A High Contrast Digital Driving 0.39 inch LCoS Panel Optimized for Waveguide AR Glass

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ABSTRACT

A high contrast 0.39 inch 1080p Liquid Crystal on Silicon panel with digital driving is introduced in this paper. A waveguide light engine is assembled with this panel. The experiment shows that the contrast is 1200:1 and the power consumption is less than 300 mW, which indicates that the panel is good for AR applications.
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1 INTRODUCTION

LCoS has been used in augmented reality glasses. This technology combines the matured CMOS manufacturing technology and Liquid Crystal Display panels, and provides a relatively good perfromance and cost effective micro-display option for AR glass. The current AR glassesare often based on bulky freeform or off-axis light engines, which has medium light efficiency. However, a light engines with thinner waveguide are preferred for AR consumer market. The challenges for waveguide light engines are remaining high contrast and efficiency after a more than 90% light loss.

1.1 General Specification Requirements of LCoS

There are several specifications for LCoS design should be concerned to optimizing the contrast and efficiency.

First is the resolution and pixel pitch. Now the prevalent resolution of LCoS are 720p and 1080p, which is sufficient for general use. And the corresponding pixel pitch are around 3um to 6um. The resolution should accommodate the common video resources. And the smaller pixel pitch is normally preferred to avoid screen door effect. The form factor of the light module is affected by the final active area. The performance of LCoS is characterized by the reflectivity and the contrast. To compensate for the light loss of the waveguide light engine, the contrast of LCoS panels should be much larger than before.

1.2 Analog Driving and Digital Driving

There are two methods for LCoS pixel driving. One is based on analog signals, which means the pixels is drived by analog voltages after DAC gamma. The scheme of analog circuit is shown in Fig.1[1]. The other one is based on digital signals, such as PWM or PCM. The circuit scheme is shown in Fig. 2[2]. Both are with extensively used.

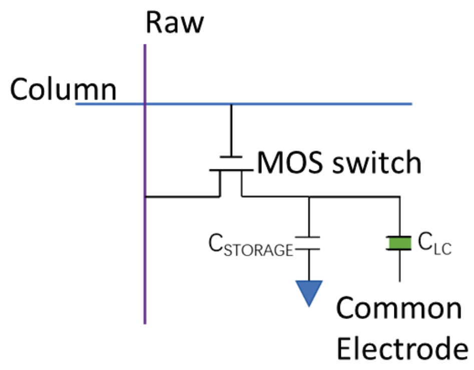

Fig. 1 Analog driving of pixel

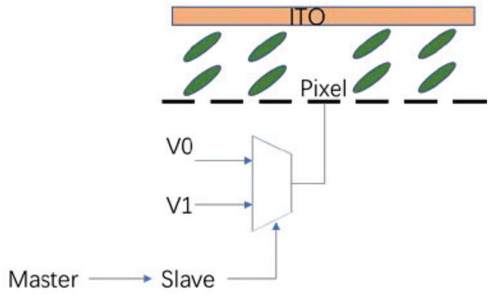

Fig. 2 Digital driving of pixel

For the analog driving method, a storage capacitor with larger capacity is normally used, which makes the pixel pitch hard to be smaller. But the system design is relatively simple. The DAC driving algorithm is transform the RGB signals to a three frame driving voltages [3]. For digital driving method, the pixel pitch could be much smaller which is good for the panel form factor. But the driving algorithm could be complex, because the gray scale has to be calculated and verified by a pulse numbers.

2 DESIGN OF THE PANEL AND SYSTEM

Our AR system includes a 1080p 0.39 inch LCoS panel, a driving board and a waveguide light engine. This paper focus on the LCoS panel design, and the light engine is bought from the market.

2.1 The Silicon Backplane

A 0.18um CMOS technology is adopted for LCoS design. Digital driving method is used, the pixel pitch is

4.5um. The digital driving could also resolve the Vcom drift problem in analog driving panels[4]. LVDS is used for high frequency signal transferring I/O.

2.2 The Driving Board

The digital driving algorithm is realized by an FPGA. Pulse width modulation method is exploited. The equivalent voltage on the pixel is defined as [1]:

$$V_{RMS} = \sqrt{\frac{\Sigma_0^N V_n t_n}{\Sigma_0^n t_n}}$$

Although the Vrms is a simple calculation, and different algorithm could cause quite different display results because of the fringe field effect, slow response time and nonlinear Electric-Optics conversion characteristic of liquid crystal. Each sub-frame should be carefully organized to get smooth and linear gray scale [5]. The pixel design should consider the possible expansion of data amount caused by algorithm and should be optimized.

2.3 The Optic Engine

The Optic Engine bought from the market is a reflective geometric waveguide light engine, which has a high efficiency comparing with the diffractive and holographic waveguide.

3 RESULTS

To verify the display performance of the panel, a waveguide light module is assembled. Photo No.IHFCB01_1920*1080 of FLAT PANEL DISPLAY MEASUREMENTS STANDARD Version 2.0(FPDM2) is used for testing. Fig. 3 shows the photo of the light module. Fig. 4 is the captured images displayed by AR glasses. The measured contrast is around 1200:1 without light engine, and around 40:1 with the light engine.

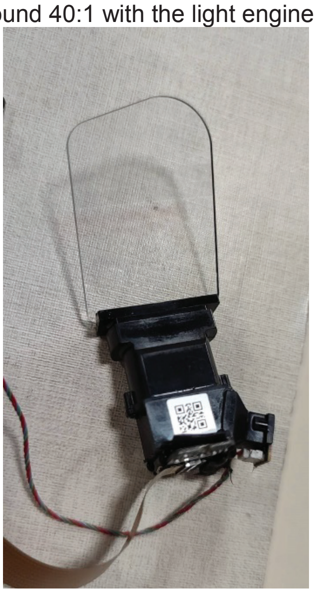

Fig. 3 The light module with the 0.39' panel and the waveguide light engine

Fig. 4 The display performance

4 CONCLUSION

The display performance of a 0.39 inch 1080p LCoS panel is shown in this paper. The digital driving algorithm is realized with an FPGA, which would be further integrated as an ASIC. The experimental result shows that the LCoS panel suits the AR application with less than 300mW power consumption.

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