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Implementing Different MPPT Algorithm For Solar Charge Controller

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Abstract: *In this paper, MPPT methods such as Perturb and Observe (P and O), Incremental Conductance and Fractional open Circuit Voltage method has been studied. Also, two converter topology, Buck and Synchronous buck converter has been Studied. Hardware implementation of the solar charge controller is done based on the software simulation data and results. Hardware is developed for 1kW system and 48V, 100Ah battery is going to be charged with it. Two MPPT method with synchronous buck converter has been implemented in hardware. This designed hardware has been tested with different irradiance condition. This proposed system can be used in golf cart to make it a stand-alone system with taking care of all protection measures.*

Keywords: MPPT.

I. INTRODUCTION

Solar energy is one of the promising sources of renewable energy. That's the reason why new innovations are evolving using day by day using solar. But this renewable energy is depended on the atmospheric condition such as sun irradiance and temperature. And due to this a solar PV panel has to be operating in specific condition in order to get maximum power from it. So, operating the solar PV panel at its maximum power point is the one of the trending topics for research over the decades.

For solar power generation efficiency is major concern. Due to the less efficiency of solar PV panel, a proper maximum power point tracking (MPPT) method is necessary. There are many MPPT techniques available to find the maximum power point in which the aim of method is to operate the PV panel at its available maximum power.

By using solar PV panel, converter and battery, standalone system can be formed which work by itself. By applying proper controlling circuit and MPPT (maximum power point tracking) method, efficiency of system & performance can be boost up. In stand-alone system, battery storage plays an essential part [2]. The batteries can be used during daytime when solar energy is available to store energy that can be utilized during the night time to supply the loads or dc-micro grid.

II. PROPOSED SYSTEM

Solar PV Panel

Solar panel with 320 W power capacity, 45 Volt of open circuit voltage (VOC) and 9.28 A short circuit current (ISC), four such solar PV panels have been connected in series connection in order to make 1kW system.

Battery

Lithium-ion battery with 48 V and 100Ah capacity is going to be charge with this solar charge controller.

MPPT Charge Controller

It is an algorithm comprised in the micro controller for bring out the maximum available power from the PV panel and transfer maximum available power from the PV module to the battery (as load). MPPT is an electrical arrangement that changes the module's electrical operating point so that the modules can offer the maximum available power. This would increase solar panel capacity and usable electricity.

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The developed MPPT charge controller is placed between the solar panel and the battery. MPPT charge controller is a controller with MPPT technique inside and sensing parameter.

Features & Specifications

- Fully micro controller based interface
- Based on MPPT algorithm
- Multiple LED indication for the state of charge
- 16 × 2 character LCD display for displaying voltages, current, power, load state, etc
- Overvoltage / Lightning protection
- Short Circuit, Overload and Reverse Polarity protection
- Rated Voltage= 12V
- Maximum current = 5A
- Maximum load current =10A
- Input Voltage = Solar panel with Open circuit voltage from 12 to 25V
- Solar panel power = 50W

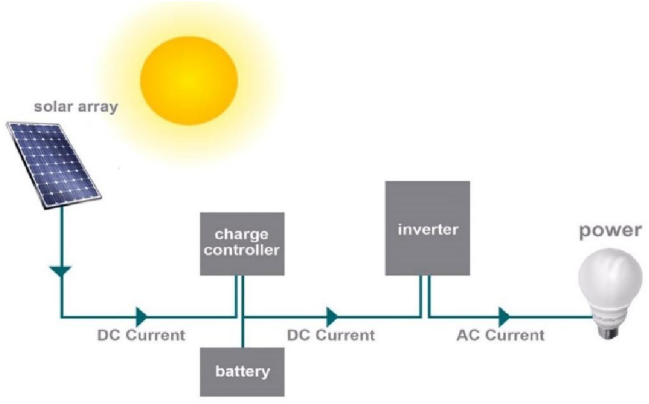
In this project we are going to build our own MPPT Solar Charge Controller using MCU and by combining many active-passive electronics. MPPT means Maximum Power Point Tracking Controller. Most solar panels produce much higher voltage than is necessary to charge a 12V battery. A 12V charging panel will actually produce 16 to 18 volts, depending on conditions, but only about 14.6 volts is necessary to charge most 12V batteries. There most of the voltage is wasted. Using the MPPT Charging Technology, we can convert the excessive voltage to current, and hence we can increase the efficiency.

In this article, we will learn about Solar Power Charging Technology and go through MPPT Charging Technology. Later using the MCU and many electronic components we will design the schematic and PCB for MPPT Charge Controller. Then by writing the MCU C code, we can program the MCU Nano to visualize all the charging parameters related to MPPT Solar Charge Controller on a 20×4 LCD Screen. The code has all the parameters and functions to measure Solar Panel Voltage, Current, Power, Battery Voltage, Charger state, SOC, PWM duty cycle, load status.

Later we can test the Charger the whole day and find out whether it is perfectly working or not. This design is suitable for a 50W solar panel to charge a commonly used 12V lead-acid battery. This article is very detailed with a lot of explanation and design methods involved which we shall discuss.

III. WHAT IS A SOLAR CHARGE CONTROLLER?

A solar charge controller is an electronic device that regulates the flow of electrical current from a solar panel to a battery or a bank of batteries.



It ensures that the battery is not overcharged or undercharged, which can damage the battery and reduce its overall lifespan. The solar charge controller also prevents the battery from discharging back through the solar panel at night. It is a critical component in a solar power system. The Solar Power can be measured using Pyranometer Sensor.

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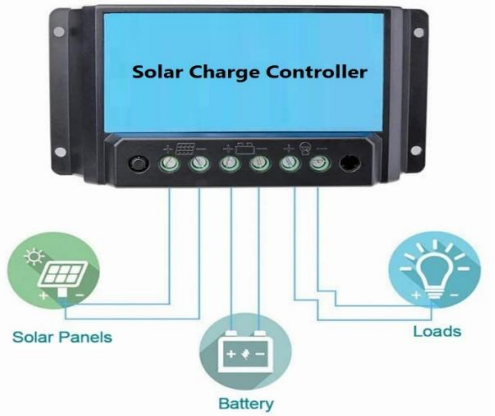
IV. TYPES OF CHARGE CONTROLLER

Every solar panel system that has batteries needs a charge controller. Its purpose is to regulate and control the power coming from the solar panels to the batteries to prolong the health of the batteries.



There are three types of charge controllers:

- Simple on-off Controller (ON OFF)
- Pulse Width Modulation Controller (PWM)
- Maximum Power Point tracking controller (MPPT)

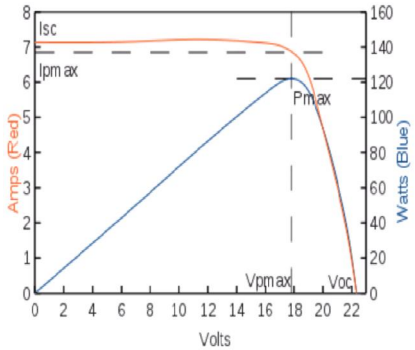
On-off controllers are very simple devices. All they do is detect the voltage of the battery bank and turn on or off the power.

Pulse width modulation controllers will charge a little bit faster than on-off controllers, and then they taper down the voltage as the battery gets full. When the battery is full, the controller switches to a float charging profile, which basically just keeps a trickle of current coming into the battery to keep it from discharging. PWM controllers will extend the life of a battery over simple on-off controllers.

V. MAXIMUM POWER POINT TRACKING CONTROLLERS (MPPT)

An MPPT (Maximum Power Point Tracking) charge controller is an electronic device that regulates the charging of batteries from solar panels by maximizing the amount of power from the solar panel that is stored in the battery. It does this by continuously adjusting the voltage and current of the solar panel to match the optimal charging voltage of the battery. This allows the battery to charge more quickly and efficiently, and can also increase the overall power output of a solar system.

Maximum PowerPoint tracking controllers are much more advanced and much more efficient than the two above-mentioned older types. These controllers are smart enough to be able to convert excess voltage into an additional current that normally would be wasted by a PWM controller.



Most solar panels produce much higher voltage than is necessary to charge a 12V battery, or 24 or 48 volts if you have that configuration. A 12V charging panel will actually produce 16 to 18 volts, depending on conditions, but only about

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14.6 volts is necessary to charge most 12V batteries. So, the MPPT controller can convert those extra volts into more current, which will charge the battery faster and be much more efficient.

VI. MPPT ALGORITHM

Perturb and observe method (P and O)

In this method, a small perturbation is added to cause the Power variation of the PV module. The Output of solar panel is periodically measured and Compared with previous power. In this process the output Power of the solar panel is increases, then the same Process continue otherwise perturbation is reversed.

Incremental conductance method (IC)

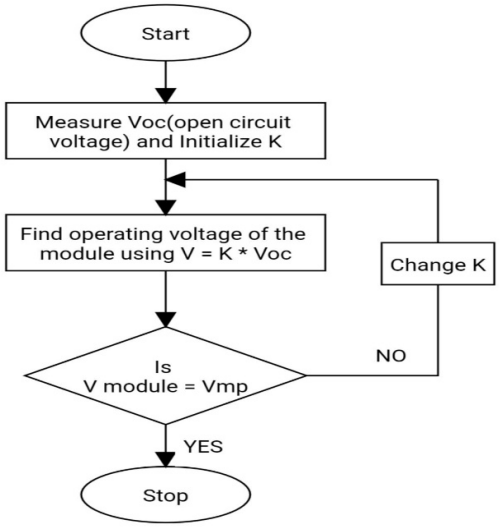
The drawback of the Perturb and Observe (P & O) Method for measuring maximum power under Increasingly changing atmospheric conditions is resolved By the Incremental Conductance method. The principle of The Incremental Conductance method is that the point at Which the slope of the PV panel power curve is zero is Called as the maximum power point.

Fractional open circuit voltage method (FOCV)

It is one of the direct method of find maximum power point tracking method. This approach use the idea that the ratio of the array voltage to the maximum PowerPoint (Vmp) and the open circuit voltage (Voc) is almost constant.

$$\frac{V_{mp}}{Voc} \approx 0.07$$

"K" lies in a range of 0.71<b<0.78. Its value is mainly dependent on module and environmental conditions. Although the technique is simple, FOCV suffers from power loss while sampling Voc A flowchart of the FOCV method is shown in Figure.



6.1. Advantages & Disadvantages of MPPT Solar Charge Controller

The MPPT controller can convert those extra volts into more current, which will charge the battery faster and be much more efficient. Another advantage of MPPT controllers is that they can handle much higher voltage configurations of solar panels to help minimize voltage drop or line losses. In other words, you can wire more solar panels in series in order to increase the input voltage, allowing you to run smaller gauge wires or travel much farther distances between panels and the charge controller without big losses. This benefit also allows you to run bigger panel arrays than you normally could with a PWM controller.

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So if you're grid-tied and you want to add some batteries in for backup power, MPPT is the only way you can do it. MPPT controllers are about 94% to 99% efficient, which can be as much as 30% more efficient than a similar PWM controller. However, they usually cost two to three times more than PWM. Because MPPT is still a new technology. They're also usually much bigger than a PWM controller.

MPPT controllers are critical for off-grid solar panel systems in cold climates or areas with lots of cloud cover, as they can extract every bit of solar power that's available. One of the only other drawbacks to MPPT is that they don't work very well in low light conditions because they have a hard time finding that sweet spot of maximum power. Luckily, those conditions don't last very long, and it more than makes up for it the rest of the day.

VII. MICRO CONTROLLER

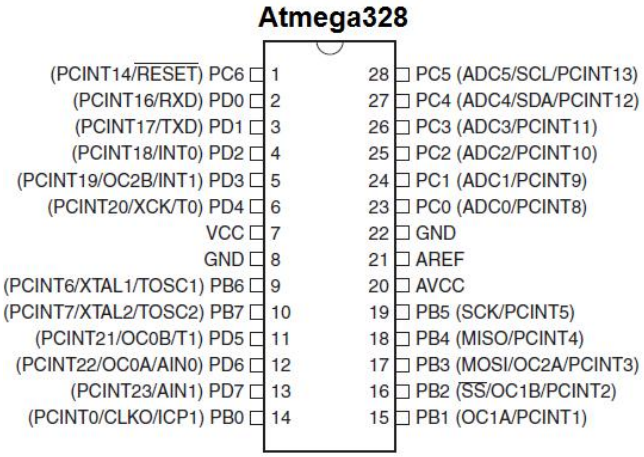
The project is based on a pre-programmed Atmega micro controller. The complete system divided in different sections. Analog sensor interfacing, analog to digital converter (ADC), WIFI Communication, Relay Output, LCD Display, and power supply section

The circuit used in this kit uses only one IC – the Atmega. It is one of the RISC architecture Based high-performance flash micro controllers from MICROCHIP. The IC is preprogramed. Using a micro controller greatly reduces the component count while providing more features than could be found using dedicated logic ICs. Cost is also lower. It is pre-programmed with software to provide all the timing functions.

Atmega is an 8-bit, low-cost, high-performance flash micro controller. Its key features are 32k words of flash program memory, 192 bytes of data RAM, eleven interrupts, three I/O ports, 10-bit ADC and only 35 powerful single- cycle instructions (each 14-bit wide). The ADC simplifies the overall embedded system design by providing a direct interface for voltage temperature, pressure, motion and other sensors.

7.1.ATMEGA328 Microcontroller

Introduction to ATmega328. ATmega-328 is basically an Advanced Virtual RISC (AVR) micro-controller. It supports the data up to eight (8) bits. ATmega-328 has 32KB internal builtin memory. This micro-controller has a lot of other characteristics. You should also have a look at Introduction to PIC16F877a (it's a PIC Microcontroller) and then compare functions of these two Microcontrollers.



ATmega 328 has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. Moreover, ATmega-328 has 2KB Static Random Access Memory (SRAM). Other characteristics will be explained later. ATmega 328 has several different features which make it the most popular device in today's market. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable Serial USART, programming lock for software security, throughput up to 20 MIPS etc. ATmega-328 is mostly used in Arduino. The further details about ATmega 328 will be given later in this section.

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VIII. HARD WARE REQUIREMENT

- Micro controller
- 16 x 2 LCD Display
- MOSFETS Driver IC's
- MOSFETS
- Power Inductor
- LM7805 Voltage Regulator
- Crystal Oscillator
- Bridge Rectifier Diodes
- DC Power Supply
- Solar Panel
- 12V Rechargeable Battery

8.1.Soft wear Requirement

- Eagle CAD for PCB Designing
- Embedded "C" Compiler for MCU Programing
- Proteus for Circuit Simulation
- MS-Offish for Documentation
- Adobe-Acrobat reader for Documentation

8.2 Project Plan

- Block diagram designing.
- Study of Component
- Market survey for components
- Circuit designing
- Circuit testing on bred board
- Order PCB layout designing And PCB making
- PCB testing
- Components soldering and assembling
- Hard ware testing
- Micro controller programming
- PC interfacing and programming
- Testing and trouble shooting
- Project report making

IX. CONCLUSION

A solar charger controller with different MPPT (Maximum Power PointTracking) algorithms offers efficient and optimized charging for solar panels.

These algorithms adapt to varying environmental conditions, extracting themaximum power from the solarpanels, enhancing energy efficiency, and ex-tending battery life.

Users can choose the most suitable algorithm based on their specific needsand environmental factors for improved solar energy harvesting.

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