2019 9th International Conference on Education and Social Science (ICESS 2019)

The Design of a Practical Low-Voltage High Current Switching Power Supply

Ning Wang [a], Min Ji [b] and Chong Zhao [c]

Xijing University, Shaanxi Xi'an, 710123, China

[a]25676332@qq.com, [b]995010771@qq.com, [c]432577048@qq.com

Keywords: Active clamp position; Synchronous rectification; Proactive converter

Abstract. This paper briefly introduces the design process of a switch power supply with an output voltage of 3.3 V and an output current of 20 A.

Introduction

With the development of power supply technology, low voltage and high current switching power supply has been paid more and more attention because of its high technical content and wide application.

In order to achieve higher speed and better performance with lower power consumption, the power supply voltage is required to be lower and lower, and the transient performance index is getting higher and higher. Therefore, the switch power supply is required to be higher and higher. Using the original circuit topology and rectifier method can not meet the current requirements. In order to meet the needs of the development of IC chips, people began to study new circuit topology.

Because the output voltage is very low, synchronous rectifier naturally becomes the inevitable choice of this low-voltage high-current power supply. The complexity and reliability of the product are tested. Synchronous rectifier generally chooses self-driven synchronous rectifier. There are three topologies that can be combined well with self-driven synchronous rectifier circuits: active clamp forward converter, complementary control half-bridge converter, and two-stage structural converter. Compared with the two-stage structural converter, the active clamping converter and the complementary control half-bridge converter use less devices and are more attractive.

Basic Technology

Active clamp forward converter.

The circuit topology of the active clamp position synchronous rectifier forward converter is shown in Figure 1 and the working principle is shown in Figure 2.Prior to theDT period, the switch tube S1 was turned on and the excitation current iM was negative,That is, from Cr through S1 to Tr., in the DT stage, the drive pulse ugs of the switch tube S is turned on, while ugs1 = 0, so that the S1 is turned off. Under the action of Vin, the excitation current is changed from negative to positive. The original edge power passes through the transformer to the auxiliary side. Charge the inductor L at the output end; During the(1-D) T period, ugs = 0, S is off, ugs1 arrives to enable S1 to pass, and iM charges the Cr through the S1 reverse diode, under the action of the resonant circuit composed of Cr and Tr leakage inductance. IM from positive to negative, Transformer reverse excitation. From the above analysis, it can be seen that the active clamping forward converter Transformer core operates in a bidirectional symmetric magnetization state, improves the iron center utilization rate, and the steady state voltage of the clamping capacitor is automatically adjusted with the switch occupancy ratio, so the occupancy ratio can be greater than 50 <UNK>; When Vo is certain, the stress of the main switch and the auxiliary switch does not change much with Vin; Therefore, it can adapt to the situation of large input voltage range within the range of space occupancy ratio and switching stress. The disadvantage is the addition of a pipe, which makes the circuit complicated.

  DOI: 10.25236/icess.2019.237

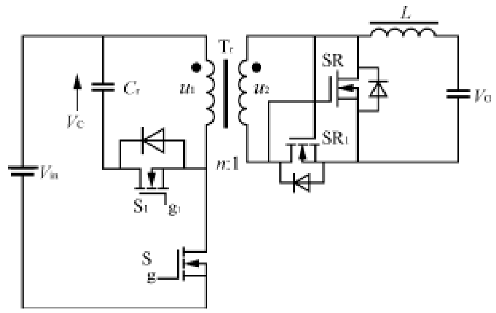

Fig 1. Active clamp position synchronous rectifier forward excitation circuit diagram

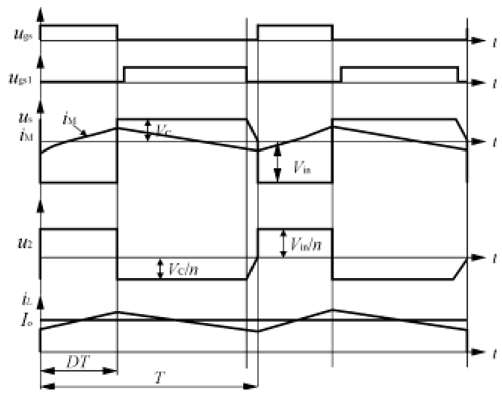

Fig 2. Working principle diagram of active clamp bit circuit

Synchronous rectification technology

The basis of synchronous rectification technology is the use of MOSFET instead of diode rectifiers. The voltammetry characteristic of MOSFET conduction is a linear resistance, called the general resistance RDS, and the low pressure MOSFET new devices have very small general resistance, such as: IRL3102(20V, 61A), IRL2203S(30V, 116A), IRL3803S(30V, 100A) The general state resistors are 0.013 Ω, 0.007 Ω, and 0.006 Ω, respectively. When they pass through the 20A current, the general state pressure drops by less than 0.3 V. In addition, the short power MOSFET switch time and high input impedance make MOSFET the preferred rectifier for low-voltage high-current power converters. The power MOSFET is a voltage-type control device. When it is used as a rectifier, it requires that the control voltage be synchronized with the phase of the voltage to be rectified to complete the rectifier function. Therefore, it is called a synchronous rectifier circuit. Fig. 1 is a typical pressure-relief "synchronous" switching converter circuit(a "normal" pressure-relief switching converter circuit when there is no SR in the circuit).

Circuit Design

The designed power supply parameters are as follows: the input voltage is 50(1 ± 10 <UNK>) V, the output voltage is 3.3 V, the current is 20A, and the operating frequency is 100 kHz.

The main circuit topology used is shown in Figure 1. Since the active clamping position uses a FLYBACK clamping circuit, its clamping capacitance voltage is:

$$V_c = V_{in}\frac{D}{1-D}$$

The selected control IC chip is UC3844, and its maximum occupancy ratio is 50%, so the voltage on the capacitor is Vin at most, and the capacitance resistance pressure is 60V or more. As long as it is large enough, the circuit can be properly operated. The clamp capacitor selected by this circuit is 47μF / 100V.

The drive of the active clamp pipe S1 must be separated from the ground on the original edge of the transformer, and the drive signal of the S1 must be reversed from the switch tube S-drive signal.

UCC3580 can be used to drive the two tubes, but this chip is not common. Therefore, UC3844 and IR2110 are selected here. The control signal from UC3844 is used as the low-end input of the IR2110. Its antiphase signal is used as the high-end input of the IR2110. The high-end drive of the IR2110 is isolated through an internal self-propelled circuit. In this way, we achieve the purpose of driving two switch tubes.

In the output rectifier circuit, when the continuation diode(ie, the reverse diode of the SR) is directed by the forward voltage, the SR switch should be driven in a timely manner to reduce pressure drop and loss. However, in order to prevent SR and SR1 from leading at the same time, causing a short circuit accident, there must be a "dead zone" time, which still depends on the diode D. SR switches are instantaneous and the continuum diode is instantaneous, so the switch speed is required very high. In addition, IRL3102 is selected from the perspective of cost.

The design of the Transformer is similar to that of a normal forward converter Transformer, but it is only necessary to consider the driver of the synchronous rectifier. The drive opening voltage of the selected synchronous rectifier is about 4V, the circuit output voltage is 3.3 V, and the output end is equivalent to a pressure-relief circuit. The maximum occupancy ratio is 0.5, so the transformer side voltage is at least 6.6 V. Because the Silicon oxide layer between the gates and sources of the MOSFET has limited pressure, it is permanently damaged once it is penetrated. Therefore, the actual maximum voltage between the upper gate and the source voltage is between 20 and 30 V. If the voltage exceeds 20 V, it should be at the gate. Stabilize the voltage tube.

Experimental Results and Waveform Analysis

The Uds waveforms of the switch tubes S1 and S are shown in Figure 3, RefA is the pressure drop waveform of the S tube, 50V/div, RefB is the pressure drop waveform of the S1 tube, and 50V/div. The circuit works at Vin = 60V at this time. The switching stresses of S1 and S are about 120V and D = 0.5. Fig. 4 is the transformer output voltage, which is the drive signal of the synchronous rectifier SR1 and SR. The positive part is the drive signal of the SR, and the negative part is the drive signal of the SR1. The waveform obtained from the experiment is basically consistent with the analyzed waveform, except that there are small spikes in the voltage at the moment of switching, which is caused by the stray parameters of the circuit. The working efficiency of this circuit is measured at about 90% , which basically meets the design requirements.

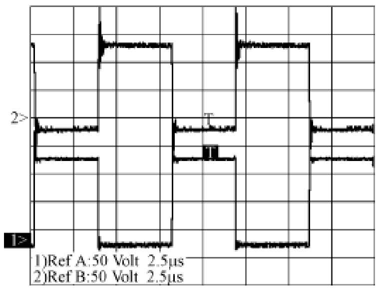

Fig 3. UDS waveforms of switch tubes S and S1

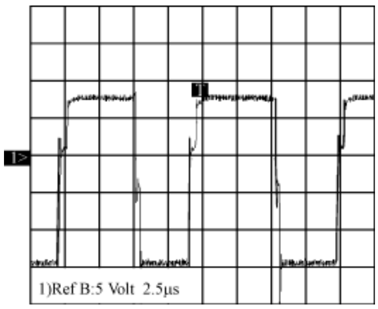

Fig 4. Drive waveform of synchronous rectifier

Summary

The switch power of 3.3 V/20A supply design shows that active inverter and synchronous rectifier circuits are used in the design of high-voltage, high-current forward circuit, without PFC circuits, can achieve high efficiency.

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