ISSN NO: 2770-4491
April 2025

Development Of An Autonomous 3 KW Inverter For Solar And Wind Mini Power Plants

B.E. Egamberdiev, H.H.Mamirov
Institute of Military Aviation of the Republic of Uzbekistan
e-mail: bahromprof@gmail.com

Abstract: The paper presents the results of the development of a 3 kW inverter design for solar and wind mini power plants used for the national economy and industry, as well as the design and manufacture of a pilot batch of solar inverters designed for use as part of photovoltaic or wind power plants.
Keywords: construction, inverter, mini solar and wind power plant, power, energy storage system, electrochemical battery, microcontroller control

Introduction

Alternative and renewable energy sources are attracting increasing attention worldwide. The growing interest in them is caused by environmental considerations on the one hand and the limited availability of traditional terrestrial resources on the other. A special place among alternative energy sources is occupied by the applications of design development and creation of prototypes of a 3 kW inverter for solar and wind mini power plants [1-4].

Energy efficiency and energy conservation, being priority areas for the development of science, technology and technology, were included in the Energy Strategy of Uzbekistan for the period up to 2030, which underlines the importance of this area for the modernization and technological development of the Uzbek economy, increasing its competitiveness. Modern processes of production, transmission and consumption of electric energy, without which a modern economy is impossible, require its multiple conversion, for which powerful semiconductor inverters are used, the efficiency and reliability of which depend on the efficiency and reliability of all consumers of electricity. The most important stage in the design of an inverter is the selection of a topology and a modulation method that will ensure the best technical and economic performance of the designed device. The availability of selection criteria and procedures at this stage reduces the likelihood of errors and reduces the design time of a semiconductor device. Thus, the task of ensuring the validity of design decisions and the formation of selection criteria is relevant. To date, a large amount of materials has been accumulated in the field of power electronics on the development of new and improvement of existing circuit solutions in order to increase the efficiency of autonomous voltage inverters. At the same time, the question of comparing fundamentally different modulation schemes and algorithms remains open.

The current state of research on this issue lies in the fact that various large-scale photovoltaic and wind power plants have been developed in world practice, and inverters with a capacity of up to 300 watts are being developed in our republic, which requires research on the development of more powerful inverters for photovoltaic and wind power plants.

Currently, solar inverters are not manufactured in the Republic of Uzbekistan, and they have to be purchased with foreign currency. There is also no production of some other components of solar and wind power plants – battery charge controllers, support structures, solar guidance systems, low-voltage (12 V) energy-efficient light sources, that is, there is a significant gap in this area from developed countries.

Based on the above, it can be concluded that the design and industrial production of a solar inverter is a very urgent problem for the Republic of Uzbekistan.

Currently, one of the limiting factors in the large-scale use of both solar cells (SE) and solar stations based on them is the creation of prototypes of a 3 kW inverter for solar and wind mini power plants. There is a growing need for simple and cheap inverters with parameters exceeding those of currently common inverters used for the national economy and industry.

The development of sectors of the national economy and industry requires increasing application of the design and creation of prototypes of a 3 kW inverter for solar and wind mini power plants. Currently, the

ISSN NO: 2770-4491
April 2025

design development and creation of prototypes of a 3 kW inverter is an urgent problem, it has important national economic significance.

This paper describes the design of a 3 kW inverter, the manufacture of a laboratory sample, laboratory tests, the development of design documentation in the scope of a preliminary design, and the manufacture of a pilot batch of inverters.

It should be noted that all existing inverters have a non-stationary nature of energy generation, which means that an energy storage system (electrochemical battery) is needed, and this, as a rule, electrical energy is generated in the form of a constant voltage in the range from 12 to 48 volts.

Research methods. Based on the above, in order to develop and create a 3 kW inverter design for solar and wind mini power plants, it is planned to analyze the characteristics of existing inverter designs and develop requirements for a solar inverter. Design of the power part of the 3 kW inverter and the electronic control circuit of the inverter.

Research results. A 3KW inverter with a rectangular output voltage of 220V and a frequency of 50 Hz has been designed and manufactured (Fig. 1-4), as well as a modular inverter with a power of up to 3 kW, with a sinusoidal output voltage of 220V and a frequency adjustable in the range from 50 to 400 Hz. The inverters developed by us (Fig.1-4) show a high level of reliability, overload capacity, and built-in electronic protection systems. The results of laboratory tests of a solar power plant with an output power of 3 kW show a better indicator in terms of technical characteristics compared to the results of other authors.

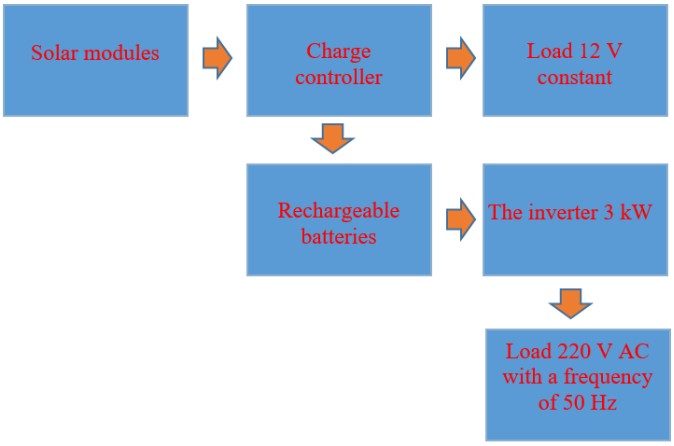


Fig.1 Block diagram of the solar module

The block diagram shows the main inverter systems, where:
1. Solar modules;
2. Charge controller;
3. Load 12V constant;
4. Rechargeable batteries;
5. The inverter 3 kW;
6. Load 220 V AC with a frequency of 50 Hz.

The main function in the block diagram is performed by an inverter. An alternating voltage of 220 V is applied to the load by changing the constant voltage received from the battery of the inverter, the frequency of which should be 50 Hz. The power of the inverter is 3 kW. The need for such powerful inverters is growing.

For this reason, when using such inverters, no additional equipment is required, only an increase in the number of batteries.

The functions of the inverter are controlled by a controller. When controlling the function of the inverter, the controller performs the main function. As a result of the charge level change, the controller controls the battery charge. The constant voltage generated by solar panels and wind turbines is transmitted to the battery. This process allows for uninterrupted power supply.

Currently, many power outages are caused by faulty transmission lines. Such interruptions themselves affect the work processes in production and in household appliances. Because smart heating systems installed in apartments must be provided with electricity without interruptions. If the heating system stops functioning during the winter season as a result of a 10-hour power outage.

If an inverter is installed in this apartment, then there are malfunctions in the heating system. A separate inverter and battery can be installed for the heating system. The number of batteries is selected depending on the power of the system. The disadvantage of this system is that if the connection on the line is not repaired within 10 hours, the amount of charge in the batteries will run out.

Advantages and disadvantages of the inverter:

1. One of the important advantages of the inverter is its low cost, no more than 1,500,000 soums, taking into account all the necessary components and installation
2. A relatively simple device to manufacture.
3. The components used in the manufacture are available and available in a wide range in almost any electrical goods store.
4. Low energy consumption.
5. Easy to install, and frequency stability.

The disadvantage of the inverter is that additional components are required to ensure voltage stability. Thermistors and automatic devices must be installed to ensure the operation of the heating system[5-8].

The electronic part of the inverter (Fig. 2) is based on ten transistors connected in parallel.

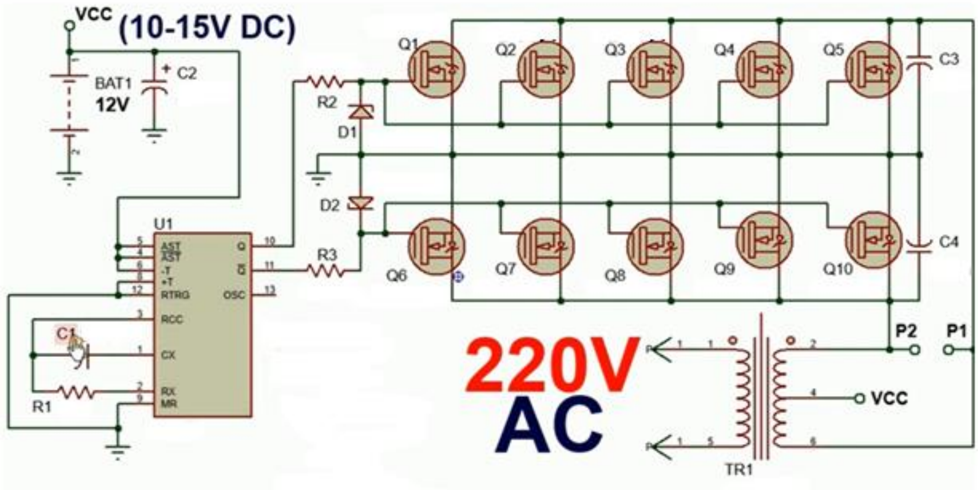


Fig. 2. Schematic diagram of the inverter

A constant voltage is applied to the PWM modulator, the output of the PWM modulator is connected to two transistor outputs. The output signals of the transistors are connected to the first winding of the transformer. The first coil of the transformer consists of two windings, to which a positive voltage is connected. The collector terminal of the transistors is connected to the second winding. The emitter output of the transistors is connected to the sixth winding. The voltage received from the transformer of the second winding is 220 V, the frequency is 50 Hz. Frequency stability is provided by the PWM modulator. The opening and closing time of the transistors is regulated by the modulator.

Operational characteristics of the inverter Table 1

Name of the parameter	Parameter value
Rated power	3 kW
Maximum power (for 3 minutes)	3,5 kW
Short-term (up to 5 seconds) overload capacity from nominal value	50%
DC input voltage	From 12 to 48 V
AC output voltage (frequency 50 Hz)	220 V
Efficiency factor	88%..........90%

 ISSN NO: 2770-4491
April 2025

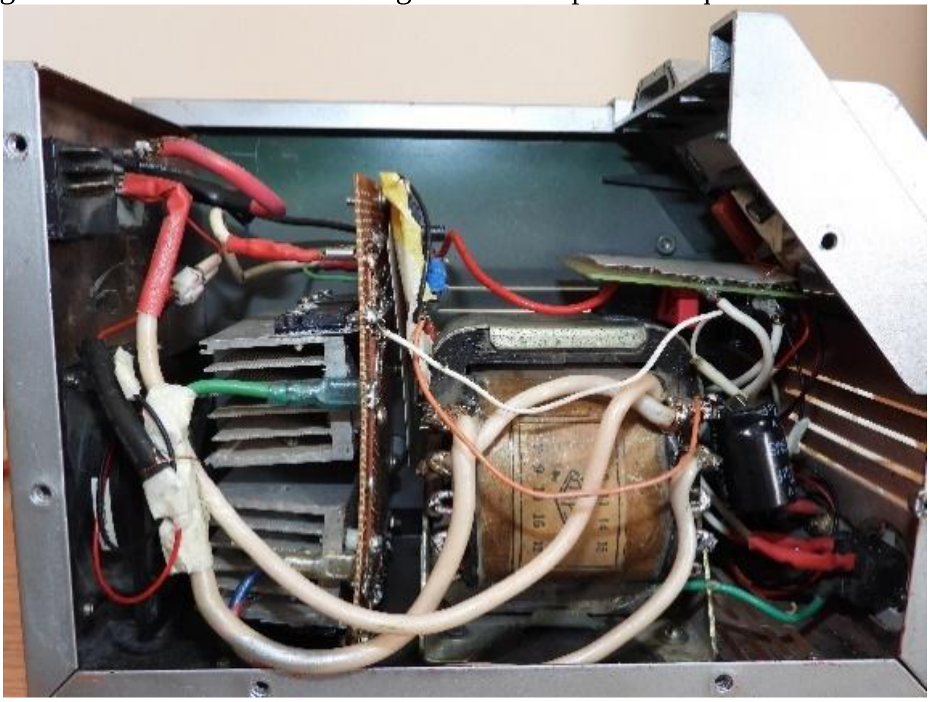
Reverse voltage protection at the input	A diode connected in parallel to the input bus
Harmonic ratio (at rated power)	No more than 5%
Stable output voltage (when fully charged with a working battery) and maximum load	From +5 to -5 %
Weight	Not more than 16 kg
Service life	At least 10 years old
Continuous operation time	Unlimited
Average uptime	More than 200,000 hours (at 40^{0}C)
Permissible humidity values during operation	0-90% non-condensing moisture

The table shows the main requirements of the inverter, of which are:
1) Output voltage stabilization with input voltage and load changes;
2) Output frequency stabilization;
3) close to the sinusoidal shape of the output voltage curve.

In addition, the development of inverters requires an integrated approach to minimizing the weight and dimensions of inverters with strict energy constraints and extremely high requirements for reliability and unification.

They try to ensure the specified requirements by: schematic methods; application of a new element base and modernization of traditional elements; constructive improvements; more complete use of the element base. Therefore, an integrated approach to the design of inverters is more correct, although more complex, when each specific type of device is built on the basis of both circuit and structural and element solutions and improvements.

The variety of solutions in the implementation of voltage converters urgently requires solving the optimization problem, which consists in determining the structure of the circuit and the parameters of the elements according to numerous criteria reflecting the most important requirements for the inverter.



ISSN NO: 2770-4491
April 2025

Fig.3. 3KW inverter with a rectangular output voltage of 220V and a frequency of 50 Hz

Fig. 4. 3KW inverter with a rectangular output voltage of 220V and a frequency of 50 Hz

Conclusion.

Criteria for evaluating the effectiveness of autonomous inverters with PV have been developed, including an assessment of efficiency, weight and size indicators, voltage quality indicators, as well as indicators of active, reactive and full power.

The dependences of the efficiency and specific gravity of A and on the TVMP are obtained at capacities of 3 and 5 kW at input voltages of a DC voltage source of 24 and 48 V.

It is shown that the efficiency of the AI at a voltage of 48 V with a converter power of less than 3 kW is 1-1.5% higher than the AI with an input voltage of 24 V. With a power of 3 kW or more, the efficiency does not differ by more than 2%.

At the same time, one of the important advantages of the inverter is its low cost, taking into account all the necessary components and installation, low noise, and relatively simple design.

Literature:

1. 1.Усков А. Е. Статические преобразователи и стабилизаторы автономных систем электроснабжения: монография / О. В. Григораш, Ю. П. Степура, А. Е. Усков. - Краснодар, 2011. - 188 с.
2. Усков А. Е. Автономные инверторы солнечных электростанций: монография / Краснодар; КубГАУ, 20 11, -126 с.
3. Пятикопов СМ. Классификация автономных инверторов / СМ. Пятикопов. Ш Российская НПК. Физико-технические проблемы создания новых технологий в АПК. СтГАУ «АГРУС». - Ставрополь, 2004, с. 176 - 179.
4. Пятикопов СМ., Богдан А.И. Регуляторы напряжения автономных инверторов / СМ. Пятикопов, А.И. Богдан. Сб. науч. тр. Энергосберегающие технологии, оборудование и источники питания АПК. Кубгау. - Краснодар, 2005, с.328-332. 5
5. B.E.Egambediev, I.I.Bakhadirov, D.A.Musadjanova, N.A.Musajanova, M.B.Ostonova Application of dielectric and conductive epitaxial films in silicon technology Journal of Computational Analesis and Applications 2024., vol.33,NO.7, pp. 513-519
6. Лабунцов В.А. Автономные тиристорные инверторы / В.А. Лабунцов, Г.А. Ривкин, Г.И. Шевченко. Москва: Энергия, 1967. 160 с.

ISSN NO: 2770-4491
April 2025

7. Б.Э. Эгамбердиев, С.Х. Якубов, Х.Х.Мамиров Разработка конструкции инвертора мощностью 3 квт для солнечных и ветровых миниэлектростанций: Сб.трудов Международный конференции “Проблемы и путирешения эффективного использования альтернативных источников энергии”. Узбекистан, г.Карши 2024г, стр.559-561
8. Томашевский, Д.Н. Автономные инверторы: учебное пособие / Д.Н. Томашевский.- Екатеринбург: Изд-во Урал. ун-та, 2019.- 120 с.