Improvement of Low Gray Scale Linearity using Multi-Luminance-Level Subfield Method in Plasma Display Panel

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ABSTRACT

New multi-luminance-level subfield method is proposed to improve the low gray-level color reproducibility of Plasma Display Panel. Multi-luminance levels can be expressed per sustain pulse in low gray scale by applying the different auxiliary pulses in the same sustain-pulse subfields, thereby suppressing a low gray-level contour.

I. INTRODUCTION

Plasma display panel (PDP) is an emerging consumer electronic appliance as a new large-area full-color wall-mounted digital television. However, the image quality of PDP including dynamic false contour and low gray-level contour is not sufficient for the high-class television [1]. For compensation of nonlinear electro-optical transfer characteristic in CRT, the video signal received by a television is the gamma-corrected signal. On the other hand, the PDP-TV has a linear electro-optical transfer characteristic in a conventional driving method, and the inverse gamma correction is required to display images correctly. Because of inverse gamma correction, several gray levels are merged into a fixed output luminance level, especially for the low input signal up to 50. This merging effect causes abrupt change in visual gradation patterns leading to the low gray-level contours.

LOW GRAY-LEVEL CONTOUR

A signal processing method using error diffusion and dithering has been suggested to improve a gray-level expression in a low gray-level region [2], which can reduce the low gray-level contour more or less. However, this method must use sustain pulse number modulation with 256 gray-level sustain pulses in displaying an image, and cannot solve the low gray-level contour problem fundamentally. In order to counteract the disappearance of several low gray levels due to the inverse gamma correction, it is the best method to increase the luminance-steps available for the low gray scale. In particular, the minimum luminance level per one sustain pulse should be reduced to improve the low gray level expression capability. In this sense, a new multi-luminance-level subfield method is proposed to improve the low gray-level color reproducibility. This method can express the various luminance levels in the same sustain pulse subfield condition by reducing the minimum luminance level by means of the auxiliary address pulses during a sustain-period.

The conventional cell structure of a single pixel comprising the red, green, and blue cells and the three electrodes X, Y, and Z of a 42-inch digital PDP television is illustrated in Fig. 1 (a). In the conventional PDP driving scheme, the luminance level for each pixel is controlled by a combination of 8 subfields in which each subfield consists of the X-Y sustain pulse pairs for representing

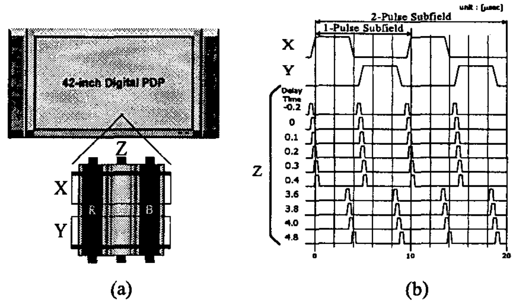

Fig. 1 (a) Cell structure and three electrodes of conventional PDP-TV, (b) new driving scheme for multi-luminance-level subfield method in low gray level

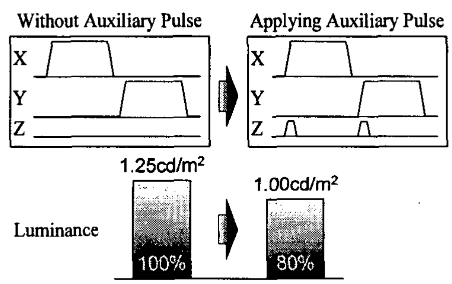

Fig. 2 An example of multi-luminance-level subfield method by applying auxiliary pulses in sustain period

1, 2, 4, 8, 16, 32, 64 and 128 for 256 gray levels. No signal is applied to the address electrode during a sustain-period. In this driving method, the luminance levels are controlled by the number of the sustain pulses, so that the minimum luminance level depends on the luminance that one sustain pulse can create. In the conventional driving method, this minimum luminance level is relatively high, thereby resulting in the low gray level contour due to the inverse gamma correction.

MULTI-LUMINANCE-LEVEL SUBFIELD METHOD

In this work, only the luminance of 1- and 2-pulse subfields is controlled by applying the auxiliary pulses to the address electrodes with various conditions shown in Fig.1 (b). As a result, the luminance of 1-pulse subfield can be varied from 70 % to 114 %, whereas the luminance of 2-pulse subfield can be varied from 31 % to 112 %, indicating that 1- or 2- pulse subfields can represent multi-luminance levels.

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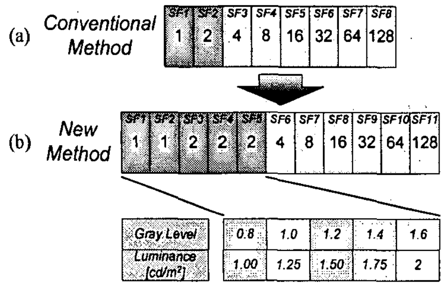

Fig. 3 Subfield formations and gray levels of each subfield (a) in conventional method and (b) in multi-luminance-level subfield method

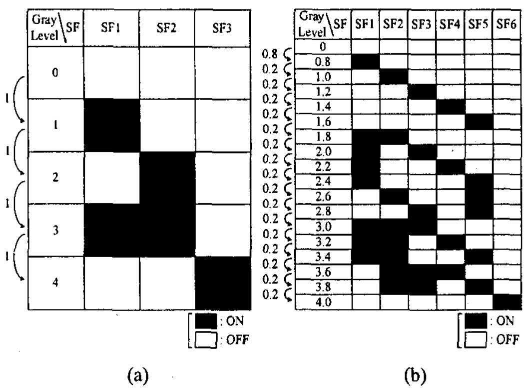

Fig. 4 Subfield selection algorithms for expression gray-levels between 0 and 4 (a) in conventional method and (b) in multi-luminance-level subfield method

One example for controlling the luminance using the multi-luminance-level subfield method is given in Fig.2. The new method changes the total subfield numbers from 8 into 11 by selecting the 2 luminance-steps in 1-pulse subfield and 3 luminance-steps in 2-pulse subfield, respectively, as illustrated in Fig. 3. The resultant 5 luminance-steps in the 1-pulse and 2-pulse subfields can improve the expression capability in the low gray levels between 0 and 4, compared with those of the conventional case, as shown in the subfield selection algorithms of Fig. 4. After the inverse gamma correction adopting the new method, 12 luminance-steps are obtained instead of conventional 3 luminance-steps for input signal up to 30, as shown in Fig. 5.

RESULTS

Figs. 6 and 7 show the inverse gamma correction simulation results of gamma-corrected images that contain gray-level up to 50, when analog method (a), conventional digital method (b), and multi-luminance-level subfield method (c) are used. The gray-levels of each simulation result are stretched up to 250 for a displaying purpose. As illustrated in the simulation results of inverse gamma correction for the images of Figs. 6 and 7, the multi-luminance-level subfield method suppresses the low gray-level contours that appear in the conventional digital method, and improves the color reproducibility to almost the same level compared with the analog method.

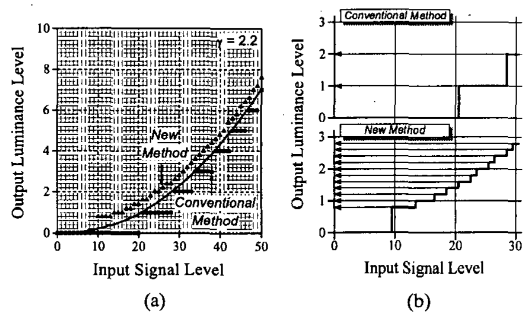

Fig. 5 Inverse gamma correction tables of conventional method and multi-luminance-level subfield method for gray-levels (a) between 0 and 50 and (b) between 0 and 30

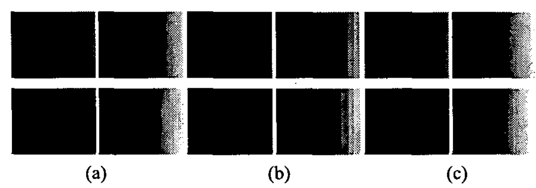

Fig. 6 Simulation results of inverse gamma correction for red, green, blue and white gradation images using (a) analog method, (b) conventional method, and (c) multi-luminance-level subfield method

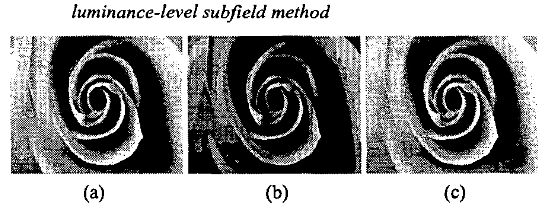

Fig. 7 Simulation results of inverse gamma correction for yellow rose image using (a) analog method, (b) conventional method, and (c) multi-luminance-level subfield method

CONCLUSION

New multi-luminance-level subfield method is proposed to improve the low gray-level color reproducibility of plasma display panel-television (PDP-TV). The luminance levels in 1-pulse and 2-pulse subfields can be fine-tuned into 5 luminance-steps by applying various auxiliary pulses to address electrode in the same sustain-pulse subfields. As a result, it is confirmed that the new multi-luminance-level subfield method can suppress a low gray-level contour in the inverse gamma corrected images of PDP-TV.

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