ISSN NO: 2770-4491
Date of Publication:07-10-2022

Selection of Compronents for Tracking Systems of A Solar Plant

Sultonov Shuxrat Davlyatovich
Docent
Ferghana Polytechnic Institute
Ferghana, Uzbekistan
abrortak78@mail.ru
Tojiboyev Abror Kahorovich
Senior Lecturer
Ferghana Polytechnic Institute
Ferghana, Uzbekistan
abrortak78@mail.ru

Annotation: The article presents a methodology for selecting electrical and mechanical components of solar installation tracking systems to improve the overall efficiency of a solar installation.

Key words: tracking system, component, controller, azimuth angle, research.

Introduction. At present, some progress has been made in the development and practical application of solar installations, but they are still expensive, which hinders their use on a large scale. Therefore, one of the main tasks in the development of practical developments in the use of solar energy is the creation of solar power plants with acceptable technical and economic characteristics. This requires constant improvement of existing installations, as well as the creation of more advanced versions of various design schemes [1].

Studies conducted in recent years have shown that one of the promising, potentially and economically competitive areas of solar energy utilization is the creation of solar installations based on parabolic trough collectors. The energy obtained in such installations can be used in agriculture and communal services, industry and in everyday life for various purposes, including for heat supply, cold production, electricity generation using a steam turbine cycle, or in direct energy conversion devices. [2]

To increase the energy efficiency of a solar parabolic trough installation, a mechanism for a system of orientation behind the Sun is needed. The following orientation systems can be considered:

a) two-axis tracking with continuous adjustment to ensure the perpendicularity of the incidence of direct radiation on the surface of the concentrator;

b) single-axis tracking parallel to the Earth's axis of rotation with continuous adjustment to obtain the maximum energy of the incident radiation;

c) single-axis tracking around the horizontal north-south axis with correction to obtain the maximum energy of the incident radiation;

d) single-axis tracking around the horizontal east-west axis with constant adjustment to obtain the maximum energy of the incident radiation.

The two-axis orientation system makes it possible to use the maximum incident radiation, but such systems have a high capital cost. Single-axis orientation systems make it possible to use a minimum of incident radiation energy, but they have a low cost.

Tracking systems are equipped with sensors for registering deviations from the correct orientation, as well as systems for making the necessary corrections. In some cases, orienting systems at the end of the working day allow you to set the concentrator with the mirror surface down or in a position corresponding to the beginning of the next day.

Analysis of the developed designs of orienting systems showed that for standard designs the tracking error is about 0.1-0.6 deg. considered admissible [2]. However, it should be noted that the higher the tracking accuracy, the higher the efficiency of the parabolic trough installation.

Researchers have developed numerous options for the orientation of solar parabolic cylindrical systems with photoelectric sensors or with computer microprocessor program control. However, the development of these systems is quite complex and does not give the above marginal error due to various

ISSN NO: 2770-4491
Date of Publication:07-10-2022

errors. In this regard, we have developed the simplest, but rather effective design of a solar tracking system - a solar tracker for a parabolic trough installation.

As noted above, to achieve the maximum energy efficiency of a parabolic trough setup, a one- or two-axis solar tracking system is required. The studies carried out in [1] showed that, with the use of a single- and two-axis tracker, the energy efficiency of a solar installation can be increased by 20-50%, depending on the geographical location.

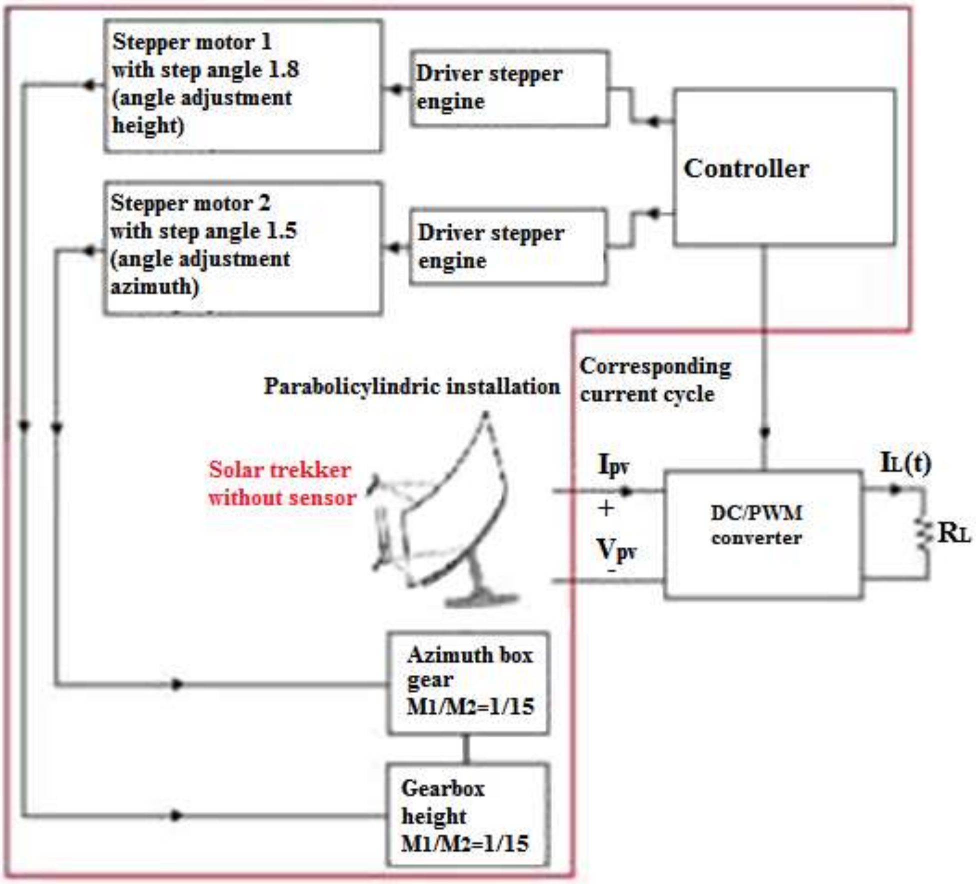

Figure 1. The structure of a parabolic trough biaxial tracking system, including the proposed sensorless solar tracker

For example, in [2], the output power of a photovoltaic module is increased to 33% compared to a stationary photovoltaic module using a two-axis solar tracker, while the magnitude of the improvement factor depends on the latitude of the area and others.

Used in solar power installations, one- and two-axis trackers are divided into two types: sensor and non-sensor solar trackers. Based on the sensor, the solar tracker acts as a closed system in which photosensors are used to provide appropriate feedback signals to track the direction of the sun using a feedback control system [11]. For example, a single axis solar tracker that uses two light dependent resistor (LDR) sensors to provide feedback signals to get the correct azimuth angle showing the sun's daily path [3].

Development and implementation of a solar tracker proposed without a sensor for a parabolic trough installation of biaxial tracking

The solar tracker consists of a controller, a stepper motor 1, which is connected to the altitude gearbox, a stepper motor 2, which is connected to the azimuth gearbox, an altitude gearbox that rotates the photovoltaic panel in a vertical plane around the altitude axis, and an azimuth gearbox, which is similar to rotates the photovoltaic panel in the horizon plane around the azimuth axis. The controller calculates the altitude and azimuth angles and issues a set of corresponding control signals for two stepper motors, which explains the following.

The declination angle is calculated by the first controller as:

ISSN NO: 2770-4491
Date of Publication:07-10-2022

$$\delta = \sin^{-1}\left(\sin(23.45^{\circ})\sin\left(\frac{360}{365}(d-81)\right)\right) \quad (1)$$

where δ is the angle of declination and d is the number of the annual day, so that January 1 is counted as d = 1. The altitude above sea level, the angle denoted by α, is:

$$\alpha = \sin^{-1}(\sin(\delta)\sin(\varphi) + \cos(\delta)\cos(\varphi)\cos(15^{\circ}(MCB-12))) \quad (2)$$

where φ is the latitude of the solar tracker and UTC is the local solar time. After that, the azimuthal angle is determined, denoted by the letter β:

$$\beta = \cos^{-1}\frac{\sin(\delta)\sin(\varphi) - \cos(\delta)\cos(\varphi)\cos(15^{\circ}(MCB-12))}{\cos\alpha} \quad (3)$$

The azimuth angle is 0 to 180° when the hour angle (15° (UTC-12) is negative (morning) and 180 to 360 when the hour angle is positive (afternoon). [4]

Implementation without sensor solar tracking system

A sensorless solar tracking system consists of a small photovoltaic module attached to a parabolic trough setup, a DC/PWM converter, a controller, two stepper motor drives, two stepper motors, and two gearboxes. To build an accurate solar tracker, a set of electrical and mechanical components must be chosen so that very precise rotation of the photovoltaic panel around the altitude and azimuth axes can be established. In this study, in order to provide high resolution rotation for a photovoltaic panel, so that each rotation step is only 0.12, the following components were chosen:

- Stepper motors: two identical stepper motors with 1.8° step angle were used; one for adjusting the elevation angle and the other for adjusting the azimuth angle.

- Stepper Motor Drivers: Two identical stepper motor drivers are used for precise automatic control, smooth and accurate operation of the two stepper motors. Each driver provides the appropriate control signals and supply voltage to the stepper motor, as a result of which it rotates in accordance with the direction and number of steps requested by the controller.

- DC/PWM Converter: A simple DC/PWM converter used in the built system is shown in fig. 3. It consists of only one MOSFET switch S, which switches with a constant switching period Ti = 1/fi and a duty cycle DS =tS-on/Ti, where fi and tS-on are the switching frequency and the turn-on time S respectively. When S is on, the load Current IL(t) flows through S and is supplied to the load RL. When S is off, IL(t) immediately goes to zero, so during tSon, the load current IL(t) is expressed as:

$$I_L(t) \approx \frac{V_{pv}}{R_{ds}+R_L} = I_B \quad (4)$$

where Rds is the static drain on the source resistance of the MOSFET switch S.

In steady state, Vpv is approximately constant and the inductance filter voltage loss Lpv is negligible, so the load current IL(t) can be considered as a constant current IB during tS-on. Thus, the load current IL(t) can be estimated as PWM. The waveform is shown in fig. 4. The term of the direct (average) load current, denoted by IL DC, can be obtained as:

$$I_{L-DC} = D_S\frac{V_{pv}}{R_{ds}+R_L} \approx D_S I_B \quad (5)$$

It comes out of the equation. (5) that the duty cycle DS is a control signal that regulates the DC load current to a certain level.

- Controller: The controller calculates the altitude and azimuth angles using equations (1) - (3) and then outputs control signals that must be fed to the two stepper motor drivers in order to properly rotate the two direction stepper motors with the rotation angles calculated by the controller.

- Parabolic trough setup: The new design uses only one sensor, which is actually a smaller, 5W solar panel attached to a power plant hub. This sensor is independent of bias voltage. The panel itself can generate

ISSN NO: 2770-4491
Date of Publication:07-10-2022

voltage depending on solar radiation. Changing the sensor property does not affect the detection algorithm, so it easily avoids the problem of false positives. In addition, the surface area of the sensor is significant. Therefore, there is less chance of false positives due to cloud shadows. It was also found that the solar tracker developed here causes a smaller error in determining the position of the sun.

- Mechanical components: The system consists of two identical gearboxes shown in fig. 1. Altitude gearbox is used to rotate the PV module in the vertical plane around the altitude axis, and the azimuth gearbox rotates the PV module in the horizontal plane around the azimuth axis. Thus, the height gearbox was mounted horizontally on the axis of the PV module, while the azimuth gearbox was positioned vertically..

Benefits of using these two gearboxes:

Each stepper motor has a rotation angle of 1.8°, and its special gearbox has a gear ratio of 1/15, so each revolution step of the stepper motor (1.8°) is converted into a rotation step of 0.12 on the output shaft of the gearbox connected to the shaft of the parabolic hub a power plant on which a photovoltaic panel (5 W sensor) is attached. This provides a very small rotation step of only 0.12 to rotate the PV panel about the altitude and azimuth axes, and thus significantly reduces the tracking error.

Since the gear ratio is N1 = N2 ¼ 1 = 15, each gearbox increases the holding torque of the corresponding stepper motor by 15 times. Thus, the torque on the secondary shaft of the gearbox used to rotate the PV module / panel is greatly increased. For example, each stepper motor used in this study has a holding torque of 9 kg-cm, so the torque is about 135 kg-cm, which is enough to move even a heavy and large photovoltaic panel in practical applications.

The combination of the gear box connected with the stepper motor allows us not to use any braking system or torque reducer, and this not only greatly reduces the production cost, but also simplifies the structure of the solar tracker.

Each gearbox consists of only two very simple wheels, so in practice it is not any expense or problem to maintain them.

Conclusion. In general, the conducted study of electrical and mechanical components led to the conclusion that the use of a sensorless parabolic installation based on a biaxial solar tracker would be useful in obtaining energy efficiency improvements. If production cost is more important, a sensorless biaxial solar tracker would be a good choice.

References:

1. Muxitdinov M.M., Ergashev S.F. Solnechnqe parabolicheskie ustanovki // Tashkent: Fan, 1955
2. Oleshkevich M.M., Losyuk Yu.A. Netraditsionnqe istochniki energii. Uchebno-metodicheskoe posobie dlya studentov vuzov. Minsk. BGPA, 2001g.
3. Mak-Veyg D. Primenenie solnechnoy energii.- M.: Energoatomizdat, 2001 g.
4. Ergashev S.F., Muxitdinov M., Tojiboev A.K., Rustamov U.S, Issledovanie energeticheskoy effektivnosti preobrazovaniya energii invertora. Farg'ona politexnika instituti, Ilmiy texnika jurnali, 2013,2, Farg'ona 2013 yil.
5. Тожибоев А.К., Султонов Ш.Д. Измерение, регистрация и обработка результатов основных характеристик гелиотехнических установок // Universum: технические науки : электрон. научн. журн. 2021. 11(92).
6. Хакимов М. Ф., Тожибоев А. К., Сайитов Ш. С. Способы повышения энергетической эффективности автоматизированной солнечной установки //Актуальная наука. – 2019. – №. 11. – С. 29-33.
7. Тожибоева М. Д., Хакимов М. Ф. Исследование спектральных характеристик прозрачно-тепловой изоляции приемника //Главный редактор: Ахметов Сайранбек Махсутович, д-р техн. наук; Заместитель главного редактора: Ахмеднабиев Расул Магомедович, канд. техн. наук; Члены редакционной коллегии. – 2021. – Т. 4. – С. 17.
8. Тожибоев А. К., Немадалиева Ф. М. Комбинированные солнечные установки для теплоснабжения технологических процессов промышленных предприятий. результаты

ISSN NO: 2770-4491
Date of Publication:07-10-2022

разработки и испытаний //Современные технологии в нефтегазовом деле-2018. – 2018. – С. 253-256.
9. Эргашев С. Ф., Тожибоев А. К. Расчёт установленной и расчётной мощности бытовых электроприборов для инвертора с ограниченной выходной мощностью //Инженерные решения. – 2019. – №. 1. – С. 11-16.
10. Тожибоев А.К., Мирзаев С.А. Применение комбинированной солнечной установки при сушке сельскохозяйственных продуктов // Universum: технические науки : электрон. научн. журн. 2021. 10(91).
11. Тожибоев, А. К., and А. Р. Боймирзаев. "Исследование использования энергосберегающих инверторов в комбинированных источниках энергии." Экономика и социум 12 (2020): 230-235.
12. Тожибоев А.К., Хошимжонов А.Т. Применение фотоэлектрического мобильного резервного источника электропитания в телекоммуникации // Universum: технические науки : электрон. научн. журн. 2021. 12(93).
13. Davlyatovich, S. S. ., & Kakhorovich, A. T. . (2021). Recombination Processes of Multi-Charge Ions of a Laser Plasma. Middle European Scientific Bulletin, 18, 405-409.