Recent LCD driving technologies for stereoscopic FHD 3D display system

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Abstract
In this paper, we describe the latest LCD driving technology which helps to realize the stereoscopic 3D display system with FHD resolution by using the 240Hz LCD panel. The 240Hz LCD system has two times more data than current 120Hz and can cover the crosstalk due to the progressive scan.

1. Introduction
The three-dimensional (3D) display is a method to provide images of original objects as they really show to the observer. The principle of 3D display is to satisfy the physical and psychological cues of 3D perception as many as possible. Among them, the binocular disparity, which means the left and right eyes require different images, is the simplest and most effective way which helps to realize the 3D display with flat panel display. The stereoscopic 3D display is a method using 3D glasses to separate the images for left/right eyes respectively. Since the images for left/right are similar but different, the amount of data for 3D display should be increased from that of conventional 2D display to keep the image resolution. Recently, with the progresses in driving technology and intra-panel interface, full-HD (FHD) 240Hz LCD module has been developed and the high performance of it revealed a way to realize stereoscopic FHD 3D display system with single LCD panel.

2. Base technologies for 240Hz driving
There are two kinds of way to increase the amount of displayed data. The first one is to increase the number of pixel in LCD panel. The problem is that none of them is an easy solution in the viewpoint of driving technology. The driving of LCD is basically to provide display data to each pixel with accuracy. Since the LC is a dielectric substance, the driving of pixel can be changed by charging the LC with electrode and thin film transistor (TFT). The issue is that the LCDs for most applications are driven by line-by-line driving method which is also called progressive scan. The progressive scan means that the pixels in a single gate line are charged at the same time by several data lines and the pixels in different gate lines share the data line. As a result, the driving of LCD panel is a time-multiplied way and pixels in each line has only a short amount of driving time or charging time. Since the large size LCD panel normally consists of a-Si TFTs, insufficient charging time may result abnormal display. The figure 1 shows a graph of ideal charging time for various resolutions and driving speeds. As shown in Fig. 1, the charging time of FHD 240Hz is only 3.7 μs and known as not sufficient for normal display. The ultra definition (UD: 3840 x 2160) with 120Hz have same charging time with FHD 240Hz and also needs a breakthrough. Therefore, it is important for the a-Si TFT LCDs to ensure enough charging time (at least 7.4 μs).

Another problem for the LCD using s-PVA structure is that one display pixel is divided by high/low sub-pixels to improve the viewing angle. As a result, it is needed to provide different data to each subpixels and the number of driving lines should be increased.

The half-gate two-data (hG-2D) and charge-shared s-PVA (CS-PVA) driving structure has been proposed to resolve the above problems and the world's first 240Hz FHD LCD-TV has been announced in SID ’09 [1-4].
As mentioned above, it is important to increase the driving speed or display resolution for 3D display. However, each improvement has its own appropriate applications. Since the auto-stereoscopic 3D display normally divide the left/right images using different pixels, it is better to increase the display resolution than the driving speed. On the contrary, the increase of driving speed is much more important for the stereoscopic 3D display using the time-sequential driving. With this point of view, the 240Hz FHD LCD driving can be a breakthrough for practical stereoscopic 3D display system.

3. Principle and discussion

The 240Hz LCD driving technology can propose a new concept of stereoscopic 3D display using the LC shutter glasses without polarization controller. In conventional stereoscopic 3D system which adopts the polarization glasses, a special 3D filter or 3D panel is needed to modulate the polarization of display. As a result, those systems require additional process and cost for realizing 3D display. Moreover, the image quality in 2D display was also affected. In the proposed 240Hz 3D system, there is no need of additional 3D filter or 3D panel and we can achieve both low cost 3D display and high quality 2D display without any degradation.

The basic principle of LC shutter glasses 3D display is simple – to open the left/right eye using optical shutter in glasses and show the related left/right images in the display device in time-sequential manner. Therefore, if the left/right images are shown with 60 frames each in a second, driving speed of 120Hz is needed to prevent left/right mixing (3D crosstalk). However, in time-sequential driving of real LCD panel, the 120Hz driving is insufficient due to the progressive scan. Figure 2 shows an example of 120Hz left/right image displaying and the 3D crosstalk during the scan period. Since the most of displaying time is on the scan period, the 120Hz LCD is not suitable for 3D display using LC shutter glasses.

In 240Hz LCD, the frame rate is doubled. As a result, there is an additional frame between every two frame of 120Hz and they can be used to remove the 3D crosstalk. The basic way is to display a black screen in the additional frames to prevent the left/right image from mixing. Figure 3 shows the concept of 240Hz 3D driving using LC shutter lens which reduces the 3D crosstalk by insertion of black frame between left/right image frames. During the scan period of each frame, the left/right images are mixed with not each other but the black screen. Therefore, the 3D crosstalk due to the progressive scan can be resolved using the above proposal.

In the proposed method, the 3D display function is realized only by the driving technology. As a result, there is no need of 3D device in the LCD panel and that guarantees high quality 2D display in the viewpoint of luminance, contrast ratio, and low motion-blur of 240Hz driving. In the 3D mode, a high quality 3D image is also achieved using the time-sequential 3D driving.
Fig. 3. Principle of 240Hz 3D driving with LC shutter glasses

4. Summary

With recent progresses in LCD driving technology, stereoscopic FHD LCD-TV has been realized using the hG-2D and CS-PVA structure. The proposed system can provide both a blur-free 2D motion picture and high resolution 3D image and established a basis for practical 2D/3D display system.

5. References