



A Survey and Comparative Study of Auxiliary Winding in Single-Stage APFC Constant Current Buck-type SMPS Topology

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Abstract: Power supply is one of the dominant fields. It has many applications like Lab equipment, Mobile industry, medical devices, telecommunication devices, data converters, and so on. Many studies and researches are carried out in this area. Every electronic device needs a power supply to function, so it can be said that power supply section is inseparable. In this paper, a study is done on auxiliary winding based VCC supply in single-stage active PF corrected low side constant current buck-type (CC Buck-type) SMPS chip so that an optimized solution can be found to carry out the research work.

Index terms – Active power factor correction (APFC), Single-stage, primary-side control, primary-side regulation (PSR), AC-AC-DC converter, Constant current buck (CC Buck), Power supply unit (PSU).

1. INTRODUCTION

All electronic circuit needs a source of VCC/VDD voltage supply, especially the electronic devices (IC Chip) which uses AC main supply. Therefore, they must be provided with a circuit that will operate at a different voltage instead of the standard AC supply, and this is achieved with a special type of circuit known as a power supply unit. This power supply is divided into two groups. The linear power supply is the most common type of design, and is used for powering resistive, capacitive and inductive loads. Large filter capacitors are used for DC filtering, reserve current can provide extra current for short period of time without any damage to related circuit. The output is also free from high-frequency noise (EMI) which would make it practical to use with access controls.

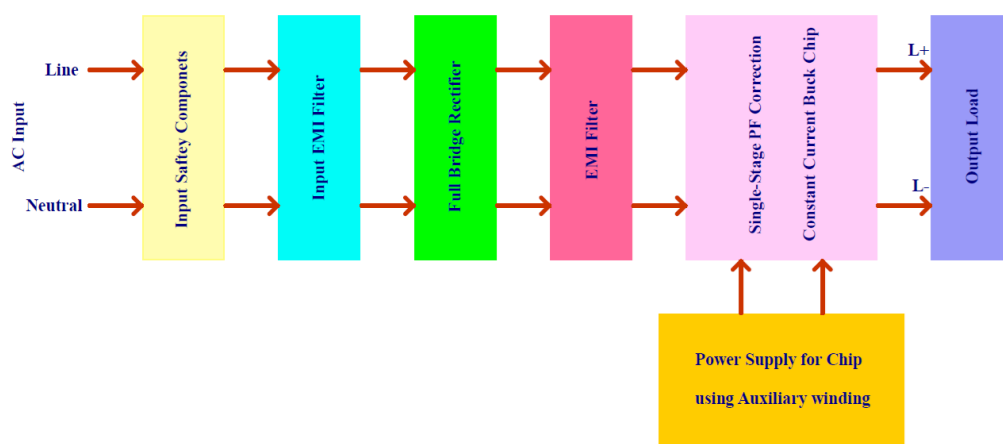


Figure 1. Block diagram of single-stage APFC buck-type constant current SMPS with external auxiliary winding power supply

In figure 1, a single-stage APFC buck-type PSR is integrated with current-mode control. It is proposed and adopted for improved output current and load voltage regulation, and reduces the power factor loss, iTHD noise and secondary noise influence on the output current accuracy [6]. This method reduces both of current and voltage stress greatly and improves EMI performance and overall system efficiency.

For the reliable and stable operation of a power converter, control circuit is an important circuit. Two methods are developed to feed the required DC voltage to the control chip in a buck converter:

- Independent DC voltage source (Figure 2); and
- Winding-type auxiliary power supply (Figure 3).

In several applications, auxiliary winding of the main power inductor of transformer is used to provide self supply of controller IC [1].

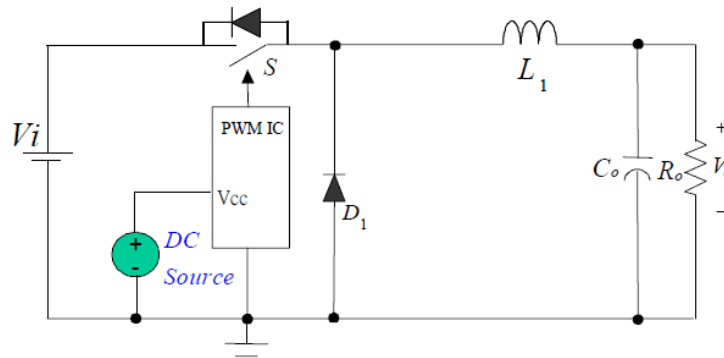


Figure 2. Independent DC voltage source

Due to high cost, independent DC voltage source is quite unpopular in the industry application. It supplies the required DC voltage V_{CC} for the pulse-width modulation (PWM) IC in a typical buck converter.

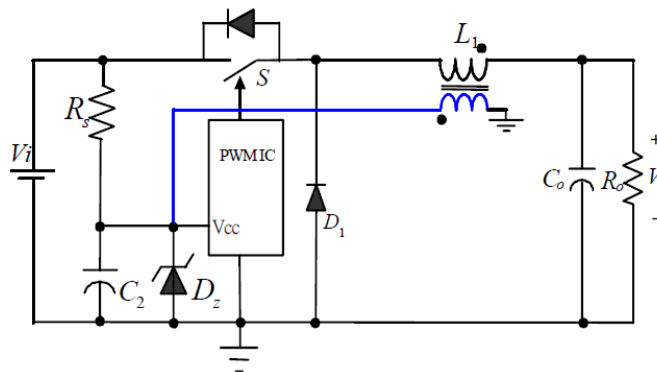


Figure 3 Winding-type auxiliary power supply

Winding-type auxiliary power supply [2] includes a Zener regulator (R_s resistor, D_z diode and C_2 capacitor) to provide the startup current of PWM IC. After switch S begins to operate, L_2 (auxiliary coupled winding) starts to charge capacitor C_2 and then supplies the Zener-regulated DC voltage to PWM IC. This method is popular due to its cost-effective solution. There is another method too to supply the required DC voltage V_{CC} for the control IC in a typical electronic ballast circuit, i.e., by using Charge-pump type of DC voltage [3]. This concept can be further applied in Buck converter.

2. Charge Pump Power Supply for the Control IC of Buck Converter

Lin, Ray-Lee, and Hung-Ming Chen [4] in his paper had proposed a charge-pump auxiliary power supply without any additional magnetic circuit. To validate the performance of the work, a 50kHz, 48V buck converter with this charge-pump auxiliary power supply is implemented, and the application of the proposed work can be extended to other converters, like Zeta, fly back, buck and Buck-boost. The proposed work achieves a stable operational voltage and experimental results show less turn-off switching loss of the proposed circuit. The efficiency was found to be 93.4% at the heavy-load condition. Bai, Yongjiang, et al. [5] had also given a novel topology to eliminate the auxiliary winding of transformer in his work.

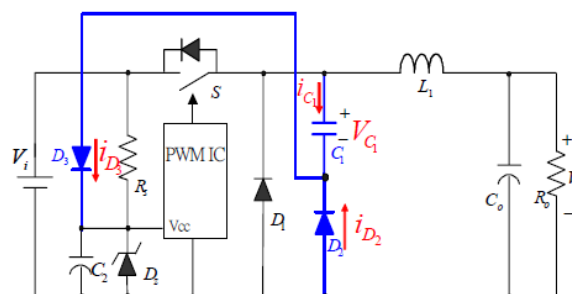


Figure 4 Charge Pump Power Supply for the Control IC of Buck Converter by Lin, Ray-Lee, and Hung-Ming Chen

3. Self-Bias Supply Scheme for the Control Circuit in Power Converter

Shen, Lijuan, et al [6] had presented self-bias supply method (also referred as paralleled self-bias supply) for the control circuit in DC-DC converters to achieve better efficiency. The principle of this new topology is realized by an additional switch, a diode and the logic circuit. The proposed method can achieve better efficiency, high quality and more stable voltage in comparison to other methods (auxiliary winding, linear voltage regulator). This proposed method can reduce the switching losses, and is validated on a 64-W flyback converter prototype.

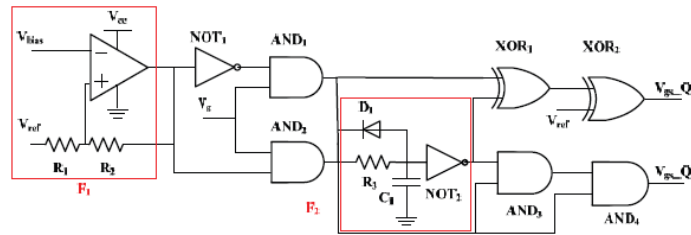


Figure 5 Main logic circuit of the proposed method by Shen, Lijuan, et al

Study of external auxiliary winding voltage and current wave-form of self supply for a chip (IC) is shown in Figure 6.

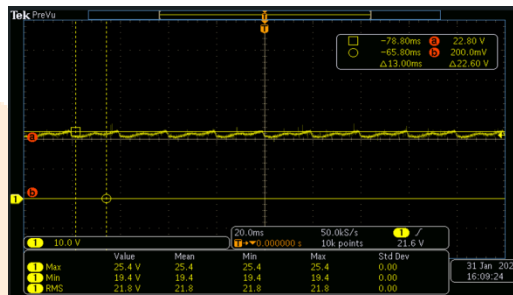


Figure 6. Actual measurement of auxiliary winding power supply voltage for regulated chip operation using oscilloscope

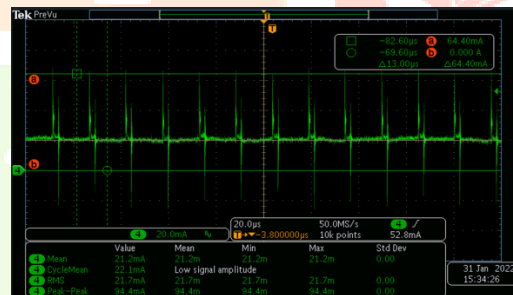


Figure 7. Actual measurement of auxiliary winding power supply current for regulated chip operation using oscilloscope

We have evaluate and analysis waveform of external auxiliary power supply of active power factor corrected buck-type constant current switch mode power supply using digital Oscilloscope and found the requirement of operating voltage and current.

In Figure 8, it is shown that during under light load condition or AC input voltage zero crossing detection, for smaller inductor current, the auxiliary winding voltage can not accurately reflect the output voltage [7].

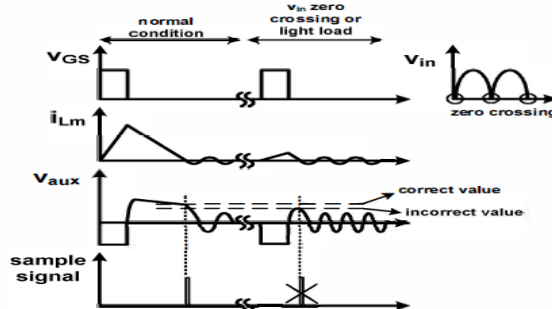


Figure 8. Actual measurement of auxiliary winding voltage under different conditions by Lin, Ying-Ting, et al

4. CONCLUSION

In this paper, a study is carried out for various auxiliary power supply based methods. From the study it can be concluded that various approaches have its own pros and cons (like increase in package size and cost) also needs further optimization too.

We can optimize the circuit by integrating auxiliary winding.

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