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Full screen LCD display module based on Mini LED

Qingfu Xu
Guangxi Normal University, Guilin, 541004, China
xqf2525@126.com

Abstract

In recent years, Mini LED products have developed rapidly, and enterprises have invested heavily in the construction of production lines. Mini LED technology is a brand-new display technology that upgrades traditional LCD screens, effectively improving contrast and enhancing visual expression. A full screen LCD display module based on Mini LED uses FPGA of Alter cyclone 10 as the main control to decode the video signal. Simultaneously, STM32 is the CPU of the backlight drive controller to control the drive of the backlight. Then, through the corresponding backlight control algorithm and local dimming technology, the module achieves high contrast, low power consumption and high dynamic range imaging (HDR). The test results show that the full screen LCD display module based on Mini LED has the characteristics of high resolution, high contrast, low power consumption and high cost-effectiveness, with the input of HDMI and DP signals. It has the unique advantages of Mini LED products and high cost-effectiveness.

Keywords

Mini LED; Local dimming; FPGA; STM32.

1. Introduction

In recent years, the country and relevant units have successively introduced new policies to support and promote the development of 8K ultra-high definition, Mini/Micro LED [1], and naked-eye 3D display industries. Chinese companies such as BOE, Huaxing, Hongli Smart, Ruifeng Optoelectronics, Guoxing Optoelectronics, and Longli Technology have invested heavily in the construction of multiple Mini LED production lines. However, due to China's immature technology mastery and late investment in Mini LED products, the production capacity has not yet been fully unleashed.

Mini LED technology is a new display technology, which can be regarded as an upgraded version of the traditional LCD screen, mainly to effectively improve contrast and enhance image expression. Unlike OLED self-illuminating screens, Mini LED technology requires LED backlight as a support to display images. Traditional LCD screens are equipped with LED backlights, but ordinary LCD screen backlights often only support unified adjustment, and cannot individually adjust the brightness of a certain area. Even for a small number of LCD screens that support backlight partition adjustment, the number of backlight partitions is still very limited. Mini LED technology can make LED backlight beads very small, allowing for the integration of more backlight beads on the same screen, thus dividing them into more detailed backlight partitions. This is an important difference between Mini LED technology and traditional LCD screens.

With the support of Mini LED technology, the screen has multiple backlight partitions, which can individually control the brightness of a small area of the screen, so that the bright area is bright enough, and the dark area is dark, and the limitation of picture performance is smaller. When a certain part of the screen needs to display black, you can dim or even turn off the small backlight partition in this part to obtain more pure black and greatly improve the contrast,

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which cannot be achieved by ordinary LCD screens. With the support of Mini LED technology, it can have a contrast close to that of an OLED screen.

2. Mini LED module hardware structure

Mini-based The LED full-screen liquid crystal display module uses Mini LED backlight instead of traditional backlight, which can achieve high saturation with quantum dot film [2] or fluorescent film, and has the characteristics of thin thickness.

The full screen LCD display module based on Mini LED adopts Mini LED backlight instead of traditional backlight, and can achieve high saturation with fluorescent film. Thus, the module has the characteristics of thin thickness. The structure of the Mini LED backlight module is shown in Figure 1.

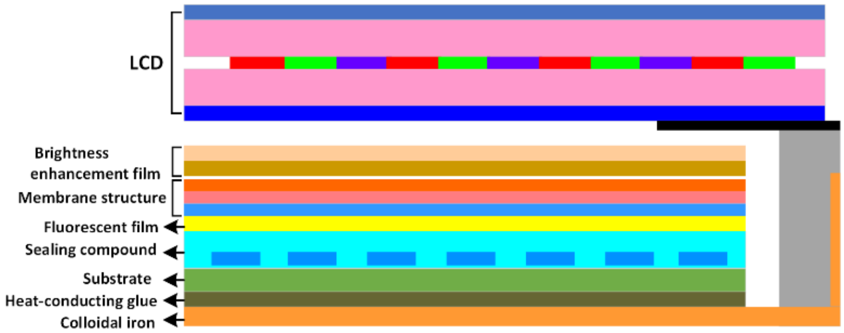

Figure 1: Structure diagram of Mini LED backlight module

The full screen LCD display module based on Mini LED adopts local dimming technology [3,4] to achieve high contrast, low power consumption, and high dynamic range imaging (HDR). As shown in Figure 2, both LCD and Mini LED screens need to display a "circle". Traditional LCD screen (Figure 2(b)) is usually side-lit backlights [5] and can only be fully lit as a whole. On the other hand, The Mini LED screen (Figure 2(a)), due to its numerous backlight partitions, can be independently controlled by simply turning on the backlight in the display area.

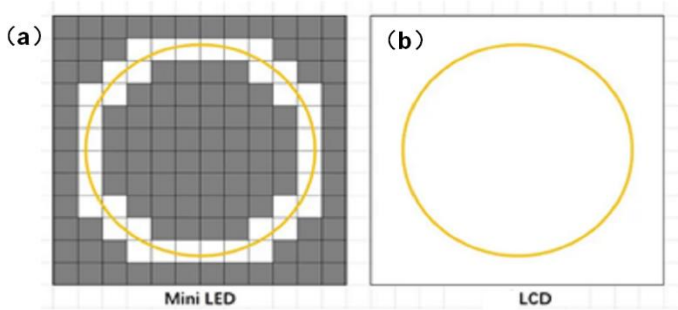

Figure 2: Two screen display methods (a) Local dimming of Mini LED and (b) fully lit of LCD

The full screen LCD display module based on Mini LED adopts a design that separates the lamp beads and the driving circuit. The interfaces of the Mini LED backlight are individually led out for driving control. The structure of the backlight driver is shown in Figure 3, which is simple and easy to implement.

The full screen LCD display module based on Mini LED supports DP and HDMI inputs, so it is necessary to analyze the input video, decode the DP and HDMI input signals, output LVDS/EDP, RGB signals, and output them to the full screen display. Decoding hardware block diagram is shown as Figure 4.

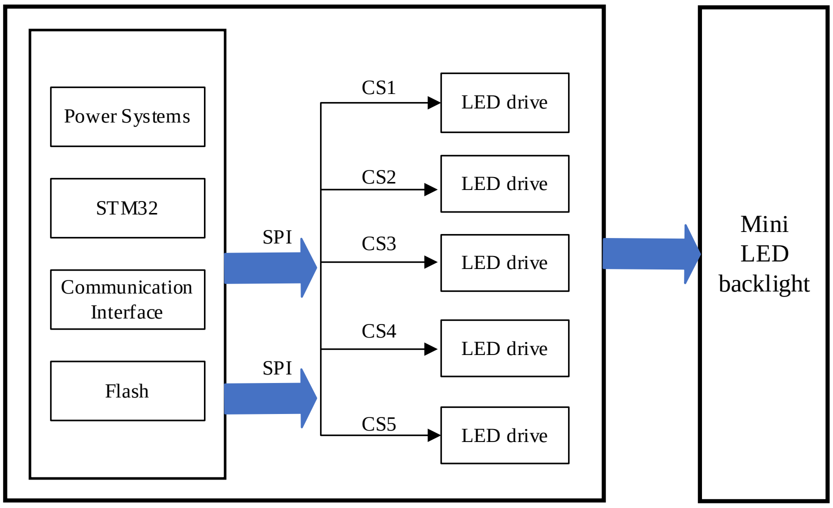

Figure 3: Backlight driver scheme

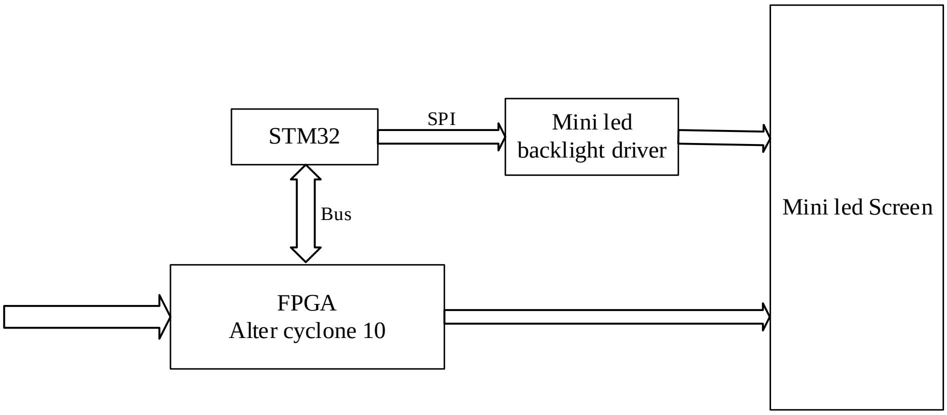

Figure 4: Decoding hardware block diagram

The full screen LCD display module based on Mini LED adopts FPGA of Alter cyclone 10 as the main control, which has a high main frequency and can achieve 2K frequency division resolution, supporting dynamic image decoding output. FPGA paired with fast DDR3 meets the requirements of RGB control algorithm. And the STM32 microcontroller serves as an auxiliary control to complete LED backlight driving control.

3. The software algorithm of the display module

The software core of the display module is mainly the backlight control algorithm and the resolution adjustment algorithm.

3.1. Backlight control algorithm

First, the corresponding relationship between the brightness of RGB image and LED brightness is established, and the light diffusion function is used as the weight of the value range of backlit LED brightness. Then, the weight of different LED luminous intensity levels in the luminance radiation region of LED is accumulated, and the largest weight is taken as the brightness of the backlight LED. Finally, the LCD display image is calculated using the LED backlight diffusion image and RGB image of LCD generated according to the LED brightness. After the LED brightness matrix is obtained, the LED backlight module is driven, and the backlight diffuses the image behind the LCD panel. Among them, generating LCD panel images can be divided into two steps. The first step is to generate a backlight brightness image using LED brightness; The second step is to generate LCD panel images.

3.2. Resolution adjustment algorithm

In order to generate LCD panel images, it is necessary to adjust the resolution of the LED backlight brightness map and the LC panel display image to be consistent. Based on the optical characteristics of the LED backlight module, a point spread function (PSF) for backlight LED is established, and the LED brightness array is extended to a backlight brightness map that is consistent with the resolution of the LC panel using the PSF. For different displays, it is necessary to model based on the backlight optical characteristics of the display to obtain the backlight brightness corresponding to each pixel on the LC panel.

The LCD resolution of the display used in the experiment is 1920 * 3840, and there are 36 * 66 backlight units in total. On average, each LED corresponds to about 60 * 60 pixels. Use luminance meter of Konica-Minolta CS-150 to measure the brightness both a single LED and the corresponding area around the LED. After normalization adjustment, the actual measurement of 7 * 7 light diffusion matrix C is obtained. The 36 * 66 LED brightness matrix L is enlarged twice and then convolved with the matrix C, and this step is repeated 5 times to obtain a 1152 * 2112 resolution brightness map. Finally, use the bilateral linear interpolation method to enlarge the matrix L to the same size as the LCD panel resolution with 4K.

4. Conclusion

The test results show that the full screen display module based on Mini LED can meet the input of HDMI and DP signals, reaching 2K display resolution. Mini LED display modules have unique product advantages and cost-effectiveness. Their production will drive the integration of high-end new display industry chain resources, and promote industry transformation and upgrading. It is applied to ultra-high definition and ultra-fine pitch Mini LED display products.

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