On The Development of the Color Sequential LCD

Chia-Lin Liu*, Masaya Okita*, Chi-Fang Huang**, Chi-Neng Mo*, Wen-Chih Tai*,
Kuang-Lang Chen*

Central Research Institute, Chunghwa Picture Tubes, Ltd.*
Institute of Communication Engineering, Tatung University**,
1127, Hopin Rd., Padeh City, Taoyuan, Taiwan, 334
E-mail: liujl@cptt.com.tw Tel. +886-3-3675151 Fax. +886-3-3773159

Abstract

Color sequential display is a well known technology. However, due to the slow response time of LC, the CSD has not been used in LCD. We have developed a unique LC color display, which can improve LC response time, improve the driving system, improve the gamma drive issue and increase the color gamut to more than NTSC120%. It also can get very low power consumption merit.

Keywords: color sequential, LCD, LED, Driving

1. Introduction

Color sequential display was originally developed by CBS Labs. for CRT type display. The structure is shown in Figure 1. However, due to the need of bulky mechanical color wheel, it was not adopted for consumer application.

Not until 1977, TI company has successfully developed the consumer CSD used in DLP DMD chip for projection display. DMD chip and DLP is shown in Figure 2 and Figure 3. Using DLP technology, CSD can be comfortable accepted by human eyes and promote in the market. The method transfer from the DLP technology to LCD. The difference is LCD has no color wheel and LC response time is not fast like DMD chip.

However when CSD is used in LC display, due to the slow LC response time, it causes the color break-up effect. Many design efforts have been tried, such as; RGBG, RGBW, RGBD etc.

Figure 1: Baird double color (R, B-G) display system

Figure 2: DMD chip

Figure 3: DLP display through Color Filter wheel to show image

CPT is successful to change liquid crystal, cell gap,
2. Color sequential system in LCD

To build like fast DLP color wheel system in LCD, it needs fast drive ability in LCD. Shown in Figure 4, CPT has success built 15.4” LCD [3] which can drive more than 240Hz.

![Figure 4. 15.4”LCD Panel structure](image)

Due to LC response time is not enough; therefore design the lower cell gap to speed up LC response time also it depend on lower PS height. In 15.4”, it can arrive Ton+Toff less than 2.5ms. The Figure 5 show TFT cell structure.

![Figure 5. TFT cell gap structure](image)

3. To reduce color sequential side-effect

In fast LCD panel, can easily to arrive more than 240Hz. Many driving skill be used in CSD system such as RGBW, RGBD, RGBG [4]. It shows as following Table 1.

<table>
<thead>
<tr>
<th></th>
<th>RGB</th>
<th>RGBW</th>
<th>RGBD</th>
<th>RGBG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color breakup reduction</td>
<td>Worse</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Power consumption</td>
<td>Good</td>
<td>Worse</td>
<td>Worse</td>
<td>Normal</td>
</tr>
<tr>
<td>Design perplexity</td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
</tbody>
</table>

Table 1. compare RGB, RGBW, RGBD, RGBG

Another side-effect of CSD was gamma issue. White LED does not equal to Red + Green + Blue in different gray level cause by LC response is very slow. Therefore by use black frame insertion can let W equal to R+G+B.

<table>
<thead>
<tr>
<th>Delay Time</th>
<th>NBFI RGB Ratio</th>
<th>BFI RGB Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.4ms</td>
<td>70.43%</td>
<td>100%</td>
</tr>
<tr>
<td>-0.7ms</td>
<td>84.59%</td>
<td>100%</td>
</tr>
<tr>
<td>0</td>
<td>78.81%</td>
<td>100%</td>
</tr>
<tr>
<td>0.7ms</td>
<td>60.12%</td>
<td>100%</td>
</tr>
<tr>
<td>1.4ms</td>
<td>55.66%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2. compare NBFI (No Black frame insertion) and BFI (Black frame insertion)

4. Color sequential merit in product
Using color sequential can simplify color filter process shown in Figure 6. In the next step, to remove BM to Array process. CF process request just only simple ITO glass in CSD system.

Figure 7 show it was easy to get color gamut more than NTSC120% depend on pure LED.

CSD system also a power saving system. In normal use, it can saving up to 6W than traditional R, G, B LED backlight system in 15.4"LCD Panel. CSD system also can supply micro mode just only require 1W in 15.4"LCD Panel. Figure 8 shows under sunlight and backlight off picture quality.

5. Conclusion

It is quite challenging to apply CSD in LC display. We still have some unsettled human vision issues need to be resolved. In this paper, we have built a fast response panel and fixed some side-effects. It gives some distinguished merits to the 15.4"color sequential LCD product.

6. Reference

[1] U.S.Patent 1,691,324