A New Driving Waveform to Improve Dark Room Contrast Ratio in AC Plasma Display Panel

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Abstract

In this study, a new driving method is suggested to improve the dark room contrast ratio. The principles of the method are that the reset facing discharges occur between scan and address electrodes instead of surface discharge and that the discharge occurs only for the cells that experienced sustain discharge in preceding sub-field after the first sub-field. The dark room contrast ratio is improved more than 7 times compared with the conventional method.

1. Introduction

Dark room contrast ratio of the PDP becomes more important with the growing interests in home theater applications. It is defined as the ratio of display luminance to background luminance, and primarily is determined by the display's lowest background luminance level. Currently, the slowly increasing and thereafter decreasing ramp waveforms have been used to produce a stable positive-resistance gas discharge that can generate the necessary levels of wall voltage without emitting very much light.[1-3]

In current driving scheme by ADS (Address and Display period Separated) method[4,5], however, one sub-frame is divided into 8~12 sub-fields[6,7] and each sub-field involves the reset discharge period that is mainly related with the background luminance. Therefore, even though the ramp waveform is used in reset period, there is a limitation to improve the contrast ratio.

2. Concept of Suggested Method

Figure 1(a) shows a conventional driving waveform sequence to achieve 256 gray scales. This driving sequence is well known as ADS method with ramp type voltage waveform in reset period. In this method, one sub-frame consists of 8~12 sub-fields, and each sub-field consists of reset, address and sustain periods. Figure 1(b) shows the driving waveform sequence of the suggested new driving method (ICR: Improved waveform of Contrast Ratio). The first sub-field of ICR is the same with the conventional method. At the end of sustain period of the first sub-field, almost all of the ON cell charges have been erased by the ramp type erasing pulse whereas positive wall charges for the OFF cells in address electrode have remained. However, from the second sub-field, the sustain common electrode in the reset period has almost the same voltage with scan voltage of scan electrode by floating the common electrode or applying the same voltage with scan electrode. In this study, in order to minimize the circuit cost, the common electrode is floated to realize almost the same reset ramp voltage waveform with scan electrode in the reset period from the second sub-field.

In this method, the following driving process after the first sub-field can be possible.

1. The OFF cells in the preceding sub-field proceed to address period without reset discharge, because the wall charges made by previous reset discharge can be maintained in the OFF cells. Therefore, the OFF cells do not make any discharge light in reset period.
2. The ON cells in preceding sub-field have lost almost all wall charges by the ramp type erase pulse at the end of the preceding sub-field. Moreover, common and scan electrodes have almost the same voltage waveform. Therefore, the surface discharge between them does not occur, whereas facing discharge between scan and address electrode occurs. Especially, the wall charges made by this facing discharge will assist the addressing discharge to make stable writing action with low addressing pulse voltage [8,9].

From the background light point of view in the reset period, the reset discharge light between common and scan, and between scan and address electrodes for all cells is emitted for the conventional driving scheme. However, for the suggested method only the reset discharge light between scan and address electrodes for the ON cells in preceding sub-field is emitted from the second sub-field. Therefore, it is possible to increase dark room contrast ratio by the suggested driving scheme.

3. Experimental

In this study, 7-inch test model PDP has been used. There are a total of 60 scan lines and 23,040 cells. The same driving conditions are employed for both conventional and suggested driving schemes as shown in Figure 1 (a) and (b). The width of scan pulse is designed to be 2μs, and the address period is about 0.9ms. The reset up and down time is designed to be

100μs and 150μs, respectively. These conditions provide stable positive-resistance discharge. The voltages of V_r, V_s, V_a and V_{ysc} as shown in Fig. 2 are set to 390[V], 155[V], 80[V] and 80[V], respectively.

In this study, a total five sub-field have been used and the period of one sub-frame is 7.65ms.

In order to test the contrast ratio, the background and display luminance of the samples are measured by the luminance colorimeter (BM-7, Topcon Co.). The light emitted by one cell is precisely measured by a highly sensitive detector. The light detector consists of an avalanche photo-diode (APD), a temperature compensating bias circuit and a low noise I-V amplifier circuit (C5460. Hamamatsu Co.). The dynamic characteristics for both the conventional scheme and the ICR are also examined

4. Results and Discussion

Figures 2(a) and (b) show typical test voltage waveforms of address(A), sustain(X), and scan(Y) electrodes in the reset, address and sustain periods after the first sub-field for the conventional and suggested methods, respectively. Moreover, the lower part of Figures 2(a) and (b) show the corresponding discharge light waveform when the ON cell in the preceding sub-field is not addressed.

Figures 2(a), the conventional method, shows two reset discharges at the ramp-up and ramp-down part, which are due to the surface and facing discharges between electrodes X, Y and A. However, Figure 2(b), the suggested ICR method, shows one reset discharge only from the ramp-up part, which may be due to the following reasons. The reason that there is no discharge in the ramp down period is that electrode X has almost the same voltage as electrode Y in the reset period. Therefore, in the conventional method the strong surface discharge is predominant. However, in the ICR method the weak facing discharge is predominant.

Figures 3(a) and (b) show the waveforms when addressing the OFF cell(s) in the preceding sub-field. Figure 3(a) shows two reset discharges, which are the same as Fig. 2(a) in the reset period, since all cells are reset regardless of ON and OFF cells in every sub-field. In this case, when an address pulse is applied to the electrode A, an address discharge occurs, which leads to the sustain discharge in the sustain period. However, from Figure 3(b) it can be noticed that the reset discharge does not occur in the reset period, because the OFF cells are holding the wall charges formed during the preceding sub-field. Therefore, the stable discharge occurs under the condition of low address voltage by the aid of the wall charge formed in the preceding sub-field. As a result, the cell can stably turned ON by the sustain pulses, although the reset discharge is not occurred

Figures 4(a) and (b) show the waveforms when addressing the ON cell(s) in the preceding sub-field. Figure 4(a) shows the same discharge light waveform as Figure 3(a), since all cells are reset regardless of ON and OFF cells in every sub-field in conventional method. Figure 4(b), however, shows the facing discharge light in the reset period, which is the same as Figure 2(b). Under these conditions, stable addressing is also possible with low address voltage with the aid of the wall charges that are formed by facing discharge. Therefore, the cell can also be turned ON by the sustain pulse.

As a result of Figures 2, 3 and 4 in the reset period of ICR scheme, the weak facing discharge occurs only for the ON cells in the preceding sub-field, which may lead to low background luminance and high contrast ratio. Moreover, the driving operations of ICR are the same as the conventional method.

Table I shows background luminance, display luminance and contrast ratio for both the conventional and ICR driving methods when driven by the waveforms of Figure 1 in a dark room. The results in Table I are obtained under the driving conditions with only 5 sub-fields. For these two methods, the display luminance is almost the same, 154 cd/m^2, but the background luminance shows a significant difference, that is 0.75 cd/m^{2}and 0.10 cd/m^2 for the conventional and ICR driving methods, respectively.

The difference in background luminance may be increased with an increase in the number of sub-fields, because the conventional driving scheme generates background light from the surface and facing discharges included in every sub-field, whereas ICR generates weak background light from the facing discharge for ON cells after the first sub-field. As a result, the dark room contrast ratio for ICR is improved significantly, that is, the dark room contrast ratio for the conventional method and suggested ICR method are 205.3 and 1540, respectively.

It may be very important to point out that the reset discharge does not occur in the ramp-down region during the reset period of ICR under the same driving ramp voltage waveform conditions as the conventional method as shown in Figures 2, 3 and 4. This may be due to the facing discharge in the ICR method instead of the surface discharge in conventional method.

Figure 5 shows the dynamic characteristics, that is, address or reset characteristics when address or reset voltage is applied. Figure 5(a) shows the reset characteristics as a parameter of the reset voltage when V_a=70V and V_{ysc}=80V as shown in Figure 1. Figure 5(b) shows the address characteristics as a parameter of the address voltage when V_r=400V and V_{ysc}=80V as shown in Figure 1. From Figures 5(a) and 5(b), the sustain voltage margin is almost the same for both conventional and ICR methods. However, the reset and address voltage of ICR are somewhat higher than the conventional ones, which may be within the driving voltage range of the circuit elements. Some high reset and address voltage may be due to the insufficient accumulation of the wall charge during the reset period, which may be a disadvantage of ICR. We will study further to improve these points

4. Conclusion

We have proposed new driving method (ICR) that can improve the dark room contrast ratio dramatically. The ICR method uses a facing discharge during the reset period between scan and address electrodes only for the ON cells in the preceding sub-fields after the first sub-field. As a result, the contrast ratio by the ICR method is about 7 times higher than that of the conventional method.

Moreover, the dynamic characteristics for both conventional and suggested ICR methods are almost the same.

5. References

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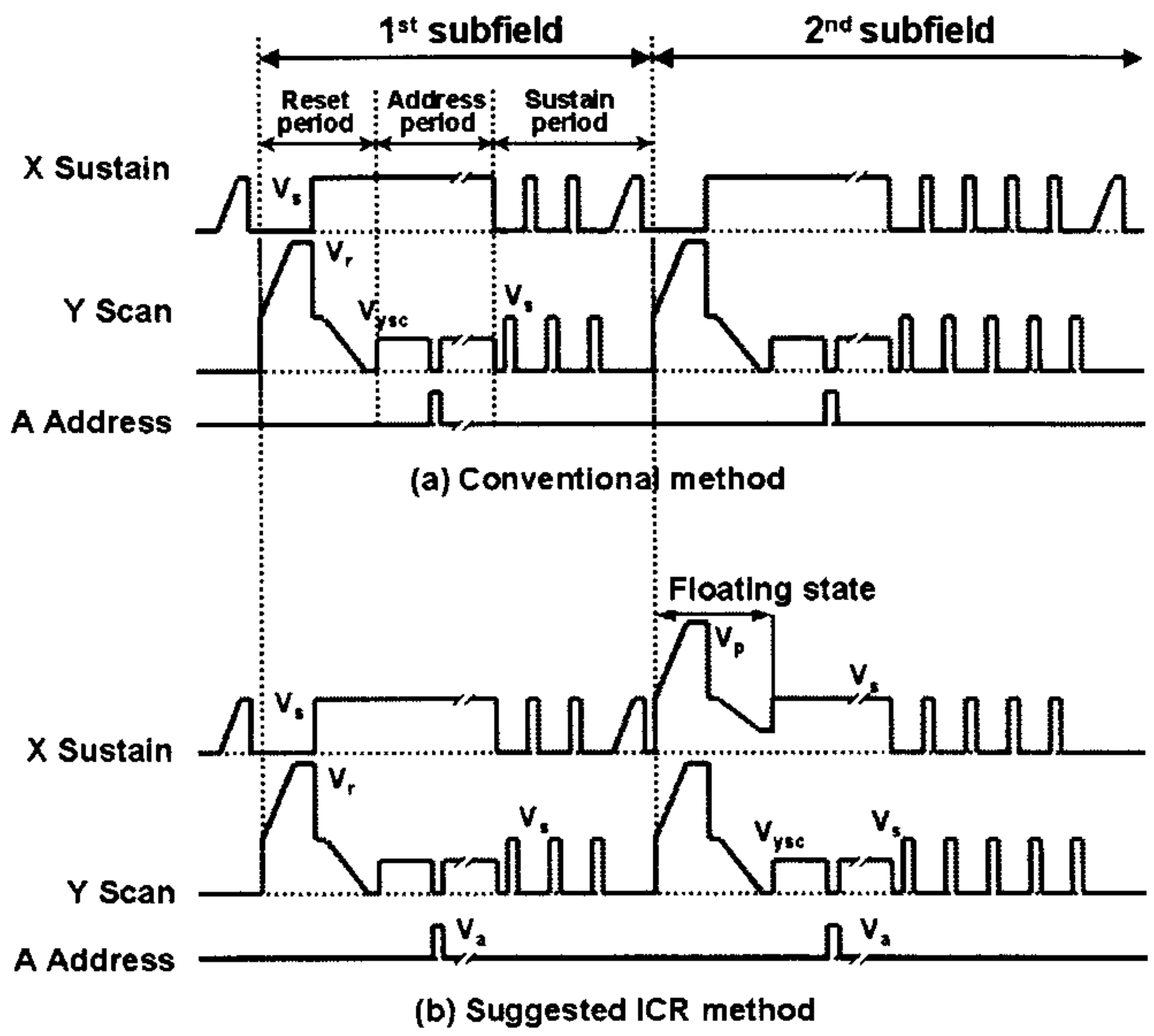
TABLE I

Background luminance, display luminance and contrast ratio for both conventional and ICR method when driven by the waveform of Fig. 2 in dark room.

	Conventional method	***Suggested ICR***
Background Luminance [cd/m^2]	0.75	0.10
Display Luminance [cd/m^2]	154	154
Dark room Contrast ratio	205.3	1540

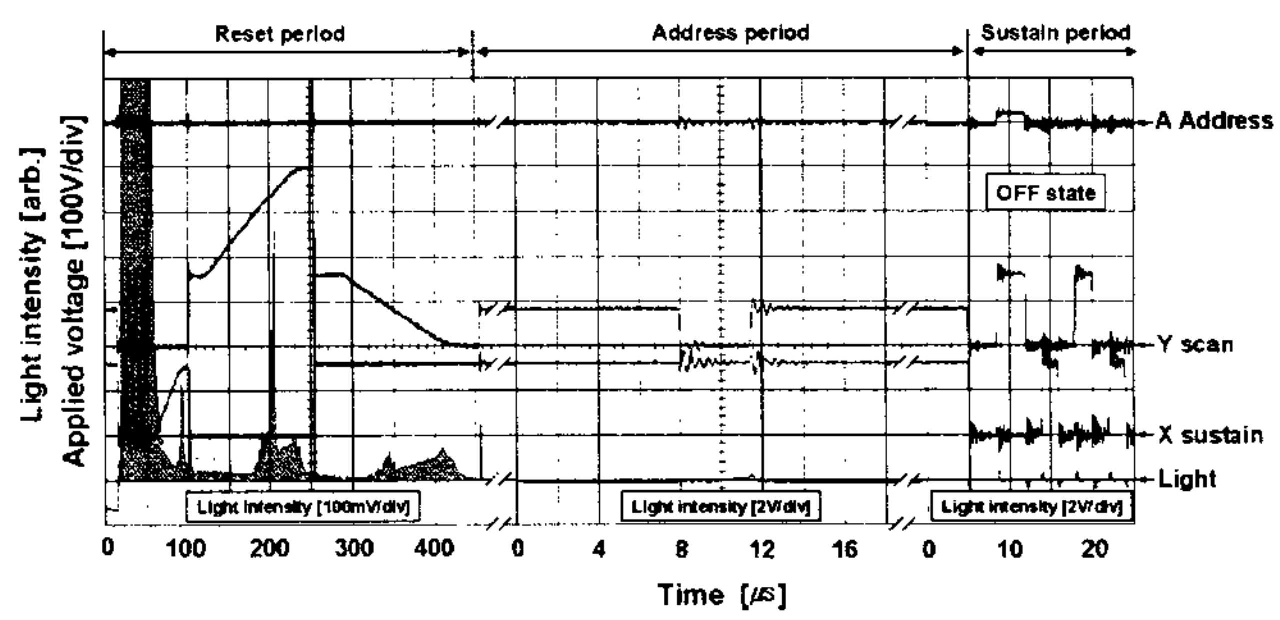


— One sub-frame(5 sub-field) : 7.65ms, Address period : 0.9ms

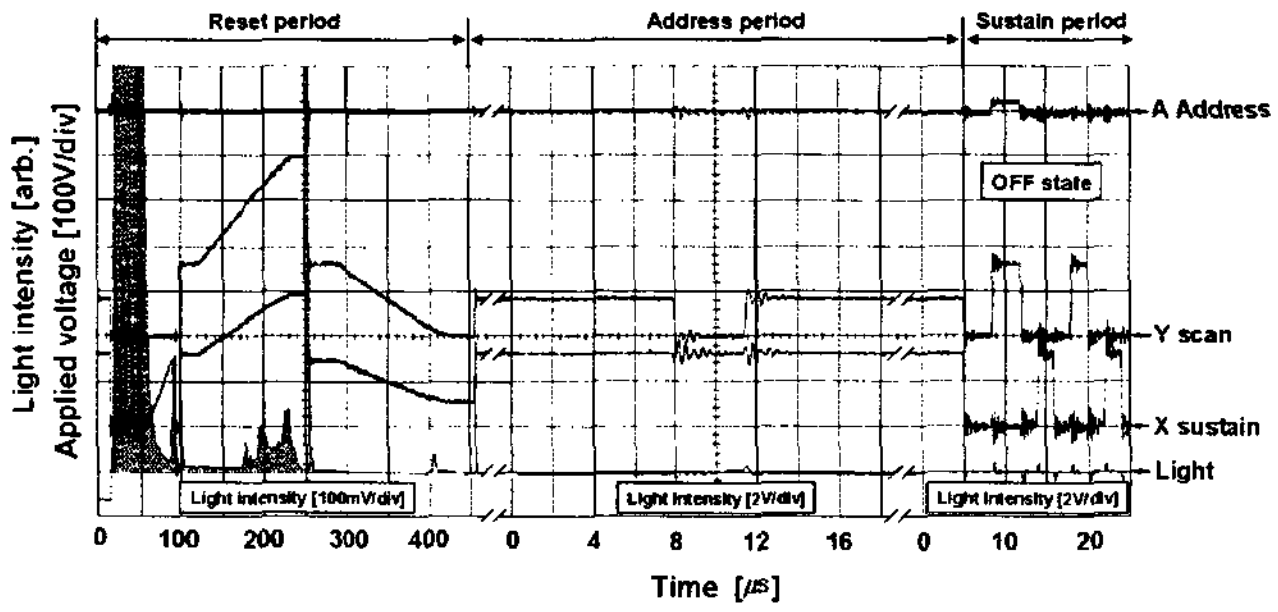
— Reset up time : 100μs, Reset down time : 150μs

— V_r: 390V, V_s: 155V, V_a: 80V, V_{ysc}: 80V

Fig. 1 Schematic diagram of driving waveform

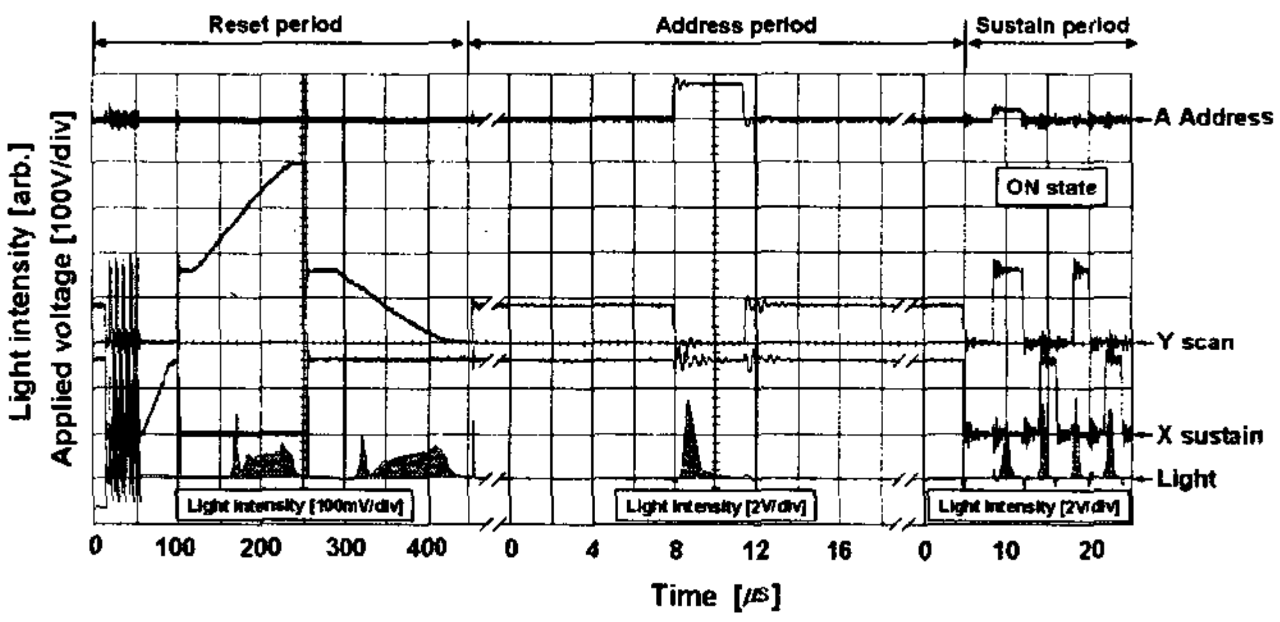


(a) Conventional method

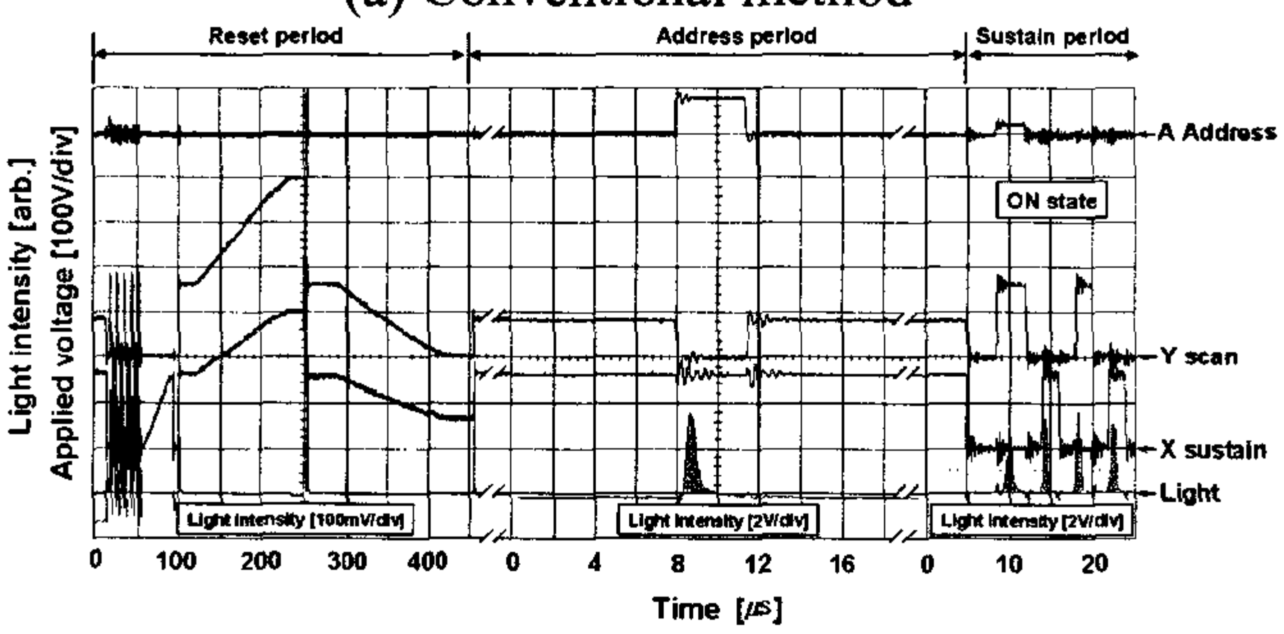


(b) ICR method

Fig. 2 Typical driving voltage and discharge light waveforms when the ON cell of the preceding sub-field is not addressed in this sub-field.

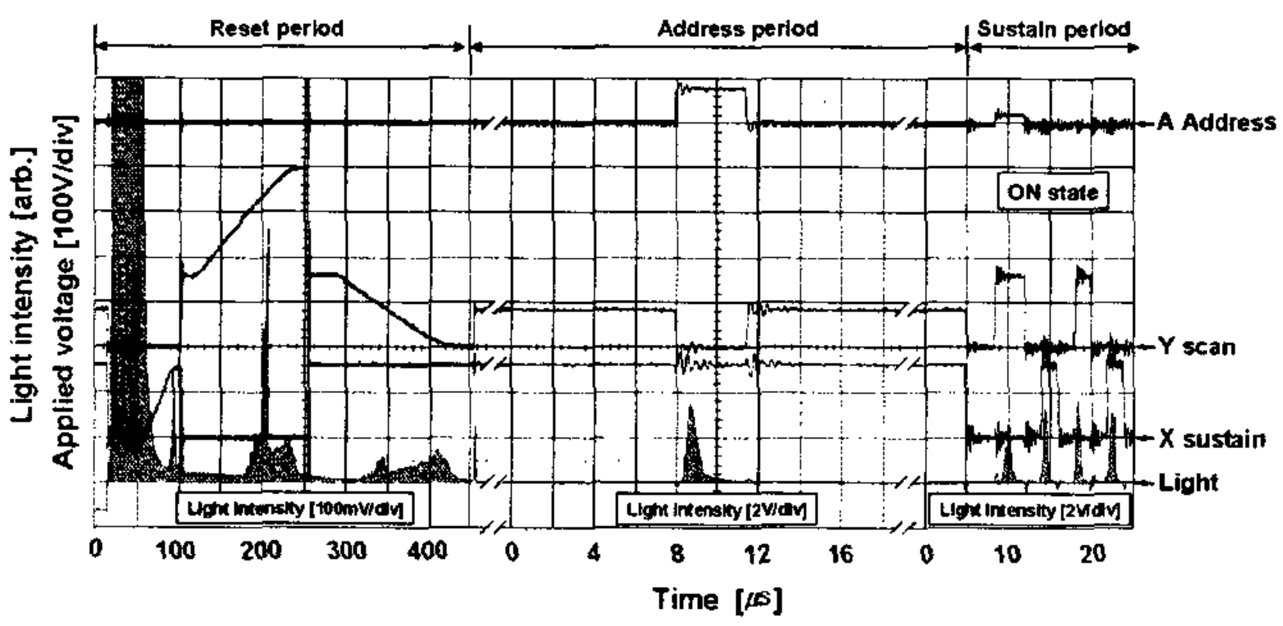


(a) Conventional method

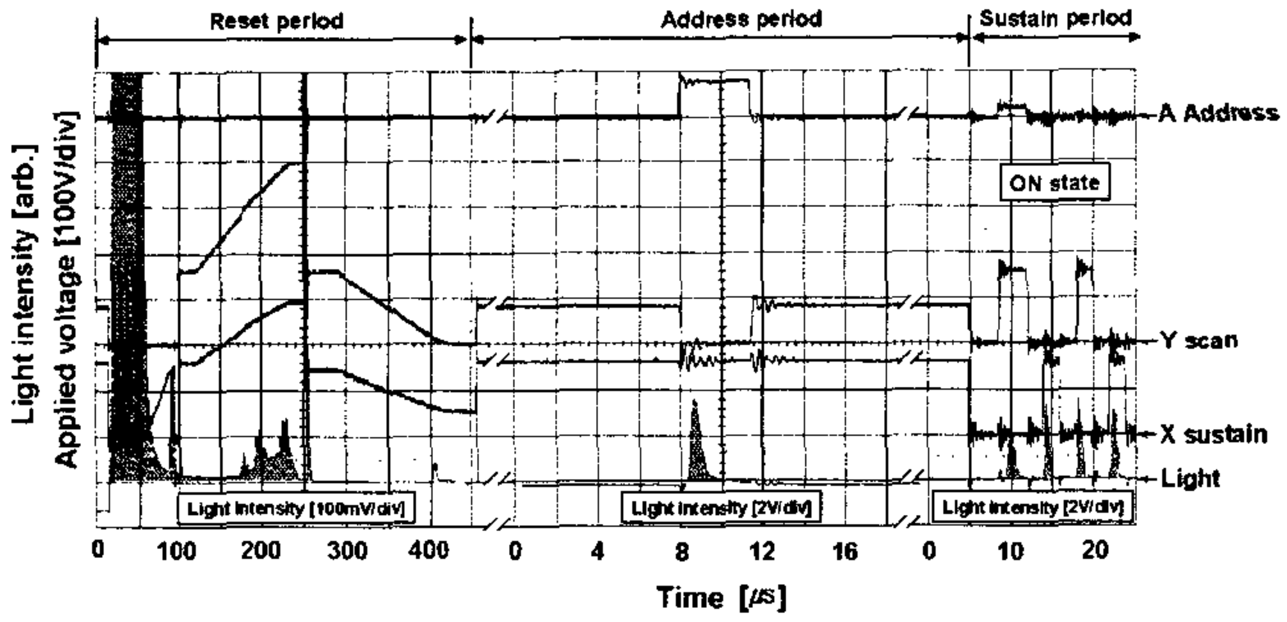


(b) ICR method

Fig. 3 Typical driving voltage and discharge light waveforms when addressing the OFF cell of the preceding sub-field.

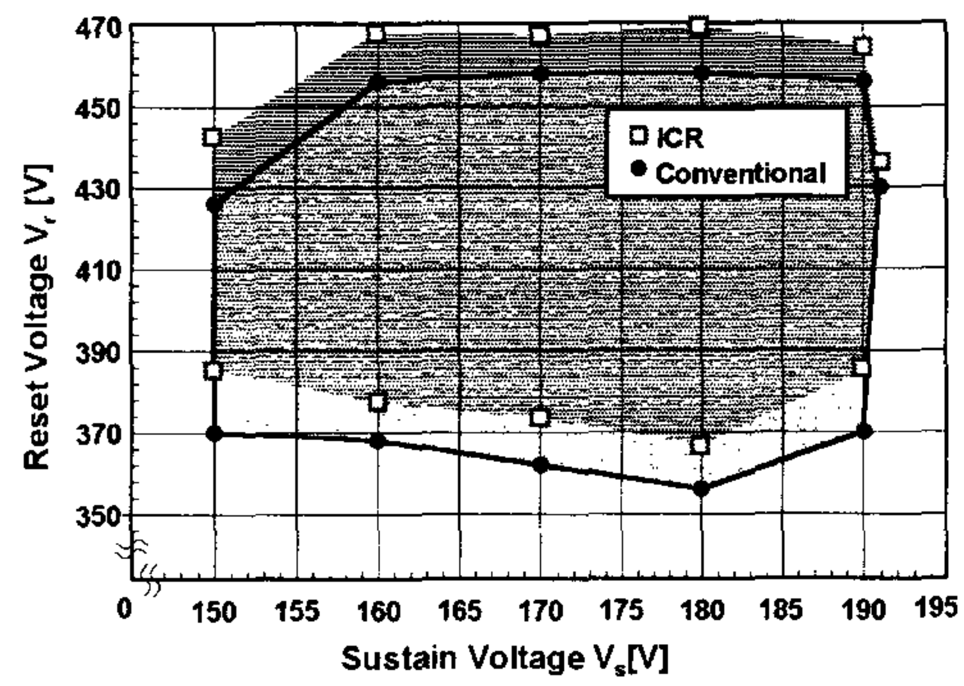


(a) Conventional method

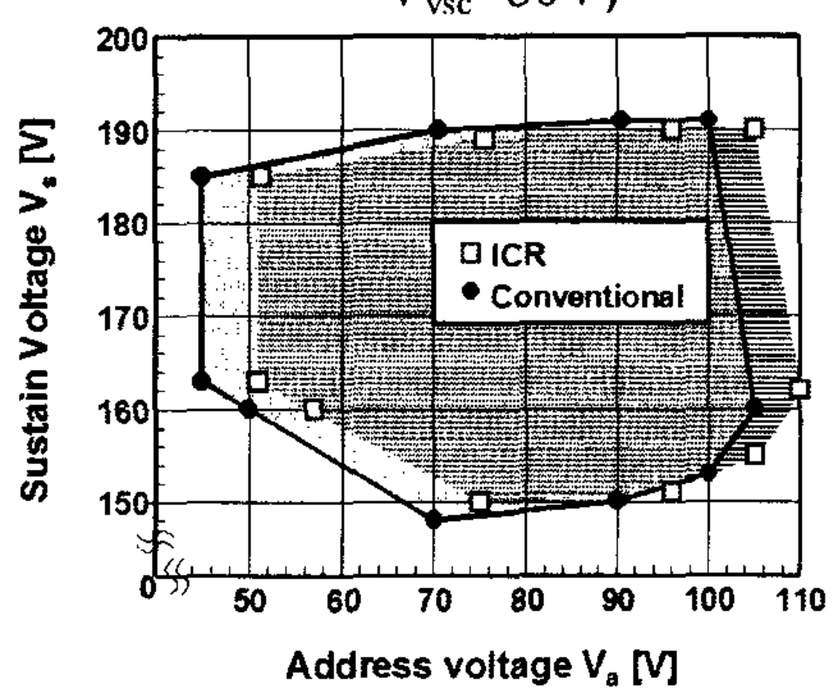


(b) ICR method

Fig. 4 Typical driving voltage and discharge light waveforms when addressing the ON cell of the preceding sub-field.



(a) Dynamic sustain characteristics (V_a =70V, V_{vsc}=80V)



(b) Dynamic address characteristics (V_r =400V, V_{ysc}=80V)

Fig. 5 The dynamic characteristics for both conventional and ICR method.