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A Study of False Contour Noise in Moving Images through Consideration of the Phosphor Decay Time of AC PDP

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Abstract

The dynamic false contour noise was analyzed with consideration for the phosphor decay time of an ac PDP by computer simulation based on the measurement of the 1/10 phosphor decay times of the primary colors red, green and blue at the main wavelengths of each phosphor. The noise level of dynamic false contour is strongly dependent on phosphor decay time. The noise level decreases incrementally with the phosphor decay time, whereas the noise width increases. The moving velocity of an object does not affect the noise level. The entire experiment was performed under the condition of 8 subfields ADS driving scheme, 2.5[μsec] scan speed, and 5 [μsec] sustain period with VGA grade panel.

Key Words : AC PDP, dynamic false contour noise, decay time

1. Introduction

Recently, many types of flat panel TVs such as PDPs (Plasma Display Panel), OLEDs (Organic Light Emitting Display) and LCDs (Liquid Crystal Display) have been introduced on the display market. In the large-size display market over 40 inches, there is intense competition between PDPs and LCDs. The main issues of the competition are manufacturing cost, low power consumption, and picture quality[1].

It is generally understood that the PDP is superior to the LCD regarding the quality of the moving image due to its very high speed response, which has its origin in gas discharge physics. Many groups have reported, however, that the PDP displays some contour noise when an object moves on the screen (dynamic false contour noise). It is understood that dynamic false contour noise is caused by the subfield method which is a technique of gray scale representation in the PDP[2-4].

Some groups have analyzed this problem and have proposed many techniques to overcome it[5-6]. The decay characteristics of the phosphors the generating primary colors which stimulate human eye have not been considered, however. To understand the phenomena accurately, these decay times must be considered because that the human eye recognizes only visible rays.

In this paper, dynamic false contour noise dependent on phosphor decay time was studied using computer simulation.

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2. Modeling of dynamic false contour noise

2.1 Conventional model

Fig. 1 shows the conventional model of a dynamic false contour noise evaluation with the conditions of 8 subfield driving, 127-128 gray level pattern and 1 pixel/frame of moving velocity. The light emission period is marked in gray. (a), (b), and (c) in Fig. 1. The dashed lines are the tracking lines of the points on a retina perceiving the light of the image. To the human eye, the perceived level of gray is the integrated stimuli of each point depicted by the thick red lines in the figure. The perceived pattern is distorted to a higher gray level at the interface of the original gray levels.

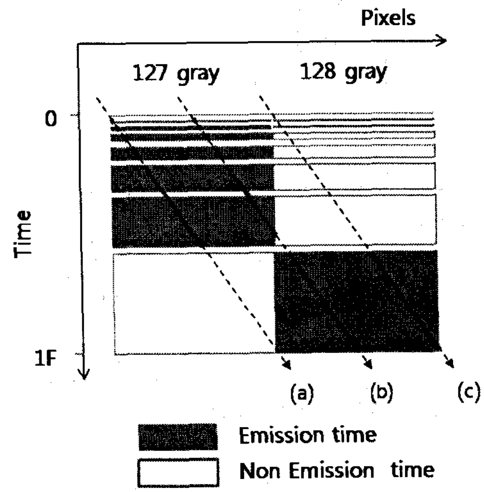

Fig. 1. The schematic diagram of the conventional model for a dynamic false contour noise evaluation with the conditions of 8 subfield driving, 127-128 gray level pattern and 1 pixel/frame of moving velocity

In this conventional model, it is assumed that the emission occurs only during discharge. If there is no discharge, then there is no emission. In reality, visible light emission does not stop abruptly after a sustained period because the phosphor of the PDP cell continues emitting light, during the next subfield though the intensity decreases.

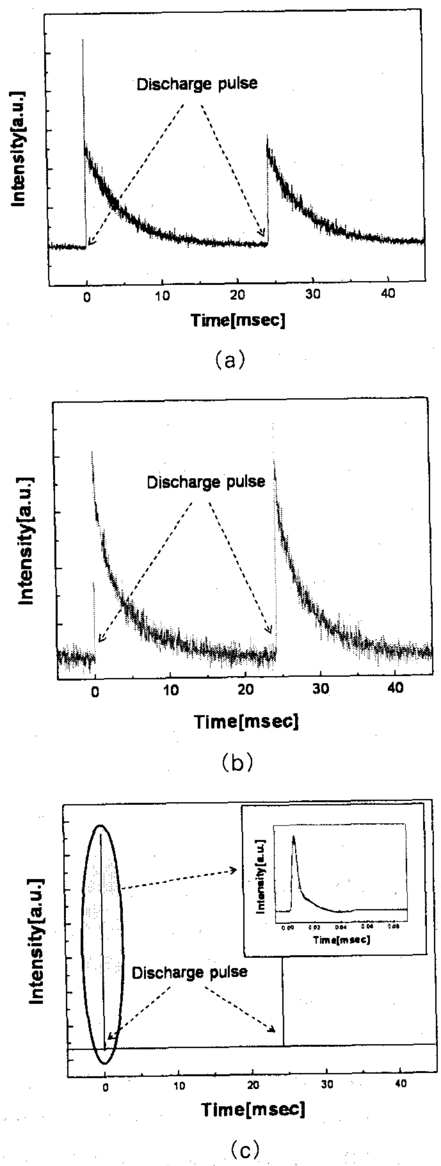

Fig. 2. The decay characteristics of red (a), green (b) and blue(c) phosphor emission of PDP

2.2 Phosphor decay time

First, the phosphor decay time was measured in order to understand the characteristics of decay of light emitted from the PDP phosphor. To simplify the measurement of the decay time, the wavelength at which the emission spectrum has the maximum intensity for each color was selected. The selected wavelengths were 592nm, 526nm and 450nm for red ($(Y,Gd,Eu)_2O_3$), green ($(Zn,Mn)_2SiO_4$) and blue ($(Ba,Eu)MgAl_{10}O_{17}$).

Fig. 2 shows the decay characteristics of phosphor emission measured by a PMT (Photo Multiplier Tube) with a monochromator. The emission was generated by a low frequency 40Hz discharge pulse train to guarantee that the measured decay characteristic is caused by only one discharge. (a), (b) and (c) of Fig. 2 are the results of the red, green and blue phosphor, respectively.

As shown in the figure, the intensities of light decrease very slowly in the cases of the red and green phosphor, whereas it does not for the blue phosphor. The estimated 1/10 decay time of one discharge are 11[msec], 8[msec] and 18[μsec] for the red, green and blue phosphor, respectively. A long decay time causes the phosphors of the PDP, especially red and green, to continuously emit light after the sustain period even though the sustain discharge has finished. Therefore, the conventional dynamic false contour noise analysis model as mentioned previously should be modified for a more accurate analysis.

2.3 The modeling of dynamic false contour noise analysis considering the phosphor decay time

To model the dynamic false contour noise while considering the phosphor decay time, it is assumed that the emission from phosphor decays exponentially. The time dependent intensity function could be written as Eq. 1.

$$I(t_0,x,t)=\begin{cases} I_0\exp(-\frac{t-t_s}{t_d}), & t\geq t_s \\ 0, & t<t_s \end{cases} \qquad (1)$$

where, Io is the initial intensity of light due to a sustain discharge, t0 is the time that the sustain pulse is applied, x is a point somewhere on an object on the screen and td is the decay time constant. For convenience, the initial intensity of I0 is set to 1 if the sustain discharge occurs at a given time and place, or set to 0 if it does not.

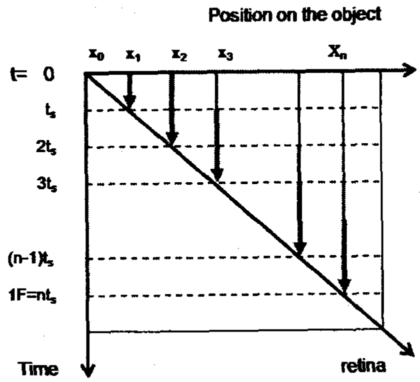

Fig. 3. The calculation of integrated stimulus on a point of the retina considering phosphor decay with a moving object

The accumulated stimulus on a point of the retina of an observer when an object moves in a horizontal direction on the screen (Fig. 3) is calculated by the following.

Step 1. set *stimulus* = 0

Step 2. set t=0, k=0

Step 3. $stimulus = stimulus + \sum_{i=0}^{k} I(it_s, x_k, t)$

Step 4. set k=k+1, t=t+t_s

Step 5. if k≤n, then go to step 3
Step 6. finish

If (x_n-x_0) in Fig. 3 is the same as the pixel width, then the velocity of the moving object is 1 pixel/frame. The time step t_s is set to half the time of the sustain pulse period. From this calculation, the accumulated stimulus on the point of the retina during a frame can be obtained and hence, the dynamic false contour noise. In this experiment, the driving scheme is the same as the conventional one. The number of subfields is 8 in a frame, the sustain period is 5[μs], the scan speed is 2.5[μs], the number of scan line is 480 and the reset time of each subfield is 200[μs].

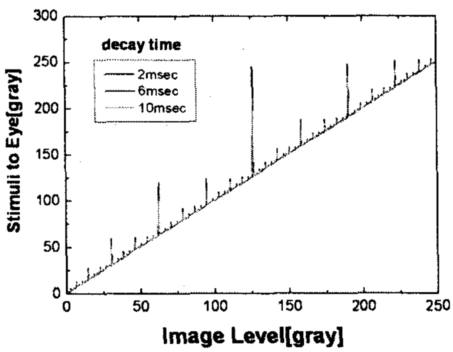

Fig. 4. Dynamic false contour noise of ramp pattern moving to right at a velocity of 1 pixel/frame with the different phosphor decay time

3. Experimental Results

The dynamic false contour noise with a ramp pattern moving right at a velocity of 1 pixel/frame was simulated with a different phosphor decay time (Fig. 4). As shown in the figure, the stimuli are different from the original input gray levels. At a level of gray around 128, the gray distortion has its maximum value. The decay time does not influence the gray level at which the dynamic false contour noise arises.

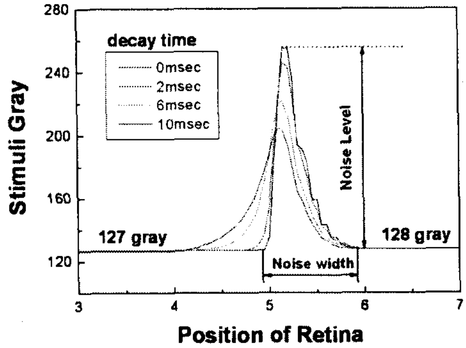

Fig. 5. Dynamic false contour noise of 127-128 gray pattern moving right with the velocity of 1 pixel per frame

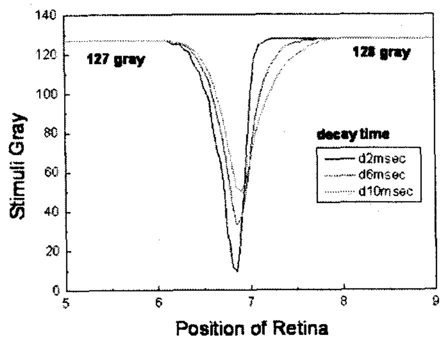

Fig. 6. Dynamic false contour noise of 127-128 gray pattern moving left with the velocity of 1 pixel per frame

To analyze this more deeply, a dynamic false contour noise around the gray level of 128 with a 127-128 gray pattern was simulated, and the result is shown in Fig. 5. The left and right side of the retina perceive the same gray level of stimulus as the original input gray independent of the decay time. At the boundary between the two grays, the noise level decreases according to the decay time, whereas the width of noise becomes wider. Because the human eye is more sensitive to the noise level than the width, the longer decay time has the advantage of lessening the noise. Where the direction of movement is reversed, the contour noise is reversed (Fig. 6). The difference in direction does not cause a difference in noise level or noise width.

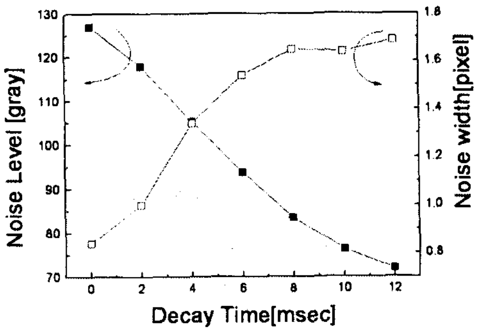

Fig. 7. Noise level and width according to the decay time with a 127-128 gray pattern moving right at the velocity of 1 pixel per frame

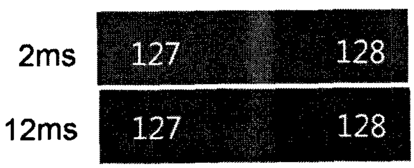

Fig. 8. Distorted gray patterns with different cases of phosphor decay time(upper: 2[msec], lower: 12[msec])

Fig. 7 shows the noise level and noise width according to the phosphor decay time under the same condition as Fig. 5. The zero decay time condition results in a maximum distortion of intensity of the 127 gray level. The noise level lowers with an increasing decay time and a 12[msec] decay results in a 71 gray level distortion, which is about 60[%] of the maximum noise level. On the other hand, the noise width increases according to the phosphor decay time. Minimum noise width could be obtained at the zero decay time condition, and a 12[msec] decay time results in a 1.7 pixel noise width.

The estimated perceived pattern to the eye is shown in Fig. 8 for an object moving to the right at a velocity of 1 pixel/frame. The noise line is more clearly seen in the case of a 2[msec] decay time as opposed to the 12[msec] as mentioned above.

Fig. 9 shows the dynamic false contour noise level according to a moving velocity of a 127-128 gray pattern. These noise levels do not differ greatly from each other. This is because the test pattern has only 2 grays of 127 and 128. The increment of the moving velocity causes the retina of the observer to scan more pixels at a given time. The test pattern used was composed of only 2 groups; the left side was 127 gray and the right was 128 gray. Therefore, the stimuli accumulated on the retina do not differ much.

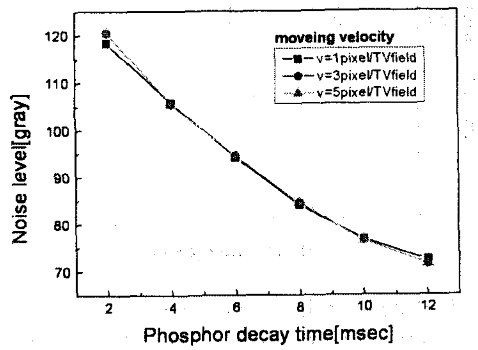

Fig. 9. The noise level according to the moving velocity of an object with a gray level of 127 and 128

4. Conclusion

A simulation code for an experiment on the evaluation of dynamic false contour noise was developed considering the features of phosphor decay time. To verify the evaluation, the emission characteristics of red, green and blue phosphors were measured separately. The measured 1/10 decay times of red, green and blue phosphor in

PDP were 11[msec], 8[msec] and 18[μsec], respectively.

The results obtained from the experiment using the developed simulator show that the noise level decreases according to the decay time, whereas the noise width increases. Also, the moving velocity does not affect the noise level with the test pattern that was used.

Generally, a long decay time causes the degradation of sharpness in moving images, hence the moving picture quality. Therefore, in spite of the advantage of a long decay time which reduces dynamic false contour noise, other effects should be taken into consideration. Another important issue is the differing characteristics in the decay time of phosphor. The decay time of blue phosphor in particular is much shorter than those of the red and green phosphors. This may cause color distortion in moving images. Therefore, further analysis of decay time-dependent picture quality will be very useful. The developed simulator will contribute to the enhancement of the PDP picture quality.

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Biography

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