Low Voltage Current Controlled Driving Method for AC PDP

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Abstract

This paper presents a new driving method that can drive AC PDPs with low voltage and controlled-current for the sustaining period. The discharge current flowing into the AC PDP is limited in this method. Thus, the power consumption for the discharge is reduced and the discharge input power to output luminance efficiency is improved. Experimental results using this driving method showed that we could drive an AC PDP with a voltage source as low as 146 V and that luminous efficiency of 1.33 lm/W can be achieved.

1. Introduction

The PDP is receiving attention as a next generation large size display, but some of its characteristics such as power consumption, picture quality and cost should be improved before it can be widely used. Also, the efficient driving method for high-resolution display should be developed.

The power consumption of the PDP has been quite improved recently, but it is a still major problem of the PDP. In AC PDP, most power is consumed during the sustaining period and the major cause of the power consumption during the sustaining period is the discharge current [1] that flows into the AC PDP when the discharge is fired. In conventional sustain driving methods, the voltage across the panel is kept constant even after the discharge is fired [2]. Thus, large current has to be supplied from the power supply because the capacitance across the panel is drastically reduced once the discharge is fired.

2. Current Controlled Driving Method

High voltage is necessary for the firing of discharge in AC PDP but the same high voltage is not necessary for the progression of discharge once it is started. Fig. 1 shows the Current-Controlled Driving Method proposed in this paper. In this driving method, for the sustaining discharge, the AC PDP is charged up with the current that is supplied from the charge storage capacitor *Cs* through the inductor *L* [3]. Once the voltage across the panel becomes the firing voltage, the discharge is started. While the discharge continues, only limited current is supplied to the panel through the inductor *L* in this method. In consequence, the voltage across the panel decreases as the discharge progresses because the capacitance across the panel increases.

Since the power supplied to the panel while the panel discharges is reduced in this driving method, the input power to output luminance efficiency is improved compared to the efficiency in the conventional driving methods. Furthermore, since the power supply is connected to the large storage capacitor *Cs*, and since the PDP is charge up with the current from the storage capacitor through the *L-C* resonant circuit, the necessary voltage of the power supply is as low as about half of the voltage necessary in the conventional driving method [4].

3. Switching Sequence and Operation

The switching and operation sequence of the Current Controlled Driving Method is as follows.

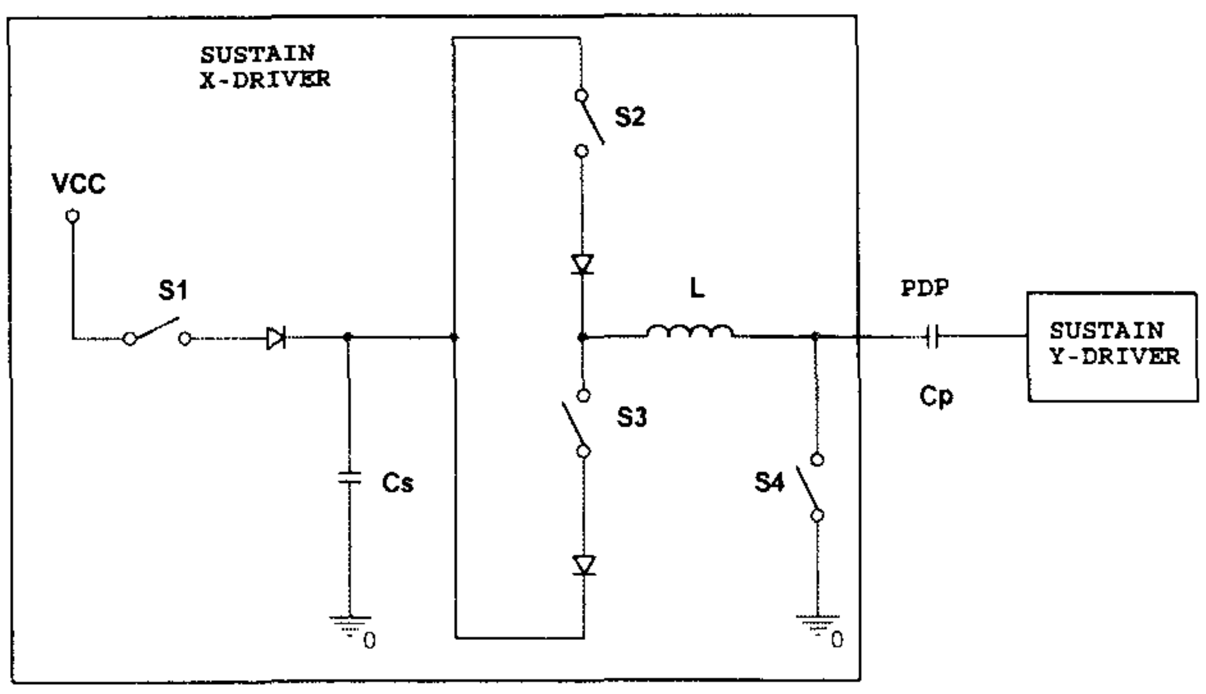

Fig. 1 Current Controlled Driving Method

First, *Cs* is charged to *VCC* by closing the switch *S*1. Next, the charge stored in *Cs* is supplied to the panel through the inductor L by closing the switch *S*2. If the capacitance of *Cs* is much larger than the capacitance of the panel *Cp*, then the voltage across the panel will increase toward twice the voltage of *VCC*. When the voltage across the panel becomes the firing voltage, the discharge will be fired. After the discharge is completed, the charge accumulated in the panel is restored into the storage capacitor through *L-C* resonance by closing *S*3. Then *S*4 is closed to ground the side of the panel.

The conventional sustain driving method that uses the energy recovery circuit requires accurate switching timing, but it is not necessary in Current Controlled Driving Method because the panel discharge by itself when the voltage across panel reaches the firing voltage.

4. Experimental Test for Minimum Power Supply Voltage

The Current Controlled Driving Method was realized as shown in the circuit diagram of Figure 2. A 4-inch panel consisting of 42 scan lines and 108 addressing lines was used. The switches were implemented using IRF740 NMOS and the switch MOSFETs were driven by IR2110 driver ICs.

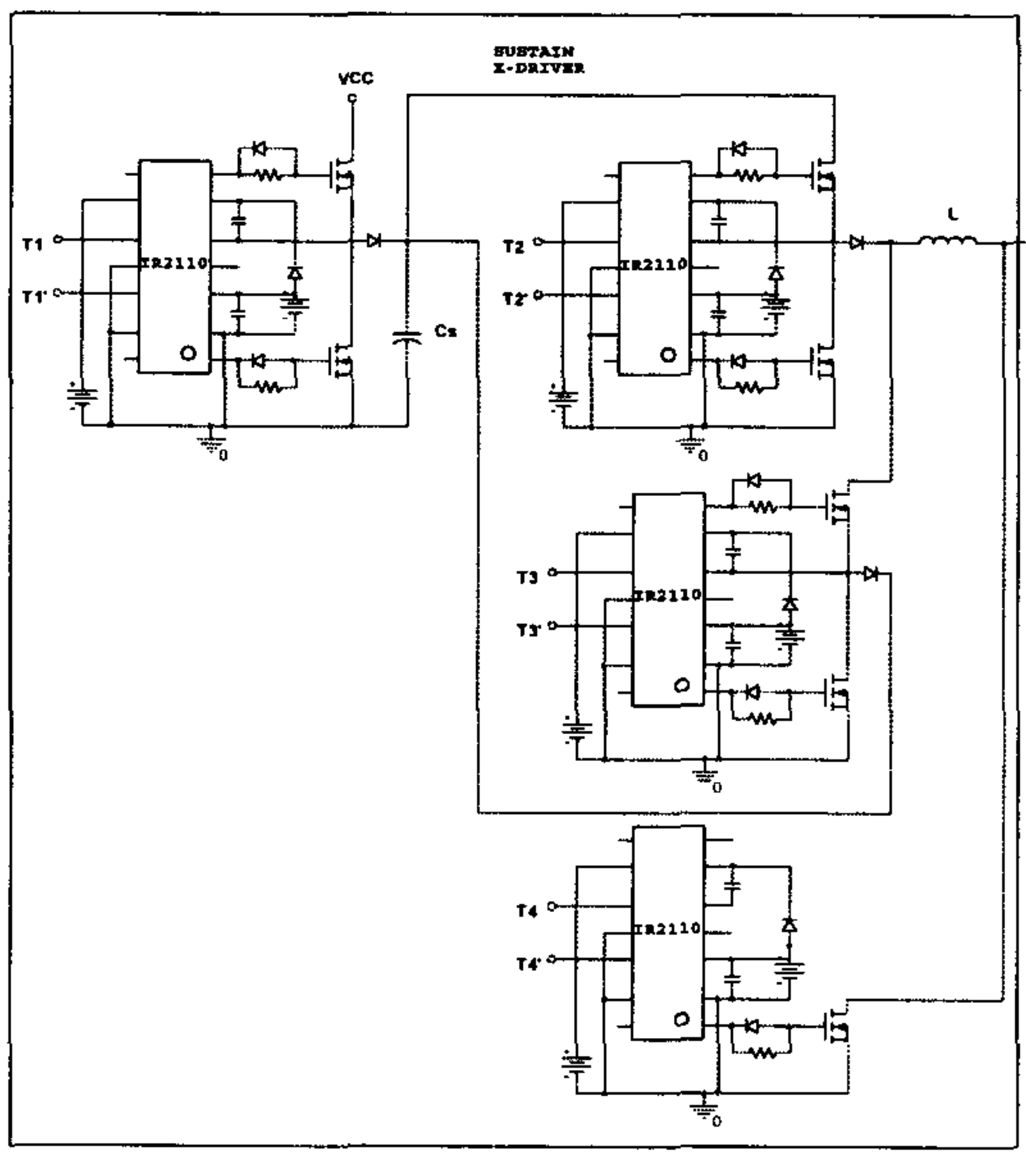

Fig. 2 Circuit diagram for the Current Controlled Driving Method

IR2110 generates floating gate-source voltage for the switch MOSFET. The switches are controlled by the pulse signals applied to the terminal T1, T2, T3 and T4.

Setting the inductance of *L* at 264uH, the minimum DC power supply voltage necessary to ignite the discharge was measured for different values of *Cs*. Fig. 3 shows the measured minimum supply voltage as a function of the capacitance of *Cs* when the circuit drove the full panel (42 lines), a half of the panel (21 lines), 10 lines or 5 lines. When 47uF was used for *Cs*, the necessary DC power supply voltage was minimum and almost constant for all the cases of the panel load.

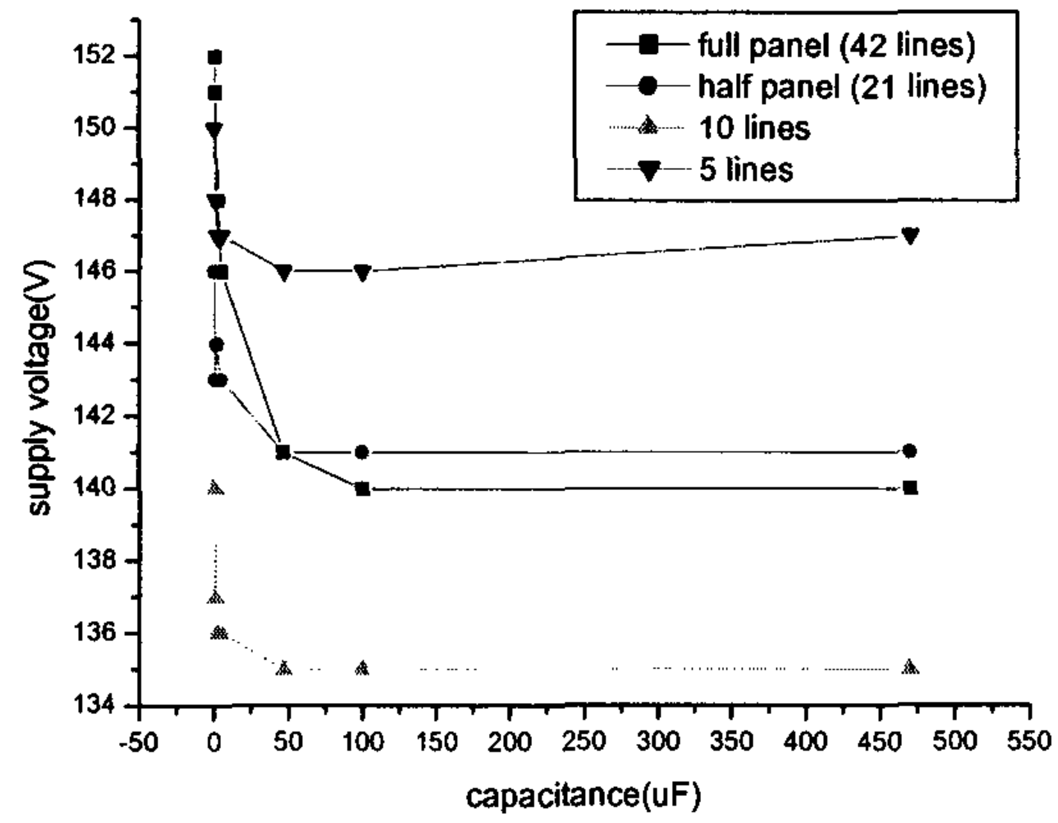

Fig. 3 Supply voltage as a function of capcitance

Setting the capacitance for *Cs* at 47uF, the minimum DC power supply voltage necessary to ignite the discharge was measured for different values of *L*. Fig. 4 shows the measured minimum supply voltage as a function of the inductance of *L* for different panel loads.

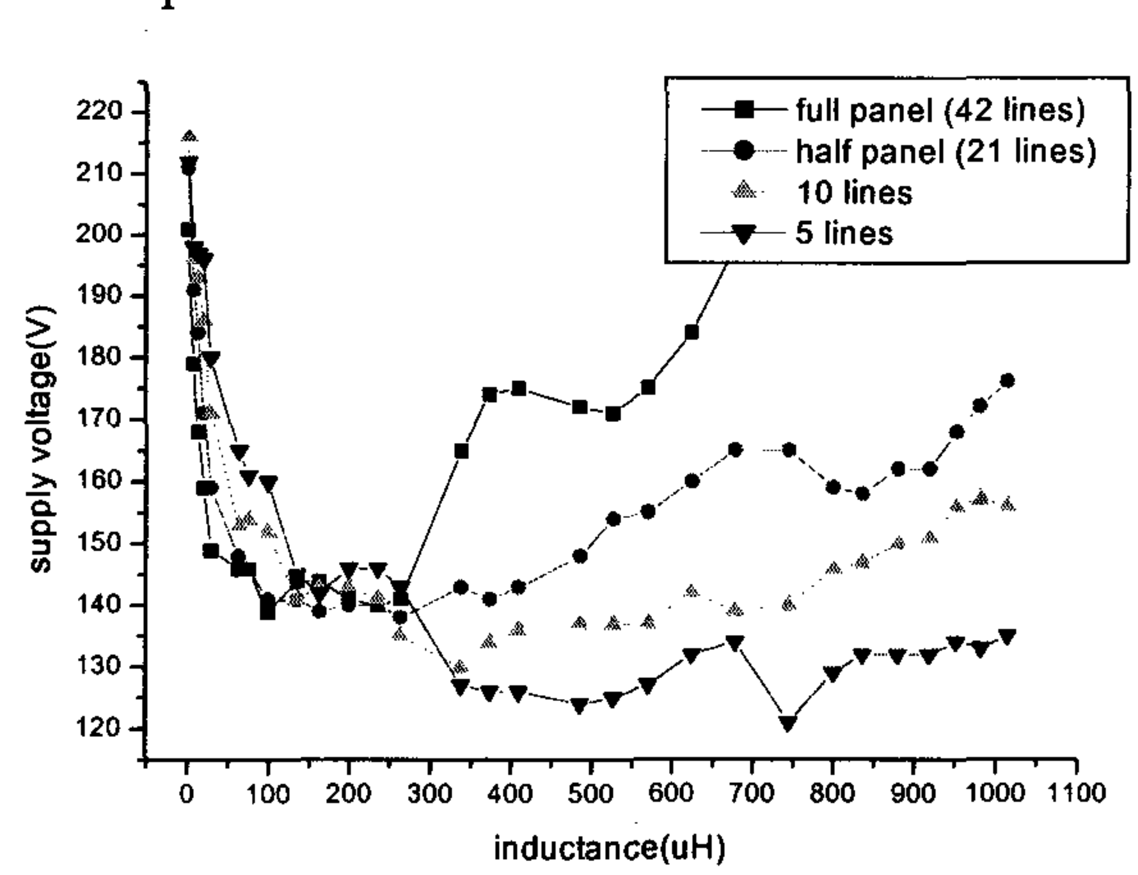

Fig. 4 Supply voltage as a function of inductance

From the results shown in Fig. 4, it can be seen that, if we use dc power supply voltage above 146V, 47uF for *Cs* and 136~264uH for *L*, the Current Controlled Driving Method can stably drive the 4-inch panel for all the cases of load. 146V is lower than 213V that is necessary when the conventional sustain driving method is used for the same panel by 67V.

5. Power Consumption and Luminous Efficiency Measurements

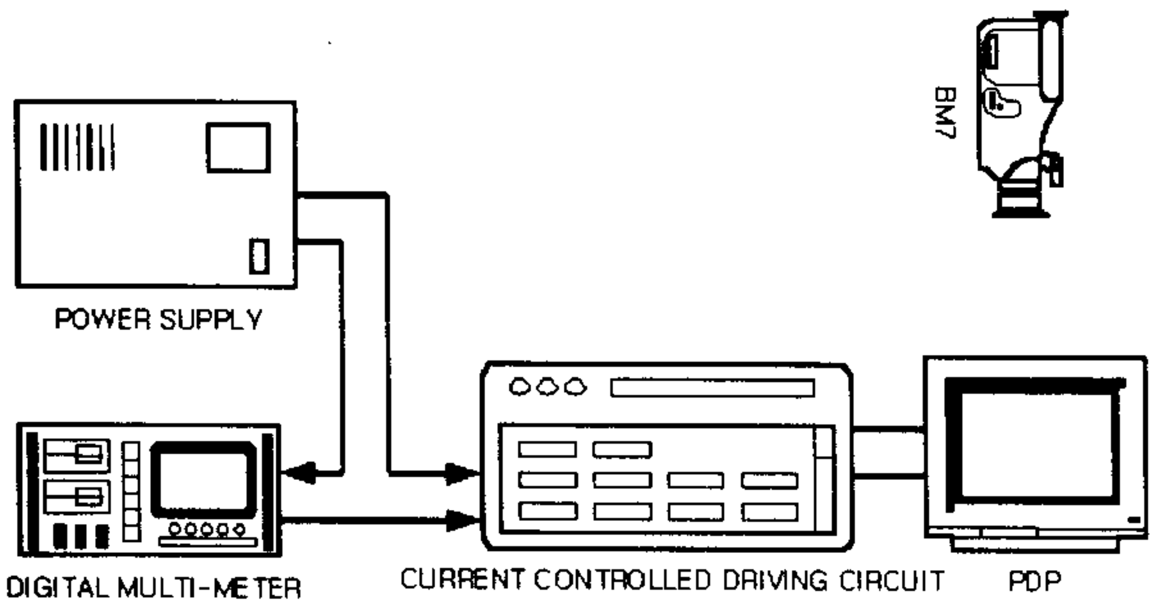

Fig. 5 Experimental Setup for measurement of power consumption and luminance

Fig. 5 shows the experimental setup for the measurement of power consumption and luminance [5]. By multiplying the voltage from the DC power supply and the average current measured with the digital multimeter, the power consumption of the system including the driving circuit and the panel was measured. The results are shown in Fig. 6. Also, the luminance was measured with luminance colorimeter, BM7.

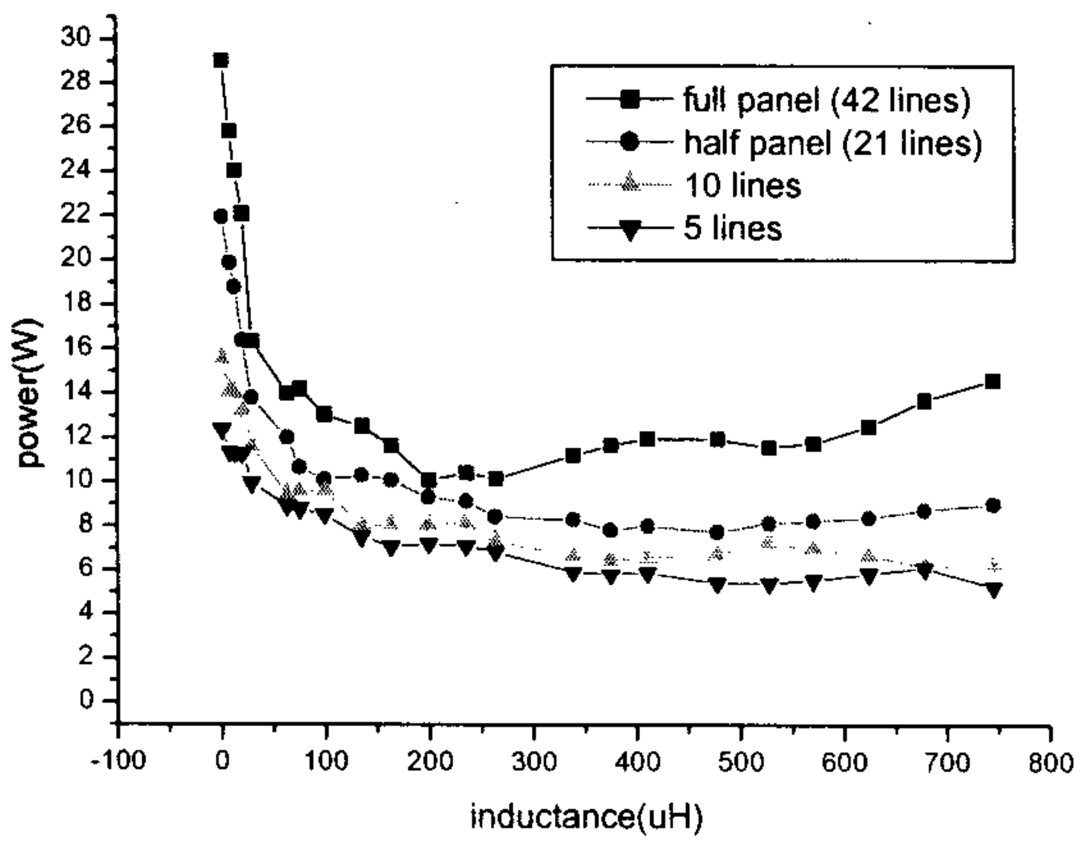

Fig. 6 Power consumption as a function of inductance

The measured power consumption when the conventional sustain driving circuit was used is compared with the power consumption when the current controlled driving method was used in Table 1. From Table 1, we can see that, when we used 47uF for Cs and 264uH for L in the Current Controlled Driving Circuit, the power consumption was reduced by 60.7% for the full panel load case, by 42.8% for half panel, by 5.3% for 10 lines, and increased by 2.2% for 5 lines.

Table 1 Comparison of power consumpton

Panel Load / Driving method	Full panel (42 lines)	Half panel (21 lines)	10 lines	5 lines
Conventional Sustain [W]	25.9	14.76	8.61	6.12
Current Controlled [W]	10.17	8.44	7.36	6.87
Power Reduction [%]	60.7	42.8	5.3	-2.2

The luminous efficiency is expressed as

$$\eta = \frac{\pi BS}{P_i} = \frac{\pi BS}{V(I_{on} - I_{off})} \qquad (1)$$

where B is luminance, S is display area, P_i is input power, V is input voltage, I_{on} is average current when the load is on and I_{off} is average current when the input voltage is right below the turn-on voltage [5]. If we use the input power into the panel for P_i in Eq. (1), Eq. (1) represents the luminous efficiency of the panel. If we use the input power into the system that includes the driving circuit and the panel for P_i in Eq. (1), Eq. (1) represents the luminous efficiency of the system [6].

Fig. 7 shows the luminous efficiency of the system consisting of the current controlled driving circuit and the panel shown in Fig. 5. Table 2 compares the luminous efficiency when the conventional sustain driving method was used and when the current controlled driving method was used with *Cs* of 47uF and *L* of 264uH. From table 2, we can see that, by using the Current Driving Method, we improve the luminous efficiency by 150.9% for the full panel load case, by 81.6% for half panel, by 0% for 10 lines and by 7.4% for 5 lines.

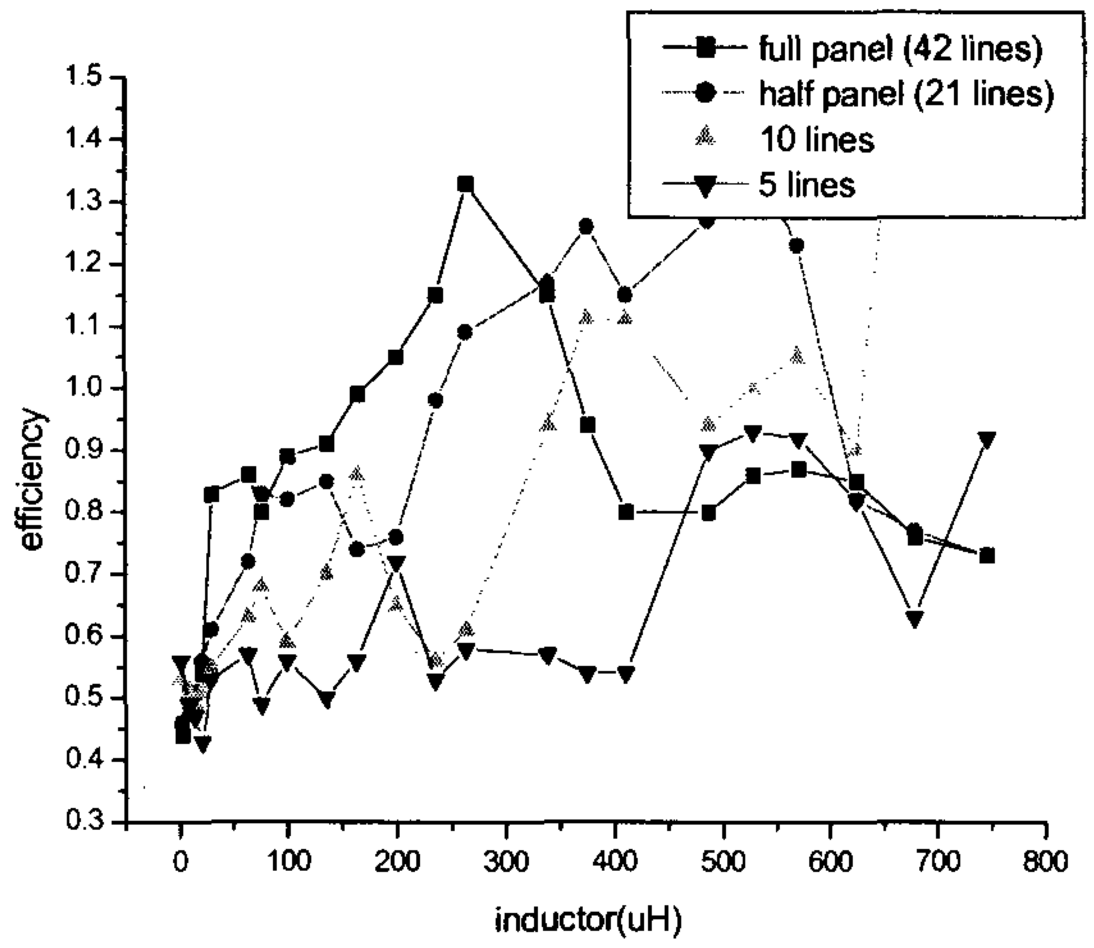

Fig. 7 Luminous efficiency as a function of inductance

Table 2 Comparison of luminous efficiency

Panel Load / Driving method	Full panel (42 lines)	Half panel (21 lines)	10 lines	5 lines
Conventional Sustain [lm/W]	0.53	0.6	0.61	0.54
Current Controlled [lm/W]	1.33	1.09	0.61	0.58
Efficiency Improvement [%]	150.9	81.6	0	7.4

6. Conclusion

We proposed a new sustain driving method for the AC PDP. Since the power supplied to the panel while the panel discharges is reduced in this driving method, the input power to output luminance efficiency is improved. Since the power supply is connected to the large storage capacitor *Cs* and the PDP is charge up with the current from the storage capacitor through the *L-C* resonant circuit, we can drive AC PDPs with a power supply of low voltage using this method.

It was experimentally shown that we could stably drive a 4-inch panel with 146 V and with luminous efficiency of 1.33 lm/W for full panel load.

7. References

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