MODIFIED SOLAR CHARGE CONTROLLER DESIGN

DADAVALI S.P

Assistant Professor, Govt. First Grade College, Kengeri, Bangalore-560060

***

***Abstract*--**A Solar charge controller is a device needed for monitoring and controlling the charging of battery bank connected to PV modules. Main function of Solar charge controller is to limit the rate at which electric current is added to or drawn from batteries. It prevents overcharging and may protect against over voltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The term "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack. Solar charge controller provides a specific voltage required by battery. A basic charge controller simply performs the necessary function of ensuring that your batteries cannot be damaged by over-charging, effectively cutting off the current from the PV panels (or reducing it to a pulse) when the battery voltage reaches a certain level. A Maximum Power Point Tracker controller performs an extra function to improve your system efficiency.

Index terms—Maximum power point tracking (MPPT), Photo-voltaic Array (PV Array)

I. INTRODUCTION

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery charger. Charge controllers are sold to consumers as separate devices, often in conjunction with solar or power generators, for uses such as RV, boat, and off-the-grid home battery storage systems. In solar applications, charge controllers may also be called solar regulators. Some charge controllers / solar regulators have additional features, such as a low voltage disconnect (LVD), a separate circuit which powers down the load when the batteries become overly discharged (some battery chemistries are such that over-discharge can ruin the battery). A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full. Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Pulse width modulation (PWM) and maximum power point tracker (MPPT) technologies are more electronically sophisticated, adjusting charging rates depending on the battery's level, to allow charging closer to its maximum capacity. A charge controller with MPPT capability frees the system designer from closely matching available PV voltage to battery voltage. Considerable efficiency gains can be achieved, particularly when the PV array is located at some distance from the battery. By way of example, a 150-volt PV array connected to an MPPT charge controller can be used to charge a 24- or 48-volt battery. Higher array voltage means lower array current, so the savings in wiring costs can more than pay for the controller. Charge controllers may also monitor battery temperature to prevent overheating. Some charge controller systems also display data; transmit data to remote displays, and data logging to track electric flow over time. Solar charge controller has three basic functions:

1. To limit the voltage from the solar panel and regulate the same so as not to overcharge the battery.

2. Do not allow the battery to get into deep discharge mode while dc loads are used.

3. To allow different dc loads to be used and supply appropriate voltage.

II. SOLAR CELL CIRCUIT

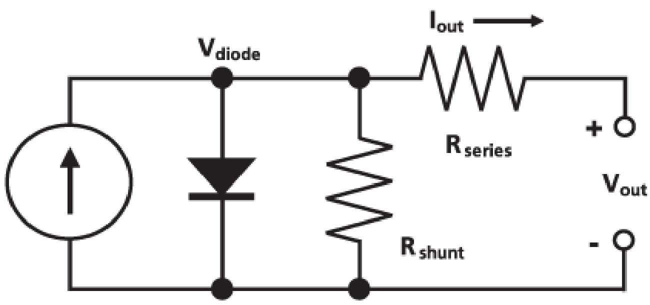

Fig.1: Solar Cell Equivalent Circuit

A photovoltaic array consists of several photovoltaic cells connected in series and parallel. Series connections are responsible for increasing the voltage of the module whereas parallel connections are responsible for increasing the currentin the array. Typically, a solar cell can be modelled by a current source and an inverted diode connected in parallel to it.

III. MPPT POWER TRACKING

Maximum power point tracking (MPPT) is a technique that charge controllers use for wind turbines and photovoltaic (PV) solar systems to maximize power output. PV solar systems exist in several different configurations[1]. The most basic version sends power from collector panels directly to the DC-AC inverter and from there directly to the electrical grid. A second version, called a hybrid inverter, might split the power at the inverter, where a percentage of the power goes to the grid and the remainder goes to a battery bank. The third version is not connected at all to the grid but employs a dedicated PV inverter that features the MPPT. In this configuration, power flows directly to a battery bank. A variation on these configurations is that instead of only one single inverter, micro inverters are deployed, one for each PV panel. This allegedly increases PV solar efficiency by up to 20%. New MPPT equipped specialty inverters now exist that serve three functions: grid-connecting wind power as well as PV, and branching off power for battery charging.

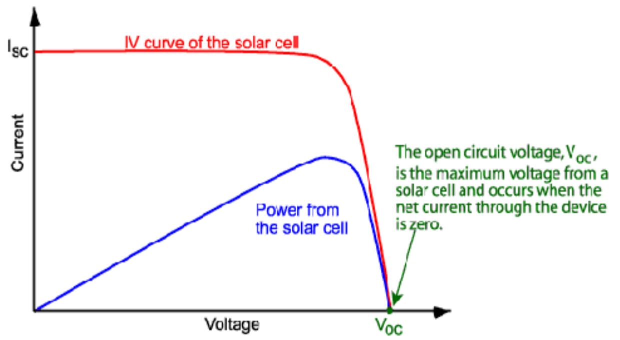

Fig.2: Solar Panel Voltage/Current Characteristics

IV. BLOCK DIAGRAM OF SOLAR SYSTEM

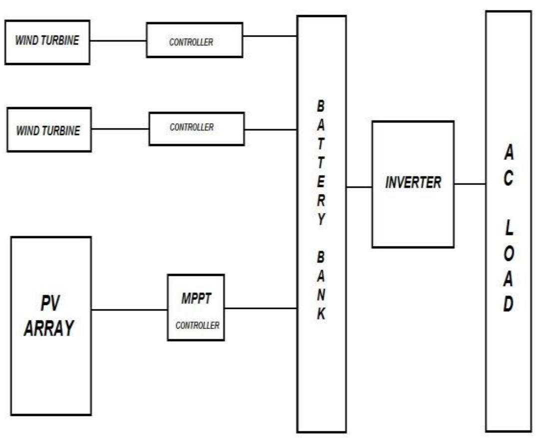

Fig.3: charge controller for AC system

1. PV Array

Solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. There are different types of solar panels available but the two most popular technologies used in today's solar energy market are silicon, which is consider a first-generation technology and thin film which is a second-generation technology.

2. Battery

The batteries used in photovoltaic MPPT charge controller served as a way to store energy so that devices can be powered in the event that the sun is not shining and when

More power is needed than can be provided by the solar arrays at a given time. The battery bank should provide a large energy capacity, run at 12V, and provide a large output current to handle high power loads.

3. Inverter

The inverter is the final stage of the system. It is through the inverter that the user has the opportunity to access the power stored in the batteries that was originally generated in the solar panel. The main functionality of the inverter is to take the DC voltage stored in the batteries and transform it into AC voltage that can be used by small household appliances or sent to grid for commercial purpose.

4. MPPT Controller

"Maximum Power Point Tracking" as used in solar electric charge controllers. A MPPT, or maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid.

V. DESIGN OF SOLAR CHARGE CONTROLLER

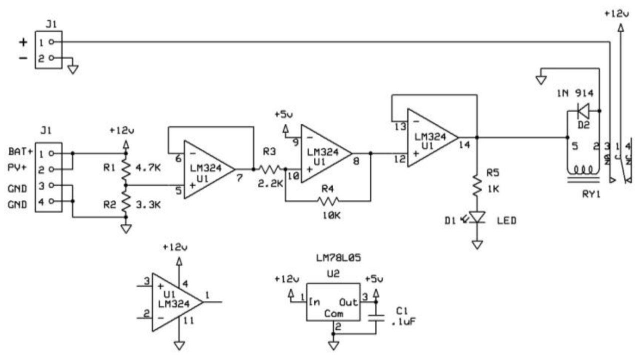

Fig.4: Circuit which protect battery from getting over-drained.

In the circuit shown above, for the voltage divider R1 and R2 of values 4.7k and 3.3k is used. Voltage at 3.3k is used as input to LM324 IC which is configured as voltage follower, output from which is used as input in Voltage comparator at 2^{nd} IC (LM324). If battery is over draining then voltage at 3.3k falls low, and hence input to the voltage comparator will fall below 5V, and hence output load is disconnected and hence over draining of battery is avoided.

Voltage divider:

Current through resistor 4.7k and 3.3k

Current = 12 / (4.7+3.3) k

⇨ 1.5mA

Hence voltage at 3.3k resistor is,

V=1.5mA * 3.3K

⇨ 4.95V

Using voltage follower, the input to the comparator circuit will be 5V,

Comparator logic;

If 5V at pin 10 then output will be HIGH

If < 5V at pin 10 then output will be LOW

Current through LED,

Current through led= 5 / 1k

⇨ 3mA

Relay logic,

If pin 14 is HIGH, then relay is ON

If pin 14 is LOW, then relay is OFF

VI. WORKING

When solar radiations falls on the solar cell, due to photoelectric effect, charge is induced in cell, many such cells are arranged in series to increase the voltage, when required voltage is reached, each of such array are arranged in parallel to increase the current their by increasing the total power output from the solar panel. A voltmeter is connected in parallel to solar panel to mark the voltage which measures about 12-15V, and an ammeter is used for reading the total current flow from the panel which seems to be around 200mA to 1.5A. Solar charge controller is used for charging up the battery from panel power, the output is also derived from solar charge controller itself, the maximum current delivered varies from one charger to another, standard voltage rating of a solar charging are 12V, 24V, 48V. When battery is completely charged, solar charger stops charging battery. In module we used a solar charger that can produce a maximum of 10A output current, above which the fuse burns. Charge controller will limit the voltage from panel to battery and restrict it to 12 V which is the nominal voltage for battery charge, when solar radiation is high, voltage from panel will increase but due to Buck-boost converter in the MPPT charger excess voltage will be trimmed-off, and hence protect battery from getting damaged. MPPT charge controller also avoids battery from getting over-drained. Over-drain of charges from battery results in loss of charging ability. And hence battery over draining should be avoided. Fig 8 represents the circuit, which avoids battery from over-drain of charge.

VII. RESULT

Results are obtained for solar charge controller circuit by simulation using NI multi-sim. When battery voltage is above 11v, the charge controller circuit will allow a load to take up charge from the battery. When battery voltage is below 11v, the charge controller disconnects a load from battery.

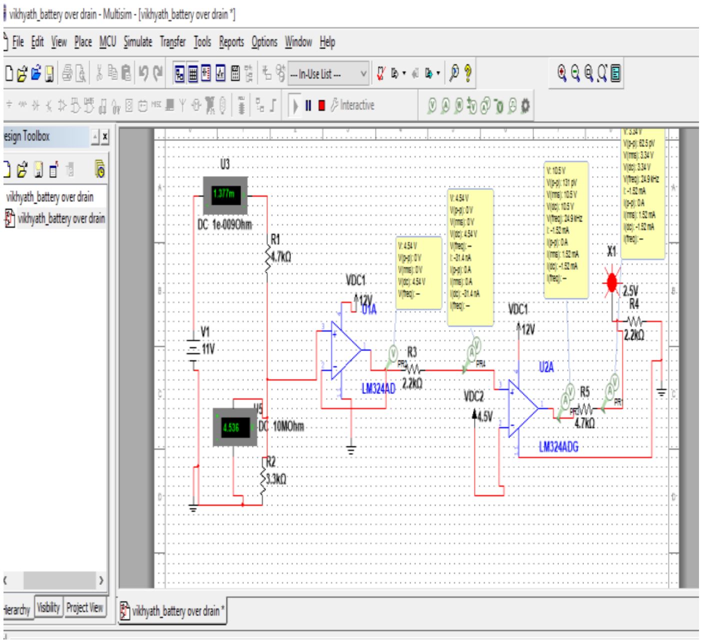

Fig.5: When load connected to battery

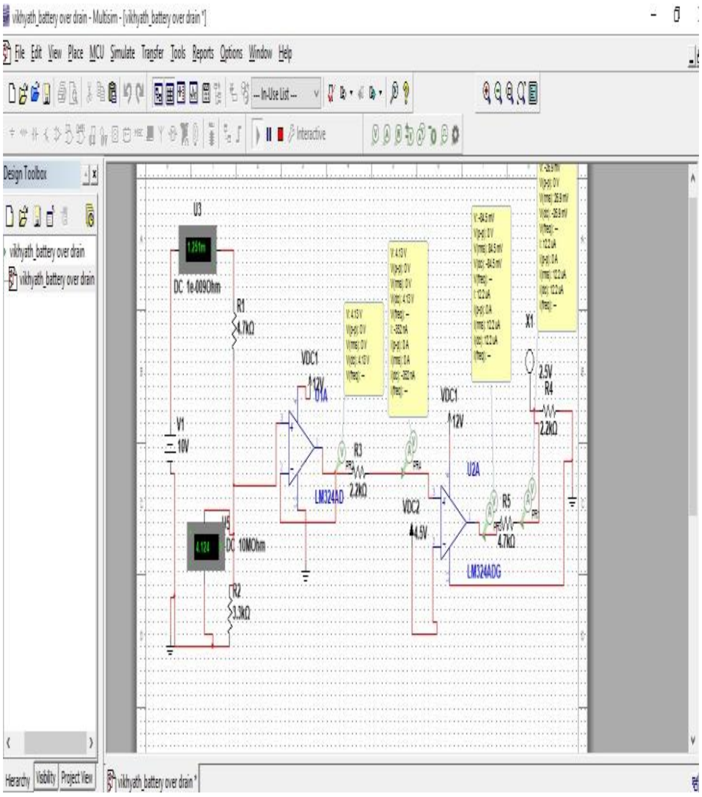

Fig.6: When load disconnected from battery

DC source acts as battery source; DC source is varied to represent variation in battery voltage. LM324 is used for comparator and voltage follower, in follower circuit i/p voltage is outputted as it is, and is used as input for comparing with reference voltage at second LM324 comparator. If battery voltage falls below 10.9V, voltage at 3.3k falls to 4.34V and hence when compared to 4.5V, the output is turned off. Output can be connected to relay for controlling AC devices.

VIII. CONCLUSION

In existing PWM solar charger controller, PV panel is connected to battery directly, so that if any increase in voltage happens it will directly affect battery by charging it with higher than nominal voltage. The newly designed solar charger will reduce battery damage chances, by not letting the panel to supply whatever voltage comes from it, and not allowing the load (AC or DC) to completely drain out the charges from battery, and hence avoid battery from entering dead state wherein which it lacks ability to recharge. Remote and Rural village Electrification & domestic lighting applications. By installing a solar system in house reduces the cost of electricity, and if solar radiation is high (which is true for Karnataka)can even earn money by supplying excess generated energy to grid.

IX. REFERENCES

[1]S. M. Çinar and E. Akarslan ,—On the Design of an IntelligentBattery Charge Controller for PV Panels|| ,Electrical EngineeringDepartment, University of AfyonKocatepe, Afyonkarahisar, Turkey,October 2012.

[2]Patil A.R, Atar K.D, Potdar A.A, Mudholkar R.R —Embedded fuzzymodule for battery charger control||, International Journal ofAdvanced Research in Electrical, Electronics and InstrumentationEngineering, Vol.2, Issue 8, August 2013..

[3] J.H.Lee, Student Member, IEEE, H.S.Bae, Student Member, IEEE,and B.H.Cho, Senior Member, IEEE —Resistive control for aphotovoltaic battery charging system using a microcontroller||, IEEETRANSACTIONS ON INDUSTRIAL ELECTRONICS, VIL.55,NO.7,JULY 2008.

[4] O P.Sathya, Dr.R.Natarajan, — Design and implementation of12V/24V closed loop boost converter for solar powered Led lightingsystem||, International Journal of Engineering and Technology (IJET), Vol 5 no-1,Feb-March 2013.

[5] Geeta Laxmanrao Kale, N.N. Shinde — Implementation of prototypedevice-off grid-charge controller-suitable for wind solar hybrid||,department of energy technology, Shivaji University, India.

[6] Mohd Tariq, Sagar Bhardwaj, MohdRashid,|| Effective batterycharging system by solar energy using c programming andmicrocontroller||, American Journal of Electrical Power and EnergySystems,2013;2(2):41-43.

[7] M.A.S.Masoum, S.M Mosavi, and E.F.Fuchs,||Microprocessorcontrollednew class of optimal battery chargers for photovoltaic applications, ||IEEETrans. Energy Convers.,vol.19,no.3, pp.599606,Sep.2004.