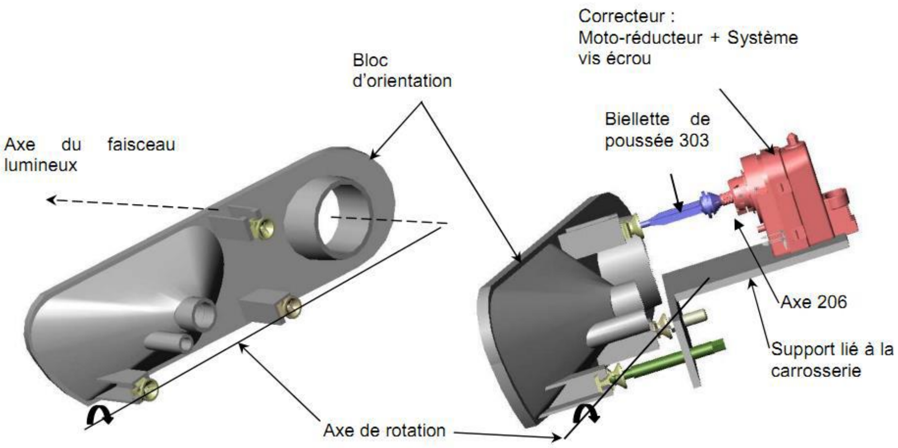


Figure 4: Kinematic chain of the headlight levelling system

The motion of the orientation block is realized by the action of the push rod 303 fixed in the extremity of the axis 206 which is linked to a geared motor associated to a screw nut system (figure 5).

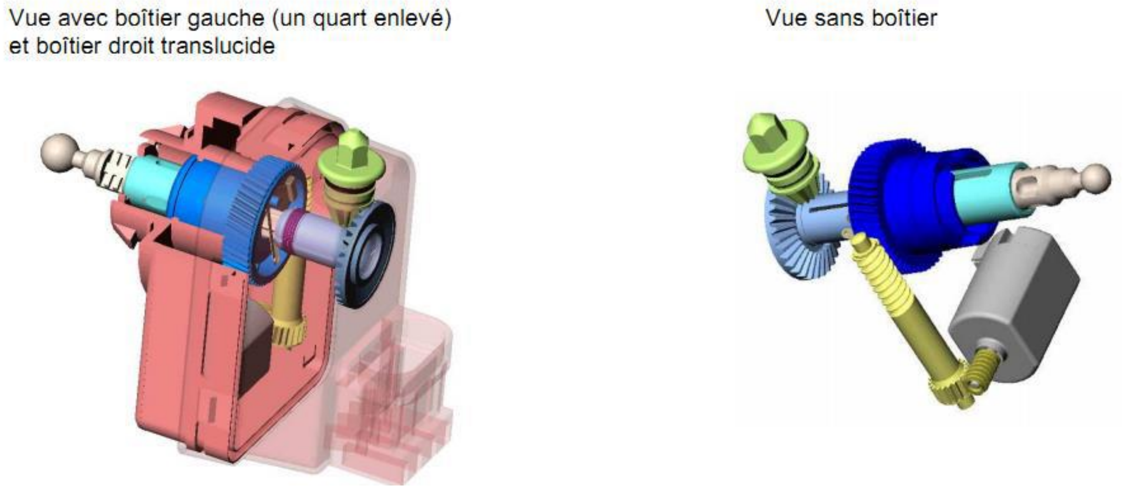


Figure 5: Architecture of the geared motor associated to the screw nut system

Power supply

Two power stages are used in the headlight levelling system; a buck-boost converter to supply the luminous sources and a buck converter to supply the geared motor. The DC link of the power stages is provided by the low voltage battery.

Sensors

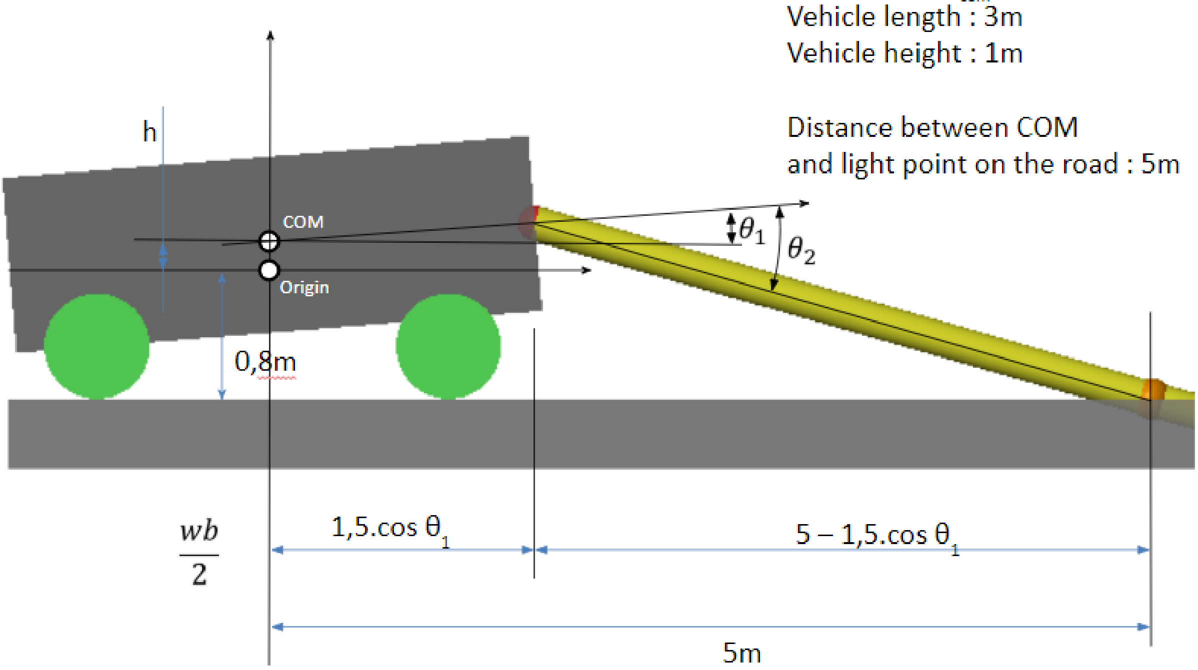
In the headlight levelling system, the quasi-static correction needs three sensors:
1. Two Hall Effect sensors to measure the displacement of the vehicle trim under the effect of the embedded load. Both are fixed on the rear and front axels of the vehicle
2. Displacement sensor which is a linear potentiometer to measure the screw nut position.

Analysis

θ_1 vehicle pitch angle (measured)
θ_2 lighting beam angle (computed)
h vehicle vertical position (measured)

Wheelbase : 2m
Ground clearance : 0,3m
Wheel radius : 0,3m
Steady state x_{com} = 0,8m
Vehicle length : 3m
Vehicle height : 1m

Distance between COM and light point on the road : 5m



$$\theta_2 = -\tan^{-1}\{(0{,}8 + h + 1{,}5\sin\theta_1)/(5 - 1{,}5\cos\theta_1)\} - \theta_1$$

Based on the general description of the headlight levelling system given above, complete the block scheme of figure 7 by the name of each physical component of kinematic chain and complete it by the control loops and law to use for the correction. Add inputs/outputs of each block:

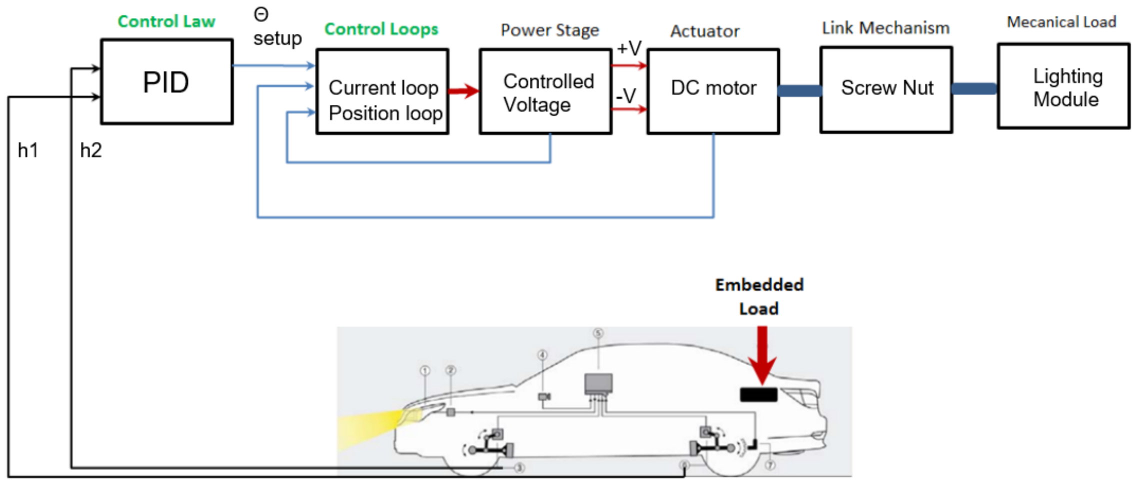


Figure 7: Block scheme of the headlight levelling system

In figure 7,
1. Define the control law to use in order to deduce the angular position set point of the DC motor in terms of the vehicle pitch angle estimated from the measurements h1 and h2 (see figure 7 and Analog and Digital Sensors。
2. Give the details the control strategy and the control loops to implement.
3. Defined the type of controllers to use for this application.
In the figure below, you find the description of the kinematic chain of the headlight levelling

system with:

- DC motor
- worm and wheel gears
- Screw nut system
- Orientation block with spherical joints and levers

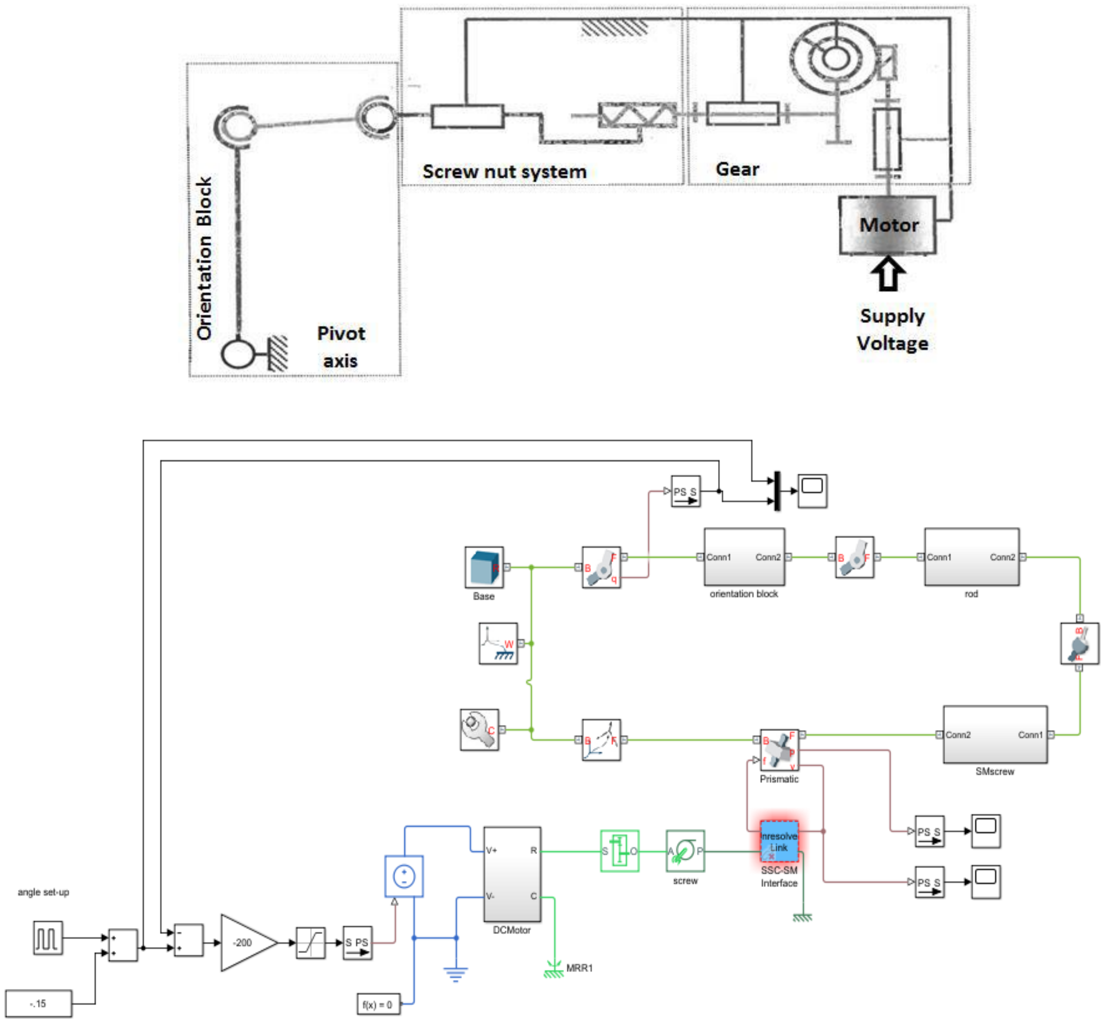


Figure 7: Kinematic chain of the headlight and Matlab Simulink modelling

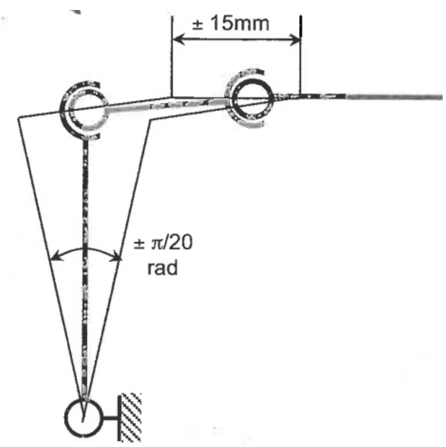
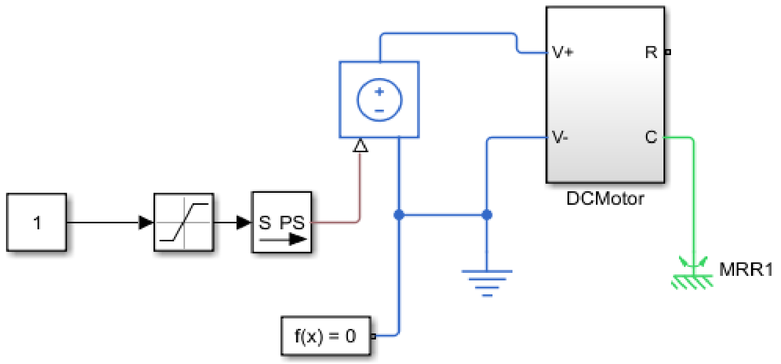
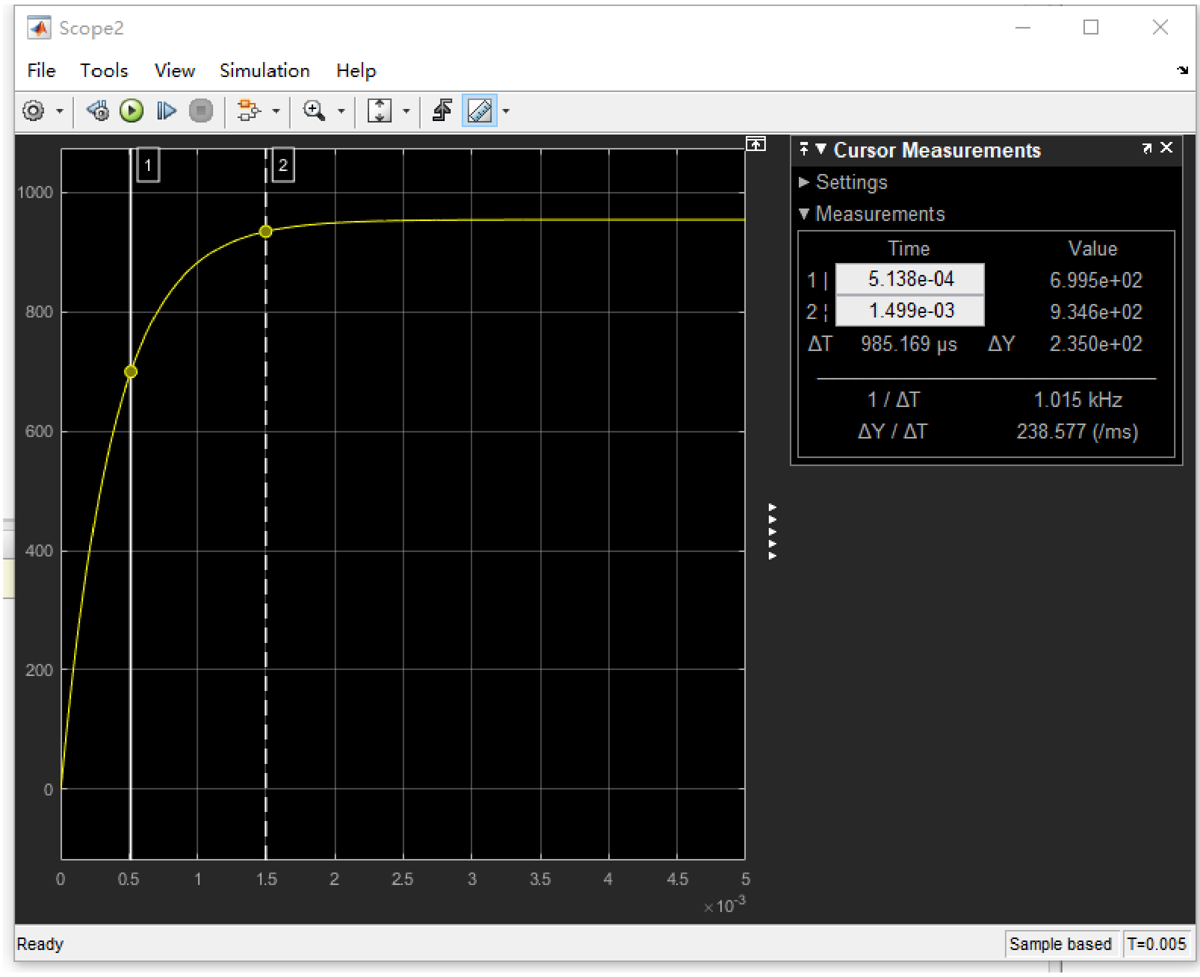


Figure 8: Orientation block of the lighting sources

In the same directory, the model of the DC motor is available. Keep it in your directory and apply a step supply voltage of 1V in order to get a velocity response.

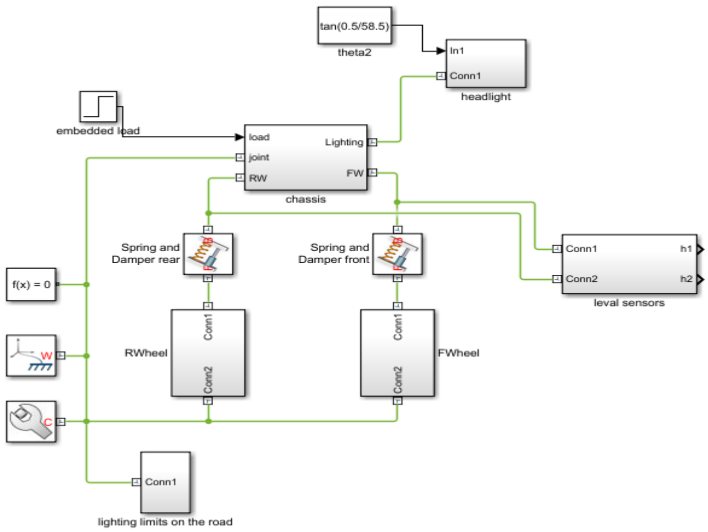




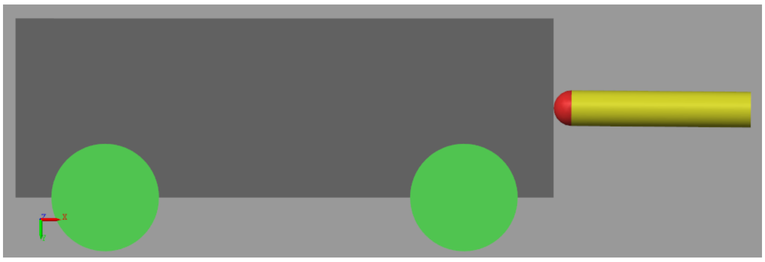
In the simplified model, the moment of inertia of the DC motor is designed to be very small, so the time to reach the target speed after the DC motor is powered on is very short. It means that the response speed approaches zero, and in actual system design, this response time will be much larger than this value.

In the same directory, take the simplified model of the 2D vehicle dynamics and keep it in your directory.
- Validate it using some embedded loads and evaluate the pitch angle θ with the value deduced from h1 and h2 using the Simscape block of the sensors.
- Define the input/output variables of the model and use **linmod** to deduce the equivalent transfer function of the model.

- Apply the same input to the transfer function and the model. Plot the output responses. Compare and conclude.
- Keep the equivalent model for an eventual use in **the experimental work**

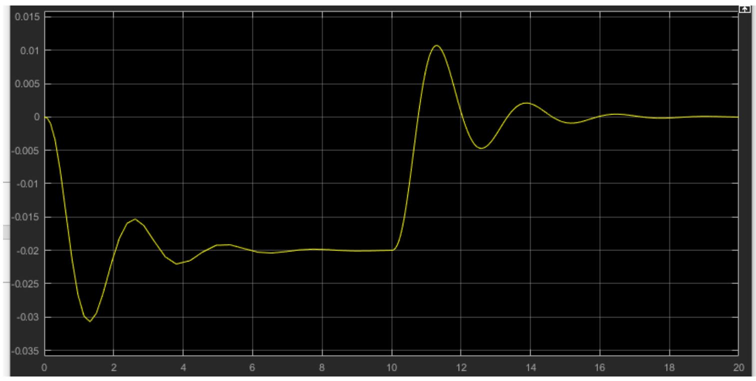


Simulink model for vehicle



Simplified vehicle model and lighting corn

We preset the vehicle's suspension and other basic parameters in the model, and loaded a 500kg weight in the carriage as a demonstration case, and obtained the following pitch angle fluctuations：



Assembly all the model components to create the simulator of the headlight levelling system in closed loop. Simulate the operation mode:

1- Without the control laws

Without any embedded load.

With an embedded load creating positive and negative variations around the stable position of the vehicle (pitch angle = 0).

Comments the responses you get from both

2. With the control laws

1. Keep the embedded load and make corrections on the motor position set point in order to maintain the light beam at 60 m whatever the embedded load maybe.
2. Plot the DC motor position, velocity, current and orientation angle for two or three use cases
3. Comment the results and conclude

From the beginning of this simplified case, we designed the PID control loop, and we directly obtained the transfer function of the loop with the help of MATLAB:

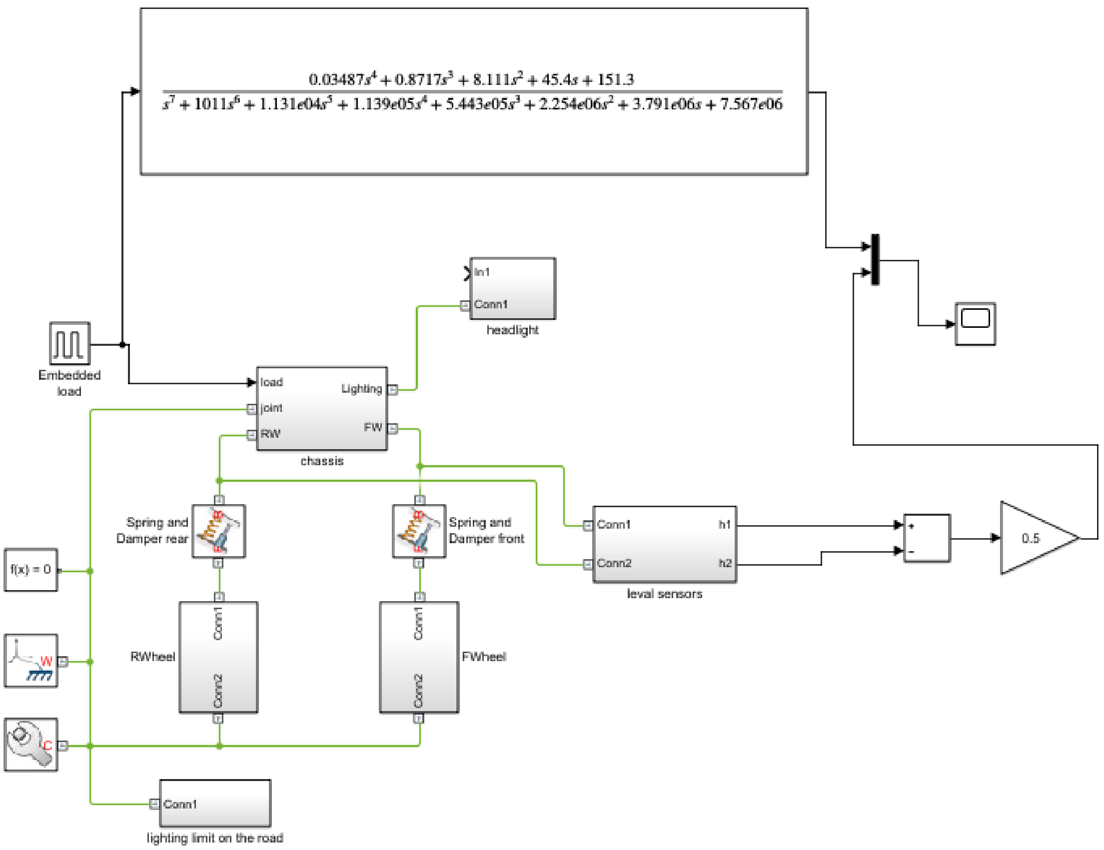
```
Continuous-time state-space model.


sys =

                         0.03487 s^4 + 0.8717 s^3 + 8.111 s^2 + 45.4 s + 151.3
  -----------------------------------------------------------------------------------------
  s^7 + 1011 s^6 + 1.131e04 s^5 + 1.139e05 s^4 + 5.443e05 s^3 + 2.254e06 s^2 + 3.791e06 s + 7.567e06

Continuous-time transfer function.
```

Input the transfer function to the control loop.



Simulink model with control loop

Now we make comparison of the assembled model with and without control loop.

Without control loop:

With control loop:

We can easily make a shot conclusion, consider the control loop, during the embedded load on vehicle which will lead a pitch angle of vehicle, the light corn has been well control in target point 60m. Theoretically, this system effectively avoids the upward movement of light caused by changes in the vehicle's attitude, thereby generating glare and increasing safety risks.

In the following chapters, many more advanced lightings technologies will be introduced, but their overall control principle is based on the design of this control system. In the future technology development, in order to increase the reliability of the system, DC motor will g gradually replaced by other more reliable technologies, and even completely eliminated the mechanical transmission structure through optical design, but their electromechanical principles are almost the same.

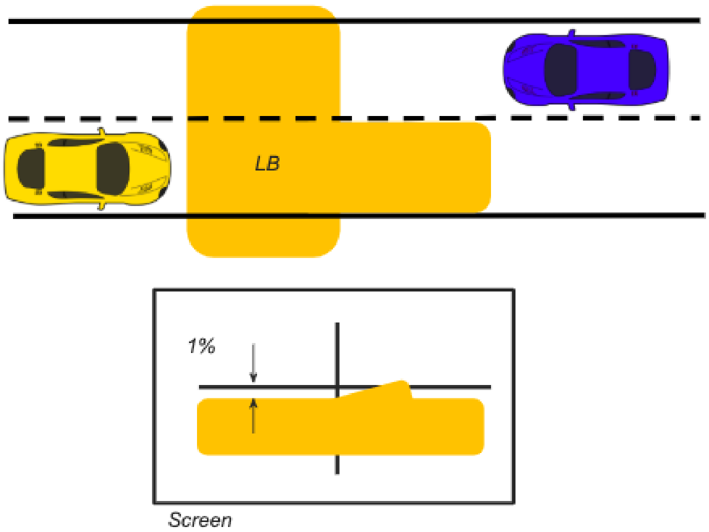
Adaptive Driving Beam Headlighting System

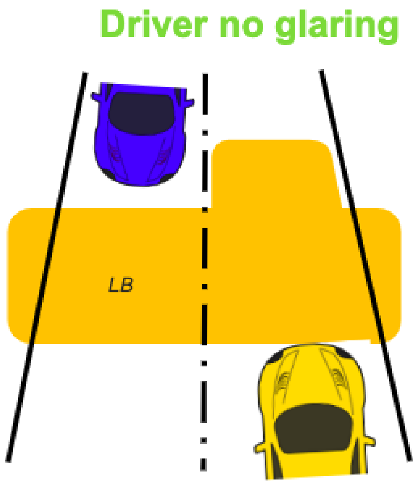
Introduction and its application

The basic ADB system has actually been used in a large number of mid-to-high-end models, and all Volkswagen POLOs starting in 2019 have begun to come standard with ADB systems. The most basic function of the ADB system is to help the driver to automatically control the on and off of the high beam. Similarly, the birth of the ADB system is also to further improve driving safety and reduce safety risks when driving at night.

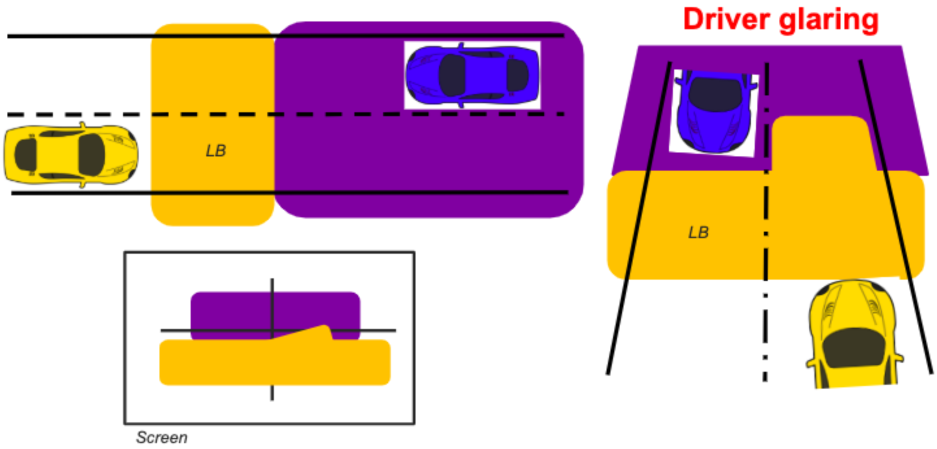
Considering that the use environment of the high-beam system is lower than that of the low-beam system, it is usually used in extremely harsh light sources outside the city, remote mountainous areas and other environments, even on high-quality highways because of the speed Faster, the driver needs a longer viewing distance to respond to risks in advance, and high beams are often used. When meeting cars or vehicles appearing in front of the traffic, you need to turn off the high beam. This is not only a traffic regulation requirement, but also to avoid the glare of the high beam. The oncoming vehicle or the vehicle in front creates a visual blind zone, causing a traffic accident.

In the next few pictures we will elaborate how the glare of the high beam system is generated, and how to reduce the glare through the ADB system.





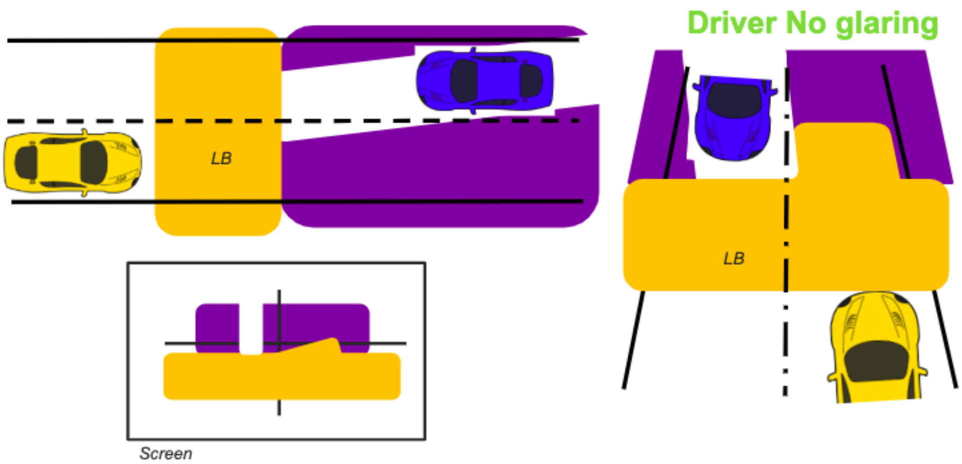
As shown in the picture above, the yellow vehicle is moving forward and meets the blue vehicle. As shown in the SCREEN diagram, the design of the traditional low beam has limited most of the light exposure to the horizontal exposure range. The 15-degree cutting line is designed to reverse the direction according to left driving or right driving. The purpose is In order to increase the visible distance of the vehicle's forward direction, it will not cause glare to the passing vehicle. But let's look at the situation where the high beam is on.



In the screen icon, the purple area is displayed as the high-beam illumination range. A large number of light sources are far higher than the horizontal position. Under dark conditions at night, it can effectively increase the driver's visible distance and traffic sign information. However, at this time, when vehicles on the opposite side appear, we will find that the entire blue vehicle is exposed to glare, which affects driving safety. This is why in the process of obtaining a driver's license, we are required to turn off the high beam lights immediately when a meeting occurs.

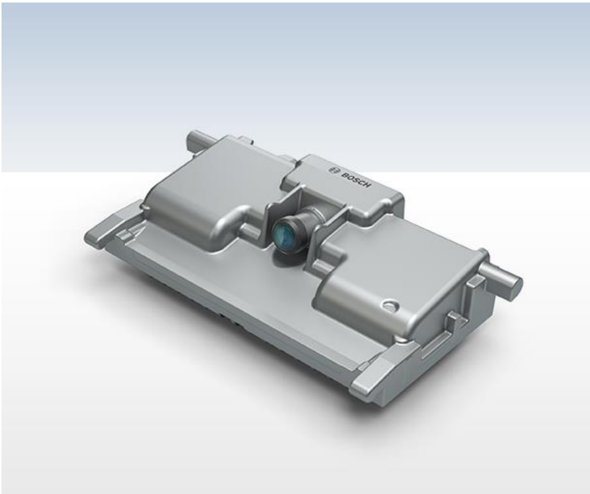
On vehicles without an ADB system, turning the high beam off and on requires a manual operation by the driver. Frequent operation of the high-beam light switch will inevitably cause short-term distraction of the driver, or leave the steering wheel with one hand, etc., which may cause risk uncertainty to the driving safety, especially the operating environment where driving at night is very easy to cause fatigue Increase the number of operations in the middle, accelerate the fatigue and increase the risk of driving.

Because the operation of the high beam requires the driver to constantly judge the driving environment, which includes the judgment of the environmental brightness and the judgment of road conditions such as driving during the driving process. The processing of more information will speed up the formation of driver fatigue and also mean an increase in driving risk. The ADB system can determine the driving environment in front of the vehicle through the on-board camera, and automatically recognize and judge the lights of vehicles in the surrounding environment under low light conditions, thereby automatically turning on and off the high beam lights. Reduce the frequency with which the driver operates the switch, thereby reducing the driving burden and reducing the probability of traffic accidents.



In the basic ADB system, if the camera detects the vehicle in front, it will directly turn off the purple high-beam headlights. However, with the continuous improvement and development of lamp application technology, only the high-beam headlights in specific areas are turned off, and they are always maintained. The light in other areas is always bright, which is further reduced because when the high beam is completely turned off, there is a lack of visible brightness outside the glare area for sudden road traffic conditions such as wild animals or pedestrians who suddenly break into the main road, and no traffic sign Miss the highway exit and much more.

An important sensor in the ADB system should be introduced here, that is, the camera sensor. This sensor is not needed in the AFS system, but it is indispensable in the ADB system.



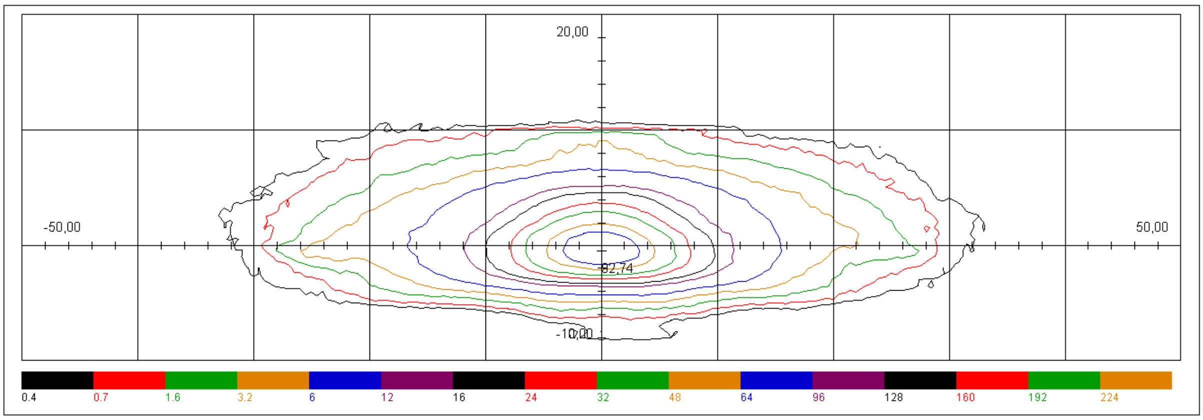
During assisted driving and autonomous driving, the vehicle must always be aware of changes in the surrounding environment. Camera modules must reliably detect objects and people and respond appropriately to them. For example, Bosch's multifunctional cameras use high-performance system-on-chip (SoC) and Bosch microprocessors for image processing algorithms. Its unique multi-path method combines classic image processing algorithms with artificial intelligence methods for comprehensive scene interpretation and reliable target detection.

With its algorithmic multipath approach and system-on-chip, image processing is performed using the following technical paths:

The first is the conventional method that is used today. With a pre-programmed algorithm, the camera can recognize the typical appearance of object categories such as vehicles, cyclists or road markings. However, the second and third functions are new. For the second function, the camera uses optical flow and moving structures (SfM) to identify raised objects on the roadside, such as curbs, a central reserve or a safety barrier. Track the motion of associated pixels. A three-dimensional structure is then approximated based on the two-dimensional camera image. The third function is to rely on artificial intelligence. Thanks to a machine learning process, cameras have learned to classify objects such as cars parked on the side of the road. The latest generation can distinguish road surfaces from road surfaces through neural networks and semantic segmentation. Use other paths as needed: These paths include classic line scan, light detection, and stereo parallax.
With the help of these new functions, modern automotive systems can effectively respond to road conditions ahead and achieve precise control of lights.

Matrix Beam system Optical Design

Optical Design is a core technology component of matrix headlight technology. Let's first understand how the matrix headlight system should be designed from the light distribution of traditional high-beam lights. Reading this paragraph may require some simple optical basics. Due to the limited space, I will not repeat the basic optical principles here. I prefer to explain the working principle of the matrix headlight system.



Light distribution of traditional high beam

High beam light distribution requirements

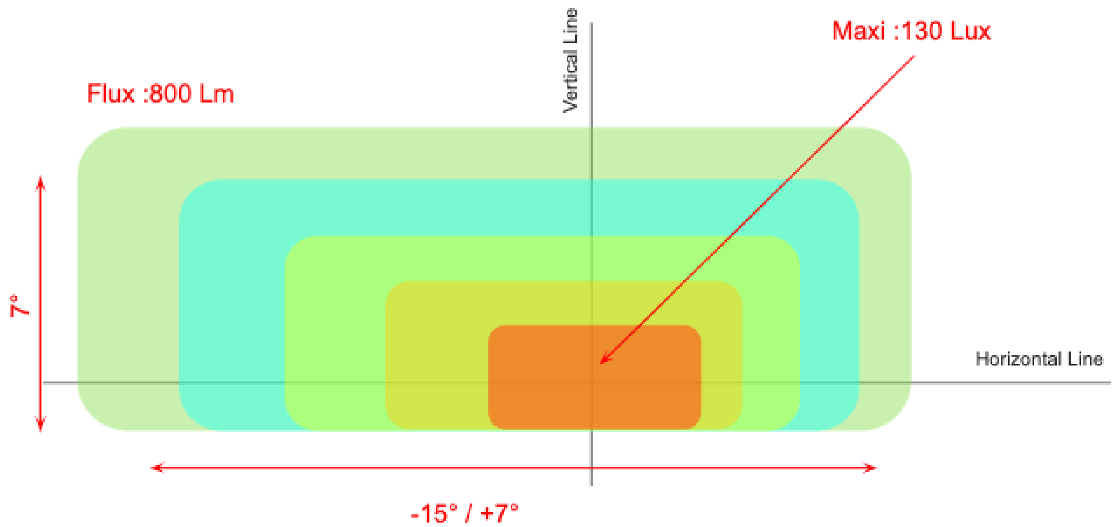
The maximum illuminance value (Emax) of Class B headlamps should be not less than 32lx and not more than 240lx;
the maximum illuminance value (Emax) of Class C headlamps should be not less than 32lx and not more than 180lx;
the maximum illuminance of Class D headlamps the value (Emax) should not be less than 51.2lx and not more than 180lx;
the maximum illumination value (Emax) of the E-level headlamp should be not less than 70lx and not more than 180lx.
HV point illuminance value should not be less than 80% Emax. For Class B headlamps, starting from the HV point, the illuminance value from left to right horizontal distance up to 1125mm should not be less than 12lx, and the illuminance value from distance up to 2250mm should not be less than 3lx.

After understanding the basic high beam headlight requirements, we started to design matrix high beam headlights, so according to the needs of the vehicle or the needs of customers and end customers, we must determine the information at once:

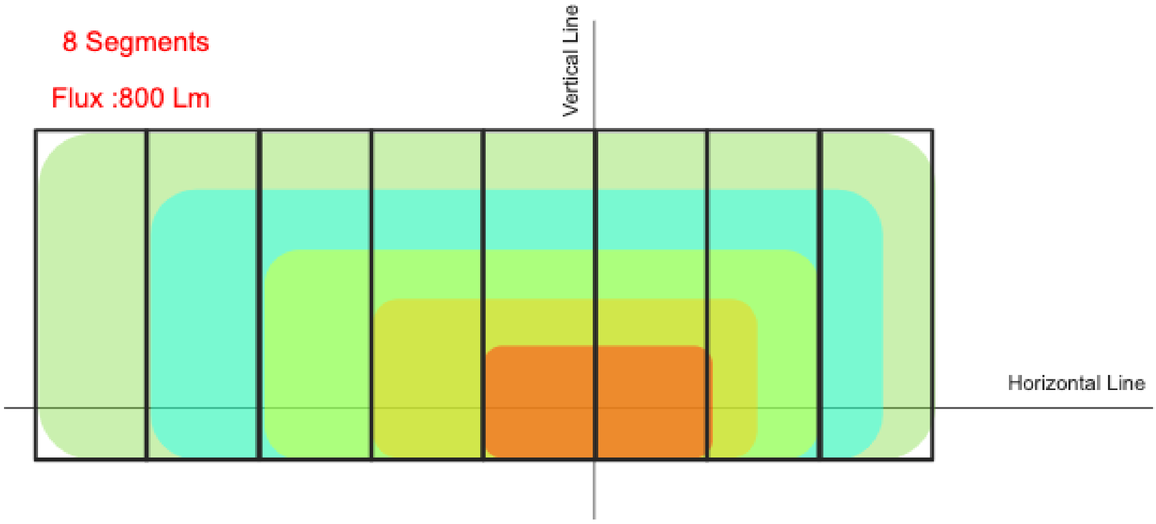
- Beam Maxi point
- Beam width of whole optical system
- Beam projection area height
- Tunnel resolution (minimum controllable degrees)
- Number of segments
- Beam flux in total
- Size of each pixels

Based on the above information, we need to obtain the following four key information as input for system design:

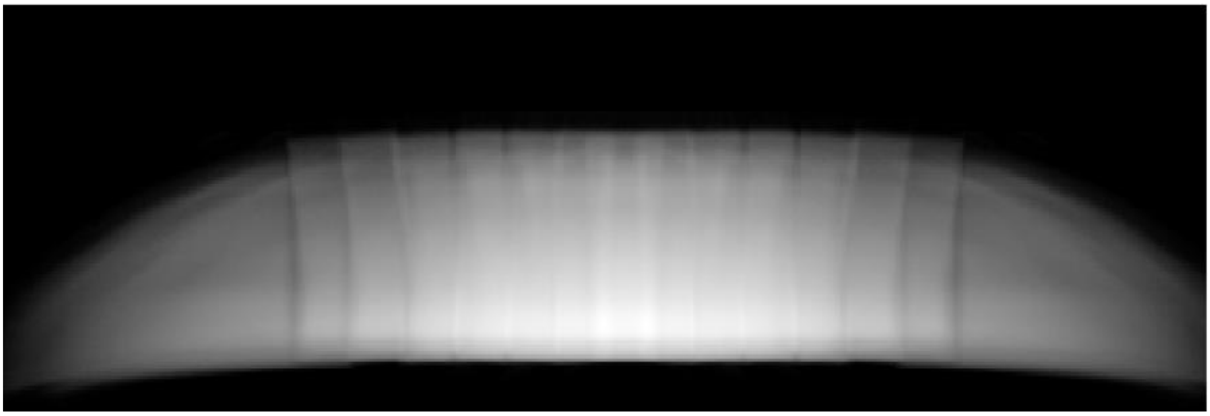
- Leds numbers
- Packaging size
- Module numbers
- Lens numbers



As shown in the figure above, this is the light distribution preset of the matrix module we first made at the beginning of the optical design. Vehicles usually have two left and right headlights, so in order to save costs and achieve more segments, we designed the unilateral optical system to be asymmetric. However, when the left and right headlight modules work at the same time, the light type distribution will be symmetrical. Next, we assume the design of a single-sided 8 segments optical system to explain the optical working principle of the matrix headlight in detail.

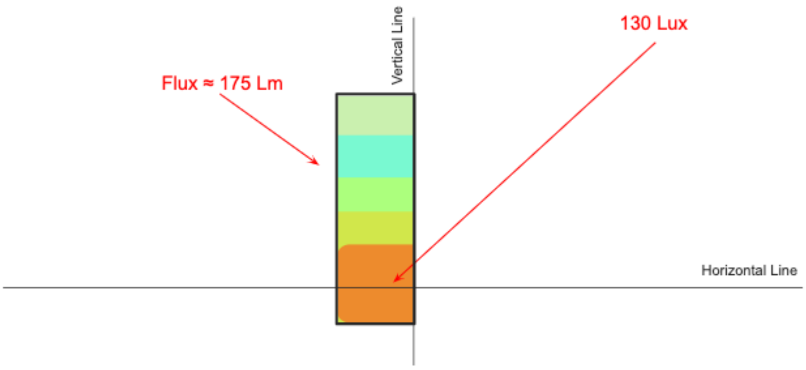


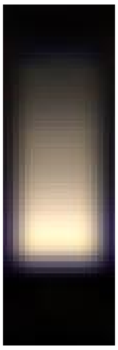
The entire lighting area is evenly divided into 8 areas evenly. Then make the optical design according to the lighting needs of each optical area. However, we immediately discovered that when the matrix high beam is always on, it must not only meet the regulations required by traditional high beams, but also have many technical difficulties that require customer service. For example, the distribution of light between each controllable light source must be sufficient. Even. The following figure shows that if we simply divide all the illuminated areas, we can find that there are different degrees of bright spots and dark areas in each optical partition.



Sector design example.

Taking the first segment as an example, we can achieve the requirements in conceptual design through the design of optical lenses. In the process of designing the optical system, the optical efficiency of the lens, the maximum luminous brightness of the LED itself, and the efficiency of the LED cooling system must be considered at the same time. The maximum output of an LED under stable conditions was initially obtained. The LEDs we selected were extremely small In the heating space, the final stable output lumens value is about 100lm, which is far from the 175lm we want to achieve in our conceptual design. In addition, the effect shown in the previous picture, the light type defects that would be produced by a single LED to achieve lighting control in an independent area. Valeo's optical team achieves the purpose of subdividing the controllable area and eliminating the dark areas between the areas by superimposing the LED lighting areas. At the same time, the addition of more LEDs disperses the heat generated by a single LED It helps to evenly distribute the heat on the entire heatsink.





Formulas:

The engineers of the optical team realized the distribution of the all-light type area through the form of multiple modules + multiple LEDs. And achieve more precise area control through the optical displacement of each sub-module. Here are some of these formulas for reference:

Tunnel number function of interlacing：
Tunnel Nbr* = (Interlacing Nbr x Led Nbr/Module) - (Interlacing Nbr - 1)

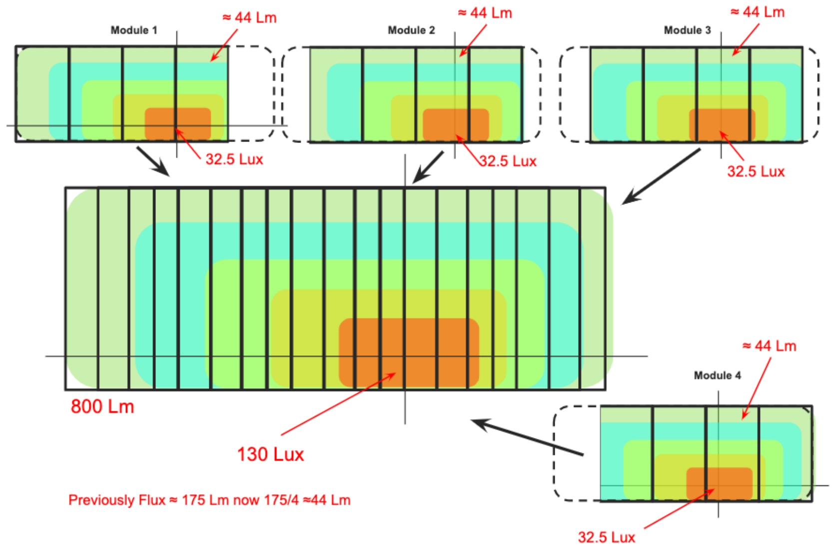
Pixel performances function of interlacing：
Beam Performances= Interlacing Nbr x Pixel Performances

Pixel size function of pixel number and interlacing：

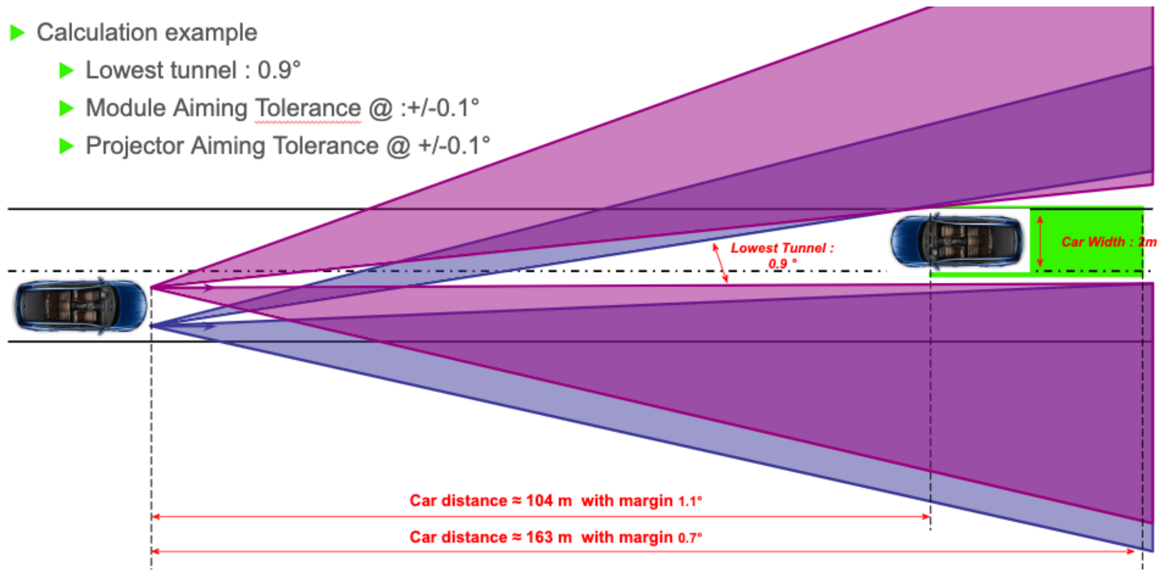
Pixel Width [°]= Beam Width [°] x Interlacing Nbr / (Led Nbr + (Interlacing Nbr-1))

Tunnel size function of pixel size and interlacing：

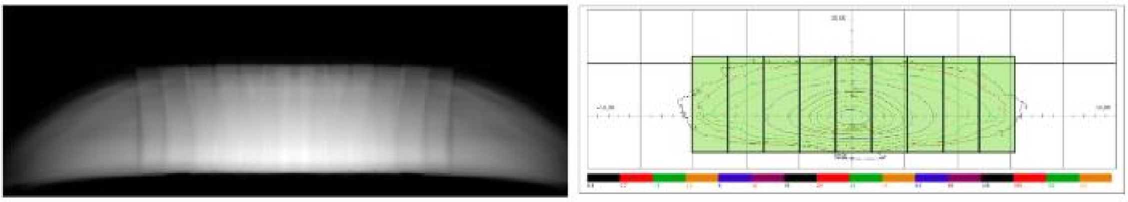
Tunnel Size = Pixel Size / Interlacing Nbr



Because in this case there is only the control of the lateral area, a simple trigonometric function can be used to calculate whether each area should be on or off. Even small errors in the design and production of a true optical system can cause the entire system to fail. An error of 0.1 Degree may also cause major traffic accidents.

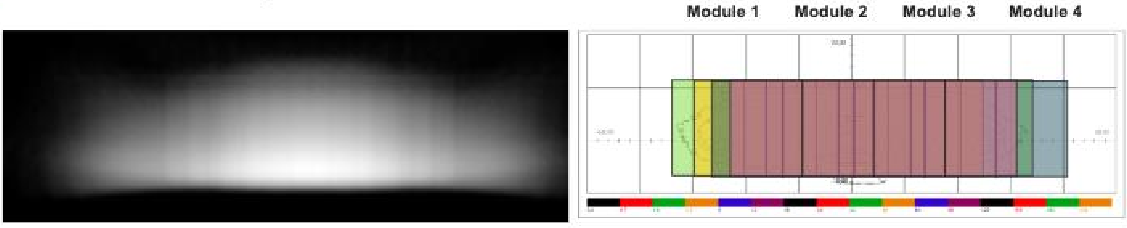


Solution N°1 : Discretization



- **Beam uniformity** - **Module size** + **Pixel resolution** + **Tunnel resolution**

Solution N°2 : Interlacing : 4 Modules

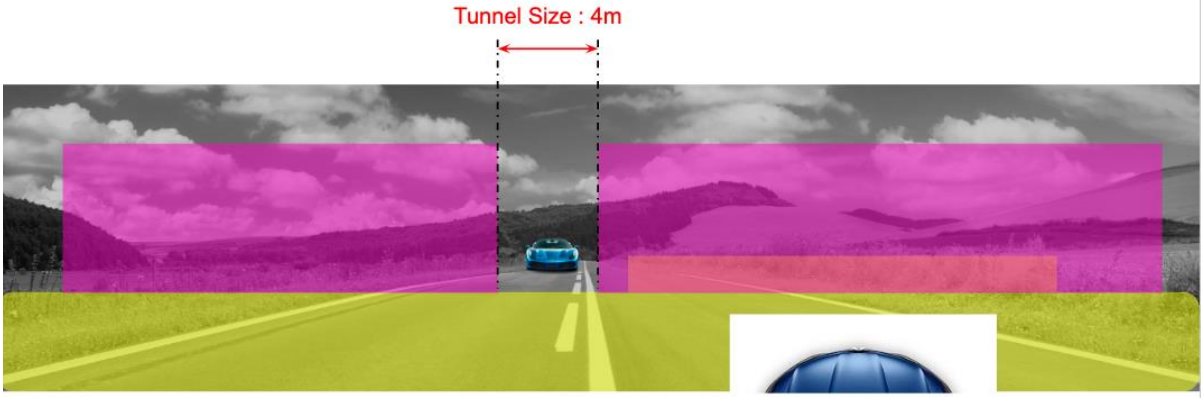


+ **Beam uniformity** + **Module size** - **Pixel resolution** + **Tunnel resolution**

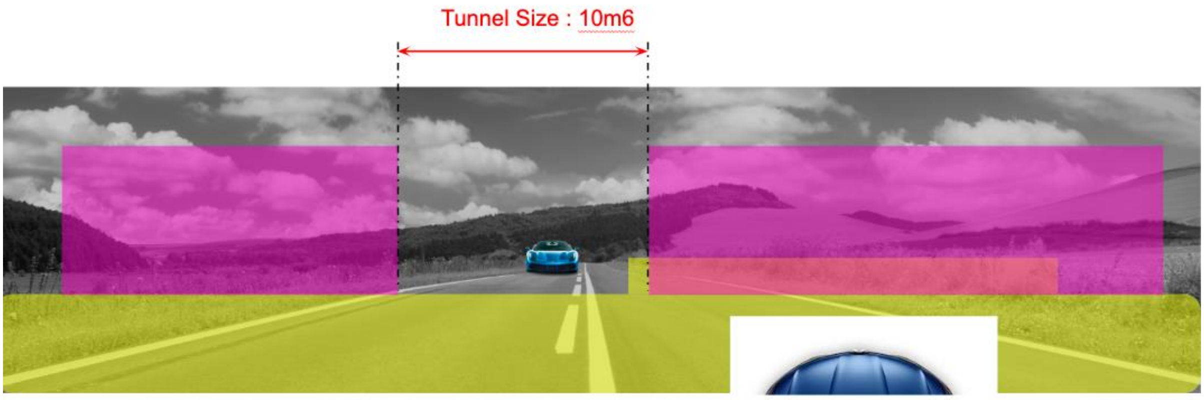
From the above simulation results, it can be seen that the multi-module stacked light distribution almost completely eliminates the dark areas between the matrix areas and improves the optical uniformity of the entire system.

Precision:

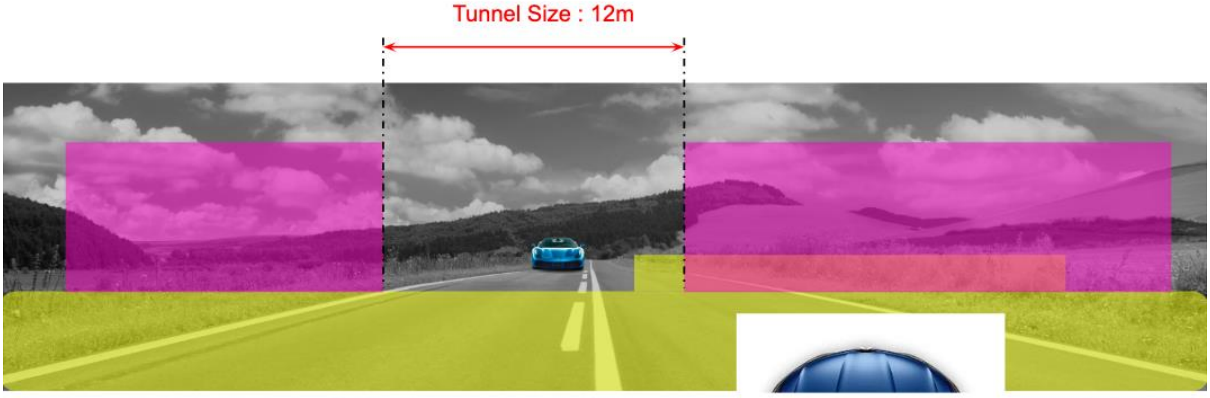
Beam Pattern Incoming Car @ 250 m with aiming tolerance +/-0.1°



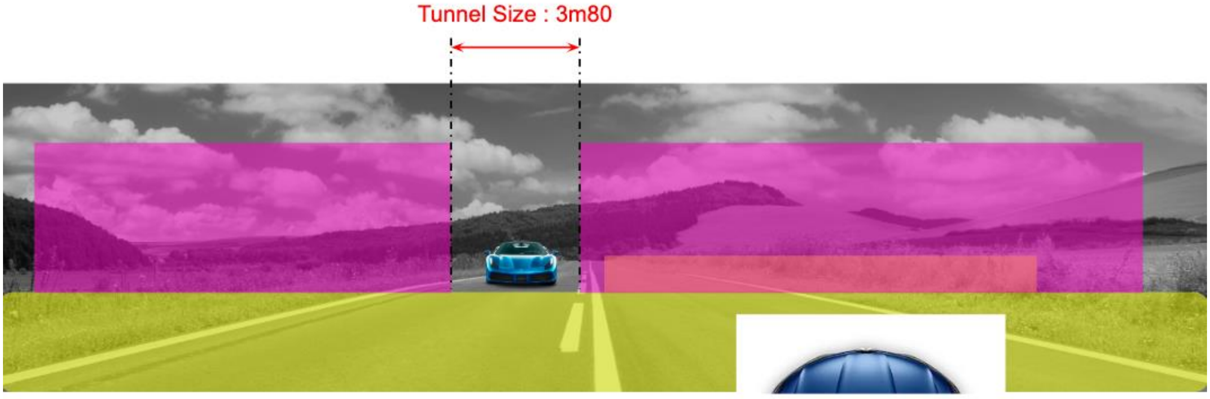
Beam Pattern Incoming Car @ 250 m with aiming tolerance +/-0.7°



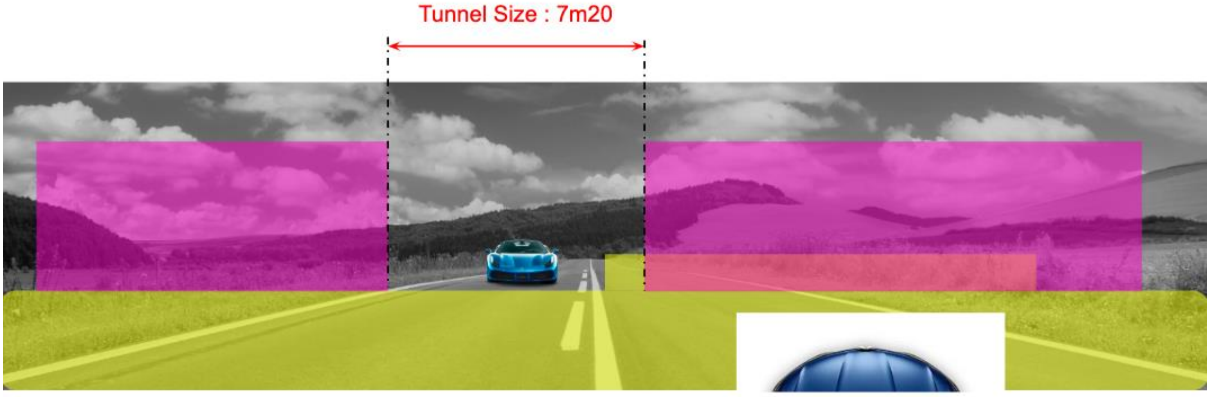
Beam Pattern Incoming Car @ 250 m with aiming tolerance +/-1°



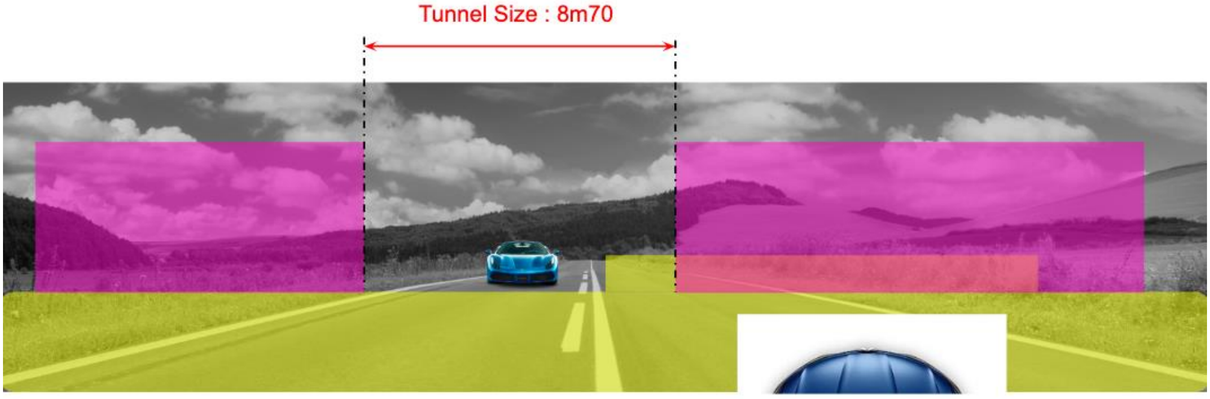
Beam Pattern Incoming Car @ 150 m with aiming tolerance +/-0.1°



Beam Pattern Incoming Car @ 150 m with aiming tolerance +/-0.7°



Beam Pattern Incoming Car @ 150 m with aiming tolerance +/-1°



Digital lighting system based on MXB technology

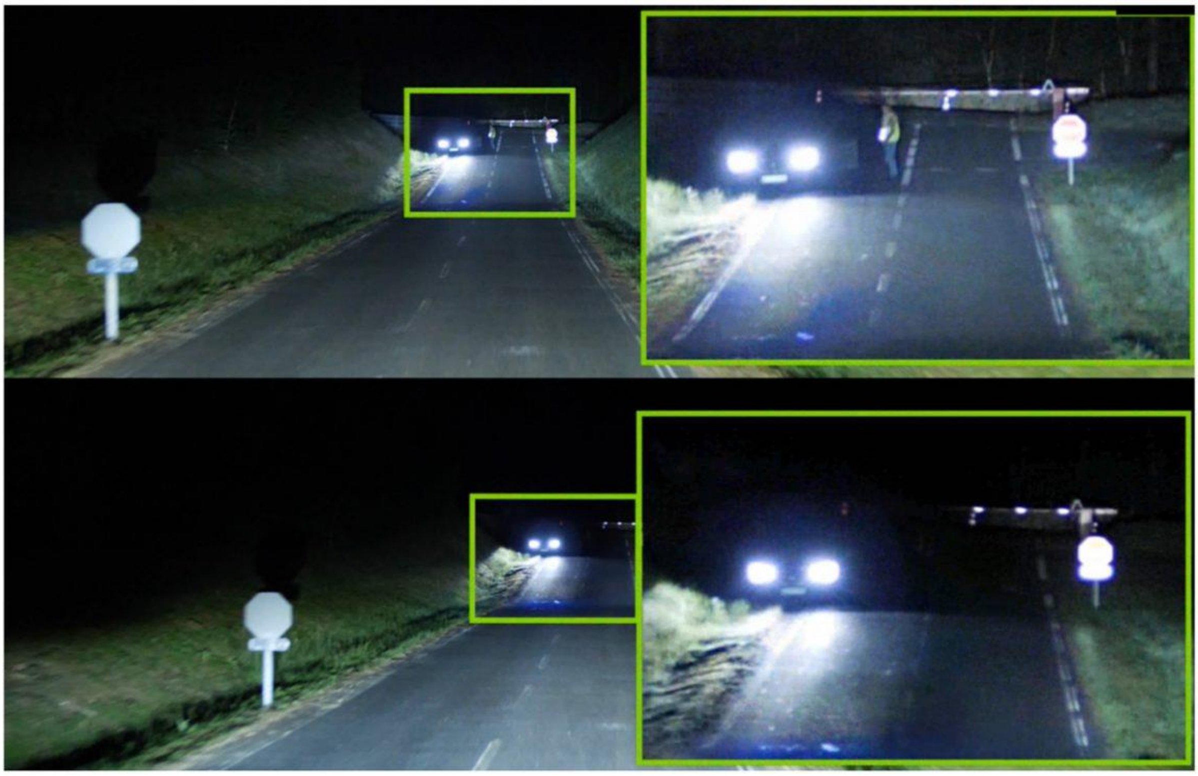
Since the first serial ADB systems developed by Volkswagen with vertical mechanical shadows, two other technologies have been proposed to find the best balance of performance, resolution, and cost.

First came the Matrix Beam on Audi's A8 of 2013, followed by several systems using four to 16 segments per headlamp.

The second wave was launched in 2017 by Mercedes-Benz in the E-Class with three rows of pixels in one single module. In these technologies, increasing the number of pixels to a few hundred brought a lot of improvements in the latest car serial releases in the horizontal resolution, going from a few to 28 pixels on a row with the Mercedes E-Class.

DVN has kept on top of the progress, reporting on wonderful night drives with A8, TT, A7, A6, then E-Class, S-Class and others.

Those solutions offer an ADB mode wherein a complete vertical stripe above the low beam is switched off to prevent glaring the other road users. To improve the resolution for a better light close to oncoming cars and for road markings, we have seen several demo-cars (and now production cars, like the Maybach and e-Tron) with DMD technology.



Valeo, for their part, have developed another solution to improve the resolution. They call it PictureBeam, and it's a lighting and road projection system.
PictureBeam Monolithic ADB – 4,000 pixels

The PicureBeam system provides a high-resolution (around 4,000 pixels) ADB with light all around the detected vehicles. It brings the function one step closer to being a real glare-free high beam, with a high accuracy in the cutoff position.

The technology is based on a monolithic LED, developed and produced by CREE, with 3,696 pixels to produce a high definition beam on the whole field. The main purpose of this module is to produce a high definition beam on the whole field. This module also makes it possible to do road marking for ADAS, but from 15 m in front of the car.

The 4-kpx Monolithic solution offers a resolution of 0.28° in both directions in the complete angular range of the high Beam, in order to keep a high-intensity light level everywhere where it is not dazzling the other road users.

With a 0.28° resolution over a full horizontal extent of 20° outboards and 16° inboards, this drawback linked with digital functions is now solved and the complete field of view where light needs to be finely adjusted is covered. Up to now, even with a high resolution, a dark shadow only consisting in 0% / 100% deactivation/activation of some pixels is perceived as a disturbing inhomogeneity in the beam (dancing light).

The module is composed of 4 major components corresponding to the main functions to be addressed:

– Monolithic light source to emit light
– Projection optics to project the light emitted by the source
– Cooling system to evacuate the energy emitted by the source
– Electronic board to drive and power the LED allowing driving each pixel individually.

ADB: MONOLITHIC 4K

ADB : CONVENTIONAL

Compared to other HD systems (like DMD or LCD), for which the luminous source itself is separated from the light spatial modulator, it is the most compact solution and most simple in terms of number of components.

The low beam delivers a flux of 1,250 Lm (with the flat module), a hot spot of 25 Kcd.
The high beam delivers a flux of 2,100 Lm with a hot spot of 75 Kcd.
Picture Beam Monolithic Road Projection
Road marking consists in projecting patterns on the road, with positive or negative contrast. These are to help the driver, as well as other road users, with mostly safety related features. They could be lane marking, highlighting certain areas, road signs projection, information displays.

Until now, most of these functions have been demonstrated with projection units using hundreds of thousands of pixels, like DMD or LCD technologies, and barely with discrete pixelated light source.

PictureBeam Monolithic Road Projection is based on a monolithic LED with 1,232 pixels to project elements on the road. The solid angle covered by this module roughly corresponds to the solid angle covered by a DMD module. This module also, participates in the ADB.
Night drive

The weather was fine, but maybe too many cars on the road with advantages and disadvantages.
The headlamp is equipped with three modules;
– The module which gives a flat light to have large light close the car
– The Picture Beam Monolithic Lighting based on a monolithic LED with 3 × 1,232 pixels to produce a high definition beam on the whole field
– the Picture Beam Monolithic Road Projection GEN1 based on a monolithic LED with 1,232 pixels to project elements on the road. The solid angle covered by this module roughly corresponds to the solid angle covered by a DMD module.
The first feeling, I never have had in all the former night drives with ADB, is that the Picture Beam is a real high beam. Only the opposing car is shadowed out.

The second important feeling is the perfect dynamic homogeneity. Dynamic homogeneity is a key element, to avoid to distract the attention of the driver. The full digital adjustment of each pixel intensity of the 4-kpx module allows perfect dynamic homogeneity in all situations. The glare-free area is finely vertically adjusted, so that there is no potentially disturbing projection of bright-dark contrast lines, and that the surrounding of the glare-free area is lit. This is only achievable with a high number of pixels. The dancing light I objected to in other lights I've assessed, is absent in this light.

What about the new assessed functions?
Few of them are interesting: among the several functions presented:
– One of the most important function made possible by HD Lighting is the Lane Marking or Construction lines which can be done either with positive or with negative contrast.

Different shapes are also available, with either stripes reproducing the road marking lines, or a complete “carpet” in front of the vehicle, or even “2D Lanes” with also transversal stripes, for example, to provide distance information.
This function was not useful in this night drive but I think it is one of the most important function about road marking

– The second interesting function is the projected arrow located at the exact location of the exit, with dynamic positioning upon the vehicle speed. This can be also used in advance, to help the driver to be positioned on the right lane, before a direction change on the motorway. In that case, a more simple message than an arrow, or a simple light movement, can be helpful. It can also be helpful to reduce the risk of confusion when the driver can use several directions: case of complex motorway exit or of many roundabouts.Other possibility for arrows are for example the replication of Turn Signal, with clear arrows.
– Projection of a sign

PEDESTRIAN MARK

NO PEDESTRIAN MARK

The sign on the road could alert the pedestrian of a potential danger. It could be a line on the ground, simulating a “do not cross line”, or a simple halo, or a flash on the lower body area of the pedestrian.
Safety distance projection
“When the vehicle is getting too close from the leading one, alert messages as simple as highlighted zones or a series of transversal light bars could be used. The setting of these bars, as well as the projection distance can be defined by the user, while their activation can be coupled with the front radar or lidar.
“Less important for me is the information are road signs display, after their reading thanks to the front lighting camera, or information coming from the vehicle, such as external temperature display, or risks of icy road.

They are also a direct redundancy to images which are usually set on the HUD, In the end, displaying these signs on the road is not suitable, should be and could be replaced by information on HUD,
This night drive shows not only the fantastic job done by the lighting industry these last 10 years since the arrival of LEDs, but more importantly the huge challenges in front of us about the resolution, resolution further than 30 m away to improve light and resolution from 0 to 30 m for road markings.

Several mainstream development directions of advanced ADB systems

ADB (Adaptive Driving Beam) is an intelligent anti-dazzling high beam system, which is mainly composed of high and low beam automatic switching of high beam and Adaptive Cut-Off technology. Compared with the AFS system, the ADB system adds more sensors, such as a camera. Through a more complete analysis of the road conditions ahead, ADB can provide better lighting effects without causing glare to other vehicles on the road. The system determines the illumination range, brightness, and angle of the lights based on information such as the environment, weather, roads, vehicle speed, traffic flow, and relative position with other vehicles.

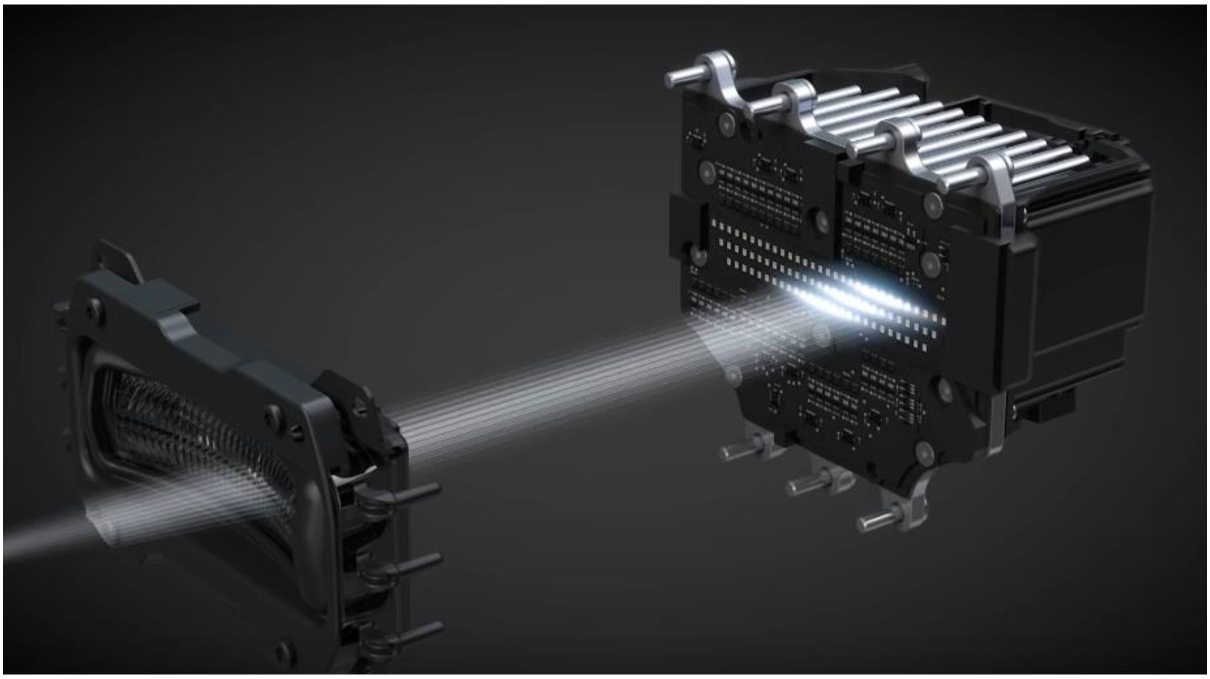
ADB application case example:

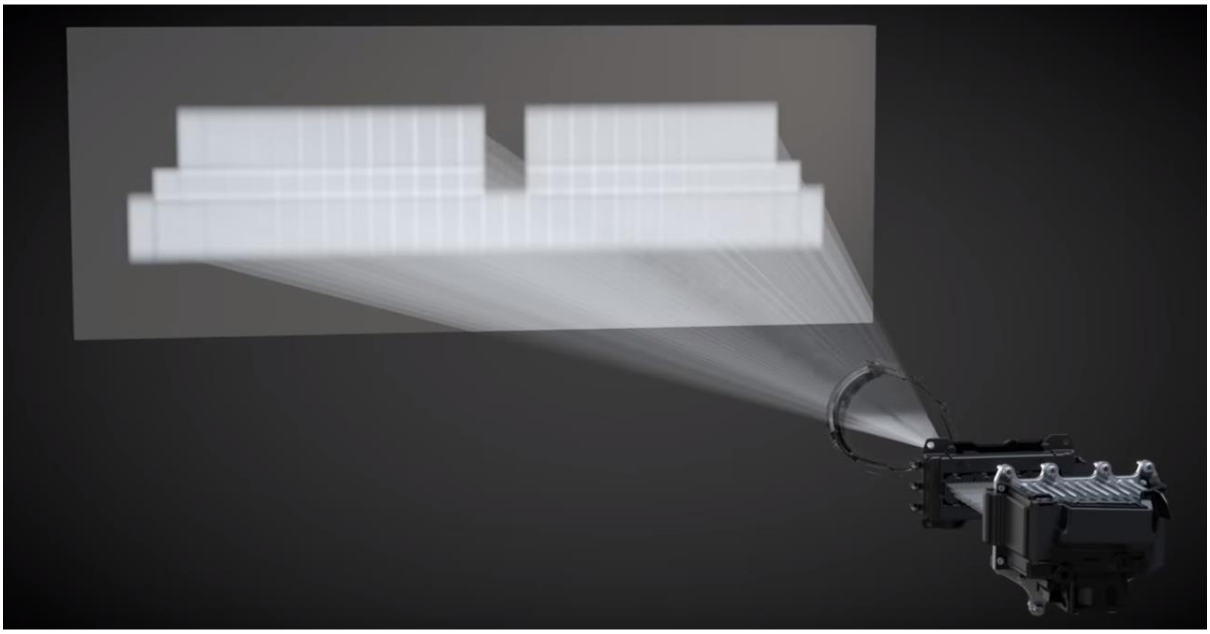
Early intelligent car lights were introduced by installing a rotatable baffle or stepper motor in the lampshade to control the horizontal movement of the light bulb to adjust the light irradiation area, and the movement of the horizontal light will give the driver of the car and the opposite driving The driver brings some troubles, and the customer experience is average. With the development of a multi-pixel LED system, each matrix is independently controlled by a driving computer and sensors to illuminate different areas. When there are no other vehicles on the road, the multi-pixel LED lights All LED lights will be lit, this time is the high beam. When there are other vehicles on the road, the control system turns off some of the LEDs according to the real-time road conditions, so that the dark area formed protects the drivers in other vehicles from glare interference, and the user experience is greatly improved. At present, there are four types of multi-pixel LED car headlights:

1. **Matrix LED**

LED lamp beads have the characteristics of small size and fast response. Use multiple LEDs to arrange them in a matrix and control them. With the use of multiple individually controllable (Individual Addressable), it is the easiest way to realize multi-pixel smart headlight Program. Compared with ordinary LED headlights, because matrix LED headlights use multiple LED lamp beads, they need more channels of driving. At the same time, each or several LED lamp beads must be equipped with light to make them independent pixel units. At present, many OEMs have used Matrix LED lights, and the relevant technology has also been relatively mature. The uncertainty of development is low and the cycle is relatively

short. However, limited by the size of the LED lamp beads, there is limited space for future pixel upgrades. Including the Valeo MXB module Gen2.0, what we introduced its optical design in the previous paragraph is based on this concept.
Matrix LED car light shows as following case





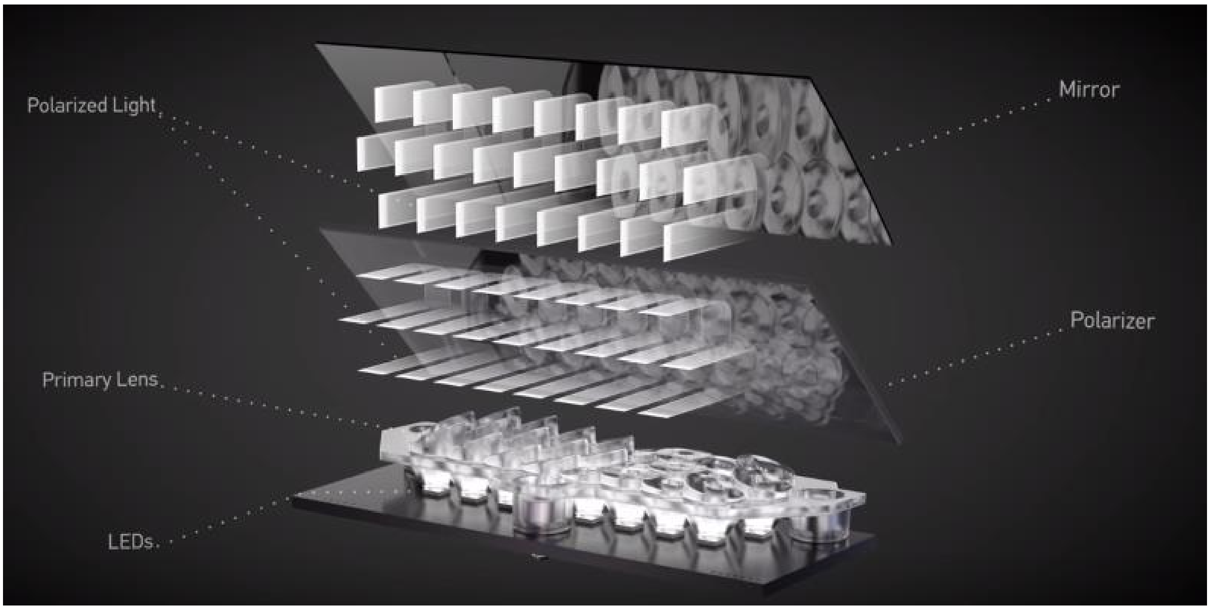
Representative enterprise: Hella, the “Matrix HD84 Headlight Module” shown by the company in 2017 contains a total of 84 LEDs, each of which is controlled by a separate chip, which can achieve a light intensity of 0-100%. The module can make different light distribution schemes according to different traffic conditions, weather conditions and road conditions. Once other vehicles enter the light distribution area of the headlights, this set of lights from Hella can choose to conceal the other vehicle dynamically. In the area, to prevent glare, when the user encounters a traffic sign or a slippery road, the light group will automatically reduce the brightness of the LED to avoid blurred vision of the user or the driver across the road. At present, Hella's light set has been equipped on the new generation Mercedes-Benz E-Class.

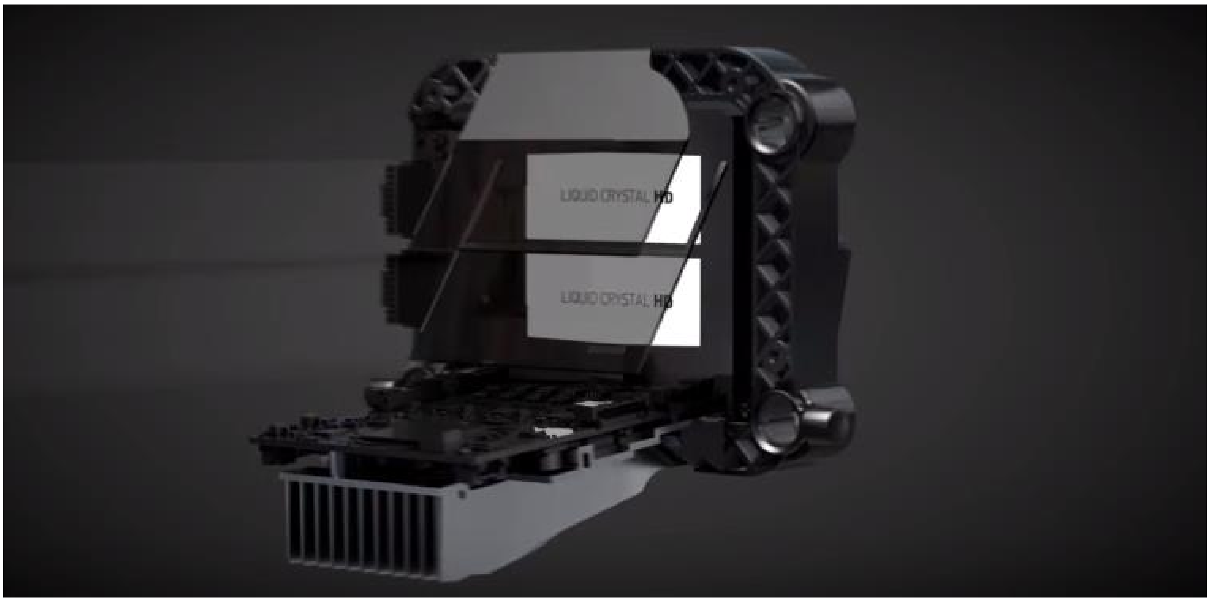
2. **LCD type**

As the demand for intelligent cars becomes higher and higher, the OEMs' requirements for the number of pixels of smart car headlights are gradually increasing. At the same time, the lighting functions of smart headlights are required to have both display functions. LCD (Liquid Crystal Display) is the most mature display technology, and its related drive and control technology industry chain is also quite mature, so LCD has naturally become one of the choices for the intelligent headlight light source control system. The LCD headlight system can send instructions to the LCD module through the control system, and finally send the direction and intensity of the pixel display to the front at a frequency of 60 times per second. Provides cars with high-resolution and clear imaging lighting and display experiences.

The current LCD-type headlights can achieve tens of thousands of pixels. LCD-type has the advantages of relatively low cost, relatively small size, wide light-type stretchable angle, and high light-dark contrast. Its main limitations are the loss of polarizers and liquid crystal panels, the optical and energy utilization efficiency of LCD headlights is relatively low, and the space for improvement is limited.

LCD + LED car light principle display



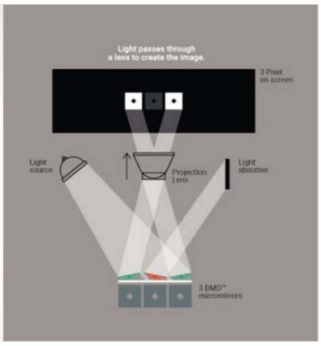


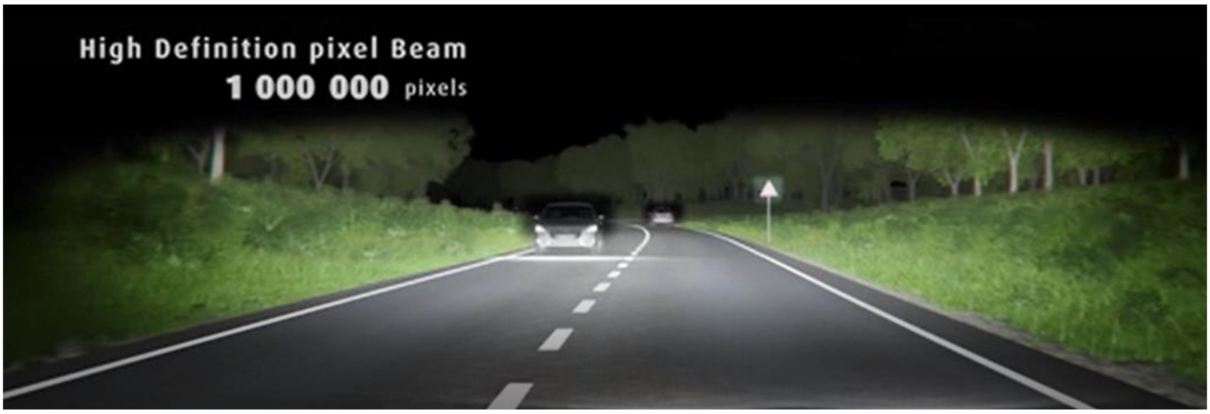
Representative companies: Hella, in 2017, Merck, Stuttgart University, Porsche, Elmos Semiconductor, Schweizer University of Paderborn, etc., developed an LCD-based headlight. LCD car light technology can be used in 30,000 pixels projected on the road, and its exposure range can be intelligently adjusted according to different road conditions. Moreover, it can rely on vehicle software to adjust its lighting mode. The driver can let the system find the best lighting effect for himself. In addition, when the system detects that there are reflectors or objects that can cause reflections, the headlights can avoid them or reduce the brightness in a targeted manner. Furthermore, it can also rely on GPS to project arrows in the direction of the road.

3. **DMD type**

Similar to the reasons for the development of LCD-type smart headlights, DLP technology (Digital Light Processing) based on DMD devices (Digital Micromirror Device) as the mainstream technology of current projection equipment has naturally become a multi-pixel smart Alternative technical route for lamp light source system.
Similar to current projection technologies, both LEDs and lasers can be used as light sources for DLP systems. The advantage of LED (Laser) + DLP is that the technology is relatively mature, and the main parameters such as brightness and efficiency are also good enough.

DMS + LED car light display





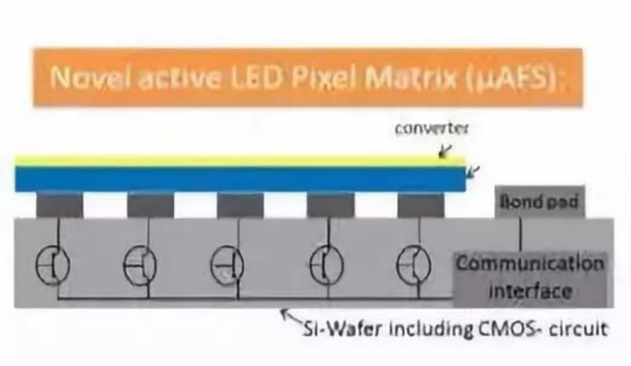
Representative companies: Valeo, first serial application is planned end of 2020.
A Valeo lighting system architecture has been developed to control this device:
The architecture can be easily interfaced with the vehicles' architecture as it is based on the standard CAN interface.
A dedicated electronics board was developed for this architecture (PCS board - Photometry Control System) which enables, thanks to the CAN signals generated by the hosting vehicle, to generate video flux in real time. This video flux is then sent to the DMD modules.
In addition to the HD function - which allows the beam to take whatever shape we want -, this opens up a lot of new perspectives for functions to increase comfort and safety, such as:
GPS information
Warning messages
Virtual lines to indicate where the vehicle is going....

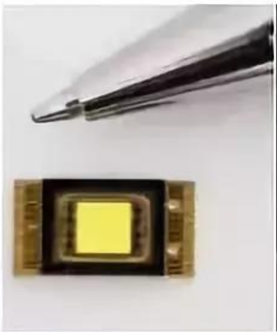
Functions:
The most important functions of the PictureBeam DMD are:
High definition, multi-spot glare-free high beam
Projection of information on the road (navigation information, pictograms, warnings in case of potential danger, etc.)
Improve the visibility of the car’s sensors
Draw the car's gauge on the road to facilitate travel when driving through construction areas or narrow road sections
Communicate with other road users
Project carmakers’ images or logos, creating a customized welcome scenario.

4. **Dot matrix LED (uAFS)**

uAFS is the abbreviation of Addressable LED Pixel Array, which is an LED headlight lighting technology specially developed for multi-pixel intelligent headlight systems. Traditional LED car lights just integrate multiple independent LED chips into one LED package device. After the external driver provides power, the entire chip lights up at the same time. (Independent

LED devices) LED devices are matrixed and controlled separately, but the number of lamp beads is relatively small. The uAFS car light is a matrix CMOS control circuit integrated in the silicon substrate of thousands of LED chips. In combination with the control chip, each chip can be individually switched and adjusted for brightness. Independently controllable pixels in the headlight type. The main advantages of uAFS are reflected in lower system cost, smaller system size, and high energy efficiency.

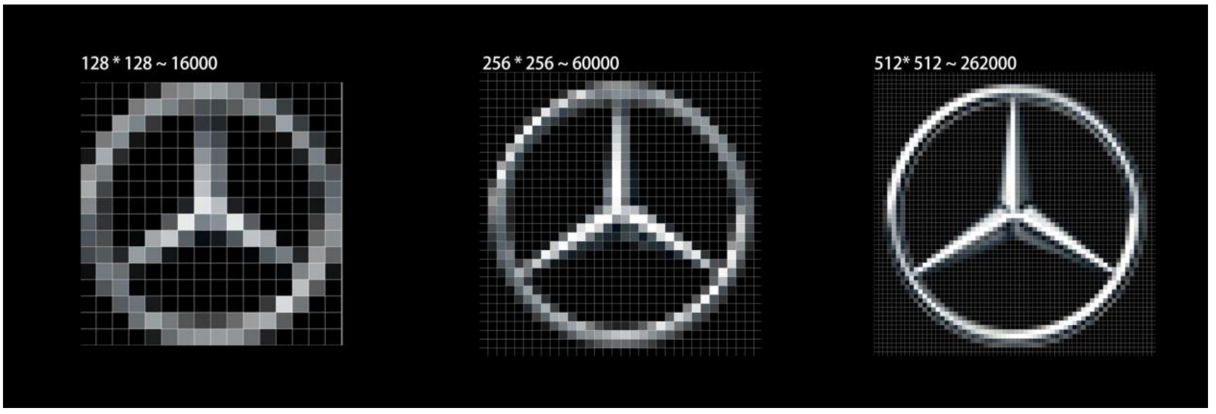




Representative companies: Osram and Hella, Osram, Daimler, Fraunhofer Association for the Promotion of Applied Research, Hella and Infineon form a research alliance funded by the German Federal Ministry of Education and Research (BMBF) for three and a half years, 2017 The headlight demonstration model was successfully developed in 1981 and field tests were completed. This vehicle light can realize the basic solution of intelligent high-resolution LED headlights. The solution includes three LED light sources per headlight, and each LED light source has 1024 individually controllable light points (pixels). The headlight can continuously analyze the car's driving conditions and weather conditions, road direction, car driving speed, whether there is a car coming in front, and the distance between the car and other vehicles, etc., and adjust it very accurately to ensure that it is always available. Optimal lighting conditions without dazzling other drivers. The project has been tested by Mercedes - Benz.

Write at the END

In the course of doing this research, Hale, one of Valeo's competitors, released SSL up to 30,000 pixels |. HD headlight technology, which will be officially mass-produced in 2022, so we don't have to think about “how much profit do car headlights need? As if the automotive headlight industry has no end to the competition for high projection projection headlights. Mercedes-Benz once did such a research. If we want to achieve complete V2V communication between vehicles and pedestrians in the era of digital headlights, how many pixels of projection-type headlights can meet the requirements and complete information transmission? The following three pictures are trying to clearly show the Mercedes logo in the projection headlight technology with different pixels. Because the icon information usually needs to be projected to the ground, the pixels of the entire module cannot be used to display the logo. In most cases, only limited pixels can be used to project limited information.

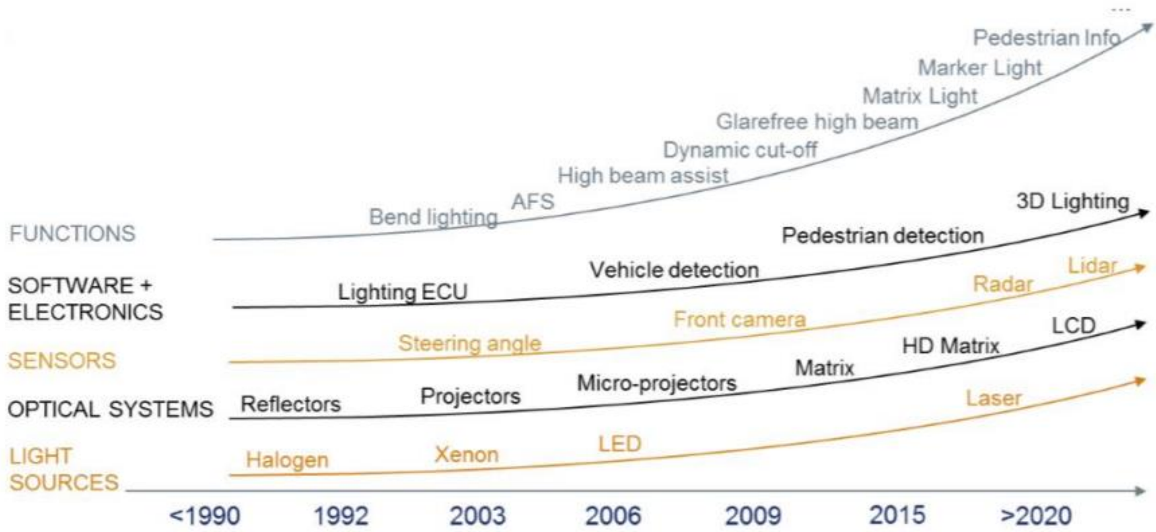


As the entire automotive lighting system continues to become higher and more complex, higher requirements are placed on the stability of the lighting system, as well as high requirements on the stability of the components themselves. In the traditional lighting industry, a lighting function only needs to control the turning on and off of a light source. If the function cannot work, the driver can also detect the failure of the function in time. At present, the failure of any LED in the LED headlight system or the failure of any chip in the driving power supply will cause the entire system to fail, thereby causing a traffic accident.

In the design of the intelligent headlight system, the redundant design of the circuit system and the accelerated rise of costs are the challenges that the entire industry will face. Purely commercial competition makes it easy for people to ignore the core function of the automotive lamp itself: safety. Increasing driving safety at night is always the most important mission of car lamps. The world's major automotive regulations require that they work hard to follow the development of new technologies and try to standardize and standardize recent technologies through reasonable technical standards. However, it is obvious that to test more than 300,000 luminous light sources in the traditional way, and to ensure that each pixel is completely consistent and reliable, this is almost an impossible task, in which 1 or 2 key pixels are disabled, and the projection On the actual road, it can usually reach a distance or width of 1 to 3 meters, which is likely to cause the driver to lose valuable braking distance or other reaction time to avoid risky operations.

In addition to continuously improving system design and production reliability, V2V communication technology can be used as a redundant design for such risks. Some manufacturers have considered the use of L2 level driverless technology image recognition camera sensors to detect and receive vehicle signals transmitted by high-frequency flicker of lamps, but they have not been successful. At present, the refresh frame rate of camera sensors used in image recognition is usually only 30 ～ 120fps, far from being able to interpret the strobe information of visible light. If you replace it with a specific light sensor (which can reach 1.5Ghz), you will find that if it encounters foggy weather or uncontrollable factors such as high temperature, the transmission of visible light information will be Becomes very unreliable. The access of 4G or 5G signals may become a possible direction to solve such problems. However, this is not the scope of the lighting industry to study.

Written at the end, I would like to emphasize here that I hope that the first-tier suppliers of the big automobile manufacturing industry will continue to introduce advanced technologies for the purpose of commercial profit and market competition, let alone "improve driving safety" It is always the core value of automotive lighting design.



(New technology road map for headlamp of vehicle)

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