NEW DRIVING SCHEME FOR IMPROVING COLOR TEMPERATURE OF PLASMA DISPLAY PANEL

Heung-Sik Tae[1], Sung-Il Chien, Ki-Duck Cho and Sang Hun Jang
School of Electronic and Electrical Engineering, Kyungpook National University
1370, Sangyuk-Dong, Buk-Gu, Daegu, Korea
[1]E-mail: hstae@ee.knu.ac.kr

ABSTRACT

This paper presents a new driving scheme for improving the color temperature of Plasma Display Panel-Televisions (PDP-TVs). Auxiliary address pulses, plus sustain pulses applied to sustain electrodes, are applied only to address electrodes with blue phosphor layers during a sustain-period, thereby resulting in increasing the luminance of blue cells among the red, green, and blue cells. When compared with the conventional driving scheme, the proposed driving scheme can improve the color temperature of PDP-TVs without reducing the luminance.

1. INTRODUCTION

Plasma Display Panels (PDPs) have exhibited great potential as flat-panel devices for large-area (>40-inch) full-color wall -mounted digital High Definition Televisions (HDTVs) [1], [2]. Currently, 42-inch PDP-HDTVs are on the verge of being produced on a large scale as electric home appliances. However, for the successful commercialization of high quality digital HDTVs, further improvements to PDP-HDTVs are needed, especially in image quality, including contour noise, contrast ratio, and color temperature [3], [4], [5]. In particular, it is very important to improve the color temperature for the realization of a high quality color image in the digital PDP-TVs. The color image with a high color temperature can make a human eye feel more brilliant than that with a low color temperature. This work focuses on a new driving method for improving the color temperature of PDP-TVs.

In this work, the proposed driving scheme is compared with the conventional driving scheme. In addition, the effects of the new driving scheme on the improvement of the color temperature of a plasma display panel are examined based on the measurement of the color temperature of the white color in PDP-TV.

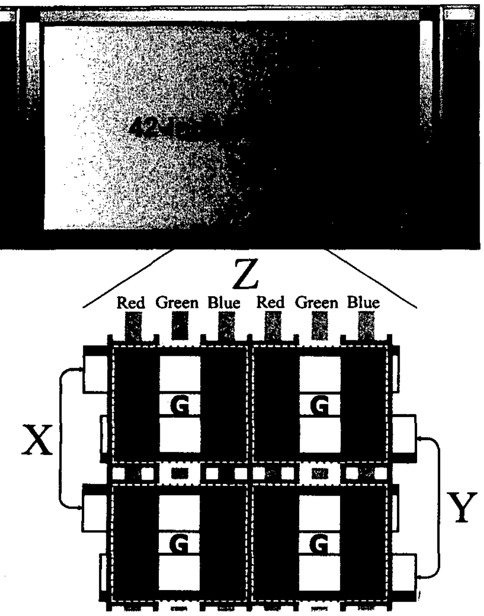
2. COLOR REPRODUCTION CHARACTERISTICS IN PLASMA DISPLAY PANEL

The full color realization of a PDP-TV is made through the combination of the red, green, and blue visible lights emitted from the stimulation of the red, green, and blue phosphor layers in the PDP cells. The red, green, and blue phosphor layers are only excited by the vacuum ultraviolet (VUV; 147 nm, or 173 nm) produced from Xe or Ne excitation during the plasma discharge in the PDP cells, so that the red, green, and blue visible lights are produced from the VUV stimulation of the red, green, and blue phosphor layers. Accordingly, the qualities of the red, green, and blue colors are determined by the conversion characteristics of the phosphor layers into the visible emission, indicating that the color reproduction characteristics in PDP-TVs inherently depend on the interaction between the phosphor layers and the VUV emission produced during the plasma discharge.

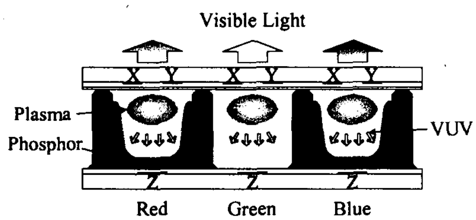
Figure 1 (a) shows the top view of conventional red (R), green (G), and blue (B) cell configurations of a 42-inch PDP-TV and the related three electrodes, X, Y, and Z, where X and Y are the sustain electrodes and Z is the address electrode. The sustain electrodes, X, and Y are used in a sustain-period, during which the red, green, and blue visible lights are emitted for displaying an information, while the address electrode, Z is used in an address-period, during which the wall charges are accumulated for the subsequent sustain-period. One single pixel, which is the minimum unit for producing a full color image, consists of the R, G, and B cells, and its dimension is 1080 μm in the VGA degree of a PDP-TV.

Figure 1 (b) shows the cross sectional view of a single pixel of a 42-inch PDP-TV. When the sustain voltage pulses applied alternately to the sustain electrodes, X and Y are greater than the breakdown voltage, the plasma discharge is produced in the R, G, and B cells, and the VUV is generated during the plasma discharge. The red, green, and blue lights are emitted from the R, G, and B phosphor layers stimulated by the VUV emission. In addition, the visible emission is emitted from the gas discharge itself in the cells. In other words, the orange light of 585 nm wavelength is emitted due to the excitation of Ne during the plasma discharge. This Ne visible peak from the gas discharge is a main source for the degradation of the color purity in the PDP-TVs. Accordingly, the full color gray scales in the PDP-TVs are realized through

Manuscript received June 25, 2001



(a) Top View



(b) Cross-sectional View for a single pixel

Fig. 1. Conventional cell structure of 42-inch PDP-TV and layout of three electrodes, X, Y, and Z, where X and Y are the sustain electrodes and Z is the address electrode.

the combination of the red, green, and blue visible lights including the Ne orange emission.

3. COLOR TEMPERATURE IN PLASMA DISPLAY PANEL

A low color temperature in PDP-TV results from a low intensity of the blue light emitted from the stimulation of a blue phosphor layer, as compared with that emitted from red or green phosphor layers. This problem is inherently due to the low quantum efficiency of a blue phosphor material itself. In the current PDP technology, it is very difficult to develop a new blue phosphor material with high quantum efficiency. Accordingly, in addition to developing a new blue phosphor material, there has been lots of research on the development of a color temperature in PDP-TVs.

An asymmetric barrier rib structure was suggested to improve the color temperature [6]. However, this type of structure causes a decrease in the luminance and perturbation of the discharge conditions due to the asymmetric discharge volume among the red, green, and blue cells. In particular, this method can cause the decrease in the voltage margin between the data writing and the data display, which is a requisite for the stable driving.

Another approach has been suggested to improve the color temperature using the optical filter [7, 8]. The key idea is to reduce the orange color emission of 585 nm using the optical color filter. This unnecessary orange color is produced from the Ne excitation, which is necessary for the low voltage plasma discharge. In addition, since the Ne visible emission produces an intensive luminance, it contributes to increasing the luminance of PDP-TVs. Accordingly, the optical filter has a disadvantage of reducing the luminance of PDP-TVs, even though it can improve the color temperature.

As an alternative method, signal processing that reduces the number of sustain pulses for displaying a green and red color has been utilized to improve the color temperature of PDP-TVs. This method is based on the reduction of the red and green luminance because of the low blue luminance in PDP-TVs. Consequently, this method also causes a serious degradation in the image quality when displaying a green and red gradation image.

Accordingly, this study proposes a new driving method, which directly enhances the intensity of the blue light emitted from the blue cells by applying auxiliary voltage pulses to only the blue phosphor layers in the address electrode during a sustain-period, thereby improving the color temperature of PDP-TVs.

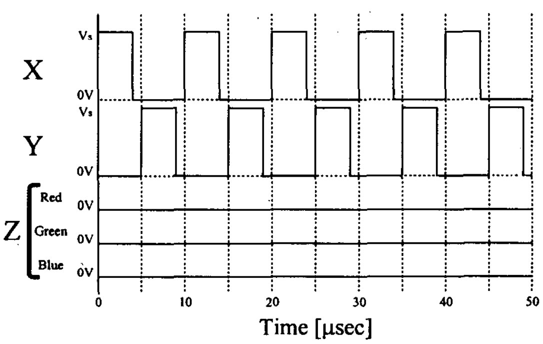


Fig. 2. Conventional driving scheme for voltage pulses applied to three electrodes X, Y, and Z during sustain-period.

4. CONVENTIONAL DRIVING WAVEFORMS IN SUSTAIN PERIOD

Figure 2 shows the conventional driving scheme for the voltage sustain pulses applied to the three electrodes, X, Y, and Z, during a sustain-period. The red, green, and blue visible lights for displaying information are emitted during a sustain-period. As shown in Fig.2, the sustain voltage pulses are alternately applied only to the sustain electrodes X and Y so as to emit the red, green, and blue lights for displaying a full-color image, whereas no voltage pulses are applied to the address electrode Z during the sustain-period.

In general, the address electrode Z is only used when preparing an accumulation of wall charges prior to a sustain-period during which full-color images are displayed. In other words, the address electrode Z is only used during an address-period, and not during a sustain-period. As shown in Fig.1 (a), the sustain electrodes X, and Y are commonly located on the R, G, and B cells. Consequently, the luminance of the R, G, and B cells increases or decrease simultaneously depending on the variation of sustain voltage or driving frequency. Hence, the conventional driving scheme shown in Fig. 2 cannot improve the color temperature if the cell structure has a symmetrical configuration shown in Fig.1(a).

5. NEW DRIVING WAVEFORMS IN SUSTAIN PERIOD FOR IMPROVING COLOR TEMPERATURE

Figure 3 shows the new driving scheme in which voltage pulses are applied to all three electrodes, X, Y, and Z, during a sustain-period. As shown in Fig.3, square sustain pulses are applied to the sustain electrodes X and Y with a frequency of 100KHz and a duty ratio of 40 %. The used gases are Ne (96 %) and Xe (4 %) and the pressure in the cells is 400 Torr. Simultaneously, auxiliary voltage pulses with an amplitude of 150 V and width of 800 nsec are applied to only the blue phosphor layers in the address electrode Z in the rising edges of the sustain pulses. These auxiliary pulses then can excite the atoms near the address electrode, if the widths and amplitudes are properly controlled, thereby improving the luminance of the blue cells. We have already reported the improvement of luminance and luminous efficiency using the address voltage pulse during a sustain-period [9]. The detailed physical mechanism for improving the luminance and luminous efficiency due to the auxiliary address voltage pulses are explained in the reference of [10].

We have measured the white lights emitted form the one hundred pixels comprising the 100 red cells, 100 green cells, and 100 blue cells in the PDP-TV, using the PR-704 photo-spectrometer. Figure 4 shows the changes in the spectrum of the red, green, and blue lights emitted from the one hundred pixels of the PDP-TV in the case of applying the auxiliary address voltage pulse with an amplitude of 150V and a width of 800 nsec to the blue cells with the blue phosphor layers.

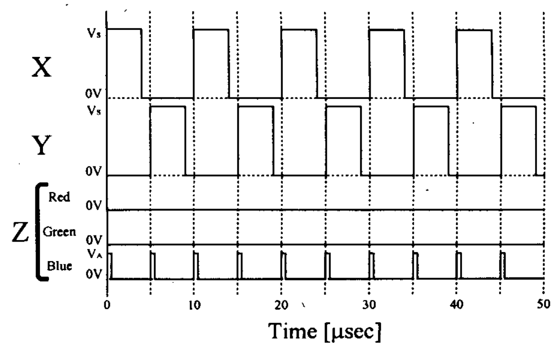


Fig. 3. New driving scheme for voltage pulses applied to three electrodes X, Y, and Z during sustain-period.

As shown in Fig.4, when these auxiliary voltage pulses with very short widths are uniquely applied to the blue phosphor layers in the Z address electrodes, only the blue light intensity emitted from the blue cells is increased without affecting the green and red light intensities. This indicates that the color temperature of PDP-TV can be improved without a decrease in the total luminance, even though PDP-TV has a symmetrical red, green, and blue cell structure.

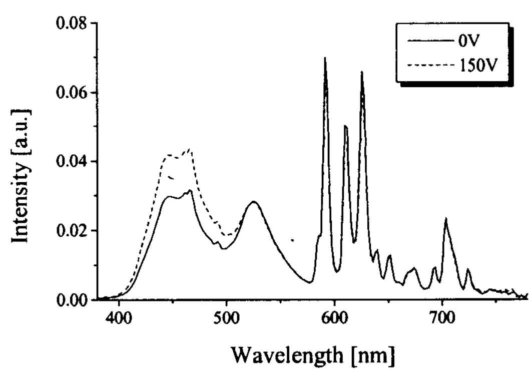


Fig. 4. Changes in spectrum of R, G, and B light emitted from PDP-TV relative to variation in auxiliary pulse voltage applied to blue phosphor layers in Z address electrode during sustain-period.

Figure 5 shows the changes in the color temperature of PDP-TV when the auxiliary address voltage pulses applied the Z address electrodes with blue phosphor layers increase from 0 V to 150 V. At the 0 V condition, that is, when any other auxiliary address voltage pulse except the sustain voltage pulses is not applied to the Z address electrode, the color temperature of 5,400 K is obtained, and its chromaticity coordinate is (0.333, 0.301), as shown in Fig. 5. When the auxiliary address voltage pulses with an amplitude of 150 V and a width of 800 nsec, are applied to the Z address with the blue phosphor layers plus the sustain voltage pulses during a sustain-period, the color temperature of 8,400 K is obtained, and its chromaticity coordinate is (0.302, 0.271), as shown in Fig.5. The auxiliary address voltage pulses due to the increase in the blue luminance cause the 55% improvement of the color temperature.

In conclusion, the color temperature is improved from 5,400 K to 8,400 K without a decrease in the total luminance of PDP-TV using the new driving scheme. We expect that the color temperature of PDP-TV can be improved above 10,000 K if the amplitude and width of the auxiliary address voltage pulses are properly controlled.

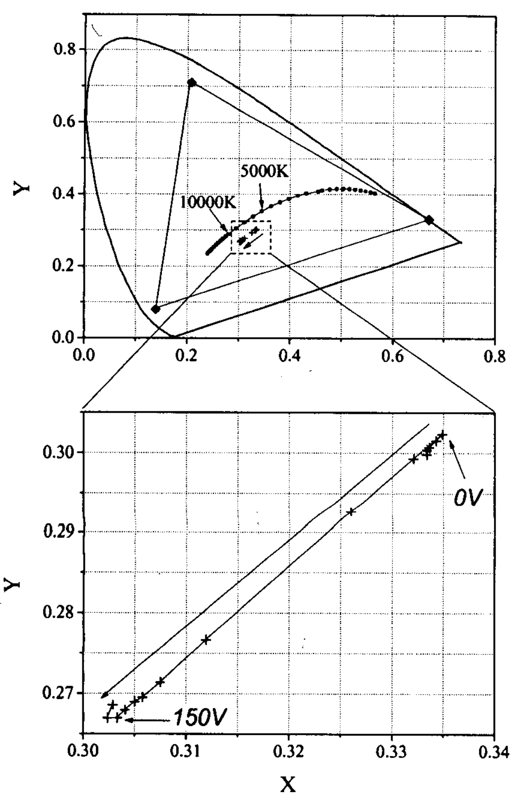


Fig. 5. Changes in color temperature of PDP-TV relative to increase in auxiliary pulse voltage applied to Z address electrode during sustain-period

6. CONCLUSION

A new driving-scheme for improving the color temperature of Plasma Display Panel-TVs is proposed. Auxiliary pulses are applied only to address electrodes with blue phosphor layers during a sustain-period, thereby resulting in increasing the luminance of blue cells. When compared with the conventional driving scheme, the proposed driving scheme can improve the color temperature without a decrease in the luminance of Plasma Display Panel-TVs based on the changes in the amplitudes of auxiliary address voltage pulses.

ACKNOWLEDGEMENTS

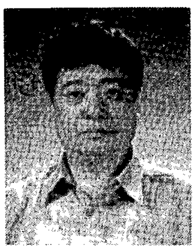
This work was supported by the Brain Korea 21 project in 2001.

REFERENCES

[1] Bernard Mercier, Eric Benoit, and Yves Blanche, "A New Video Storage Architecture For Plasma Display Panels", *IEEE Trans. Consumer Electronics,* Vol.42, No.1, February 1996, pp.121-127.
[2] T. Kurita, M. Seki, J. Koike, Y. Takano, T. Yamamoto, H. Kokubun, K. Kobayashi, H. Murakami, Y. Sasaoka, and K. Takahashi, "A 42-INCH DIAGONAL HDTV PLASMA DISPLAY", *Proceedings of International Conferences on Consumer Electronics,* 1997, pp.55-58.
[3] Shigeo Mikoshiba, "Visual Artifacts Generated in Frame-Sequential Display Devices: An Overview", *SID '00 Digest*, 2000, pp.384-387.
[4] Larry F. Weber, "Plasma Display Device Challenges", *Asia Display '98 Digest*, 1998, pp.15-27.
[5] T. Okamura, S. Fukuda, K. Koike, H. Saigou, T. Kitagawa, M. Yoshikai, M. Koyama, T. Misawa, and Y. Matsuzaki, "PDP Optical Filter with Sputtered Multilayer Coatings and Organic Dyes", *IDW '00 Digest*, 2000, pp.783-786.
[6] Larry F. Weber, "The Promise of Plasma Displays for HDTV", *SID '00 Digest*, 2000, pp.402-405.
[7] Y. Sano, T. Nakamura, K. Numomura, T. Konishi, M. Usui, A. Tanaka, A. Tanaka, T. Yoshida, T. Yoshida, H. Yamada, O. Oida, and R. Fujimura, "High-Contrast 50-in. Color ac Plasma Display with 1365×768 Pixels", *SID'98 Digest, 1998*, pp.275-278.
[8] T. Okamura, S. Fukuda, K. Koike, H. Saigou, T. Kitagawa, M. Yoshikai, M. koyama, T. Misawa and Y. Matsuzaki, "PDP Optical Filter with Sputtered Multilayer Coatings and Organic Dyes", *IDW'00 Digest*, 2000, pp.783-786.
[9] Sang Hun Jang, Ki-Duck Cho, Heung-Sik Tae, Byungcho Choi, and kyung Cheol Choi, "Improvement of Luminance and Luminous Efficiency Using Address Voltage Pulse during Sustain-Period of AC-PDPs", *IDW'00 Digest*, 2000, pp767-770.
[10] Sang-Hun Jang, Ki-Duck Cho, Heung-Sik Tae, Kyung Cheol Choi, and Seok-Hyun Lee, "Improvement of Luminous and Luminous Efficiency using Address Voltage Pulse during Sustain-Period of AC-PDP", accepted for publication of *IEEE Transaction on Electron Devices*, 2001.

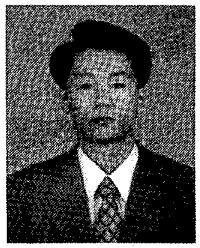
BIOGRAPHY

Heung-Sik Tae received the B.S. degree in electrical engineering from Seoul National University, Seoul, Korea, in 1986 and M.S. degree and Ph.D. in plasma engineering from Seoul National University in 1988 and 1994, respectively. Since 1995, he has been as associate professor in School of Electronic and Electrical Engineering, Kyungpook National University in Daegu, Korea. His research interests include the optical characterization and driving circuit of plasma display panel, the design of millimeter wave guiding structure, and MEMS or thick-film processing for millimeter wave devices. Dr. Tae is a member of IEEE and also a member of the Society for Information Display (SID).



Sung Il Chien received the B.S. degree from Seoul National University, Seoul, Korea, in 1977, and the M.S. degree from the Korea Advanced Institute of Science and Technology, Seoul, Korea, in 1981, and Ph.D. degree in electrical and computer engineering from Carnegie Mellon University in 1988. Since 1981, he has been with School of Electronic and Electrical Engineering, Kyungpook National University, Daegu, Korea, where he is currently a professor. His research interests are computer vision, and color image processing. Dr. Chien is a member of IEEE.

Ki-Duck Cho received the B.S. and M.S. degree in electronic engineering from Kyungpook National University, Daegu, Korea, in 1999 and 2001, respectively. He is currently working for the Ph.D. degree in electronic engineering at Kyungpook National University. His current research interests include the driving circuit design of PDPs (Plasma Display Panels).



Sang-Hun Jang received the B.S. and M.S. degree in electrical engineering from Kyungpook National University, Daegu, Korea, in 1996 and 1998, respectively. He is currently working for the Ph.D. degree in electronic engineering at Kyungpook National University. His current research interests include the design and fabrication technique of new cell structure in an AC-PDP.