**Backlight Control Technology for Liquid Crystal Display TVs**

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1. Introduction

Liquid Crystal Display Televisions (LCD TVs) sometimes suffer from motion blurring caused by the hold-type display (a still image is displayed for one frame) and/or low contrast due to the backlight system. This paper describes the prevention of motion blurring by means of an impulse-type display, and the enhancement of contrast by controlling the backlight brightness based on the image information in multiple sections of the screen.

2. Motion Blurring of LCD TV

2.1 Hold-type display

A moving image on the TV is produced by continuously displaying images at the frame rate of 1/60 s. The hold-type display refers to the method of displaying each frame for 1/60 s.

Figure 1 shows a conceptual illustration of the hold-type display of a circle moving upward from the bottom. The response time of the LCD is assumed to be fast enough for the frame rate of 60 images per second. While the viewer’s line of sight is continuously moving upward with time, a real object (not a TV) is always present in the viewer’s line of sight, but the image in the hold-type display remains at the same display position for 1/60 s. As a result, the viewer recognizes the circle at a position backward from the line of sight, and perceives the object with a tail (motion blurring).

2.2 Double rate driving

Figure 2 illustrates the same image as shown in Fig. 1 in the double-rate driving mode. Interframe images are estimated from a sequence of images at the frame rate of 60 frames per second, and then displayed at the rate of 120 frames per second. Consequently, while the circle is still present backward from the viewer’s line of sight, the amount of blurring is halved from the level at the rate of 60 frames per second. If interframe images are further estimated in the same manner, the display rate can be 240 frames per second, and the amount of blurring would be further halved.

![Fig. 2 Reduction in blurring by double-rate driving](image)

As depicted in Fig. 2, while motion blurring can be reduced by the double-rate driving, it is true only when interframe images are correctly estimated from the images at the frame rate of 60 frames per second.

In reality, as shown in Fig. 3, images can be estimated fairly accurately in such relatively simple cases where the background of the moving circle is uniform, whereas if a still object is present in the background of the moving circle (a tree in Fig. 3), or the moving object has a complicated shape or pattern, the estimation may be incorrect, resulting in a deformed or blurred image.

2.3 Impulse-type display

Figure 4 depicts the concept of the impulse-type display. The LCD acts in the same manner as the hold-type display, but the display time is made shorter by reducing the on-time of the backlight. While the viewer’s line of sight moves upward with time, the circle at a position backward from the line of sight is recog-
nized only during the on-time of the backlight and is invisible during the off-time, resulting in a reduced amount of blurring.

Unlike the double-rate driving, it is not necessary for the impulse-type display to estimate images to increase the frames, and even for a complicated image, an effect to reduce the blurring is always ensured in a stable manner without any incorrect estimation.

In the above explanation, the response speed of the LCD is assumed to be fast enough for the frame rate of 60 frames per second, and the motion blurring occurs in the hold-type display mode. In reality, however, it takes time for the LCD to respond, as illustrated in Fig. 5. Therefore, when the backlight on-time is shortened for the impulse-type display, as shown in Fig. 5, it is turned on at the longest time elapsed after the LCD has begun to respond. With this technique, the blurring due to the LCD’s slow response speed (image lag) is also improved.

The whole screen of the LCD does not respond at once, but in a sequential manner from the top to the bottom (in some cases, from the bottom to the top). Therefore, as shown in Fig. 6, the backlight area needs to be divided into multiple sections, which are turned on in sequence according to the response of the LCD (sequential turn-on).

For such an impulse-type display, the backlight needs to have a fast on/off speed, and the backlight area needs to be divided into individually controllable multiple sections. Recently, LCD modules with a backlight that is fast enough for turning on/off and section controllable such as an LED backlight have become relatively easily available. The on-time of the backlight for impulse-type display is shortened and hence the brightness is lower than for the hold-type display. Nevertheless, sufficient brightness is becoming ensured even for the impulse-type display by means of transmittance improvement of the LCD and brightness enhancement of the backlight.

3. Contrast Ratio of LCD TV

An LCD TV displays an image by activating the backlight and controlling the transmittance of the LCD pixels in front of the backlight. This causes the following problems: the backlight remains on even when a black image is displayed, and light leakage from the backlight prevents the LCD from displaying a fully dark image even if the transmittance of the LCD is reduced. That is, the ratio of white to black (= contrast ratio) cannot become higher.

A conventional backlight control to overcome this problem is to increase the brightness when the image (scene) is bright and reduce it when dark. This method increases the brightness ratio of the bright scene to dark scene (dynamic contrast ratio). However, the contrast ratio within one image (static contrast ratio) depends on the performance of the liquid crystal panel and this backlight control method cannot increase the static contrast ratio.

Consequently, the backlight area is divided into multiple sections as shown in Fig. 7, and the brightness of each backlight section is controlled based on the image. This increases not only the dynamic but also the static contrast ratios. An example of such backlight module shown in Fig. 7 is equipped with LEDs on both sides, and divided into 2 horizontal and 8 vertical sec-

![Fig. 3 Image estimation for double-rate driving](image)

![Fig. 4 Display in impulse-type display](image)

![Fig. 5 Turn-on timing of backlight](image)
tions. As a result of the vertical division into 8 sections, the above-described sequential turn-on control is implemented for the impulse-type display, which improves the motion blurring while the control is not too complicated because of the small number of sections, that is, a good balance is achieved between the cost and the image quality. If the cost is further reduced in the future, the number of sections could be increased for even more effective control.

4. Future Prospects

In response to the evolution of devices and changes in the market demands, we have pioneered the application of technologies, which so far could not be used, to improve the image quality. Based on technical trends and consumer behavior, we will continue to develop technologies in preparation for the timely commercialization of the products.

Reference