Design of the backlight inverter for multi-lamp driving

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Abstract

As a LCD monitor is larger and thinner, a Cold Cathode Fluorescent Lamp (CCFL) for backlight in LCD monitor gradually becomes longer and thinner. The backlight of a large LCD monitor, however, has a limitation in its brightness. In this study, a parallel multi-lamp is used in order to supply enough brightness. Though the CCFLs are made through a detail and equal manufacturing process, they don't have exactly the same features individually in their brightness, frequency, voltage and current. Consequently, it is difficult to have equal brightness at an early lighting condition or during lighting time.

In this paper, a parallel multi-lamp which can have the same output under the same condition is designed. For this, 18 inch LCD monitor with four lamps is used. An inverter for multi-lamp driving is also used in this study.

The newly designed inverter shows more than 90% efficiency in its brightness input and output. Besides, it is also available for a multi-drive of other lamps.

1. Introduction

This paper describes a backlight inverter of multi-lamp driving. Current model of LCD monitors has been bigger and thinner. Accordingly, lamps become larger and thinner than ever and have higher brightness. Thin and long lamps have wide range at max brightness.

Generally, the monitor with 18 inches has 4~6 lamps and 19 inches 6~8 lamps, respectively. These structures of inverter for operating lamps require small type, high power and efficiency.

The inverter for lighting CCFL requires high striking voltage and the sustainning voltage, current, transformer of same quality and inverter. The CCFLs are made through detail and equal manufacturing process, but they don't have the exactly same features in their brightness, frequency, voltage and current. In this paper, the inverter is designed for multi-lamp driving of 18 inches LCD monitor.

In this experiment, two lamps are inserted in LCD monitor, upside and downside. Also, the inverter consists of a driving IC and two step-up transformers. By using the new inverter, we obtained more than 90% efficiency.

The result of the experiment shows that the output quality of the lamps is almost the same. Therefore, it can be said that the newly designed inverter can be used generally, and also it is possible for other lamps to be used for a multi-drive.

2. Cold Cathode Fluorescent Lamp

Major difficulties in designing CCFL backlight inverters stem from the characteristics.

The CCFL has many advantages such as high brightness, high efficiency, low power consumption, longevity, low heat emission, and flicker free turn on/off. Thus, CCFLs are often used for LCD backlights, scanners, and decorative lighting.

In this experiment, we used 18 inches monitor (LG-Philips model ;LM181E3). The striking voltage of the lamp is typically 1.5 times higher than the sustaining voltage. The lamp used has a striking voltage of 1kV and has an operating voltage range of 700-800V. It is for prevention of flickering with maintenance of lighting.

The CCFL has nonlinear characteristics.

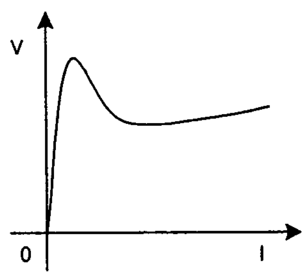


Fig. 1 Characteristic of the firing

The CCFL is described using the characteristics of the firing in fig. 1. It is as follows. As the current rises by 120[%], the brightness also rises linearly. When the current is larger than 120[%], the brightness does not increase any longer because the temperature also rises.

The brightness is changeable according to the frequency of inverter because the fire frequency changes the momentum of electron and the degree of generating ultraviolet ray. As the frequency is increased, the brightness is increased due to the limit value. The frequency is in the range of about 45 ~ 60 [㎑].

3. Inverter for multi-lamp driving.

3.1 Inverter for cold cathode fluorescent lamp driving.

The inverter circuit to run CCFL consists of three parts. It is composed of DC/DC converter part for various input voltage, DC/AC part for discharge lamp and brightness control part for brightness adjust of monitor screen [1].

3.2 The Full-bridge type inverter for 4 lamp driving.

A new topology of inverter is full-bridge series resonance type. Transmitting more electric powers, it is efficient because the number of the lamps increases and they are longer. Actually schematic diagram of inverter shows fig. 2 [2].

The primary side of the circuit consists of two switch elements (MOSFET P-type, N-type), a booster trans and series capacitor for resonance with the inductance of the primary side of the trans.

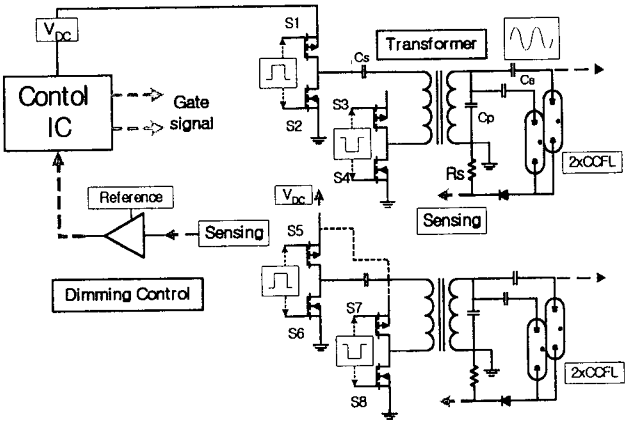


Fig. 2 Inverter for multi-lamp driving

The second side of the transformer consists of 2 series capacitance of high voltage type for division of current by lamp and the parallel capacitance for high efficiency and discharge voltage at starting. A general system consists of the same structure as in fig.2.

The power convert part is reconstructed as in fig. 3. This fig shows a simple system of two lamp driving part.

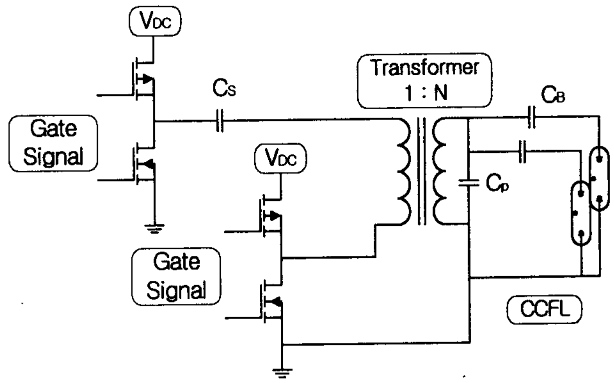


Fig. 3 Full-bridge type series resonant inverter

Since the characteristics of the lamps are different respectively, series capacitance is inserted at the second side of the transformer between the lamps in order to transmit current equally. It makes use of the characteristic of discharge lamp in that voltage is the main factor at the lighting time, while current is the main factor after lighting.

The comparison of the inserted capacitance and impedance of discharging lamp reveals that the lamp has much higher impedance value than the capacitance before lighting, while it has much lower impedance value than the capacitance after the lighting. As the voltage conducted in the lamps during the turning-off and the impedance of the lamps are not as high as the impedance of capacitance during the turning-on, it can be said that there is equal division of current between the lamps.

In fig. 3, a parallel capacitance is inserted in the second side of the transformer. It assists the generation of operating voltage by resonance. Also, the efficiency is improved by the inductance of the transformer [3].

The suitable value of circuit elements is calculated using a numerical formula. The DC/AC part of the fig.3 is reconstruct for showing the max state. The simplified circuit of the inverter is shown in fig. 4.

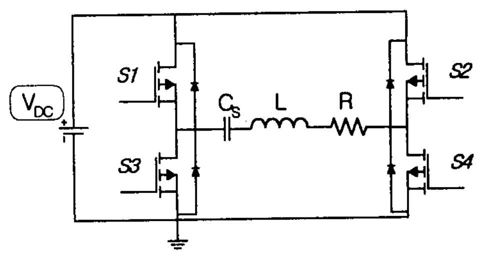


Fig. 4 Simplified circuit of the inverter

In fig. 4, the equivalent circuit is full-bridge form of series resonance. Transformer is L, the lamp and series-parallel capacitance is R. Special component of the circuit is derived by using the following way.

On the initial condition, input voltage is 12 volts; input maximum current is 2A; inverter output power is 24W and driving frequency is 55±2㎑. Besides, it requires Q_L and

Z_o by quality value. Input resistance value is calculated as in eq.[1] and input power is as in eq. [2].

$$R=\frac{8V_I^2}{\pi P_I}\cos^2\Phi \tag{1}$$

$$P_I=\frac{24}{0.95} \tag{2}$$

A condition of frequency is as follows.

$$f/f_O=\frac{1}{2}\left(\frac{\tan\Phi}{Q_L}+\sqrt{\left(\frac{\tan^2\Phi}{Q_L^2}+4\right)}\right) \tag{3}$$

The component value of the resonant circuit is

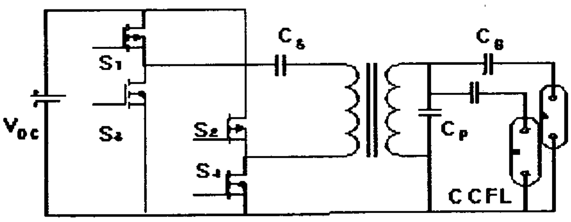
$$C=\frac{1}{\omega_O Q_L R} \tag{4}$$

$$L=\frac{Q_L R}{\omega_O} \tag{5}$$

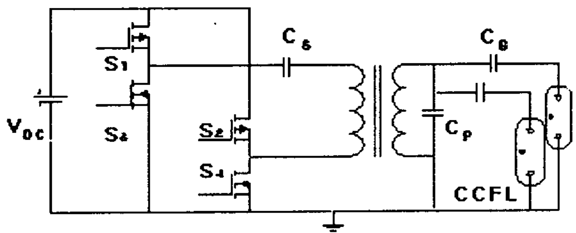
The characteristic impedance is

$$Z_O=\sqrt{\frac{L}{C}} \tag{6}$$

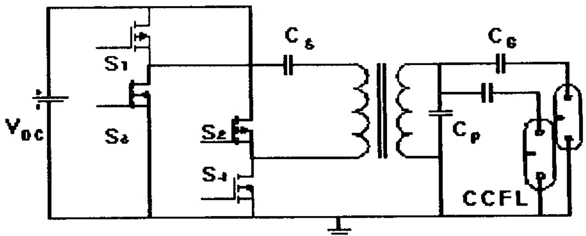
The inductance value of transformer is 140uH:600mH; the series capacitance of resonant is 2uF; and the parallel capacitance of high voltage is 33pF.



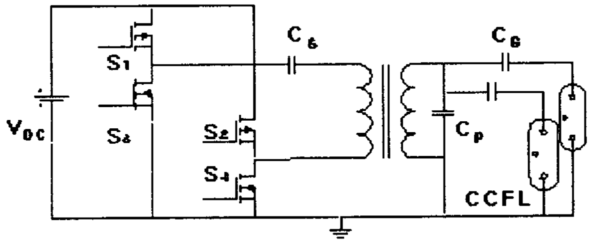
(a) mode 1



(b) mode 2



(c) mode 3



(d) mode 4

Fig. 5 Operating modes

The operation is divided into four operating modes as shown in fig. 5. Fig. 3 shows that the operation of mode 1 and 2 is similar to that of mode 3 and 4.

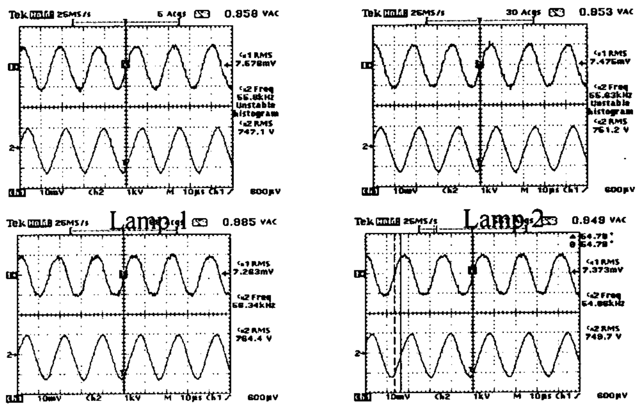
In mode 1, S_1 and S_4 are conducting. The energy is supplied to the load and the capacitor is charged. The circuit shown in fig. 5(a) is similar to an L-C series resonant circuit.

In mode 2, S_1 and S_4 are off, so the resonant returns to the power source.

Modes 3 and 4 are the same as modes 1 and 2, with the exception that the direction of the current is reversed in the CCFL and the alternate pair of switches is active.

4. The waveform of the result

The figs. 6~8 show the output waveform. It is measured at the maximum brightness with the output current of 7.5mA. Channel-1 is current waveform and channel-2 is voltage waveform. Fig 6 shows maximum brightness. Fig 7 shows 80% brightness approximately. Fig 8 shows minimum brightness at the lighting condition.



Lamp 1 Lamp 2

Lamp 3 Lamp 4

Fig. 6 Output waveform of the lamps(Max. Brightness)

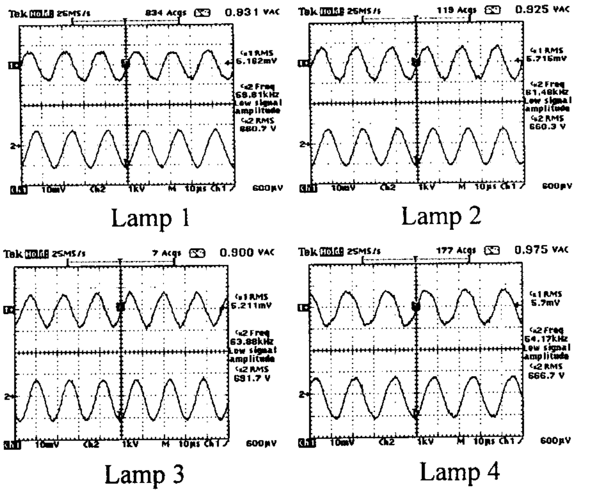


Fig. 7 Output waveform of the lamps(Mid. Brightness)

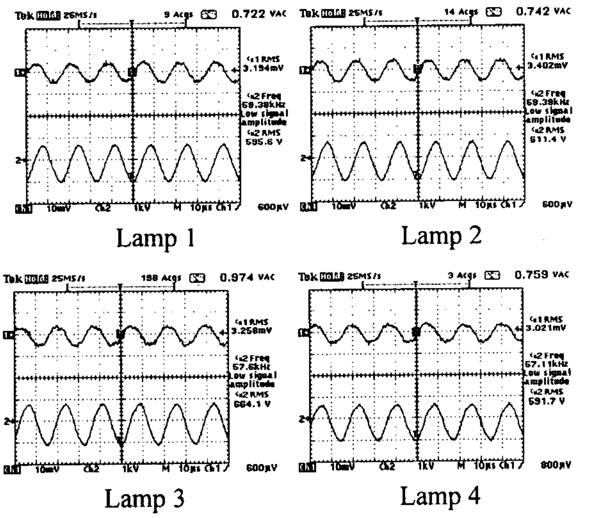


Fig. 8 Output waveform of the lamps(Min. Brightness)

5. Conclusion

In order to design a backlight inverter for multi-lamp driving, 18 inches LCD monitor that has 4 lamps is used in this study. The two lamps are on the upside of the monitor, while the other two are on the downside. up and down each two lamps. It consists of the inverter circuit using full bridge type, control IC and two boosters. The result of the experiment shows a newly designed backlight inverter gets more than 90% improvement in efficiency of input/output. Moreover, as the output current of the lamps is nearly the same, this inverter has the possibility of being used for multi-lamp drive.

Acknowledgements

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