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INTELLIGENT SUN TRACKING SYSTEM USING FLC IMPLEMENTED ON FPGA

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ABSTRACT- Solar energy is becoming increasingly attractive as we faced with global climate changes & less availability of fossil fuel in India. solar energy is free, non-polluting, and inexhaustible & We can generate at load site so transmission cost & losses is nil. A solar panel receives the most sunlight when it is perpendicular to the sun's rays, but the sunlight direction changes regularly with changing seasons and weather. Currently, most solar panels are fixed, i.e., the solar array has a fixed orientation to the sky and does not turn to follow the sun. To increase the unit area illumination of sunlight on solar panels we can track the panel such that it can received maximum sun rays. The design apparatus holds the solar panel and allows the panel to perform an approximate 3-dimensional(3-D) hemispheroidal rotation to track the sun's movement during the day and improve the overall electricity generation.

KEY WORDS: Fuzzy controller, FPGA, Sun tracker.

1. INTRODUCTION

Day by day increasing demand of energy renewable energy play vital role to fulfill demand of energy. the sources of renewable energy are Solar energy ,wind energy, biomass, Tidal etc[3] Out of these sun is prime source of energy. we can get electricity by using photo voltaic , photo-thermal process. Photovoltaic is the process to convert light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity. Photo-Thermal process intensity of solar radiation varies with time and the temperature of water raises depended on the amount of solar radiation & high pressurize steam drives turbine produces electricity. The amount of energy obtain from PV panel is directly proportional to the amount of sun light received 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 in MPPT technique we know maximum power is transfer from source to load when source resistance is complex conjugate to load resistance but complex nature of I-V characteristics of solar panel we required to add such complex resistance at the load side to get maximum power & these is achieved in MPPT technique .In solar tracking system we used movable panel such that they can track the sun position by open loop or closed loop system. In open loop system we can move the panel by motor at fixed time interval & In closed loop system some feedback mechanism is used to take sun position & panel always faces sun.These method needs some intelligent controller to track the sun such as conventional PID controller & fuzzy Controller. There is significant change in the performance of controllers with the introduction of Fuzzy systems. Fuzzy controller tuned for third order system with a high dead time which is difficult to control by the use of conventional controller. FLC has been widely used for nonlinear, high order & high dead time plants[4].we can implement FLC by using microprocessor or microcontroller. but disadvantages like it is always sequential i.e. for real time application & flexibility concerned FPGA is better suited. it is used for implementing the hardware circuit. Advantage of VHDL as C can only handle sequential instructions. VHDL allows both sequential and simultaneous executions[5]. Now FLC implemented on FPGA drives dc motor attached with solar panel & keep it in front of towards the sun.i used stepper motor because it high degree of accuracy The stepper motor is known by its important property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle. Stepper motors effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by using FLC.

1.1 Sun tracking system

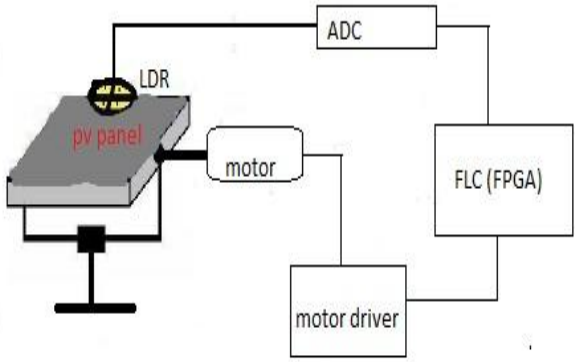

Fig.1 A Block Diagram Of Sun Tracking System

Two Light Dependant Resistor sensors are mounted on the solar panel used to coverts light energy into proportional analog voltage and placed in an enclosure as shown in Figure (1). 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. The light source intensity received by the sensors are different, the system obtains signals from the sensor output voltage in the four orientations. The sensor output voltage value inferred by voltage type A/D converter, in this work is used ADC0804 & given to FPGA kit according to fuzzy logic processing FPGA Provides signal dc motor via motor driver for current driving purpose. the motor rotate & it fixed the position of panel towards the sun.

2. FLC System

FLC has three basic parts that are: fuzzification, rule base, Difuzzification. Error and change in the error are the inputs to the fuzzy logic controller. Output of the fuzzy logic controller is provided to current driver for boosting of current for stepper motor winding . FLC for sun tracking system is shown in figure 2, it consist of three basic part fuzzyfication, interfarece(rule base) & defuzzfication. LDR available in different sizes (as shown in figure 1) but mostly bigger size LDRs are used because bigger size LDR having more compassion and required less time to change output when input change.

2.2 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 like Mathematical model of the control system is not required. Totally depend upon operators experience. It deals with non linearity's 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 is 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.

2.3 sun tracking system

Every FLC has three basic parts that are: fuzzification, rule base, Difuzzification. 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 2, it mainly consist of three basic part and these are discussed as follow:

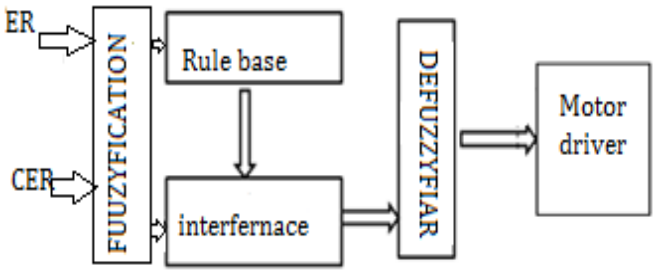

Fig. 2. Block diagram of fuzzy logic controller .

Here the inputs Error(Err) and change in the error(CE) getting from the sensor. This inputs converted into the fuzzy input and output will get after fuzzification. This output is then fed to the motor to control it. As shown in above figure 2,

2.4 FUZZYFICATION

Fuzzification is the process that converts numerical values into grades of membership of fuzzy set members For each input and output variable selected, we define two or more membership functions (MF). We have to define a qualitative category for each one of them, for example: low, normal or high. The shape of these functions can be diverse but we will usually work with triangles and trapezoids For example triangular membership function for error, change in the error and output is shown in the figure 3, 4 and 5 respectively.

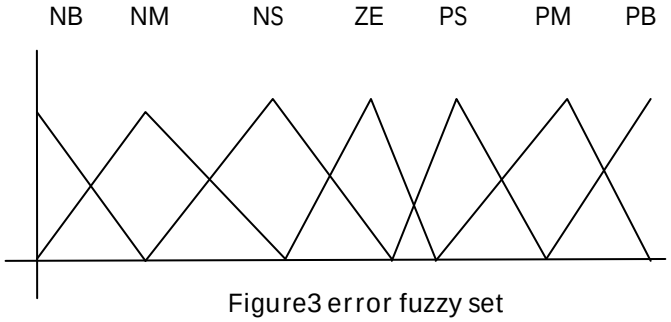

Figure3 error fuzzy set

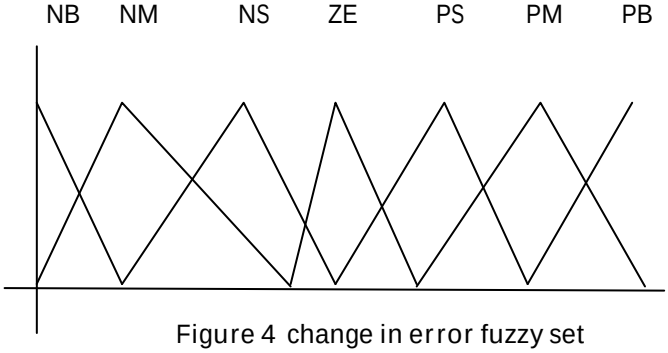

Figure 4 change in error fuzzy set

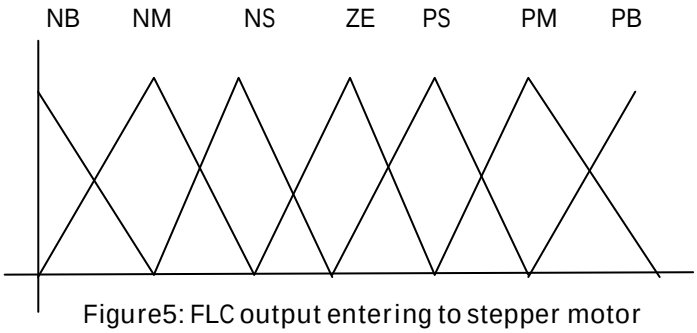

Figure5: FLC output entering to stepper motor

2.5 Rule base (Decision Matrix)

Once the input and output variables and MF are defined, we have to design the rule-base (or decision matrix of the fuzzy knowledge-base) composed of expert IF previous circumstances THEN conclusions rules. These rules transform the input variables to an output that will tell us the risk of operational problems (this output variable, risk of a problem, also have to be defined with MF, usually low, normal and high risk). Depending on the number of MF for the input and output variables, we will be able to define more or less potential rules. The easier case is a rule base concerning only one input and one output variable

For example:

If ERROR is PS and CHANGE IN ERROR is NS then OUTPUT will be ZE If ERROR is PB and CHANGE IN ERROR is NM then OUTPUT will be PS

Table 1: Control rule-base for fuzzy logic controller

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	PB	PB
PS	NM	NNS	ZE	PS	PS	PB	PB
PM	NS	ZE	PM	PM	PM	PB	PB
PB	ZE	PS	PB	PB	PB	PB	PB

NB-Negative Big PB -Positive Big ZE-zero
NM-Negative medium PM -Positive medium
NS-Negative small PS -Positive small

2.6.DIFUZZIFICATION

Reverse of fuzzification is Difuzzification it converts fuzzified output into the normal crisp output. Different methods for Difuzzification are available like maximum defuzzyfication technique in these method the output with the highest membership function these technique is very fast but is only accurate for peaked output second method is weighed defuzzyfication technique in this method the output is obtained by the weighted average of the each output of the set of rules stored in the knowledge base of the system & third method is centroid defuzzyfication technique This method is also known as center of gravity or center of area method. This technique was developed by Sugeno in 1985 The centroid defuzzyfication technique can be expressed as

$$x^* = \frac{\int \mu_i(x)\, x\, dx}{\int \mu_i(x)\, dx}$$

where x^* is the defuzzified output, m^i is the membership of the output of each rule, and w_i is the weight associate with each rule. In these method computationally faster and easier and gives fairly accurate result for these we used center of gravity method for FPGA implementation.

4. CONCLUSIONS

The paper presents a solar tracking based power generation system. The tracking controller based on the fuzzy algorithm is designed and implemented on FPGA by using Spartan embedded system . cadmium sulphide light dependant non linear resistor is used to detect the light intensity. The stepper motor move the panel according to sun light & produces maximum sun energy.

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