A Study of Illumination System with Electronic Ballast

Yonggao Jin
Dept. Electronical Engineering CNU
Yousung ,Teajon , 305-764 , Korea
Phone 82-42-821-7603

Sejin Seong
Dept. Electronical Engineering CNU
Yousung ,Teajon , 305-764 , Korea
Phone 82-42-821-5654

ABSRACT - The electronic fluorescent lamp ballast can promote the lighting efficiency up to 10-20% by driving high frequency with frequency transformation technique, and can completely eliminate the flickering phenomenon occurring from 60Hz frequency. The electronic ballast provides very high energy saving effects for it has high power factor than traditional ballast, and it is convenient to use, can extend the life cycle of fluorescent lamp for it starts at once by driving with high frequency. However electronic ballast needs high price, and it has the bad stability and reliability. This paper provides illumination systems, which drive dozens of fluorescent lamps at the same time, to overcome these shortcomings of electronic ballast and utilize the advantage of electronic ballast.

1. INTRODUCTION

The electronic fluorescent ballast can promote the lighting efficiency about 10-20% by raising the power frequency to 400-600 times of usual frequency with frequency transformation technique, and completely eliminates the flickering phenomenon occurring with 60Hz usual frequency. The electronic ballast usually provides 0.9-0.98 power factor, and it is much higher than the power factor provided by the traditional ballast which has 0.5-0.8 power factor.

By experiment when driving 40W fluorescent lamp, traditional ballast consumes about 8W, however electronic ballast consumes less than 1.5W, and electronic ballast has high energy saving effect. The electronic ballast can work at -40^0C - +40^0C range and AC source with 100V - 220V, and it is as convenient as an incandescent lamp to be used for starting at one driven by high frequency. On the other hand, it can extend the life cycle of fluorescent lamp because it can start the lamp at once with the approach of soft-start technique using high frequency. However, it has shortcomings of high price, low reliabi- lity and generating electronic wave disturbance.

This paper provides illumination systems, which drive dozens of fluorescent lamps at the same time, to overcome these shortcomings of electronic ballast and utilize the advantage of electronic ballast.

2. CONSTITUTION OF ILLUMINATION SYSTEM

There may be two approaches to construct illumination systems driving dozens of fluorescent lamps at the same time.

The approach in fig.1 can be used when the distances between lamps are long.

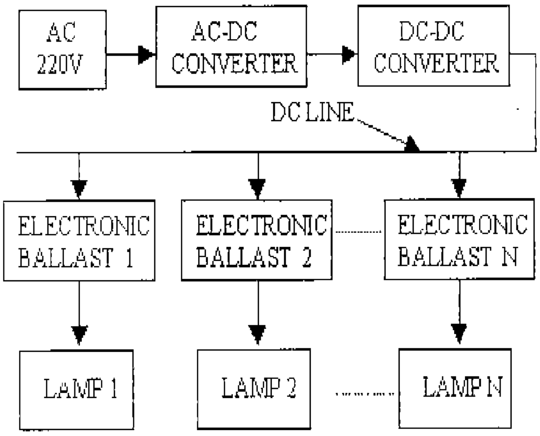

Fig.1 Constitution of illumination system1

About 400V DC is obtained through boost converter after rectifying 220V AC source. The 100V DC voltage is enough for driving fluorescent lamp, therefore, 400V voltage is lowered to 200V DC with DC-DC converter for lowering the rated voltage of element of the electronic ballast and increase reliability. This voltage is provided to each electronic ballast through DC line. The method can maximize the power efficiency by using one high power factor AC-DC converter to obtain direct current, promote the reliability and reduce costs highly for it has no rectifying parts in each electronic ballast but only has high frequency transformation parts. The line voltage drop is low as well because the power transmitted to each ballast is DC current. Therefore indoor illumination system can be constructed.

The approach in fig. 2 can be used when the distances between lamps are short.

220V AC power is converted to 400V DC voltage through high power factor AC-DC converter, and then it is converted to 200V DC voltage using DC-DC converter. This 200V DC voltage is converted to 18KHz AC voltage by using DC-AC inverter. This 18KHz voltage is supplied to each lamp through AC line. The simple L, C, PTC elements are needed to drive the fluorescent lamp, therefore the price can be lowered and the reliability can be promoted greatly.

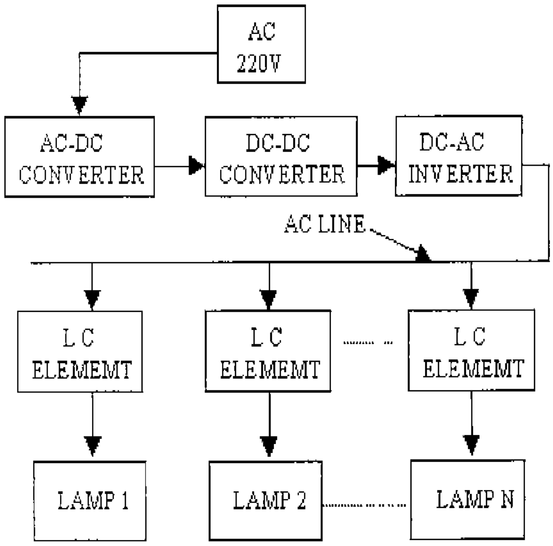

Fig.2 Constitution of illumination system2

However, the distance between lamps should not be long because the voltage drop in the transmit line is high for the sake of high frequency. This method can be used to construct large advertisement boards.

3. WORKING PRNCIPLE OF SYSTEM 1

3.1 CONVERTING METHODE OF AC TO DC AND DC TO DC

Fig.3 shows the circuit of AC-DC and DC-DC convert.

For convert AC to DC using a boost converter of PWM control type it has high power factor , the output voltage is regulated about 400V DC. Overvoltage protection circuit is used for the output voltage will be too high in no load state.

The buck converter of PWM control type is used for DC-DC converting. It is possible to use resonance type converter for reducing the switching loss, but the circuit will be complex.

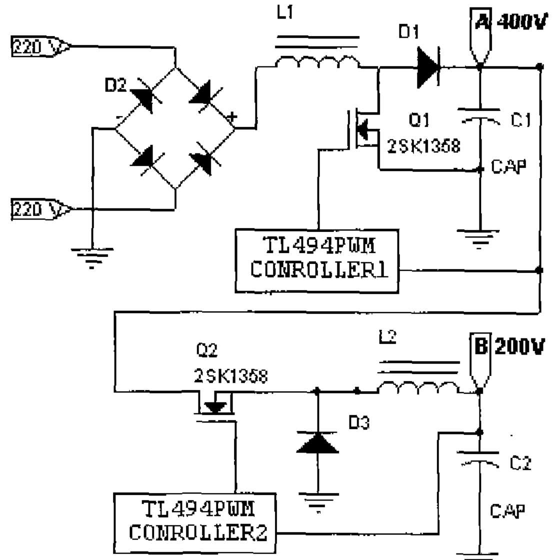

Fig3. Converting citcuit of AC-DC and DC-AC

The waveforms of voltage and current in AC 220V input side are shown in fig. 4.

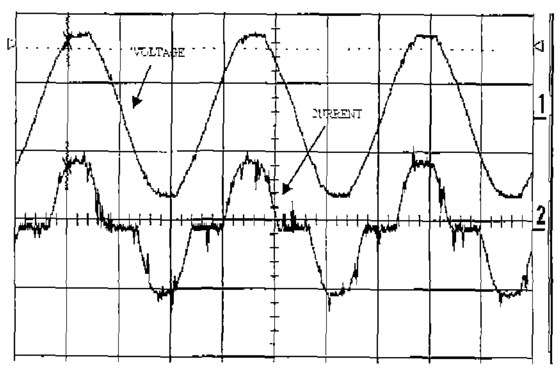

Fig4. Waveform of voltage and current of AC input side

3.2 WORKING PRINCIPLE OF ELECTRONIC BALAST

The reliability, durability, cost and electronic wave disturbances should be considered in designing electronic ballast.

The parts which are damaged easily in electronic ballast are power transistors. In this experiment VDMOSFET is used instead of power transistor to overcome the shortcoming of transistor carrier delay effect and secondary breakdown voltage. The VDMOSFET has high switching speed, less dynamic loss and good heat stability. So the reliability and durability can be promoted by using it to design ballast. Fig. 5 is the circuit of electronic ballast.

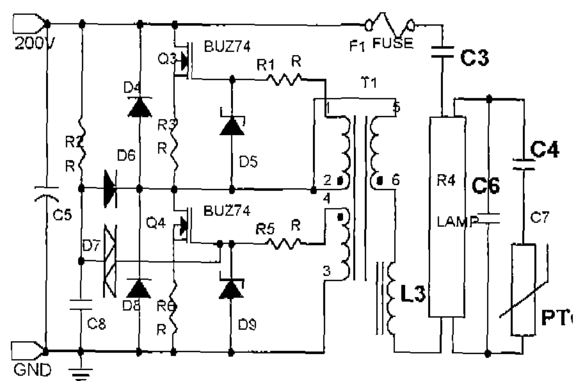

Fig5. Circuit of electronic ballast

It is a half bridge type circuit, and performs high frequency transforming by switching two power VDMOSs with feed back current transformer. In this approach switching is performed when the output current of circuit switching element is zero, and the switching loss is minimized.

Capacitor C5 is used as high frequency filtering, and diode D4 and D8 are used as power element protection. The zener-diode D5 and D9 protect VDMOS by limit input voltage. The circuit working method is as follows. After switching on the C8 is charged through resistance R2. Q4 will be opened and Q3 will be closed when the voltage of C8 reaches the break over voltage of diac D7. The output current generates the positive-feedback in the input side through transformer coil 5-6 , and the state of Q3 and Q4 are maintained. The output current will start to be decreased after reaching some value because it passes through the resonance circuit consisting of L3 and C6. When the current reaches near to the zero, reverse direction EMF is generated in coil 1-2 , and it opens Q3 and closes Q4. Repeat of this process maintains self-oscillation, and the output voltage is rectangle wave form but the current is near to the sin-wave.

Fig.6 shows voltage and output current waveforms of Q3, and Fig.7 shows voltage waveforms at two ends of fluorescent lamp and current through the fluorescent lamp.

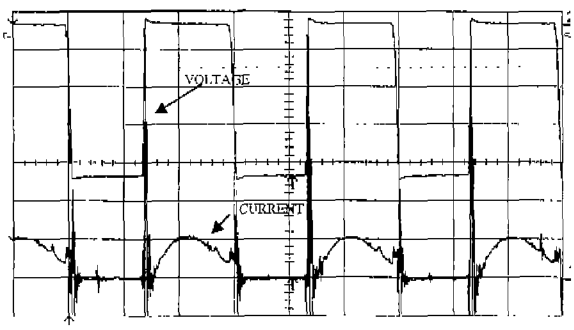

Fig6. Waveform of VDMOS side voltage and output current

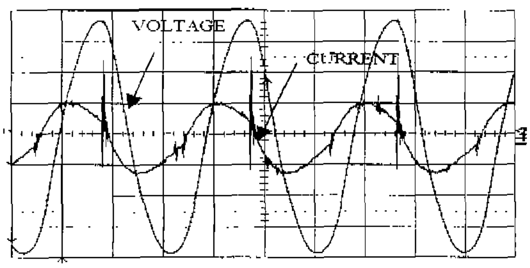

Fig7. Waveform of voltage and current of fluorescent lamp

The process of fluorescent lamp starting is as follows. After switching on the circuit is oscillated with the previous principle. This time PTC has low resistant value because of steady state temperature. The starting current, therefore, is decided in (1).

$$I_0 = \frac{V}{(R + R_p + j\omega L_3 + \frac{1}{j\omega C_4})} \quad (1)$$

I_0 is starting current of fluorescent lamp, V is DC power voltage, R is lamp resistance, R_p is the resistance of PTC at normal state temperature, ω is decided in (2).

$$I_1 = \frac{V}{R + \frac{1}{j\omega_1 C_3}} \qquad \omega = \frac{1}{\sqrt{L_3 C_4}} \quad (2)$$

After 1~2 seconds the resistance value of PTC will be increased with the increasing temperature of it, and it generates resonance in L_3 and C_6.

The resonance current value is decided by the (3).

$$\omega_1 = \frac{1}{\sqrt{L_3 C_6}} \quad (3)$$

After the resonance, a high voltage with high frequency, which is many times of DC power voltage, is generated at the C_6 , and it start lighting the fluorescent lamp in an instant. After starting the resonance point will be moved for C_6 is parallel to X of the equivalent resistance of fluorescent lamp.

The electronic ballast designed in this way is simple in circuit, high efficiency and stable.

4. WORKING PRINCIPLE OF SYSTEM 2

The waveform of AC line should be sine-wave to minimize the electronic wave disturbance. The point technique is how to produce sine-wave with high efficiency . Fig.8 shows the circuit. After generating PWM signal by comparing sine-wave and saw-wave, transistors are driven by switching method. This output of PWM wave generates sine -wave through the high frequency filter which is consisted of L6 and C16.

The higher frequency of sin-wave is, the better the circuit to avoid earshot frequency is. However frequency of carrier wave should be high to obtain high sine-wave frequency, but the switching loss will be increased with high carrier wave frequency. Therefore 18KHz sin-wave and 68KHz carrier wave are adopted in this experiment. Each lamp driving circuit is simply consisted of some L, C elements shown as Fig. 8.

5. RESULT OF EXPERIMENT

Using the approach in system structure 1, fluorescent lamps can be located at long distance positions by transmitting the power with DC though it has higher cost than system structure 2. Using the approach in system structure 2, fluorescent lamps should not be located at long distance positions by transmitting the power with high frequency, but its cost is low. Additionally, the illumination intensity of whole system can be controlled by regulating DC voltage.

REFERENCES

[1]. Electronic World , Vol.9 , pp.34-36 ,1997 CHINA.

[2]. Electronic Paper ,Vol.5, No.20 , pp.158 ,1994 CHINA.

[3] Journal of the Korean Institution of Illuminating and Electronic Installation Engineers . Vol.10. No.2 , pp. 15 -22 , 1996.

[4]. Kaouhei.Y.Kenichi.I.and anjou, A.,"Electronic Ballast for Flourescent Lamp Operated by Constant Current

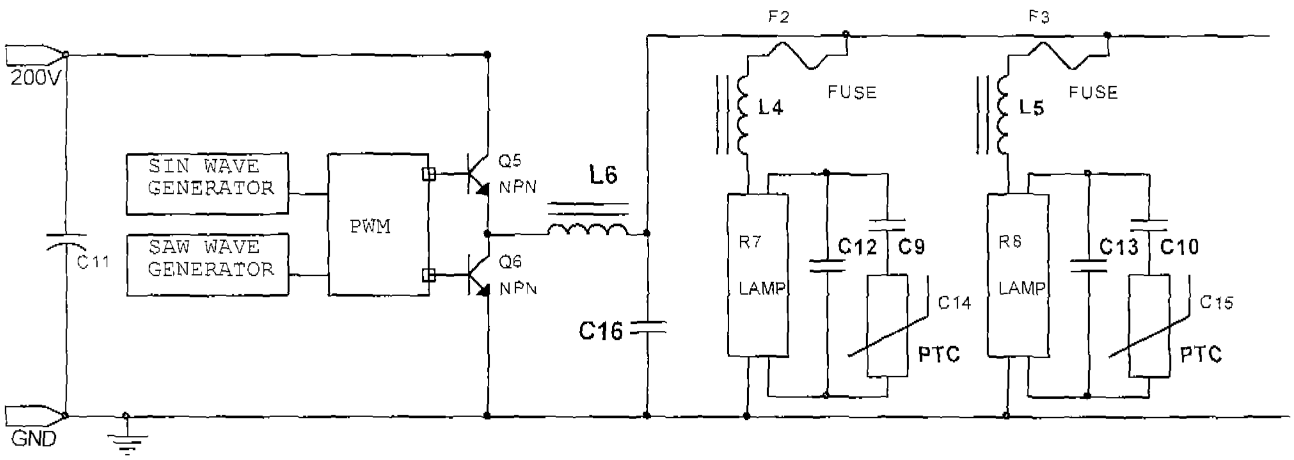

Fig8. Circuit of system2 constitution