A single stage based on ARM PFCLED drive power control method

Hong-Li Cheng†, Jian-Nan Wang

College of electrical and control engineering
Xi'an University of Science and Technology, Xi'an, 710054, China
†*E-mail: chhl@xust.edu.cn; 498286424@qq.com*

The traditional power factor correction (PFC) LED drive power due to its input rectifier circuit for nonlinear circuits, can bring a large number of high frequency current to power grid harmonic, the rectifier bridge after large capacitor filter will reduce the conduction Angle of input voltage, reducing the power supply for numerical, at the same time, reducing the power conversion efficiency. For this problem, A single-stage PFC circuit is designed based on ARM control. The topology of main circuit adopts the flyback type, putting forward a kind of based on fuzzy PID control strategy, and making more intelligent and flexible control method. In order to improve the power factor, improve the power conversion efficiency. Matlab/simulink simulation results shows that the single stage power system power factor, output current and other parameters are according to the design requirements.

Keywords: Single-stage PFC; The flyback converter; The fuzzy PID; Matlab/Simulink.

1. Introduction

Single stage active power factor correction circuit with a set of control circuit and a switch tube to realize the input stage current waveform correction, and quickly adjust level output voltage with load[1][2].It has the advantage of power due to the high value, low total harmonic content, low distortion rate. In addition, it can be under a wide range of input voltage and frequency band.

Almost of the design of the switch power supply the isolation type DC/DC topologies. DC/DC isolation structure can be divided into normal shock, flyback converter, bridge, half bridge and push-pull. Because of the flyback type circuit structure is simple, and easy to implement, in addition to this, flyback type circuit topology can be in the case of large input voltage range to ensure the stability of output current[3][4][5]. So, in this article choose the flyback type topological structure in the main circuit. Then, a digital control strategy based on ARM platform are presented in this article, at the same time achieving the PFC and DC-DC control [6][7][8].

2. The System Structure

As shown in Fig.1,The system consists of front-end protection circuit of power supply EMI filter circuit, rectifier circuit, flyback converter circuit, output filter circuit, isolation sampling circuit, ARM power circuit, driving circuit and ARM control circuit.

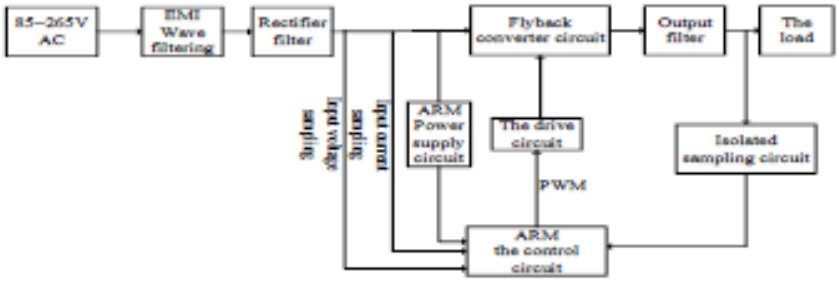

Fig1 Single stage power factor correction system

3. System Hardware Design and Software Design

3.1 The control circuit and parameters design of the PFC circuit

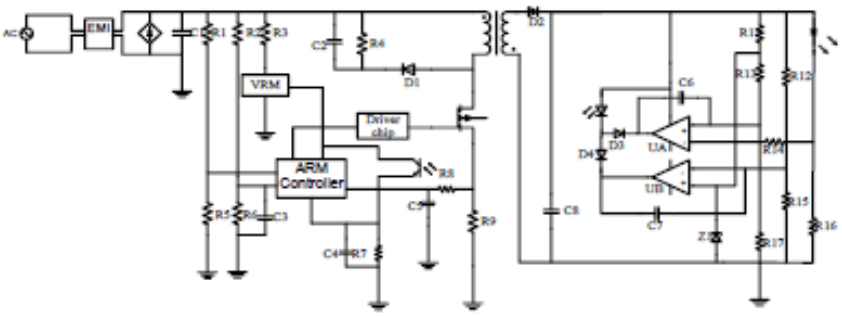

Fig.2 System principle block diagram

As is shown in figure above, the AC input circuit is composed of R1, R5, providing voltage signal, The feed forward input circuit is composed of R2, C3, R6,The transformer primary side inductor current sampling circuit is composed of C5,R8,R9,and A feedback circuit PC817 optically coupled isolator. The ARM controller is processed by program analysis, which makes the average value of the inductor current of the transformer is matched with the input voltage amplitude, and the current will follow the sinusoidal signal of the input voltage, and complete the control of the PFC loop. Constant current limiting circuit has two independent operational amplifier UA,UB and optical couplier device, Figure 2 sampling resistor R16 for detecting output current into voltage value of

the input to the negative terminal of the UA, The positive input of UA is the signal after R11, R13 and R17, which is based on the voltage of the reference voltage 2.5V.Amplifier output by the Optical coupler PC817 coupled to the ARM controller, forming a constant current control loop, the ARM controller and the program analysis, the duty cycle to control the output current of the corresponding output. In addition, The output voltage of the circuit is divided into R12 and R15, The voltage signal on the R15 input to the op amp UB negative terminal and the reference signal is compared, after the optical coupler PC817 coupled to the ARM controller is voltage control loop.

3.2 Main circuit parameter design

3.2.1 *Extreme value of input voltage*

Input voltage range of 85V to 265V, by the following formula (1) (2)

$$V_{inpeak} = \sqrt{2} \cdot V_{\max} \tag{1}$$

$$V_{invalley} = \sqrt{2} \cdot V_{\min} \tag{2}$$

Vmax is the maximum AC input voltage, and Vmin is the minimum AC input voltage. This can get the maximum input voltage is 375V, the minimum input voltage is 120V.

3.2.2 Maximum duty ratio

When the switch tube is switched on, the primary side current of the transformer rises linearly:

$$I_{rise} = \frac{V_{invalley} \cdot t_{on}}{L_p} \tag{3}$$

When the switch is turned off, the inductor current of the primary side begins to decrease. At this time, the voltage at both ends of the inductor is the voltage of the secondary side of the transformer, and the secondary side of the transformer is V_F, so the calculation formula of the original side current of the transformer is calculated:

$$I_{drop} = \frac{V_F \cdot t_{\text{off}}}{L_p} \tag{4}$$

Since the current rise in part and the part of current drop should be completely equal, so by the formula (5)

$$D_{\max} = \frac{V_F}{V_F + V_{invalley}} \tag{5}$$

The maximum duty ratio can be obtained for 0.45.

3.2.3 Transformer parameter calculation

By analyzing the parameters of the input and the output side, the inductance of the transformer primary side can be calculated by the formula (6).

$$L_p = \frac{V_{invalley} \cdot t_{on\max}}{\Delta I} \tag{6}$$

The original inductance can be obtained as 523uH.

According to the output of the power supply and the core transmission power, and the traditional AP method, this paper chooses EI35 ferrite, tables AP=1.3343cm2, Ae=101.4mm2, Aw=131.59mm2, B=0.2T: current density proportional coefficient Kj=366: X=-0.12.
By formula (7).

$$N_p = \frac{V_{invalley} \cdot t_{on\max}}{\Delta B_{ac} \cdot A_e} \tag{7}$$

The number of turns of the original side of the transformer can be 53 turns, and the side turn number is 13.

3.3 System control strategy

Fuzzy control is a rule based control, fuzzy PID control based on fuzzy control adaptive parameters, according to the error and error change rate in different time, using the fuzzy rules of PID controller KP, KI, KD three parameters on-line self-tuning, so as to meet the different error and error rate of different control parameters the requirements, and the controlled object has good dynamic and static performance. In this design, KP, KI, KD parameters need to be given an initial value, according to the change of error and error e rate ec, and according to the fuzzy rules of the on-line tuning of PID parameters, then use the parameter setting of the digital incremental PID algorithm, so as to realize the control the target, in order to achieve satisfactory control effect.

3.4 Software design

The software design process as shown in Figure 3,power up initialization, given the initial duty ratio of Do, after the operation of the system, sampling the output current, if the load short circuit, the system finishes running, otherwise continue

to sampling the output voltage of Uo. When the output voltage is greater than 28V, the system is over voltage protection, end of operation. If the output voltage is less than or equal to 28V, the system will continue to detect the input voltage and the primary inductance current, after sampling the voltage and current into the program for the corresponding processing, get the new duty, according to the new duty ratio of PWM wave generated by the isolation driving circuit to control the flyback converter, reading the AD conversion results, program is cycle operation.

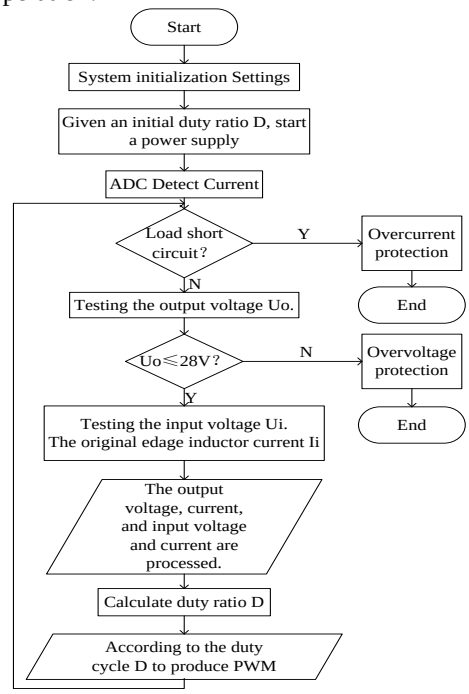

Fig.3 Software flow chart

4. Simulation Results and Waveform Analysis

4.1 Simulation result

Table 1 is the power factor, output voltage, output current, and power efficiency under different simulation conditions.

Table.1 Simulation results under different input voltage and load conditions

Ui	Ro	Ii	Uo	Io	PF	η
85V	10Ω	0.25A	19.32V	2.95A	0.97	86.6%
	15Ω	0.31A	24.33V	2.95A	0.97	87.7%
	20Ω	0.37A	28.56V	2.95A	0.97	86.2%
220V	10Ω	0.31A	19.05V	2.95A	0.97	85.2%
	15Ω	0.37A	24.09V	2.93A	0.97	86.6%
	20Ω	0.43A	27.71V	2.93A	0.97	84.5%
265V	10Ω	0.38A	18.98V	2.95A	0.98	84.2%
	15Ω	0.47A	23.95V	2.92A	0.98	85.1%
	20Ω	0.53A	26.91V	2.92A	0.98	84.4%

4.2 Single stage PFC simulation waveform

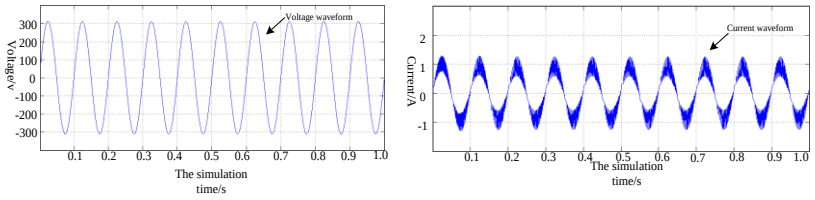

Fig.4The input voltage and input current waveform before power factor correction

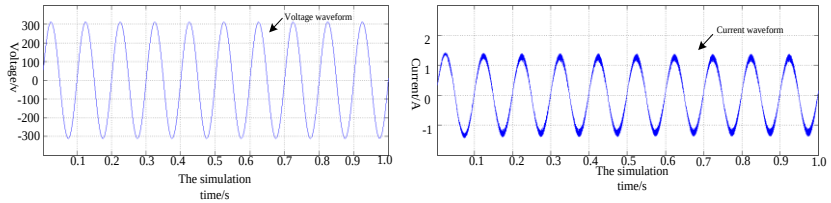

Fig.5The input voltage and input current waveform after power factor correction

It can be seen from the figure 4 that the current waveform has a certain distortion, and the input current waveform at the peak of the emergence of a number of burr. It can be seen from the figure 5 after the PFC, the input current phase tracking voltage phase, and the peak of the input current is improved, the PF value can reach 0.98.

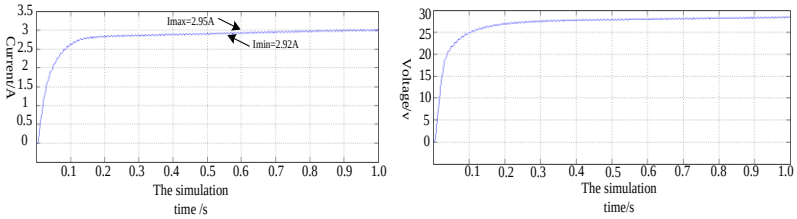

Fig.6 Output current and Output voltage

Figure 6 is the maximum AC input conditions, single stage PFC power output voltage and current waveform can be seen from the figure, the output voltage is stable at about 28.5V, the average value of the output current is stable at about 2.95A.

5. Conclusion

The control strategy of single stage PFC circuit is proposed in this paper. The application of fuzzy PID control strategy to the flyback topology circuit, and the regulation of PF value and the function of output constant current is studied. Compared with the power system without adding fuzzy PID control before,the PF value is improved, and the power efficiency is improved. Modeling and Simulation of the whole system. The results show that the power factor can reach 0.98, and the power supply efficiency can reach above 85%, Output constant current in 2.95A. It can provide long working conditions for the LED load.

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