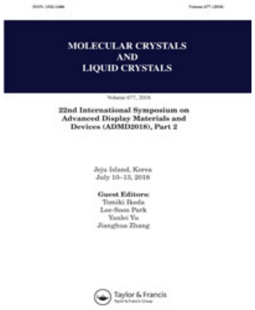

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Voltage Margin and Luminous Efficiency by Changing Positive and Negative Sustain Voltage in AC Plasma Display Panel

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ABSTRACT

In the AC PDP, drive waveforms are applied to three electrodes, respectively, and positive voltages are alternately used for the two electrodes during the sustain period. When the driving waveforms of two electrodes are corrected in the state where one of the three electrodes is grounded for the low cost of the driving circuit, positive and negative voltages are alternately applied to only one electrode during the sustain period, and an asymmetric discharge is generated differently from the conventional case. An asymmetric discharge indicates a strong discharge once, followed by a weak discharge. It was observed that a strong discharge occurred when negative voltage was applied and a weak discharge occurred when positive voltage was applied. When a positive voltage is applied, the potential difference between the three electrodes is the same as in the conventional case. However, when a negative voltage is applied, the voltage also affects the write electrode, so that the discharge becomes strong. Asymmetric discharges decrease the margin and efficiency of the sustain voltage, so that a symmetrical discharge must be generated. In order to generate the symmetric discharge, we proposed a method of applying positive and negative voltage heights and slopes of the waveform differently, and obtained voltage margin and efficiency similar to the conventional one.

KEY WORDS

AC PDP; asymmetric discharge; positive and negative; voltage margin; efficiency

1. Introduction

The AC plasma display panel (AC PDP) are currently facing a crisis in the television market because of their higher power consumption and price than other displays. However, AC PDP has some advantages such as excellent image quality and low manufacturing cost because it is self-luminous device because there is no afterimage due to fast response characteristic on the screen [1]. One of the major reasons why AC PDP is not popular is high price, so if price can be lowered, it will be revived in the display market. In AC PDP, the production price excluding labor costs is divided into the

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material of the panel part, the manufacturing process, and the driving circuit component value. Among them, the most efficient part to lower the price is the drive circuit part [2]. In the driving circuit part, there is a method of lowering the unit price itself and a method of reducing the number of parts. Although manufacturers try hard to reduce the cost of parts, they are faced with limitations, so efforts should be made to reduce the number of parts while enabling the same operation.

In the structure of AC PDP, one cell is composed of three electrodes, two of which are arranged at constant intervals on the top plate, and one is located in the vertical direction in the bottom plate [3]. So, three driving circuits to make the driving waveform is needed. A method of displaying a screen in an AC PDP is to selectively combine several sub-frames having different amounts of light during one TV frame time [4]. One sub-frame time is divided into reset, write, and sustain periods, respectively. The reset period is a period in which the plasma discharge is weakly generated for the first time, wall charges are accumulated in the cell, and then redistribution is performed so that the discharge can easily occur in the write period, and in the writing period, when voltages are applied to the electrodes in the horizontal and vertical directions, a plasma discharge is generated using the wall charges accumulated before. At this time, wall charges are generated in the cell and relocated, so that the selected cell is memorized [5]. In the sustain period, as square pulses are alternately applied to the two electrodes on the upper plate, the sustain discharge is produced only in selected cells and no discharge is produced in cells that are not selected [6, 7].

As mentioned above, the AC PDP has three electrodes structurally, so three driving circuits are connected to each electrode. If one of the three driving circuits is reduced, the number of parts can be drastically reduced and the price can be greatly reduced. In previous studies, the drive waveforms were modified to reduce one electrode and apply a drive circuit to only two electrodes [8]. That is, the driving waveform in one electrode was moved to the other two electrodes. In the AC PDP, when a discharge occurs inside the cell, wall charges accumulate on each electrode. The wall charges are controlled by the voltage applied to the three electrodes to produce the next discharge in the conventional method, whereas, in the new driving method, various problems such as misfiring discharge have occurred because the wall charge is controlled by only two electrodes. In particular, since the wall charges are not stably accumulated during the reset period, undesirable misfiring discharge is generated in the write and sustain periods. To prevent misfiring discharge, a voltage is applied to the write electrode during the reset and sustain period for adjusting the amount of wall charge so that a discharge is not produced in the unselected cells. Meanwhile, when the characteristics of the discharge produced during the sustain period in the selected cells are measured, it is observed that the discharge produces asymmetrically. In the conventional driving method, symmetrical discharge produces because positive square waveforms are alternately applied to two electrodes on a top plate. However, in a new driving method, as the positive and negative voltages are applied to only one electrode, the voltage difference among three electrodes is different with conventional method.

In this study, we measured the waveform of the sustain discharge by the conventional and new driving method and experimentally examined the effect of the asymmetric discharge produced by the new driving method on the sustain voltage margin and the luminance efficiency. In order to produce the sustain discharge symmetrically in the new driving method, two methods have been proposed. First, the voltage height was adjusted differently while the positive and negative voltages were applied, and second, the slope of the voltage was adjusted. The sustain voltage margin and the luminous efficiency were measured when the discharge produced symmetrically by the two methods and compared with the conventional driving method.

2. Experiment

Figure 1 shows a cross-sectional diagram of one cell in an AC PDP with three electrodes used in this experiment. Three electrodes are composed of sustain (X) and scan (Y) electrodes on the upper plate, and write (W) electrode on the lower plate. The X and Y electrodes are arranged in parallel on the upper plate, and a W electrode is arranged in the lower plate in a direction perpendicular to the two electrodes of the upper plate. The barrier rib between the cells on the lower plate is omitted from this figure. As the surface discharge is produced between the X and Y electrodes on the upper plate during the sustain period in which light is generated in the AC PDP and the electrode on the upper plate may be damaged due to the production of strong plasma discharge, electrodes are protected by the dielectric layer as shown in the figure so as not to be directly exposed. The VUV generated by the plasma discharge excites the phosphor coated on the lower plate, and light is generated, and people can see the RGB light passing through the dielectric again.

Figure 2 shows the waveforms of the conventional driving method applied to three electrodes (a) and a new driving method in which waveforms are applied to only two electrodes (b) during one sub-picture period. The AC PDP displays brightness in a combination of several sub-frames during one TV frame time, and sub-frames are divided into reset, write, and sustain periods, respectively. In the reset period, a weak discharge is generated due to a high voltage, and the wall charges accumulated in the previous time in all the cells are made to be in the same state and redistributed. After the reset period, the wall charge inside the cell is changed to a state for producing a write discharge. In the write period, when the scan waveforms are sequentially applied to the Y electrode for each cell and pulses are selectively applied to the A electrode, the address discharge produces only in the selected cell and wall charges are accumulated again. That is, in the case of producing the address discharge, because the distribution of the wall charges changes differently from the previous one, a memory effect is

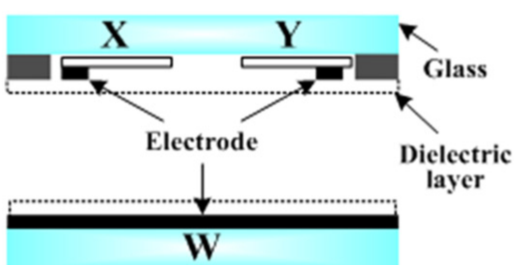


Figure 1. Cross-sectional diagram of one cell in AC PDP with three electrodes.

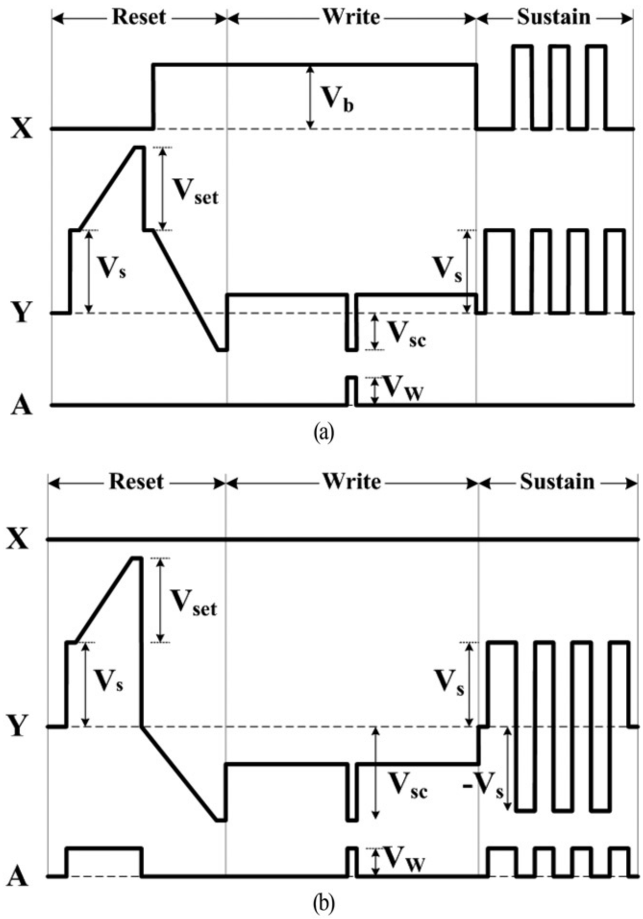


Figure 2. Conventional (a) and new (b) driving waveforms during one sub-frame time.

Table 1. Voltages applied to conventional and new driving methods

	Conventional	New
V_{set}	190	190
V_s	170	170
$-V_s$	0	−170
V_w	60	60
V_{sc}	−50	−200
V_b	150	0

generated in which the next discharge produces only in the selected cell. In the sustain period, a square waveform is alternately applied to the X and Y electrodes, and a discharge is generated only in the selected cells in the write period, thereby generating light. Comparing Figure 2 (a) and (b), the voltage waveform at the X electrode in Figure 2 (a) is grounded in Figure 2 (b) and shifted to the Y electrode by the disappeared voltage of the X electrode. Therefore, since the driving circuit is not required for the X electrode, the number of necessary parts can be reduced. In Figure 2 (b), the voltage is applied to the write electrode during the reset and sustain periods to prevent misfiring discharge due to positive and negative voltages.

Table 1 shows the voltage levels applied to the conventional and new driving methods in Figure 2. In the new driving method, since the voltage of the X electrode is absent, the V_{sc} of the Y electrode is changed by that amount instead of the V_b being changed to zero.

Table 1 shows the specifications of the panels used in this experiment. The width of the bus electrode, the width of the ITO electrode, and the distance between the two ITO electrodes are described in the upper plate, and the width of the writing electrode, the height of the partition, and the width of the partition are shown in the lower plate. Ne (93%) - Xe (7%) was used as the mixed gas inside the panel.

3. Result and discussion

Figure 3 shows the applied voltage and the wave form measured during the sustain period in the conventional and new driving methods. In Figure 3 (a), the top two waveforms are the alternating applied sustain voltage on the X and Y electrodes, and the

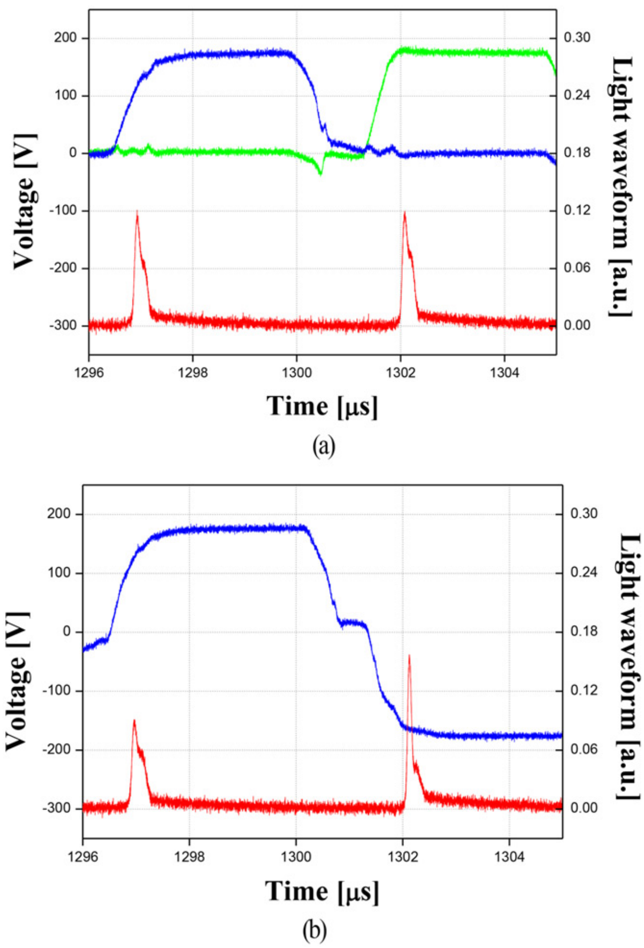
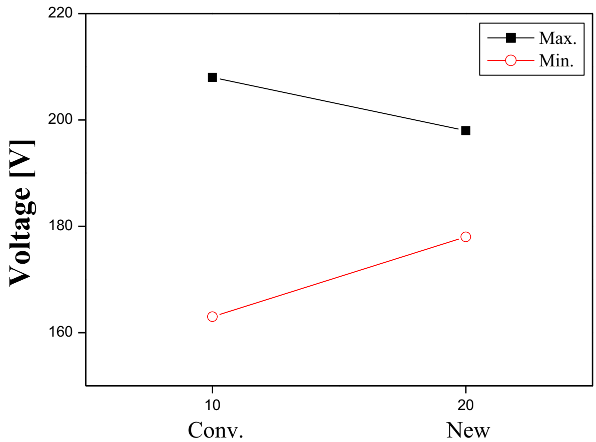
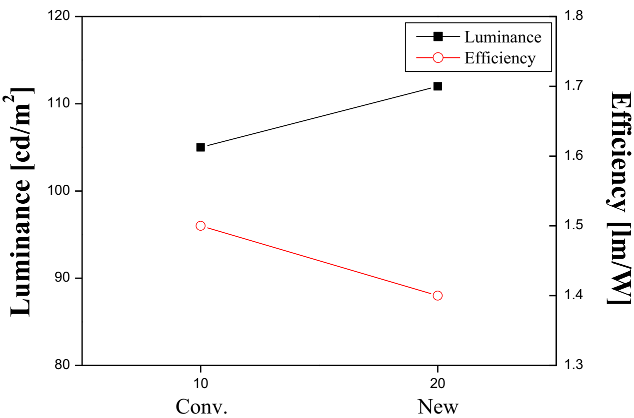


Figure 3. Voltage and light waveforms during sustain period when applying conventional (a) and new (b) driving method.



(a)

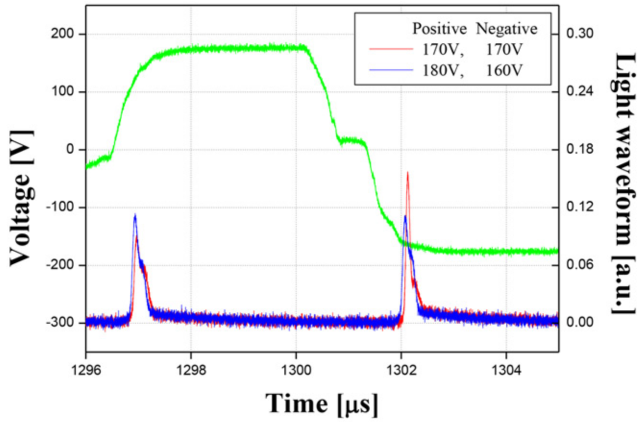


(b)

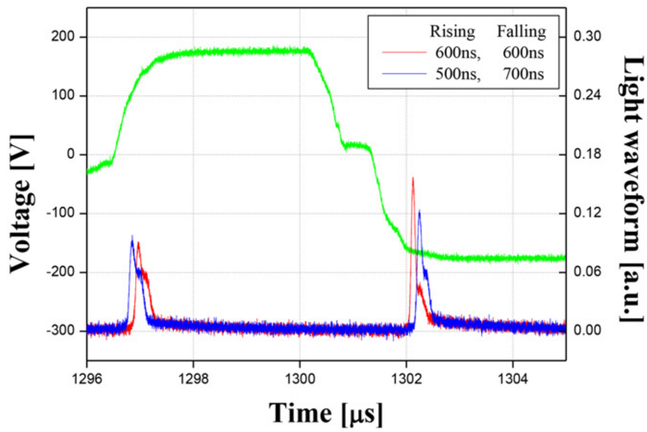
Figure 4. Sustain voltage margin (a) and luminous efficiency (b) adopting conventional and new driving method.

bottom waveform shows the measured light when each voltage is applied. It can be seen that the light waveform occurs symmetrically in the conventional driving method. In Figure 3 (b), since the X electrode is in the grounded state, only the voltage waveform at the Y electrode is displayed and its light waveform is measured. Compared with the conventional driving method, in the new driving method, the discharge at the Y electrode is weak when a positive voltage is applied, and is strongly produced when a negative voltage is applied. In the conventional driving method, as the sustain voltage is alternately applied in the positive direction, a discharge occurs only between the X and Y electrodes on the top plate. However, in the new driving method, when a negative voltage is applied, a discharge produces also with the A electrode of the lower plate, so that a light waveform occurs largely. On the other hand, since a part of the wall charge inside the cell is erased by a large discharge produced by applying a negative voltage, a discharge is weakened when a positive voltage is next applied.

Figure 4 is a graph of the sustain voltage margin (a) and the luminous efficiency (b) when applying the conventional and new driving methods. The sustain voltage margin



(a)



(b)

Figure 5. Comparison of light waveforms (a) when positive and negative voltages are applied differently and (b) when the rising and falling times of the voltage waveform are changed in new driving method.

means a range from a minimum voltage at which sustain discharge can be successfully produced to a maximum voltage at which misfiring discharge starts to occur. Generally, the wider the voltage range, the higher the probability of stable discharge. Figure 4(a) shows that the voltage margin of the new driving method is reduced by about 20 V compared with the conventional method. The reason why the minimum voltage is increased is as shown in Figure 3(b) because the discharge is weak when a positive voltage is applied. That is, the discharge is likely to fail at a low positive voltage. Also, the reason why the maximum voltage is lowered is that the discharge becomes too strong when a negative voltage is applied, so that there is a high possibility that a misfiring discharge occurs naturally even at a high voltage. Figure 4(b) shows the measured luminance and efficiency using the conventional and new driving methods. The luminance slightly increased due to the strong discharge, but the efficiency was rather lowered. The strong discharge is generally proportional to the luminance, but the efficiency is low because the amount of current is rapidly increased and the power consumption is

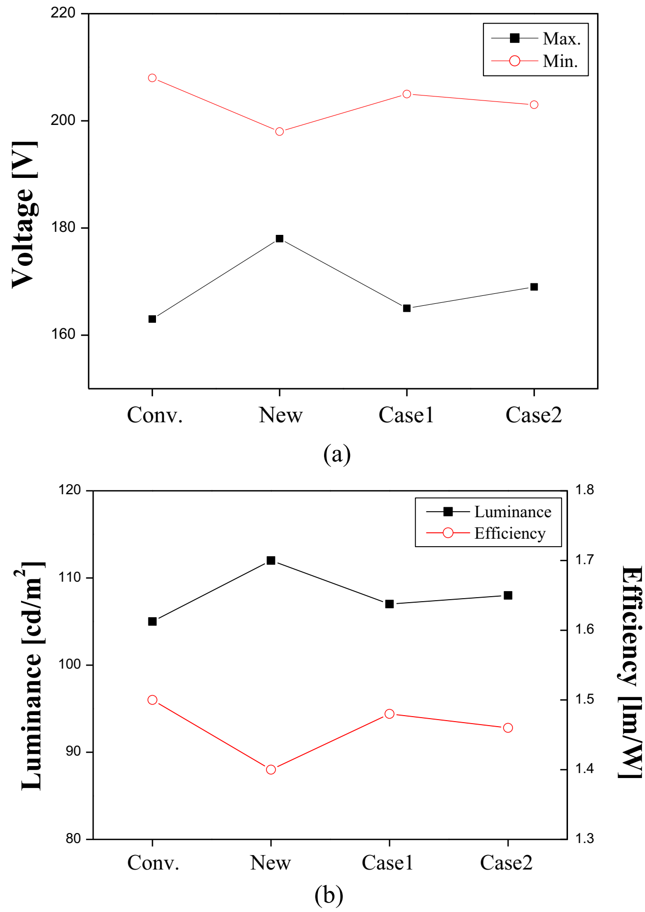


Figure 6. Changes in sustain voltage margin (a) and luminous efficiency (b) when using conventional, new, and two proposed driving method: changing voltages and slope.

increased accordingly. Generally, the current is lower because the current is lower than before, so the power consumption is lowered. Generally, in the case of a weak discharge, the current is lower and the power consumption is lowered [9].

The asymmetric sustain discharge not only reduces the sustain voltage margin but also reduces the efficiency, so a symmetrical discharge must produce. In addition, the symmetrical discharge can continue to produce more stably than the asymmetric discharge. In general, the height of the voltage and the slope of the waveform are proportional to the intensity of the discharge. As the discharge is weak when the positive voltage is applied and the discharge is strongly produced when the negative voltage is applied during the sustain period, the asymmetric discharge can be improved if the positive voltage is increased and the negative absolute voltage is lowered. As shown in Figure 5 (a), when the absolute values of the two voltages were equal to 170 V, an asymmetric discharge was produced, but when the positive voltage was changed to 180 V and the negative voltage was changed to -160 V, it was found that the almost symmetric discharge was produced.

On the other hand, the slope of the waveform is related to the rising or falling time. When the time is short, the slope is fast. On the contrary, the slope is slow in the case of the long time. In this experiment, the rising and falling time of the driving waveform was 600 ns as shown in Figure 5 (b), but the rising time was shortened to 500 ns to make the slope steep in the waveform with weak discharge and the falling time was increased to 700 ns to make the slope slow in the case of the negative discharge with strong discharge. As a result, although a complete symmetrical discharge was not produced, a slight improvement was obtained. The symmetric discharge can be obtained if the slope is further adjusted, but there is a limit because it requires a circuit problem and a design change of the energy recovery circuit. In Figure 5(b), since the discharge was produced strong or weak by the change of the slope, the light waveforms of the improved method were occurred earlier in the positive voltage and behind in the negative voltage. In other words, discharge was produced fast due to the high slope at positive voltage, and late due to the low slope at negative voltage.

Figure 6 shows the change of the sustain voltage margin (a) and the luminous efficiency (b) according to the conventional, new and proposed driving methods. Case 1 is the experimental result by the change of the voltage, and Case 2 is the experimental result by the change of the slope. The driving margin was reduced when the new driving method is applied, but the improved method was improved to the conventional level. Likewise, the proposed luminance efficiency method is more improved than the new method. Likewise, the proposed method is more improved than the new method in luminous efficiency. Especially, it was found that the driving voltage margin and the luminous efficiency were more effective when the voltage was changed than the change of the slope in the two proposed methods.

4. Conclusions

In the AC type plasma display panel using three electrodes and driving circuits, a new driving method in which one electrode was grounded and only two driving circuits were used was proposed to reduce the number of parts of the circuit and to lower the cost in the previous study. The discharge was produced asymmetrically during the sustain period of the new driving method, resulting in low voltage margin and luminous efficiency. In order to produce sustain discharge symmetrically, we proposed a method of changing the magnitude of the voltage and a method of applying the slope differently when the positive and negative voltages were applied, and the discharge characteristics were improved. In particular, when voltage was applied differently than changing the slope of positive and negative voltages, the voltage margin and luminous efficiency similar to those of the conventional method could be obtained.

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