

A variant of the uninterruptible power supply circuit with double conversion

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Abstract. The article discusses the main structural schemes of three types of uninterruptible power supply sources: backup; interactive; double conversion. The main functions of which are: performing the function of a backup or emergency power source; performing the function of protective devices, improving the quality of the power supply voltage. The features of operation, advantages and disadvantages of three groups of uninterruptible power supplies are also disclosed. New approaches in the structural and circuit design of uninterruptible power supplies based, including on the use of renewable energy sources are disclosed. Based on the analysis, one of the variants of the block diagram of an uninterruptible power supply with a double conversion of the system is presented and explanations and principles of its operation, as well as advantages and disadvantages are given.

1 Introduction

With the increasing dependence of business on IT and the increasing requirements of information systems for power supply, the need for uninterruptible power supply systems is becoming increasingly obvious.

Uninterruptible Power Supply (UPS) is widely used to protect IT equipment from power outages and substandard power supply. This is additional equipment designed to power IT systems or other devices during a short-term (up to several tens of minutes) disconnection of the main power supply, as well as to protect against interference and surges in the power grid and maintain power parameters within acceptable limits. That is, UPS can also be used to improve the quality of power supply [1].

Separately, it is possible to single out a guaranteed power supply system, which is designed to provide consumers of the first category with uninterrupted electricity during its regular long-term disconnections from the external network. Such a system provides consumers with high-quality voltage during its fluctuations, short-term and long-term power outages in areas of so-called "uncertain power supply". The electrical network in such systems can be used as the main or additional source, depending on the quality of the connected electricity and the purpose of the power system. It can also be used to obtain additional power at the established power supply limit to power a dedicated load line, as well as to profit from the sale of excess solar electricity to a grid company [2-4].

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According to the design, the UPS can be divided into desktop, floor and rack. The main purpose of any UPS is to protect the load from possible problems in the power supply circuits.

Thus, UPS smooth out small and short—term power surges, filter the supply voltage, but their main task is to feed the load for some time after the voltage hits the mains. Many models with the help of software can automatically shut down the IT equipment when there is a prolonged absence of voltage in the supply network, as well as restart it when the mains power is restored or by timer. Some UPS provide functions for monitoring and recording power supply parameters (such as temperature, battery level and other indicators), displaying voltage and current frequency parameters, output voltage and power, emergency warning, etc. When the voltage drops in the power grid, any UPS switches the load to battery power, but there are important differences [5-7].

The purpose of this work is a brief comparison of UPS of different classes and refinement of one of the options.

2 Main Part

According to the principle of operation, UPS are divided into three main classes: standby UPS (off-line), line-interactive (line-interactive) and UPS with double conversion (on-line). The type of UPS is determined by the ratio of parameters at the input and output of the device. In the former, the frequency and output voltage are determined by the frequency and input voltage; the latter stabilize the output voltage when the frequencies coincide, and the UPS with a double conversion converts the alternating voltage into a constant and again generates an alternating (sinusoidal) voltage at the output, the characteristics of which do not depend on the parameters at the input of the UPS.

In standby (or passive) The UPS load is powered directly from the mains, usually through an interference-suppressing filter. In case of a power failure, the load is switched to backup power from an inverter powered by batteries. Such UPS are simple and inexpensive, have high efficiency, but do not stabilize the voltage and frequency of the power grid, and switching to battery power occurs in a few milliseconds. Their power is usually small — from 220 to 2000 VA.

A typical application of backup UPS is the protection of a PC or auxiliary equipment, where the significance of stored information or operations performed is relatively small. This topology is not suitable in case of frequent outages or poor-quality power supply.

To protect more important equipment, for example, entry-level servers, network and telecommunications equipment, it is better to use line-interactive UPS. They provide stabilization of the supply voltage in a given range and reduce the influence of transients on the operability of the protected equipment.

Linearly interactive UPS support the parameters of the supply voltage and synchronously switch the load to the inverter when it disappears. In them, the inverter is connected in parallel to the power grid, it regulates and stabilizes the output voltage, simultaneously charging the batteries. Sometimes the UPS is supplemented with autotransformers, which allows you to expand the voltage regulation range without switching to the battery.

The advantages of this technology are voltage stabilization, shorter battery switching time and a well—approximated sinusoidal voltage form at the UPS output.

Line-interactive UPS systems can be used to protect professional workstations, mid-level servers, switches, routers and other network equipment, but they are not suitable for protecting complex and expensive equipment sensitive to electromagnetic interference, power voltage fluctuations and power frequency instability, for example, medical equipment.

Linear interactive UPS systems are also not suitable for protecting continuous technological processes, as well as for building centralized systems of guaranteed power supply, where it is important to ensure complete independence of the electrical parameters at the UPS output from the parameters at the input.

A kind of linear interactive systems - UPS with delta voltage conversion. Thanks to the improved feedback, the voltage on the load is regulated smoothly, rather than stepwise, and the frequency of the output voltage is stabilized.

The main advantage of a delta-conversion UPS is its high efficiency. However, it is achieved when the network voltage parameters correspond to the nominal values, the input load impedance has only an active component, and the UPS itself is loaded at full capacity. Otherwise, the load on the main and delta inverter increases, or the efficiency of using the input transformer decreases, which worsens the efficiency. The same effect is caused by the expansion of the input voltage range for normal operation. As a result, having an advantage in efficiency (2-3%) in ideal conditions, UPS with delta conversion lose linearly interactive in real conditions.

The most technically advanced class of uninterruptible power supplies — dual conversion systems — guarantee electrical output characteristics close to ideal, both in voltage and frequency. You have to pay for this by complicating and increasing the cost of the design.

Dual conversion systems provide very short battery switching times and have high electrical output characteristics. Such UPS are suitable for mission-critical applications, protection of powerful servers and clusters, telecommunication equipment and local networks. They have a high efficiency in the double conversion mode (95-96%) and a sinusoidal shape of the output voltage.

In such UPS, the input AC voltage is converted by the rectifier to DC, and then by the inverter back to AC. Even with large input voltage deviations, the UPS supplies the load with a pure sinusoidal stabilized voltage. The inverter is connected in series with the main power supply source and is always on. When the input voltage disappears, it switches to battery power.

In normal mode, when powered from the mains, electricity is supplied through a rectifier and an inverter, simultaneously recharging the batteries. In case of loss or power failure at the UPS input, the inverter is powered by batteries. Switching takes place without using a static switch, so switching to battery operation is instantaneous. The static key in this scheme is used only to switch to the automatic bypass mode to power the load in case of a significant failure in the UPS operation.

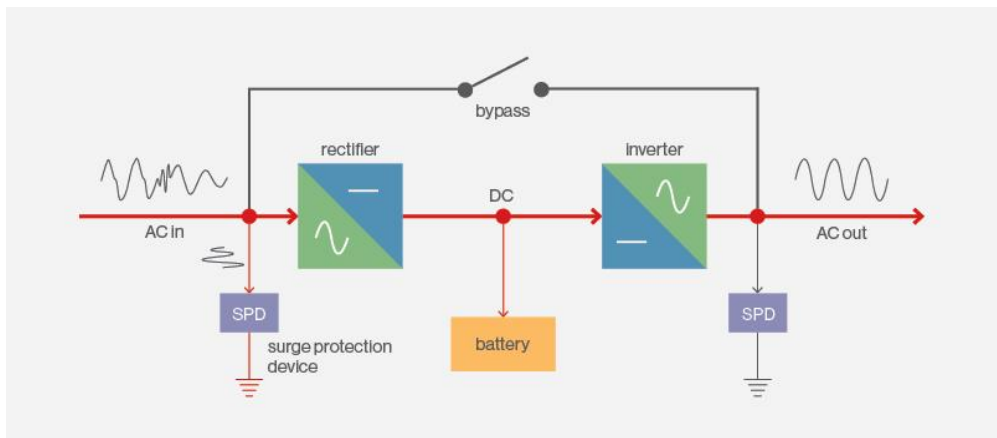


Fig. 1. UPS with double conversion in emergency mode (SPD — power filter).

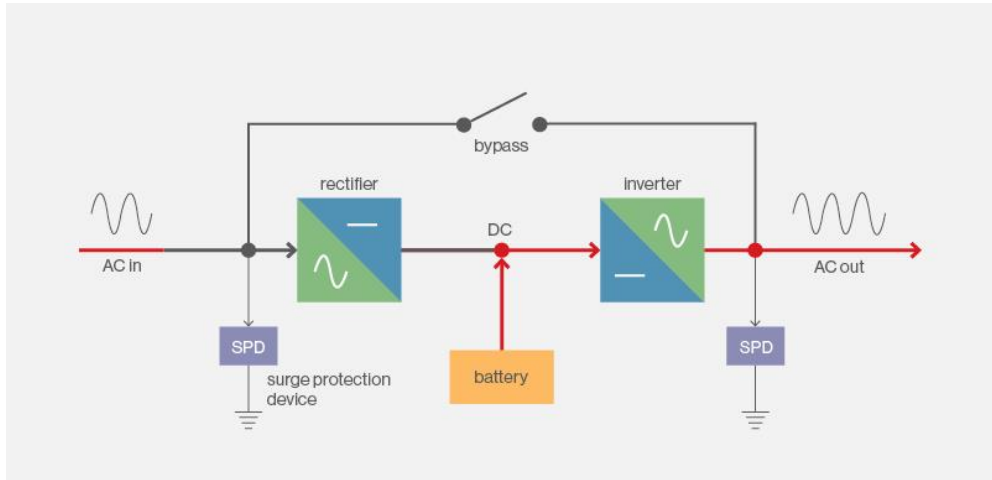


Fig. 2. UPS with double conversion in emergency mode.

The UPS with double conversion supports accurate voltage and frequency control at the UPS output, the transition to bypass is carried out smoothly. The manual bypass can be used for maintenance and "hot" replacement of batteries and the UPS itself.

Such UPS are distinguished by constant voltage and frequency stabilization, continuity of the output voltage phase, no load effect on the network, complete power filtration. But there are also negative sides — the complexity of the design and the high price, relatively low efficiency. The power range of the manufactured devices is very wide — from 600 VA to several hundred kVA.

Below is a diagram of a modified UPS with a double conversion.

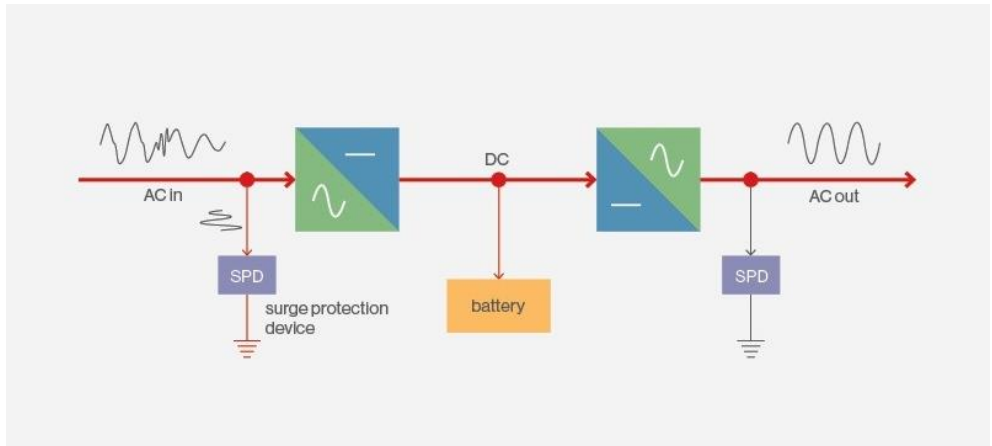


Fig. 3. The scheme of the modified UPS with double conversion.

In the above version, there is no switching to the battery. An inverter constantly powers the load. Therefore, there are no transients at all. Thus, the scheme is simplified.

3 Conclusions

Based on a comparison of UPS of different classes, a variant of refining one of the options was proposed. The advantages of the modified UPS with double conversion are: maximum filtering of the mains voltage from interference and emissions; interference generated by the load is not passed back into the network, the load is powered by a "pure" sinusoidal power supply, stabilized in magnitude, frequency and voltage form, complete absence of switching from the battery. Disadvantages include complexity and higher cost, additional energy consumption for double voltage conversion, reducing efficiency.

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