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Active clamp for increasing efficiency of switching power supply

Switching power supplies are widely used in almost all spheres of life. The main reasons are high performance, compact size, efficiency (80–90 %) and improved stabilization target. Virtually all modern electronics, including IBM, audio, video and other devices, is powered by switching power supplies. Nowadays, trend of electronics is aimed at miniaturization of electronic equipment, including power supply, and improve the efficiency. Therefore the aim of the paper is to present way of increasing efficiency and reduced dimensions through the use of mode active clamp in converter.

Principal of switching power supply construction

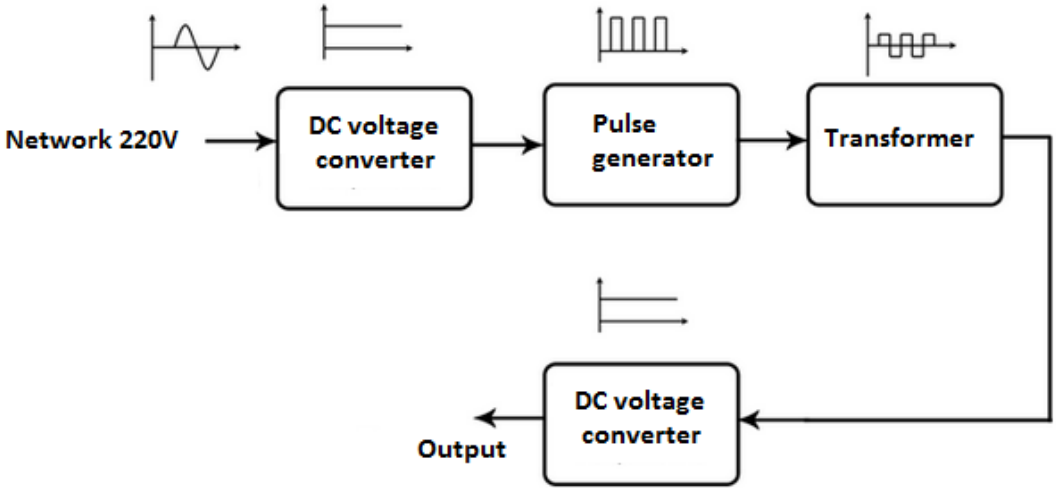

Fig. 1. Block diagram

Consider the block diagram of a simple switching power supply, which is the basis of all switching power supplies.

The first block converts AC to DC voltage. This converter usually consists of a diode bridge, which rectifies AC voltage, and capacitor, with smooth ripple of rectified voltage. However the block has additional elements: filters of mains voltage and thermistors for smoothing the current surge during start up.

The next block – pulse generator obtained from DC voltage by closing and opening electronic key (there will be use mode active clamp). This pulse goes to the primary winding of the transformer. The frequency of generating pulses of different power supply is different and lies in the range of 30–200 kHz. The transformer provides the main functions of the power supply: galvanic isolated from the network and regulation voltage to the required values.

The last block converts AC voltage, obtained from the transformer, to DC voltage. Block consists of rectifying diodes and voltage ripple filter. In this block filter ripple is much harder than in the first block because it consists of a group of capacitors and inductor.

Mode active clamp

Active clamp of forward converter allows obtaining high efficiency and small size of the transformer. Consider the working principle of this mode.

At first time transistor Q1 is turned on, the transformer converts the voltage Vin to the voltage across the secondary winding of the transformer ratio ($U_{Ns} = V_{IN} \frac{N_S}{N_P}$). Capacitance Cc is charged to

a voltage equal to Vin / (1 – D), and no current through it flowing. The coefficient D shows how full duty cycle conversion.

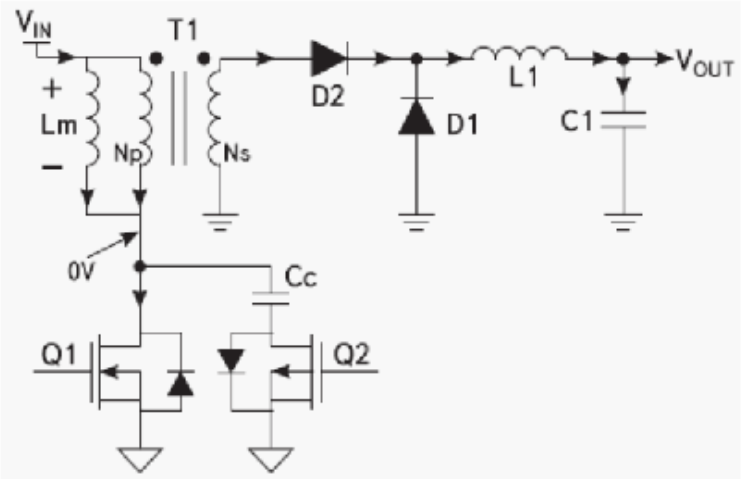

Fig. 2. The working principle

Then (fig. 3) transistor Q1 closes and current flows through capacitor Cc charging it. The value of the magnetizing flux in the core is reduced, since the energy is transferred to the circuit Cc and Q2. In the secondary circuit load is supplied through diode D1. This stage will continue for as long, as the capacity Cc not charged to a value larger than Vin, and the amplitude of the magnetizing current reaches zero.

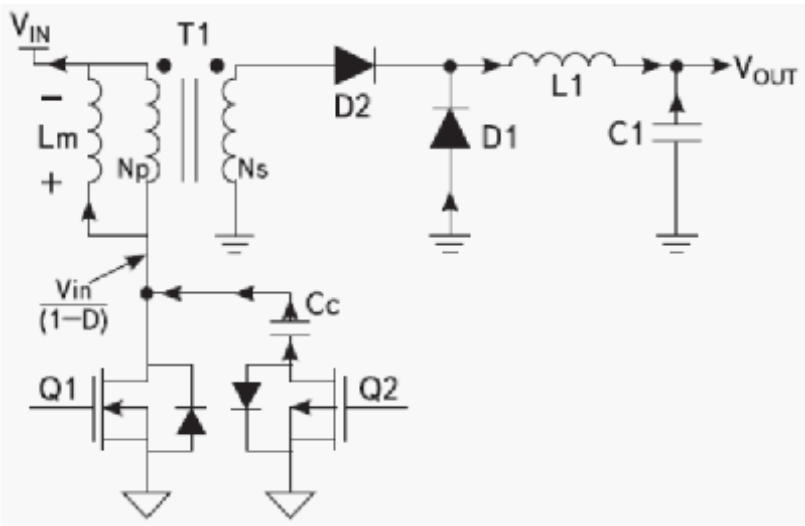

Fig. 3

Then current of primary winding flows in the opposite direction. This direction is caused by excess energy on capacitor as a result of the discharge of inductor through capacitor. Physics steady state results in the equalization circuit capacitor potential to the value Vin, and the magnetizing current must take the same value as at the first time. Transistor Q2 is turned off and all process in circuit repeat.

The main advantages of active clamp mode:

1) magnetization reversal transformer produces the optimum voltage. Accordingly, we have the minimum overload voltage of components at the maximum possible transformation ratio;

2) greatly reduced noise when switching transistor, since the energy of his switching significantly reduced;

3) reduced dynamic losses;
4) on the power key there are no voltage surges caused by the leakage inductance;
5) power stroke is limited only by the maximum overload voltage elements.

Some disadvantages of this mode:

- Difficult implementation;
- presence of an additional transistor;
- complexity of generating the control signal.

The main reason that declines efficiency of the power supply is switching losses of transistor key. Using active clamp mode these losses a disappear, because switching transistor key happens at low voltage. Therefore dynamic losses are reduced and efficiency increases. Also active clamp mode can work on high frequency. But this mode is not implemented.

References

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