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Automatic Solar Tracking and Phase Selection Using Honeywell ML50 PLC

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Abstract: This paper aims at automatically monitoring and controlling the position of the solar panel based on intensity of light falling on the photo sensors. The system also detects the available phase in a three phase power supply and automatically switches to the active phase. In the absence of power in all of the phases, power is procured from the solar charged battery. This ensures a constant supply of power, 24 hours a day, 7 days a week. The whole operation is governed by a PLC. The PLC used is Honeywell ML50.

Keywords: Inverter; phase detection; photovoltaic cell; solar energy; solar power generation.

I. INTRODUCTION

Over the past few decades, excessive usage of energy has led to the depletion of conventional energy sources such as fossil fuels, which in turn resulted in rise in costs, greenhouse effect and global warming. Nowadays, renewable energy is an efficient and ideal source of energy [1]. One of the most commonly used renewable energy sources is solar energy. Solar energy with its abundance and inexhaustibility is one of the most promising new energy sources [2]. Interconnected electric power generation of photovoltaic solar power is the most important application. Nevertheless, some difficulties arise due to low density of solar energy, intermittence of solar rays, changing light intensity and direction with time, which necessitated higher requirements for devices collecting and manipulating solar energy [3].

In recent years, automation has been gaining wide popularity. This is because automation results in reduction of labour, conservation of energy and materials and improved quality, accuracy and precision. Programmable logic controllers have mainly been incorporated in industrial automation. Initially, PLCs were used to replace relay circuits. Eventually, they were recognized for more complex operations due to their flexibility and ability to perform logical operations such as timing, counting, comparing and processing. PLC has been used in this system to ensure higher efficiency and reliability [4].

This paper designed and developed an automatic sun light tracking system based on programmable logic controller. It not only automatically adjusts the orientation of the solar panel according to sun light direction, but also switches from the missing phase to any available phase in a three phase supply system. In case, there is no supply in any of the phases, an inverter is made use of to ensure uninterrupted supply of power [5].

II. AUTOMATIC SOLAR TRACKING SYSTEM

The automatic tracking system comprises of LDRs, the solar panel and the geared motor. It detects the presence of sunlight by making use of the light dependent resistors. Depending on the intensity of light sensed and the program stored in the PLC, the direction to which solar panel should be rotated is determined. Action signals are communicated to the motor through relays as outputs.

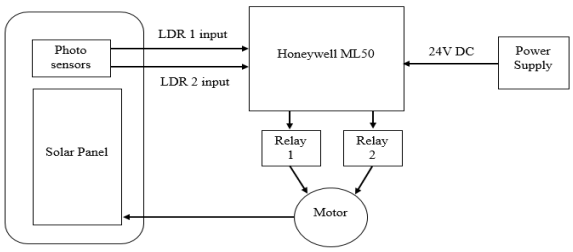

Fig. 1 Block Diagram of Automatic Solar Tracking System

A. Light Dependent Resistor

It is a variable resistor. The resistance value decreases with increase in intensity of incident light. An LDR is generally made of a high resistance semiconductor such as cadmium-sulphide. If light falling on the device is more than a threshold frequency, photons absorbed by the semiconductor give bounded electrons sufficient energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

B. Solar Panel

Solar energy can be harnessed using photovoltaic cells. Photovoltaic cells are the basic units of the solar tracking system. The word photovoltaic is derived from the Greek word 'photo' meaning light and 'voltaic' meaning electricity. Thus, photovoltaic means producing electricity from light energy. Output power procured from photovoltaic cell is dependent on the amount of light incident on the cell. Many factors such as time of the day, season, position and orientation of panel affect the output power. Photovoltaic cells are the basic units of the solar panel. Solar panels give maximum output power when sunlight falls vertical to the solar panel.

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C. Geared Motor

A geared motor is a type of DC motor with a gear assembly attached to the motor. The speed of motor is measured in terms of shaft rotations per minute (RPM). The gear assembly helps to increase the torque, thus reducing the speed. Using the correct combination of gears in a gear motor, the speed of a geared motor can be reduced to any desirable figure. This concept where gears reduce the speed of the motor but increase its torque is known as gear reduction.

III. AUTOMATIC PHASE SELECTION

The main goal of this section is to maintain a continuous AC supply to a single-phase load by an automatic switching of load from the missing phase to any available phase in a three-phase system. In this section, step down transformers are used to step down 230V supply from the three phases to be given as inputs to the PLC. Relays are used to connect PLC to the load. The Normally Open (NO) pins of relays represent phases R, Y, B and the inverter. All Normally Closed (NC) pins are grounded. Presence of voltage in any of the phases is detected and according to the PLC program output is given to the four relays. Thus, a constant supply to the load is provided. It is ensured that only one relay is switched on at a time to prevent short circuiting.

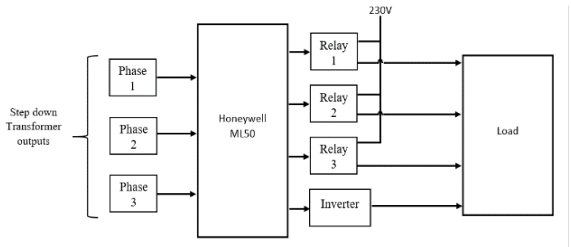
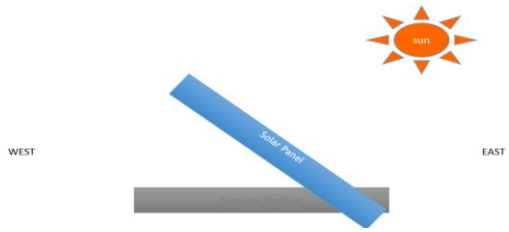


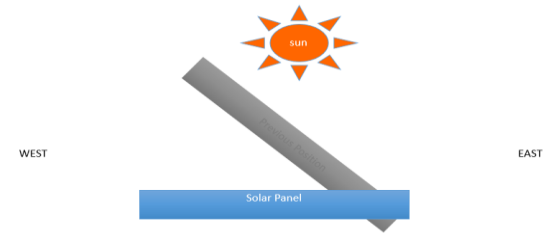
Fig. 2 Block Diagram of Automatic Phase Selection

IV. PROGRAMMABLE LOGIC CONTROLLER

PLC is an industrial grade computer capable of being programmed to perform control functions. It uses programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic so as to control machines and processes [6]. PLC is the brain of this system. All the operations in the system are controlled by the PLC. Honeywell ML50 PLC is used [7]. PLC programming language refers to the method by which the user communicates information to the PLC. Ladder diagram is the most commonly used PLC language. It is a graphical depiction of a process with rungs of logic, similar to relay logic schemes.



(a)



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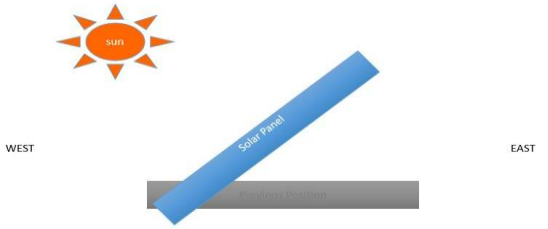

(c)

Fig. 3 Operation of Solar Tracker; (a) Morning (b) Noon (c) Evening

According to the ladder program fed into the PLC, when output of LDR2 (west) is high, the solar panel is made to move backward in the east to west direction. If LDR2 gives a low output, the solar panel moves in the forward direction.

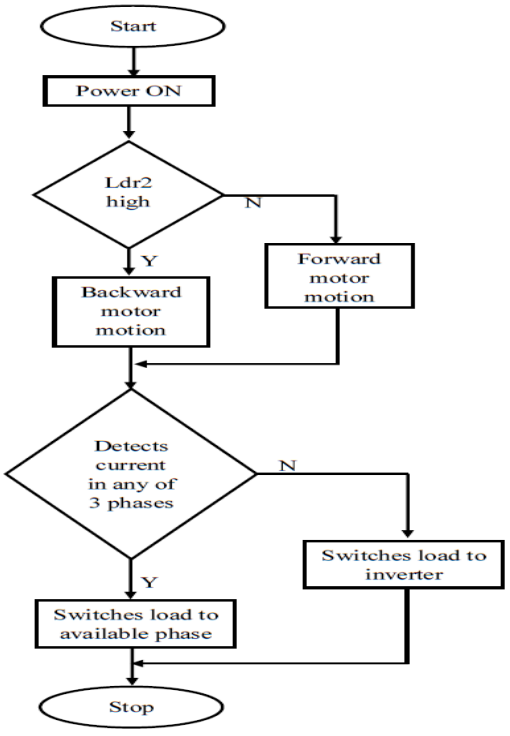

Fig. 4 System Flowchart

In the case of the automatic phase selection, if high value is detected in any of the three phases, load is switched to that phase using relays. Program is coded such that, at a time, load is connected to only one phase to prevent short circuit. If all the phases give a low value, load is connected to the inverter.

PLC I/O configuration is as shown. Inputs to the PLC include outputs from LDR1 and LDR2.

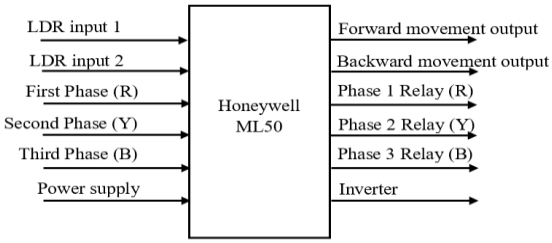

Fig. 5 PLC I/O Configuration

It is regulated to the range of 0-5V. These are given to the analog input ports of the PLC. Inputs obtained from stepped down outputs of transformers from R, Y and B phases are around 24V. A voltage of 24V is required for the operation of the PLC.

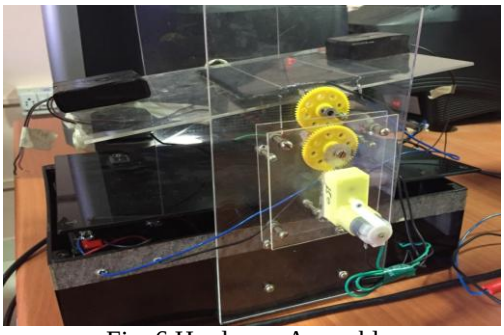

Fig. 6 Hardware Assembly

V. CONCLUSION

The prototype discussed in this paper automatically tracks the sun using PLC and store the solar energy harnessed in a battery. It also switches a single-phase load from the missing phase to any available phase in a three phase system. The solar tracker moves about a single axis (from east to west and vice versa). LDRs were sufficient to measure the light intensity falling on the solar panel. Under the same conditions, the generating power of automatically tracking solar panel equipment is about 35% more than fixed ones. Relays were used to interconnect the output of PLC to the load in the three phase system. Uninterrupted power supply was successfully provided to the single-phase load.

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