UDC 121.548.5 (045)

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ANALYSIS OF SOLAR POWER PLANT'S EFFICIENCY

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Abstract— *Structure of Solar Power Plant is proposed. Described principal of operation modes for night and day. Shown average power statistics for cell module.*

Index terms—Solar power plant; solar panels; solar tracking; solar cell power.

I. INTRODUCTION

As knows, the high and expensive price of solar power plant and relatively low efficiency are the most important reasons that make problems of their widespread among costumers. Improving the efficiency of solar power plant only possible in two ways: technological and technical improvements that will reduce the need area of solar cell surface on saving required power output and therefore reduce the cost of energy.

Talking about actual power of solar panels, it directly depends on the angle of incidence of solar cell surface and sunlight beams, then the density of incident sunlight is also affection on results.

To solve this task, we are started to use rotary mechanism that allows us to always keep solar panels' surface always on optimal angle to the sun. This approach helped us to increase the production of electricity in the winter about to 10 %, and in the summer up to 40 % [3].

II. STRUCTURE MODEL OF SOLAR POWER PLANT

Solar power plant based on many general structure blocks that responsible only for appropriate function of the system overall. All of them are independent and could be interchanged with improved version or version that could be best suited to environmental configuration. Each structural block plays a role in forming of overall performance of solar plant (Fig. 1).

Accumulative power supply unit

This block is a most important unit of solar power plant, main function is to control all energy subsystems on different layers of work cycle. Starting from collecting energy from PV-panels and supply all internal consumers such as MCU, motor drivers etc. Also this unit balance power output to external consumers.

Control subsystem

This group of units resolve the basic problem of solar power plant – how to in most efficient way help supply unit to collect energy. This group relies on MCU, driver units and feedback sensors.

Characteristics recorder unit

Or observer. This unit perform collecting tasks from all of systems that have values that are changing in time. This kind of data will help us in generation of different reports that will have aggregated data.

We will concentrate on microcontroller and feedback subsystems since they are important to efficiency [2].

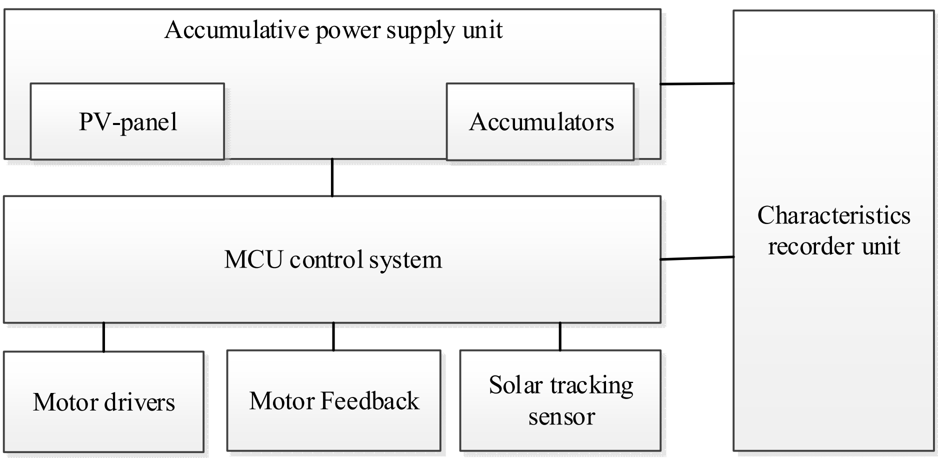

Fig. 1. Structural scheme of solar power plant

III. Operation modes during day and season of the year

The strongest influence on the efficiency of the solar power plant have [1]:

– meteorological parameters, like intensity of solar radiation and the temperature of the outside air;

– design properties of solar cells, like kind of surface protection layer and type of photovoltaic cells.

Absorbing surface of solar power cells has a protective transparent insulation in most cases made from glass. The main problem of this solution is that sun rays are refracted on it, scattered and partially reflected. Table 1 shows the dependency of the reflectance of solar rays at different angles of incidence.

Therefore, the deviation from the normal sunlight for solar power plant surface at an angle of 30 degress will not have any noticeable how impact on the effectiveness of its work and the angle of incidence.

Concerning energy of solar, each element is designed to support a certain current at a given voltage, but in contrast to other power sources, solar cell characteristics are very dependent on the amount of light falling on the surface.

To justify the use of sun tracking system for automatic positioning in solar power systems, we will display law of direct power lost due to misalignment and angle of incidence misalignment:

$$N = 1 - \cos(i).$$

This dependency can be expressed as the general criteria of effectiveness of the system in the form of mathematical formula:

$$P^* = \max_{i \in i_C} P(i),$$

where P^* is power maximum; i is angle of incidence; i_c is set of possible angles of incidence.

Table 1

Dependency of the reflectance of sunlight at different angles of incidence (glass) and direct power lost

Angle of incidence of sun rays, i	0	10	20	30	40	50	60	70	80	89	90
Coefficient of reflection, %	4.7	4.7	4.7	4.9	5.3	6.6	9.8	18	39	91	100
Direct power lost, %	0	1.5	6	13.3	23.4	35.7	50	65.8	82.6	98.2	100

IV. Operation modes during day and season of the year

To achieve the goal of minimizing the error angle between the sun and the normal platform solar panels can be used by different control techniques, that could be described in two groups.

Working group contains different tracking modes implementation at software control system. First of all, object route (sun route at sky) are already defined for region of usage and could be calculated beforehand to create a position by time dependency rule.

Auxiliary group consists of techniques that helping in auto tracking and catching best suitable position for current environment configuration. This group describes behavior of sunrise mode (rotation from west to east after sunset). Also, this group suppose some maintenance modes that could be used to manual positioning of solar power plant.

As the output of this two control groups we have different operation modes for *day* and *night modes*.

Main purpose of *day mode* is to provide optimal position of solar cell to sun beams, it means that platform must keep, ideally, angle of 90 degrees. By analyzing plot of direct power lost due to misalignment could be made conclusion that acceptable angles of misalignment could vary from 0 to 8 degrees, where maximum power loss we have upto 1 %. Assuming concrete solar power plant acceptable power loss could be calculated with relation to power consumption of motor drivers power consumtion and power consumption due all forces that might impact control cycle when motor drives are in active phase.

As result, when acceptable angles are defined or calculated for concrete solar power plant, step rotation mode must be used for addition energy saving, that means no real-time tracking with real-time positioning control cycles must not be performed.

When control system is entering into the *night mode* several preparations must be started to optimize energy consumption of inner subsystems of solar power plant like turning off real-time tracking via sensors etc. Moreover, as a major task of this mode, surface of power plant must be rotated to calculated sun position on sunrise time and active timers to enable *day mode.*

Average statistical characteristics was obtained for each used module at last week of November at Table 2.

TABLE 2

AVERAGE STATISTICAL CHARACTERISTICS OF USED MODULES

Characteristic \ Values	*Ideal*	*Nov'14*
Max power, P_{max}	180	122
Voltage at max power, V_{mpp}	36	34
Current at max power, I_{mpp}	5	3.6

CONCLUSIONS

The control system will collect all the supporting data to calculate the new position of the platform at the end of each stage. It very important to use optimal angle for step mode because it provide significant power save, as well as, using night mode, when platform's surface start to rotate to calculated started point. In next stage of development, there will be provided additional structural block with statistics subsystem, this device will be collect and aggregate received realtime data for power consumption, max power, voltage and currency values with liking to time.

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Received 28 August 2014.

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В. М. Синєглазов, Д. П. Карабецький. Системи автоматизованого проектування сонячної електростанції

Запропоновано описову модель сонячної енергетичної установки. Визначено прямі втрати потужності в залежності від кута неузгодженості. Розроблено алгоритм керування сонячної електростанції.

Ключові слова: система автоматизованого проектування; сонячна електростанція; сонячні батареї; алгоритм стеження за сонцем.

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В. М. Синеглазов, Д. П. Карабецкий. Системы автоматизированного проектирования солнечной электростанции
Предложена описательная модель солнечной энергетической установки. Определены прямые потери мощности в зависимости от угла рассогласования. Разработан алгоритм управления солнечной электростанции, описан дневной и ночной режим работы солнечной повротной платформы. Показаны статистические характеристики солнечной панели.
Ключевые слова: система автоматизированного проектирования; солнечная электростанция; солнечные батареи; алгоритм слежения за солнцем.

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