A Report on Lab Project:

Homemade Arduino Based MPPT charge controller

Submitted To

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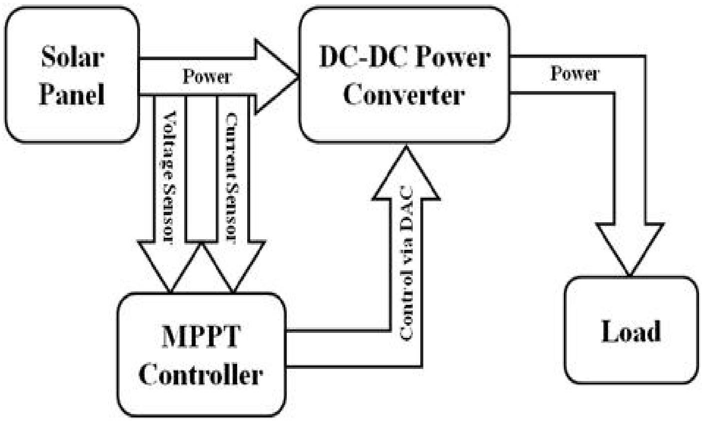
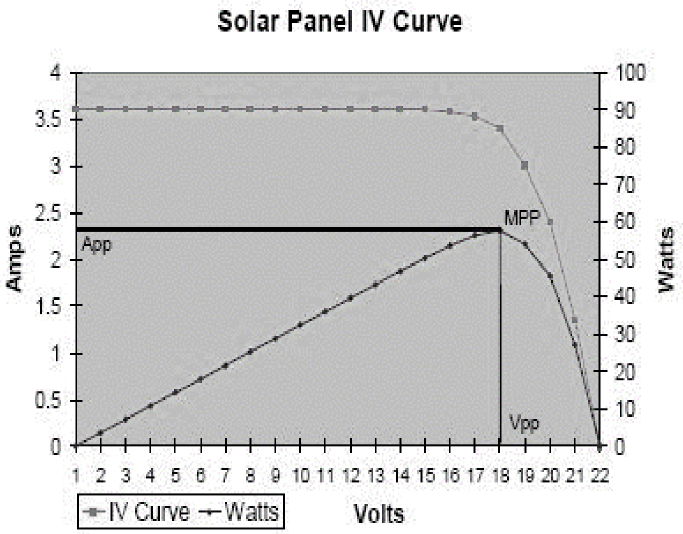
Theory & Background

To maximize a photovoltaic (PV) system's output power, continuously tracking the maximum power point (MPP) of the system is necessary. The MPP depends on irradiance conditions, the panel's temperature, and the load connected. Maximum power point tracking (MPPT) algorithms provide the theoretical means to achieve the MPP of solar panels; these algorithms can be realized in many different forms of hardware and software. PV systems that lack MPPT rarely operate at the most efficient, MPP. This is why the rated power of the solar panel is almost never realized when connecting a load. The goal of this project was to rapidly develop, construct, and test a working solution to the MPP problem with a limited budget.

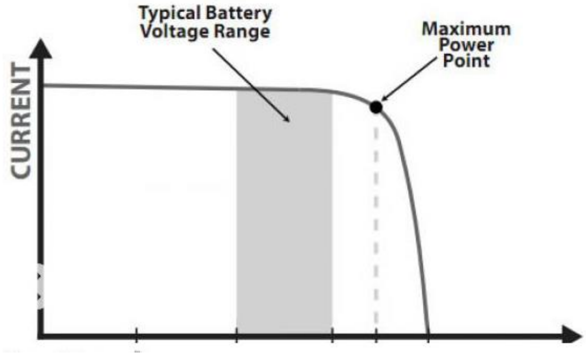


To understand why the PPT can increase the efficiency of solar power charging system, a closer at the electrical characteristics of a solar panel is necessary. Solar panels convert photons from the sun striking their surfaces into electricity of a characteristic voltage and current. The solar panel’s electrical output can be plotted on a graph of voltage vs. current: an IV curve. We represent the current in amps and voltage in volts. The resulting line on the graph shows the current output of the panel for each voltage at a specific light level and temperature. The current is constant until reaching the higher voltages, when it falls off rapidly. This IV curve is applicable to the electrical output of all solar panels.



The maximum power point tracking (MPPT) is a higher efficient DC-DC converter technology compared to "shunt controller" and "pulse width modulation (PWM)" technologies.

Using a non-MPPT charge controller is like connecting the battery directly to the solar module. A traditional charge controller may charge a battery with the voltage that is dictated by the battery. By nature, the voltage of a fully-charged battery is higher than that of a discharged-battery. Consequently, the power drawn by an empty battery is usually lower than that of a full battery. The MPPT utilizes whole module power by dictating the voltage of the battery charging state. The charge controller keeps the voltage and current at an optimized level where the modules deliver the most juice.



Let's explain with an example:

Assume that we are using an Evergreen ESA 210 Solar panel, (please not this module is just to illustrate the example and is no longer in production) which has the Vmp of 18.3 volts and the Imp of 11.48 amperes. (11.48A x 18.3V = ~210 watts)

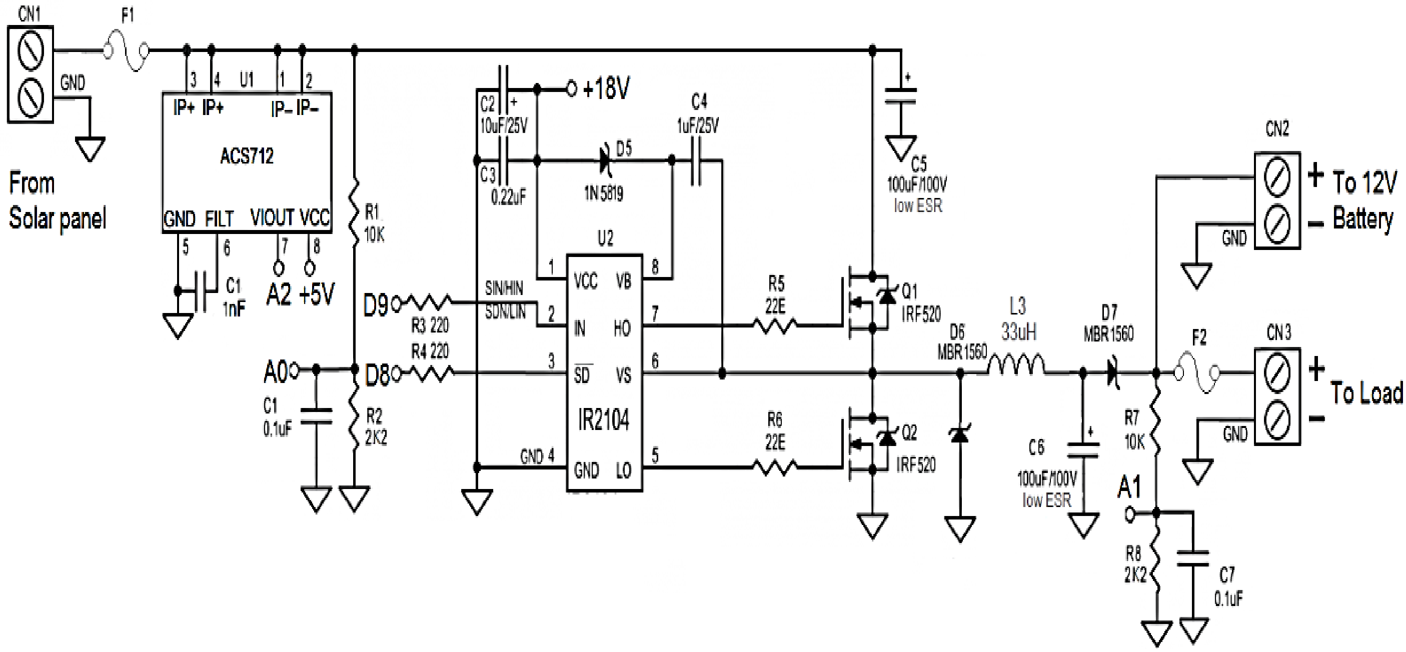
An empty 12V battery may generally have 12.2 volts. Therefore the battery would charge by 11.48A x 12.2V = 140 Watts. It's significantly less than the maximum available output (210 watts) of the module.

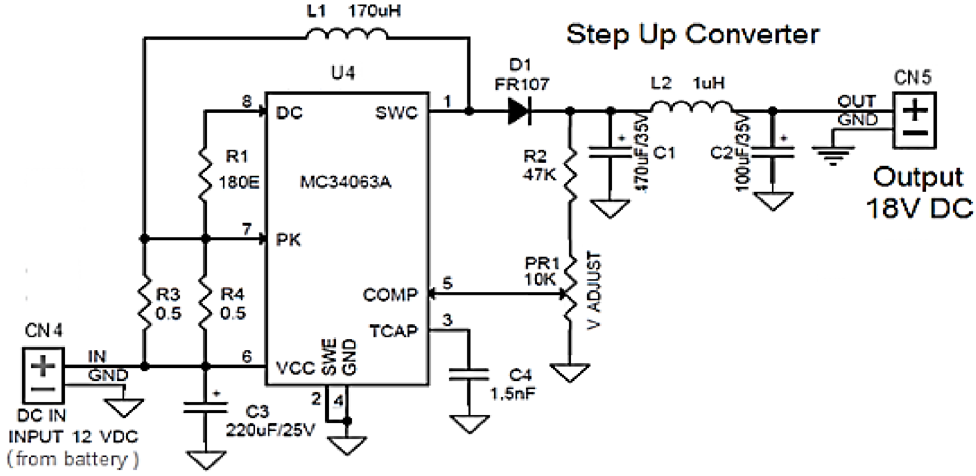
What a MPPT charge controller does is that it boosts the voltage and the current of the system, as close as the I-V curve of the module. In this case, the MPPT charge controller charges the battery at almost 18.3 V and 11.48A, while using the most out of the solar panel.

Main features of MPPT solar charge controller

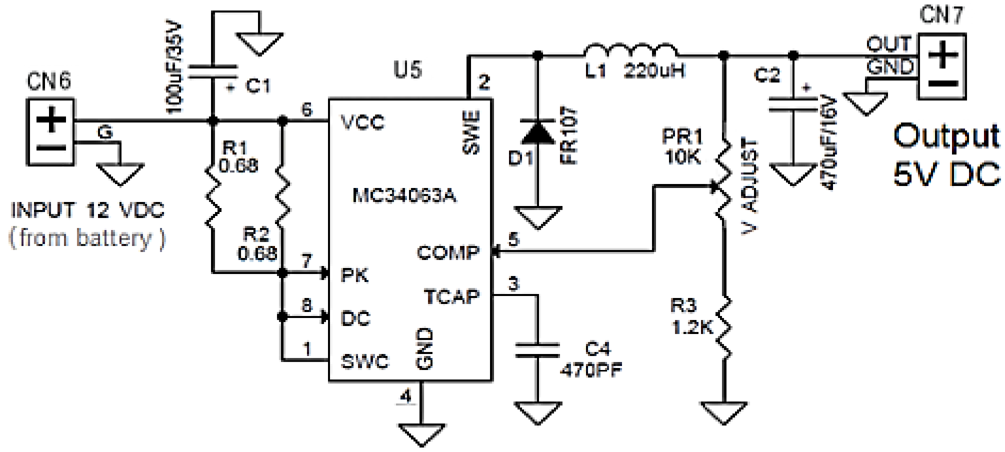
- In any applications which PV module is energy source, MPPT **solar charge controller** is used to correct for detecting the variations in the current-voltage characteristics of **solar cell** and shown by I-V curve.
- MPPT **solar charge controller** is necessary for any solar power systems need to extract maximum power from PV module; it forces PV module to operate at voltage close to maximum power point to draw maximum available power.
- MPPT **solar charge controller** allows users to use PV module with a higher voltage output than operating voltage of battery system. **For example,** if PV module has to be placed far away from charge controller and battery, its wire size must be very large to reduce voltage drop. With a MPPT solar charge controller, users can wire PV module for 24 or 48 V (depending on charge controller and PV modules) and bring power into 12 or 24 V battery system. This means it reduces the wire size needed while retaining full output of PV module.
- MPPT **solar charge controller** reduces complexity of system while output of system is high efficiency. Additionally, it can be applied to use with more energy sources. Since PV output power is used to control DC-DC converter directly.
- MPPT **solar charge controller** can be applied to other renewable energy sources such as small water turbines, wind-power turbines, etc.

Circuit Diagram:





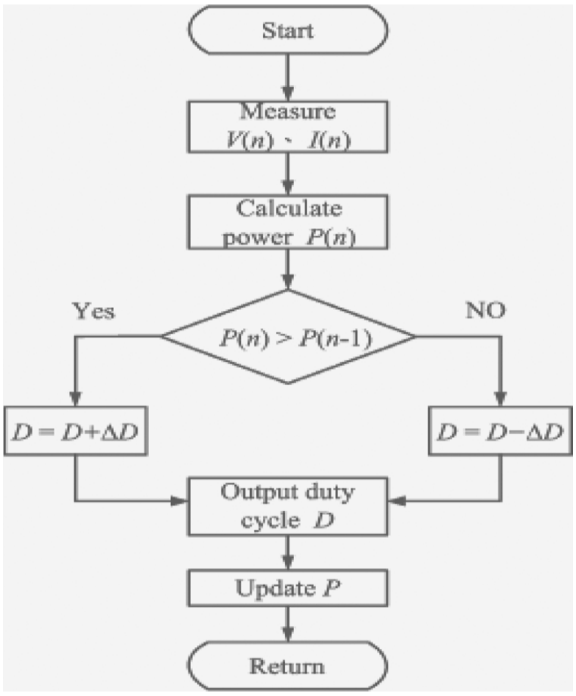
Step Down Converter



Algorithm used:

- ❖ Increase the conversion ratio of the DC/DC converter.
- ❖ Measure the solar panel watts.
- ❖ If the solar panel watts are greater than the last measurement,
- ❖ Then it is climbing the front of hill, loop back and do it again.
- ❖ Else if watts are less than the last time measurement,
- ❖ Then it is on the back side of the hill, decrease the conversion ratio and loop back to try again.

This hill climbing algorithm occurs about once a second in the PPT and it does a good job of keeping the solar panel operating at its Maximum Power Point.



Hardware & Costing:

Component	Units	Rate (taka)	Cost (taka)
Diode FR207	02	40	80
Schottky 5819	02	15	30
Resistors (All)	-	-	50
Capacitors (All)			140
Inductors (All)	-	-	190
IRF 530	02	40	80
B20200G	02	80	160
10K pot.	02	25	50
IR2104	01	120	120
ACS712	01	170	170
Wire	-	-	200
MC34063	02	30	60
ARDUINO	01	390	390
Breadboards	04	70	280
TOTAL			~2000

Arduino Code:

Arduino codes were basically obtained from Tim Nolan's website. But due to hardware mismatch and unavailability of some components, codes were modified significantly to work for our purpose.

Limitations:

1. **No lCD** monitor to observe MPPT implementation could be implemented.
2. No **led indicator** to show battery voltage level was implemented.
3. We did not have any **solar panel** during construction of the project. So, could not create a real development environment.
4. We could not manage to make **toroidal coil** inductor, which is much required for a dc power conversion device. And also ICs with **exact current rating** could not be confirmed. So, we never actually used 12V lead acid battery to run the circuit. Rather, we used 9V battery to see if the circuit works or not.

Future Development:

1. Proper **power supply** that complies with 12V actual system can be made.
2. **High precision** current sensor can be used.
3. **Lcd** monitor and **LED** lights can be implemented.
4. Wifi module **ESP8266** can be interfaced to make remote access possible.
5. More **efficient** mppt algorithm can be used to find better result.

Final remark & Disclaimer:

MPPT solar charge controllers are produced **commercially** by different industries using **Microcontrollers**. But it is **less common** project for Arduino. So, this project is just a **weak prototype** of an actual MPPT charge controller.

All equations, diagrams, Arduino coding etc. have been derived from various online resources.