Design of Intelligent Controller for Solar panel Tracking System

J. Ravichandran, lecturer senior grade,
Dept of Instrumentation and control engineering, Sri Krishna Polytechnic College-Coimbatore

Abstract- **A solar tracking generating power system is designed and implemented. An expert controller, sensors and input/output interface are integrated with a tracking mechanism to increase the energy generation efficiency of solar cells. In order to track the sun, cadmium sulphide light sensitive resistors are used. To achieve optimal solar tracking, a fuzzy algorithm is developed. A field programmable gate array is applied to design the controller such that the solar cells always face the sun in most of the day time. The needs for increasing the power generation make the use of solar cells plays an important role in the daily life. For this reason, it is important to use solar tracking system to increase or getting almost optimum amount from solar cells. In this paper, proposed intelligent controllers were designed and used to make solar cells facing the sun over the year.**

Index Terms- Solar Tracking, Two-Axis Tracking, Field Programmable Gate Array, Fuzzy Control.

I. INTRODUCTION

The Energy is one of the prime issues in today's world. Because of increasing population, energy need and energy cost has increased tremendously in recent year. During the process of energy production, nature gets damaged and global worming type generated. Because of all these aspects solar energy which is the clean source of energy becomes more important. Solar cell converts solar energy into electrical energy. The amount of energy obtain from PV panel is directly proportional to the amount of sunlight acquired by that solar panel. As domestic and industrial application of solar energy is increased, that needs to extract maximum power from solar panel. Three factors that affect the efficiency of collection process are; solar cell efficiency, intensity of sun radiation and storage technique. But as because of material used for the manufacturing of solar cell, it is difficult to improve the efficiency of the solar cell, hence it is necessary to improve efficiency of collection process. There are three methods by which efficiency of collection process can be improved and these are: sun tracking, maximum power point tracking method, and both. This paper presents sun tracking technique to harness the output power of PV panel. In the sun tracking system solar trackers are used. A solar tracker is the device that is used to align a single photovoltaic panel or an array of PV modules with the sun, so the tracker can improve the systems power output by keeping the sun in focus for whole day and thus increase the effectiveness of the equipment over the fixed position system. Sun position is mainly depending on two things that are time of the day and season. Output power of the PV panel is high when sun radiations are perpendicular to the PV panel. Solar tracker tracks the position of the sun and rotates the PV panel according to sun position so that PV angel becomes parallel to sun and sun radiation makes 90^oangle with PV panel. Sun tracking system help to improve efficiency of the collection process. Sun tracking is mainly of two types depending on the manner in which path of the sun is determined and that are: Dynamic sun tracking and fixed control tracking. Dynamic tracking system actively searches for sun position at any time of the day. Fixed control tracking does not actively searches for sun position. In dynamic tracking method light sensors are mounted on tracker at various positions. If sun is not facing the PV panel directly means panel is not parallel to the sun then there will be a difference between the outputs of a light sensor compare to another. This principle is used in dynamic tracking. Whereas the fixed control tracking pre-recorded data of sun position for different time and different season for particular site is used. In this method forgiven current time, current day and year position of the sun is calculated.

II.SOLAR TRACKER

Solar tracking system uses a stepper motor as the drive source to rotate the solar panel as shown below. The position of the sun is determined by using tracking sensor, the sensor reading is converted from analog to digital signal, and then it passed to a fuzzy logic controller implemented. The controller output is connected to the driver of the stepper motor to rotate PV panel in one axis until it faces the sun.

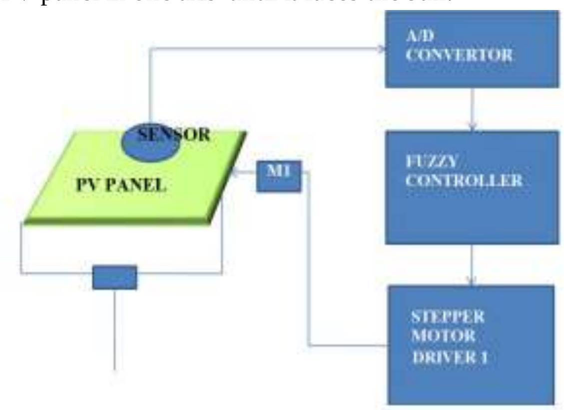

Fig: 1, Solar tracking system

The proposed solar tracking systemis one of the most important methods used for obtaining the solution to analysis and design the controller for sun tracking system is the computer simulation. All simulations are implemented using MATLAB R2013aProteus 7 Professional and Xilinx_ISE 13.

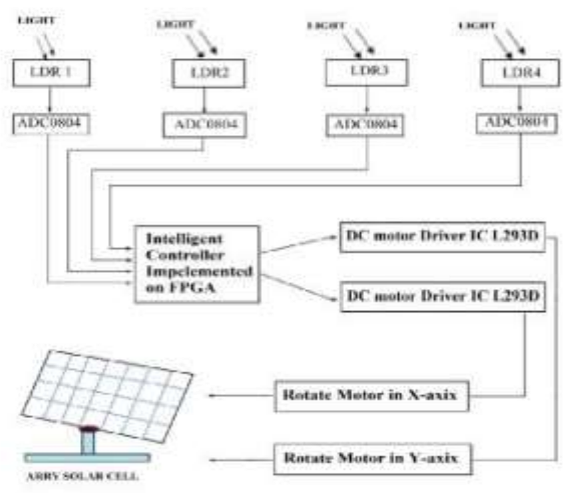

Fig: 2, Proposed solar system tracking system

III.SENSORS

There are two sensors used in the sun tracking system: photo sensor, and position sensor.

A. Photo Sensor

Light dependent resistor (LDR) is used to construct the sensor, because it is the most reliable sensor that can be used for light sensing. LDR is basically resistor whose resistance varies with intensity of light, so more intensity gives less resistance. Different LDR sensors available in the market are, the biggest size is used to construct the sensor because the more area of the sensor mean more its sensitivity or less time taken for output to change when input changes.

Tracking Sensor Design

The tracking sensor is composed of two similar LDR sensors, which are located at the east, west, or south, and north to detect the light source intensity. The LDR sensor forms a 45° angle with the light source. At the LDR sensor positions, brackets isolate the light from other orientations to achieve a wide-angle search and quickly determine the sun's position. To sense the position of Sun in one axe say east/west, two LDR sensors are mounted on the solar panel and placed in an enclosure. It has a response which is similar to the human eye. The east and west LDR sensors compare the intensity of received light in the east and west. When sun's position shifts, here the light source intensity received by the sensors are different, the system obtains signals from the sensors' output voltage in the two orientations. The system then determines which sensor received more intensive light based on the sensor output voltage value interpreted by voltage type A/D converter. The system drives the step motor towards the orientation of this sensor. If the output values of the two sensors are equal, the output difference is zero and the motor's drive voltage is zero, which means the system has tracked the current position of the sun.

B. Position Sensor

Position sensor used to determine the location of the PV panel to prevent the panel from the impact when it reaches the edges, and to get the PV panel to the starting point at the night. This sensor used a variable resistor (potentiometer) located on the rotor of the motor and rotate with it, and the value of the resistor (R) varies with the rotation as shown in Figure 2.

When the position reaches the values at the PV at the edges, the controller stopped the motor and immune it from rotating in that direction. At the night the

LDR sensors are very dark light and their values are very big, in this situation the controller go to night Subroutine to rotate the PV panel until the position sensor has the starting point value.

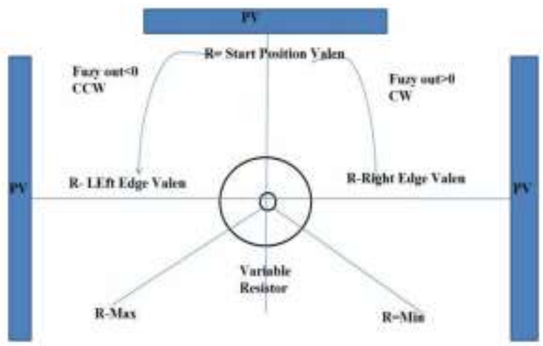

Fig: 3, Sensors

IV.CONTROLLER

In sun tracking system, to rotate the PV panel according to the sensors output intelligent controller is needed. Hence in sun controller tracking intelligent controller like PID or fuzzy logic controller can be used. Fuzzy logic controller is having advantages over PID controller and these are:

- Mathematical model of the control system is not required.
- Totally depend up on operator's experience.
- It deals with nonlinearities of the system.
- Linguistic system definitions can be converted into control rule base or control algorithm. Fuzzy logic controller can be implemented on the microcontroller.

Microprocessor PLD, FPGA. Microcontroller is having some disadvantages that are microcontroller is more economical and having problem while dealing with control system because it required high processing speed. FPGA is faster than microcontroller. It is suitable for fast implementation of controller and can be programmed to do any type of digital function. FPGA is more flexible and because of it FPGA have additional function and user interface control and it reduce the requirement of additional external component.

FLC Design

FLC has two inputs which are: error and the change in error, and one output feeding to the stepper motor driver. There are two widely used approaches in FLC implementation: Mamdani and Sugeno. In this thesis, Mamdani approach has been used to implement FLC for the sun tracker.

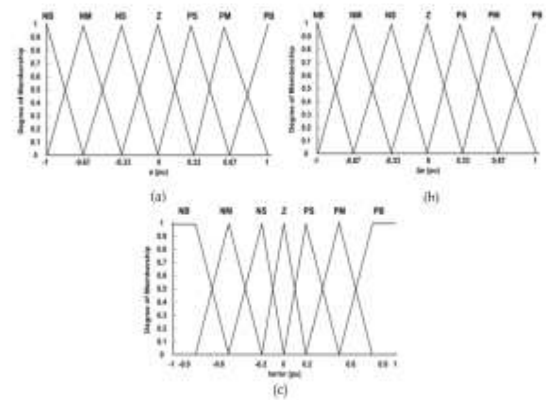

Fig: 4, controller design

Control Rule Base

The knowledge base is defined by the rules for the desired relationship between the input and output variables in terms of the membership function. The control rules are evaluated by an inference mechanism, and represented as a set of: IF Error is ... and Change of Error is ... THEN the output will....

For example:

Rule1: IF Error is NS and Change of Error is ZE THEN the output is NS. The linguistic variables used are:

NB: Negative Big.

NM: Negative Medium.

NS: Negative Small.

ZE: Zero.

PS: Positive Small.

PM: Positive Medium.

PB: Positive Big

ΔP \ ΔV	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

V.EXPERIMENTAL RESULTS

This experiment applies four solar cell panels. Every two panels are connected in series as a set. There are four panels; this means there will be two sets. Then, we connect these two sets in a parallel configuration. Solar cell array can be composed of many small sets by series connection and parallel connection. While sets are in a series connection, the output DC voltage of the solar generating power system will be raised. While sets are in a parallel connection, the output DC current of the solar generating power system will be raised. Therefore, series and parallel connections can be used suitably to produce desired output DC voltage and current. Since solar cells are difficult to be produced, every solar cell panel has its own characteristics. In addition, environmental factors such as dust, clouds, etc., may cause different voltages and currents in different sets. Another problem is that some sets may be loads for other sets. In this case, the temperature of set will be risen because of power consumption. When the internal temperature of a solar cell panel is over 85°C~100°C, the set will be broken. Furthermore, all voltage will be applied in the set, when there are some broken sets in the solar cell array. Therefore, a bypass diode is in a parallel connection to a set for solving the above problem. Thus, a low impedance path of energy dissipation can be provided for each set to overcome a problem of many sets connection. The power Intelligent Solar Tracker using Concentrated Photovoltaic and Fuzzy Logic45generation comparison of fixed angle type and tracking systems the experimental data of the solar generating power system are measured outdoors.

VI.CONCLUSION

In this paper, fuzzy logic controller is fabricated on modern FPGA card (Spartan-3AN, Xilinx Company, 2009) to increase the energy generation efficiency of tracking controller received from solar cells. By implementing a sun tracker controller using fuzzy logic controller to keep the PV panel pointing toward the sun by using a stepper motor. The use of stepper motor enables accurate tracking of the sun. LDR resistors are used to determine the solar light intensity. Sun tracking generating power system is designed and implemented in real time. The proposed sun tracking controller and the proposed controller for grid-connected photovoltaic system are tested using Mat lab/Simulink program, the proposed FLC shows an excellent result. The proposed solar tracking power generation fuzzy controller is able to track the sun light automatically. It is an efficient system for solar energy collection. It is shown that the sun tracking system using fuzzy controller with FPGA technology is 24% energy efficient than a fixed sun panel system.

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