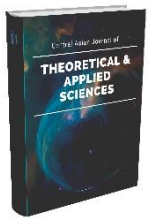

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Automated System for Measuring the Performance of Solar Water Heaters Based on Portional Hot Water Preparation

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Abstract: *This work presents the developed automated system. The block diagram of computer registration of experimental data of a solar water heater operating on the basis of batch preparation of hot water is presented. In this system, modern microprocessor tools are used, as well as an instrumental, software system that allows experiments to be carried out on solar installations for the purpose of statistical analysis of energy characteristics. The developed automated system uses a sensor with the output of unified analogue signals, which are processed and transmitted to a computer device through the RS-485 and RS-232 interfaces.*

The measuring system is developed on the platform of the instrumental software package "TRACE MODE", which, taking into account the transience and inertia of the energy effect, makes it possible to trace the indicators of the heat treatment process. The use of an interference suppression filter in the measuring channel allows the system to be protected from the influence of various external influences and electromagnetic interference. In the control circuit, in parallel with the output switching contact, a spark arresting element is installed, using the example of an RC circuit.

KeyWords: *solar plant, automated system, solenoid valve, solar water heater, noise filter, evaluation algorithm, multichannel.*

After the global energy crisis in the 70s of the last century, the development of unconventional and renewable energy began. At present, the total capacity of operating power plants based on renewable energy sources is about 600 GW, which is almost twice the capacity of all operating nuclear power plants in the world [1].

On the territory of the Central Asian region, the priority areas of research in the field of solar energy are:

1. Improvement of solar power plants (SPP), allowing to generate electrical and thermal power on an energetically significant scale without negative impact on the ecological environment [2].

2. Experimental research and practical application of solar parabolic-cylindrical power plants [3].

3. Development for the widespread use of heat pipes as heat sink for solar parabolic-cylindrical installations [4].

4. Research to improve the efficiency of photoelectric conversion (solar radiation flux, ambient temperature, wind speed, optimal compliance of the system with the load) [5].

5. Development and improvement of existing hybrid structures for air and water cooling, heat removal from panels, forced cooling [6].

In automated systems for measuring the energy indicators of solar installations, certain structures and algorithms are formed, which consist of the following main parts:

- the object of research is the solar energy system;
- sensor;
- secondary, microprocessor-based device;
- actuating mechanism;
- computer recorder of experimental data.

The experimental data measuring system consists of functionally combined measures, measuring instruments, measuring transducers, computers, other hardware and software modules installed to measure one or more energy quantities. The main task of measuring systems is to generate signals of measuring information in the form most convenient for automatic processing and control, transmission and use in registration systems [7].

This paper proposes the most effective and at the same time economical measuring system (Picture 1) using modern microprocessor tools, as well as an instrumental, software system that allows an experiment of solar installations for the purpose of statistical analysis of energy characteristics. In an automated system for computer registration of energy characteristics, sensors with the output of unified analogue signals in mA or mV are used. Analog signal converters generate a digital signal through the "RS-485" interface, which is converted into an "RS-232" interface for connection to the serial port of the computer.

The measuring system is developed on the platform of the "TRACE MODE" instrumental software package, taking into account the time characteristics of tracking indicators, since the process of generating energy, depending on weather conditions, can be either short-lived or inertial.

For example, the measurement of temperature characteristics does not require the organization of measurements for a transient energy effect.

The functional diagram of the system being developed contains the following blocks: a solar energy object, a measurement sensor, a secondary microprocessor controller and a recorder of measurement results – a computer.

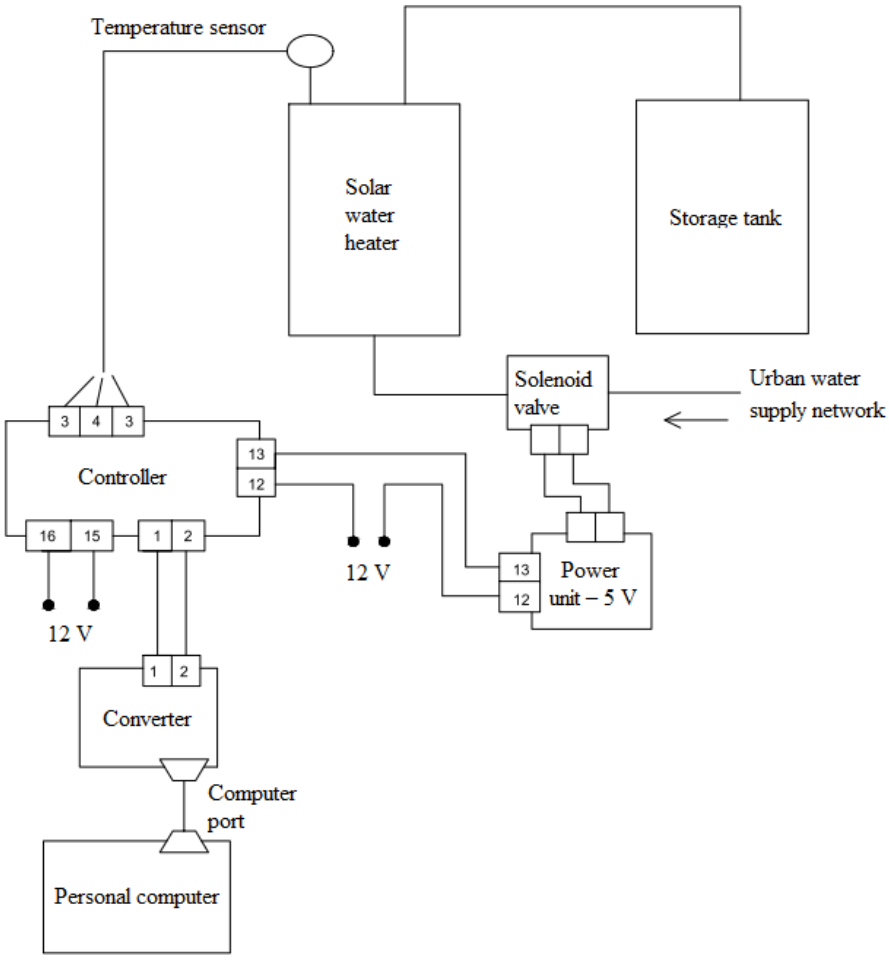

Figure 1. Schematic diagram of an automated system for computer registration of experimental data of a solar water heater.

An automated system for computer registration of experimental data of a solar water heater for batch preparation of hot water for direct use by the consumer operates as follows (Picture 1). Coldwater is supplied either through the city water supply network or through other similar sources, the only necessary condition in this process is to ensure the water flow with the minimum required pressure. At the beginning of the process, the solar water heater, located in the south-facing direction and installed at an appropriate angle of inclination, must be pre-filled with water. When the temperature set by the program is reached, according to the signal from the thermal temperature sensor, the microprocessor controller issues a signal to the solenoid valve, according to which the solenoid valve automatically opens. We receive cold water from the source, gradually displacing a portion of the water heated by the solar water heater into the storage tank. Since the displacement water has a relatively low temperature, the temperature sensor now records a different setpoint and gives a signal to close the solenoid valve. The heat sensor signals are processed by the controller. Changes in indicators over time are recorded by a special computer program "TRACE MODE".

In the proposed scheme, a measurement and control system is organized for the statistical evaluation of the performance of a solar water heater in real conditions.

When carrying out experiments for the correct operation of the measuring system, it is necessary to ensure protection against the influence of various external influences and electromagnetic interference. For this purpose, an interference suppression filter is used in the measuring channel circuit, and spark suppression

elements, for example, an RC circuit, are installed in the control circuit in parallel with the output switching contact. In addition to hardware protection, there is also the possibility of using software digital low-pass filters. In the microprocessor-based measuring systems that the author of this article uses, special software algorithms have been developed for filtering measuring signals, as well as special software configurators that allow you to configure the system for this experiment, taking into account the connected measurement sensor.

The measurement results are displayed and recorded in special system trends (Picture 2).

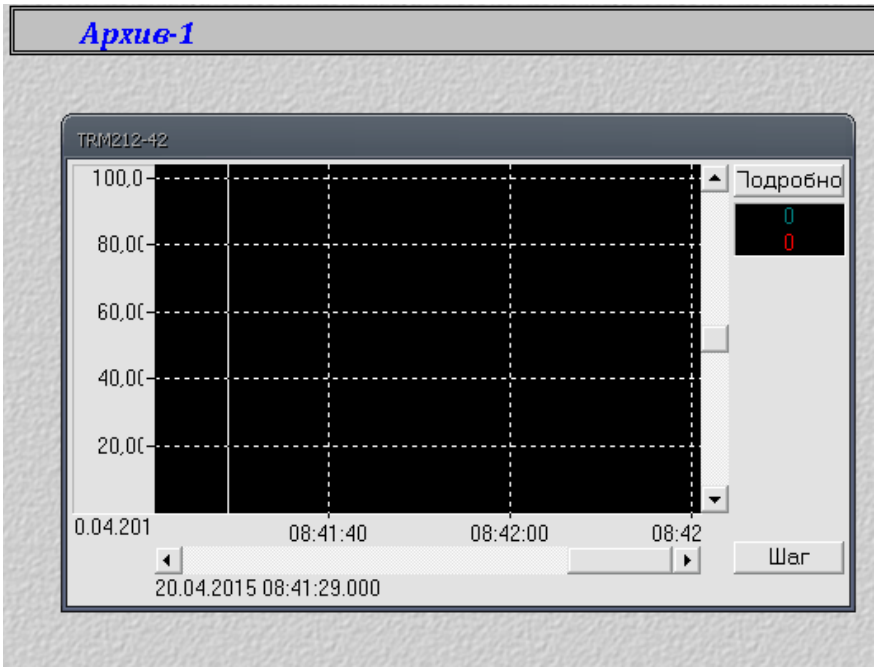

Figure 2. Trends of an automated system based on archived data.

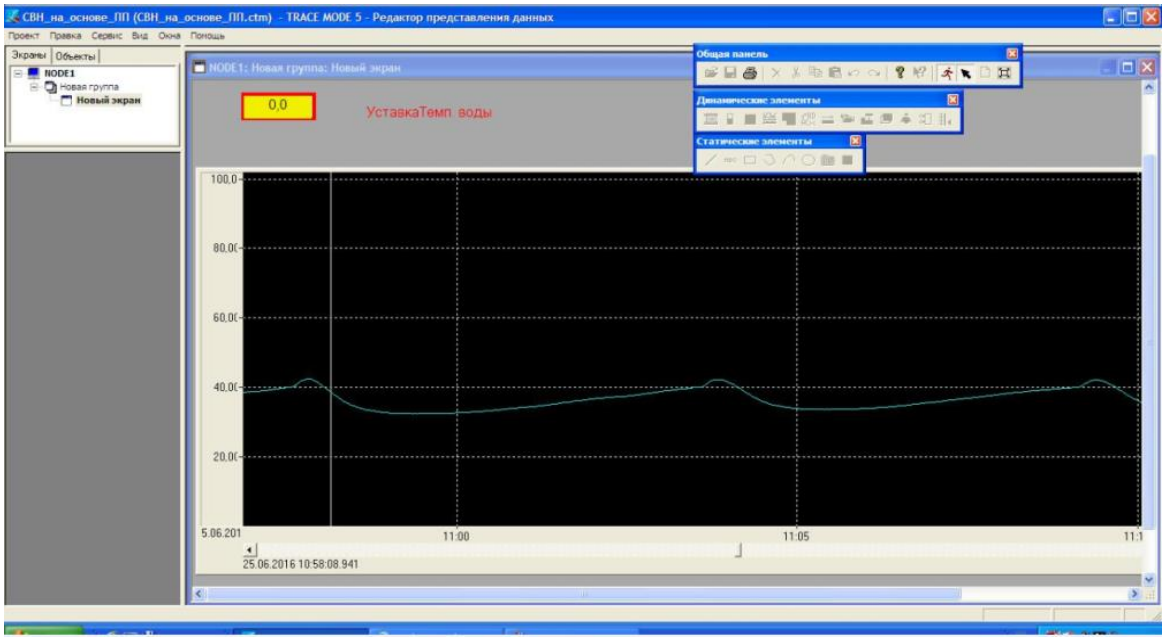

Figure 3. The window for viewing experiment results.

The development of modern solar installations requires constant improvement of methods and means for determining their characteristics (the use of solar simulators, high-precision spectroradiometric equipment and measuring systems with analog, digital and computer processing of results) [8].

The automated measurement system provides a special algorithm for assessing the performance of a solar energy system, depending on the redistribution of solar radiation during the day. The algorithm, developed on the basis of a statistical comparison of a certain amount of recorded data, develops appropriate recommendations for temperature "setpoints" for pumping heated water. Then the operator, in manual mode or with the help of a computer in automatic mode, enters the recommended values for the “setpoints” to the microprocessor controller. The speed of measuring and controlling the output capacity can significantly reduce heat losses and increase the efficiency of the solar system as a whole.

Testing of the developed experimental model of an automated system for measuring, recording and processing the results of energy indicators of experimental data of a solar water heater and the environment showed the operability and practical feasibility of their use, since the error in the readings of these devices is ± 0.2 %. The value and uniqueness of the proposed system lie in the fact that it is universal, multichannel, does not require special training of the experimenter in setting up the system for various energy processes.

In general, the use of the element base of modern microelectronics makes it possible to create more compact and modern devices that allow automating the process of measuring, recording and controlling the energy indicators of solar systems.

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