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FPGA Based Standalone Solar Tracking System

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Abstract- MPPT and solar Tracking system are two systems to improve the efficiency of solar panel. The sun tracker is a automated solar panel that follows the position of the sun throughout the day to harness the output power. Sun tracking increases the output power production by keeping the panel parallel to the sun so that sun radiation makes 90° angle with panel. This paper presents sun tracking system implemented in real time. Sun tracking system composed of fuzzy logic controller implemented on FPGA, sensors, PV panel, stepper motor, input-output interface

Index Terms- Fuzzy **Controller, FPGA, Sun Tracker**

I. INTRODUCTION

Increasing population demands more energy therefore energy cost have increased tremendously in recent year. During the process of energy production, nature gets damaged and global worming type generated. Reservoirs of conventional energy sources are limited. Because of all these aspects solar energy which is the clean source of energy becomes more important.

Solar cell convert solar energy into electrical energy. The amount of energy obtain from PV panel is directly proportional to the amount of sun light 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.

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 panel become parallel to sun and sun radiation makes 90° angle with PV panel. So 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 in the fixed control tracking pre-recorded data of sun position for different time and different season for particular site is used. In this method for given current time, current day and year position of the sun is calculated.

II. SUN TRACKING SYSTEM

Sun tracking system is composed of stepper motor to rotate the solar panel, sensors controller as shown in Figure 1. It is composed of sensor, PV module, stepper motor, controller. Light sensors are mounted on the edge of the solar panel. That sensor determines sun intensity then sensors readings are given to the controller. Controller determine sun position and
rotate the stepper motor to align solar panel with sun orientation.

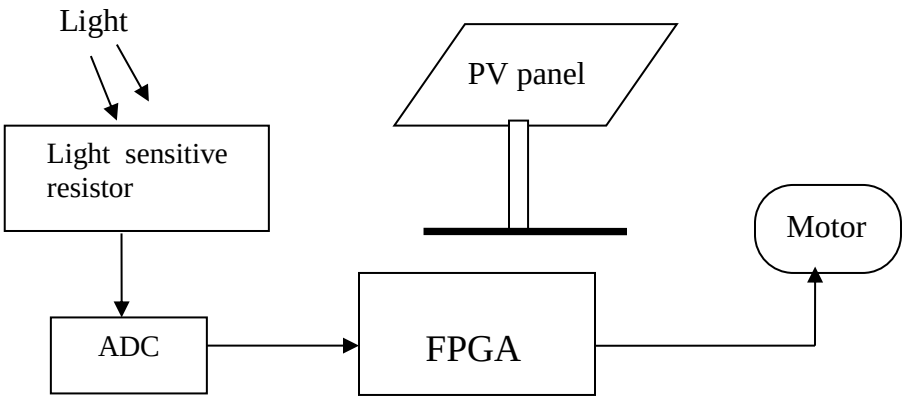

Figure 1.:Block diagram of sun tracking system.

A. SENSOR

Sun tracking system mainly consist of two type of sensor photo sensor and position sensor

1. Photo Sensor

LDR is used as photo sensor. LDR means Light Dependent Resistor and here it is used for light sensing. Resistance of LDR varies with the intensity of light. Intensity of light and resistance of LDR having inverse relation means when intensity of light is high, resistance of LDR is low. LDR are available in different sizes (as shown in figure 2.) but mostly bigger size LDRs are used because bigger size LDR having more sensitivity and required less time to change output when input change.

2. Position Sensor

Position sensor is used to prevent the PV panel from the impact when it reaches to the edges and move the panel to the starting position in night.
CW: Clockwise rotation.
CCW: Counter clockwise rotation

When PV panel reaches at its edge value, then controller stops the motor and prevents it from rotating in same direction to avoid it breakage problem. At night sensor are in very dark night so the outputs of the sensors are very big, then controller goes in night subroutine and rotate panel in starting position

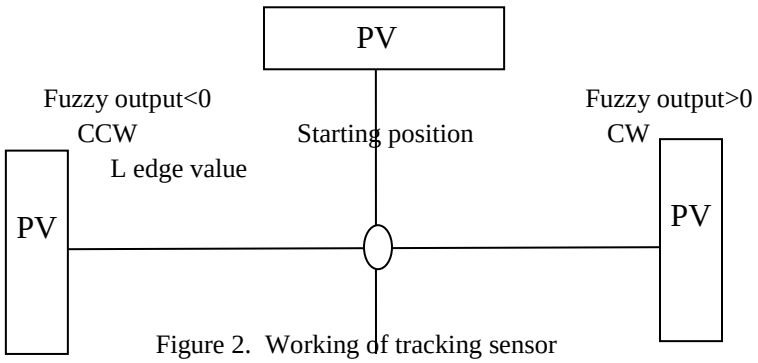

Figure 2. Working of tracking sensor

III. FUZZY LOGIC CONTROLLER

In sun tracking system, to rotate the PV panel according to the sensors output intelligent controller is needed. Hence in sun tracking intelligent controller like PID controller 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 upon operators experience.
- It deals with nonlinearities of the system.
- Linguistic system definitions can be converted into control rule base or control algorithm.

3.1 FLC for Sun Tracking System

Every FLC has three basic parts that are: fuzzification, rule base, difuzzyfication. Error and change in the error are the inputs to the fuzzy logic controller. Output of the fuzzy logic controller is fed to the stepper motor driver. FLC for sun tracking system is shown in figure 3, it mainly consist of three basic part and these are discussed as follow:

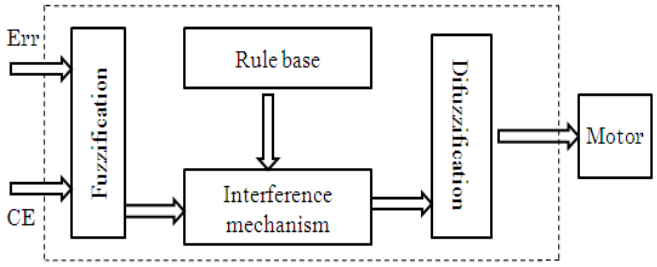

Figure3. Block diagram of fuzzy logic controller for sun tracking system

Here the inputs Error (Err) and change in the error (CE) come from the sensor. This inputs converted into the fuzzified input and output will get after fuzzification. This output is then fed to the motor to control it. As shown in above figure 3, every fuzzy logic controller have three basic part as mentioned above and these are discussed as follow

3.1.a Fuzzification

Fuzzification is the process that converts numerical values into grades of membership of fuzzy set members. There is a degree of membership function for each linguistic term that applies to that input variables. Membership functions is of different type like triangular membership function, trapezoidal membership function. For example same triangular membership function used for error, change in the error and it is shown in fig 4. Membership function for output is shown in the figure 5.

3.1.b Control rule base

Control rule base depends on the operators experiences. Depending on that experience knowledge base is developed which establish relationship between input and output variables in term of membership function. Structure of the control rule base is as follow:

If ERROR is ..... AND CHANGE IN ERROR is.....then OUTPUT will.....
For example:

If ERROR is NB and CHANGE IN ERROR is NM then OUTPUT will be NB.

Er/CE	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PB	PB
PM	NS	ZE	PS	PM	PM	PB	PB

PB	ZE	PS	PM	PB	PB	PB	PB

Table 1: Control rule-base for fuzzy logic controller.

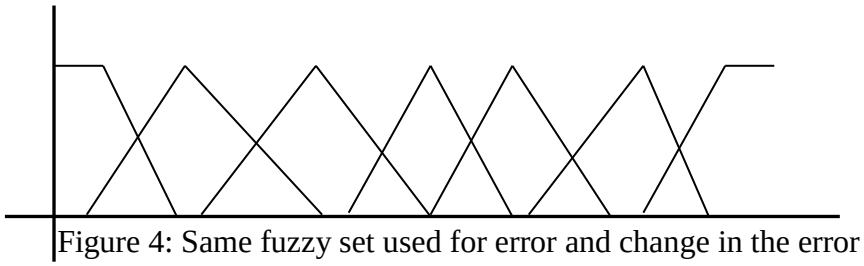

Figure 4: Same fuzzy set used for error and change in the error

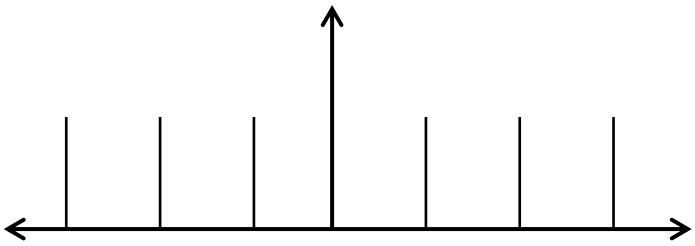

Figure 6:Fuzzy set of the output of the FLC

3.1. c Difuzzyfication

Reverse of fuzzification is difuzzyfication. Difuzzyfication converts fuzzified output into the normal crisp output.

IV. IMPLEMENTATION AND RESULTS

4.1 Hardware part:

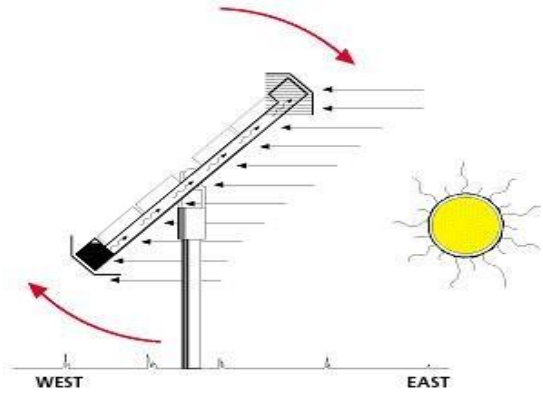

Fig 7: Rotation of solar panel according to the sun

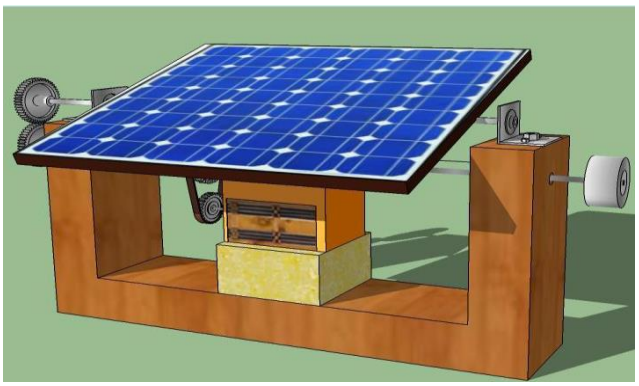

Fig 8: Sun Tracking panel prototype

4.2 Software part:

Xilinx_ISE software is used fore coding of FLC for Sun tracking. Spartan 3 kit is used to implement that code on hardware platform. Then we obtain following result while comparing output power generated by fixed position solar panel and sun tracking panel

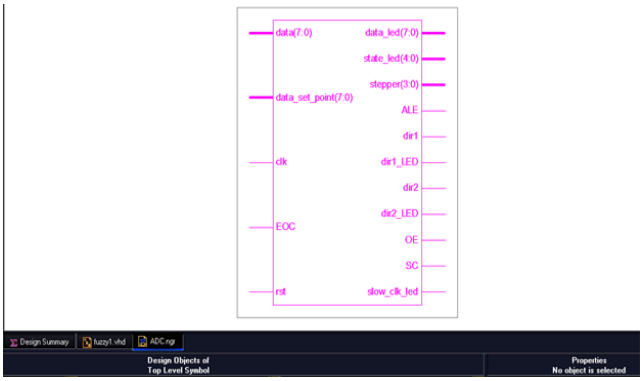

Fig 8: RTL schematic for FLC for sun tracking controller

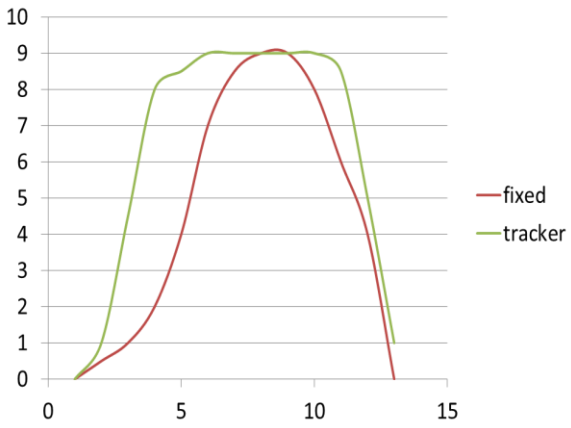

Fig 9: Comparison graph of output power of fixed and tracker panel

V. CONCLUSION

Here the main aim behind this project is improvement in efficiency of PV panel. Efficiency can be increased by developing automatic sun tracking panel. FPGA based sun tracking system tracks the sun all day and rotates the motor to the sun orientation hence acquires maximum sun radiation throughout the day. Hence sun tracking system is having maximum efficiency than fixed position PV panel.

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