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FUZZY LOGIC BASED CHARGE CONTROLLER IN SOLAR PV FOR LIGHTING SYSTEMS

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Abstract: The power demand has been increasing day by day due to population growth, new industrial development, future needs, etc. Meeting power demand is one of the challenging factors for fossil fuel-based power generation alone as well as the environmental issue of carbon footprint. Consequently, there is a need to concentrate on alternate energy sources to meet the power demand. Here we have discussed the photovoltaic (PV) cell operation under various weather conditions are analyzed. And based on the performance, The MPPT controller is developed by using fuzzy logic control. The proposed system has been modeled in a MATLAB environment, and the system performance has been analyzed. Finally, the simulation results are evaluated and compared with conventional methods for proving the effectiveness of the proposed system.

Keywords: MPPT, fuzzy, PV, MATLAB

INTRODUCTION

The maximum power point tracking (MPPT) plays a major role in the photovoltaic (PV) power system. The PV power generation changes concerning sunlight irradiance and temperature. Nowadays, many researchers develop different MPPT techniques for improving the MPP in the PV system. MPPT techniques are used to measure PV voltage and PV current during the online condition. Here, the direct method has been developed by using the fuzzy logic controller to track the MPP of the PV system. This method is very robust and easy and meanwhile, no mathematical model is required for designing the controller. Here MPPT algorithm has been tested with numerical simulation in a MATLAB environment, and the PV performance at constant and variable irradiance as well as the temperature has been analyzed.

RELATED WORK

A. Solar Powered Led Street Light With Auto Intensity Control

It was proposed to conserve the energy of the battery, which is acquired from the solar panels. The main aim of this project is to keep the required lightning during the peak hours, especially during huge traffic hours, and then to gradually reduce the lightning in sync with the approaching evening hours. The light-emitting diode comprises the chemical compound. When the direct current from the battery passes through the light, then it gives the light and it requires very little current. A controller is a very significant device in the solar street light, used to decide the status of the charging and lighting by a switch on or switch off. Some recent controllers are pre-programmed and it consists of a battery charger, a Led lamp driver, a driver, a secondary power supply, an MCU, and a protection circuit.

B. Solar Inverter Using Sg3525 PWM Controller

The solar inverter is used to convert solar energy stored in batteries into AC power. The solar inverter is designed using SG3525 PWM controller IC. Solar energy is stored in batteries using a solar charge controller. Push-pull dc to ac converter topology is used, this inverter can be used to 100W. Also, the Push-Pull topology of dc to dc converters is used to convert the DC voltage source into AC voltage. A Step-up transformer is used to the step-up voltage from 12 volts to 220 volt AC. Center tap transformer is used in this project. The voltage divider circuit at the output is used to give feedback to SG3525. SG3525 control duty cycle of PWM using this feedback voltage. If you want to know how the SG3525 PWM controller controls output voltage and duty cycle of PWM,

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C. Microcontroller Based Solar Power Inverter

There are many components used are microcontroller, solar panel, timer IC555, Drivers, MOSFET, Capacitor, resistor, diode. An important piece of the solar power supply is the DC to AC inverter which converts the DC voltage from a battery to an AC voltage that is necessary to operate electronic components. Due to the delicate nature of this equipment, an inverter that is capable of producing a pure sine wave is necessary to avoid noise and wear on delicate and expensive gear. Many of these devices are very expensive so it is the goal of this project to design a DC/AC inverter capable of producing a pure sine wave for use with domestic equipment. The Objectives of this project is to design an inverter that can be derived by a 24V battery and can be used to operate AC loads while minimizing the conventional inverter cost and complexity using the controller. This can be achieved by generating a pure sine wave inverter from the solar panel reducing the dependency on fossil fuel and limited energy sources.

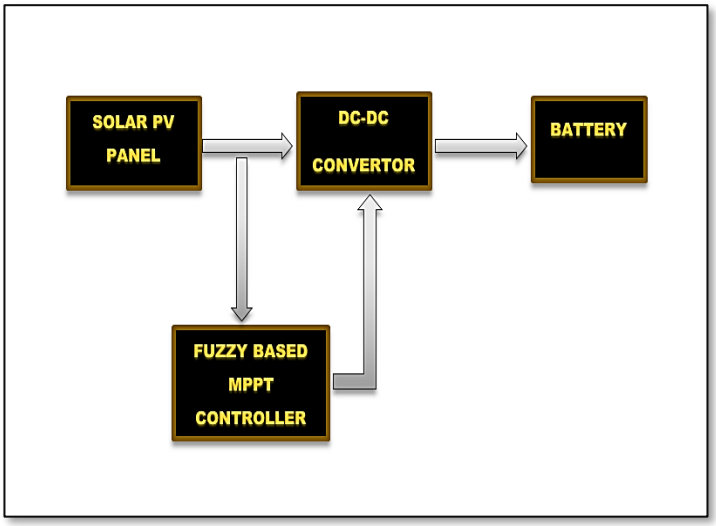
D. Solar Powered Auto Irrigation System

In this system, Making use of generated solar power for the auto-irrigation system. In this system, the solar power stored in a battery drives a motor to pump water. This system uses a microcontroller to control the motor by sensing the soil condition with the sensor. The system is programmed in Keil software in such a way that while receiving the sensing information about the land, it automatically turns the relay that directs the motor to start. A microcontroller in this project is used to sense the soil condition as dry, then the comparator sends the command to the microcontroller, and also it sends an instruction to the relay-driver IC then, it reminds the motor to pump water to the crops. Here comparator acts as an interface between the sensors and microcontroller to be an interface. The status of the soil and the water pump is indicated using a LCD display which is interfaced to the microcontroller. In the same way, when the sensor senses the soil condition as wet, then the microcontroller sends the instruction to the relay to switch off the motor.

METHODOLOGY

MPPT technologies have an important role in PV power generation for optimal power generation at various weather conditions. Here we have discussed and analyzed fuzzy logic controller-based MPPT controller for 10 W PV system. The proposed fuzzy-based MPPT block diagram represents the structure of the fuzzy controller that has two inputs and one output. The fuzzy membership function has been designed by the trapezoidal method for both input and output membership values. The defuzzification of the proposed fuzzy controller has been used for the center of gravity. The MPPT fuzzy controller has two inputs as PV voltage and PV current. The MPPT fuzzy controller generates a duty cycle based on the input of the fuzzy controller and is fed into the boost converter. Finally, the fuzzy rules for interference are designed based on changes in PV voltage and current under various weather conditions that includes temperature and irradiance. The designed fuzzy controller has been implemented in MATLAB simulation of the 10 Watts PV system and its boost converter for battery charging.

Block Diagram Of The Proposed Model



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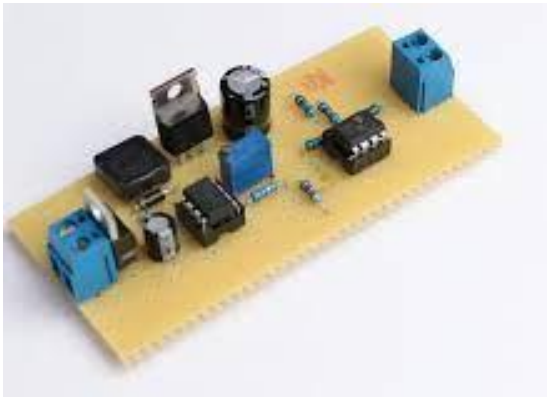
HARDWARE REQUIREMENT

1) Solar PV Panel

Solar panel 10W 12Volts 36 cells (41 X 30 cm) is a collection of solar (or photovoltaic) cells, which can be used to generate electricity through the photovoltaic effect. Here the individual unit of solar cells are arranged in a grid pattern on the surface of panels. Thus, it can also be described as a collection of photovoltaic modules, mounted on a structure which support the entire arrangement. A photovoltaic (PV) module is a packaged and connected assembly of (6 : 10) solar cells. When it comes to wear-and-tear, these panels are very hardy. Solar panels wear out extremely slow. In a year or two, their effectiveness decreases only about one to two percent or even lesser (negligible). Most solar panels are usually made up of crystalline silicon cells.

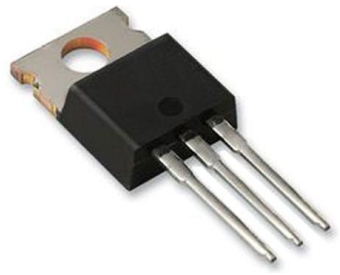
2) Sepic Converter

A SEPIC is essentially a boost converter followed by an inverted Boost converter, therefore it is similar to a traditional boost converter, but has the advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch S1 is turned off enough, the output (V0) drops to 0 V, following a fairly hefty transient dump of charge. SEPICs are useful in applications in which a battery voltage can be above and below that of the regulator's intended output.



3) MOSFET

The functionality of MOSFET depends on the electrical variations happening in the channel width along with the flow of carriers (either holes or electrons). The charge carriers enter into the channel through the source terminal and exit via the drain.



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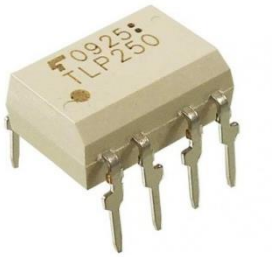
4) Opto Coupler

TLP250 is an isolated IGBT/MOSFET driver IC. The input side consists of a GaAlAs light-emitting diode. The output side gets a drive signal through an integrated photodetector. Therefore, the main feature is electrical isolation between low and high power circuits. It transfers electrical signals optically via light. TLP250 has an input stage and an output stage. It also has a power supply configuration. It is more suitable for MOSFET and IGBT. The main difference between this and other MOSFET drivers is that it is optically isolated. Its mean input and output side are isolated from each other electrically. But electrical signal transfers between both sides through an optical signal. It works like an optocoupler. The input stage has a light-emitting diode and the output stage have a photodiode. Whenever the input stage LED light falls on the output stage photodetector diode, the output becomes high.

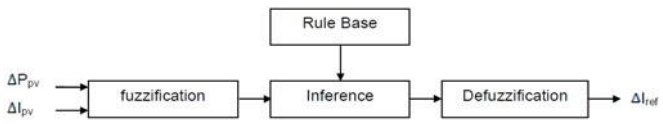


5) *PIC Microcontroller*

PIC (usually pronounced as "pick") is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller,] and is currently expanded as Programmable Intelligent Computer. The first parts of the family were available in 1976; by 2013 the company had shipped more than twelve billion individual parts, used in a wide variety of embedded systems.

6)*Fuzzy Control System*

The fuzzy logic controller has a wide range of applications in renewable energy applications. The use of fuzzy logic controllers has been increased over the last decade because of their simplicity, deal with imprecise inputs doesn't need an accurate mathematical model, and can handle nonlinearity [10]. FLC can be used as a controller to obtain the maximum power that the PV modules capable of producing under changing weather conditions. The process of FLC can be classified into three stages, fuzzification, rule evaluation, and defuzzification. These components and the general architecture of a FLS are shown in Fig. 7. The fuzzification step involves taking a crisp input, such as the change in the voltage reading, and combining it with stored membership function to produce fuzzy inputs. To transform the crisp inputs into fuzzy inputs, the membership function must be first assigned for each input. Once the membership functions are assigned, fuzzification takes real-time inputs and compares them with the stored membership function information to produce fuzzy input values. The next step of fuzzy logic processing is the interference for evaluating the fuzzy processor that uses linguistic rules to determine what control action should occur in response for the given set of input values. The result of rule evaluation is a fuzzy output for each type of consequent action.



The last step in fuzzy logic processing in which the expected value of an output variable is derived by isolating a crisp

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value in the universe of discourse of the output fuzzy sets. All of the fuzzy output values will be modified into their output membership function respectively. One of the most commonly used defuzzification techniques is called the Center of Gravity (COG) or centroid method.

6) *Switching Diodes*

Switching diodes perform one of the most basic functions in a circuit. Robust performance is a must, whether for standard or high-speed switching, controlled avalanche, or low-leakage current. The broad voltage range in both standard SMD packages as well as leadless DFN for miniaturization process, our AEC-Q101 automotive-qualified solutions meets our 'next-generation design challenges more efficiently. Even when your application operates in harsh environments or under extended temperature conditions (175 °C).

7) *Load Resistor*

At the most basic level, the load resistance is the cumulative resistance of a circuit, as seen by the voltage, current, or power source driving that circuit. This includes the resistance of the wires and the resistance of any devices connected to those wires. Everything between the "place where the current goes out" and "the place where the current comes in" contributes to load resistance. Sometimes, this even includes a load resistor. A load resistor is a resistor that has the sole function of increasing the load resistance of the circuit to a specific level.

8) *Battery*

A lantern battery of 6-volt cells are used to supply electricity for illumination such as torch lights and flashlights that needs higher energy capacity. These batteries are rechargeable batteries that are comprised of multiple arrays of cells inside, they have a large capacity of energy storage

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SOFTWARE REQUIREMENTS

1) *MATLAB 2013*

MATLAB is a proprietary multi-paradigm programming language and numeric computing environment developed by MathWorks. Here we have used version 2013. Although MATLAB is intended primarily for numeric computing, an optional toolbox uses the MuPAD symbolic engine allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems. As of 2020, MATLAB has more than 4 million users worldwide. MATLAB users come from various backgrounds in engineering, science, and economics.

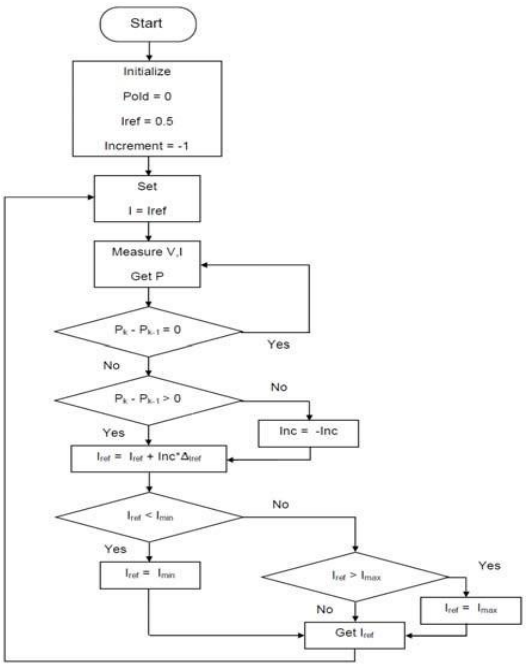
2) *MPPT Algorithm*

Maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating approximately the maximum peak power point of the PV panel under varying weather conditions, like solar irradiance, temperature, and load. MPPT algorithms are typically used in controller designs for PV systems. The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times.

3) *Fuzzy Logic Control*

MPPT using Fuzzy Logic Control gains several advantages of better performance, robust and simple design. Besides, this technique does not require knowledge of the exact model of the system. The main parts of FLC, fuzzification, rule-base, inference, and defuzzification, are shown in Fig. 4. In the proposed system, the input variables of the FLC are the change in PV array power (ΔPpv) and the change in PV current (ΔIpv), whereas the output of FLC is the magnitude of the change of boost converter current reference (ΔIref), the command for controlling the current drawn from the PV.

The flow chart of the proposed FLC is shown



In the proposed design, in terms of several linguistic variables by using seven fuzzy subsets, which are denoted by NB (negative big), NM (negative medium), NS (negative small), Z (zero), PS (positive small), PM (positive medium) and PB (positive big). The membership functions for the variable are shown.

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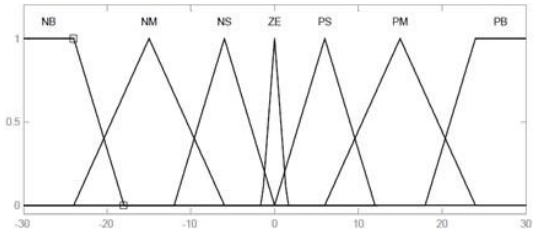
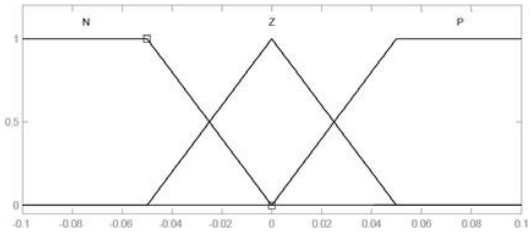
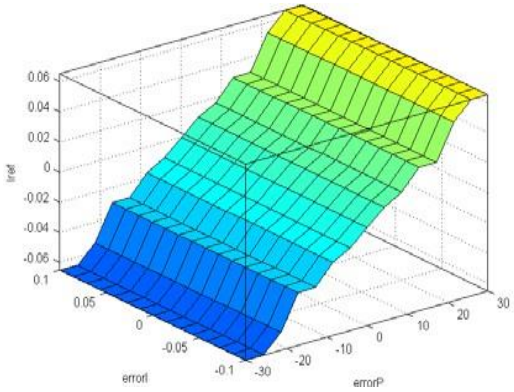


Membership Functions of the 1st Input Variable 1st (ΔPpv)



Membership Functions of the 2nd Input Variable 2nd (ΔIpv)



Sugeno Control Surface, Output Variable (ΔI_{ref})

Rules for the proposed FLC

Rule no.	If ΔPpv	And 9ΔIpv	Then ΔIref	Singletons
1	PB	P	PB	0.065
2	PM	P	PM	0.03
3	PS	P	PS	0.01
4	ZE	P	PS	0.01
5	NS	P	NS	-0.01
6	NM	P	NM	-0.03
7	NB	P	NB	-0.065
8	PB	Z	PB	0.065
9	PM	Z	PM	0.03
10	PS	Z	PS	0.01
11	ZE	Z	ZE	0
12	NS	Z	NS	-0.01
13	NM	Z	NM	-0.03
14	NB	Z	NB	-0.065
15	PB	N	NB	-0.065
16	PM	N	NM	-0.03
17	PS	N	NS	-0.01
18	ZE	N	NS	-0.01
19	NS	N	PS	0.01
20	NM	N	PM	0.03
21	NB	N	PB	0.065

RESULTS AND DISCUSSION

The proposed Fuzzy Logic Control based MPPT has been modeled and simulated using Matlab/SIMULINK and design of appropriate DC-DC buck-boost converter with a maximum power point tracking facility are presented in this paper. A new method for MPPT based fuzzy logic controller is presented and compared with the conventional MPPT method with improved results. The models are tested under disturbance in both solar radiation and photovoltaic temperature. Simulation results show that the proposed method effectively tracks the maximum power point under

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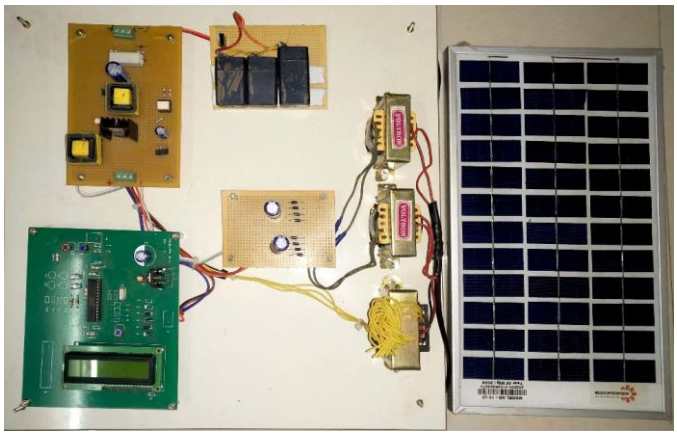
different ambient conditions. The oscillation around MPP is decreased and the response is faster in compared with the conventional methods maximum power point tracking.



Image(i) Hardware

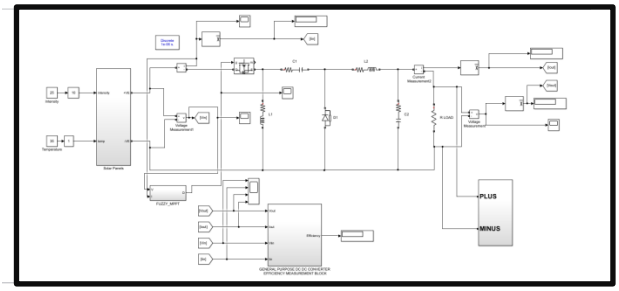


Image (ii) Simulation

FUTURE SCOPE

However, there are some limitations in the proposed solution which can be addressed in future implementations. Hence, the following features are recommended to be incorporated in future versions. High-capacity batteries are expected to be charged for heavy loads. The controller needs to be improved in error correction for desired output in the algorithm.

CONCLUSION

This paper deals with grid integration of PV power systems with intelligent controller-based energy management to improve the power quality. The above objectives are achieved by modeling of mathematical design of the PV system and simulating the PV system at various weather conditions with a fuzzy-based MPPT system. The fuzzy-based energy management system is developed and tested under various power demands, and then the operation of battery charging and discharging is analyzed. Finally, the proposed objective of grid integration of PV system is simulated in MATLAB, and system performance under various operating conditions is analyzed. The improvement of power quality simulation results is compared with the 1547 standard and proves the effectiveness of the proposed system. at various weather conditions with a fuzzy-based MPPT system. The fuzzy-based energy management system is developed and tested under various power demands, and then the operation of battery charging and discharging is analyzed. Finally, the proposed objective
of grid integration of PV system is simulated in MATLAB, and system performance under various operating conditions is analyzed.

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