Optimization of solar energy conversion power plant parameters

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Abstract. Autonomous power supplies based on solar batteries (SB) and wind generators are increasingly used. The structure of such systems, in addition to the SB itself, includes a re-chargeable battery (AB), a cable network, a load switch and a charge controller that performs, with an excess of the SB power, the functions of maintaining a given charging current or charging voltage AB, and power deficit SB providing a mode of selection of maximal power from SB. In this paper, a mathematical model of such a system and its elements is presented.

Introduction

Some of the most important renewable sources of energy are sun and wind. Solar and wind energy is abundant, the sun is available everywhere, and there are very few windless regions on Earth. Since the very beginning of the development of renewable energy, Russia remains among the lagging countries. The share of electricity production from renewable energy sources in the Russian Federation in 2015 was less than 0.25% of the total volume, compared to an average world value of 19.5%. For the development of highly efficient solar and wind energy in our country, domestic research and development in this field is needed. The purpose of our research is the development of a mathematical model of the control system of the converter of renewable energy sources.

Analysis of the volt-ampere characteristic

Tracking the maximum power point is the way that is used to obtain the maximum possible output power of photomodels, wind turbines, magdino, electric motors operating in the regenerative braking mode. For this method, digital devices are used that analyze the current-voltage characteristic to determine the optimum mode of operation of the photomodel. I built a model in Simulink, which implements the search algorithm for the maximum power point (Fig. 1).

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Fig. 1. Model of the maximum power point search.

The purpose of the device for monitoring the maximum power point is to measure the output characteristics of the photocell and apply a suitable resistance (load) to obtain maximum power in any environmental conditions. Such devices are usually integrated into an electrical energy converter that provides the conversion of current or voltage, filtering and controlling various loads, including electrical networks, batteries or motors.

Modeling mppt controller

The MPRT controller works by controlling the maximum energy peaks. This technology, which allows you to charge the battery with a nominal voltage lower than the nominal voltage of the solar battery.

The controller automatically finds the maximum power point of the solar module system. This allows you to get an increase of 30% to the generated power modules in general for the year.

Fig. 2. The scheme of MPPT controller activation.

By monitoring the maximum power point (Maximum Power Point Tracking) and converting the SB voltage to a lower but higher current strength, the power of the source is maintained with such a conversion. The efficiency of the MPRT controllers is about 94 - 98% - very high efficiency. In other words, in order for the battery to charge, the solar module must apply voltage to the battery higher than the battery voltage. To the installed controller, terminals from the photovoltaic system and the wind generator are simultaneously connected.

The operating voltage of the module with a nominal voltage of 12V under standard conditions of passivation (illumination 1000 W / m2, temperature 25 ° C, spectrum AM1.5) is usually in the range 17-18V. This working voltage of the solar module is selected so that on a hot, sunny day, the working voltage of the module, which has heated much above 25 ° C, dropping to about 15 V, still exceeded the voltage of the full charge of the battery (at a temperature of 25 ° C this voltage for lead- acid battery is 14.4V).

Designing the system of conversion of renewable energy sources

The final stage of the simulation of the Aviatest autonomous hybrid installation is the construction of a model in Simulink based on the characteristics of a real installation. We use six solar panels, a wind generator and a developed MPPT controller.

The model shown in Fig. 3, realizes the scheme of operation of this electrical installation. The opportunity is provided to connect consumers of 24V, 220V and transfer of excess electrical energy to a three-phase network.

Fig. 3. Model of hybrid power plant.

During the modeling of the daily operation of the renewable energy system, the output was supported by an alternating voltage of 220V with a current strength of at least 6.1A at nighttime with street lighting and daylight up to 12.5A with less load and more solar radiation. With sufficient current to maintain the load of consumers, "free" electricity was used to charge solar batteries, and, when the solar cells are charged to the full level, the remaining energy will be transferred to the network.

Conclusion

In this article, research and development of an energy efficient control system for a converter of renewable energy sources with the function of searching for a maximum power point for solar panels and a wind generator were presented.

In order to better understand what the converter should be and what functions it should have, we studied typical solar power plants, windmills and photovoltaic modules, their operation principle, characteristics and various dependencies. Since our goal was to develop a control system that can extract the maximum output power, we therefore investigated the maximum power point of the hybrid installation and the search algorithm, the survey method was used to select the perturbation and observation method.

In the program Matlab SIMULINK a power system consisting of solar panels and a wind generator, a MPPT controller and an electric current converter was modeled. The opportunity is provided to connect the load voltage of 12V, 24V, 220V, power transmission to the network, charge of accumulator batteries. For correct operation of the MPPT controller, a special block was created that contained the TMM search algorithm. As a result, various time diagrams were obtained, which confirm the correctness of the presented model. For example, almost on all time diagrams there are oscillations around the maximum power point, which indicates correct operation of the algorithm and the whole converter as a whole.

In the era of global expansion of electric power production from inexhaustible natural sources, our country continues to lag behind the world average indicators for the development of wind and solar energy. Now more than ever, research in this area is important, and despite the fact that Russia possesses substantial reserves of fossil fuels, the development of a safer, more environmentally friendly and reliable energy sector will enable the subsequent generations to give a decent life and energy independence.

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