Adaptive Functions in Timing Controller for 8K4K High Resolution and Large Size Panel Application

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ABSTRACT

Many panel makers keep committed to manufacture 8K4K LCD panel in recent years. There are some panel issues accompanying by higher resolution and larger panel size, like source driver ability and side viewing color shift (especially in the VA type panel). We propose the adaptive functions to improve the image quality for high resolution and large size panel in Timing Controller (T-CON).

1. INTRODUCTION

The 8K4K LCD panel demand is increasing since these years. Worldwide panel makers successively release 8K4K panel to meet consumer requirement. But accompanying larger panel size and higher resolution, there naturally suffers some corresponding issues. The first is, source driving ability insufficiency due to panel architecture like 1D1G flip pixel or 2G1D, the sub pixel data charge level affected by previous sub pixel at the same source driver and different panel area loading that lead to color inaccuracy. The larger panel side viewing color shift is the second problem especially in the VA type LCD. The 8 domain VA is more helpful to improve wide viewing color shift than 4 domain VA but decrease the panel transparency. The 4 domain VA with digital color shift technology is the suitable way to improve wide viewing color shift meanwhile maintain panel transparency. As following we will introduce corresponding functions: a. Spatial Over Drive (Spatial OD) to compensate source driver ability, b. Digital Low Color Shift (DLCS) to improve wide viewing angle color shift.

2. Function Description

2.1 Spatial Over Drive

The resolution of 8K4K panel is twice of 4k2K panel at horizontal and vertical direction separately. In 8K4K resolution panel the gate driver charging time is shorter than 4K2K resolution panel at the same frame rate, therefore source driving ability should be corresponding higher than 4K2K resolution. Unfortunately, there still exists insufficient driving ability even charging time optimization as Figure 1 expression.

In the figure 1 the panel driving structure is 1D1G flip pixel. There exists different spatial performance in the figure 1. The Point A is the near source driver position, and the Point B is the far away source driver position. The driving ability is decayed at Point B due to panel loading, leads to the driving voltage waveform distorted. The driving ability difference leads to brightness reduction and color shift between Point A and Point B, people would see the brightness and color difference between upper (Point A) and bottom (Point B) areas on the panel. The schematic diagram is as figure 2. The gate voltage at Point C is deformed due to panel loading, which leads to driving ability to be less than at Point A. The pixel data level is insufficient between Point C and Point A in figure 3.

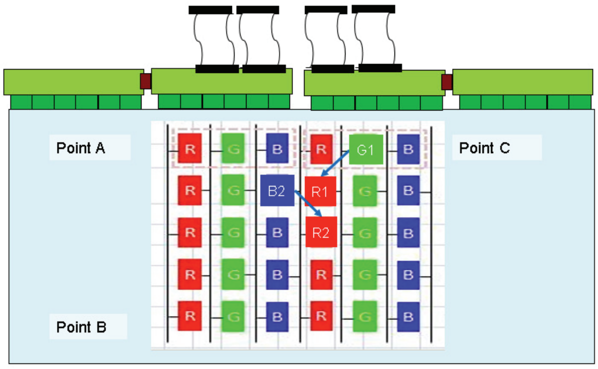


Fig. 1 1D1G Flip Pixel panel structure

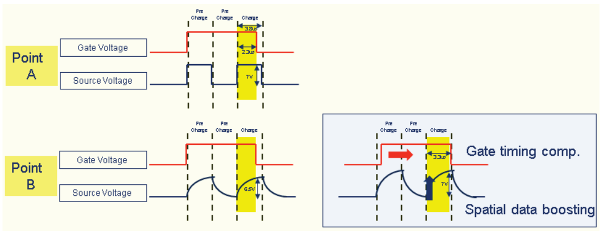


Fig. 2 Timing and driving ability schematic diagram at Point A and Point B

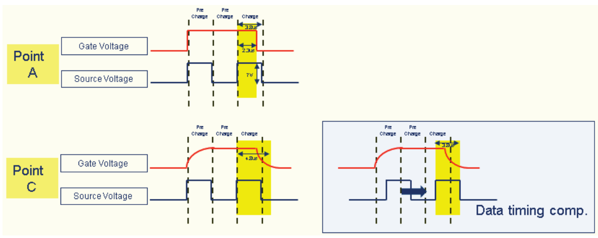


Fig. 3 Timing and driving ability schematic diagram at Point A and Point C

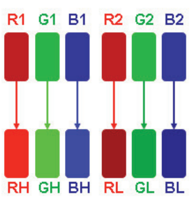
The improvement of the pixel data driving ability insignificancy due to panel loading could be carried out by adjusting gate and data driving period. Besides the sub pixel data (R1, R2) is affected by previous sub pixel data (G1, B2) at the same source driver in figure 1. To solve this problem, we design the Spatial Over Drive which boosting or decreasing the current sub pixel data refers to previous sub pixel data.

2.2 Digital Low Color Shift

Several companies in LCD industry have utilized low color shift(LCS) design technology with VA type LCDs and make color washout improvement [1][2][3][4]. The multi-domain technology is the most popular way by different input signals of main and sub area change the performance of red, green and blue pixels of side view, which will improve the washout issue of VA type LCDs. The 8-domain could improve the effect of washout issue than 4-domain, meanwhile decrease the brightness because of lower aperture ratio.

Digital Low Color Shift could improve the 4 domain side viewing color shift to be the same as 8 domain simultaneously keep the 4 domain aperture ratio. The method is to use two separated sub pixel pixels as the main and sub pixels (Fig.3).

Signals of two individual Red(Green/Blue) pixels are changed to improve its side view gamma, which is called spatial modulation and the total luminance of the two pixels normal view keeps the same [4]. That means original R1(G1/B1) and R2(G2/B2) are replaced by higher gray level which are RH, GH, and BH and lower gray level which are RL, GL, and BL (Fig.4a).



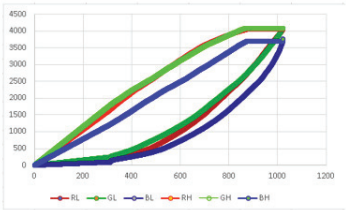


Fig.4a Fig.4b

Figure 4 DLCS spatial main(RH,GH,BH), sub(RL,GL,BL) arrangement (Fig.4a) and gamma curve(Fig.4b)

3. Function Design and Results

3.1 Design for Spatial Over Drive

The sub-pixel driving ability is affected by previous sub-pixel from the same source driver, we design the flexible spatial position designation (FSPD) to assign the previous sub-pixel spatial position for different panel driving layout (1D1G Flip Pixel, 1D2G, 1D1G). The compensation value is looked up from a 2-Domension level-to-level table, and we also design spatial gain parameters to compensate the level difference at different panel area.

The concept of design is as figure 5.

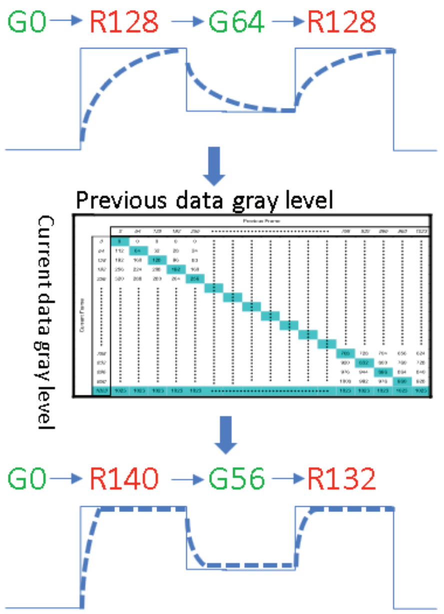


Fig. 5 Spatial Over Drive design concept

3.2 Spatial Over Driver Algorithm

Flexible spatial position designation (FSPD) which defines the spatial relation to previous data and current data. FSPD could be set according to panel driving architecture (1G1D Flip pixel, 2G1D, etc.). The current sub pixel data boosting value refers to spatial previous sub pixel data value, and is determined by 2 dimensional look up table.

For example, in the figure 5 the same source driver sub pixel data sequence is G0, R128, G64, R128 at 1D-1G flip pixel panel architecture. Before Spatial Over Drive applied, the sub pixel R128 level is insufficient (slash line) due to panel driving architecture and previous sub pixel gray level.

From G0 to R128 data sequence, G sub pixel gray level 0 is the previous data to R sub pixel gray level 128, the R128 boosting value is 140 which looks up from 2-dimensional level to level table. The same way, from R128 to G64 data sequence, G64 is changed to G56 according to 2D LUT (Look up table).

Figure 6 is the result of before and after Spatial Over Drive applied at 1D1G Flip pixel panel architecture.

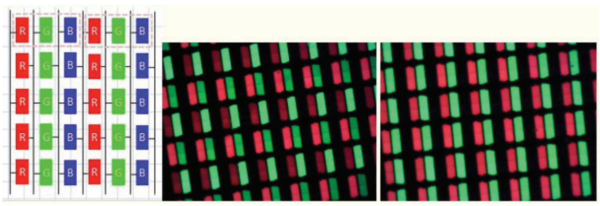


Fig.6a Fig.6b Fig.6c

Fig 6. 1D1G Flip pixel panel architecture (Fig.6a) and without (Fig.6b)/with (Fig.6c) Spatial Over Drive display result

In addition to the level to level LUT, the spatial gain weighting is another parameter to compensate the panel loading at different area. The visual dash-line caused by panel architecture is eliminated by spatial OD and spatial gain weighting in figure 7.

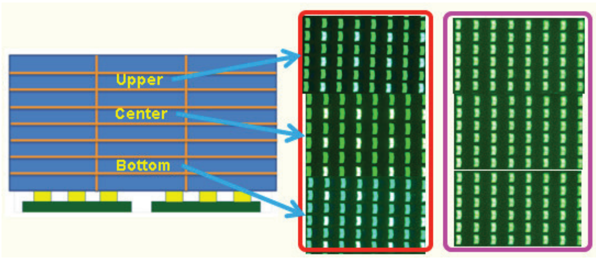


Fig.7a Fig.7b

Fig. 7 visual dash-line elimination by spatial over drive and spatial gain weighting . Visual dash-line like Fig.7a caused by panel architectuer. Fig.7b is the effect applied the spatial over drive and spatial gain weighting .

3.3 Digital Low Color Shift design

Digital low color shift could improve the viewing angle by using spatial sub pixel data re-arrange at 4 domain VA panel instead of 8 domain sub pixel panel design which suffers low panel transparency.

The digital low color shift technology applies the high-level and low-level value to adjacent same color sub pixels. The high-level value means the gray level is larger than original sub pixel gray value, and low-level is smaller than original sub pixel gray value, the spatial combination of high and low level at 4 domain behaves the 8 domain-like effect to improve the color shift at wide viewing angle as figure 8.

We design the spatial high-level and low-level assignation matrix to adapt to the different panel polarization design, besides the Smart High Low Determination (SHLD) is the strategy to dynamic decide the high level and low level for adjacent sub pixels to prevent the color error at specific patterns, like pixel or sub pixel on/off.

The drawback of DLCS is the visual dash line at the spatial high frequency content like text, object edge in the figure 9. That is the side effect of high and low values re-arrangement. Therefore, the edge detection function needs to be considered and helps to change the high and low level to eliminate the visual dash line.

We use the 3x3 pixels to be an edge detection block, and if the edge is detected, the edge weightings to high and low level are applied according to edge intensity. The higher edge intensity with higher edge weighting makes the high and low level to be closer to original sub pixels level. That would eliminate the visual dash line at the edge object.

Fig. 8 DLCS effect at wide viewing angle

For example, the high and low level of adjacent sub pixels level 128 and 64 are 176 and 54 respectively. If the edge weighting is 0.8 by edge intensity calculation, the new high and low level with edge weighting are 176-(176-128) x0.8 and 54+(64-54) x0.8 separately. The High value by edge weighting applied is about 137, and the low value is 62. They are close to original sub pixel data and visual dash line is eliminated. The effect of dash line elimination is as figure 10.

Fig.9 Visual Dash line while spatial high and low value re-arrangement

Fig.10 Visual dash line elimination effect by applied different edge weighting

The DLCS function included SHLD to determine spatial high/low level arrangement and dynamic edge weighting by edge detection intensity to improve the wide viewing angle color shift meanwhile eliminate the visual dash line.

4. Summary

We proposed the two adaptive functions which are spatial over driver and digital low color shift respectively for high resolution and large size panel application in timing controller.

The spatial over drive (Spatial OD) with FSPD and spatial gain control could compensate the source driver ability according to different panel driving architecture.

Digital low color shift(DLCS) with visual dash line elimination improve the wide viewing angle color shift as performance of 8 domain at 4 domain VA panel.

REFERENCES

[1] S. S. Kim, et al., “Invited Paper: Super PVA Sets New State of-the-Art for LCD-TV”, SID Symposium Digest, pp. 760-763,2004

[2] S. S. Kim, et al., “Invited Paper: The World’s Largest (82-in.) TFT-LCD”, SID Symposium Digest, Vol. 36. pp. 1842-1847, 2005

[3] Y.P. Huang, et al., “Additional Refresh Technology(ART) of Advance-MVA(AMVA) Mode for High Quality LCDs”, SID Symposium Digest, Vol. 36. pp.1252-1254, 2007

[4] Chih-Tsung Kang, Li-Xuan Chen, Yun Zhang, “A New Blue-Pixel Design for Improving the Side View Performance,” SID, P-98 pp.1527-1530, 2015