Pressure drop design of dc switch voltage regulator

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Abstract

Type step-down dc switching power supply work closely with people in life, is mainly used to in the research unit as the adjustable power supply, on the production line as a fixed power supply of product life experiment, it has perfect protection circuit, can satisfy the requirement of the user the use of simple and convenient. This design is based on the step-down controller LM5117 and CSD18532KCS MOS field effect tube as the core device, the peak current PWM control chip as a design way of control, and the synchronous rectifier technology that current sampling technology to reduce power consumption, low power consumption to improve the conversion efficiency. This design make full use of the LM5117 chip internal modules, including the UVLO circuit, error amplifier, oscillation circuit, PWM comparator, etc., at the same time in order to eliminate and improve big duty ratio under the system of open loop unstable phenomenon, using the chip of slope compensation circuit and to prevent overheating and damage to the device and an external an over-current protection circuit.

Keywords

LM5117 chip, Synchronous rectifier technology, PWM control,Slope compensation, Over current protection.

1. Introduction

The low-voltage type dc switch has the advantages of small power consumption, high efficiency and wide range of output stable voltage, so that it plays an important role in the electronic equipment. Therefore, its performance has a leading position in various power supply, and has a tendency to continue to develop.

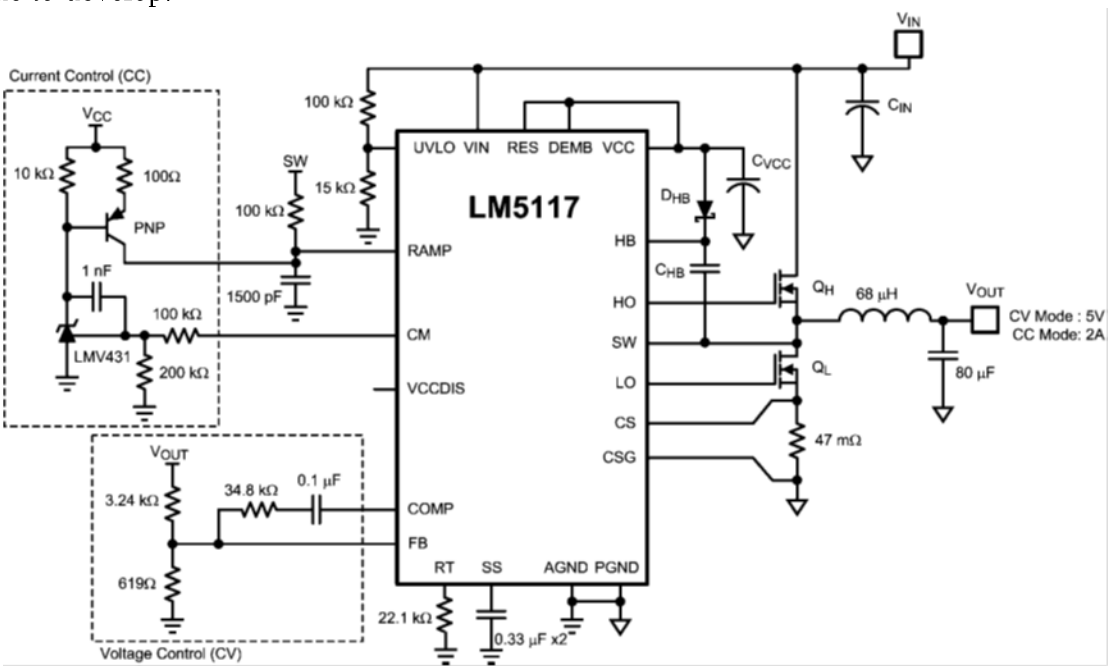

Fig. 1 main circuit diagram

2. Scheme design

This scheme is shown in Fig. 1, choose A more can meet the design requirements of LM5117 chip, this chip is the working voltage of 5.5 V to 65 V wider range gate drive, stable 3.3 A peak output drive control, adaptive dead zone time, free running or synchronous clock and the accuracy of up to 750 kHz voltage benchmark of 1.5%.

The internal heat - off circuit provided by the device can protect the controller when it exceeds the maximum node temperature. Protection function activated (usually in 165 ℃), the controller was forced to enter low power off mode, disable the drive and VCC voltage regulator. This feature prevents the device from overheating and damaging.

3. Circuit analysis and calculation

3.1 Reduce the ripple method

In order to reduce the output voltage ripple value of the switching voltage regulator, the method of increasing the parameter value of energy storage inductance L and filter capacitance C can have a significant effect. In addition, reducing the working cycle time of the power switch v (i.e. increasing the working frequency of the power switch v) can also receive the same effect. The working frequency of LM5117 can be set in the range of 50 kHz to 750 kHz. The LM5117 switching frequency is set by an external resistor connected between the RT pin and AGND pins. The resistance should be located very close to the device and connect directly to RT and AGND pins.

Therefore, this design takes 230kHz as the switching frequency. The output capacitor can smooth the output voltage ripple caused by the electric shock wave current and provide a charging power supply under the transient load condition. The formula is as follows:

$$\Delta V_{OUT} = I_{PP} \times \sqrt{R_{ESR}^{2} + \left(\frac{1}{8 \times f_{SW} \times C_{OUT}}\right)^{2}} [V]$$

3.2 DC transform method

DC conversion circuit is the main way of working pulse width debugging (PWM), the basic principle is through the direct current switch tube cut ChengFangBo (pulse), by adjusting the duty ratios change of square wave voltage.

The pulse width modulator used for traditional current mode control usually comes directly from the high - edge switching tube current. This switching current corresponds to the positive slope of the inductance current. The PWM slope with this signal can simplify the control loop transfer function to a pole response, and the inherent input voltage feedforward compensation can be realized.

LM5117 USES a unique slope generator, which actually does not measure the high side switching current, but rather to reconstruct the signal. Representation or simulation inductor current PWM comparator provides a ramp signal, the signal without leading edge spike, also need not delay measurement or filtering, while maintaining the advantages of traditional peak current mode control. The current reconstruction consists of two parts: the sampling and maintaining the current slope of the electric current of the direct current and the simulation of the electric current is obtained by measuring the circulating current of the current detecting resistance. Voltage sampling and maintenance on both ends of the detection resistance can be detected only before the next transmission time interval of the high side switch tube. The gain of the current detection amplifier is 10, and the sampling and retaining circuit provides dc level of the reconstructed current signal. As shown in Fig. 2.

3.3 Stabilization control method

Voltage method is to use sampling was carried out on the output voltage sampling circuit, feedback voltage Vf, then feedback voltage and reference voltage, Vref, by the error amplifier amplification, get VA = Av (Vref - Vf), VA as a comparator threshold voltage, then the VA and the fixed frequency of triangular wave comparison of line, after the comparator can be a control field effect tube of VB control signal, when the input voltage of the circuit Vi or load RL change caused by the output voltage Vo change, change the control signal of VB duty ratio can make the Vo is constant, a stable output voltage, which is closed loop, circuit can automatically adjust the output voltage.

The internal high gain error amplifier can produce an error signal that is proportional to the difference between the FFB's voltage and the internal accuracy of 0.8 V. The output of the error amplifier connected to the COMP pins allows the user to implement the type II loop compensation component, which is RCOMP, CCOMP, and the optional CHF. As shown in Fig.3.

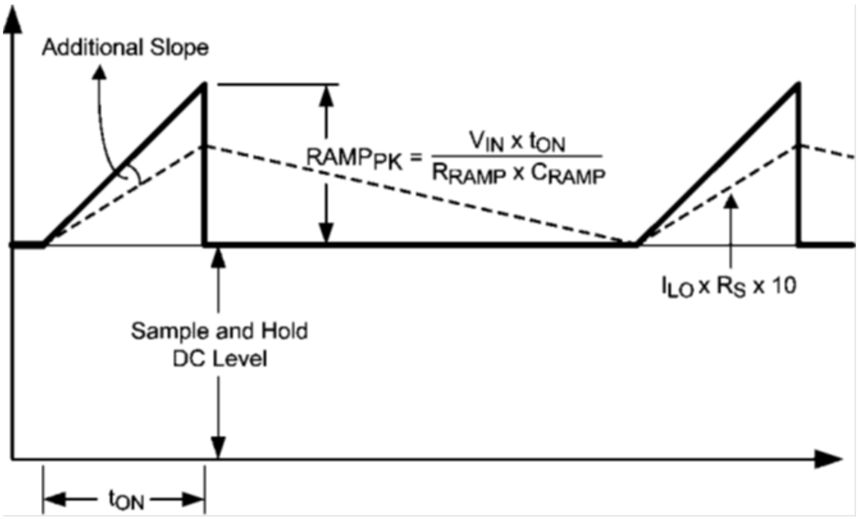

Fig. 2 DC transformation waveform diagram

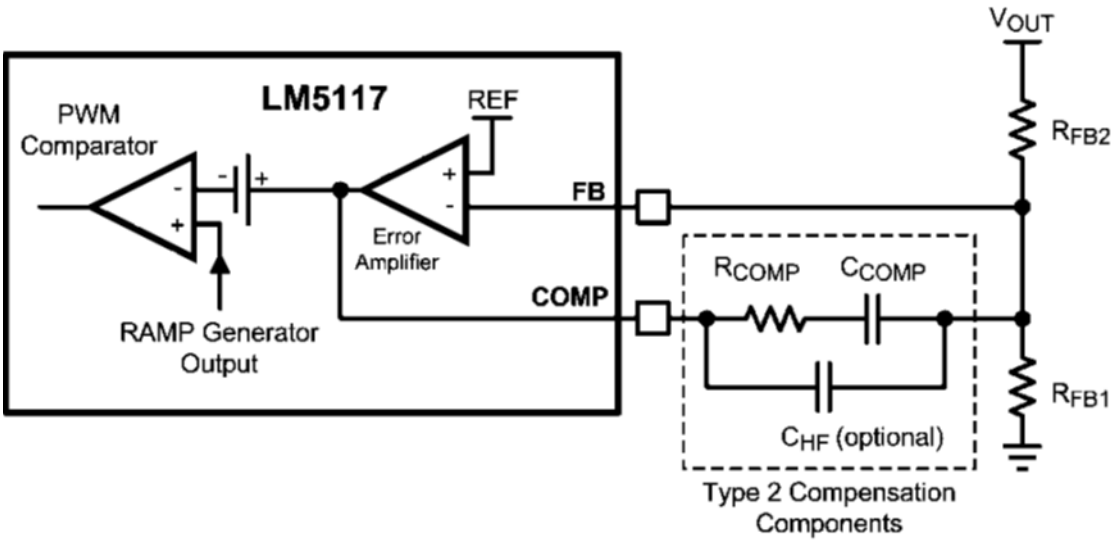

Fig. 3 feedback configuration and PWM comparator

The gain and phase characteristics of RCOMP, CCOMP and CHF can be configured to achieve a stable voltage loop gain. This network establishes a pole in DC (Fp1), a mid-range zero (Fz) for phase boost, and a high frequency pole (Fp2). Recommended RCOMP range is 2 kΩ to 40 kΩ.

FP1=0 [Hz]

$$F_Z = \frac{1}{2\pi \times R_{COMP} \times C_{COMP}} [Hz]$$

$$F_{P2} = \frac{1}{2\pi \times R_{COMP} \times \left(\frac{C_{COMP} \times C_{HF}}{C_{COMP} + C_{HF}} \right)} [Hz]$$

PWM comparator through a 1.2 V internal pressure drop, more from the ramp generator simulation current detecting signal and the COMP pin voltage, and current in the simulation signal is higher than the termination of the current period when VCOMP - 1.2 V.

4. Circuit simulation

4.1 The primary loop

The main circuit is shown in the Fig. 4.

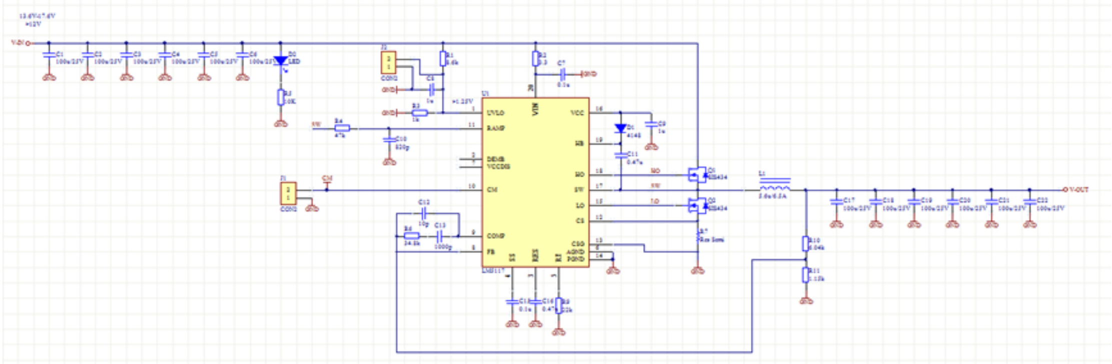

Fig. 4 main circuit

4.1.1 UVLO：

When VCC pins exceed its under-voltage locking threshold, and UVLO pin voltage is higher than 1.25 V, HO and LO drive are enabled and begin to operate normally. From VIN to AGND, a single external UVLO can be used to set the minimum input working voltage of the regulator. The design of the voltage divider must be that when the input voltage is in the required range of work, the UVLO pin voltage is higher than 1.25 V, but not more than 15V.

When the UVLO hysteresis of 0.172 V, the R1 is 8.6 KΩ circuit. When the voltage stabilizer opens the starting voltage of 12 v, R3 is 1 KΩ in the circuit.

4.1.2 Oscillator and synchronization functions

The LM5117 switching frequency is set by an external resistor connected between the RT pin and AGND pins. The resistance should be located very close to the device and connect directly to RT and AGND pins. To set an ideal switching frequency (FSW), you can calculate the resistance value by using the following formula:

$$R_T = \frac{5.2\times 10^9}{f_{SW}} - 948[\Omega]$$

Through LM5117 data manual available switching frequency should be close to 230 KHZ to reach the design requirements, therefore the formula available through circuit R9 should be 22 kΩ.

4.1.3 Error amplifier and PWM comparator

The internal high gain error amplifier produces an error signal that is proportional to the difference between the FB pin voltage and the internal high accuracy 0.8V reference. The output of the error amplifier connected to the COMP pin allows the user to implement the II type loop compensation element, i.e., RCOMP, CCOMP, and optional CHF. RCOMP, CCOMP, and CHF can configure gain and phase characteristics of the error amplifier to achieve stable voltage loop gain. The network establishes a pole at DC (Fp1), an intermediate frequency zero (Fz) for phase boost, and a high frequency pole (Fp2).

FP1=0 [Hz]

$$F_Z = \frac{1}{2\pi \times R_{COMP} \times C_{COMP}}[Hz]$$

$$F_{P2} = \frac{1}{2\pi \times R_{COMP} \times \left(\frac{C_{COMP} \times C_{HF}}{C_{COMP} + C_{HF}} \right)} [Hz]$$

To make FZ is 4.6KHz, FP2 is 460KHz, formula is available, R6 in circuit is 34.8K, C12 is 10PF, and C13 is 1000PF.

4.1.4 Diode simulation

The fully synchronous step-down voltage stabilizer is realized by the continuation NMOS, not the diode, with the ability to pump current from the output side under certain conditions, such as light load, overpressure or prebias start. LM5117 provides a diode emulation function which enables reverse current in low-edge NMOS devices. When configured for diode simulation, the low side NMOS drive is disabled when the SW pin voltage is higher than -5 mV when the SW pin voltage is higher than -5 mV, so as to prevent reverse current flow.

The diode emulation function is configured with DEMB pins. To achieve diode simulation, DEMB pins need to be connected to GND, or to float the pins. If continuous conducting is required, DEMB pins should be connected to a voltage greater than 3V and can be connected to VCC. When the SS pin voltage is lower than the internal 0.8 V benchmark, the LM5117 mandatory voltage stabilizer works in the diode simulation mode, allowing the start-up to enter the prebiased load that is used in the continuous guide configuration.

4.1.5 Soft start

The soft starting function allows the stabilizer to gradually reach the steady-state working point, thereby reducing the starting stress and surge. LM5117 can adjust the SS pins to the voltage of FB pin or the internal 0.8 V reference, whichever is lower. Internal 10 mu A soft start irrigation current gradually increases the voltage of external soft start capacitors connected to SS pins. This results in a gradual increase in the output voltage. Soft startup time (tSS) can be calculated using the following formula:

$$t_{ss} = \frac{C_{SS} \times 0.8V}{10\mu A} [\sec]$$

The LM5117 can track the output of the main power supply during soft startup by connecting a divider between the output of the main power supply and the SS pins. When the soft start sequence starts, the VSS should be lowered to below 25 mV by pulling open the pipe under internal SS. During soft start-up, when the SS pin voltage is lower than 0.8 V, the LM5117 is forced to carry out diode simulation in order to start the prebiased load. Therefore, it is not possible to reach the soft start time of 8ms and select the capacitance of 0.1μF external to the SS pin.

4.2 Other control circuit

4.2.1 Overcurrent protection circuit

As shown in Fig. 5. Get the voltage sampled from the CW LM358, after the first operational amplifier gain and reference voltage by second LM358 operational amplifier after comparison by LM393 amplifier will get high level. When the sampling voltage is lower than the reference voltage, the LM393 amplifier outputs a low level, and the PNP type BJT tube can still obtain the original output voltage by passing the relay. If the sampling voltage is higher than the reference voltage, LM393 amplifier output high BJT turn-on voltage through a diode, a relay, the normally closed switch will be off, the normally open switch will be closed after the high voltage will be self-locking function after the grounding end flow away, so as to achieve the function of overcurrent protection, preventing device overheating and damage.

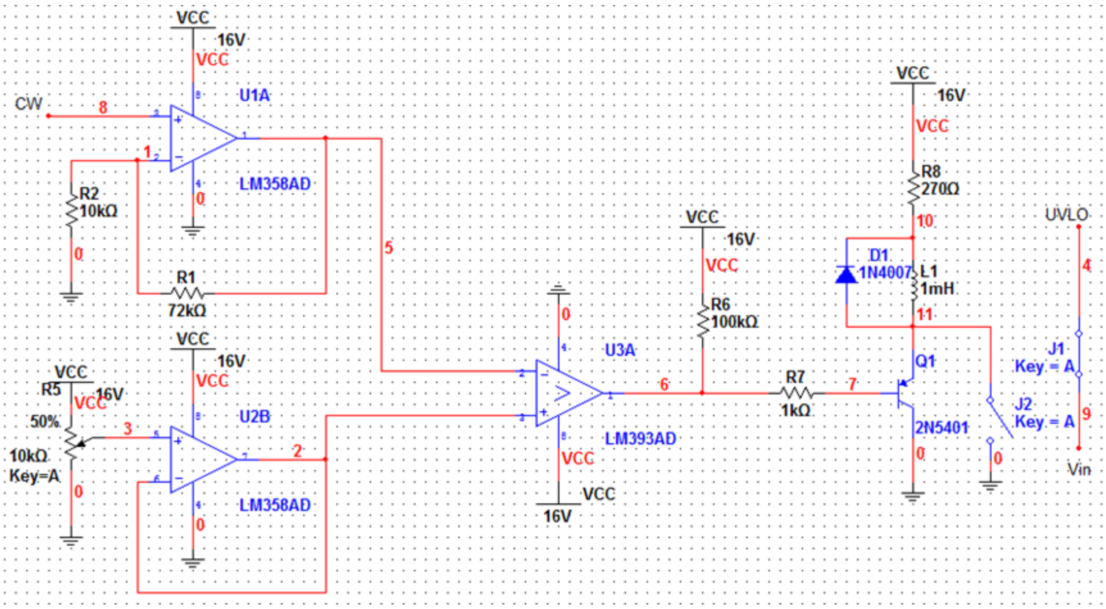

Fig. 5 overcurrent protection circuit

5. Conclusion

Type step-down dc switching power supply more and more used in our life, this design is based on the step-down controller LM5117 and CSD18532KCS MOS field effect tube as the core device, the peak current PWM control chip as a design way of control, and the synchronous rectifier technology that current sampling technology to reduce power consumption, low power consumption to improve the conversion efficiency. The problem of low signal conversion efficiency can be well solved by using this type of dc switch.

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