Design and simulation of high power secondary HID electric ballasts

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Abstract. This paper proposes a microprocessor-based control of high-power secondary HID electronic ballast design. Electronic ballasts using active power factor correction, micro processor MCU as a full bridge converter, at the same time has the function of "watchdog", working temperature monitoring function and system protection function. This paper deals with the system design and simulation, experiments show that the system, functional design, system operation and reliable, the power factor of 0.95.

Introduction

High power high intensity discharge lamps (HID) are widely used in the stadium, exhibition center, large department stores, amusement places, ports, building floodlight, fishing lure fish, can also be used for high efficient agricultural greenhouses plant fill light illumination, the highest power can reach more than 10 kw, high photosynthetic efficiency can reach more than 150 lumens/watt and is currently one of the highest luminous efficiency of light source, an irreplaceable role, with other light source as a very large application prospect in the market [1].

Inductance ballasts for power demand is high, higher than the rated output power or power frequency voltage will reduce the inductance ballasts, loss increase sharply; When using inductance ballasts still need additional trigger to start the light bulb, the power supply voltage lower is HID, and so on, it is hard to start a long time can damage the light bulb; Additional inductance ballasts power factor is low, the power grid have great interference [2].

In this paper, the working principle of the electronic ballast of design is to translate into direct current, low-frequency alternating current (ac) through the rectifier inverter will transform into a high frequency alternating current, power factor correction (APFC) and voltage adjustment, through the whole bridge switches provide the ac power supply for HID lamps. In front of the HID lights up, made up of LC ignition circuit, provides the high voltage ignition for HID lamp, make the HID lamp electrodes gasification, light HID lamps.

The principle of HID electric ballasts

General design HID electronic ballasts using special chip [3.4], and the function relatively single chip. There is no short circuit fault, open circuit fault detection function, working voltage monitoring function and lamp current detection function, stop at APFC after vibration, since the launch of no function, etc. Microprocessor, powerful, flexible application, belongs to the general components, the price is low. And as the technology to progress, processing speed and electrical properties has been able to meet the requirements of the HID ballast. This paper adopts Microchip Pic16F71 for HID electronic ballasts microprocessor, its main frequency of 20 MHZ, four way A/D MCU as A full bridge converter and controller components. HID electric ballasts microprocessor has fault control function: detect the working temperature of electronic ballast, HID lamp working voltage and HID lamp current, if produce overtemperature, overvoltage and overcurrent, the electronic ballast will perform fault handler, cut off 4 MOS tube, protect the HID lamp. The HID electric ballasts schematic diagram (1).

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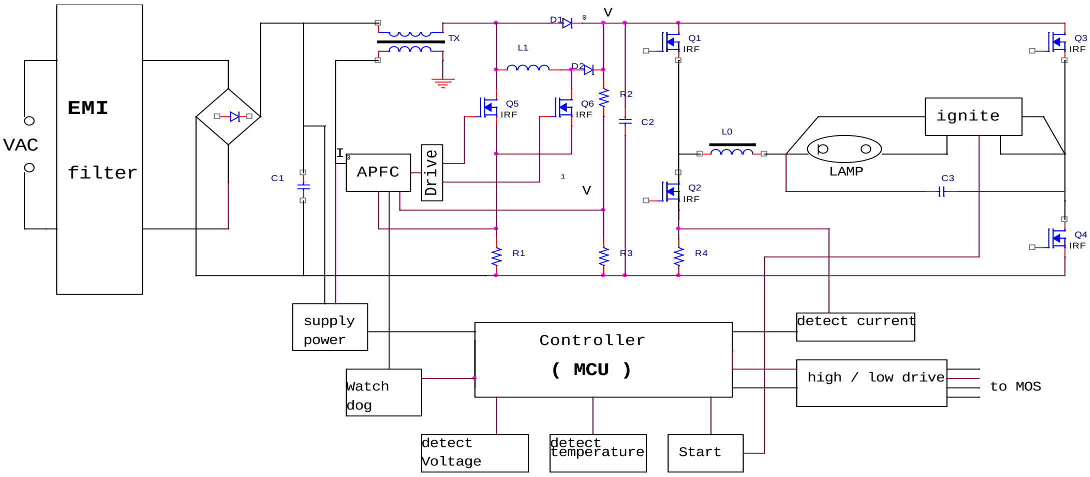


Fig.1. HID electric ballasts principle

This paper the use of the Boost APFC method, MC34262 chip is adopted to improve the power factor correction, however MC34262 chip power factor correction output power co., LTD. In order to achieve high power theory of power factor correction, on the basis of investigation and experiment, the increase of APFC circuit modules in parallel, to improve the power density, which is one of the development trend of APFC. In parallel research using focus need to solve the problem of parallel connection between the units of flow, flow characteristics of a parallel system directly determines the stability of the system and achieve the maximum power output, the circuit principle as shown in figure (1).

By the power factor correction for HID lamp 400 v dc power supply. Its working process, using the current I0 zero current detector, MOS tube when the current is zero start Q5, Q6 conduction; Testing corresponds to the voltage of the output current I1 and VI, by calculating the threshold voltage and MC34262 UCS comparison, if VI is greater than the VCS close MOS tube Q5, Q6. In MC34262 chip under the control of active power factor correction circuit about 25 KHZ high frequency oscillation, achieve the goal of power factor correction. The threshold voltage:

$$V_{CS}=0.544\times[V_{pinv0}]—V_{tn}]\times V_{pin(vi)}—0.0417\times[V_{pin(v0)}—V_{tn}]$$

The Vtn for internal reference voltage, Vpin (vo) is the output voltage detection, Vpin input voltage (vi) detection.

This system design on both ends of the HID lamp voltage switching frequency of 125 hz. "Watchdog" function, when the HID lamp ignition bright, HID lamp impedance drops to a low resistance state, instantaneous impact current of the circuit, make the APFC controller lost comparative basis, may produce resonance phenomenon, in this case the "watchdog" technology, make the zero current detector zero, quickly open the MOS tube Q5, Q6, MC34626 returned to normal work.

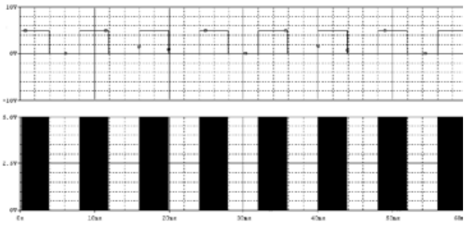
Design and simulation

The system design is a 1500 w metal halide lamp electronic ballast, HID lamp working voltage is 100 v, current 15 a, adopts ac drive, voltage switching frequency is 125 hz.

1) the HID lamp startup to normal lighting is divided into four stages. After the first stage, when the electronic ballast electricity, MC34626 began to work, at the same time to power a microprocessor, the microprocessor start test system and Settings. The second phase, the ignition phase, before ignition phase, HID lamp can be considered open circuit state, under the control of MCU, ignition pulse to the ignition circuit, on both ends of HID lamp can produce moments of 5 kv high voltage, the electrode gasification, and light; If the HID lamp current detection did not reach the specified value, the implementation of the ignition again. The third stage, is to take over and stable phase, when the HID lamp ignition, because of low resistance HID lamp, lamp voltage quickly checked low of about a quarter of the nominal voltage normally, according to the HID lamp current and voltage detection, change Q1, Q3, oscillation frequency of the MOS pipe omega, inductance L to control impedance omega (L), to achieve control of HID lamp on both ends of the

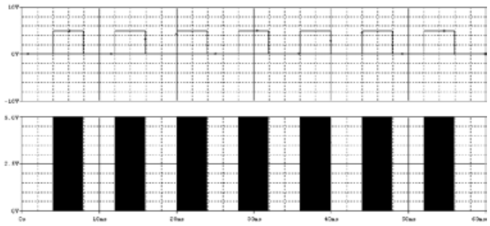
lamp voltage. Fourth stage, stage lighting, electronic ballast to the nominal voltage and current, HID lamp light normally, at this stage, Q2, Q4 MOS tube at 125 hz frequency switching voltage, in Q4 conduction, Q1 MOS tube at 20 KHZ frequency oscillation, the same Q2 conduction, Q3 at 20 KHZ frequency oscillation, Q1 and Q2, Q3 and Q4 MOS tube control voltage waveform as shown in figure (2, 3), HID lamp current waveform is shown in figure (4).

Electronic ballast ignition [8] through the Q1, Q2, Q3, Q4MOS tube alternating once every 10 milliseconds, under the stimulus of inductance L0, produce 4500 v about one every 10 milliseconds subtle high voltage pulse, as shown in figure (5).



10V/div 5V/div 5ms/div

Fig.2. Q4 ,Q1 control voltage waveform



10V/div 5V/div 5ms/div

Fig.3. Q3, Q2 control voltage waveform

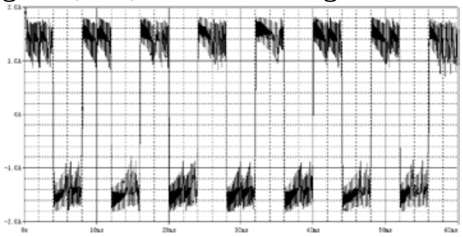


Fig.4. HID lamp current waveform
10 a/div 10 ms/div

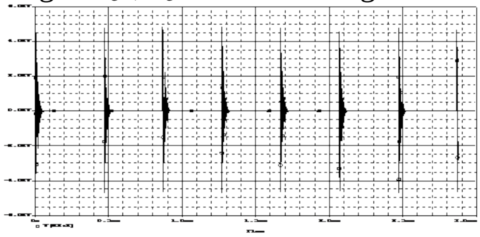


Fig.5. HID lamp ignition waveform
2000 v/div 10 ms/div

2) electronic ballast with MC34262 chips for power factor correction, adopt active booster, the controller switch frequency of about 25 KHZ, converting 220 vac ac into dc power supply of 400 v / 4 a.

MOS tube Q0 conduction time is:

$$t_{on} = \frac{2LP_0}{\eta V_{AC}^2} \tag{1}$$

V_{AC} is the input ac voltage effectively, the P_O for the output power, as the power factor, inductance L of TX.

MOS tube Q_0 trip time is:

$$t_{on} = \frac{2LP_0V_0}{V_{AC}\eta(V_0 - \sqrt{2}V_{AC}\sin wt)} \tag{2}$$

Among them, where V0 for the output voltage, omega for alternating current frequency.

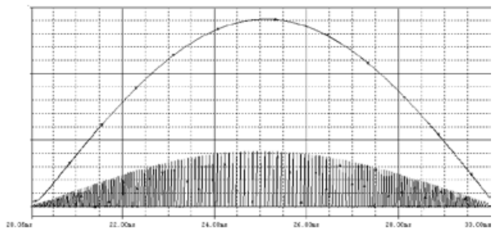
By (1) and (2) type, calculation of MOS tube Q0 switch frequency is:

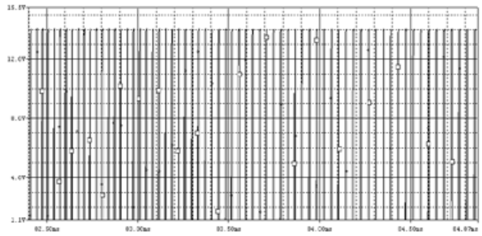
$$f = \frac{V_{AC}^2(V_0 - \sqrt{2}V_{AC}\sin wt)}{2LP_0V_0} \tag{3}$$

By (3) type, the inductance calculation formula:

$$L = \frac{V_{AC}^2\eta(V_0 - \sqrt{2}V_{AC}\sin wt)}{2P_0V_0 f} \tag{4}$$

Generally Q5, Q6 MOS tube switching frequency choose not less than 23 KHZ, Q5, in this system of Q6 frequency selection is 25 KHZ MOS tube. The input voltage and input current waveform is shown in figure (6). By formula can analyze, MOS tube Q5, Q6 conduction time is constant, and MOS tube Q5, Q6 trip time is longer as input detecting voltage increases, the MOS tube Q5, Q6 conduction and disconnect control waveform as shown in figure (7).





100V/div 10A/div 10ms/div 5V/DIV 500μs/div

Fig.6. The input voltage and current waveform Fig.7.MOS tube Q0, Q6 and waveform control

3) micro processor MCU software process

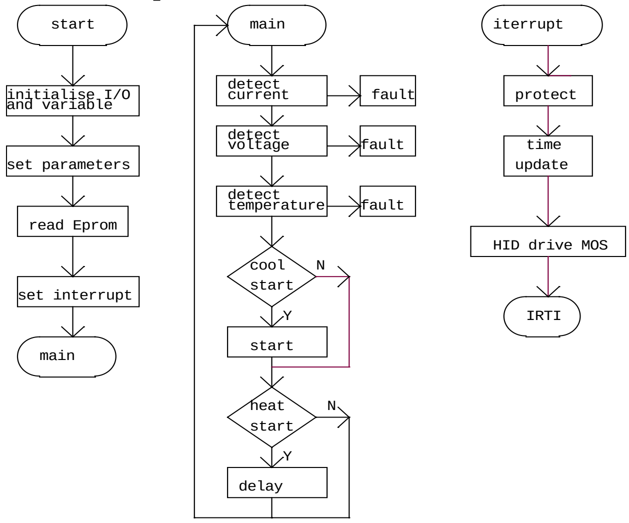


Fig.8.MCU control software process

Conclusion

The HID lamp electronic ballast design, the control part mainly adopts two chips, one is MC34262 used in active power factor correction and provide necessary HID the voltage and current. Second, the function is strong, micro processor MCU is the core component of HID electronic ballasts, it has a full bridge converter, "watchdog" reset of the system, and on the inside of the electronic ballast working temperature anomaly monitoring and protection for electronic ballast and HID lamp, and other functions, some functions are dedicated HID lamp control chip does not have, the power factor of 0.95.

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