Current-Controlled Driving Method for AC PDP and Experimental Characterization

Joon-Yub Kim and Jong-Sik Lim

Abstract - A new Current-Controlled Driving Method that can drive AC PDPs with low voltage and high luminous efficiency for the sustaining period is presented. In this driving method, the voltage source is connected to a storage capacitor and the stored voltage is delivered to the panel through LC resonance. Thus, this driving method can drive the panel with a voltage source as low as about half of the voltage necessary in the conventional driving methods. 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 146V and that high luminous efficiency of 1.33 lm/W can be achieved.

Keywords : plasma display panel, low voltage driving, low power consumption, high efficiency driving method, energy recovery circuit

1. Introduction

The PDP has been expected to be a dominant display device in large screen display applications, but some of its characteristics such as power consumption, picture quality and cost should be improved before it can be more widely used. Also, the efficient driving method for the promotion of the use of PDPs in HDTV should be developed [1, 2].

The power consumption of the PDP has been quite improved recently [3~5], but it is still a major problem for PDPs to be used in houses replacing traditional CRT displays. In AC PDPs, most power is consumed during the sustaining period and the major cause of the power consumption during the sustaining period is the discharge current [6] 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 [7, 8]. Thus, large current must be supplied from the power supply because the capacitance across the panel increases drastically once the discharge is fired.

2. Current-Controlled Driving Method

High voltage is necessary for the firing of discharge in the 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 and the switching sequence proposed in this paper. In this driving method, the AC PDP is charged up with the current that is supplied from the charge storage capacitor *Cs* through the inductor *L* [9]. First, *Cs* is charged to *VCC* by closing the switch *S*1. Next, the charge stored in *Cs* is supplied to the panel though the inductor *L* by closing the switch *S*2. If the capacitance of panel *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*. 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. After the discharge is completed, the charge accumulated in the panel is restored into the storage capacitor *Cs* through *L-C* resonance by closing *S*3. Then *S*4 is closed to ground the side of the panel.

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 of the conventional driving methods. Furthermore, since the power supply is connected to the large storage capacitor *Cs*, and since the PDP is charged 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 [10].

Also, the conventional sustain driving method that uses

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the energy recovery circuits requires accurate switching timing [11], but it is not necessary in the Current-Controlled Driving Method because the panel discharges by itself when the voltage across the panel reaches the firing voltage.

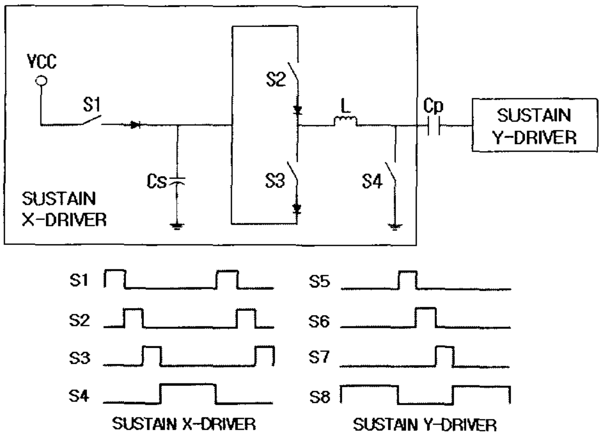


Fig. 1 Current-Controlled Driving Method and Switching Sequence

3. Experimental Setup

The Current-Controlled Driving Method was realized as shown in the circuit diagram of Fig. 2 with actual devices. 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. IR2110 generates floating gate-source voltage for the switch MOSFET. The switches are controlled by the pulse signals applied to the terminals T1, T2, T3 and T4.

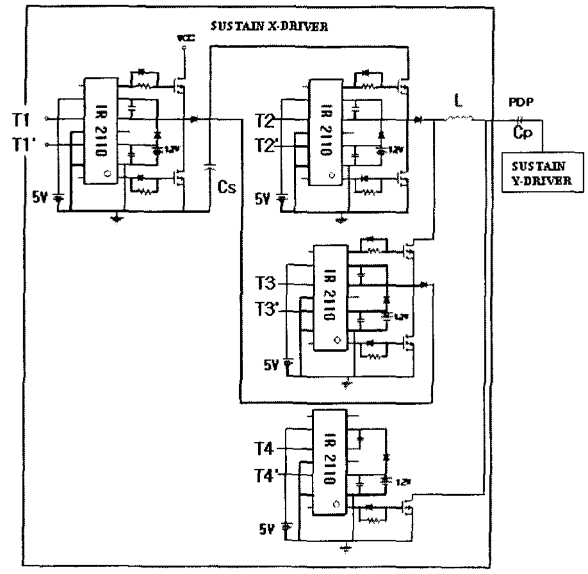


Fig. 2 Circuit diagram for the Current-Controlled Driving Method

Fig.3 shows the experimental setup for the measurement of power consumption and luminance [12]. 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. Also, the luminance was measured with a luminance colorimeter, BM7. The sustaining frequency was 83.3kHz such that the panel discharged 166,667 times per second.

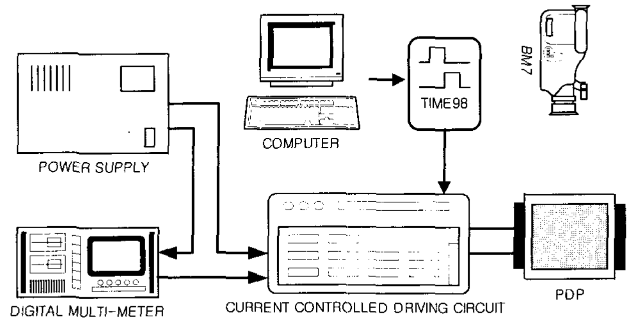


Fig. 3 Experimental Setup for measurement of power consumption and luminance

4. Experimental Results

4.1 Test for Minimum Power Supply Voltage

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.4 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 after 47uF.

Setting the capacitance for *Cs* at 47uF, the minimum DC power supply voltage necessary to ignite the discharge was

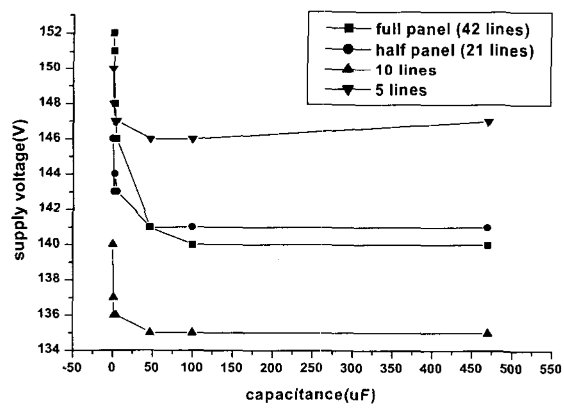


Fig. 4 Supply voltage as a function of capacitance

measured for different values of *L*. Fig.5 shows the measured minimum supply voltage as a function of the inductance of *L* for different panel loads.

From the results shown in Fig.5, 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 the 213V that is necessary when the conventional sustain driving method is used for the same panel by 67V.

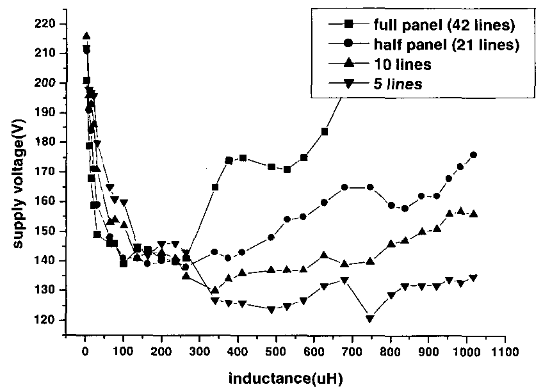


Fig. 5 Supply voltage as a function of inductance

4.2 Power Consumption and Luminous Efficiency Measurements

The measured results of the power consumption as a function inductance of *L* are shown in Fig.6. Also, the measured power consumption when the conventional sustain driving circuit was used is compared with the power consumption when the Current-Controlled Driving Circuit was used in Fig.7. From Fig.7, 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.

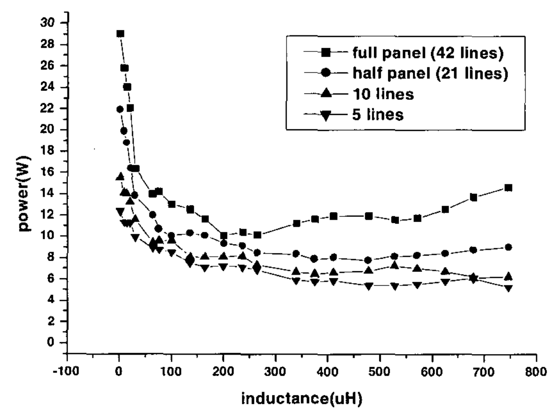


Fig. 6 Power consumption as a function of inductance

The luminous efficiency is expressed as

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

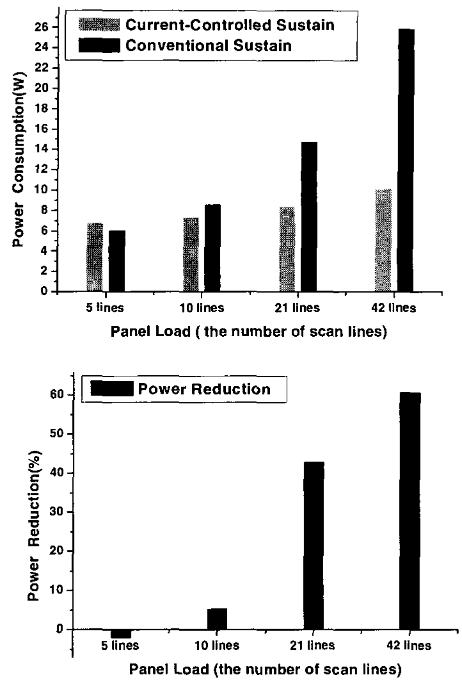


Fig. 7 Comparison of power consumption

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 [12]. 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 [13].

Fig.8 shows the luminous efficiency of the system consisting of the Current-Controlled Driving Circuit and

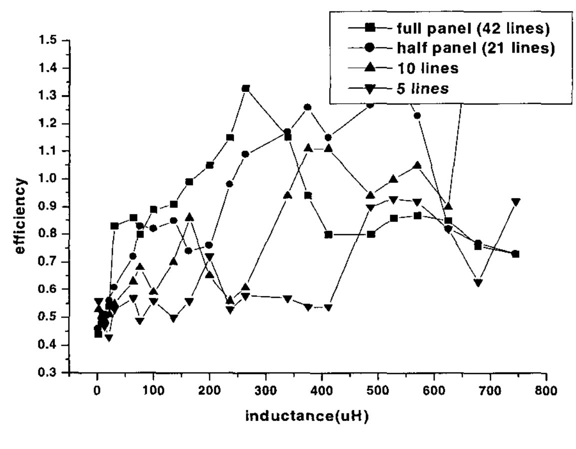
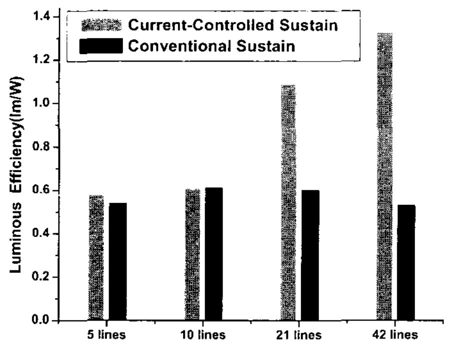


Fig. 8 Luminous efficiency as a function of inductance

the panel shown in Fig.3. Fig.9 compares the luminous efficiency when the conventional sustain driving method was used with the luminous efficiency when the Current-Controlled Driving Method was used with Cs of 47uF and L of 264uH. From Fig.9, we can see that, by using the Current-Controlled Driving Method, the luminous efficiency is improved 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.



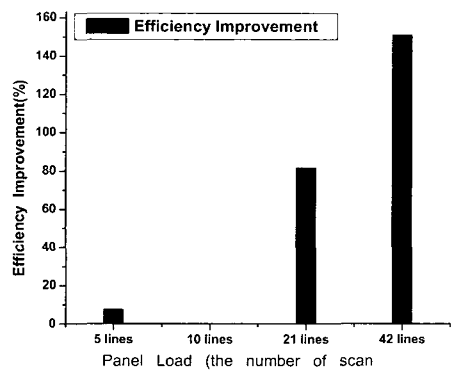


Fig. 9 Comparison of luminous efficiency

5. Conclusion

A new sustain driving method for the AC PDP was presented. 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 low voltage using this method.

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

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