New Driving Method and Circuits for Low Cost AC Plasma Display Panel

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Abstract — *New driving method and circuit layout is proposed to reduce the cost of plasma display panel. Proposed driving method, which uses only two electrodes in the three-electrode type AC-PDP, can reduce the cost of the driving circuits by 25%, thereby achieving the low cost AC-PDP.*

Index Terms — Driving Waveform, Low Cost, Plasma Display Panel, Vt closed curve.

I. Introduction

RAPID growth of the information technology in the recent years has introduced the development of the new display devices replacing the conventional models. Plasma Display Panel (PDP) is one of the noticeable display devices with the characteristics of large-size, full-color and wall-mountable digital television [1]. However, the high cost of PDP couldn't fulfill the demand for the low price, which is one of the expectations in the consumer electronic appliance market. As AC-PDP uses the plasma discharges for displaying information, AC-PDP requires high power electronic circuit components. Thus, the cost of the driving circuit contributes a large portion in the total cost of PDP module, and activities concerned with the cost reduction of the driving circuit are needed to achieve the low price PDP module. In this paper, a new driving waveform, which uses only two electrodes among three electrodes of typical AC-PDP, is proposed to contribute to the cost reduction of the PDP module.

II. Conventional Driving Method

Fig. 1 shows the cell structure of the typical three-electrode type AC-PDP. Each cell is covered by three electrodes; sustain (Z), scan (Y) and address electrode (X), and electric power is applied to a plasma discharge space via these three electrodes. Sustain (Z) and scan (Y) electrodes are covered with MgO protection layer, and address electrode (X) is covered with phosphor layer, respectively. Fig. 2 shows the typical ADS (Address Display Separated) driving scheme. According to the ADS driving scheme, there are 8 or 12 subfields in 16.67 msec corresponding to one TV-field, and each subfield is composed of three periods; reset, address, and sustain period [2]. During the reset period, all cells are initialized by ramp-type voltage

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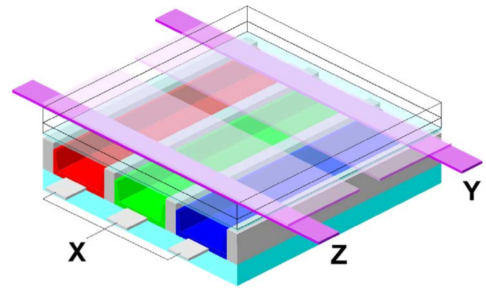

Fig. 1. Cell structure of typical three-electrode-type AC-PDP.

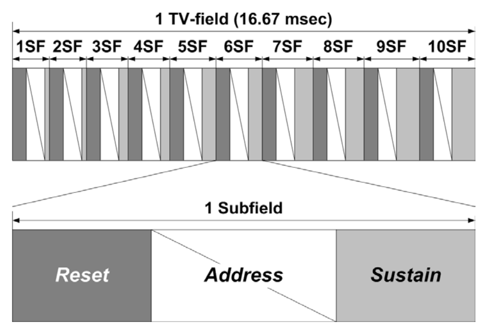

Fig. 2. Typical ADS (Address Display Separated) driving scheme.

waveforms applied to three electrodes. Next, address discharge is occurred at cells, which are designated to be turned-on according to video signal, by applying voltage pulses to Y and X electrodes simultaneously during the address period [3]. In the sustain period, alternating voltage pulses, which are applied to Y and Z electrodes, produce discharges in the cells addressed through the address period, thereby emitting visible light pulse. These three step procedures are repeated in each subfield.

Fig. 3(a) shows the conventional driving waveforms applied to each electrode during one TV-field (16.67 msec) according to the typical ADS driving scheme. At Y electrode, ramp type reset, scan, and square sustain pulse waveforms are applied during one subfield. And, dc bias and square sustain pulse waveforms are applied to Z electrode, while only address pulse waveform is applied to X electrode during one subfield. Remarkable point of the typical driving waveform is that all electrodes in the three-electrode type AC-PDP are driven by voltage waveforms, thus high voltage driving circuits for all electrodes are required.

III. Proposal of New Driving Method for Cost Reduction of AC-PDP

Fundamental concept of the new driving method proposed

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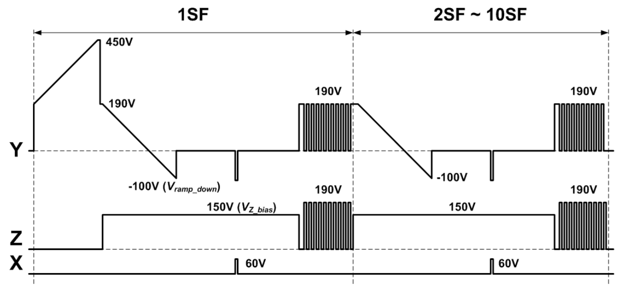
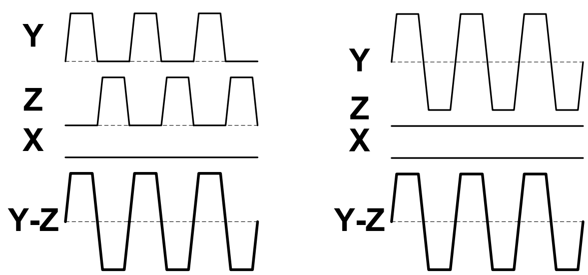
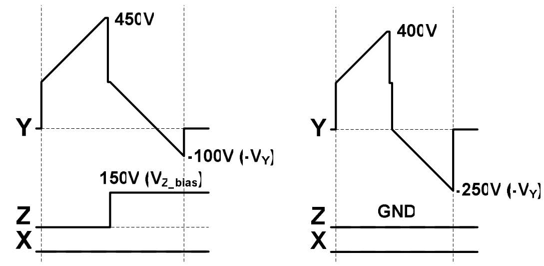


Fig. 3. Conventional driving waveforms applied to each electrode during 1 TV-field.



(a) (b)

Fig. 4. Sustain waveforms. (a) Conventional driving waveform, (b) Proposed driving waveform.



(a) (b)

Fig. 5. Reset waveforms. (a) Conventional driving waveform, (b) Proposed driving waveform.

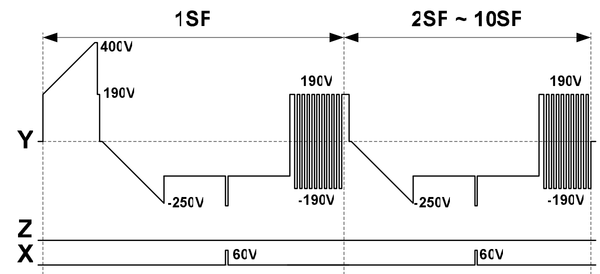


Fig. 6. Proposed driving waveforms applied to each electrode during 1 TV-field.

in this paper is the usage of the only two electrodes among three electrodes to drive AC-PDP, compensation for difference between the conventional waveform and the new waveform. As Y and X electrodes are used for the unique cell selection during the address period, we target the elimination of the driving waveform applied to Z electrode. New driving waveform is designed through four steps; a sustain waveform design, a reset waveform design, an analysis of problems, and the improvement of waveforms to resolve problems.

A. Fundamental Concept of Sustain Waveform Design

During the sustain period, a sustain discharge is produced mainly by alternating electric fields between Y and Z electrodes. Thus, if the voltage differences between Y and Z electrodes are almost the same, the sustain discharge can be produced in the same discharge mode. In this manner, a new sustain waveform is proposed as shown in Fig. 4. Although, the new sustain waveform uses only Y electrode to produce the sustain discharge, the voltage differences between Y and Z electrodes are same with that of the conventional driving waveform.

B. Fundamental Concept of Reset Waveform Design

In the conventional driving waveform, a dc bias waveform is applied to Z electrode, while a ramp-down waveform is applied to Y electrode during the reset period. On the other hand, the new driving waveform does not use Z electrode, thus the ramp-down waveform of Y electrode must be changed to compensate the dc bias waveform of Z electrode. It is well known that an initializing operation can be performed stably, when voltage condition during the ramp-down step of the reset period satisfies following equation (1) [4].

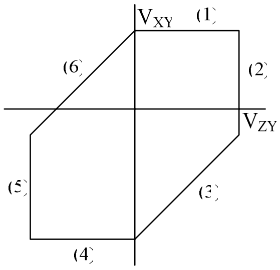
$$\left|-V_Y\right|_{CONVENTIONAL} + \left|V_{Z\_bias}\right|_{CONVENTIONAL} = \left|-V_Y\right|_{PROPOSED} \quad (1)$$

By using the theoretical equation, the reset waveform is changed from Fig. 5 (a) to Fig. 5 (b). As explained above in the fundamental concepts, the proposed driving waveform is designed as shown in Fig. 6. Remarkable point of the proposed driving waveform is that no voltage waveform is applied to Z electrode.

IV. PROBLEMS AND SOLUTION

A. Vt Closed Curve

Fig. 7 shows the schematic diagram of a Vt closed curve. The Vt closed curve is a powerful tool for the driving waveform analysis and design [5], [6]. The horizontal axis represents a cell voltage between Z and Y electrodes (V_{ZY}), and the vertical axis represents that between X and Y electrodes (V_{XY}), respectively. The Three Electrode-type AC-PDP has six kinds of threshold voltages of plasma discharge production, thus a hexagon is obtained from a cell. Horizontal axis corresponds to cell voltage between Z and Y electrodes (V_{ZY}), and vertical axis corresponds to that between X and Y electrodes (V_{XY}), respectively. Coordinate of the Vt closed curve in a cell represents a cell voltage condition of that cell. If a coordinate is placed inside of the Vt closed curve, there is no discharge. And, if a coordinate is placed outside of Vt closed curve, a discharge occurs. Generally, the threshold voltage of ZY-discharge (anode: Z, cathode: Y) and that of YZ-discharge (anode: Y, cathode: Z) are almost the same, corresponding to the side (2) and the side (5). However, the threshold voltages of XY-discharge (side (1)) and XZ-discharge (side (6)) are smaller than YX-discharge (side (4)) and ZX-discharge (side



	anode	cathode
(1)	phophor	MgO
(2)	MgO	MgO
(3)	MgO	phophor
(4)	MgO	phophor
(5)	MgO	MgO
(6)	phophor	MgO

Fig. 7. Vt closed curve and surface layers covering electrodes which are participate in discharge corresponding to each side of Vt closed curve.

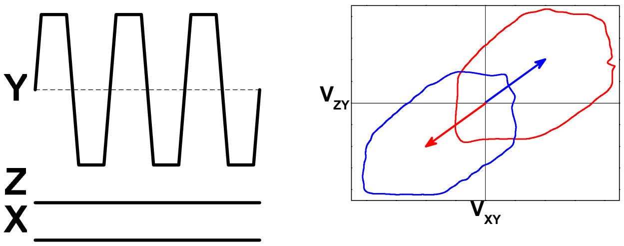


Fig. 8. (a) Proposed sustain waveforms and (b) Movement of Vt closed curves during sustain period.

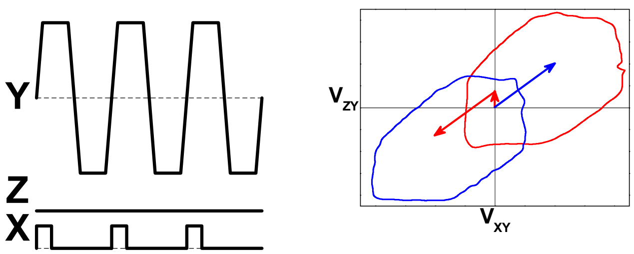


Fig. 9. (a) Improved sustain waveform suppressing phosphor degradation and (b) Movement of Vt closed curves during sustain period.

(3)), due to the difference of the secondary electron emission coefficients between the MgO protection layer and the phosphor layer. When the phosphor layer, which covers the X electrode, plays a role of the anode (side (3) and side (4)), the plasma discharge becomes unstable.

B. Improvement on Sustain Waveform

Fig. 8 (b) shows the movement of the Vt closed curves driven by applying the proposed sustain waveform in Fig. 8 (a). As shown in Fig. 8 (b), a positive sustain pulse induce a plasma discharge including YZ-discharge and YX-discharge. The YX-discharge is unstable and causes the lifetime problem of PDP panel, due to phosphor layer degradation by ion bombardment. Fig. 9 (a) shows the improved sustain waveform suppressing phosphor degradation. By applying short pulse to X electrode at the same time as the positive sustain pulse, YX-discharge portion is reduced greatly, as shown in Fig. 9 (b). For a stable sustain discharge, the width of the short pulse applied to X electrode must be controlled properly.

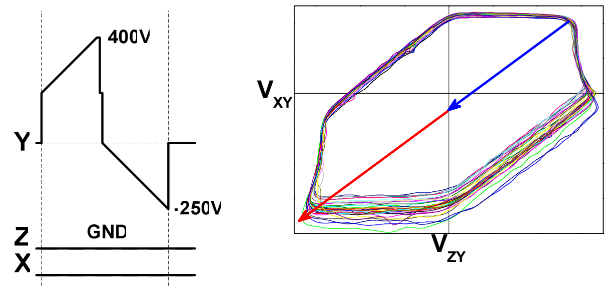


Fig. 10. (a) Proposed reset waveforms and (b) Changes of cell voltage during reset period.

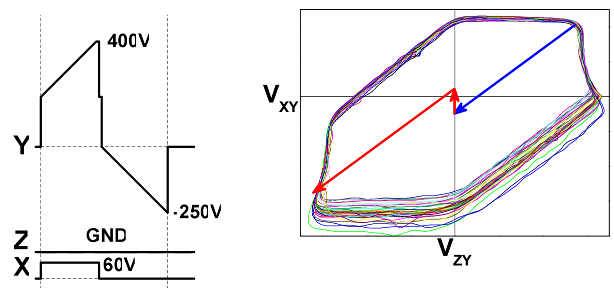


Fig. 11. (a) Improved reset waveforms suppressing unstable weak discharge and (b) Changes of cell voltage during reset period.

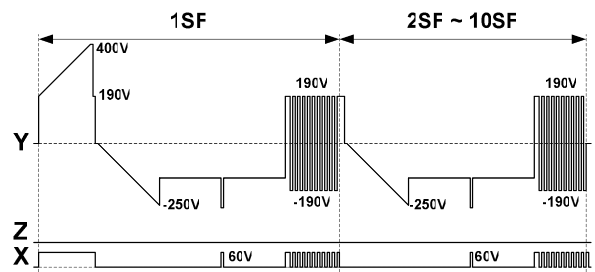
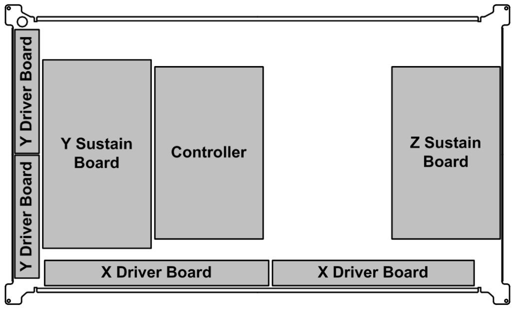


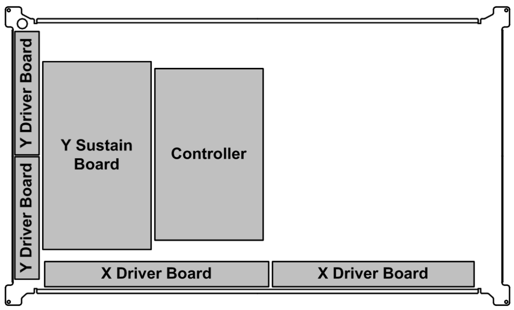
Fig. 12. Improved driving waveforms applied to each electrode during 1 TV-field.

C. Improvement on Reset Waveform

Fig. 10 (b) shows the movement of a cell voltage by applying the proposed reset waveform of Fig. 10 (a). During the ramp-up step, the cell voltage crosses YX-discharge side of the Vt closed curve, thus a weak discharge is started from YX-discharge. As the weak YX-discharge is unstable, a stable initialization by using the reset waveform is impossible, thereby inducing an undesired discharge problem (random bright dots in black image) and a discharge failure problem (random dark dots in white image). And, another important point is obtained from the Fig. 10 (b). Due to the various grain size of phosphor layer, the uniformity of threshold voltages of YX- and ZX-discharges cannot be guaranteed, thus uniform initialization is not performed for all cells. Fig. 11 (a) shows the improved reset waveform preventing the undesired discharge problem and the discharge failure problem. By biasing



(a)



(b)

Fig. 13. Layout of driving circuit board for each driving waveform. (a) Conventional driving waveform, (b) Proposed driving waveform.

X electrode with positive voltage during ramp-up step, a weak discharge is started from YZ-discharge which is stable discharge, as shown in Fig. 11 (b). Fig. 12 shows the improved driving waveforms including solutions for several problems.

Fig. 13 shows layout of the driving circuit board according to each driving waveforms. In the case of conventional driving waveform, voltage waveforms are applied to all of three electrodes, thus driving circuit boards are needed for each electrode, as shown in Fig. 13 (a). On the other hand, the proposed driving waveform is composed of voltage waveform from two electrodes (Y and X) only, thus Z sustain board can be removed, as shown in Fig. 13 (b). As a result, the proposed driving waveform can reduce the cost of the driving circuits by 25 % corresponding to cost for Z sustain board, thereby achieving the low cost AC-PDP.

V. Conclusion

The new driving method and the circuit layout is proposed to reduce the cost of plasma display panel. Proposed driving method uses two electrodes (X and Y) in three-electrode type AC-PDP, especially uses only one electrode (Y) during the sustain period. Thus, no voltage waveform applied to Z electrode, and driving circuits for Z electrode can be removed. The new driving method can reduce the cost for driving circuits by 25 %, thereby the AC-PDP cost reduction can be achieved.

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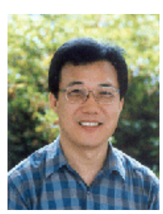

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