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Current Solutions to Indoor Design Problems

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Abstract: This article is about the efficient generation of electrical energy and its use. The generators known to this day had the appropriate efficiency and the consumer was satisfied with this. The development of science and technology has made it possible to increase the efficiency of electricity generation by connecting solar panels and wind turbines to the battery. The main element of this circuit is a device called an inverter. The article describes the definition of an inverter, its operating principle, types and methods of application. Architects and designers working on the construction of dwellings and premises, having knowledge about electrical installation of this level, will certainly achieve the desired result.

Keywords: Generating electricity, Battery, Solar Panels, Wind Generator, Inverter, Construction.

Being designers, we realized that while creating comfort and beauty in the premises, we must also ensure the long-term well-being of the room, the devices and equipment located in it. Lighting of homes, uninterrupted operation of household appliances (refrigerator, TV, computer, etc.) are part of the comfort that is created by the designer. But we don't always get the expected result - a sharp increase or decrease in voltage in homes leads to discomfort in the room. The knowledge, skill and skill of the creator in electrical engineering can make it many times easier to solve this problem. We will talk about an inverter, a device that converts direct current from a 12 V battery to alternating current with a frequency of 50 Hz and a voltage of 220 V or 380 V.

Inverter is a device for converting direct current into alternating current by changing the voltage value. Usually it is a generator of periodic voltage, in shape close to a sinusoid, or a discrete signal.

Voltage inverters can be used as a separate device or be part of sources and uninterruptible power supply systems for equipment with alternating current electrical energy.

Inverter properties

- Voltage inverters make it possible to eliminate or at least weaken the dependence of the operation of information systems on the quality of alternating current networks. For example, in personal computers, in the event of a sudden network failure, with the help of a backup battery and an inverter, forming an uninterruptible power supply (UPS), it is possible to ensure that the computers operate to correctly complete the tasks being solved. In more complex critical systems, inverter devices can operate in a long-term controlled mode in parallel with the network or independently of it.

- In addition to "independent" applications, where the inverter acts as a power source for AC consumers, energy conversion technologies have been widely developed, where the inverter is an intermediate link in the chain of converters. The fundamental feature of voltage inverters for such applications is the high conversion frequency (tens to hundreds of kilohertz). Effective energy conversion at high frequencies requires a more advanced element base (semiconductor switches, magnetic materials, specialized controllers).
- Like any other power device, the inverter must have high efficiency, high reliability and have acceptable weight and size characteristics. In addition, it must have an acceptable level of higher harmonic components in the output voltage curve (admissible value of harmonic coefficients) and not create during operation a level of ripple at the terminals of the energy source that is unacceptable for other consumers.
- In Grid-tie net metering systems, an inverter is used to supply energy from solar panels, wind turbines, hydroelectric power stations and other sources of green energy to the general electrical grid.

The operation of a voltage inverter is based on switching a constant voltage source to periodically change the polarity of the voltage at the load terminals. The switching frequency is set by control signals generated by the control circuit (controller). The controller can also solve additional tasks: 1) voltage regulation; 2) synchronization of key switching frequency; 3) protecting them from overloads, etc.

Methods of technical implementation of inverters and features of their operation

1. The inverter switches must be controllable (turned on and off by a control signal), and also have the property of two-way conductivity of current. As a rule, such switches are obtained by shunting transistors with reverse diodes. The exception is field-effect transistors, in which such a diode is an internal element of their semiconductor structure.
2. Regulation of the output voltage of inverters is achieved by changing the area of the half-wave pulse. The simplest regulation is achieved by adjusting the duration (width) of the half-wave pulse. This method is the simplest version of the method of pulse width modulation (PWM) of signals.
3. Violation of the symmetry of half-waves of the output voltage generates conversion by-products with a frequency lower than the main one, including the possibility of the appearance of a constant voltage component that is unacceptable for circuits containing transformers.
4. To obtain controlled operating modes of the inverter, the inverter keys and the key control algorithm must ensure a sequential change in the power circuit structures, called direct, short-circuited and inverse.
5. The instantaneous power of the consumer pulsates at double the frequency. The primary power source must allow operation with pulsating and even sign-changing consumption currents. The alternating components of the primary current determine the level of noise at the power supply terminals. Typical voltage inverter circuits

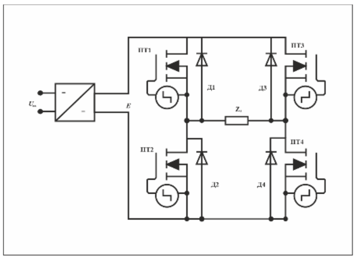

fig. 1. Bridge IN without transformer

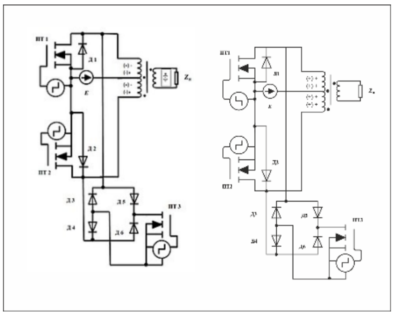

fig. 2.

The principle of constructing inverters

1. Inverters with a rectangular output voltage: Conversion of the direct voltage of the primary source into alternating is achieved using a group of switches that are periodically switched in such a way as to obtain an alternating voltage at the load terminals and provide a controlled mode of circulation in the reactive energy circuit. In such modes, the proportionality of the output voltage is guaranteed. Depending on the design of the switching module (inverter power switch module) and the algorithm for generating control actions, such a factor may be the relative duration of the key control pulses or the phase shift of the control signals of antiphase groups of keys. In the case of uncontrolled reactive energy circulation modes, the reaction of the consumer with the reactive components of the load affects the shape of the voltage and its output value.

2. Voltage inverters with a stepped output voltage curve: The principle of constructing such an inverter is that, using preliminary high-frequency conversion, unipolar stepped voltage curves are formed, approaching in shape a unipolar sinusoidal curve with a period equal to half the period of change in the inverter output voltage. Then, using a typically bridge inverter, the unipolar step voltage curves are converted into a multipolar inverter output voltage curve.

3. Inverters with a sinusoidal output voltage: The principle of constructing such an inverter is that, using preliminary high-frequency conversion, a direct current voltage is obtained, the value of which is close to the amplitude value of the sinusoidal output voltage of the inverter. Then this direct current voltage, usually using a bridge inverter, is converted into an alternating voltage in a form close to sinusoidal, through the use of appropriate principles for controlling the transistors of this bridge inverter (principles of the so-called “multiple pulse width modulation”). The idea of this “multiple” PWM is that during the interval of each half-cycle of the inverter output voltage, the corresponding pair of bridge inverter transistors is switched at high frequency (repeatedly) under pulse-width control. Moreover, the duration of these high-frequency commutation pulses varies according to a sinusoidal law. A high-pass, low-pass filter is then used to isolate the sinusoidal component of the inverter's output voltage. When using a unipolar DC voltage source (levels 0 and Ud are available, where Ud is the DC voltage supplying the inverter), the effective value of the first harmonic of the phase voltage $\boldsymbol{U_{eff}^{(1)} = 0{,}45 U_d}$

When using a bipolar DC voltage source (levels 0, -Ud/2 and Ud/2 available), the amplitude value of the first harmonic of the phase voltage $U_m^{(1)} = 0{,}5U_d$ accordingly, the effective value $U_{eff}^{(1)} = 0{,}35U_d$

4. Self-excited voltage inverters Self-excited inverters (autogenerators) are among the simplest devices for converting direct current energy. The relative simplicity of technical solutions with fairly high energy efficiency has led to their widespread use in low-power power supplies in industrial automation systems and the generation of square-wave signals, especially in applications where there is no need to control the energy transfer process. These inverters use positive feedback, ensuring their operation in the mode of stable self-oscillations, and switching of transistors is carried out due to saturation of the material of the transformer magnetic circuit. In connection with the method of switching transistors, by saturating the material of the magnetic circuit of the transformer, there is a disadvantage of inverter circuits, namely low efficiency, which is explained by large losses in the transistors. Therefore, such inverters are used at frequencies f no more than 10 kHz and output power up to 10 W. In case of significant overloads and short circuits in the load, self-oscillations fail in any of the self-excited inverters (all transistors go into the closed state).

fig. 3.

There are three operating modes of the inverter:

1. Long-term operation mode. This mode corresponds to the rated power of the inverter.
2. Overload mode. In this mode, most inverter models can deliver 1.2-1.5 times the rated power for several tens of minutes (up to 30). Starter mode. In this mode, the inverter is capable of delivering increased instantaneous power within a few milliseconds to ensure starting of electric motors and capacitive loads. Within a few seconds, most inverter models can deliver 1.5-2 times the rated power. A strong short-term overload occurs, for example, when turning on a refrigerator.

A 150 W inverter is enough to power almost any laptop from the car's on-board electrical network. 7.5 W is enough to power and charge mobile phones, audio and photographic equipment.

Three-phase inverters are typically used to produce three-phase current for electric motors, such as to power a three-phase induction motor. In this case, the motor windings are directly connected to the inverter output. High-power three-phase inverters are used in traction converters in the electric drive of locomotives, motor ships, trolleybuses (for example, AKSM-321), trams, rolling mills, drilling rigs, and in inductors (induction heating installations). The figure shows a diagram of a thyristor traction converter according to the Larionov-star circuit. Theoretically, another version of Larionov's "Larionov-triangle" circuit is possible, but it has different characteristics (equivalent internal active resistance, copper losses, etc.).

Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generates voltages with stepped waveforms. Switch commutation allows capacitor voltages to be added that reach high output voltages, while power semiconductors only have to withstand reduced voltages. The figure on the right shows a schematic diagram of one phase segment of inverters with a different number of levels for which the power of semiconductors is represented, represented by an ideal switch with several positions. A two-level inverter generates an output voltage with two values (levels) relative to the negative terminal of the capacitor [Fig. (a)], while a three-level inverter generates three voltages and so on. Imagine that m is the number of phase voltage steps relative to the negative terminal of the inverter, then the number of steps in voltage between two load phases is k, $k = 2m + 1$ and the number of steps p in the phase voltage of the three-phase load in the connection $p = 2k - 1$

There are three different topologies for multi-level inverters: diode clamped (neutral clamped); fixed to the capacitor (mounted capacitors); and cascaded multi-element with separate DC sources. In addition, several modulation and control strategies have been developed or adopted for multi-level inverters including the following: multi-level sinusoidal pulse width modulation (PWM), multi-level selective harmonic cancellation and space vector modulation (SVM). The main positive aspects of multi-level inverters are as follows:

1. They can generate output voltages with extremely low distortion and lower dv/dt.
2. They draw input current with very low distortion.
3. They generate less common mode (CM) voltage, thus reducing stress in motor bearings. Moreover, by using sophisticated modulation techniques, CM voltages can be eliminated.
4. They can operate with lower switching frequency.

Topology of cascaded multilevel inverters

The various inverter topologies presented here are based on the series connection of single-phase inverters with separate DC sources. The figure on the right shows the power supply circuit for one phase section of a nine-level inverter with four cells in each phase. The resulting phase voltage is synthesized by adding the voltages generated by the different regions. Each single-phase full bridge inverter generates three pin voltages:

+ Vdc, 0, и -Vdc. This is made possible by connecting capacitors in series with the ac side through four power switches. The resulting output AC voltage swing from -4Vdc до 4 Vdc with nine levels and a stepped waveform, almost sine wave, even without the use of filters.

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