

# Modified Ramp-Reset Waveform Robust for Variable Panel Temperature and its Discharge Characteristics

Soo-Kwan Jang<sup>\*\*a</sup>, Heung-Sik Tae<sup>\*a</sup>, Soon-Bae Kim<sup>b</sup>, Eun-Young Jung<sup>b</sup>, Kwang-Jong Suh<sup>b</sup>, Jung-Chull Ahn<sup>\*b</sup>, Eun-Gi Heo<sup>\*b</sup>, Byung-Hak Lee<sup>\*b</sup>, and Kwang-Sik Lee<sup>\*b</sup>

## Abstract

By the voltage threshold (Vt) close-curve measurement method, the changes in the discharge characteristics such as a firing voltage and IR emission among the three electrodes were examined relative to the low or high panel temperature ranging from  $-10$  to  $80^{\circ}$ . The variation in the panel temperature was found significantly influence the surface discharge between the MgO surfaces rather than the plate gap discharge between the MgO and phosphor layers. Based on this experimental observation, a modified reset waveform that alleviates the surface discharge during a ramp-up and -down period was developed. By adopting the proposed reset waveform, a stable address discharge could be obtained irrespective of the panel temperature variation.

**Keywords** : panel temperature, Vt close-curve, reset waveform

## 1. Introduction

Recently, the image quality of plasma display panels is enhancing rapidly and considerably [1]. However, in order to further improve the image quality of AC-PDPs, a full high definition (HD) PDP requires stable driving condition with a wider driving margin irrespective of the variable panel temperature. The panel temperature or ambient temperature is one of the important factors determining the stable discharge in PDP cells because the discharge characteristics are varied by the panel temperature. Despite this, there has only been a few researches on done the relation between the panel or ambient temperature and the discharge characteristics [2-4].

In this paper, the changes in the discharge characteristics such as a firing voltage and IR emission among the three electrodes (X-Y, A-Y, and Y-A) were

examined relative to the low or high panel temperature ranging from  $-10$  to  $80^{\circ}\text{C}$ . In this study, the investigation was based on the Vt close-curve analysis[5, 6]. Using the experimental observations, a modified reset waveform that can produce a stable address discharge irrespective of the panel temperature variation is proposed.

## 2. Observation on Discharge Characteristics under Variable Panel Temperature

Fig. 1 shows the schematic diagram of the experimental setup for measurement. The 4-in. test panel with a gas mixture of Ne + Xe (4 %) and a pressure of 400 Torr was employed in this research. Its structure and dimensions were the same as those of the conventional 42-in. wide VGA grade PDP with a cell pitch of  $360\ \mu\text{m}$ . The panel temperature was varied from  $-10$  to  $80\ ^{\circ}\text{C}$  by heating the glass of the front panel with an external heater. In order to observe the discharge characteristics under variable panel temperature, the Vt close-curve was measured, as shown in Fig. 2. Fig. 2 shows the Vt close-curves measured from the test panel when the panel temperatures were  $-10$ ,  $+25$ , and  $+80\ ^{\circ}\text{C}$ , respectively. As shown in the arrows of (a) and (b)

Manuscript received February 2, 2006; accepted for publication March 9, 2006.

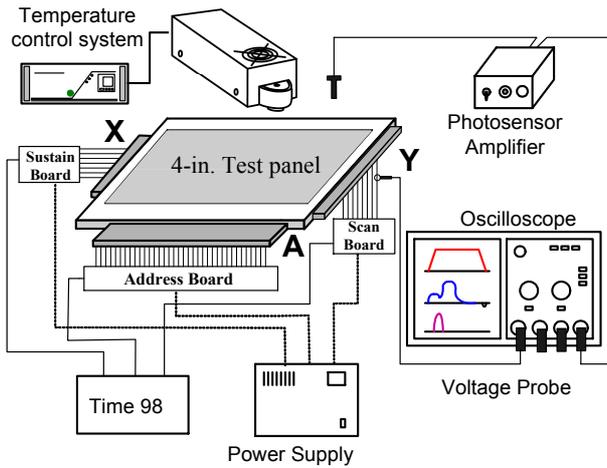
\* Member, KIDS ; \*\* Student Member, KIDS.

Corresponding Author : Soo-Kwan Jang

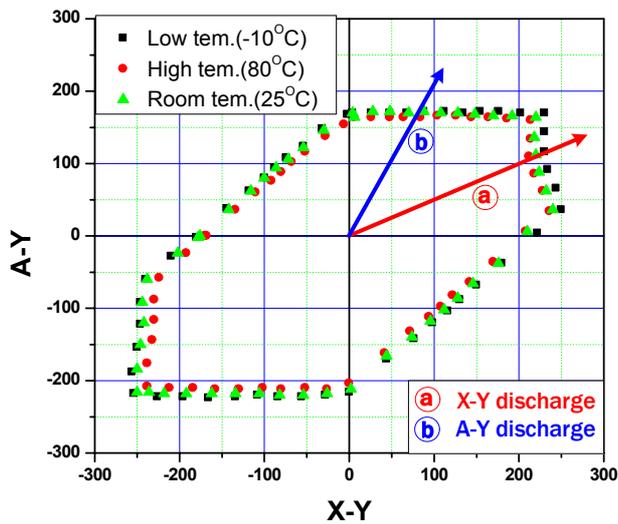
<sup>a</sup> School of Electrical Engineering and Computer Science Kyungpook National University, 1370 Sankyuk-Dong, Buk-Gu, Dague 702-701, Korea

<sup>b</sup> This work was supported by R&D Team, PDP Division, Samsung SDI Co. Ltd., Cheonan-Si Chungchongnam-Do 330-300, Korea.

E-mail : hstae@ee.knu.ac.kr Tel : +053 950-6563 Fax : +053 950-5505



**Fig. 1.** Schematic diagram of experimental setup employed in this work.

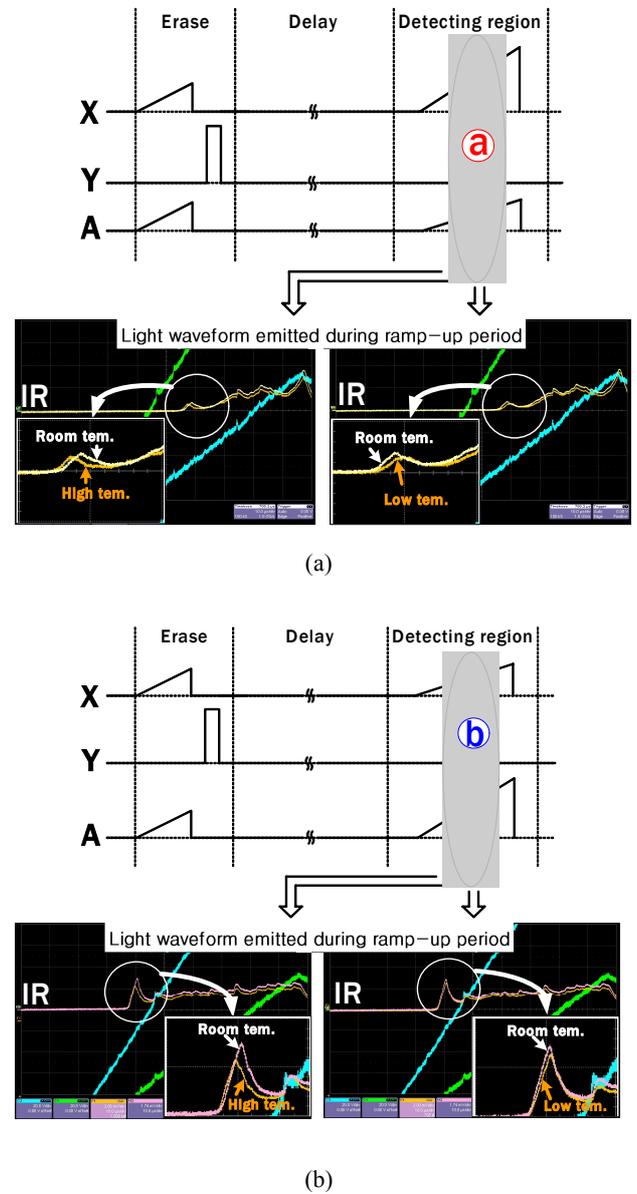


**Fig. 2.** Vt close curves measured from 4-in. test panel when panel temperatures were  $-10$ ,  $+25$ , and  $+80$  °C, respectively.

**Table. 1** Changes in discharge starting voltage among three electrodes relative to variable panel temperature.

	X-Y discharge	A-Y discharge	Y-A discharge
	MgO cathode		Phosphor cathode
	Surface discharge		Plate gap discharge
$-10$ °C	230 V	172 V	220 V
$25$ °C	220 V	172 V	218 V
$80$ °C	212 V	168 V	216 V

in the Vt close-curve of Fig. 2, the measured Vt close-curve shows that the surface discharge between the X and Y electrodes (case (a)) were influenced more than the plate gap discharge between the A and Y electrodes under the variable panel temperature. More detailed data are given in Table 1. From Table 1, the firing voltage of the X-Y discharge can be seen to have increased at a low panel temperature ( $\Delta V = +10$  V), whereas it decreased at a high panel temperature ( $\Delta V = -8$  V). However, the firing voltages of the A-Y and Y-A discharges are little changed at



**Fig. 3.** Light waveforms emitted from discharge cells at various panel temperatures: (a) X-Y discharge, and (b) A-Y discharge.

the low ( $\Delta V = 0 \sim 2 \text{ V}$ ) and high panel temperature ( $\Delta V = -2 \sim 4 \text{ V}$ ) conditions.

Figs. 3 (a) and (b) illustrate the test pulses for measuring separately the IR emission from (a) the surface (X-Y) and (b) plate gap (A-Y) discharges with a variation in the panel temperature, respectively. The initial wall charges were completely removed by the erase pulse, and the application time of the detecting ramp pulse was delayed enough to remove the priming particles. After that, the detecting ramp pulses were applied to produce only the X-Y discharge as shown in Fig. 3 (a) and only the A-Y discharge in Fig. 3 (b). In this detecting pulse, the slopes of the detecting ramp pulses for measuring only the XY discharge were  $4 \text{ V}/\mu\text{s}$  for the X electrode,  $2 \text{ V}/\mu\text{s}$  for the A electrode, respectively, and the slopes of the detecting ramp pulses for measuring only the AY discharge were  $2 \text{ V}/\mu\text{s}$  for the X electrode,  $4 \text{ V}/\mu\text{s}$  for the A electrode, respectively.

The resultant IR emissions were measured for both cases. For the X-Y discharge, the discharge in the high panel temperature was initiated more quickly than that in the room panel temperature, whereas the discharge was initiated slower for the low panel temperature. However, the discharge intensities for both the high and low panel temperatures were observed to be weaker than that in the room panel temperature. For the A-Y discharge, the discharge initiation times are almost the same for both cases, but the discharge intensities were weaker for the low and high panel temperatures

### 3. Modified Ramp-Reset Waveform Robust for Variable Panel Temperature

As observed in the previous section, the variable panel temperature can affect the X-Y surface discharge more than the A-Y plate gap discharge. Accordingly, the reset waveform stable for the variable temperature requires that the contribution of the surface (X-Y) discharge sensitive to the panel temperature in the reset discharge. In this sense, the conventional reset waveform that uses the XY discharge dominantly needs to be modified to reduce the effect of the temperature.

Fig. 4 (a) shows the conventional reset waveform and Fig. 4 (b) shows the proposed reset waveform with a ramp-type X bias for minimizing the variation in the reset and address

discharge characteristics with the panel temperature. The basic idea of the proposed reset waveform is to maxi-

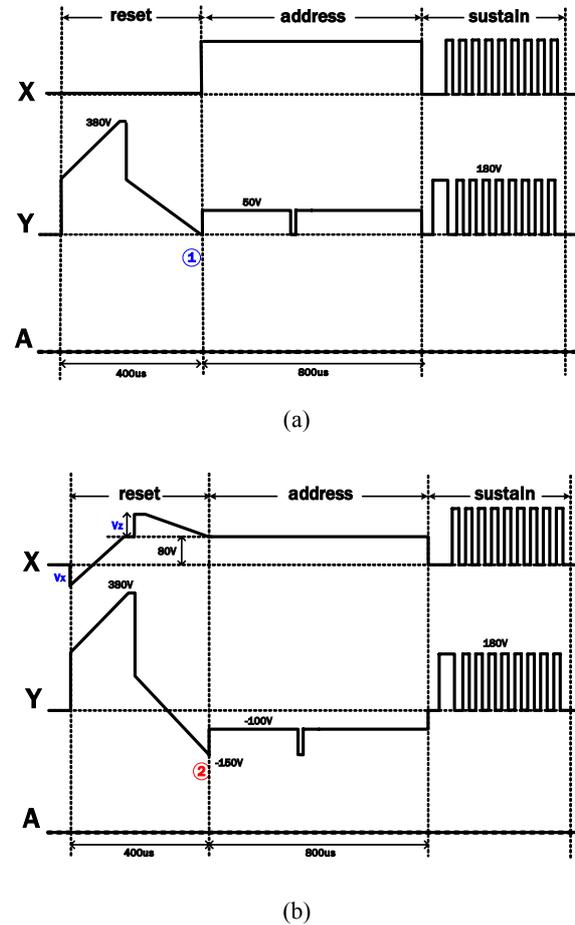


Fig. 4. Schematic diagram of (a) conventional reset waveform and (b) proposed reset waveform with ramp-type X bias.

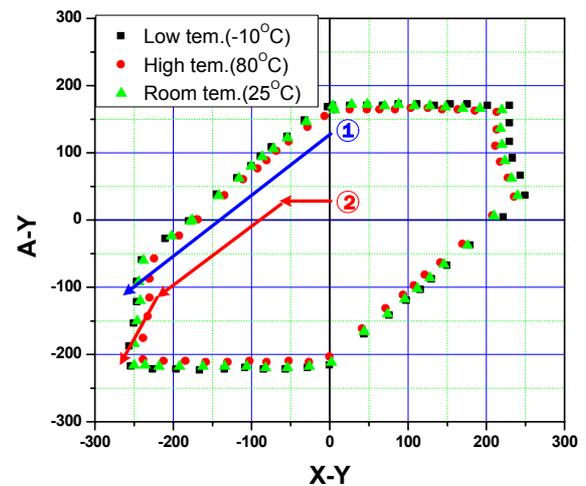


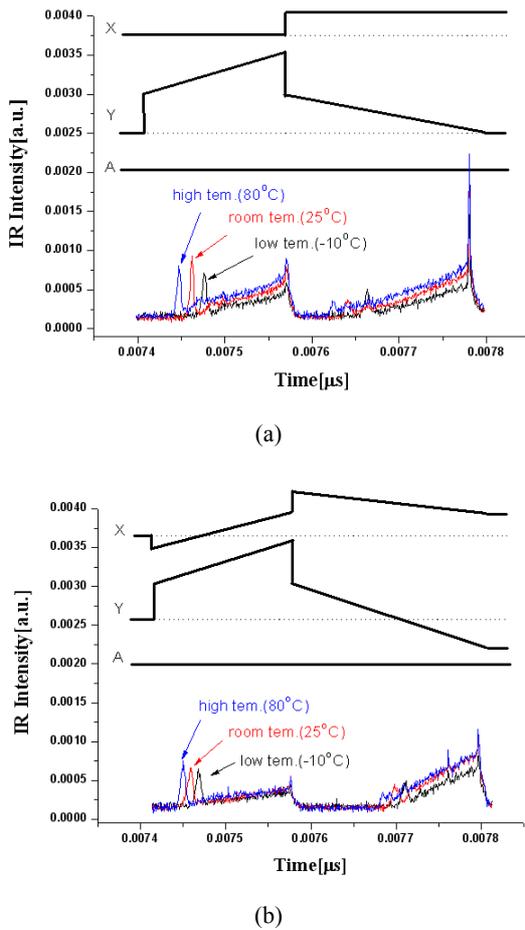
Fig. 5. Analysis of reset waveform using  $V_t$  close-curve.

mize the plate gap (A-Y) discharge by reducing the panel temperature in the reset discharge during the ramp-up and -down periods. From Fig. 5 (a) which shows the  $V_t$  close-curve that was measured at point ① by applying the convention ramp waveform was applied as shown in Fig. 4 (a), the Y-X discharge is produced as the voltage applied to the Y electrode increases, and many weak Y-X discharges are not produced until the discharge point reaches the simultaneous discharge point. In this case, the weak reset discharge tends to be very sensitive to the panel temperature. On the other hand, from Fig. 5 (a) the  $V_t$  close-curve which was measured at point ② by applying the proposed ramp waveform in Fig. 4 (b), the Y-X discharge is produced at the lower side of the Y-X discharge side due to the ramp-type X bias applied to the X electrode, and as such relatively only a few weak Y-X discharges are not produced until the discharge point reaches the simultaneous discharge point. In this case, the

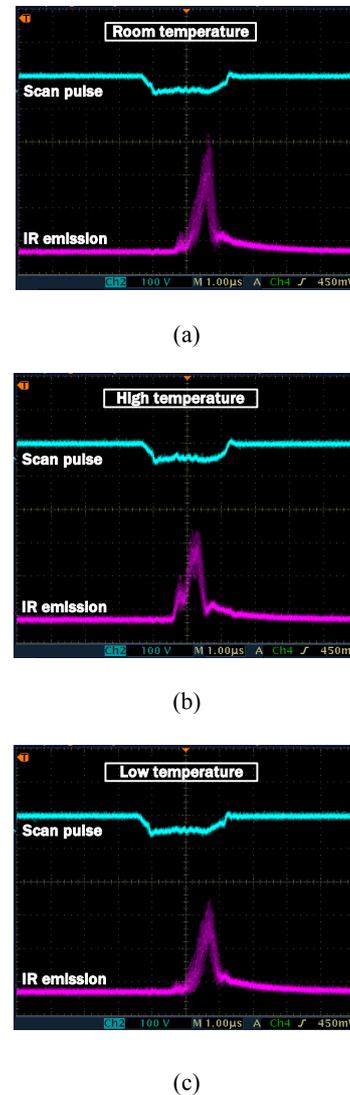
weak reset discharge tends to be less sensitive to the panel temperature.

#### 4. Address Discharge Robust Variable Panel Temperature as Result of Adopting Proposed Reset Waveform with Ramp-type X Bias

Fig. 6 (a) shows the IR emission during the reset-period measured at three different panel temperatures, i.e.,  $-10$ ,  $+25$  and  $+80$  °C where the conventional reset waveform of Fig. 4 (a) was applied. At a high panel temperature, the reset discharge is produced faster and the total amount



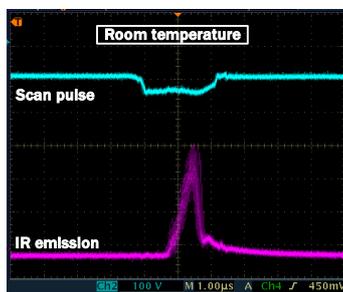
**Fig. 6.** IR waveforms measured during reset discharges at various temperatures.



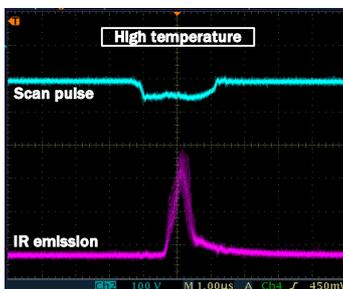
**Fig.7.** IR waveforms measured during address discharge when applying conventional reset waveform of Fig. 4 (a).

of the IR emission during the reset period is also increased, whereas the reset discharge characteristics at a low panel temperature shows the opposite to that at a high panel temperature. On the other hand, in the case where the proposed reset waveform with a ramp-type X bias was applied, the difference in the IR emission caused by the various panel temperatures tends to be minimized, as shown in Fig. 6 (b). As shown in Fig. 7, in the case of adopting the conventional of Fig. 4 (a), the different reset discharges at three different panel temperatures, i.e.,  $-10$ ,  $+25$  and  $+80$  °C cause the different address discharge.

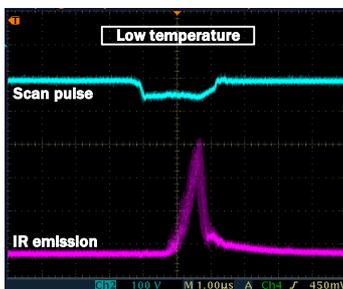
As a result of adopting the proposed reset waveform



(a)



(b)



(c)

**Fig. 8.** IR waveforms measured during address discharge when applying proposed reset waveform with ramp-type X bias of Fig. 4 (b).

of Fig. 4 (b), there seems little difference in the IR emission during the address discharge, which means that the proposed reset waveform contributes to alleviating the difference in the reset and subsequent address discharge caused by the changes in the panel temperature.

## 5. Conclusions

In the view of the discharge instability, the investigation on the relation between the discharge characteristics and the panel temperature is very important. This paper describes the experimental observation on the changes in the surface or plate gap discharge relative to the panel temperature ranging from  $-10$  to  $80$  °C based on the  $V_t$  close-curve analysis. It is observed that the variable panel temperature can affect the X-Y surface discharge more than the A-Y plate gap discharge. The modified reset waveform, which can maximize the plate gap (A-Y) discharge by reducing the contribution of the surface (X-Y) discharge sensitive to the panel temperature, is proposed. The experimental observation confirms that the proposed reset waveform can produce a stable address discharge irrespective of the panel temperature variation.

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