

## Area-Focused Luminance Control Backlight for LCD TV applications

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### Abstract

*In order to improve the image quality of a large size LCD-TV, the Area-Focused Luminance Control (AFLC) technology with data processing algorithm has been developed. The AFLC backlight consists of 16 U-shaped lamps, and controllable areas are divided into 8 blocks. Based on the AFLC technology, the backlight luminance of each block is automatically and separately controllable. Consequently, the contrast ratio is greatly enhanced whereas the corresponding power consumption is decreased as compared with those of conventional backlights.*

### 1. Introduction

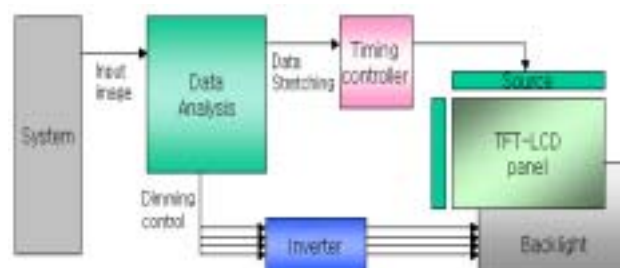
A large size LCD-TV market is explosively growing, which is due to continuous enhancement of the image quality. In general, the image quality completely depends on five primary factors: luminance, contrast, response time, color and viewing angle [1][2]. In a viewpoint of ergonomics, the contrast ratio is a most important factor because it influences on both still and moving image. However, the contrast ratio is mainly determined by a LC-panel, which is due to the fixed luminance of a backlight. Thus, studies on backlight technologies for improving the contrast ratio is needed. These days, lots of studies in this area have been fortunately done for LCD-TV applications [2]. Especially the technologies actively controlling the luminance of backlight can be an efficient solution to obtain a higher contrast ratio, a lower level of black luminance and a more reduced power consumption.

In this paper the AFLC technology will be introduced. A most efficient solution to improve contrast ratio of not only static but also moving picture for LCD TV will be shown as well.

### 2. AFLC backlight

#### 2.1 Basic Concept

In order to improve a contrast for pictures, the AFLC technologies have been developed. There are 2 main parts; one is for the AFLC backlight with U-shaped lamps and the other is for the AFLC algorithm.

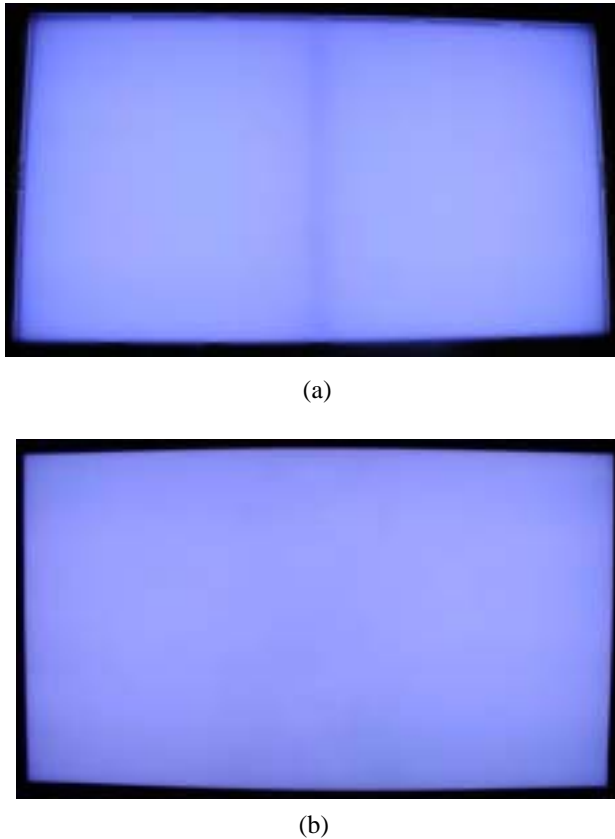


**Figure 1.** Illustrating the AFLC backlight technology using a block diagram.

Input images are transferred from the system to the Data Analysis block as shown in Fig. 1. Two types of signals such as data stretching and dimming control are created in the Data Analysis block. One is for displaying a picture and the other is for dimming the backlight.

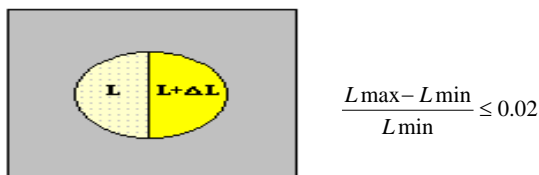
#### 2.2 Backlight Uniformity

The AFLC backlight consists of 16 U-shaped lamps and inverters. The structure is similar to a conventional backlight, except for the shape of lamps only. The active area is divided into 8 blocks for brightness control. Each block control contributes to enhance the contrast. In the middle of backlight in Fig.2-2 (a), bright and dark spots are repeatedly shown due to the bending part of the U type lamp. However, the reflector with some treatments disappear these repeating pattern.



**Figure 2-2.** Full white images: (a) with no reflector treatment ( $L/L = 0.054$  (in the middle area)) and (b) with reflector treatments ( $L/L = 0.02$ ).

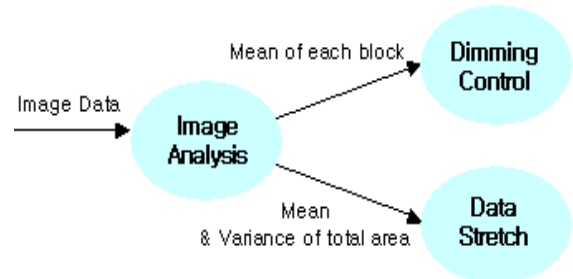
To measure uniformity of the AFLC backlight, we used three kinds of methods that are to measure the luminance of 17 points over the LCD for uniformity estimation, to inspect by human eye and to apply the Weber-Fechner's law. According to the Weber-Fechner's law, we cannot distinguish the difference of the luminance in the nearby areas, if  $L/L$  is lower than 0.02.



**Figure 3.** Weber-Fechner's law

## 2.3 AFLC Algorithm

The AFLC algorithm is divided into two parts as shown in Fig. 4. One is for local dimming of the backlight and the other is for data stretch.



**Figure 4.** Structure showing the AFLC algorithm.

In the first part, the input-image data are analyzed and the representative values are calculated for each of backlight blocks, and then control signals for dimming are sent to each block.

In the second part, the data stretch is adaptively applied according to the histogram of the input image, and so the output image can be clearly appeared. For discriminating the shape of the histogram, the mean and variance of the input image are used. As a result, the much higher contrast image can be shown in still and moving picture than former backlight brightness control methods [1][2].

### Conversion of RGB to YUV:

To detect a brightness factor (Y value), the basic conversion of the input RGB to YUV is done as below. The following equations are used for conversion of RGB to YUV,

$$Y = 0.29900R + 0.58700G + 0.11400B$$

$$U = -0.16874R - 0.33126G + 0.50000B$$

$$V = 0.50000R - 0.41869G - 0.08130B$$

### Calculation of Mean and Variance:

The following equations are used to obtain Mean and Variance of Y,

$$\text{Mean}(Y) = \sum \frac{Y}{N}$$

$$\text{Variance}(Y) = \sum \frac{Y^2}{N} - \left( \sum \frac{Y}{N} \right)^2$$

, in which  $N$  : Total pixel count

YUV to RGB Conversion:

A modified RGB signal is made by combining the Y luminance data, modified by data stretch, and the U and V signals, converted from the previous RGB to YUV.

The following equations are used to obtain RGB data,

$$R = 1.00000Y + 1.40200V$$

$$G = 1.00000Y - 0.34414U - 0.71414V$$

$$B = 1.00000Y + 1.77200U$$

### 3. Impact

The AFLC technology improves the contrast of a LCD TV and then, the image quality is enhanced by the AFLC technology: the bright image is brighter, and the dark image is darker in the same frame. The power consumption based on the AFLC technology is also decreased in comparing with that of a conventional backlight.

#### 3.1 Contrast

The contrast in a same frame is remarkably improved by application of the AFLC technology for every frame, as measured the ratio of the brightest to the darkest part in the static scene.



Figure 5. Examples of the contrast in a same frame.

### 3.2 Power consumption

#### 3.2.1 Still pictures

The power consumption has always a decreasing effect by the amount of the hatched area shown in Fig. 6 whenever it subjects to the dimming curve like the graph below. It basically depends on the luminance component of the input image, i.e., the ratio of lighter to darker picture image in a static state.

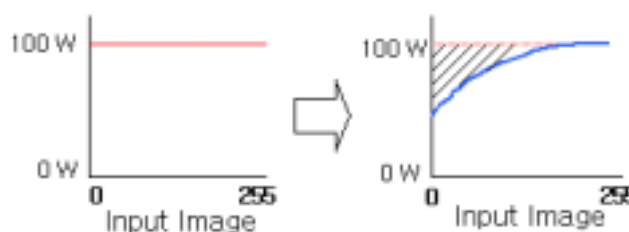


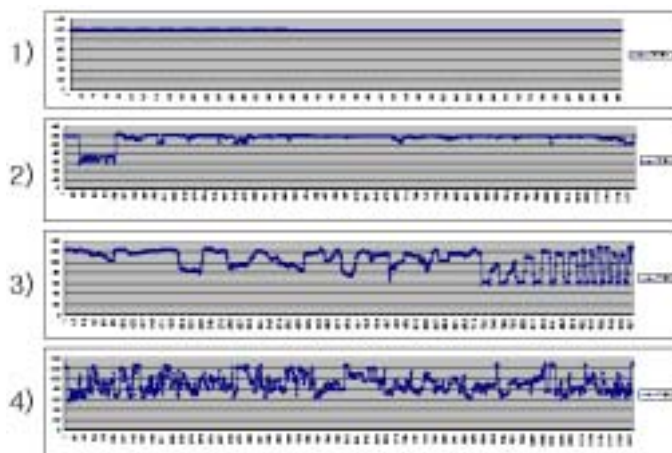
Figure 6. Reduction of the power consumption.



Figure 7. Power consumption for still image.

#### 3.2.1 Moving pictures

The power consumption varies according to a type of the picture displayed. It has a constant value of 112.8W under the normal state not using the AFLC technology as shown in Fig. 7 and Fig. 8 (1). It shows a decreased effect of 5 % in average in Fig. 8 (2) and of 15 % in Fig. 8 (3), a bright scene like an animation and a picture like a soap opera, respectively. The Fig. 8 (4) shows an example, e.g., the movie "Matrix II" having lots of dark scenes for which it has a decreased effect of 25 % as compared with that of Fig. 9 (1). However, it could be measured differently by changing light source and dimming curve.



**Figure 8.** Power consumption for motion picture illustrating variation of the power consumption for 1) the conventional backlight, 2) the overall-bright scene using the AFLC technology, 3) the bright and dark mixed scene using the AFLC technology, and 4) the dark movie.

#### 4. Conclusion

Optical uniformity over the backlight is within a spec less than 1.3. It can be successfully achieved by optimizing the pitch of lamps and by treating the reflector in the point of intersection of the U-shaped lamps.

Here are two characteristic algorithms developed in this study: the first is to control the inverter by classifying the input image signal according to each category followed by investigating the dimming factors which is suitable for the category analyzed.

The second is to stretch the data for activation of so vivid image.

In addition, the emitting region of the backlight can be effectively divided and the luminance partly controlled according to the input picture using the U-shaped lamps. Thus, both static and dynamic picture quality can be increasingly elevated through improvement of the contrast in a same frame.

Consequently, the AFLC technology based on the characteristic data processing algorithm can be utilized for various types of illuminating sources: e.g., CCFL, EEFL, flat lamp, and LED.

#### 5. References

- [1] K. D. Kim, S. H. Baik, M. H. Sohn, J. K. Yoon, E. Y. Oh, and I. J. Chung, "Adaptive Dynamic Image Control for IPS-mode LCD TV," SID 2004 digest, pp.1548-1549.
- [2] E. Y. Oh, S. H. Baik, M. H. Sohn, K. D. Im, H. J. Hong, J. Y. Bang, K. J. Kwon, M. H. Kim, H. Jang, J. K. Yoon, and I. J. Chung, "IPS-Mode Dynamic LCD-TV Realization with Low Black Luminance and High Contrast by Adaptive Dynamic Image Control Technology," IMID 2004, pp 799-802