Improvement of Color Temperature using Auxiliary Address Pulse Driving Scheme in 42-in. WVGA Plasma Display Panel

Ki-Hyung Park, Eun-Cheol Lee, Ki-Duck Cho, Heung-Sik Tae, and Sung-Il Chien

Abstract

Auxiliary address pulse driving scheme is proposed for controlling and improving the color temperature of the 42-inch WVGA ac-plasma display panel (ac-PDP) without sacrificing total luminance. Under a white-background, the color temperature of 42-inch ac-PDP is improved by about 1,700 K, whereas under a black-background, the color temperature of 42-inch ac-PDP is improved by about 3,200 K. In addition, by properly controlling the luminance in the R, G, and B cells, the color temperature of 42-inch ac-PDP can be raised from 5,827K to 10,705K.

Keywords : ac-PDP, auxiliary pulse, color temperature, luminance

1. Introduction

A plasma display panel (PDP) is the most promising flat panel display device for large area (>40-in) full color wall-hanging digital high definition televisions (HDTVs). However, there are still some problems such as an image quality, a manufacturing cost, and a luminous efficiency. These problems will need to be eliminated in order for PDP to occupy the market of large flat panel display devices. In connection there to, the driving scheme was proposed to improve the color temperature by applying than auxiliary pulse to the address electrode during a sustain period [1, 2]. However, the validity of the driving scheme has only been examined with a small size (4 inch or 7 inch) test panel.

In this paper, an auxiliary address pulse driving scheme was proposed in order to improve the image quality of ac-PDP, such as a color temperature and it was verified by testing it on a 42-inch WVGA ac-PDP without using any additional equipments such as a circuit board and a DC-power supply.

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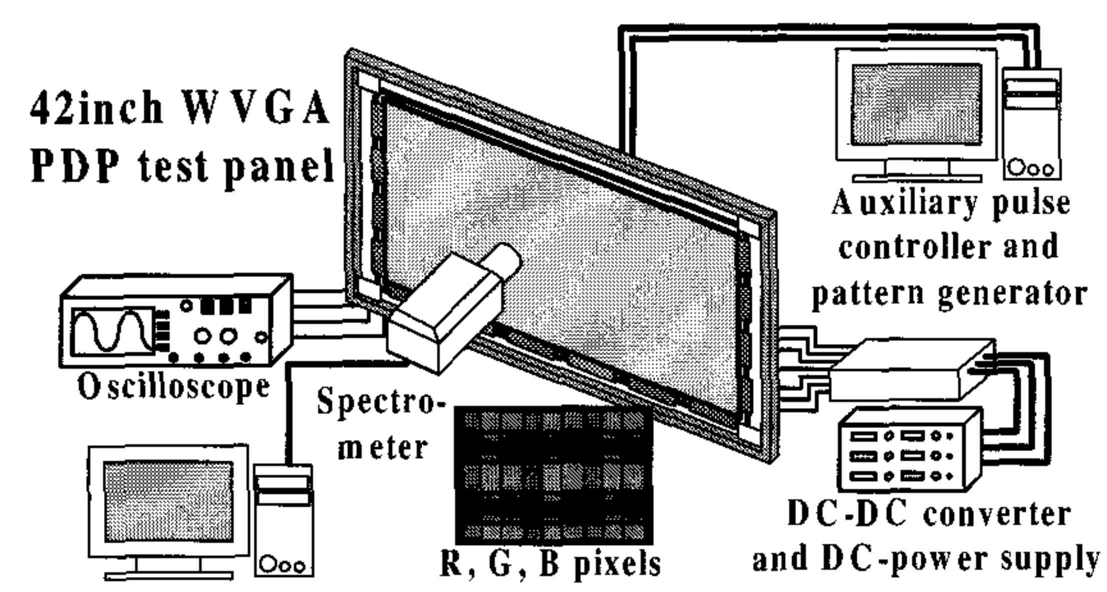
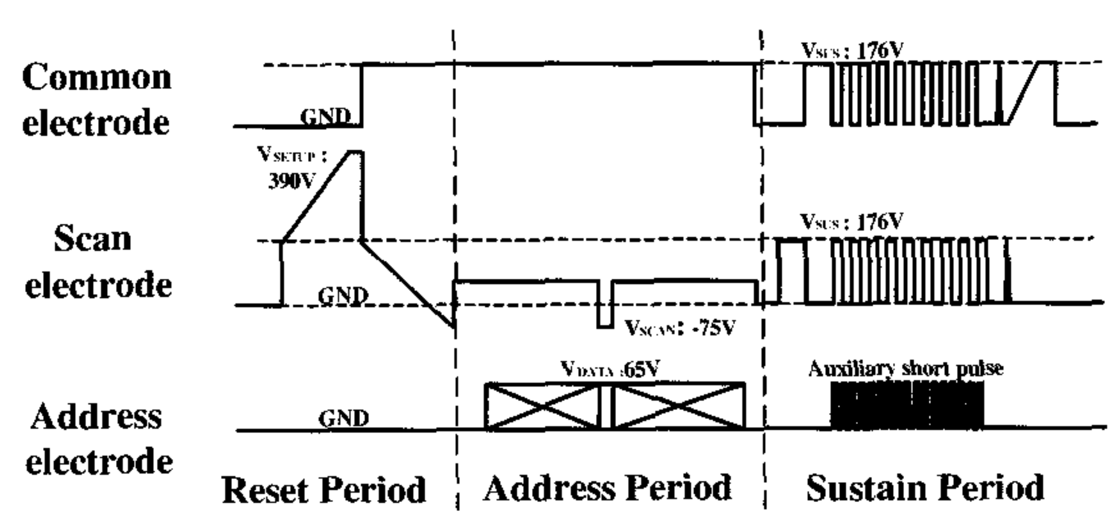
2. Experimental setup

Fig. 1 (a) shows a 42-inch WVGA ac-PDP test panel and optical-measurement systems that was employed in this experiment. The 42-inch WVGA ac-PDP panel used in this



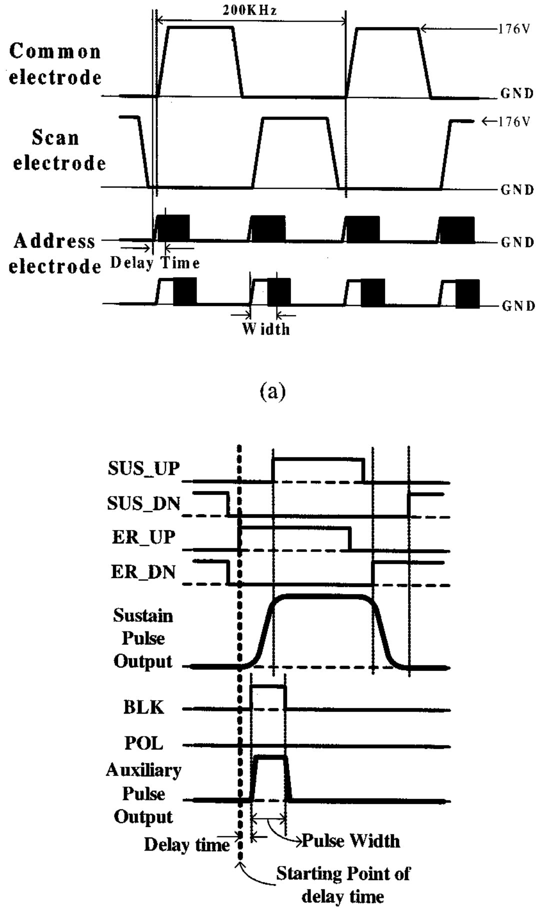
(a)



(b)

Fig. 1. Schematic diagram (a) of 42-inch WVGA ac-PDP test panel and optical-measurement system and one subfield driving waveforms (b) used in this study.

work is the same as the PDP-TV sold commercially. So, it has an asymmetric stripe barrier rib structure as shown in the picture of pixels in Fig. 1 (a) [3]. PR-704 spectrometer was used to measure the luminance and the spectrum of the visible light (380 nm~780 nm) emitted from the PDP panel. Fig. 1 (b) shows the corresponding driving waveform in a subfield used in this experiment. The common-electrode and scan-electrode waveforms were the same as those of the commercial product, whereas, in the new driving scheme, the auxiliary short pulses were applied to the address-electrode during a sustain-period to control the color temperature. For a driving margin, however, the auxiliary pulse was not applied to a pair of the first sustain pulse having a large width.



(a)

(b)

Fig. 2. Applied sustain pulse and auxiliary pulse (a) during sustain period and control signals (b) of sustain pulse and auxiliary pulse.

Fig. 2 (a), shows the driving waveforms applied to each electrode during a sustain-period except the reset- and address-period. The sustain voltage is 176 V and the sustain frequency is 200 kHz. The position and width of auxiliary pulses were controlled by the main control chip and ROM coded by the computer, whereas its amplitude could be easily controlled by the external dc-power supply shown in Fig. 1 (a). The amplitude of auxiliary pulses was fixed at 65 V and this voltage was the same as the one of address pulses during an address-period.

Table 1 is the power output truth table of data driver IC (STV7610A) used in 42-inch WVGA ac-PDP [4]. Signal BLK and POL were used to control the auxiliary pulse during a sustain-period. To obtain the high address voltage output, the signal BLK was set to be high and the signal POL was set to be low. On the other hand, to obtain the 0-level address voltage output, the signal BLK was set to be low. Fig. 2 (b) shows the timing of logic control signals and the output of a sustain pulse and an auxiliary pulse. The starting point of an auxiliary pulse's position was synchronized with ER_UP, as shown in Fig. 2 (b). Here, the ER_UP and ER_DN are the control signals for energy recovery circuit, whereas the SUS_UP and SUS_DN are the control signals of the sustain circuit.

Table 1. Truth table of data driver IC [STV7610]

Power Output Truth Table

Qn	STB	$\overline{BLK}$	$\overline{POL}$	Driver Output	Comment
X	X	L	X	L	Output low
X	X	H	L	H	Output high
X	H	H	H	Qn	Data latched
L	L	H	H	L	Data copied
H	L	H	H	H	Data copied

Fig. 3 shows the six image patterns used in this experiment, where the upper three red, green, and blue images are displayed under the white-background and

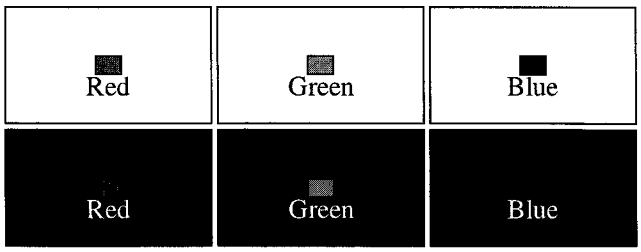


Fig. 3. Test image patterns with white- or black-backgrounds used in this experiment.

the lower three red, green, and blue images are displayed under the black-background. In order to control the power consumption, the 42-inch ac-PDP employed in this work has a function that the numbers of sustain pulses were varied according to the average luminance level of a displayed image. Then, the background of test images was white or black to fix the number of sustain pulses. Thus, the images under the black-background have the maximum sustain pulses, whereas the ones under the white-background have the minimum sustain pulses.

3. Results and discussion

Fig. 4 shows two different new driving schemes with auxiliary pulse during a sustain-period. The auxiliary pulse with short delay time (350 ns or 400 ns) and short pulse width (200 ns) is suggested as a luminance enhancing pulse for increasing the luminance, whereas the auxiliary pulses with relatively long delay time (900 ns) and wide pulse width (1000 ns) is proposed as a luminance lessening pulse for reducing the luminance without any disturbance of sustain discharge [2]. In the luminance enhancing pulse, when the red and green cells have 400 ns delay time and the blue cells have 350 ns delay time, the maximum increase of the luminance was achieved in the 42-inch ac-PDP used in the current research.

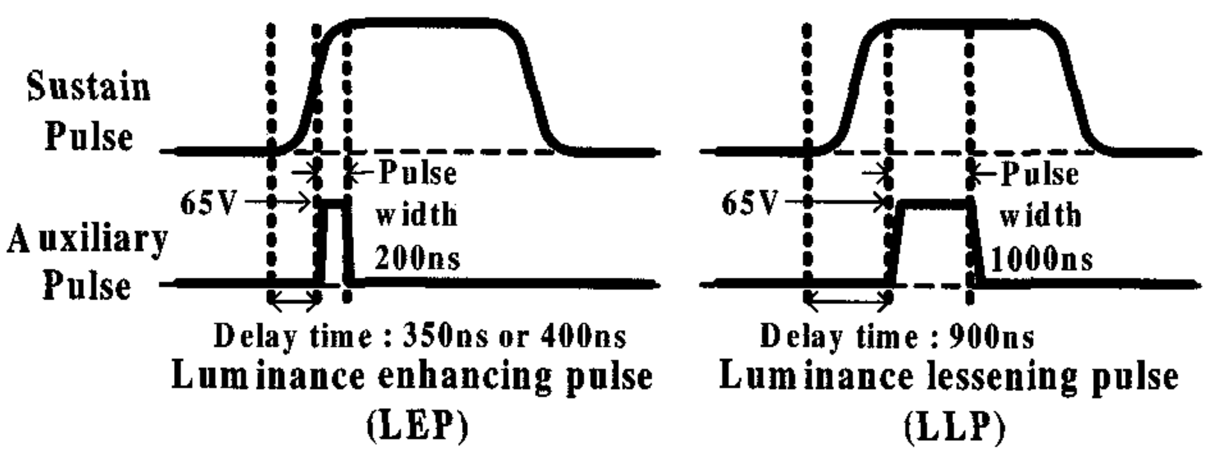


Fig. 4. Two different pulses for improving color temperature.

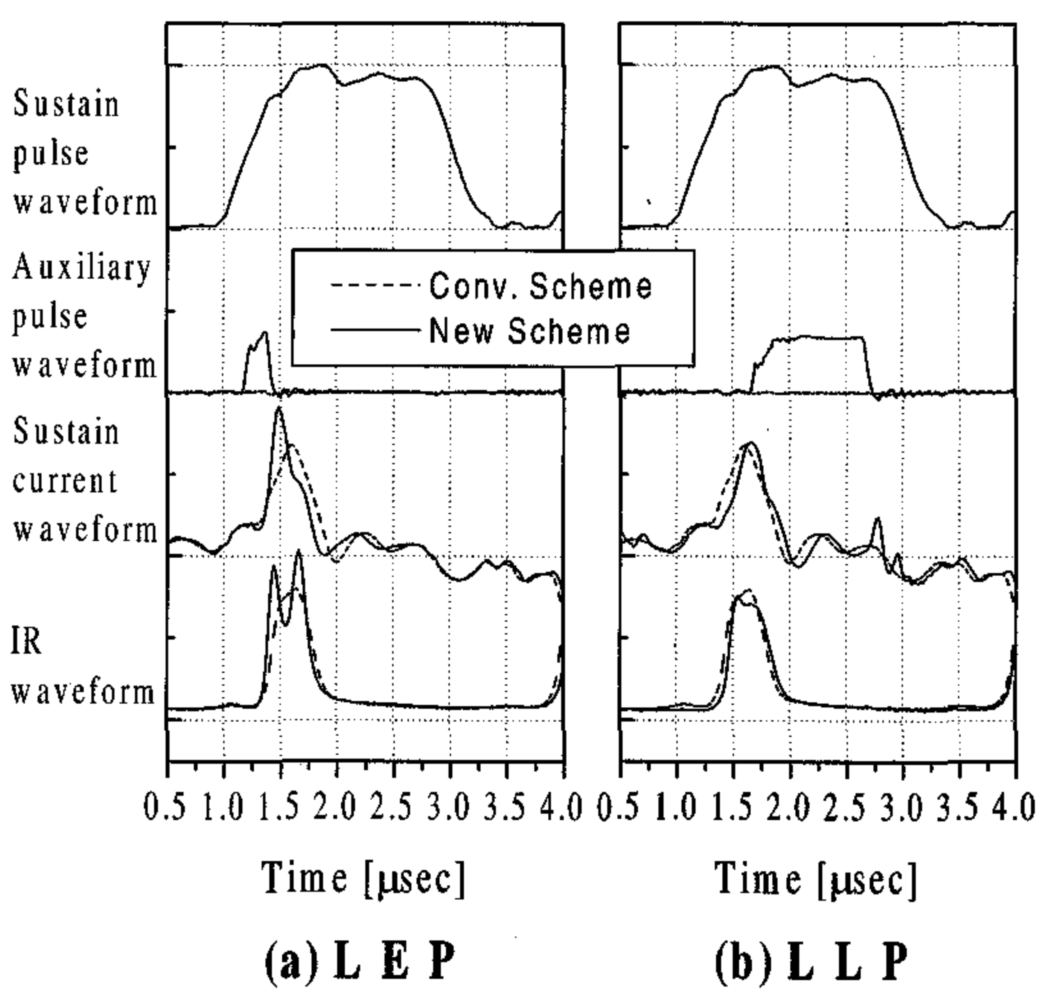


Fig. 5. Changes of sustain current and IR (828 nm) waveforms measured in case of adopting two different auxiliary pulses.

Fig. 5 shows the changes in the sustain current and IR waveforms captured from 42-inch ac-PDP under the full white pattern when two different cases of new driving scheme were applied. In the case where the luminance enhancing pulse (LEP, i.e., the delay time and pulse width of auxiliary pulse are 400 ns and 200 ns) was applied as shown on the left side (a) of Fig. 5, the peak of the discharge current was slightly shifted to the left direction and the corresponding IR peak intensity showing the double peaks was increased. This result indicates that the auxiliary pulses applied to the address electrode play significant role in enhancing the additional excitation toward the address electrode [2, 5]. On the other hand, in the case of where the luminance lessening pulse (LLP, i.e., the delay time and pulse width is 900 ns and 1000 ns) was applied as shown on the right side (b) of Fig. 5, the peak of sustain current moved to the right direction and the peak intensity of IR was decreased slightly. This is attributed to the slight suppression of the wall charge accumulation due to the application of auxiliary pulse during the sustain-period [2].

The changes in the luminance and the CIE color coordinates, x and y, of the R, G, and B cells are listed in Table 2 for both white and black, backgrounds the 'reference' data were measured under the conventional driving scheme, whereas the 'luminance enhancing' and 'luminance lessening' data were measured with the new driving scheme. As shown in Table 2, the luminance and

Table 2. Changes in luminance of R, G, and B cells with each background

		White-Background			Black-Background		
		Luminance	x	y	Luminance	x	y
Reference (Conv.)	Red	44.37 cd/m^2	0.5949	0.3604	167.4 cd/m^2	0.6281	0.3618
	Green	91.39 cd/m^2	0.2593	0.6458	346.2 cd/m^2	0.2603	0.6673
	Blue	22.59 cd/m^2	0.177	0.118	99.43 cd/m^2	0.168	0.0994
Luminance enhancing case	Red	47.85 cd/m^2	0.5909	0.3602	228.6 cd/m^2	0.6304	0.362
	Green	110.2 cd/m^2	0.2538	0.6497	435.5 cd/m^2	0.2539	0.6739
	Blue	27.43 cd/m^2	0.1691	0.1126	125.4 cd/m^2	0.1666	0.0984
Luminance lessening case	Red	40.9 cd/m^2	0.5906	0.3589	156.7 cd/m^2	0.6265	0.3617
	Green	86.09 cd/m^2	0.2606	0.6435	326.5 cd/m^2	0.2611	0.6656
	Blue	21.35 cd/m^2	0.1796	0.1203	93.74 cd/m^2	0.1708	0.1017

color purity varies depending on the color of the background. In the test panel used in this experiment, the total number of the sustain pulses for displaying the white background was 490, whereas the total number of the sustain pulses for displaying the black background was 1902. The difference in the sustain pulse between both background images was about four times. In the case of applying the LEP, under the white background, the luminance was increased by about 8 % (44.37 cd/m^2 → 47.85 cd/m^2) for the red cell, 21 % (91.39 cd/m^2 → 110.20 cd/m^2) for the green cell, and 21 % (22.59 cd/m^2 → 27.43 cd/m^2) for the cell. On the other hand, under the black background, the luminance was increased by about 36 % (167.4 cd/m^2 → 228.60 cd/m^2) for the red cell, 26 % (346.20 cd/m^2 → 435.50 cd/m^2) for the green cell, and 26 % (99.43 cd/m^2 → 125.40 cd/m^2) for the blue cell, respectively. In the case where the LLP was applied, under the white background, the luminance decreased by about 8 % (44.37 cd/m^2 → 40.90 cd/m^2) for the red cell, 6 % (91.39 cd/m^2 → 86.09 cd/m^2) for the green cell, and 6 % (22.59 cd/m^2 → 21.35 cd/m^2) for the blue cell. On the other hand, under the black background, the luminance decreased by about 6 % (167.4 cd/m^2 → 156.70 cd/m^2) for the red cell, 6 % (346.20 cd/m^2 → 326.50 cd/m^2) for the green cell, and 6 % (99.43 cd/m^2 → 93.74 cd/m^2) for the blue cell. These results show that the effect of applying the auxiliary pulses differs depending on the types of background images and the types of cells (i.e., red, blue, and green cells) in the 42-inch test panel. The reasons for this are as follows. First, the test PDP used in this work had an asymmetric stripe barrier rib structure, i.e., the discharge volumes were different for the R, G, and B cells. This caused the discharge characteristics in the R, G, and B cells to differ from one another when the auxiliary pulses were applied. Second, the amount of sustain current flow was varied according to the background image, causing the resultant variation in the sustain current to induced the distortion and the voltage-drop of the sustain waveform. Accordingly, when the test image patterns were displayed on the white-background, the amount of sustain current was increased, causing the resultant distortion and voltage drop of the sustain waveform to be come larger than that in the black-background. This large distortion and voltage drop of the sustain waveform in the white-background causes the discharge characteristics to deteriorate. Furthermore, since the distortion and voltage drop of the sustain waveform affects the initiation of the sustain discharge, they will more likely affect the LEP more than the LLP. Third, in the test PDP employed in this work, the number of the wide-width sustain pulses was 30 regardless of the number of the total sustain pulses. Under the white-background, the number of the total sustain pulses was 490, therefore the number of the sustain pulses with an auxiliary pulse was 460, except for the wide-width sustain pulses. On the other hand, in the case of the black-background, the number of the total sustain pulses was 1902, therefore the number of the sustain pulses with an auxiliary pulse is 1872, except for the wide-width sustain pulses. In the total sustain pulses, the application rate of auxiliary pulses was about 94% under the white-background but about 98% under the black-background. From these results, the difference in the application rate of the auxiliary pulse depending on the types of background images, i.e., white and black background images, can be said to induce the difference in the luminance increase rate according to the number of the total sustain pulses.

Fig. 6 shows the changes in the spectra emitted from the R, G, and B cells with black-background image, respectively. In this figure, the intensities of the R, G, and B lights changes separately, depending on the choice of the auxiliary pulsing conditions. This implies that the proposed auxiliary pulse is capable of controlling the R, G, and B luminance separately.

Table 3 shows the changes in the correlated color temperature, CIE color coordinates, x and y, and luminance. The values in Table 3 were calculated through an Inter-

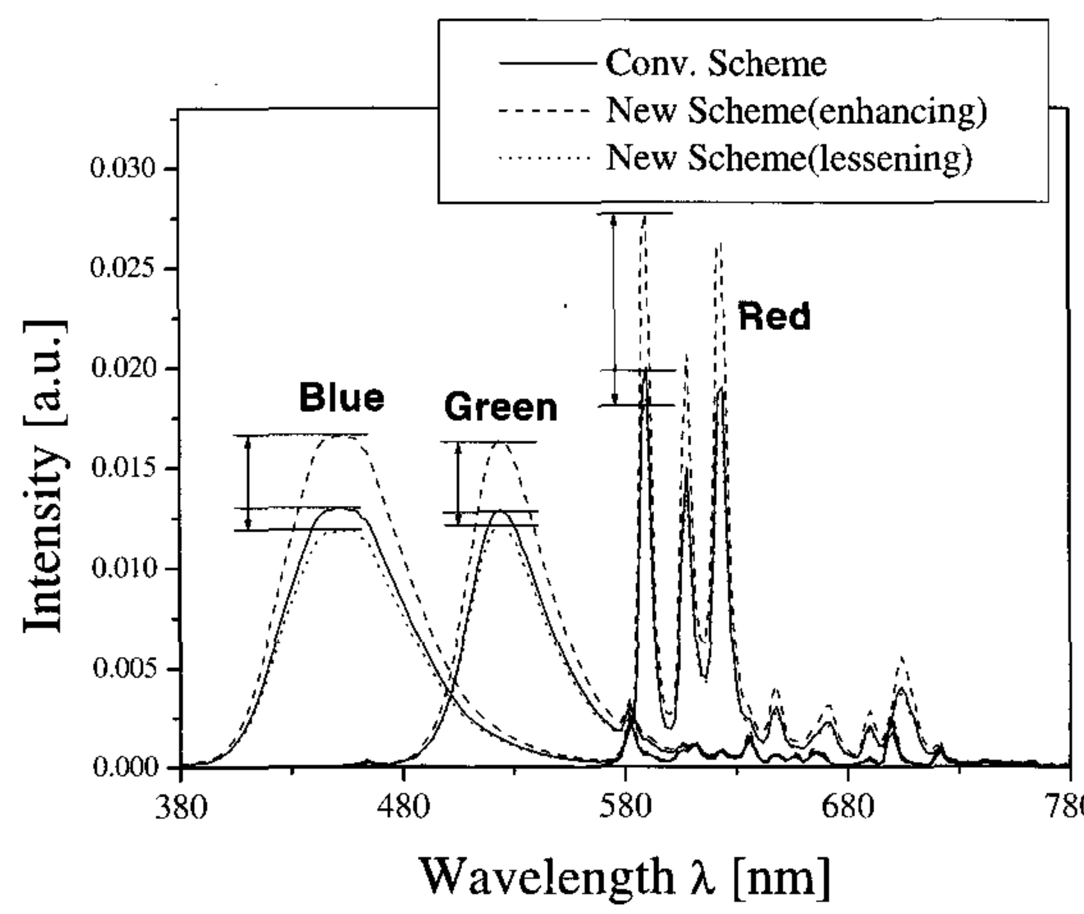


Fig. 6. Changes in spectra emitted from R, G, and B cells with black-background.

Table 3. Examples of change in correlated color temperatures, CIE color coordinates, and luminance

	White-Background				Black-Background			
	Color temp.	x	y	Luminance	Color temp.	x	y	Luminance
Ref.	6237 K	0.3154	0.3471	158.4 cd/m^2	7541.1 K	0.2997	0.3094	613.1 cd/m^2
Case A	7474.6 K	0.2975	0.3211	163.2 cd/m^2	10035 K	0.2829	0.2833	639.1 cd/m^2
Case B	6023.2 K	0.3201	0.3474	161.8 cd/m^2	5827.8 K	0.3262	0.3136	674.2 cd/m^2
Case C	7165.7 K	0.2981	0.3397	185.5 cd/m^2	7265.2 K	0.3036	0.3094	789.6 cd/m^2
Case D	6577.8 K	0.3086	0.3465	154.9 cd/m^2	7963.7 K	0.2944	0.3086	602.4 cd/m^2
Case E	7938.8 K	0.2911	0.3201	159.7 cd/m^2	10705 K	0.2781	0.2822	628.4 cd/m^2

Ref. : No auxiliary address pulse
Case A: Adopting the LEP to only the blue cells
Case B: Adopting the LEP to only the red cells
Case C: Adopting the LEP to the R, G, and B cells
Case D: Adopting the LLP to only the red cells
Case E: Adopting the LEP to the blue cells and the LLP to the red cells

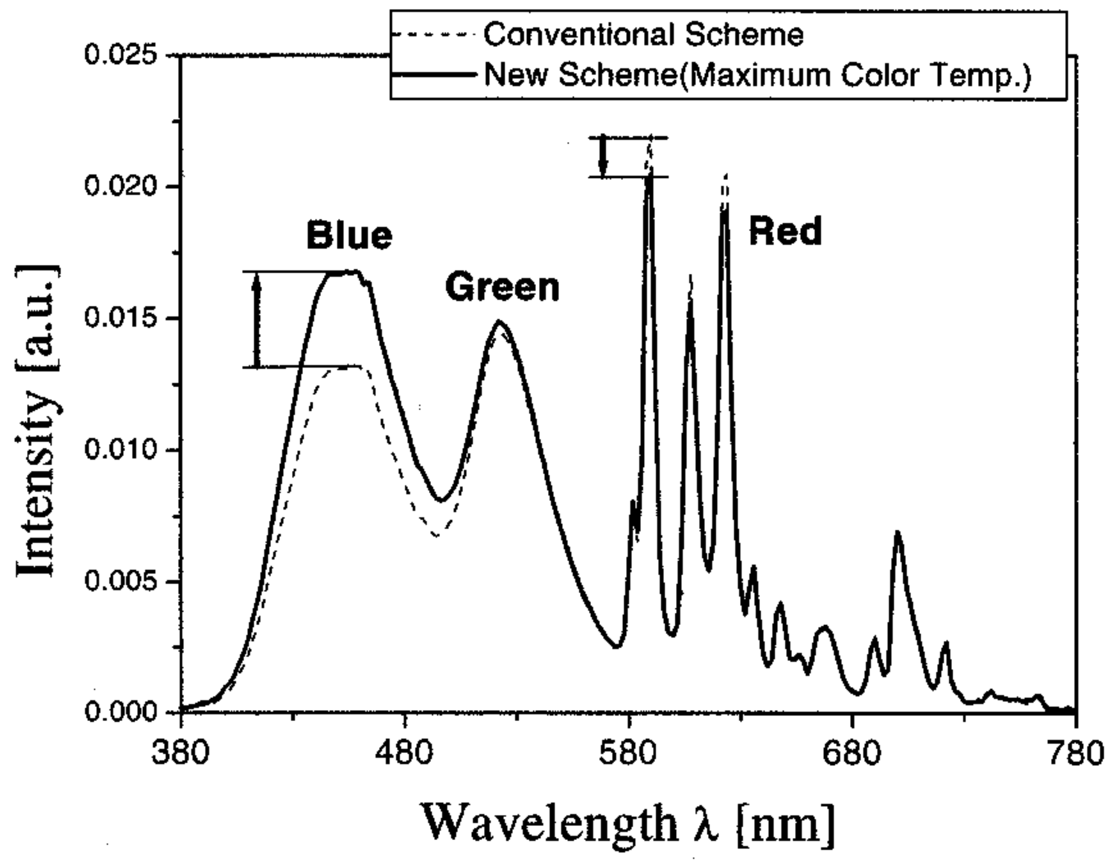
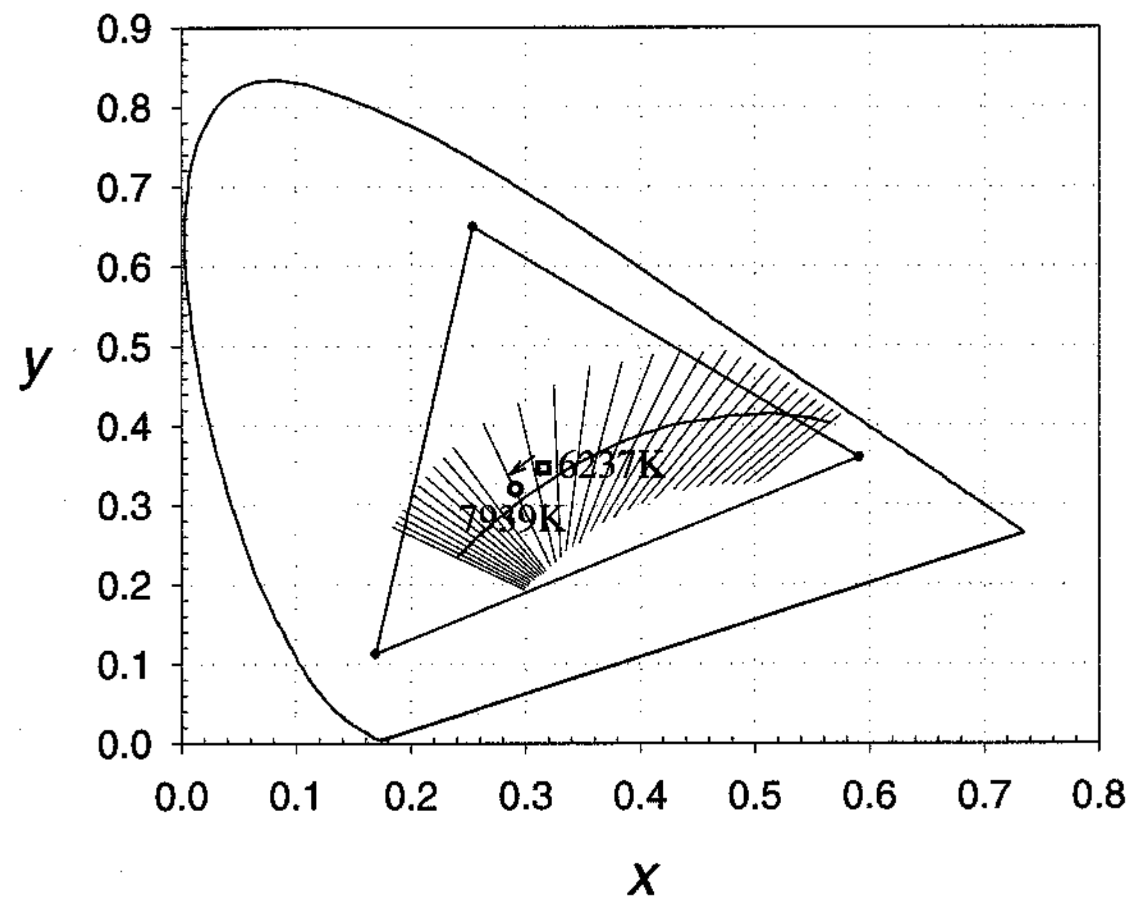
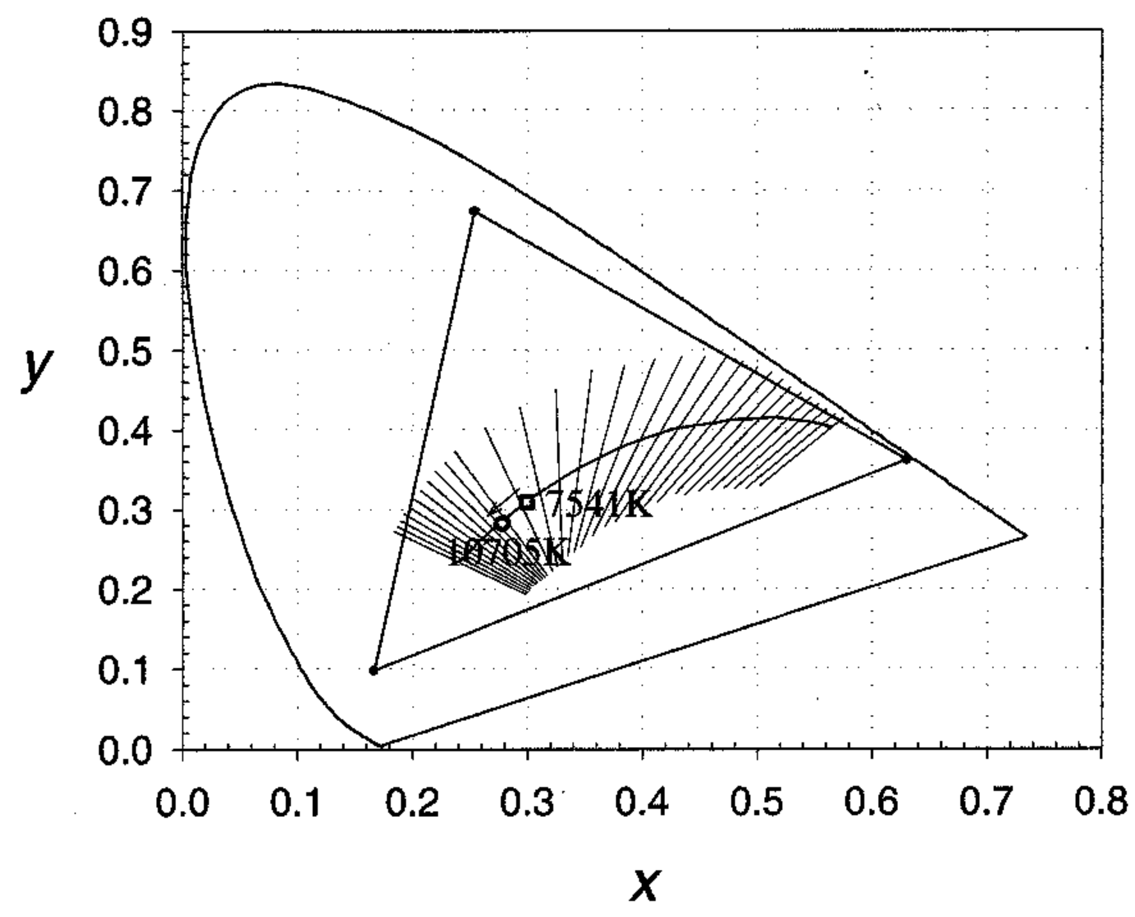


Fig. 7. Visible spectra of white color with black-background when color temperature was maximum.

polation method [6] by using the spectrum data shown in Fig. 6 which were measured by the PR-704 spectrometer when the luminance of the R, G, and B cells was controlled separately. The color temperature was varied from 5,828 K to 10,705 K when the various auxiliary pulses were applied according to way in Table 3. In Case E, i.e., when the blue luminance was increased and red luminance was decreased simultaneously, the color temperature improved to a maximum point of 3,200 K without any decrease in total luminance under the black-background. The visible spectra of white color in Case E were compared with those of white color in the conventional case, as shown in Fig. 7. Fig. 8 shows the changes in the color temperature of 'Case A' and 'Case E' of Table 3 related to the black body locus on CIE (1931) chromaticity coordinates. According to Fig. 8, in the case where the new driving scheme was adopted, the color temperature improved and the chromaticity coordinate was found to be close to the black body locus.



(a) White-background



(b) Black-background

Fig. 8. Changes in color temperatures related to black body locus on CIE (1931) chromaticity coordinates.

4. Conclusions

In this paper, an auxiliary address pulse driving scheme was introduced in order to improve the color temperature, and its validity was verified by testing it under various color image patterns of the 42-inch WVGA ac-PDP panel with about 1.2 million small discharge cells. By applying of the auxiliary address pulse driving scheme, the color temperature was controlled without using any additional equipment, and could be changed from 5,828 K (case B) to 10,705K (case E) on the black body locus without any reduction of the total luminance in the 42-inch

WVGA ac-PDP panel.

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