ASIC Design Controlling Brightness Compensation for Full Color LED Vision

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Abstract: This paper describes ASIC design for brightness revision control, A LED Pixel Matrix (LPM) design and LPM in natural color LED vision. A designed chip has 256 levels of gradation correspond to each Red, Green, Blue LED pixel respectively, which have received 8bit image data. In order to maintain color uniformity by reducing the original rank error of LED, we adjusted the specific character value "a" and brightness revision value "b" to pixel unit, module unit and LED vision respectively by brightness characteristic function with "Y=aX+b". In this paper, if designed custom chip and brightness revision control method are applied to manufacturing of natural color LED vision, we can obtain good quality of image. Furthermore, it may decrease the cost for manufacturing LED vision or installing the plants.

Keyword: About 10 words. LED brightness compensation, ASIC design, LPM, LED vision

1. INTRODUCTION

In the information society, much of information data are emerged into multimedia environments; accordingly various kinds of information media are possible in recent year. Especially, there have been many research projects on display devices, which are most effective way to convey information data [1]. LED vision as an optical vision information media has many advantages to service various kind of data to many users under various environment [2]. LED vision is a kind of electronic board, many LEDs are properly arranged to use as public information or commercial advertisement by character, graphic and moving picture. Full color LED vision is consist of 3 LED devices displaying Red, Green, and Blue color into one LED pixel, and digital images are displayed by majority of LED pixels arranged as a matrix form, M×N resolution of image display is required M×N LED pixels [1].

In LED vision, equal of brightness from LED lamp is most important to make image clear and uniformly distributed [3]. In this case, we have to replace or rearrange the fault device. Generally, as a matter of fact one LED vision has hundreds and thousands of LED devices, it needs outrageous cost and time to prevent from reduce quality of displayed image.

Control of LED vision is displayed by properly conversion using VGA, video controller in PC, and output signal from VGA. Therefore, existing method has a complexity of wiring and because PWM (Pulse Width Modulation) method is applied to main control unit, when screen is wide, the board becomes more complex due to its increased devices and it is hard to assemble or disassemble. Also in order to expand brightness control levels to 65,536 levels, some kind of CPU and DSP chip are needed in main control unit for adopting PWM in spite of partial fault that is spending element. Therefore in the case of a defection of main control unit, entire display of image could be stopped.

Also, we developed brightness revision control system maintaining color uniformity by adjusting white balance. Generally, we revised brightness by calculating operating current of each pixel on the basis of characteristic curve of LED device when we named "a" as a specific characteristic value, "b" as a brightness revision value according to using time, "X" as a operating current value, and "Y" as brightness value. And to solve the reduction problem of brightness for long used LED devices, we increase entire mean of brightness value by adjusting "b" value from the brightness characteristic function.

2. NATURAL COLOR LED VISION SYSTEM

Figure 1 shows the organization of LED vision; each part is simply described as below.

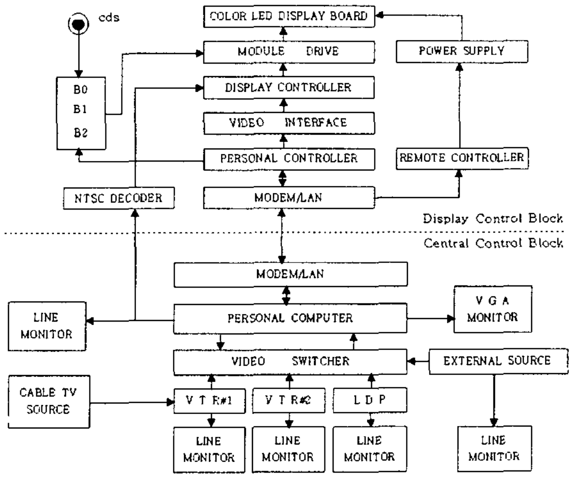

Fig. 1 Block diagram of full color-LED vision

2.1. Main Control Unit

Main Control Unit, centrally control PC, make display screen, control the contents and select and control display screen from the input signal in automatically or manually as a role of controller.

2.2. Display control unit

Display control unit has a role of control unit, which downloads various messages received from control PC of Main Control Unit to its own memory, and data is displayed by specific order like number, contents and time etc.

2.3. Operating Software

Operating Software is categorized as two kinds. Control PC of Main Control Unit is in charge of entire Operating System in vision system, and Control PC of Display control unit implement required function for operating vision.

3. WHITE BALANCE

Natural LED vision is generally consist of 16×16 Pixel Matrix, and operating driver is placed to display information data of image that is a LPM (LED Pixel Matrix) Module, then LPM modules are formed by matrix form. Even though the size of LPM module depends on the entire size it must contain 3 kinds of LED devices which have Red, Green, Blue color respectively. By adjusting the intensity of R, G, B color, we can see various color and we can take various color by combination of R, G, B color. A property of color is expressed as color, brightness and saturation.

However, in optical vision devices, brightness is most important and white balance is also important to express complementary color. It is accurate and against a natural color LPM module from the situation it will be able to express a white the each R, the G and B LED pixel to count and to input the video data of 8 bit are confront hereupon the gradation of 256 levels. In each pixel, 256 levels of gradation associated with R, G, B can finely adjust brightness of 16,777,216 levels and can display soft and uniform image. For the expression of white balance the ratio of red (R), green (G) and blue color (B) like showing in equation (3-1) must accomplish the balance [5].

$$Y = 0.30R + 0.59G + 0.11B \qquad (3\text{-}1)$$

In equation (3-1), Y means the brightness value with 1, which means white color. Generally, we display white color to construct R, G, B pixels of LPM modules and each resistance value will be adjusted to include white color on the color map. But it is difficult and expensive work that resistance value is measured by brightness measurement device for each pixel.

4. DESIGN OF LED PIXEL MATRIX MODULE

In natural color LED vision system, Color LED Display Board, Module Drive and Display Controller are consist of many pixels which are made of Red, Green, Blue LED device. We construct LED pixel matrix module by 16×16. Also, 8bit image data is input to each Red, Green, and Blue LED pixel so as to create 256 levels of gradation. Brightness can be adjustable as 16,777,216 levels by using combination of Red, Green, and Blue in each pixel with 256 levels of gradation. Finally, we describe natural color LED pixel matrix module to design as a customer chip, which is consisting of properly designed circuits. Figure 2 shows block diagram for full color-LED pixel-matrix modules and each blocks are described as following.

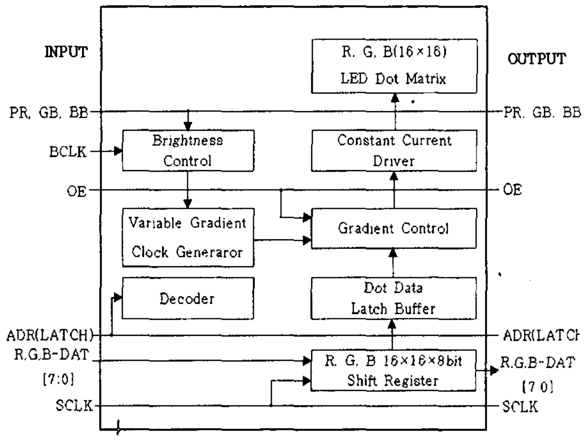

Fig. 2 Block diagram for full color-LED matrix modules

4.1. Shift Register

Shift Register receives 8 bit of Red, Green, Blue Image data in parallel then, sequentially shifts Image data by SCLK clock, and has output unit for shifted data which is transferred to next R, G, B-DAT.

4.2. Pixel data latch buffer

8 bit Image Data of each Red, Green, Blue generated from Shift Register decode ADR signal which has Address information, and these decoded signals are latched to Pixel Data Latch Buffer in each Column by using Clock signal.

4.3. Decoder

Decoder offers ACLK1□ACLK16, clock signals of Pixel Data Latch Buffer in each Column, to latch ADR(Latch) and decode input data.

4.4. Brightness Control

We specified the luminosity of R, G, and B as 8 stages and perceived surround luminosity using sensor, then by using these signal, we impress 3 bit to each RB, GB, and BB.

4.5. Variable Gradient Clock Generator

Variable Gradient Clock Generator received output variable Clock pulse in some period to be offered to Gradient Control by variable pulses which are PA0 has a 1 pulse, PA1 has 2 pulses and PA7 has 128 pulses. Figure 3 present an example for one of 8 stages.

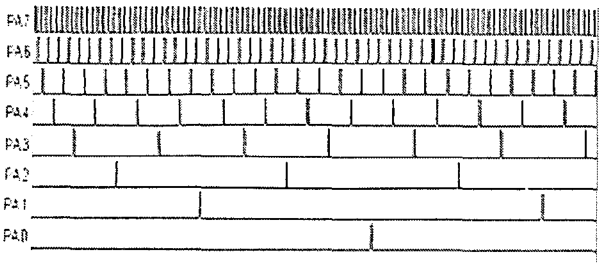

Fig. 3 Timing Chart Of Brightness Minute Control

4.6. Gradient Control

Gradient Control synthesizes latched 8 bit Image data of Red, Green, Blue in pixel Data Latch Buffer and PA0 PA7 pulses generated from Variable Gradient clock Generator when value of bit data is 0, there is no pulse and value of bit data is 255, there are 255 pulses. So there are 256 levels of brightness for each R, G, and B signal.

4.7. Constant Current Driver

Constant Current Driver controls variable pulse output in order to proper to each Red, Green, Blue LED characteristics of LED Pixel Matrix, which is correspond to 256 levels of brightness.

5. PROPOSED BRIGHTNESS COMPENSATION METHOD

LED devices have a problem, decreased quality of displaying image, due to original brightness error. Also, original brightness value can be decreased by characteristic of LED device. So each LED device has deviation of decreasing range.

To solve the above problem, we designed Display unit by using LED with similar rank then revise brightness using following method. Figure 4 shows characteristic curve of LED.

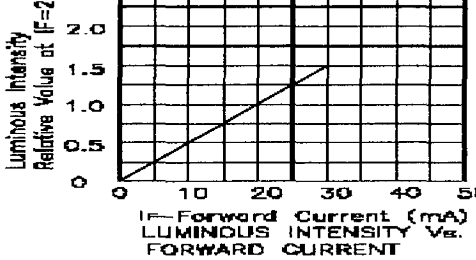

Fig. 4 Characteristics curve of LED

All LED have a common characteristic which is linear to variation of current value. Because characteristic curve of LED has a equation "Y=aX+b", when "a" is original characteristic value, "b" is brightness revision value for time, "X" is operating current value, and "Y" is brightness value, operating current value can be estimated by brightness characteristic function. In order to complete above method, we take each Red, Green, Blue of LED vision using Digital Camera, and make brightness data by using image processing algorithm, and revise error of each pixel using average brightness to estimate operating current value. Using calculated value, we process adjustment of color, brightness of image data in step by step. In figure 5, It is possible to revise error range of LED rank to zero using fine adjustment from -128 to +128 levels which are correspond to 8 bit R, G, B image data.

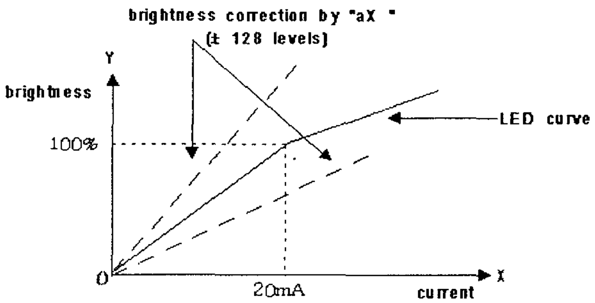

Fig. 5 Brightness compensate for LED apply to "a"

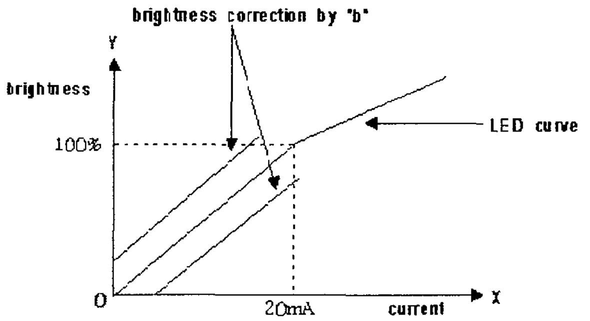

Fig. 6 Brightness compensate for LED apply to "b"

In figure 6, As we use LED vision for long term, in order to solve the problem of decreasing LED brightness, we design the logic using brightness revision value "b". Image data from graphic card operate with R, G, and B data for Logic design. And reduced brightness data can be revised by using high bit of R, G, and B Data which characteristic function of LED is shifted in parallel.

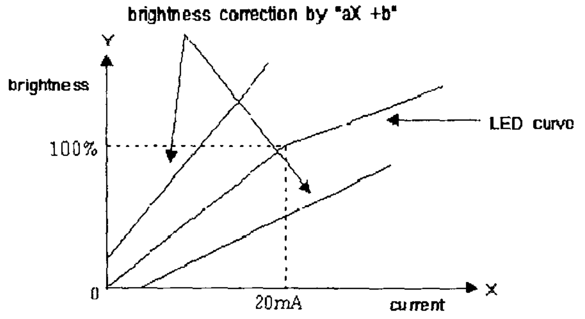

Fig. 7 Brightness compensate for LED apply to "aX+b"

Figure 7 shows that original characteristic value "a" properly calculated for characteristic curve to maintain White Balance close to zero, by using "b", brightness revision value for using time, we can compensate reduced revision value to maintain first state for some interval by variable highest bit of each R, G, B data.

Figure 8 shows brightness revision controller in LED vision.

Figure 8 is consist of digital camera which take image data from LED vision, connecter which connect physically and electrically, operating data storage unit and image processing units which adjust color and brightness of image data, and Control unit which update operating data.

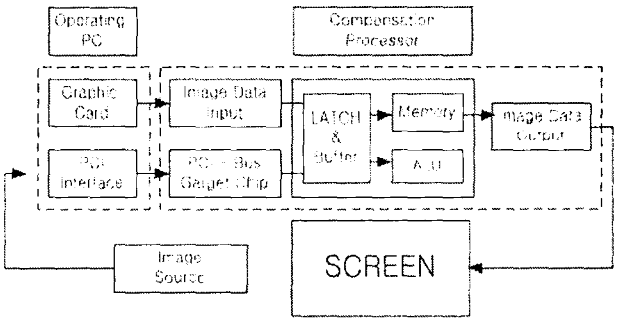

Fig. 8 Block diagram of brightness compensation control system

Figure 9 shows slot type brightness revision control system. this control system implemented under MAX+PLUS II version 10.1 using ALTERA FLEX10K10TC144-3, and PCB is produced by using Lay out Plus of OR-CAD corp.

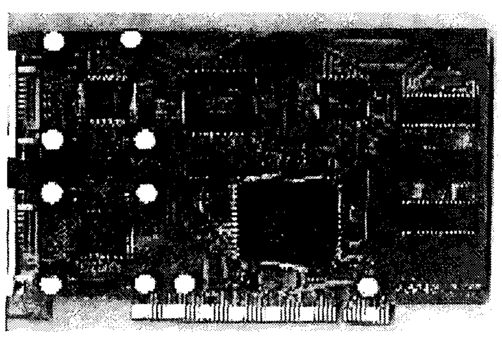

Fig. 9 Proposed brightness compensation control system

6. COLOR CONTROL ASIC DESIGN AND ANALYSIS OF FEATURE

6.1. Circuit design for color control system

The circuit of proposed color control system is simulated and designed under MAX+PLUS II 9.5 of ALTERA using primitive cell to modify circuit. Figure 10 shows output signal from the simulation.

In Figure 11, we verified that conversion control pulse as shown in figure 3 generate different pulse that PA0 has generated a 1 pulse, PA1 has generated 2 pluses and PA7 has generated 128 pulses. From the simulation result, we confirmed that shift resister and data register are properly operated for Red, Green, Blue input.

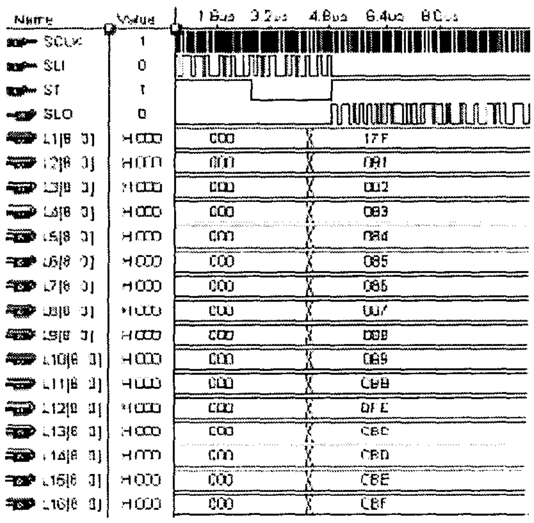

Fig. 10 Simulation result for shift register/pixel data

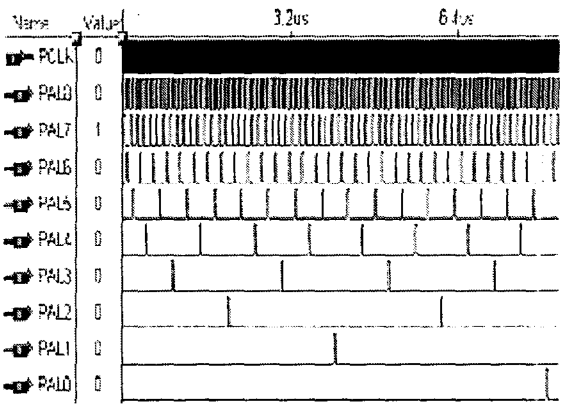

Fig. 11 Simulation result for PWM generator latch buffer.

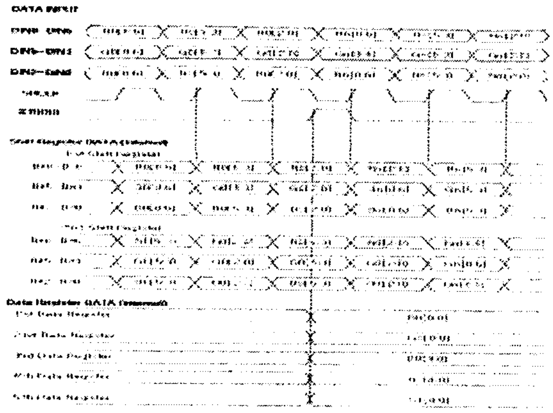

Fig. 12 Timing diagram of Input signal

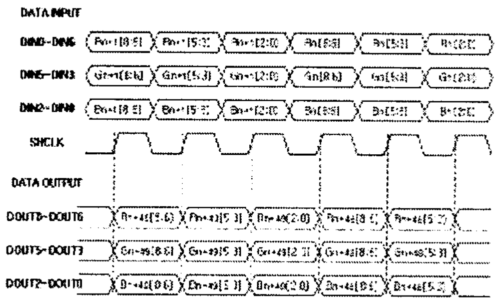

Fig. 13 Timing diagram of Output signal

6.2. Design Process

ASIC design is implemented under 0.25μm process, that process is possible between 5V to 3.3V in core, external interface is possible to 5V, layout verification is considered by DRC process which verify design rule and LVS which is compare schematic and layout. We used GDS layout data format, physical verification tool Dracula DRC & LVS and 23 Layers of Mask Layers.

We used Virtuoso Layout for layout and Composer Schematic Editor for schematic produced by CADENCE, this tool makes I.C design procedure from front-end to back-end possible, also able to design and develop under framework environment.

For simulation, Avant which is consist of Hspice simulator and waves is used, and all Layout simulation is processed under Solaris from Sun Enterprise 3500 with 336MHz 2CPU and 512Mbyte of memory.

7. DESIGN VERIFICATION AND SIMULATION RESULT

It needs more time and cost to implement by H/W, there is long period to design a chip. Therefore, S/W simulation is necessary before implementing H/W. The verification of circuit design, firstly, we have to verify how correspond to simulation result and modify the circuit.

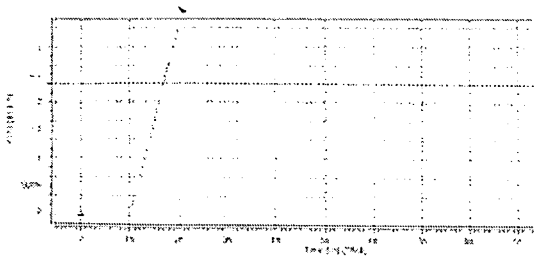

Fig.14 Operation characteristic of CMOS NOT gate

Most circuit is consist of analog device which made of constant current, and In digital part, 2 input, 3 input, 4input, 6input, 8input, 9input of AND, 2 input, 3input of OR, 2input 4input of NAND, and NOT cell, after designing basic cell, we implemented in a block by block. Basic cell have to operate precisely for high and low operation, figure 14, 15 show Hspice Simulation result of NOT gate, one of the basic gates, and PWM Generator.

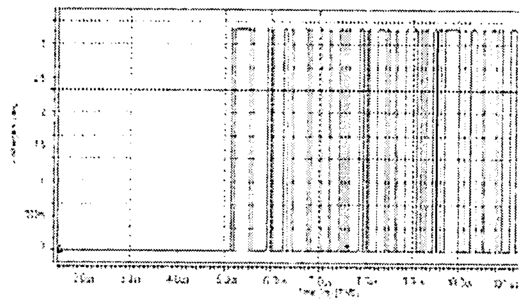

Fig. 15 Result of PWM Generator Simulation

In verification step, we simulated cell-by-cell and synthesized each cell to make entire cell, all cells must have no error in verification step. As shown in figure 14, 15, each cells show the result of proper operation in timing margin, drive cells are added to each output device to consider fan out, overall CMOS devices are 35,000.

Figure 16 shows layout plot of entire cell, figure 17 and 18 show top structure of layout and layout of output LED driver respectively.

Arrangement of entire layout is arranged by direction of outside output Pin as shown in figure 17, in figure 18, output device of LED Driver is made of Op-Amp by using current source.

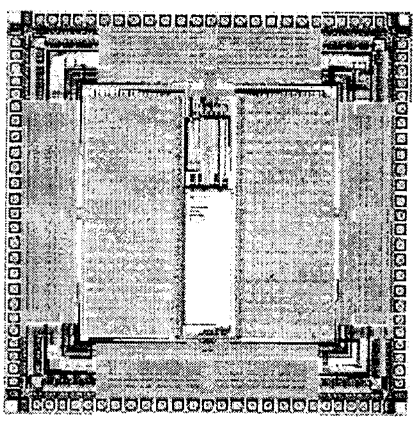

Fig. 16 Total Layout plot

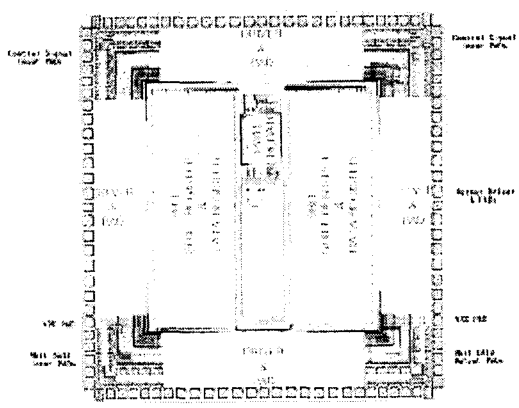

Fig. 17 Top Layout Structure

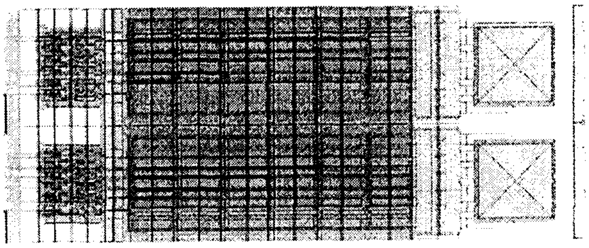

Fig. 18 LED driver output Structure

8. CONCLUSION

The ASIC chip for LPM brightness compensation control has its own characteristics as follow.

1. Image data and address information is input to operate LPM, output of module is connected to next input and so it is available to real-time processing, simple wiring, also assemble and disassemble is very simple.
2. 8 bit of R, G, and B data is input for each pixel of LPM, and use 256 levels of gradation control methods. Therefore, 16,777,216 levels of brightness can be adjustable. Also each pixel is designed to operate independently. In comparison with pixel dependent method, it is more improved that has high quality of image data by maintaining high brightness.
3. Displaying image data is automatically converted with next display image data input.
4. There is no vibration and decreasing efficiency due to duty cycle.
5. Entire adjustment of brightness is possible by 8 levels.
6. By adopting DSP chip, it needs less cost and time to product and install image display device using module
7. It is possible to process in real-time by using simple logic except using CPU or DSP for PWM operation.
8. Custom chip is used for variable size of module without adding circuit.
9. Minimization, improvement of confidence and reducing the cost of image display device of module can be done.
10. Images are displayed uniformly and softly without different color.
11. Production period can be reduced for longtime test and replacing parts of LED vision in the manufacturing step.

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