Luminance Control for given gray level by the Asymmetric Sustain Pulse in ac PDP

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Abstract

Need of a dimmer function becomes more important with increasing interest on a HDTV for home theater applications. In a conventional ac PDP, a possible method to reduce luminance of a whole panel is to reduce a total number of sustain pulses and then to change the gray level. However, the reduction of the total sustain number causes the step of luminance to be rough. Moreover, it is impossible to control the luminance of the panel for a given gray level. In this paper, a simple and robust method is proposed to control linearly the luminance of whole panel by applying the asymmetric sustain pulses in the display period of the ADS driving scheme. As the range of luminance control by the proposed method is about 50% for a given gray level. Moreover, it is experimentally verified that the proposed method shows similar dynamic margin performances compare with the conventional method.

1. Introduction

Since Bitzer and Slottow developed the plasma display panel (PDP) at the University of Illinois in the 1960s, many companies and laboratories had made efforts to commercialize the PDP which has advantages of a large screen size, a slim thickness, a light weight, a simple structure, a high resolution, a fast response, and a wide viewing angle. The ac PDP which was commercialized in the late 1990s has recently achieved a good performance and an image quality, and are promising to be an attractive solution for a high-definition television [1]. However, improvement of a luminous efficiency, an image quality, and cost-reduction is still necessary to compete with other candidates of HDTVs (LCD, and OLED, etc.)[2]. Especially improvement of an image quality is one of concerns of all display manufacturers with start of a digital broadcasting and popularization of a DVD (Digital Versatile Disk).

Both gray-scale expression and brightness control in the ac PDP are performed using pulse number modulation, which make it difficult to control panel brightness flexibly according to ambient luminance level. Independent control of brightness with the gray scale can't be made so far. However, necessity of a dimmer function becomes more important with increasing interest on a HDTV for home theater applications. Up to now, a possible method to reduce luminance of a whole panel is to reduce a total number of sustain pulses and then to change combination. However the reduction of the total number causes expression of image to be poor.

In this paper, we propose simple and robust method that applies asymmetric sustain pulses in the display period of the ADS driving scheme to overcome this problem and realizes independent control of panel brightness.

2. Experimental

Figure 1 shows the principle structure of a discharge cell in the ac PDP. The size of the discharge cell is about 0.27mm by 0.81mm with height of 0.13mm. Tri-primary colors (R, G, B) are obtained from RGB phosphors excited by vacuum ultraviolet photons emitted from a gas discharge [3]. The 7-inch test panel having XGA resolution has been used in this study. The specification of the panel is summarized in Table 1.

As the driving method of the ac PDP, a ramp type address-display separated (ADS) scheme has been widely used [4-5]. A picture is typically divided into 50 or 60 fields. In ADS method, the field is divided into eight subfields. Each subfield has an address and a display periods and the address period composes with a reset and an address steps as shown in Fig.

2(a). The role of the reset step is to erase wall charges accumulated on dielectric surfaces of discharge cells in a previous subfield, and to make same surface condition before next addressing. The role of the address step is to make new wall charges on the dielectric of each discharge cell by applying an address pulses between a scan and an address electrodes. The role of the display period is to make an image on the panel by applying sustain pulses to all display electrodes. In this case, only selected discharge cells that have been addressed in the address step are turned on. The number of sustain pulses is decided corresponding to the weight of luminance for each subfield. When the discharge is successfully done at a first sustain pulse and sufficient wall charges are left behind, the cell can be driven with a low voltage down to near a sustaining minimum point. Therefore it is possible to control a panel brightness by changing the sustain voltage from second to a last pulse. In this way we can maximize the controllability of discharge cells to the degree limited by their physical nature.

Fig. 2(b) shows the driving waveform sequence of a suggested method. An adopted driving scheme is same as a conventional method, the ramp type ADS scheme, except for a variation of Vz. The width of scan pulses are generated by a scan driver IC is designed as 3 μs which has a similar pulse width to a conventional 42 inch ac PDP. Each address step of eight subfields is designed to be about 1 ms. A reset up, and down time is designed to be 100μs, and 150μs, respectively. These conditions provide stable positive-resistance discharges. The voltage of Vr, Vs, Va, and Vysc as shown in Fig. 2 is set to 410[V], 180[V], 70[V], and 80[V], respectively. Total eight subfields have been used and the time of a field is 16.7ms. No energy recovery circuit was applied [6-7].

In order to test a luminance control, a luminance and a discharge current are measured by a luminance colorimeter (BM-7, Topcon Co.) and a current trans. (CT-1, Tektronix Co.).

Table 1. Specifications of a 7-inch ac PDP

Front panel		Rear panel	
ITO width	270μm	Address width	100μm
ITO gap	65μm	White back thickness	15μm
Bus width	85μm	Rib height	130μm
Dielectric thickness	40μm	Rib pitch	270μm
MgO thickness	5000 Å	Rib width	75μm
Ne+He(9.6%)+Xe(4%)	520 torr	Phosphor thickness	20μm

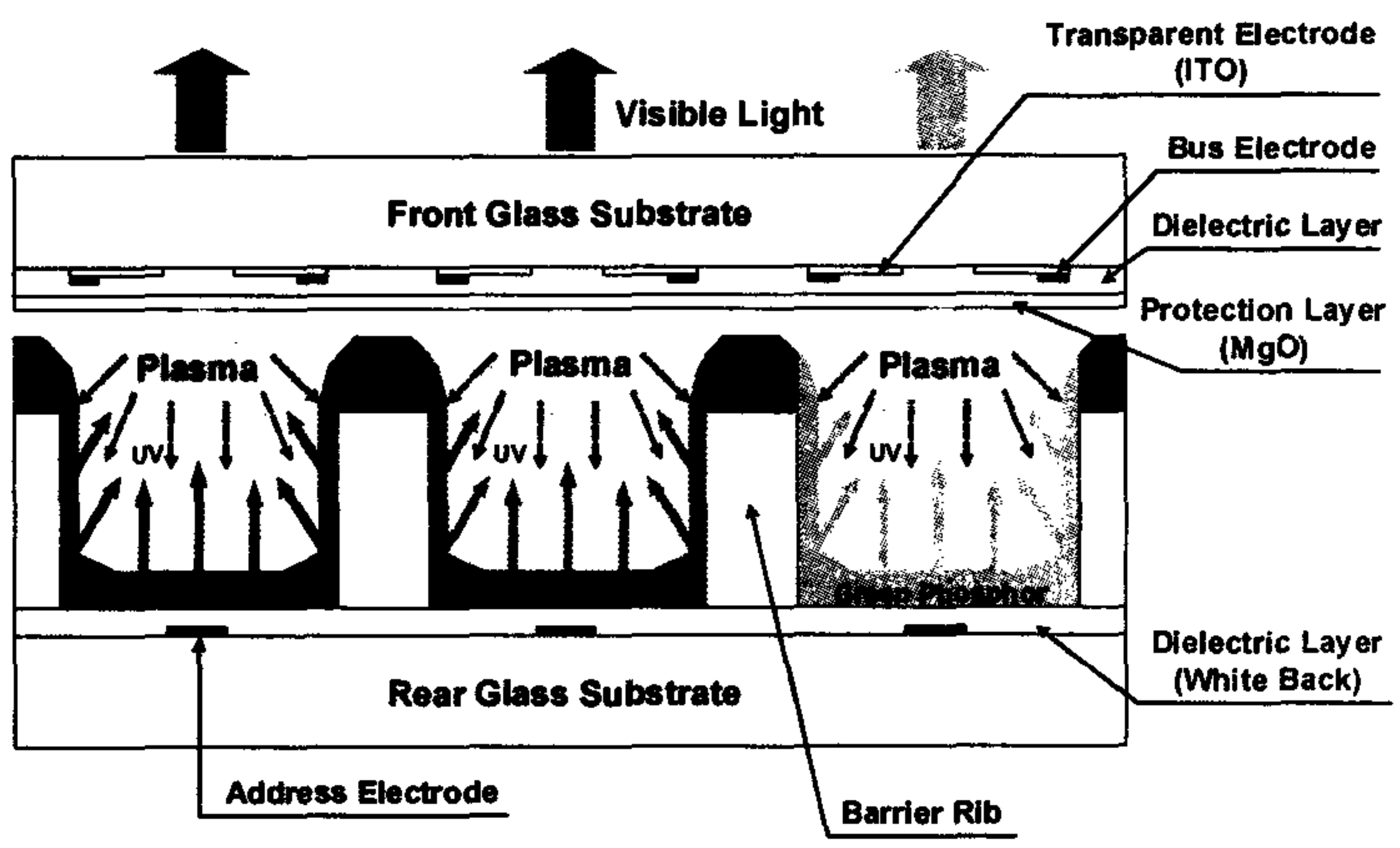

Fig. 1 Schematic diagram of ac PDP

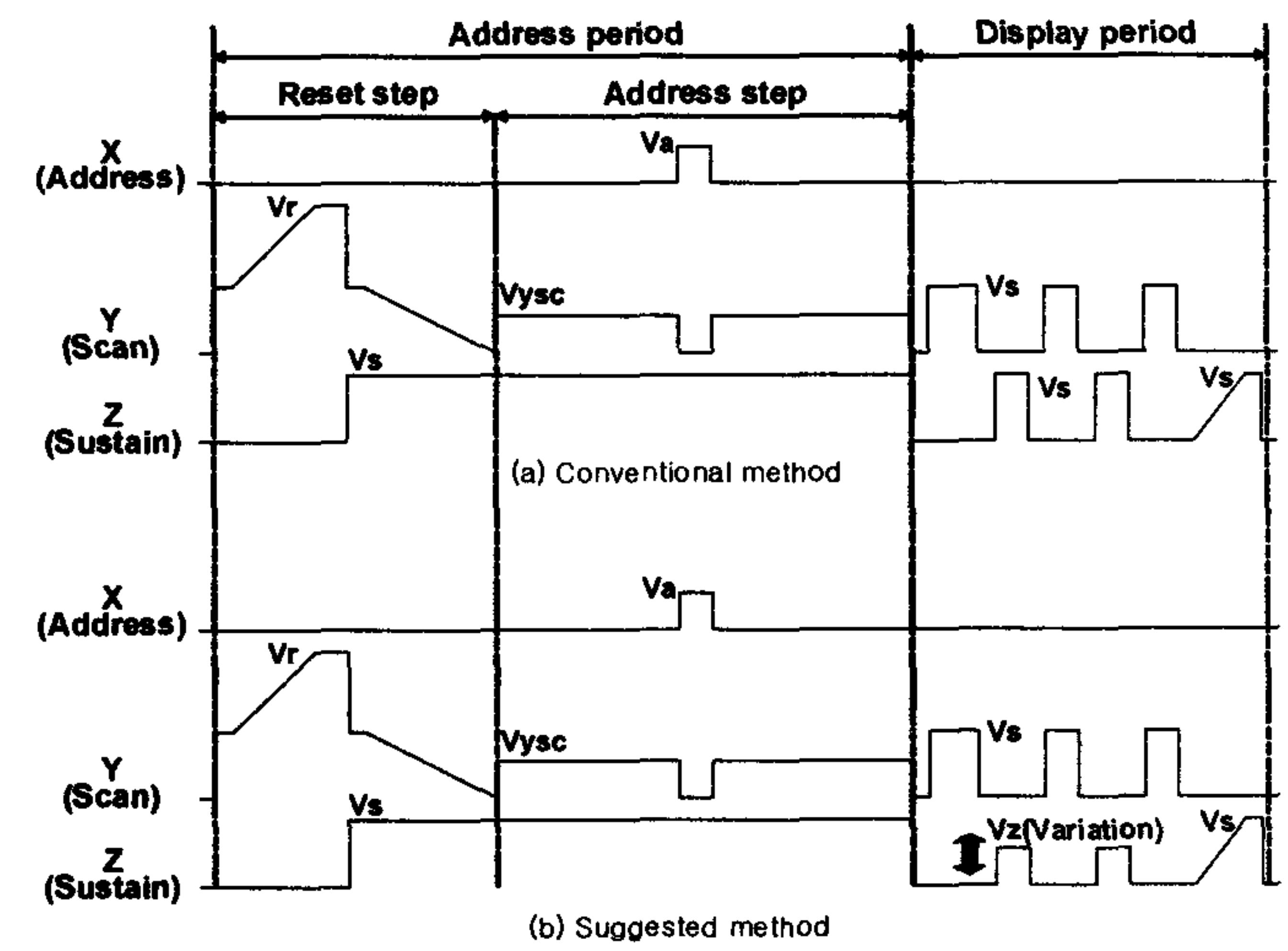

Fig. 2 Schematic diagram of driving waveform in the experimental (Ramp type ADS method).

3. Results and Discussion

Figure 3 shows current outputs for the variation of Vz that applies on a sustain electrode in the display period of ADS. The voltage of Vs that applies on a scan electrode is constant as 180V. Current outputs of display discharges increased linearly for the variation of Vz from 100V up to 180V.

Fig. 4 shows sustain pulses and time variation of current outputs in the display period of a 6 subfield. In the case of the conventional method, the voltage of Vs applies at the sustain and the scan electrodes as 180V together. Time variation of current outputs is constant as 0.5A such as Fig. 4(a). Fig. 4(b) shows sustain pulses and time variation of the suggested method. The voltage of Vs applies at the scan electrode, and that of Vz applies at the sustain electrode is 180V, and 130V, respectively. Current level is decreased fast during first to 2nd or 3rd pulse sequences and then maintained constant level as 0.2A. This means that the gap voltage between the sustain and the scan electrodes remains stable and constant level after transient state in spite of different voltages applied, that is, cells operate as if they are on the same location on the voltage transfer curve [8]. We speculate that following relation ship is satisfied for asymmetric driving condition.

$$V_{g\_high} = V_{s\_high} + V_{w\_low}$$
$$V_{g\_low} = V_{s\_low} + V_{w\_high}$$
$$V_{g\_high} \approx V_{g\_low} \text{ and } \Delta V_w \approx \text{Constant}$$

The subscripts 'g', and 's' represents gap, and sustain, respectively. V_{w_low}, and V_{w_high} is wall voltage established after distinction of low, and high sustain voltage discharge, respectively. It should be noted that all the gap and wall voltages mentioned above is averaged over multiple cells.

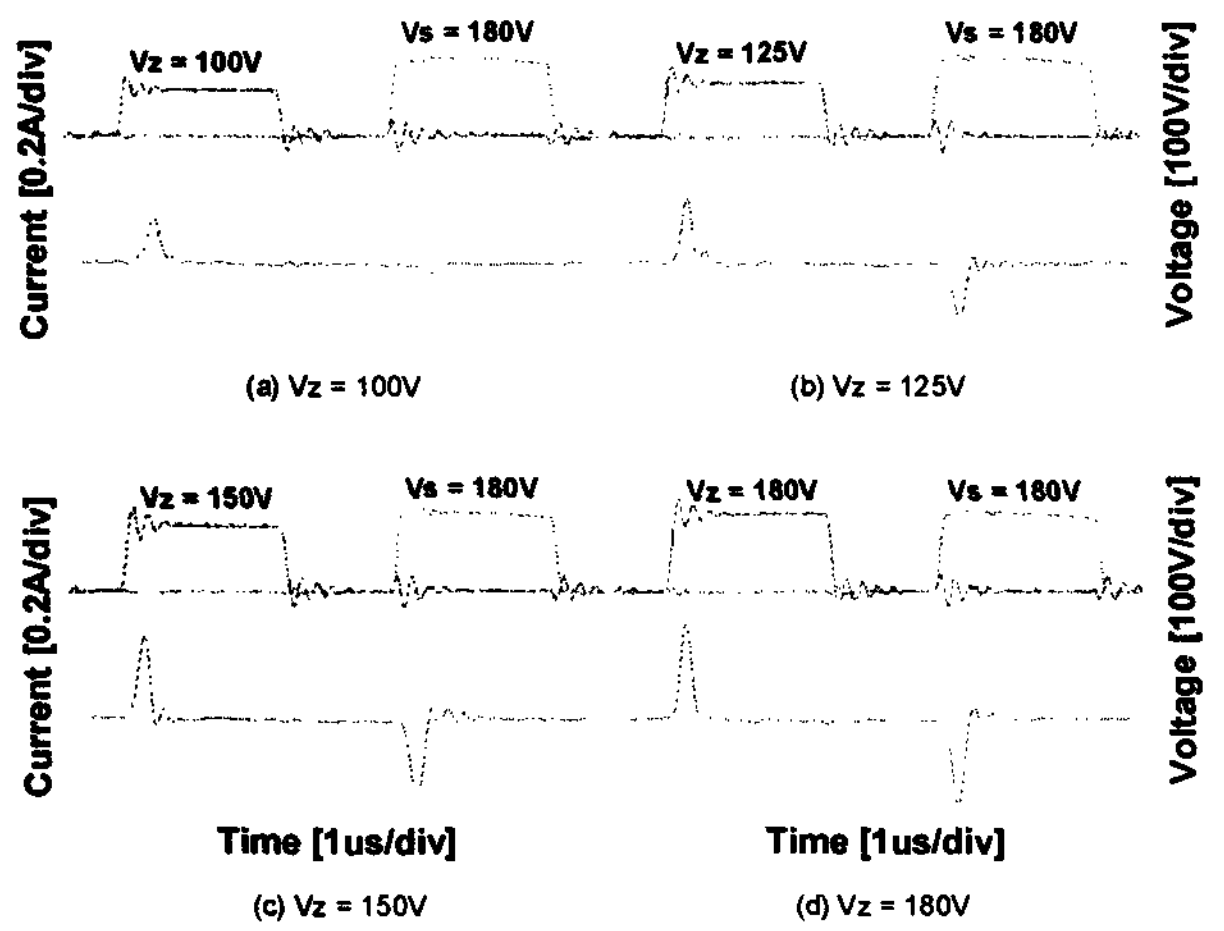

Fig. 3 Current outputs for the variation of Vz that applies on a sustain electrode in the display period of ADS

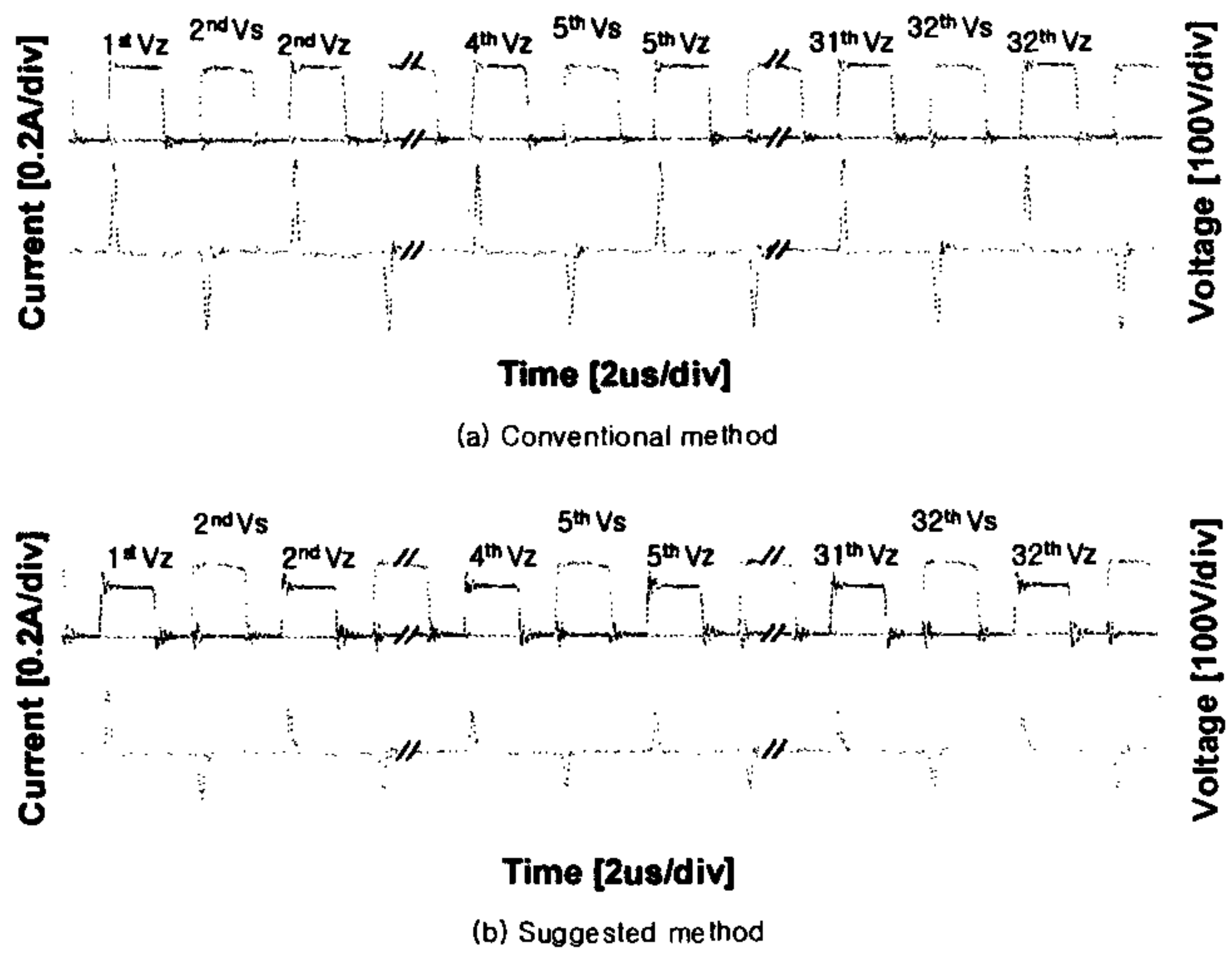

Fig. 4 Sustain pulses and time variation of current outputs in the display period of a 6 subfield

Fig. 5 shows luminance controllability for 12 gray and 256 gray levels with the sustain voltage of 180V at the scan electrode. The sustain voltage, Vz, of sustain electrode can be reduced down to 120V with the stable driving of cells. For the conventional case, we can reduce, at best, the sustain voltage down to 170. Resulting controllability of the luminance was correspond to 40~60% of its maximum luminance.

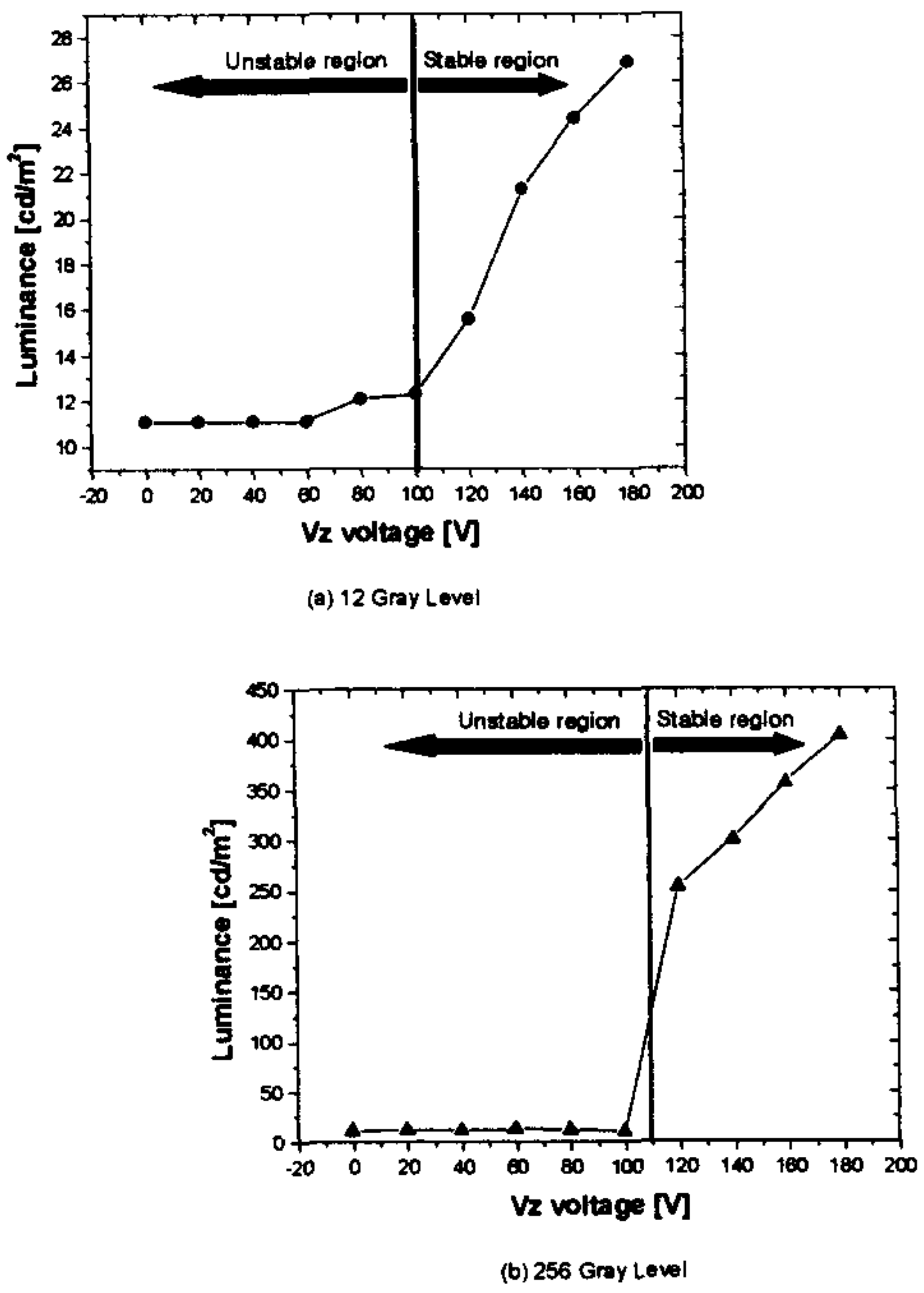

Fig. 5 Luminance controllability for 12 gray and 256 gray levels with the sustain voltage of 180V at the scan electrode.

Fig. 6 shows the range of variable luminance for the variation of a gray level. In the case of conventional method, when the gray level increases from 2 up to 50, each gray level has only one luminance weight. For example, the luminance weight of 2, and 50 gray levels is 3.7 [cd/m^2], and 87.4 [cd/m^2], respectively. In the case of suggested method, the voltage of Vz varies from 130 [V] up to 180 [V] at 10 [V] intervals. The luminance weight of each gray level varies for the variation of Vz. For example, the luminance weight of 50 gray level varies from 59.8 [cd/m^2] up to 87.4 [cd/m^2], and that of 2 gray level varies from 3 [cd/m^2] up to 3.7 [cd/m^2]. Therefore, the inferiority of the image quality for brightness-reduction of the whole panel can be prevented because the suggested method has the constant number of sustain pulses although luminance weight varies.

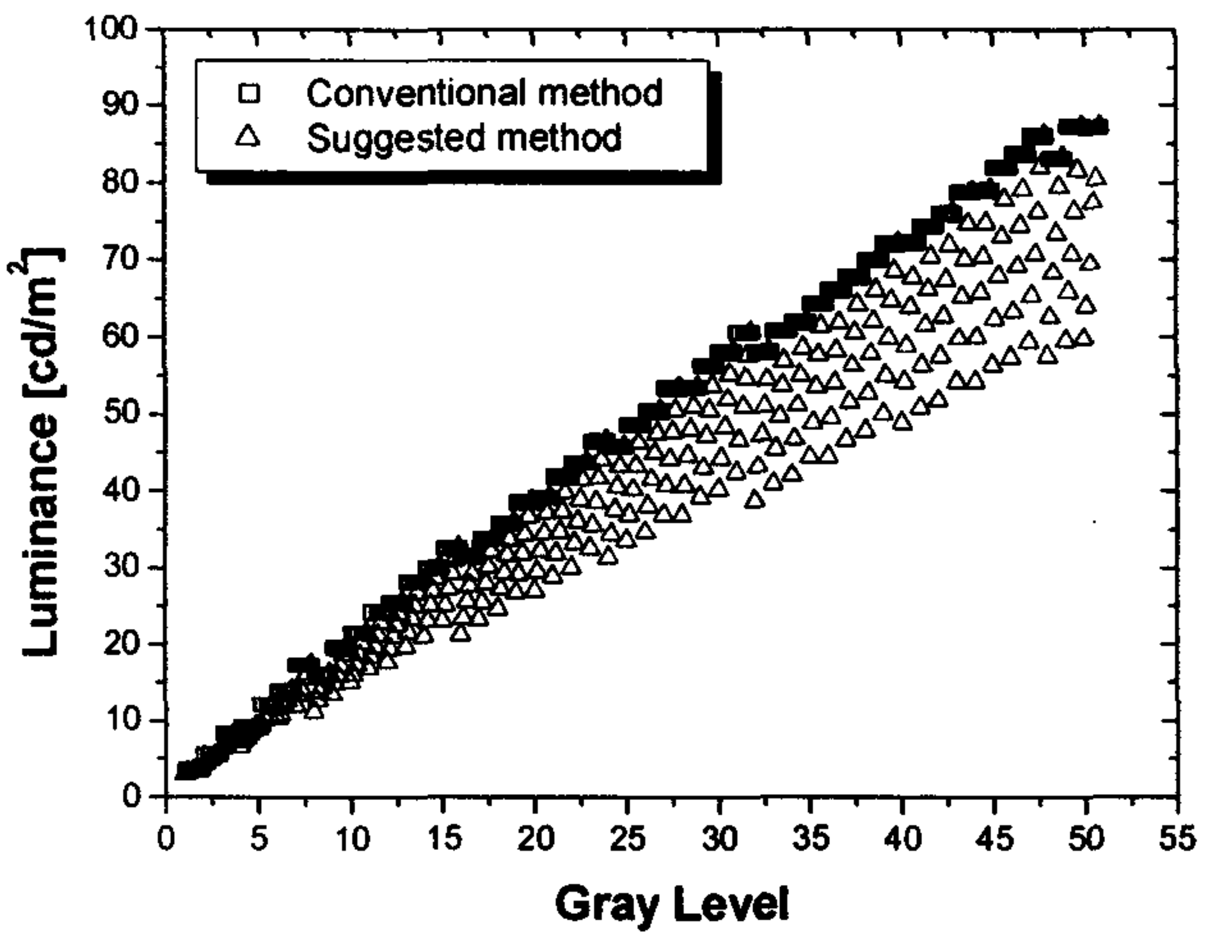

Fig. 6 Range of variable luminance for the variation of a gray level (2~50 gray level).

Dynamic margin characteristics between the reset voltage and the sustain voltage, Vs, of the scan electrode are shown in Fig. 7(a). And Fig. 7(b) shows dynamic margin characteristics between the address voltage and the sustain voltage, Vs. The sustain voltage, Vz, of sustain electrode was fixed to 130V in this case. Margin contours are shifted to the higher scan electrode voltage. These results are rather natural because the lower voltage is applied to the scan electrode side. However, the degree of shifting is less than about 10V, which is far smaller than the operation voltage reduction of the scan electrode.

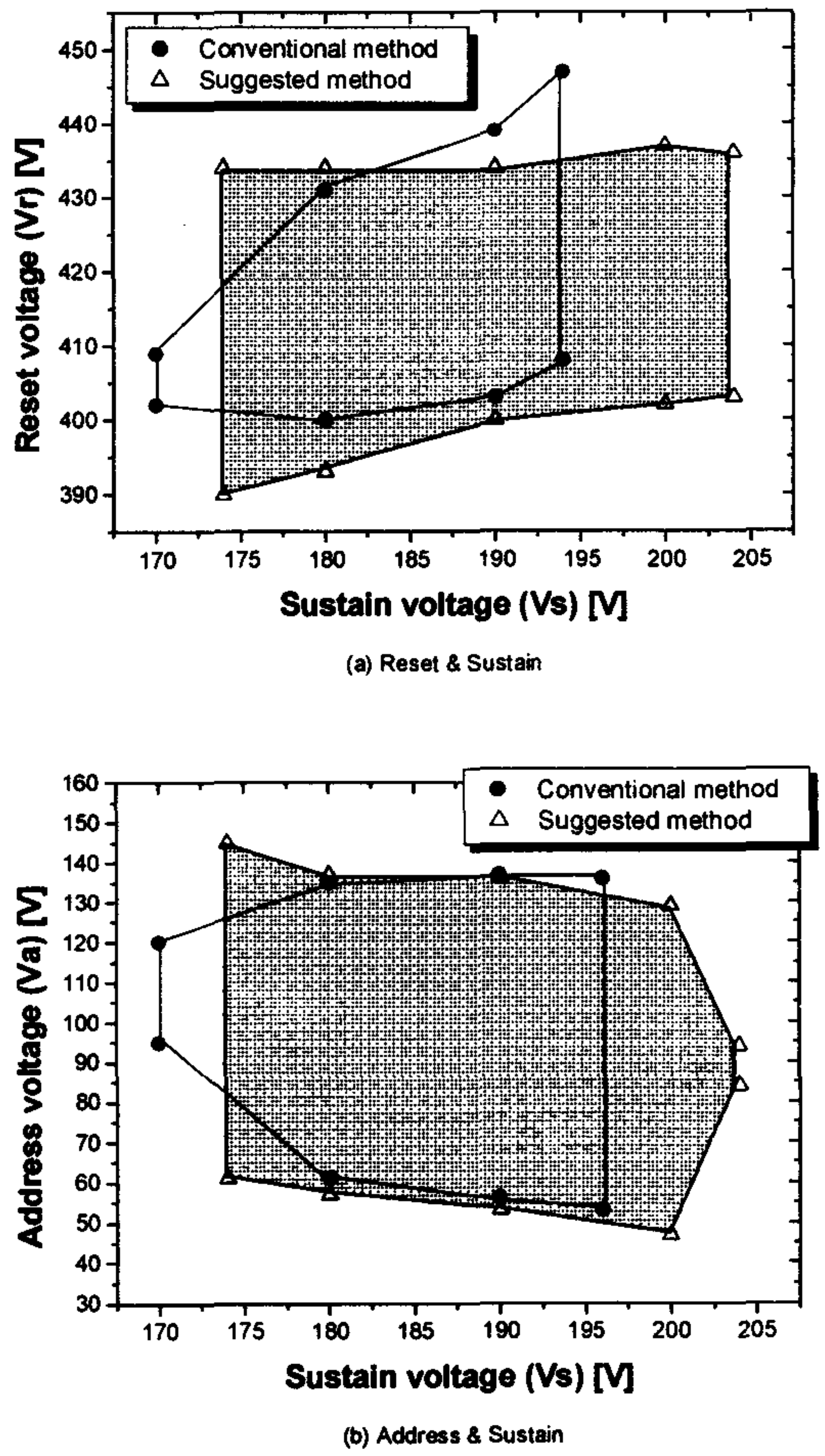

Fig. 7 Dynamic margin characteristics.

4 Conclusion

In this paper, in order to overcome the inferiority of the image quality for brightness-reduction of the whole panel and realizes independent control of panel brightness, a new driving method is suggested. The suggested method uses an asymmetric pulse amplitude of sustain electrode in the display period. As a result, a current level is decreased fast during first to 2nd or 3rd pulse sequences and then maintained constant level. Luminance reduction of about 50% was achieved except for pulse number modulation by the application of asymmetric pulse amplitude and the inferiority of the image quality for brightness-reduction of the whole panel can be prevented. Moreover, it was experimentally verified that the proposed method shows similar reset-sustain and address-sustain dynamic margin performances compare with the conventional method.

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