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Automatic Solar Tracking System using MPPT with Mirror Booster

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Abstract: This paper is to design and develop a newmicrocontroller based solar tracking system with a mirror booster based on MPPT. Solar energy is rapidly becoming analternative means of electrical source all over the world and thesolar energy becomes profitable when the solar rays are trackedwith its maximum efficiency. The best to get the maximumpower output of solar array is by sun tracking. This paperdeals with the design and construction of solar tracking systemby using LDR, PIC16F877A, Johnson motor, gear motor andmirror. Mirror is used as booster to maximize the efficiency. Thepanel and mirror will travel from south to north and vice-versa.The prototype is considered around a programmed pic16F877Awhich controls the system by communicating with sensors andmotor driver based on movement of the sun. The performanceand characteristics of the solar tracker are experimentallyanalyzed.

Keywords:LDRs, Solar Panel, Mirror Booster, Gear Motor,Tracking Mechanism.

I. INTRODUCTION

We need energy in various forms like heat, light, soundetc. The development of new technology made it possibleto convert electrical energy into any form of energy.Thisgives electrical energy an important position in the world.The running of the modern industrial structure depends onthe low cost and the uninterrupted supply of electricity. Ourreliance on fossil fuels for energy is one of the most hotlydebated issues of our generation [1]. Since the extraction ofthese fuels it requires fuel, the returns have to be greaterthan the amount of energy invested. As oil wells reach theirpeak, oil no longer freely spouts out of the ground. It becomesincreasingly difficult and expensive to pull to the surface. Theextensive use of fossil fuels has resulted in the global problemof greenhouse emissions. Moreover, as the supplies of fossilfuels are depleted in the future, they will become increasinglyexpensive. Also they have resulted in huge pollution, solar energy is becoming more important since it produces less pollution and the cost of fossil fuel energy is rising, while the cost of solar arrays is decreasing [2]. In particular, small- capacity distributed power generation systems using solar energy may be widely used in residential applications in thenear future [3]. Solar tracker is an automated solar panel thatactually follows the sun to increase the power [5]. Solar panelsare mainly made by semiconductor materials, which increasesefficiency. Unless high efficient solar panels are used, theonly way to enhance the performance is by increasing theintensity of light falling on it. Solar trackers are the mostappropriate and proven technology that increases the efficiencyof the solar panel by keeping the panels always alignedwith the sun. Even though technology for trapping solarenergy is already in existence [5]-[6], the process proposedis used to increase the overall efficiency of the system. In thispaper, we are introducing a new solar tracking mechanismwith a mirror booster. Mirror increases the efficiency LightDependent Resistors are used as sensors of the solar tracker.The designed tracker has a precise control mechanism. Thedesign and implementation methodology of a small prototypeof single axis solar tracking system with a mirror boosteris presented. The power conversion interface is important tosolar power generation systems because it converts the dcpower generated by a solar cell array into ac power andfeeds this ac power into the utility grid[4]-[6]. An inverteris necessary in the power conversion interface to convertthe dc power to ac power. Since the output voltage of asolar cell array is low, a dcdc power converter is used ina small-capacity solar power generation system to boost theoutput voltage, so it can match the dc bus voltage of theinverter [8]. This paper proposes a new solar power generationsystem is composed of solar tracking with mirror booster, adc/dc power converter, battery storage system, and inverter.Maximum Power Point Tracking (MPPT) is a techniquethatgrid tie inverters (GTI), solar battery chargers and similardevices use to get the maximum possible power from oneor more photovoltaic devices, typically solar panels. It is thepurposes of the MPPT system to sample the output of the cellsand apply the proper resistance (load) to obtain maximumpower for any given environmental conditions. In this study, a prototype is developed and tested to verify the performanceof the proposed solar power generation system.

II. SOLAR TRACKING

Solar trackers are devices used to orient photovoltaic panels,reflectors, lenses or other optical devices toward the sun. Sincethe suns position in the sky changes with the seasons and thetime of day, trackers are used to align the collection system to maximize energy production. This process is known astracking. Several factors must be considered when determiningthe use of trackers [5]. Some of these include the solartechnology being used, the amount of direct solar irradiation, feed-in tariffs in the

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region where the system is deployed, andthe cost to install and maintain the trackers.

A. Solar Panel

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure.A photovoltaic module is a packaged, connected assembly of solar cells [11]. The solar module can be used as a component of a larger photovoltaic system to generate and supply electricity rated by its DC output power under standard test Condit Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most solar modules are rigid, but semi-flexible ones are available, based on thinfilm cells.

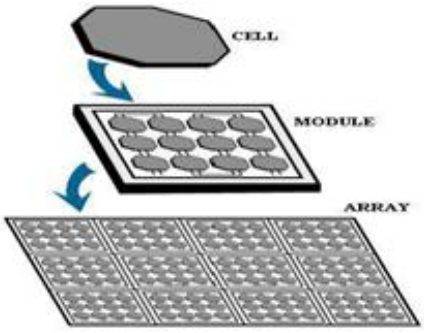

Fig. 1: solar panel

B. Principle of Photovoltaic Cell

Photovoltaic (PV) system is well recognized and widelyutilized to convert the solar energy for electric power applications. It can generate direct current (DC) electricity withoutenvironmental impact and emission by way of solar radiation. The DC power is converted to AC power with an inverter, to power local loads or fed back to the utility. Being a semiconductor device, the PV systems are suitable for most operation at a lower maintenance costs [11].

III.SOLAR TRACKING TECHNIQUE

A. Single axis Tracking System

Various ways have been experimented for tracking the sun.One of these methods is single axis tracking system. SingleAxis Sun Tracking Solar System has one degree of freedomthat acts as an axis of rotation. The axis of rotation of singleaxis tracker is typically aligned along a true North meridian.

Fig. 2: Single axis tracking system

It is possible to align them in any cardinal direction withadvanced tracking algorithms. This model is able to track and follow the Sun intensity in order to get maximum power at the output regardless motor speed. The system can be applied in the residential area for alternative electricity generation especially for non-critical and low power appliances.

B. Sensor Unit

A sensor is a device that measures a physical quantity andconverts it into a signal which can be read by an observer or by an instrument. The suns position is required to be sensed continuously. The presence of the solar panel is required to be sensed at the extreme ends. The light dependent resistors are used in the circuit to sense the change in the suns position. A photo resistor or light dependent resistor or cadmium supplied (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. A photo resistor requires a power source because it does not generate photocurrent; a photo effect is manifested by change in the materials electrical resistance. Cadmium supplied (CdS) photo resistor is used in the designed prototype. To utilize the photo resistor, it is placed in series with another resistor. A voltage divider is thus formed at the junction between photo resistor and another resistor; the output is taken at the junction point to pass the measured voltage as input to the microcontroller. The sensors are used for tracking both azimuth and altitude angle. The figure 3 shows the LDR.

C. Motor

The motor chosen for the proposed system is a DC motorwith geared arrangement and a Johnson motor. It is used toachieve desired speed in moving the panel according to suns position. 12V, 10rpmDC geared motors are used for aligning the mirror. The most important effect of using DC motor withgeared arrangement in single axis tracker system is to getmechanical stabilityof mirrorwithoutspending much power for DC motors. When the mirror is not desired to move, the DC motors are not driven and is kept in stable position due to mechanical lock mechanism in the gear system of DC motors. A Johnson motor of rating 12v,10 rpm,10 kgcm is used for driving the solar panel. Johnson motor is choosen as the torque required to drive the panel is higher compared to driving the mirror. So the electrical efficiency of the solar panel has also been increased in this manner.

Fig. 3: LDR

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D. Control Unit

This microcontroller has been used in proposed system.

Microcontroller is the heart of overall system. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (Complementary Metal Oxide Semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count [6]. The main advantage of CMOS is that it is immune to noise than other fabrication techniques .PIC16F877A analyzes the data and generates a logic signal to drive the DC motor and Johnson motor to turn the PV panel and mirror to its desired position. The initial position of the PV panel is aligned towards the sun. Putting the PV panel into its initial position prevents it turning back to suns rays in the morning.

E. ULN2003A

ULN2003A is used here for driving the solar panel. TheULN2003A is an array of seven NPN Darlington transistors capable of 500mA, 50V output.

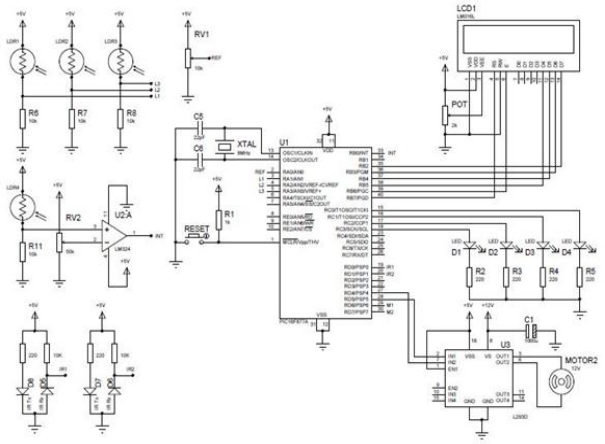

Fig. 4: Circuit diagram for control unit

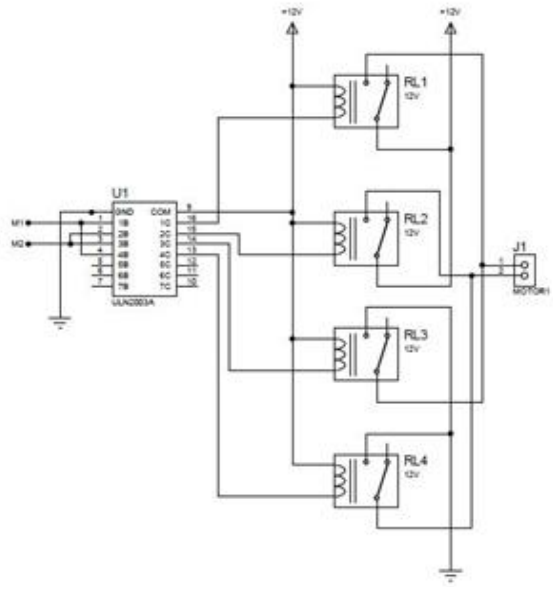

Fig. 5: Motor driver for Johnson motor

The ULN2003 is known for its high-current, high-voltage capacity. The drivers can be paralleled for even higher current output. Even further,stacking one chip on top of another, both electrically and physically, has been done. Generally it can also be used for interfacing with a stepper motor, where the motor requires high ratings which cannot be provided by other interfacing devices.Applications of the ULN2003A are in driver circuits for relays, lamp and LED displays, stepper motors, logic buffers and line drivers

F .L293D Motor Driver

L293D is a typical Motor driver or Motor Driver IC whichallows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction.Here it controls the movement of mirror according to panel. It means that you can control two DC motor with a single L293D IC. Dual H-bridge Motor Driver integrated circuit(IC). The L293D can drive small and quiet big motors as well, check the Voltage Specification at the end of this page for more info. It works on the concept of H-bridge. H-bridge is a circuit which allows the voltageto be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there two h-Bridge circuit inside the IC which can rotate two dc motorindependently. Due its size it is very much used in roboticapplication for controlling DC motors.

IV. WORKING OF PROPOSED SYSTEM AND DESCRIPTION

This paper shows the hardware implementation and itsexperimental results that validate the proper operation ofthe proposed system. Four Light Dependent Resistors (LDR) as a light sensor have been used. It is named as LDR-1, LDR-2, LDR-3, LDR-4.LDR-1 for measuring the day light intensity, LDR-2 and LDR-3 for comparison purpose and movement of mirror, LDR-4 for solar panel movement. The LDR-4, light sensors is separated by divider which will create shadow on one side of the light sensor if the solar panel is not perpendicular to the sun. The light intensity falling on LDRs 2 and 3 should be greater than the light falling on LDR-1. For the controlling circuit, microcontroller 16F877A acts as a brain that controls the movement of the motor via relay. Data received from the sensors is processed by the microcontroller (PIC16F877A). The microcontroller will send data to the two Bidirectional Johnson motors via relay to ensure solar panel is perpendicular towards the Sun. Relay controls the rotation of the motors either to rotate clockwise or anticlockwise. The solar panel that is attached to the motors will react according to the direction of the motor. If the LDR-4 value is high compared with reference at comparator ic lm324, the Johnson will rotate in forward direction .A reference value is set which is equal to the sum of the values of ldr 1 and half the value of voltage drop across rheostat RV1. If LDR-2 and ldr 3 values is low when compared with Reference, the mirror will rotate in forward direction until there is a shade in

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ldr2 or 3. Then the mirror moves in the reverse direction, until values of either 2 or 3 is greater than reference. Thus the solar panel and the mirror will automatically track towards the suns maximum intensity throughout the day.

A. Bosting the solar panel

Solar panels are a great way to make some green electricity for our home or workplace but theyre kind of expensive and sometimes the wattage produced can be a bit disappointing. If we use a sun tracking system to keep our panels facing the sun we can considerably improve the watt yield but these are not cheap and on a small system they can add considerably to the cost. Heres a really cost effective and simple way to get 75 percentage.

V. EXPERIMENTAL MODEL

A. MPPT

Maximum Power Point Tracking is a technique that grid tie inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integratedinto an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors. There are more algorithms are used in MPPT in which we are going toimplement Perturb and observe Algorithm in our project. It is simple, top-level efficiency and ease of implementation, the perturb and observe algorithm is the most commonly applied maximum power point tracking (MPPT) control scheme in photovoltaic (P V) applications.

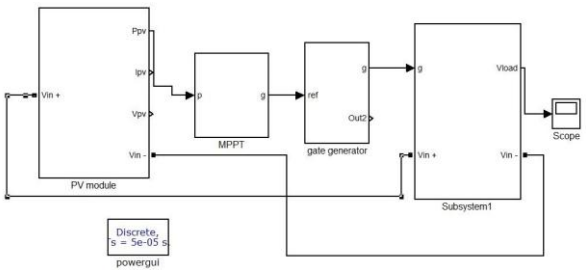

Fig. 6: simulink model of MPPT system

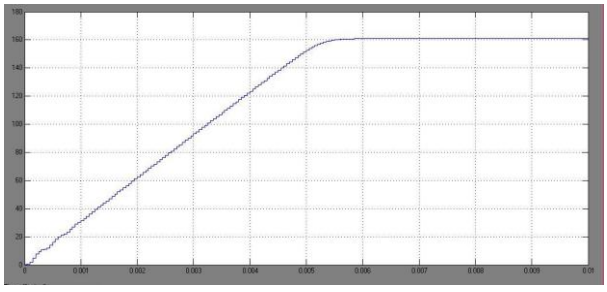

Fig. 7: Voltage graph of simulink model

Two techniques are usually used for implementing the algorithm, reference voltage perturbation where a reference value for the PV generator output voltage is used as the control parameter and direct duty ratio perturbation where the duty ratio of the MPPT converter is used directly as the control parameter.The figure 6 shows MPPT simulinkmodel.Figure 7 shows the voltage time graph of MPPT simulink output.

The figure8 shows the hardware model of the automatic solartracking system with a mirror booster and MPPT. The solar panel that is attached to the motors will react according to the direction of the motor. If the LDR-4 value is high compared with reference at comparator ic lm324, the Johnson will rotate in forward direction .A reference value is set which is equal to the sum of the values of ldr 1 and half the value of voltage drop across rheostat RV1. If LDR-2 and ldr 3 values is low when compared with Reference , the mirror will rotate in forward direction until there is a shade in ldr 2 or 3. Then the mirror moves in the reverse direction, until values of either LDR- 2 or LDR-3 is greater than referenceThus the solar panel will automatically track towards the suns maximum intensity throughout the day.Figure 9 shows the adc values of LDRs and reference voltage.

Fig. 8: complete hardware model

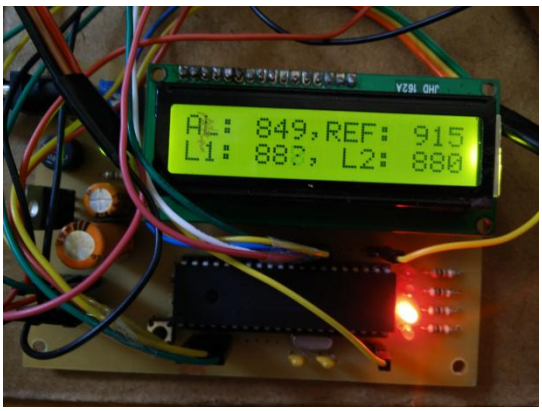

Fig. 9: Output of LDRs and reference value

VI. CONCLUSION

The micro controller based solar tracking system usingMPPT and mirror booster has been designed and implemented. In this paper we have modified existing solar tracking system with MPPT and a mirror booster to improve the tracking efficiency.The efficiency of normal solar panel is very less and it is difficult to establish it for a commercial purpose. This paper has been presenting a new methodology and a simple control of a Sun tracker that employed to follow the Sun throughout the day and produce electricity with its maximum intensity. The novel system consists of two motors to drive a panel and mirror controlled by a micro controller. LDRsensor is used here. Johnson motor is used to drive solar panel because it gives more power than gear motor. MPPT integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including batteries, or motors. Battery will not take any charge after it is fully charged. This will increase battery's life time. It also achieves the following attractive features like simple and economically, and it is useful for remote areas, household, isolated regions like ships to provide effective for large power generation even though they are bulky.

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