P.16: New Wire-based Energy-Recovery Circuit for Low-Cost Plasma Displays

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Abstract

A new energy recovery circuit (ERC) with an auxiliary Energy-recovery inductor (Air-coil) using a substitution wire is proposed for low-cost plasma displays. In the proposed circuit, only the wire (harness) across the panel is used as an auxiliary energy-recovery inductor. The use of a wire-L for both sides of the sustain circuit creates a low-cost ERC with a simple structure by reducing the number of electronic devices, including the power switches, without affecting the gas discharge characteristics.

1. Introduction

Since a plasma display panel (PDP) is a capacitive device, an energy recovery circuit (ERC) needs to be employed to minimize the reactive power consumed by the displacement current. Thus, most commercial plasma TVs include a Weber and Sakai ERC that use the LC resonance [1][2]. However, the circuit cost of a Weber ERC is high, as many switches are required for the LC resonance, including rising- and falling-switches in both the X- and Y-ERCs [3].

In this paper, the new wire-based ERC that uses a harness wire as an auxiliary energy-recovery inductor is proposed. The detailed circuit operation in the proposed ERC is examined. Furthermore, the effects of the proposed ERC on the power consumptions are also investigated under various display patterns such as full-white and full-black images.

2. Circuit operation

Fig.1. shows the electrode configuration of commercial HD plasma-TV and its cell structure of single pixel with three electrodes, X, Y, and A. As shown in Fig. 1, a single pixel is the minimum unit for displaying a full color image, and consists of three cells emitting the red, green, and blue lights based on the stimulation of R, G, and B phosphor layers by vacuum ultraviolet (VUV: 147 and 173 nm) produced from a He-Ne-Xe plasma discharge [4]. The three electrodes are positioned as shown in Fig. 1 where the X electrode is sustain one, the Y electrode is scan one, and the A electrode is address one. Electric power is supplied to produce the plasma via these three electrodes. The sustain (X) and scan (Y) electrodes are covered with MgO protection layer,

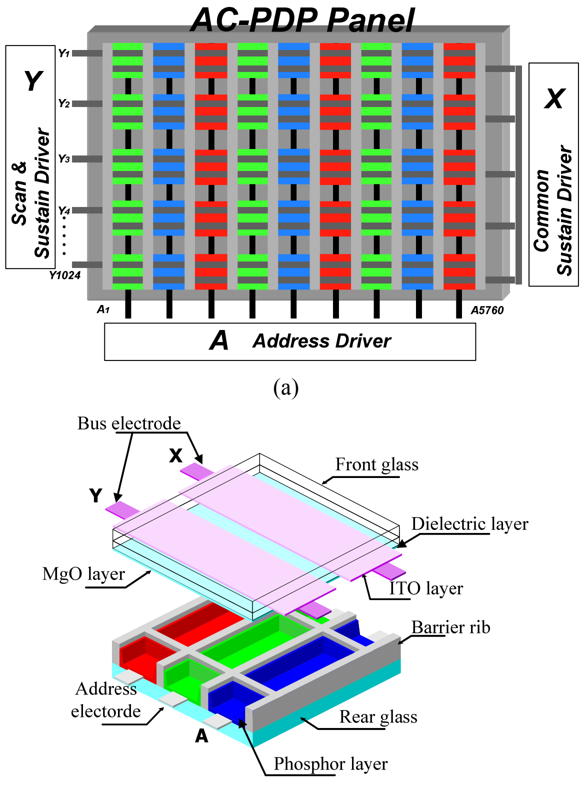
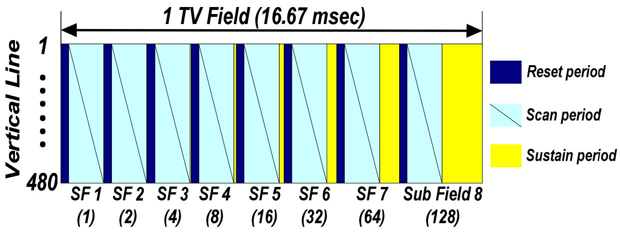


Fig. 1. (a) Electrode configuration of commercial HD plasma-TV and (b) its cell structure of single pixel with three electrodes, X, Y, and A.

whereas the address electrode (A) is covered with phosphor layer [5].

Most of ac PDPs are operated with an address-display-separation (ADS) driving scheme, which consists of separate reset, address, and sustain operation periods. One TV field, which is 16.67 ms, is divided into eight subfields, as shown in Fig. 2(a). Furthermore, one subfield has distinct reset, address, and sustain



(a)

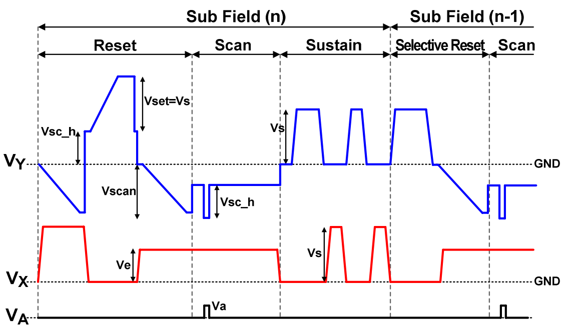


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Fig. 2. (a) Address display separation (ADS) driving scheme and (b) applied voltage waveforms.

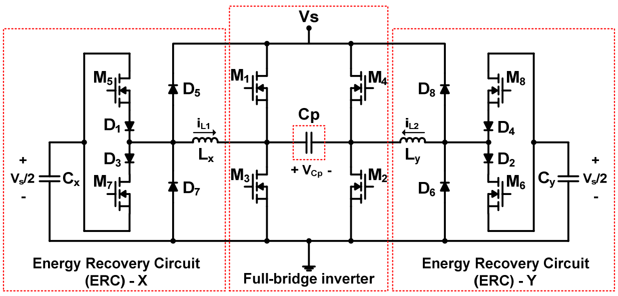
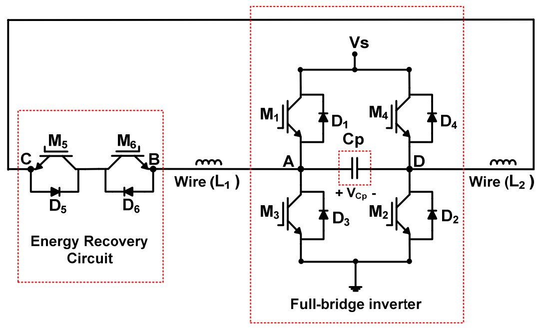
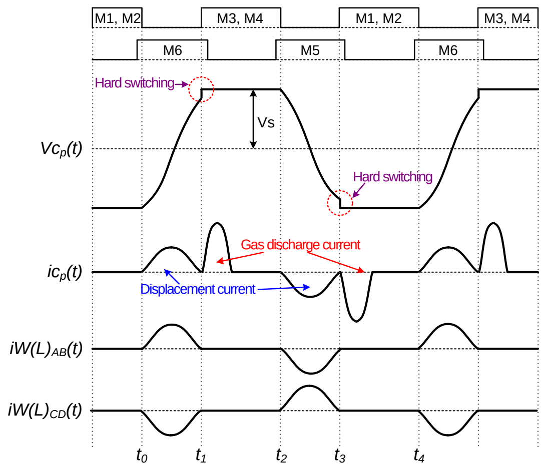


Fig. 3. Schematic diagram of the conventional Weber ERC.



(a)



(b)

Fig. 4. The proposed circuit and its key waveforms. (a) Circuit diagram of the proposed circuit (b) Key waveforms proposed circuit.

periods shown in Fig. 2(b). the reset-period, a high voltage greater than 300 V is applied between the Y-X electrodes to obtain the same initial wall charge conditions for all cells. In scan-period, the wall charges are re-accumulated only in the image display cells (i.e., on-cells) by applying the Vy with two polarities to the Y electrode and simultaneously applying the Vx and Va with positive polarity to the X and A electrodes, respectively. In the last period, the sustain discharges are produced only in previously scanned cells (i.e., on-cells). Finally, the desired image can be displayed through the luminance obtained by the sustain discharge in the panel.

Fig. 3 shows the sustain circuit with a conventional Weber ERC while Fig. 4 (a) shows the sustain circuit with the proposed ERC. The full-bridge inverters are exactly the same for both sustain circuits. However, with the proposed ERC the panel is charged and discharged from Vs to –Vs alternately, by using the parallel resonance between the panel capacitance, Cp, and inductor (Air-coil) using a substitution wire. Also, proposed ERC, the number of power switches is reduced from 4 (M5~M8) to 2 (M5~M6), the inductors reduced from 2 (Lx, Ly) to no inductor, and the external capacitors reduced from 2 (Cx, Cy) to no capacitor. In addition, the number of power diodes is reduced from 8 (D1~D8) to 0 based on using the IGBT in the proposed ERC.

As a result, the proposed ERC has significant advantages, including a simpler structure, fewer power devices, less mass, and lower cost.

Fig. 4 (b) shows the key waveforms for the sustain circuit including the proposed ERC. The operation of the proposed circuit can be divided into two half cycles, t0～ t2 and t2～ t4. Before the operations of two half cycles are symmetric, only the first half cycle is explained.

For the convenience of the analysis, all the switches are ideal. Before t0, the voltage across the panel, Vcp is maintained as –Vs with the main switches, M1 and M2, are conducting.

During the time from t0 to t1, switch M6 are turned on, and the other switches are turned off. The energy stored in the panel with its the capacitance Cp is then transferred to wire with its inductor using the series resonance between wire (L1, L2) and Cp. The panel voltage is still maintained at −Vs, the ERC wire can build up sufficient energy to generate panel voltage VCp, +Vs or −Vs.

Before t1, Vcp is clamped to Vs and the output capacitors of switches, M3 and M4, are discharged. Therefore, the voltages across M3 and M4 fall to zero.

At t1, the switches, M3 and M4, are turned on and other switches are turned off, the panel voltage, Vcp, is maintained to Vs.

During t1 to t2, it should be noted that ERC wire currents, iW_{AB} and iW_{AB}, result in the canceling of the panel discharge current in M3 and M4 simultaneously.

Due to compensating panel discharge current in the main power switches, the current stresses on the power switches M3 and M4 can be reduced as shown in Fig. 4(b).

During t1 to t2, the compensated current of the main inverter switches can be expressed as During t1 to t2, the panel voltage, Vcp, is sustained to VS. When the inductor current is zero, t2 to t3 begins. This means that the auxiliary switches are turned off under the ZCS condition at t2.

With this scheme, the abrupt charging and discharging operation is avoided and the energy stored in the PDP can be recovered effectively.

3. Experimental results and discussion

In order to investigate the feasibility of the proposed ERC, a computer simulation was performed. The plasma panel was emulated with a load capacitor. In the simulation, an 80nF capacitor and 0.5uH wire-inductors were used for the panel capacitance and the resonant inductors, respectively.

The sustain voltage and the operating switching frequency were 200V and 200kHz, respectively. Fig. 5 depicts the simulation results driven by the proposed ERC.

The pixel-pitch of the 42-in. XGA ac-PDP used in this experiment is 693 × 304 ㎛, and the discharge gas composition is Ne+Xe (11 %) gas mixtures and gas pressure is 450 Torr. The test panel has a conventional ac-PDP structure with a stripe barrier rib and three electrodes such as two sustain electrodes and one address electrode.

To verify the behavior of the proposed ERC, the sustain circuit was implemented in a 42-inch HD grade PDP. The driving conditions were switching frequency in the sustain period (fs) = 250 kHz, wire (L1 = L2) = 1.0 uH, and Vs = 207 V. Fig. 4 shows the experimental results with the proposed circuit when displaying a full-white pattern on the 42-inch PDP. Fig. 6 (a) shows one TV field consisting of 12 subfrmaes and the voltage waveforms applied to Y and X electrodes during each period. This coincides well with the aforementioned theoretical ADS waveforms.

As shown in Fig. 6 (b), the light is emitted immediately after the voltage across the PDP has reversed tis polarity and its waveform is strongly stable and uniforms, proving the high quality of screen. It was found that the IR emissions determining the luminous characteristics of the 42-inch PDP were exactly the same for both the Vx and Vy waveforms,

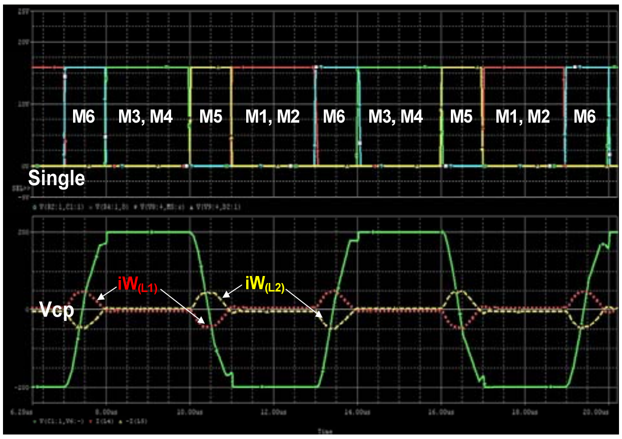
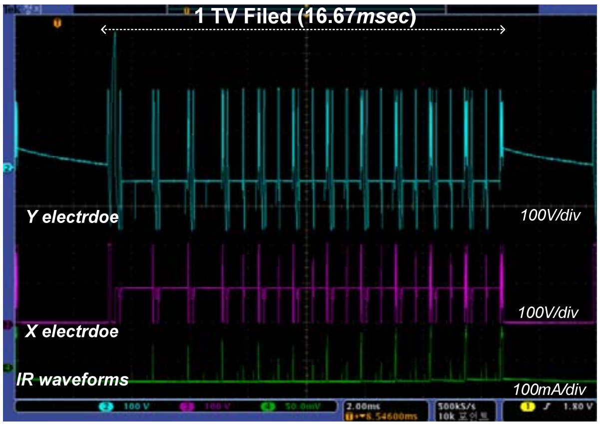
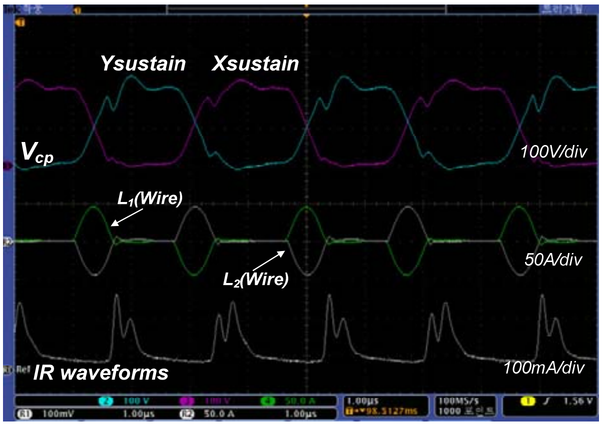


Fig. 5. Simulation results of the proposed drive (a) single (b) panel voltage [Vcp] and wire current.



(a)



(b)

Fig. 6. Experimental results when (a) voltage waveforms applied to X and Y electrodes in ADS scheme, (b) sustain waveforms displaying full-white image.

Table 1. The Number of devices for 42-inch PDP

Table 1

		Weber circuit	Proposed circuit
Gate driver IC		4 EA	4 EA
Power switch	**inverter**	4 EA	4 EA
	auxiliary circuit	4 EA	2 EA
Diode		4 EA	0 EA
Energy-recovery Inductor		2 EA (Air Coil)	0 EA (wire)
Energy-recovery Capacitor		2 EA	0 EA

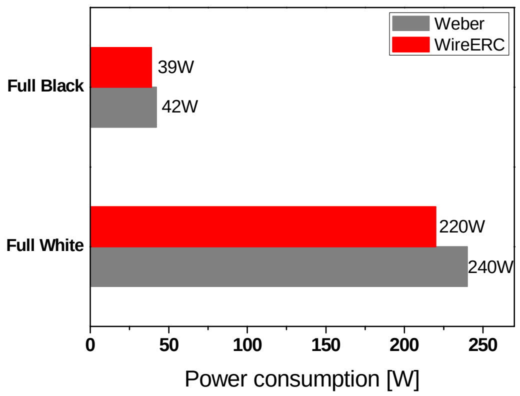


Fig. 7. Comparison of power consumption measured under various images on 42-in. PDP when using conventional Weber ERC and proposed ERC.

Table 1, the number of devices used in proposed circuit is less than that used in the Weber circuit. Therefore, it features a simpler structure, less mass, and lower cost of production.

As can be s een in Fig. 7, the comparative results for the system power consumption of each ERC under same conditions show that the proposed ERC is similar to the Weber-ERC on the whole. This result is very meaningful in the sense that the proposed circuit using the small number of devices can achieve a similar efficiency and operational characteristics to the conventional ERC with a large number of devices.

4. Conclusion

A new energy recovery circuit (ERC) with an auxiliary Energy-recovery inductor (Air-coil) using a substitution wire is proposed for low-cost plasma displays. In the proposed circuit, only the wire(harness) across the panel is used as an auxiliary energy-recovery inductor. The use of a wire-L for both sides of the sustain circuit creates a low-cost ERC with a simple structure by reducing the number of electronic devices, including the power switches, without affecting the gas discharge characteristics.

5. References

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