A kind of LED switch power supply design based on iW1706

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Abstract

Flyback switch power supply is designed based on iW1706 and used to drive LED. iW1706 is a high performance AC/DC off-line power supply controller. It using the primary side sensing and quasi resonant operation, and provides the over voltage, over current protection. The main feature and principle of iW1706 are introduced. A switch power supply of the wide voltage range input (AC 85V~265V), the output current of constant 330mA, the rated power of 5W is designed basing on iW1706. Design steps focus on the transformer design and calculation of main parameters. The experimental results demonstrate the feasibility of the design and use fewer components in the circuit to achieve a stable current output.

Keywords

switch power supply, iW1706, quasi resonant, flyback.

1. Introduction

In recent years, flyback switching power supply to get in the small electrical appliances in a wide range of applications, which marks the switching power supply technology matures, more and more areas are beginning to use switching power supply, LED lighting is no exception.However, LED drive power requirements are also rising, high efficiency, safety isolation, output stability, control accuracy, small size, low cost LED driver power supply is becoming a critical evaluation.Based on iW1706 chip features, designed a offline flyback LED driver power supply, and provides overvoltage, overcurrent protection, fewer external components, the use of relatively inexpensive switch bipolar transistors, reducing design costs .

2. Chip introduction

iW1706 using a 5-pin SOT-23 package, pin configuration shown in Figure 1. Wherein the transformer auxiliary winding VSENSE pin is sensed signal input terminal for primary regulator.ISENSE pin is the primary-side current sensing for controlling the peak current. OUTPUT pin drive signal output terminal, for driving outside the chip bipolar transistor base.

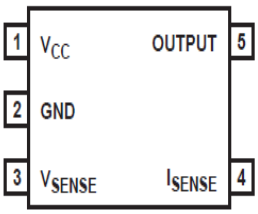


Figure 1 iW1706's pinout

Figure iW1706 is a high performance AC / DC power supply controller, which integrates the start and the input voltage detection circuit, the feedback signal conditioning circuits, D / A conversion circuit, overcurrent comparator, peak current limit comparator, double gate type transistor base drives and so on.

iW1706 use CNC technology to construct a peak current mode PWM flyback power supply, only use the auxiliary power supply can be achieved secondary winding voltage feedback, thereby eliminating the need for most of the switching power supply must be of secondary sampling and optical coupling circuit, at the same time also eliminates the need for complex feedback compensation network, which simplifies the EMI design and reduces the manufacturing cost circuit.

3. Based on the LED drive power of iW1706

Figure 2 uses iW1706 LED driver circuit design shown

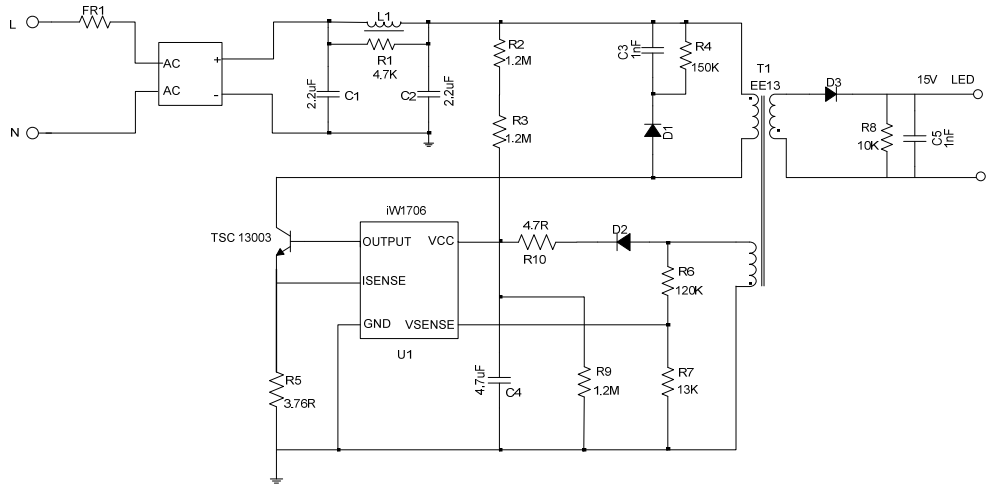


Figure 2 Based on iW1706 LED driver power supply circuit

In this paper, the design of the circuit is based on the flyback topology in DCM mode LED driver power supply. Design requirements: AC input range of 85 ~ 264V wide voltage input range, constant current output 330mA next to drive a 1W LED 5 series, the output voltage of 15V.The main circuit and works as follows

Input Protection.Fuse FR1 role is to prevent the opening of instant impact overcurrent burned other components, play a protective role.

EMI filter.Inductor L1 and capacitor C1, capacitor C2 constituting the differential mode filter, the differential mode attenuation of interference, while enhancing the ability of the anti-surge.In parallel with the secondary side of the diode D3 absorption circuit consisting of C5 and R8, and limit peak voltage rectifier can reduce outside noise interference radiation.

RCD clamp.When the flyback converter power switch off, due to the influence of leakage inductance will cause a voltage spike on the power tube damage.Clamp circuit by C3, R4, D1 composition, power switch Q1 is turned off, the leakage inductance energy released, the role of D1 is unidirectional conductive charge to C3, D1 then ended, R4's role is when Q1 turns on, the C3 charge on the freed part, so that the voltage on C3 is kept relatively constant.

Power supply circuit.The input AC voltage after filtering rectifier to convert the DC voltage, through R2, R3 to charge the capacitor C4, when the internal chip enable reaches the threshold voltage, the chip on work.Since then converted from the auxiliary winding current limit through R10, D2 rectifier, power supply to the chip after C4 filtering.

Primary side feedback circuit with constant LED current operation.iW1706 use primary-side feedback without secondary-side sensing and optical coupler.Voltage VAUX T1 auxiliary winding (number of turns for VAUX) on the result of the output voltage is transmitted.Voltage by R6 and R7 ,T1 secondary winding fed to U1 pin Vsense, by the internal constant current control circuit to adjust the output current on a constant level, regardless of the output voltage or not.The primary side current detected by the resistor R5, to perform peak current limit (PCL) and over-current protection (OCP).

4. Circuit design parameters and component selection

4.1 Core selection

Switching power supply transformer core mostly iron oxide core, it has a higher permeability, low coercive force, high resistivity.In considering the design of the core calculation method selection Ap. Ap law after law known as the core area product, first find the value of the product of the effective area Ae of Ap core window area Aw and core design, and then add some margin (10%) selected Ap similar core values.

According flyback topology, calculation formulas for Ap

$$A_{\mathrm{p}}=\frac{1.1\times P_{\mathrm{out}}D_{\max}\times 10^{3}}{\eta K_{\mathrm{p}}K_{\mathrm{T}}K_{\mathrm{U}}JB_{\max}f_{\mathrm{sw}}}(\mathrm{mm}^{4}) \tag{1}$$

Wherein, Pout is the output power of the transformer; Dmax is the maximum on-duty ratio; the expected efficiency of the transformer; Kp is assigned to the area of the primary winding, typically 0.5; KT equivalent series resistance for the primary current and the average current ratio in discontinuous flyback mode generally take 0.55 ~ 0.65; Ku fill factor for the window, generally take 0.4; J is the current density, generally take 3 ~ 10 A / mm2; Bmax for maximum operating flux density, flyback general take 0.12 ~ 0.15T; fsw is the switching frequency, according to iW1706 chip manual, that the operating frequency of 72kHz.

Dmax maximum duty cycle can be expressed as:

$$D_{\max}=\frac{0.8V_{\mathrm{or}}}{V_{\mathrm{inmin}}+V_{\mathrm{or}}} \tag{2}$$

Vor which is secondary to the primary voltage of refraction.

Select the appropriate parameters, using equation (1) and (2), which may eventually come Ap value of approximately 428mm4, taking into account the impact of the actual winding insulation layer, the fill factor to be considered here of 0.8, That Ap=AwAe/0.8=535mm4.After calculating the Ap value through core parameter table access vendors can choose a suitable heart piece, experiment, we choose EE-type core, the review found that the value of Ap EE13 570mm4, most close to the design value, so the final adoption EE13 cores.

4.2 Transformers parameter calculation

Number of turns of the transformer primary winding can be expressed as:

$$N_{p}=\frac{V_{in\min}\cdot D_{\max}}{A_{e}\cdot B_{\max}\cdot f_{sw}} \tag{3}$$

Primary peak current Ip is:

$$I_{\mathrm{p}}=\frac{2P_{0}}{\eta\cdot V_{\mathrm{inmin}}\cdot D_{\mathrm{m}}} \tag{4}$$

Primary inductance Lp is:

$$L_{\mathrm{p}}=\frac{V_{\mathrm{inmin}}D_{\max}}{I_{\mathrm{p}}f_{\mathrm{sw}}} \tag{5}$$

Since the core has been calculated EE13 model selection, so the information can be known according to the parameter value Ae EE13, so after the last calculated to obtain the number of turns of the primary winding Np to 193 turns, 188 turns adjusted to the laboratory; primary peak current Ip to 0.207A; primary inductance Lp is 3.4mH.Provided with the transformer primary turns Np secondary turns ratio NS is N, according to the basic principles of magnetic reset the transformer, there is

$$V_{\mathrm{in}}T_{\mathrm{on}}=N(V_{\mathrm{out}}+V_{\mathrm{D}})T_{\mathrm{off}} \tag{6}$$

VD is the output of the half-wave rectifier diode drop, generally take 0.5 ~ 1V. According iW1706 chip manual switch for on-time maximum of Ton 13.8us, can be calculated N = 6.7. Therefore, the

secondary winding turns for Ns = Np / N = 28.9 turns.The actual 28-turn circuit used for the auxiliary winding turns Nf take 28 turns.

4.3 Selection switch

iW1706 output end chip is connected to the base of an external bipolar transistor. The above withstand voltage bipolar transistor consists of three parts: the primary side of the mains voltage, the reflected voltage and leakage inductance of the secondary side voltage spikes caused.By the following formula:

$$V_{ce\_max} = V_{in\_max} + NV_0 + V_{PK} \tag{7}$$

Among, Vin_max is the maximum voltage input bus for 373V; Nis the primary and secondary turns ratio,calculated results for the previous 6.7; V0is the output voltage,for 15V;estimate for the maximum peak voltage100V.Thus available, Vce_max = 573V.Therefore,selection pressure is a bipolar transistor TSC13003 650V.

4.4 VSENSE pin voltage divider resistors R6 andR7 parameter calculation

Provided iW1706 power circuit output voltage drop of the rectifier diode D30.6V,the voltage on the secondary winding is Vs = 15V + 0.6V = 15.6V.

Voltage of the auxiliary winding： VAVX=(NAUX/NS) VS. And because VAUX=Vref (R6+R7)/R7, So in the end you can get

$$\frac{R_6}{R_7} = \frac{V_{AUX}}{V_{ref}} - 1 = \frac{N_A}{N_S} \cdot \frac{V_S}{V_{ref}} - 1 \tag{8}$$

According iW1706 chip manual,on-chip Vref is1.533V,thus available, R6 / R7 = 9.1.If you choose toR7 = 13kΩ,the R6 should be120kΩ.

4.5 ISENSE detection resistor R5parameter calculation

Output current I0can be expressed as:

$$I_0 = \frac{1}{2t_s}(i_{peak} \times \frac{N_P}{N_S} \times t_{dis}) = \frac{1}{2} \times \frac{t_{dis}}{t_s} \times \frac{V_{Isense}}{R_5} \times \frac{N_p}{N_s} \tag{9}$$

Which, tdis for demagnetization time, tdis is the switching period,inconstant current mode to maintain a constant proportion of them.VISENSE for ISENSE pin voltage limiter limits,according to iW1706 manual, its value is1V. After calculating the final results, R5 = 0.185 (Np / Ns) / I0,circuit designed constant current output of 330mA,thus considered R5 = 3.76Ω.

5. Test Results

In order to verify the design of flyback switching power supply performance iW1706 based, we draw its printed circuit board(PCB).The physical design of the switching power supply shown in Figure 3.

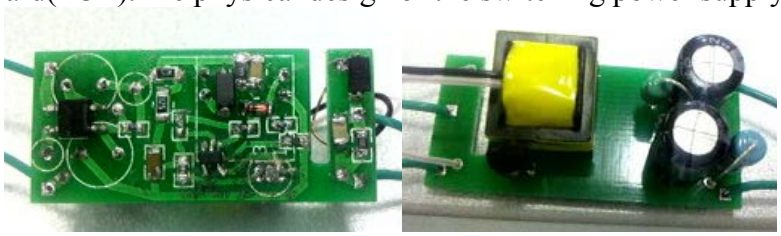
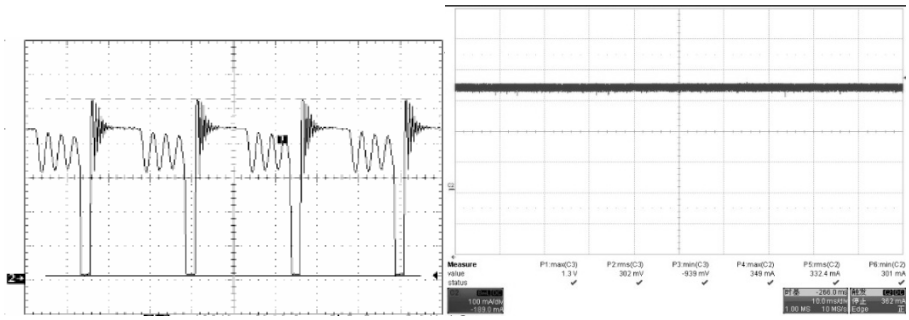


Figure3 Switching power supply design physical map(bottom left,top right picture)

The success or failure of the circuit is designed in that the output current can be stabilized at 330mA,the drive five1W of LED.Figure 4 is when the input voltage is 220V AC,open light pipe Vce wave form such as(a), the constant current 330mA output wave form is shown in (b) below.Figure (c) shows when the input voltage is AC 90V,driving five LED,the output voltage of the entire system can be seen from the figure with a multimeter measured output voltage is15.304V.



(a)Vce wave form switch (b)Wave form output current I0

(c)Driving five LED power supply system

Figure4 test results

6. Conclusion

This paper designed a flyback based iW1706 LED switching power supply for driving five series 1W LED.The working principle of the whole circuit and transformer design calculations and important component parameters.The design of the circuit input voltage is 85 ~ 265V AC,the output current is stabilized at 330mA,by driving five1W series circuit of the LED actually verify the feasibility of the design.

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