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Solar Photovoltaic Power Generation with Automatic Tracking System

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ABSTRACT: Solar energy is very important means of expanding renewable energy resources. In this paper is described the design and construction of a microcontroller based solar panel tracking system. Solar is a nonconventional source of energy, considering this we have developed solar panels so that we can fulfil our electricity need. But due to revolution of the earth, solar source i.e. sun does not face the panel continuously hence less electricity is produced. The energy panel should face the SUN till it is present in a day. The problem above can be solved by our system by automatic tracking the solar energy. The block diagram below shows system architecture it consist of a LDR sensor senses max solar power which is being given to the Microcontroller through the ADC which digitizes the LDR output. Controller then takes the decision according to then algorithm and tilts the panel towards the direction of the max energy given by LDR with the help of DC motor. The Motor is used to rotate the LDR to sense the max solar power. A Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected. It is completely automatic and keeps the panel in front of sun until that is visible. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. Residential that uses solar power as their alternative power supply will bring benefits to them. The main objective of this project is to development of an automatic solar tracking system whereby the system will caused solar panels will keep aligned with the Sunlight in order to maximize in harvesting solar power. The system focuses on the controller design whereby it will caused the system is able to tracks the maximum intensity of Sunlight is hit. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR light detector acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of Sunlight. While to rotate the appropriate position of the panel, a DC-geared motor is used. The system is controlled by two relays as a DC-geared motor driver and a microcontroller as a main processor. This project is covered for a single axis and is designed for low power and residential usage applications. From the hardware testing, the system is able to track and follow the Sunlight intensity in order to get maximum solar power at the output regardless motor speed.

KEYWORDS: arduino, photovoltaic cell, motor driver, 7805 integrated circuit

I. INTRODUCTION

In last ten years, many of residential around the world used electric solar system as a sub power at their houses. This is because solar energy is an unlimited energy resource, set to become increasingly important in the longer term, for providing electricity and heat energy to the user. Solar energy also has the potential to be the major energy supply in the future. Solar tracker is an automated solar panel that actually follows the Sun to increase the power. The sun's position in the sky varies both with equipment over any fixed position. One well-known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location, but many other approaches are used as well. Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. The solar tracker can be used for several applications such as solar cells, solar day-lighting system and solar thermal arrays. The solar tracker is very useful for device that needs more sunlight for higher efficiency such as solar cell. Many of the solar panels had been positioned on a fixed surface such as a roof. As sun is a moving object, this approach is not

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the best method. One of the solutions is to actively track the sun using a sun tracking device to move the solar panel to follow the Sun. With the Sun always facing the panel, the maximum energy can be absorbed, as the panel is operating at their greatest efficiency. The main reason for this project is to get the maximum efficiency for the solar cells. Although there are many solar trackers in the market, the price is expensive and unaffordable because the market for solar trackers is still new and only certain countries use the solar tracker such as USA and South Korea. The large scale solar tracker that normally used is not suitable for the residential use. As a result, this project will develop a Sun tracking system specially designed for residential use for a low cost solar cell. Previous researchers are used LDR and photodiode as sensors respectively. Meanwhile and used DC motor with gear and stepper motor respectively. These projects have disadvantages and some of the disadvantages are high cost during development, difficult to control motor speed and difficult to design because using microprocessor. The main objective for this project is to develop the sun tracking solar system model which is a device that follow the movement of the Sun regardless of motor speed. Besides that, it is to improve the overall electricity generation using single axis sun tracking system and also to provide the design for residential use. LDR or light dependent resistor has been chosen as the sensor because LDR is commonly used in sun tracking system. This is because LDR is sensitive to the light. The resistance of LDR will decreases with increasing incident light intensity. For the controller, AT328 had been chosen. This ATMEL programming will give the pulse to the driver to move the motor. For the driver, bi-directional DC motor control using relay has been used. The motor controller had been chosen because it can control the motor to rotate clockwise and counter-clockwise easily. DC geared motor also been chosen because it has a hold torque up to 24 kg.cm and low rpm. Last but no least, L298 is used to convert the input voltage from the source to 5 V output because integrated circuit only need 5 V to operate.

II. WORKING PRINCIPLE OF THE TRACKER

Figure shown here is the tracking device in our prototype. It is the one which follows the sun's movement throughout the day and provides uninterrupted reflection to the solar panel. The sun rays will fall on the solar panel in two ways, that is, they will fall directly on the solar panel and also the reflector will reflect the incident rays on the solar panel. Suppose at the time of sun rise the sun is in extreme east the reflector will align itself in same position by which the incident rays will fall on the solar panel. Now when the earth rotates and the sun gets shifted from its earlier position the reflection of the incident rays will also change. Thus as a result the light will fall on the sensors kept on each side of the solar panel. The tracking circuit is so designed that when reflection falls on say the sensor attached to the right of the panel, the tracker will move towards the left, and vice-versa. Similar is the case when the reflection falls on the sensor attached at the top of the panel, circuit will make the tracker to move downwards. Here we have tried to bring two simple principles together. One being, the normal principle of incidence and reflection on which our tracker works and the other is the principle on which the solar panel works, which is on the incidence of the solar rays on the photovoltaic cells, will produce electricity. This both principles are combined there and as a result of which we are able to fetch nearly double the output which the panel gives normally. Precisely speaking the tracker is liable for two kinds of rotations, one is on the vertical axis and other is on the horizontal axis. The earlier is for the right-left movement of the reflector and the later is for the up-down movement of the reflector, for aligning reflection on the panel.

III. NEED OF A SOLAR TRACKER

Photovoltaic's is the field of technology and research related to the application of solar cells as solar energy. Solar cells have many applications. Individual cells are used for powering small devices such as electronic calculators. Photovoltaic arrays generate a form of renewable electricity, particularly useful in situations where electrical power from the grid is unavailable such as in remote area power systems, Earth-orbiting satellites and space probes, remote radiotelephones and water pumping applications. Photovoltaic electricity is also increasingly deployed in grid-tied electrical systems. Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. One of the most popular renewable energy sources is solar energy. Many researches were conducted to develop some methods to increase the efficiency of Photo Voltaic systems (solar panels). One such method is to employ a solar panel tracking system .This project deals with a microcontroller based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel is always able to maintain a perpendicular profile to the sun's rays. Development of solar panel tracking systems has been ongoing for several years now. As the sun moves across the sky during the day, it is advantageous to have the solar panels track the location of the sun, such that the panels are always perpendicular to the solar energy radiated by the sun. This will tend to maximize the amount of power absorbed by PV

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systems. It has been estimated that the use of a tracking system, over a fixed system, can increase the power output by 30% - 60%. The increase is significant enough to make tracking a viable preposition despite of the enhancement in system cost. It is possible to align the tracking heliostat normal to sun using electronic control by a micro controller.

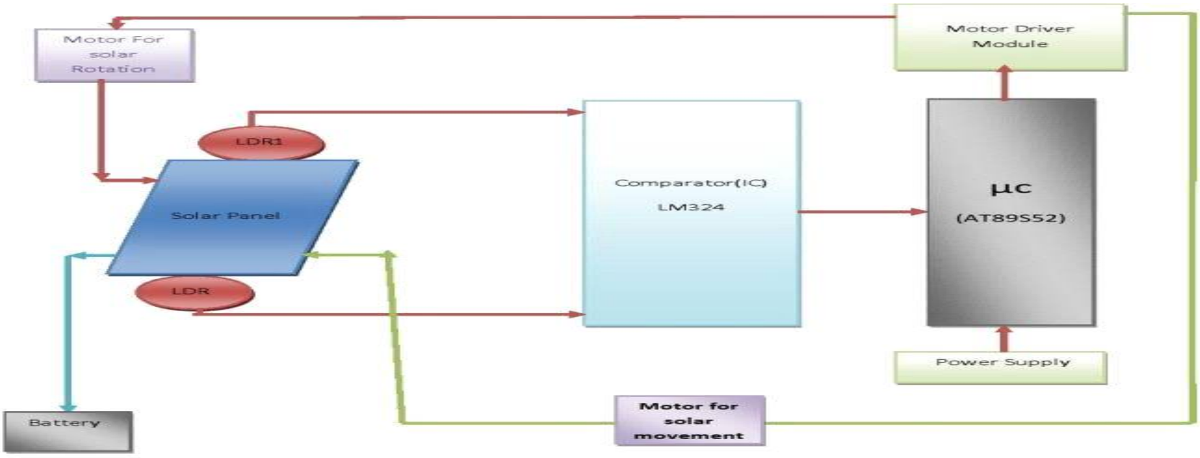

Fig.1. Block diagram of solar tracker

IV. AUTOMATIC SOLAR TRACKER COMPONENTS DESCRIPTION

The major part of this electronics system is the micro controller. All the operations are controlled by it. With the help of micro controller, you can align the solar panel according to the intensity of the sunlight. Another component is the rechargeable battery which is used to store energy which is received from the panel. The purpose of the charge control is to control the charging of the battery. Micro controller unit receives the status of the battery by the charge control unit. It has two sensors, each made up of LDR. LDR senses the intensity of sunlight and controller receives the output. Control unit decides in which direction the panel has to be rotated to get maximum sunlight. Another unit of the sensor also consists of LDRs and used for the control of lightning load. The panel can be rotated in the desired direction by the dc motor.

V. COMPONENT REQUIRED

SNO.	COMPONENTS	SPECIFICATION
1	Arduino	Atmega 328
2	Solar panel	10Watt
3	Motor Driver	L298
4	Battery	12V
5	DC Motor	10 rpm

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VI. CIRCUIT DIAGRAM

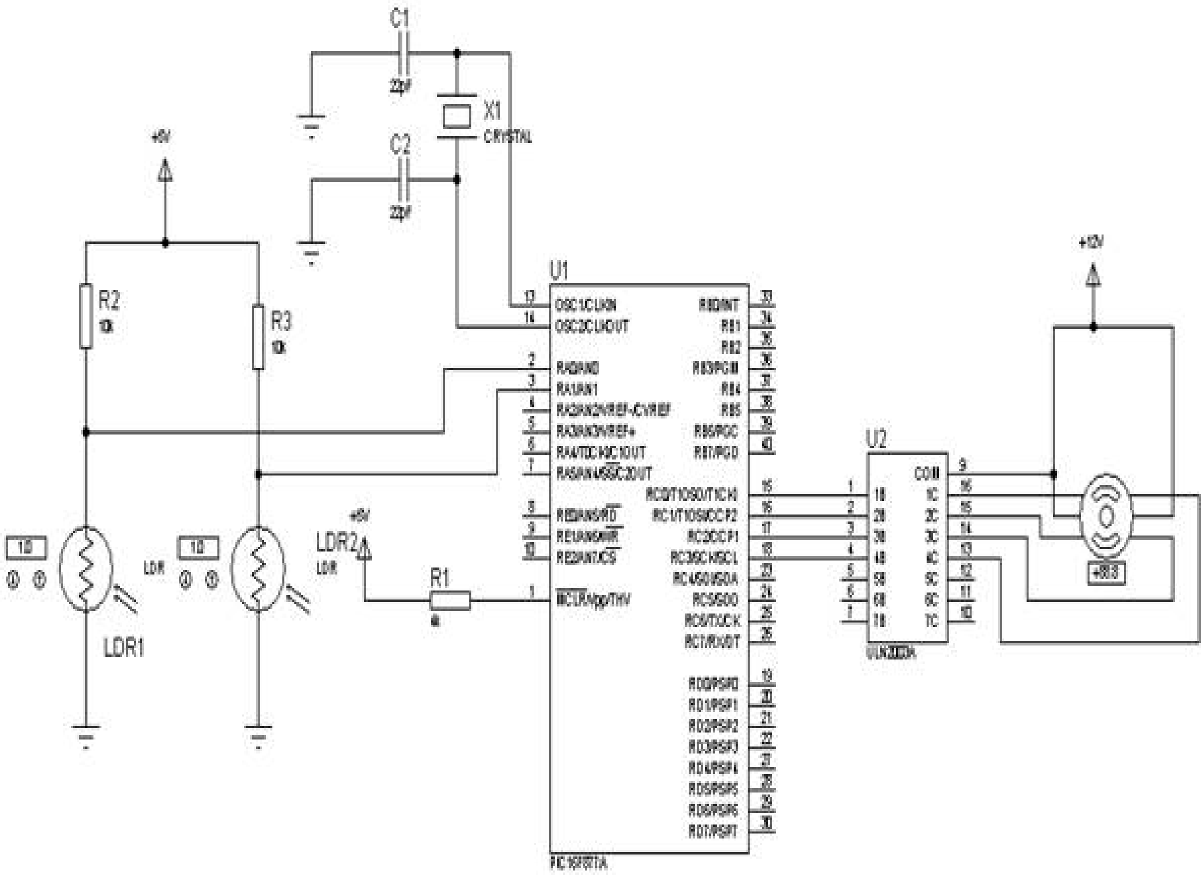

Fig.2. Circuit diagram of solar tracking system

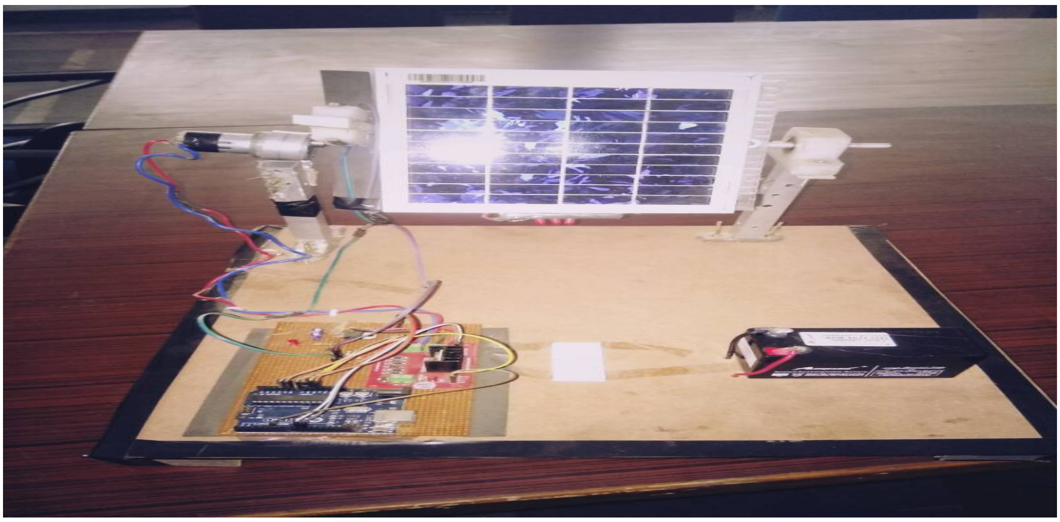

Fig.3. Hardware implementation of SPV tracking system

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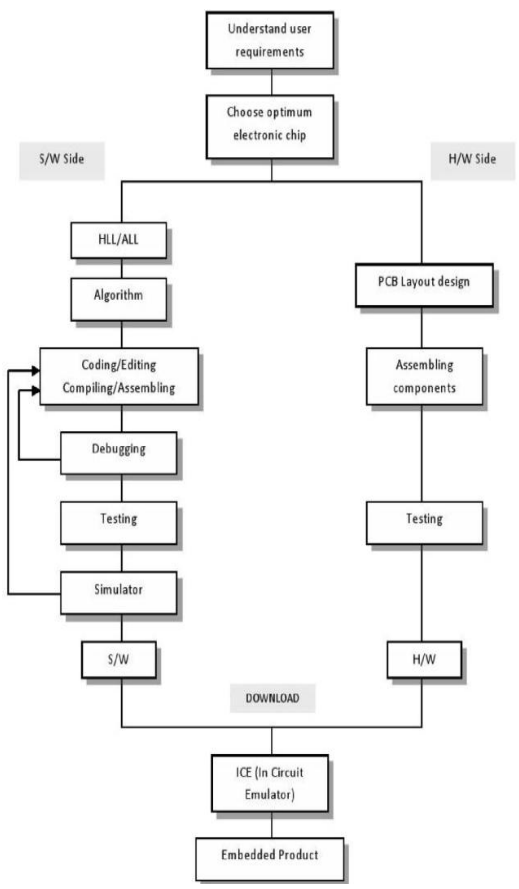
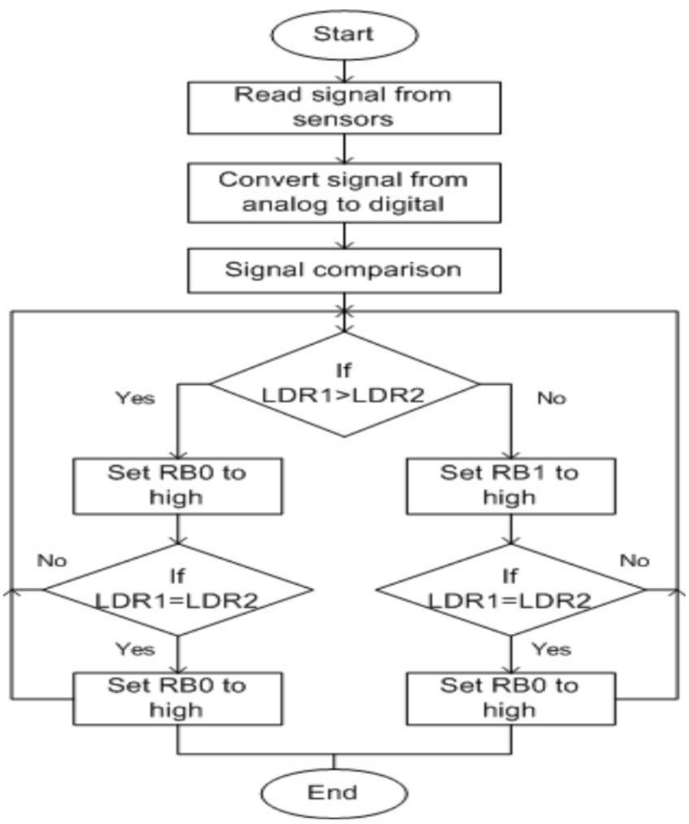
VII. CIRCUIT OPERATION

In our project we have use solar panel to convert the light energy into the electrical energy. The Sun change its position throughout the day that's why we can't able to utilize the whole light energy so we have made a tracking system in which solar panel can be rotate as per the sun changes its position. We have use the Four LDR Sensor sense the light and if the sun change its position then respective LDR Sensor sense the light and generate the highest Voltage signal and this highest voltage signal fed to the comparator IC as well as remaining sensors also give its generated voltage level to the Comparator IC. All Voltage signal of the each LDR sensor that are compared by the LM324 are fed to the microcontroller. Microcontroller receive the voltage signal from the any i/o pin of the controller and compares the each LDR output signal to with each LDR sensor output. When the controller find the Highest voltage level of any LDR sensor gives the instruction to the motor through the motor driver circuit to rotate the solar panel on the single axis in the direction of the LDR sensor which are generating highest voltage output, so the Battery can recharge appropriately through the Solar panel and we can run any electronic devices here. By using external two motor and by making connection in parallel we can move the solar penal in any direction. As by rotating the solar panel in the direction of the sun we utilize the maximum energy of the sun.

Methodology: -



Flowchart:-



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VIII. RESULT & DISCUSSION

The system is focusing on the controller design. The constructed system has been tested and some data from hardware measurement have been collected and discussed. Typical solar panel has been used and the purpose only to prove the designed system is able to operate accordingly. Therefore the surrounding effects, for instance, weather condition are not seriously considered during hardware testing. The results for the project were gotten from LDRs for the solar tracking system and the panel that has a fixed position. The results were recorded for two days, recorded and tabulated. The outputs of the LDRs were dependent on the light intensity falling on their surfaces. Arduino environment's built in serial monitor can be used to communicate with the arduino board. To collect the results, a code was written that made it possible to collect data from the LDRs after every one hour. The values from the two LDRs are to be read and recorded at the given intervals. The LDRs measure the intensity of light and therefore they are a valid indication of the power that gets to the surface of the solar panel. As a result, by measuring the light intensity at a given time, it will be possible to get the difference in efficiency between the tracking panel and the fixed one. The light intensity is directly proportional to the power output of the solar panel. The various values are obtained and converted into volts. The Vcc to the microcontroller and the LDRs is 5volts. When they are converted into digital values, the values will be in the range of 0-1023.

	LDR readings for fixed panel		LDR readings for tracking panel	
Time	LDR 1	LDR 2	LDR 1	LDR 2
0830HRS	0.225	0.196	2.757	2.930
0930HRS	0.723	0.567	3.631	3.783
1030HRS	0.733	0.816	3.900	3.798
1130HRS	3.211	2.297	3.910	3.967
1230HRS	4.888	4.941	4.990	4.897
1330HRS	3.803	3.910	4.985	4.990

Tab.1. Results for cloudy Morning and Sunny Afternoon for 16th and 17th April 2017

IX. APPLICATION

It controls movement in azimuth and zenithal directions, independent of whether the requirements are for a photovoltaic (PV) or a concentrated solar power (CSP) facility. The modules or mirrors are optimally aligned with the angle of the sun's rays to constantly optimize solar energy regardless of the sun's position. These solar tracking systems have up to a one-third higher energy yield than stationary PV system — depending on the intensity of the sunlight at the installation site because the closer an installation is to the equator, the more efficiently the PV tracking systems operate. Applications in concentrated solar power and concentrated photovoltaic require the precise tracking of solar units to focus sunlight on the target medium. Solar trackers are devices used to orient photovoltaic panels, reflectors, lenses or other optical devices toward the sun. Since the sun's position in the sky changes with the seasons and the time of day, trackers are used to align the collection system to maximize energy production. Several factors must be considered when determining the use of trackers. Some of these include: the solar technology being used, the amount of direct solar irradiation, feed-in tariffs in the region where the system is deployed, and the cost to install and maintain the trackers. Solar panels are usually set up to be in full direct sunlight at the middle of the day, facing south in the Northern Hemisphere, or facing north in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle and reduces the total amount of electricity which can be generated each day. A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky, thus ensuring that the maximum amount of sunlight strikes the panels throughout the day. When compared to the price of the PV solar panels, the cost of a solar tracker is relatively low. We provide highly efficient, proprietary single and dual axis solar tracking systems. Our single-axis solar trackers can typically increase electricity generation by 30%, while our dual-axis trackers can boost electricity generation by up to 40%.

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X. CONCLUSION

A solar panel that tracks the sun was designed and implemented. The required program was written that specified the various actions required for the project to work. As a result, tracking was achieved. The system designed was a single axis tracker. While dual axis trackers are more efficient in tracking the sun, the additional circuitry and complexity was not required in this case. This project was implemented with minimum resources. The circuitry was kept simple, while ensuring efficiency is not affected.

XI. FUTURE SCOPE

With the available time and resources, the objective of the project was met. The project is able tobe implemented on a much larger scale. For future projects, one may consider the use of more efficient sensors, but which are cost effective and consume little power. This would further enhance efficiency while reducing costs. If there is the possibility of further reducing the cost of this project, it would help a great deal. This is because whether or not such projects are embraced is dependent on how cheap they can be. Shading has adverse effects on the operation of solar panels. Shading of a single cell will have an effect on the entire panel because the cells are usually connected in series. With shading therefore, the tracking system will not be able to improve efficiency as is required.

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