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Implementation of MPPT Solar Charge Controller Using Arduino Nano

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Abstract— This paper is describing an Arduino based Solar MPPT charge controller. It has features like: LCD display, Led Indication, Wi Fi data logging and provision for charging different USB devices. It is equipped with various protections to protect the circuitry from abnormal condition. The microcontroller used is in this controller is Arduino Nano. This design is suitable for a 50W solar panel to charge a commonly used 12V lead acid battery. You can also use other Arduino board like Pro Mini, Micro and UNO. Now a days the most advance solar charge controller available in the market is Maximum Power Point Tracking (MPPT). The MPPT controller is more sophisticated and more expensive. It has several advantages over the earlier charge controller. It is 30 to 40 % more efficient at low temperature. But making a MPPT charge controller is little bit complex in compare to PWM charge controller. It requires some basic knowledge of power electronics. I put a lot of effort to make it simple, so that anyone can understand it easily. If you are aware about the basics of MPPT charge controller then skip the first few steps. The Maximum Power Point Tracker (MPPT) circuit is based around a synchronous buck converter circuit. It steps the higher solar panel voltage down to the charging voltage of the battery. The Arduino tries to maximize the watts input from the solar panel by controlling the duty cycle to keep the solar panel operating at its Maximum Power Point.

Keywords—MPPT, Arduino Nano, PV Solar Panel,Wifi

I. INTRODUCTION

A solar panel will generate different voltages depending on the different parameters like:
1.The amount of sun light.
2. The connected load.
3. The temperature of the solar panel.

Throughout the day, as the weather changes, the voltage produced by the solar panel will be constantly varying. Now, for any given voltage, the solar panel will also produce a current (Amps). The amount of Amps that are produced for any given voltage is determined by a graph called an **IV curve**, which can be found on any solar panel's specification sheet and typically looks like the figure-1. In the figure-2, the blue line shows a solar panel voltage of 30V corresponding to a Current of about 6.2A. The green line shows a Voltage of 35V corresponds to a current of 5A. [1]
We know that,

$$Power = V * I$$

As shown in the figure 2,on moving along the red curve we will find one point where the Voltage multiplied by its corresponding Current is higher than anywhere else on the curve. This is called the solar panel's Maximum Power Point **(MPP).**

FIG-1

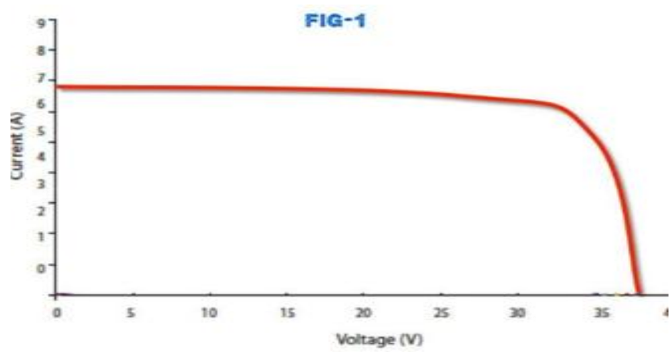


FIG-2

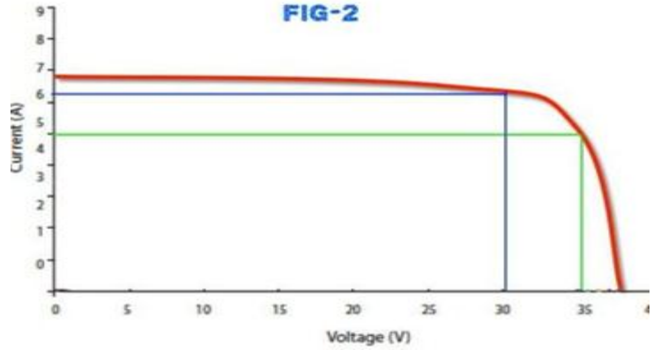
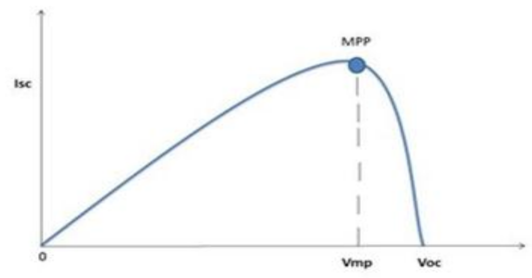


Fig-3



MPPT stands for Maximum Power Point Tracking. MPPT charge controllers used for extracting maximum available power from PV module under certain conditions. According to figure-3 We can see that the maximum power point (MPP) of a solar panel lies at the knee of the current and voltage curve.

A 12V solar panel is not really a 12V panel at all. It's really a somewhere in between 12V and 21V panel depending on what load is connected to it and how bright the sunlight is? The panel has an internal resistance which changes dynamically with differing irradiance levels. Solar panels will only deliver their rated power at one specific voltage and load, and this voltage and load moves around as the sunlight intensity changes.
For example, take a solar panel rated at 100 watts, 18V at 5.55 amps.

The 18 V at 5.5 amps means that the Solar panel wants to see a load of 18/5.5 = 3.24 ohms.
With any other load the panel will deliver less than 100 watts. So, if a static load is connected directly to a panel and its resistance is higher or lower than the panels internal resistance at MPP, then the power drawn from the panel will be less than the maximum available.

Taking a simple example say we connected the above 100W panel directly to a 12V lead acid battery, the panel voltage would be dragged down near to the load voltage of the battery as the battery's resistance is lower than the panels, but the current stays the same at 5.55 amps. This happens because Solar Panels behave like current sources, so the current is determined by the available sunlight.
Now the power (P)= V x I = 12x5.55=66.6W.
So, the Solar panel is now behaving like a 66-watt panel. This equates to a loss of 100W-66.6W = 34W (33.4%).[2]
This is the reason for using a MPPT charge controller instead of a standard charge controller like PWM. The MPPT controller is consists of a DC -DC converter where the duty cycle is varied to track the Maximum Power Point.

II. SPECIFICATION OF VERSION-3 (MPPT) CHARGE CONTROLLER

1.Based on MPPT algorithm.
2. LED indication for the state of charge.
3. 20x4 character LCD display for displaying voltages, current, power etc.
4. Overvoltage / Lightning protection.
5. Reverse power flow protection.
6. Short Circuit and Over load protection.
7. Wi Fi data logging.
8.USB port for Charging Smart Phone /Gadgets.

III. SCHEMATIC AND WORKING

The input power connector to the solar panels is the screw terminal JP1 and JP2 is the output screw terminal connector to the battery. The third connector JP3 is connection for the load. F1 and F2 are the 5A safety fuses. [3]

The buck converter is made up of the synchronous MOSFET switches Q2 and Q3 and the energy storage devices inductor L1 and capacitors C1 and C2 the inductor smooths the switching current and along with C2 it smooths the output voltage. Capacitor C8 and R6 are a snubber network, used to cut down on the ringing of the inductor voltage generated by the switching current in the inductor.

The third MOSFET Q1 is added to allow the system to block the battery power from flowing back into the solar panels at night.
In my earlier charge controller, this is done by a diode in the power path. As all diodes have a voltage drop a MOSFET is much more efficient. Q1 turns on when Q2 is on from voltage through D1. R1 drains the voltage off the gate of Q1 so it turns off when Q2 turns off.

The diode D3 (UF4007) is an ultra-fast diode that will start conducting current before Q3 turns on. It is supposed to make the converter more efficient.

The IC IR2104 is a half bridge MOSFET gate driver. It drives the high and the low side MOSFETs using the PWM signal from the Arduino (Pin -D9). The IR2104 can also be shut down with the control signal (low on pin -D8) from the Arduino on pin 3. D2 and C7 are part of the bootstrap circuit that generates the high side gate drive voltage for Q1 and Q2. The software keeps track of the PWM duty cycle and never allows 100% or always on. It caps the PWM duty cycle at 99.9% to keep the charge pump working.

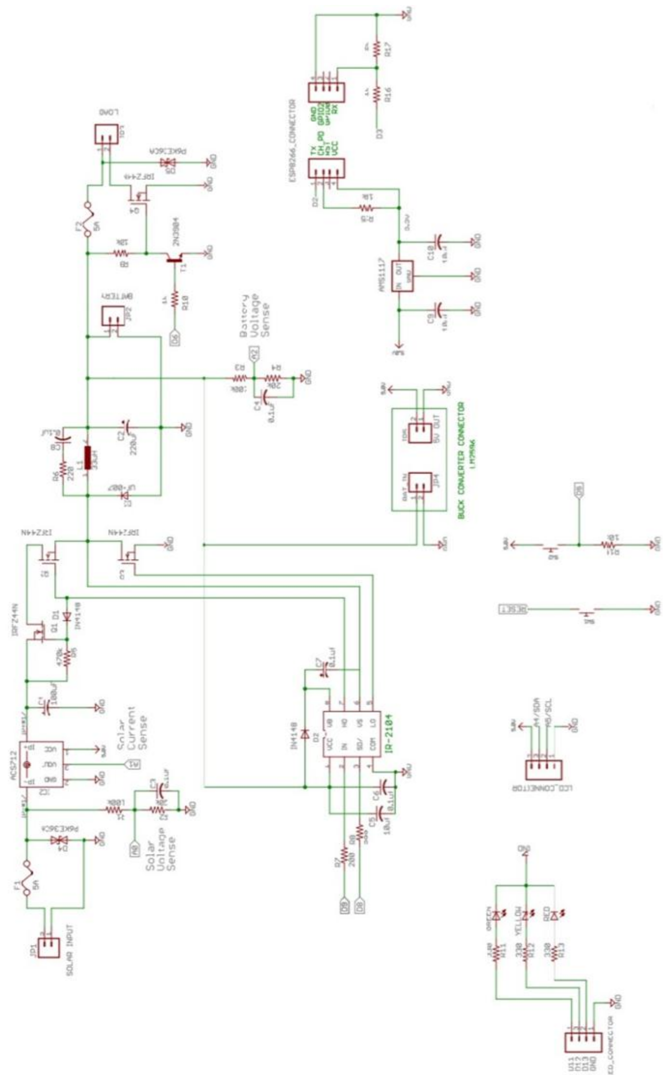
There are two voltage divider circuits (R1, R2 and R3, R4) to measure the solar panel and battery voltages. The output from the dividers are feeds the voltage signal to Analog pin-0 and Analog pin-2. [4]

The ceramic capacitors C3 and C4 are used to remove high frequency spikes.

The mosfet Q4 is used to control the load. The driver for this mosfet is consists of a transistor and resistors R9, R10.
The diode D4 and D5 are TVS diodes used for over voltage protection from solar panel and load side.

The current sensor ACS712 sense the current from the solar panel and feeds to the Arduino analog pin-1.
The 3 LEDs are connected to the digital pins of the microcontroller and serve as an output interface to display the charging state.
Reset switch is helpful if the code gets stuck. The back-light switch is to control the back light of LCD display.

IV. PROPOSED CIRCUIT DIAGRAM



V. CONCLUSION AND FUTURE SCOPE

In the final analysis, this project presents an efficient photo voltaic system with the capability of tracking the maximum power point. Each components of this system such as the solar panel, charge controller, DC-DC converter has all been discussed about. Since the purpose of this project is to design a more efficient MPPT solar charge controller using an Arduino, so we have explained the maximum power point tracking and the procedure we have followed to achieve that point. We have later done the hardware implementation and matched the data we collected showed more promising output.

Solar Energy is the ultimate source of ultra-clean, sustainable and natural energy. Most importantly it is the most cost-efficient energy source we can use in our favor and for securing financial benefits. In this regard developing more efficient charge controller is a progressive step to fulfill the need of power generation using green energy. For that purpose, it is our wish to continue further study on making the PV module more efficient. To be specific, the charge controller can be more improved by making the circuit more integrated and coming up with new algorithm to make the maximum power point tracking more efficient. Additionally, more digital logic can be implemented for maximizing the output hence reducing the physical work.

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