Section III MEDICAL ELECTRONICS AND DEVICES
Секція МЕДИЧНА ЕЛЕКТРОНІКА ТА ПРИЛАДИ

Oleksii LOPAKOV, Senior Lecturer,
Volodymir KOSMACHEVSKIY, Senior Lecturer,
Volodimyr TIGAREV, Ph.D., Assoc. Prof.,
Pavel SHVAHIREV, Ph.D., Assoc. Prof.,
National University Odessa Polytechnic, Odessa, Ukraine, e-mail: lopakov.o.s@op.edu.ua, cdlmgh@gmail.com, volodymyr_t@ukr.net, pavels9135@gmail.com

MPPT-CONTROLLER DESIGN FOR RENEWABLE ENERGY SOURCES OF BIOMEDICAL COMPLEXES

Abstract. The practical implementation of a low-voltage LED lighting system with renewable energy sources in an autonomous object of biomedical complexes and the development of a model of optimal temperature control in an autonomous object of medical purpose are considered. Also considered is the development of a method of integrated management of the power supply system using the SMART controller of the energy supply of an autonomous facility. The use of the software allows you to model complex electrical systems in which the automated control system controls an autonomous object using renewable energy sources. When solving this issue, it is necessary to implement the control of the controller of the energy supply system of the autonomous object using Smart technologies. Based on the results of the research, a general structural diagram of the Smart system was developed.

Keywords: SMART, MPPT-controller, solar panel, DC-DC converter, biomedical complexes.

Introduction

The total installed capacity of small wind power worldwide has reached 443.3 MW, and the total installed capacity of large wind power in the world has reached 240 GW. Small wind energy accounts for 0.18 % of large wind energy in various countries of the world. To date, Germany ranks first in terms of installed wind power capacity, followed by Denmark, Spain, the United States of America, and India. Development is also growing rapidly in France and China. In Denmark, 28.1 % of the country's needs are provided with electricity due to wind turbines, in China 1…2 %, in the USA it is 3…4 %.

SMART technologies are widely used in the field of telecommunications, in management and monitoring systems of biomedical objects. The abbreviation of the word SMART means specific, measurable, achievable, relevant, timed. Smart technologies are a complex combination of control and management technology that provides an autonomous object with the necessary quantity and quality of energy. At present, the active use of renewable energy sources in many developed countries of the world is accepted as a vital, strategically necessary resource that ensures the promising development of the economies of these countries. According to forecasts, the share of renewable energy (solar, wind, tidal, solar energy, etc.) in global energy consumption will increase annually and will reach 30 % by 2030, and 50 % by 2050. However, despite promising results, alternative energy sources have not yet found the level of optimal compliance with the expectations of the mass consumer.

There are different types of WU blades (wind turbines) that are designed for optimal electricity generation and for them it is enough that the wind speed is 3 m/s [1]. One of the most important problems in the use of renewable energy sources in the power supply system is the significantly non-constant value of the power generated by the solar battery, the wind turbine. The use of renewable energy sources [2, 3, 4] in the power supply system has been widely developed today in Europe, the USA, Japan, South Korea, China, Norway, Canada and other countries [3, 4, 5].

Currently, all developed countries are switching to the use of renewable energy sources such as solar [5] and wind [6], and the use of biomass is only becoming widespread. The largest

manufacturers of solar panels are Yingli Green Energy (China), FirstSolar (USA), Trina Solar (China), Suntech Power Co. (China), Canadian Solar (Canada), Sharp (Japan), JASolar (China), Jinko Solar (China), Sun Power (USA), Hareon Solar (China), Hanwha Solar One (China), Kyocera Solar (Japan), Rena Sola (China), Rec (Norway), Tianwei New Energy (China) [3, 4].

Analysis of publications and statement of the problem

Modern solar installations are equipped with advanced technologies, the article [3] suggests sun-tracking installations on which solar panels are attached, which ideally should convert the sun's radiation as much as possible, but in reality there are problems with software security and an incomplete control system of the solar battery itself and its controller. There are also problems of lack of power to power a particular building with a solar battery and suboptimal SP illumination. Solar batteries generate a direct current with a voltage of 24V. In order to use this current, a voltage converter is required. In a lighting system using LEDs [4], it is possible to use low-voltage voltage [14] without using a voltage converter.

Mostly all LED fixtures are powered by 24VDC at the input, but in all countries it is powered by 110V, 220V and 230V. An inverter is installed in the LED device itself, which converts the received voltage to 24V.

Solar battery controllers provide optimal battery charging, but due to the lack of control and monitoring of the controller operation, the batteries are not fully charged only for heating and hot water supply [3, 4].

In many works, wind turbines are combined with a diesel generator or a battery, and in these works, the installation itself is mainly calculated without automating the process of generating and consuming energy, methods for calculating a wind generator when operating at low wind speed are given.

In scientific papers [5], it is proposed to use the MPPT (Maximum Power Point Tracker) controller to control the wind turbine at low wind speeds. The obtained simulation results show that, regardless of the inclination and power of the turbine, this method provides a greater opportunity to control the wind turbine regardless of wind speed. The active and reactive power of the turbine stator is regulated. The results obtained can be used. The disadvantage at the nominal wind speed of the proposed scheme limits the speed of rotation of the blades.

The analysis of the data revealed that regardless of the technical and operational characteristics of various models of solar panels with an area of 0.2 m^2, the power of the module will be about 10W. The voltage at maximum load is approximately 24…25 V, the short circuit current is about 500 μA, the weight of this module is 2 kg, where the efficiency is 60 % and the service life of the plate is25 years. Regardless of the comparatively low efficiency of the solar panel, it is an efficient source among other renewable energy sources and autonomous power sources. The power of solar radiation at the entrance to the earth's atmosphere is 1366 per m^2.

In the article, the author presented a new concept for the formation of a control system in distributed energy based on Smart technologies. The concept of distributed energy is based on a variety of energy sources and distribution networks, which implies the presence of many consumers producing heat and electricity for their own needs, as well as directing surpluses to the general network. The author has developed an algorithm for the operation of the control process based on SMART information.

In scientific works [4, 5], it is proposed to use SMART technologies in buildings to ensure a comfortable microclimate and energy supply of the facility without loss of generated energy. When implementing SMART technologies, the automation of processes of the energy supply system of biomedical facilities was not considered.

In the article [6], SMART technologies are applied to street lighting using solar panels. The authors propose intelligent control in the urban lighting system. In this work, the controller is of functional importance, which ensures the optimization of the control of the energy street lighting system. This lighting control system is designed for 230V voltage.

In the study [5], the authors describe the energy integration management system of smart meters for electricity consumers in Smart Meters (SM). The SMs are connected to a SCADA (Supervisory Control and Data Acquisition) system that controls a network of programmable logic controllers (PLCs). The SCADA system and PLC network integrates various types of information coming from several elements of SMART technologies present in modern buildings. For implementation, programmable controllers are used, a communication channel has also been developed that provides data exchange between the SCADA system and the Matlab software. The study [6] describes only the control of the controller.

The purpose of the work

Development of an optimal SMART technology for monitoring and managing the power supply systems of an autonomous object. At the same time, the object of study is the power supply system of an autonomous object;

The method of integrated management of the power supply system using SMART control management

As a result of the analysis made, a standard block diagram of renewable energy management was applied, the power supply system in Fig. 1.

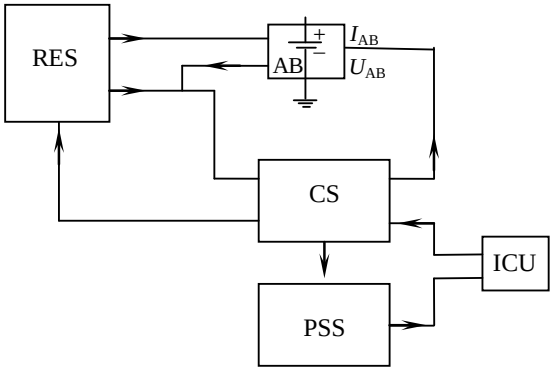

Fig. 1. Structural diagram of renewable source management control and power supply system:
RES – renewable energy source, AB – battery, CS – control system, PSS – power supply system,
ICU – information collection unit

The scheme in Fig. 1 implements the control of the operation of a renewable energy source and the power supply system of an autonomous facility. Depending on the required amount of electrical energy at a certain point in time, the control system controls the energy generation of installations operating on RES. To control the system, it is necessary to know the required amount of electrical energy, which is calculated depending on energy consumers. Energy consumers include household appliances, lighting system, heating system, climate control system, fire safety system, office equipment, audio and video equipment, and others. Together they add up to a load.

In this paper, it is proposed to use a low-voltage lighting system for research and modeling. As a result of the studies, it was found that the voltage generated by the solar panel is equal to the voltage of the LED lamp and is 24 V.

For the study, a structure was assembled, consisting of a solar panel, a converter, a battery, an LED device, a voltmeter, an ammeter and a wattmeter. An electrical circuit with measuring instruments was assembled, which is shown in Fig. 2. The number of operating batteries depends on the amount of power required by the autonomous object and on the time of day. We choose solar panels of the following characteristics (one solar panel):

– maximum power 400 W;
– short circuit current 2.98 A;
– open circuit voltage 22.3 V;
– voltage at maximum power 18.3 V;
– current at maximum power 2.73 A;
– dimensions 500×80000.

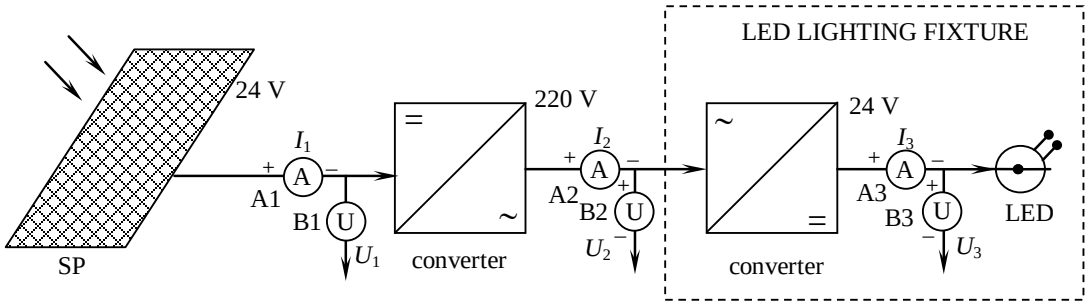

Fig. 2. General scheme of system measurement

The energy source is the solar panel of the joint venture, the voltage and current were measured before and after the converter and converter. Fig. 2 is an AC to DC voltage converter. To implement the mathematical model, the software Simulink and SimPowerSystems for visual modeling included in the MatLab package were used load, battery, solar and wind turbine (Windturbine) current sensors, battery voltage sensor, information acquisition unit (ICU) and power supply. The block diagram of the SMART technology for controlling the power supply system of an autonomous object is shown in Fig. 3.

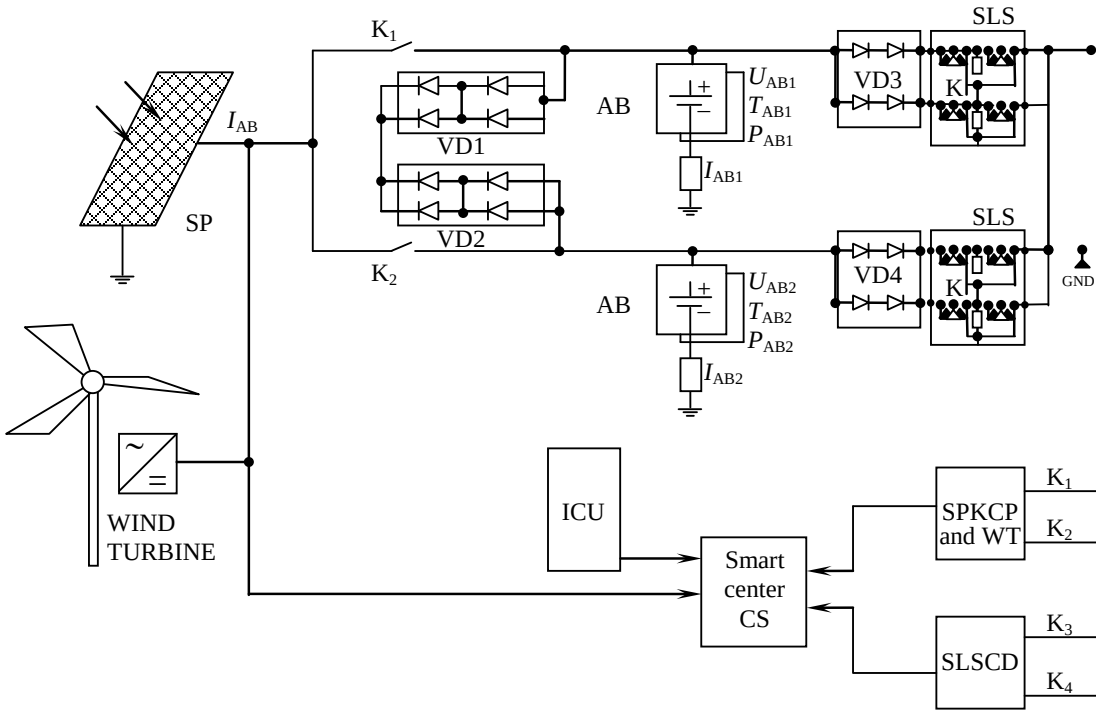

Fig. 3. Block diagram of SMART system management technology power supply of an autonomous facility

The control system controls the power switches using a driver located in the SPKCP (solar panel key control panel) and WT (wind turbine) and SLKCD (switching load key control device). The switching of keys is carried out in such a way that one pair of batteries or two pairs at once can be connected to the solar battery, depending on the charge of the batteries. In emergency situations, the power supply system of an autonomous object is carried out from batteries or a wind turbine. In case of emergencies at night, when the battery charge decreases, an alarm signal is generated, which is sent to the SMART center. In turn, the SMART center switches the facility’s power supply to another type of renewable energy source.

Conclusions

1. A mathematical model has been developed that allows you to control and optimize the operation of a solar battery depending on climatic conditions and on the degree of illumination.

2. A model of optimal control of the perceived temperature in an autonomous biomedical object has been developed.

References

1. Jerson R.P. Vaz, & David H. Wood. (2016). Performance analysis of wind turbines at low tip-speed ratio using the Betz-Goldstein model. Energy Conversion and Management, 126, 662–672.

Francisco J. Aguilara, Pedro V. Quilesa, & Simon Aledob. (2014). Operation and energy efficiency of a hybrid air conditioner simultaneously connected to the grid and to photovoltaic panels. SHC 2013, International Conference on Solar Heating and Cooling for Buildings and Industr. Energy Procedia 48 (2014). 768–777.

2. Renewables 2016 Global Status Report REN 21's. (2016). Renewables Interactive Map for country specific data, p. 272.

Renewables 2015 Global Status Report REN 21's. (2015). Annual Reporting on Renewables: Ten years of excellence, p. 251.

3. Andreeva, N. Yu., Kubov, V. I., Kubova, R. M., & Pavlenko, A. A. (2014). Study of solar radiation variation to assess the energy efficiency of solar photovoltaic batteries. Scientific work, technogenic safety, 123–133.

4. Palombaa, V., Vastaa, S., Giacoppoa, G., Calabreseb, L., Giuseppe Gulli`a, Davide La Rosaa, & Angelo Frenia. (2015). Design of an innovative graphite exchanger for adsorption heat pumps and chillers. Science Direct 69th Conference of the Italian Thermal Engineering Association, ATI2014. Energy Procedia, 81, 1030–1040.