MPPT IMPLEMENTATION OF BUCK BOOST CONVERTER FOR ROBOTICS USING SOLAR PANELS

[1]Lahari Shiva, [2]Sujatha K
[1]PG Student, [2]Assistant Professor
Department of ECE,
BMSCE, Bangalore, India.

Abstract— This project mainly aims at the efficient power management and energy management for a typical autonomous robot based on the most abundant renewable source of energy i.e. solar energy. As the robot is autonomous, it has to find its energy requirement stored in the battery. The charging of the battery is done by solar energy through solar panel during availability of the solar energy and during non-availability of solar energy charging is done through visible light (indoor bulb). In order to get the maximum power from the module and to charge the battery of robot the Maximum Power Point Tracking (MPPT) Algorithm is used because as the solar energy mainly depends on the factors such as direction of radiation, temperature which is not constant. The MPPT Incremental Conductance algorithm is used to obtain maximum power to charge the battery of the robot. Buck Boost Converter is used for step up or down the output to recharge the rechargeable battery. Here we are making use of two robot motors for loading purpose for the working demonstration, which will simulate the robot power consumption in Lab view. It has to measure the energy consumption pattern, charge left inside the batteries and also charge to required level whenever required or when the robot is in idle condition.

Index Terms— Buck Boost, Energy Management, Incremental Conductance, LabVIEW, MPPT, Power Management, Robot, Solar energy.

I. INTRODUCTION

One of the popular renewable resources is the solar energy which can be abundantly found than any other resources with the free of cost. This solar energy is the clean form of the energy obtained from the sun and it doesn't have any disadvantage like emitting the harmful substances/radiation from it. There are so many renewable resources other than solar energy such as wind, tide, water which all depends upon the other factors in order to excite that energy. But the solar energy doesn't require any other external factor to intermediate to excite to provide the energy. One form of the energy has to be converted into other in order to use for our own requirement. The solar energy is can be converted into other form for the different requirements such as to power up the house/home, for the commercial distribution of the electricity etc. The conversion of the solar energy into electrical energy is done by PV cells/panels. The solar light contains the packet of the energy called as photons and these photons excite the electrons present in the silicon for the flow of the electrons. And thus this flow of electrons is nothing but the electricity.

The main problem arises in the conversion is that it depends on the solar radiation intensity. As the solar radiation intensity increases the output electricity increases and as the solar radiation decreases the output electricity decreases. The constant output has to be stored/ supplied for the appliances as it can't fluctuate the condition of the appliances to work with. In order to overcome this situation, the constant output has to be supplied for the electronics items to work. In order to do this algorithm has to be implemented in order to obtain the constant output from the PV panels i.e. Photovoltaic Panels. The output which has to be obtained from the PV panels not only be constant but also produce the maximum output which is required for the requirement. Maximum Power Point Tracking algorithm is the one which is popular and advantageous algorithm for obtaining the maximum output.

Maximum Power Point Tracking Incremental Conductance is an algorithm used to obtain the maximum peak power voltage from solar array Photo Voltaic panel which is affected by the factors of the solar radiance intensity, solar temperature and the load which is connected to it. This MPPT Incremental Conductance based algorithm is developed in order to obtain the maximum power rate all the time and to maintain the constant output to the requirement.

II. PV CELL WORKING

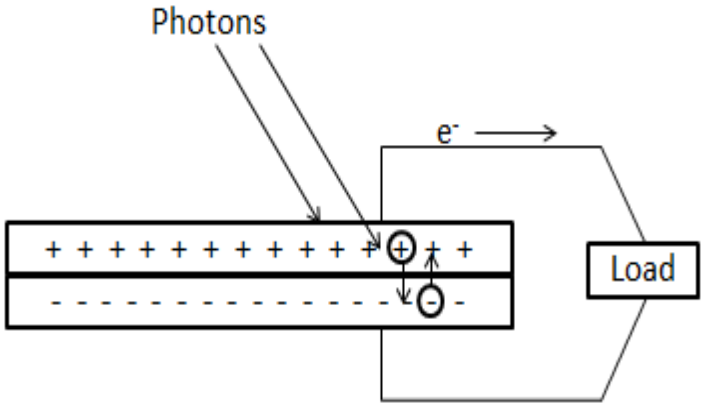

Fig1: PV Cell Working

PV Cell is made up of thin wafer with the ultrathin layer of N-type Phosphorus on which the thicker layer of P-type Boron. This N-type and P-type layers forms the P-N junction. At the atomic level there is a direct conversion of the solar radiation into electric power. The property of the photoelectric effect is responsible for this conversion of the solar radiation into electricity. This effects release the electrons by absorbing the photons present in the light, resulting in the flow of electrons i.e. current flow.

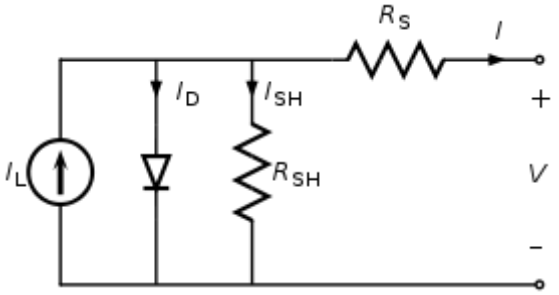

Fig2: Photovoltaic Cell Circuit

The I-V Characteristics of the PV Cell Circuit is given by

$$I = I_L - I_o\left\{\exp\left[\frac{V + IR_S}{nV_T}\right] - 1\right\} - \left\{\frac{V + IR_S}{R_{SH}}\right\}$$

Where,
I is Output Current obtained, IL is Photovoltaic Cell generated current, Io is Reverse Saturation Current obtained, V is Output Voltage, Rs is Series Resistance, n is ideal Diode factor, VT is Thermal Voltage, RSH is the shunt Resistance.

Dependence of the output power on the solar radiation intensity and on the temperature is a shown below in the graphs.
As the solar radiation intensity increases, at the certain point the power goes on increasing i.e. solar radiation intensity is directly proportional to the produced power output.

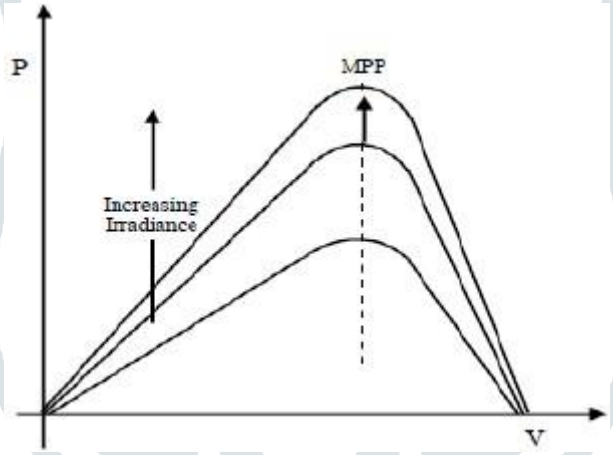

Fig3: Dependence of solar radiation intensity on the output power

As the solar radiation temperature increases, at the certain point the power goes on decreasing i.e. solar radiation temperature is inversely proportional to the produced power output.

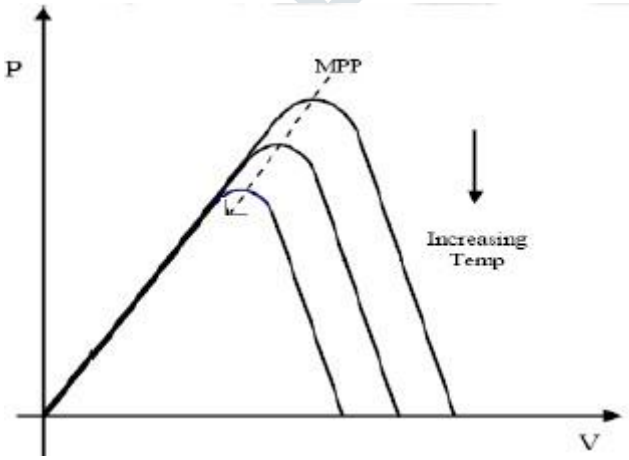

Fig4: Dependence of solar radiation temperature on the output power

III. MPPT INCREMENTAL CONDUCTANCE ALGORITHM

There are different types of algorithms present to obtain the maximum power from the PV array module. Here we are making use of the MPPT Incremental Conductance algorithm to obtain the maximum power from the module.

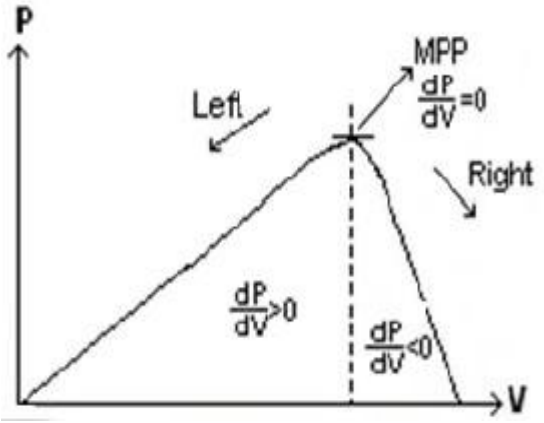

Fig5: Basic Power versus Voltage curve for the MPPT Incremental Conductance Algorithm

From the graph we can infer that power curve is equal to 0 at MPP and as we move towards left from MPP it becomes positive i.e. greater than 0 and as we move towards right from the MPP it becomes negative i.e. lesser than 0. This can be written in equations as:
At MPP:

$$\frac{dI}{dV} = -\frac{I}{V}$$

At Left of MPP:

$$\frac{dI}{dV} > -\frac{I}{V}$$

At Right of MPP:

$$\frac{dI}{dV} < -\frac{I}{V}$$

From this we can come to conclusion that whenever the derivative of the current to the voltage becomes zero the Maximum power can be obtained.

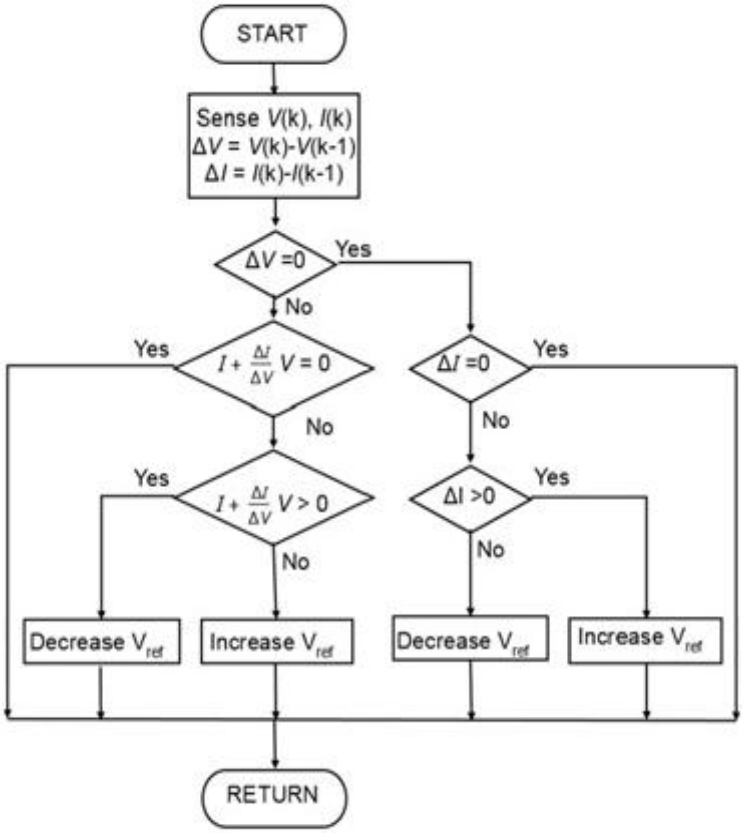

Fig6: Flow chart of MPPT Incremental Conductance Algorithm.

The flow starts with the sensing of the voltage and the current from the solar panel. After sensing the voltage, the condition is checked whether there is difference in voltage and the difference or slight change in the current and if there is no difference then the condition equations are checked. If it satisfies then reference voltage variation is done in order to the high power point.

IV. BLOCK DIAGRAM

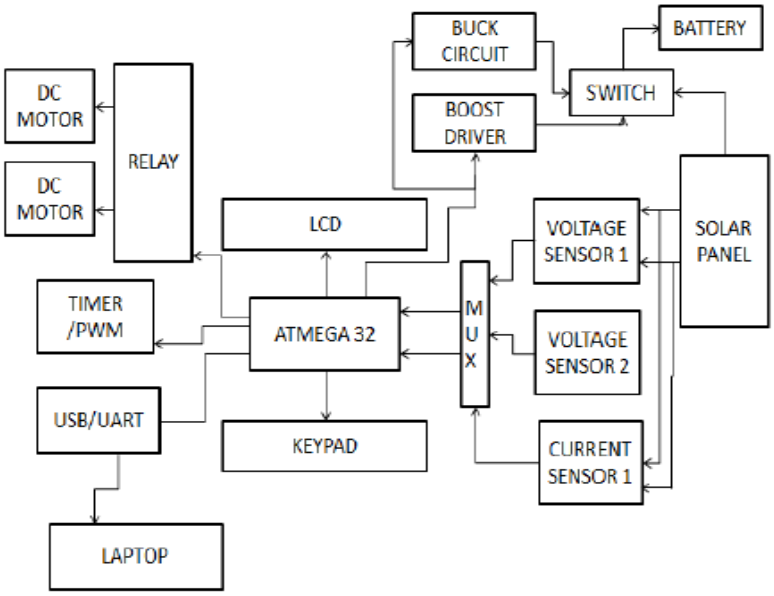

Fig7: Block diagram

The block diagram of the proposed project is as shown above.

V. HARWARE AND SOFTWARE USED

I. HARDWARE USED

Solar Panel: Solar Panel consists of array of PV cell, one which is responsible for the conversion of the solar energy into electrical energy. It is of 20W power in the sense the power of 20W electricity can be produced from that Panel.

Voltage Sensor: Voltage sensor is the one which is used to measure the voltage**.** Here two voltage sensors are used. One is used to measure the voltage of the solar panel another is used to measure the voltage of rechargeable battery.

Current Sensor: Current sensor (ACS712) is the one which is used to sense the current produced from the solar panel.

Buck Boost Converter: Buck Boost converter is also called as DC to DC converter which is used to step up or step down the voltage produced from the solar panel to recharge the rechargeable battery.

Microcontroller: Microcontroller ATMEGA32 is used here. Microcontroller is the device which is used to control the entire module through the program dumped into it.

Rechargeable Battery: Rechargeable battery is the one which is used to charge the electric power produced from the solar panel.

Relay: Relay is the electromechanical switch which is used to turn on or off the circuit and to control the voltage or the current and protects, handle the microcontroller and the other circuit.

Motor: Motor is the device used for the robotic purpose. The motor used here is 60rpm, 12V and 120mA specification.

Motor Driver: Motor Driver is used to drive the motor here since the current produced varying need to drive the motor. Motor driver used here is L298.

II. SOFTWARE USED

AVR Studio: AVR Studio is the software which is used implement the Embedded C program in order perform the action and algorithm which is required for the actions to perform in the module and this program is dumped into the microcontroller.

LabVIEW: LabVIEW used here in order to interpret the results, which is produced from the microcontroller to the laptop.

VI. METHODOLOGY

The detailed block diagram of the MPPT robot system is as shown in the fig above. As the solar radiation incidents on the solar PV panel module. The solar PV panel module converts the solar radiation into the electric power output. This electric power output which is produced will be varying as the incident intensity of the solar radiation varies with the time. At a time, the solar radiation intensity will be more sometimes less. Based on this the power output is obtained but what we need is the maximum power output all the time. For obtaining maximum power irrespective of the time and for the better utilization of the power generated by the PV module Incremental conductance MPPT method is used. This method checks the output of the PV module compares it with the battery voltage then fixes it. The mechanism is based on the principle of Impedance matching between load i.e. robot battery and Solar panel which is necessary for maximum power transfer. The impedance matching is done using DC to DC converter which in turn is controlled by Controller. This DC to DC converter is also called as the buck boost converter since it reduces the power output obtained from the PV module and recharges the battery and the another task done by it is the boosting of the low power obtained from the PV module i.e. it steps up or steps down the source voltage from the solar panel depending on the output controller. The algorithm used in the controller is to track the maximum power point based on the Incremental Conductance method. The Incremental Conductance method utilizes the concept of Incremental increase of source voltage from the solar panel. In which the slope, the solar power become zero at maximum power and stays at positive value below this point and negative value above this point.

The two voltage sensors used in this module is to record/sense the voltage that is obtained from the solar panel and that maximum power output that is recharged in the rechargeable battery. The output from the Solar PV module and from the battery is shown through the graphs of the Lab View.

VII. RESULTS

The proposed model setup is shown in the below diagram.

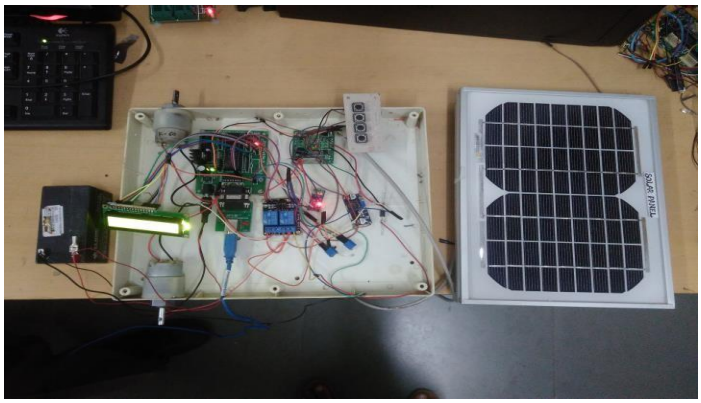

Fig8: Module Complete Setup

The LCD display of the voltage produced from the solar panel and boosted voltage which charged the battery.

Fig9: LCD Display of the Voltages Produced.

Voltage amplitude Output can be seen through the LabVIEW. The LabVIEW display front panel is shown in the fig below.

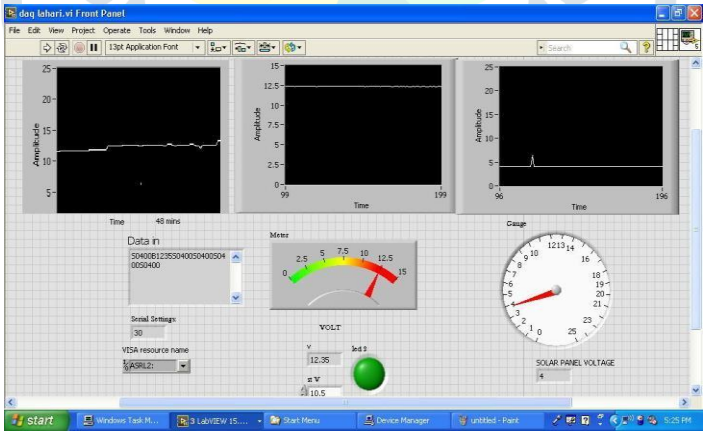

Fig10: LabVIEW Front Panel Screen of Output.

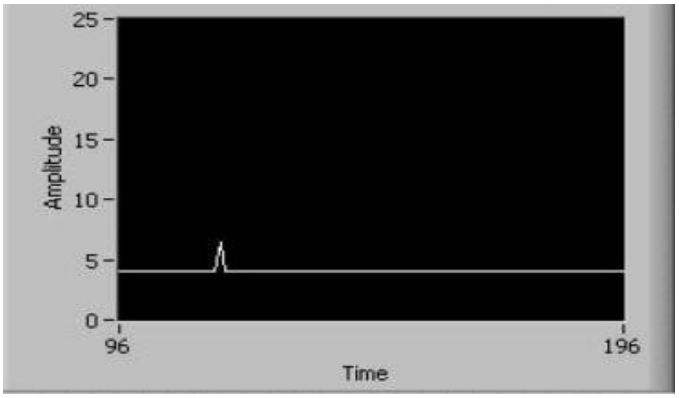

Fig11: Voltage Amplitude produced without MPPT Incremental Conductance Algorithm.

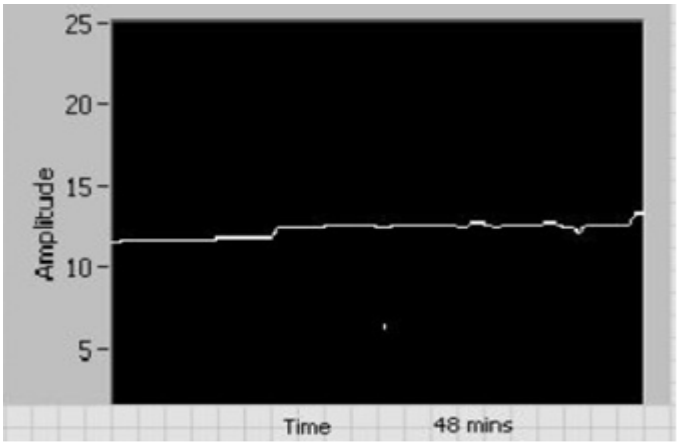

Fig12: Voltage Amplitude Produced from Solar panel with MPPT Incremental Conductance Algorithm.

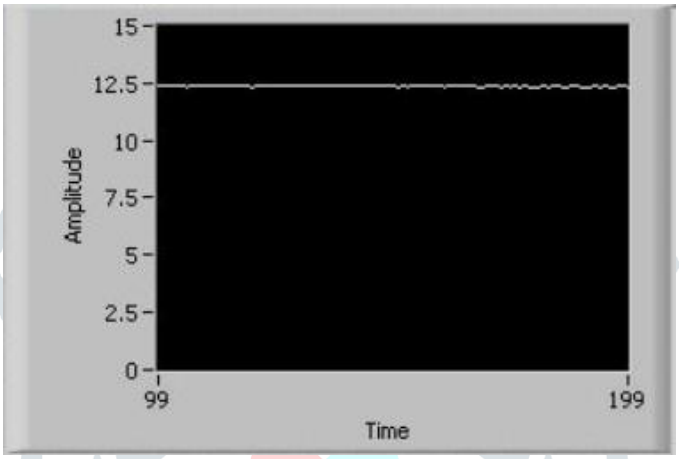

Fig13: Voltage Amplitude stored in battery and used for Robotic Motor Control.

VIII. CONCLUSION AND FUTURE ENHANCEMENT

From this it can be concluded that by using the MPPT Incremental Conductance Algorithm the power that can be obtained maximum irrespective of the solar radiation intensity and the temperature at any point of time. The future enhancement of this can be done for the getting the power even from the visible light with the lower power (Watts) and run the application module.

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