Designing and Performance Analysis for Monitoring and Management of Solar PV Battery

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Abstract - **Solar photovoltaic system consist of various electrical components e.g. Solar modules, Inverter, Battery, Switchgear, Cables & Wires etc. Battery is one of the expensive and important components among others. Maintaining the lifecycle of the battery is very much crucial task, which can be done using battery monitoring and management system. In this project we are going to use Lithium ion battery, which is known for its longer life and high charge density. The monitoring of the Lithium ion battery will be done by continuous charging current monitoring and charging percentage monitoring. The charging and discharging current will be controlled in order maintain the temperature of the battery. Temperature will be checked and monitored using high accuracy digital Temperature sensor and Microcontroller. Based on the state of charge, loads will be made ON and OFF using Electromechanical Relays based on its priority. In addition to battery monitoring and management we will be implementing Manual and Automatic IV plotting of Solar Modules with Sun Tracking Mechanism using Actuator and Microcontroller. The successful hardware implementation shows the actual idea of proposed system.**

keywords - **Solar PV, Battery Management System, Lithium ion battery, Energy Storage System**

I. INTRODUCTION

We know that for generation of electricity, Coal& Oil play vital role to provide energy as per demand. Due to this drastic usage of conventional resources and by burning of these fossil fuels leading to emission of harmful gasses like CO2 into atmosphere causing greenhouse effect. It can be decrease by using renewable energy sources. Renewable sources are clean with low environmental impact than the conventional energy source. Solar energy photo voltaic (PV) technologies have enormous growth over the past years.

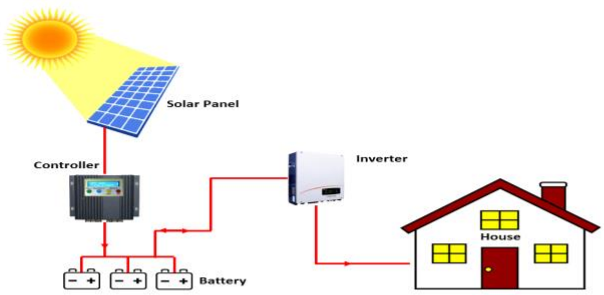


Figure 1: Diagram of complete solar PV energy system

The solar PV cell convert solar energy obtain by sunlight into electric energy. The produced power we can store, use legitimately for self-utilization or is taken care of into huge power frameworks. Therefore energy storage system is most important for balancing and managing system. Among different ESS technologies, batteries are the main storage technologies commonly used in PV systems. Due to different outputs at different period of the day from solar panel, different problems may occur in the case of solar battery. So that it is necessary to do better monitoring and management of solar PV batteries by considering different factors. In this paper we discussed about designing and analysis for monitoring and management of solar PV batteries.

II. ENERGY STORAGE

In photovoltaic system there are many technologies are utilized. According to new research ultra capacitors are use as a energy storage for photovoltaic systems. Battery innovations despite everything remains the most popular choice. There are two types of batteries which are used in solar PV system in recent trends.

(1) Lead acid battery

Three different form of lead acid batteries are currently available; these include the flooded lead acid battery and two low maintenance types, gelled electrolyte sealed lead acid and sealed absorbed glass mat (AGM) lead acid batteries.

a) Flooded lead acid battery:

It is wet cell battery filled with electrolyte, which is optimal for medium to large capacity off-grid power use.

b) Gelled Electrolyte Sealed Lead-Acid battery:

It is sealed lead acid battery that use silica gel in which electrolyte is suspended. It is optimal for most deep cycle applications.

c) Sealed Absorbed Glass Mat Lead-Acid battery:

It is sealed lead acid battery in which electrolyte is held in thin glass mat. It is most appropriate for backup applications with inconsistent deep discharges.

(2) Lithium Ion Battery:
Li-ion battery is a rechargeable battery in which lithium particles move from the negative terminal to the positive cathode during release and back while charging.

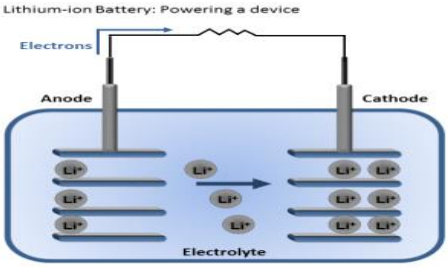


Fig: Lithim ion battery

Li-ion batteries are lighter & more compact than lead acid batteries. Also it has higher DOD and long life span as compare to lead acid battery. But somewhat it is expensive than all types of batteries**.** The energy density of Li-ion battery is higher than others. Load characteristics of this battery is good. In discharge point of view, it acts similarly like Nickel Cadmium. Li-ion battery has low maintenance. Also Li-ion cell cause less harm when disposed. Memory and scheduled cycling is not required to increasing the battery life.

III. BATTERY MANAGEMENT SYSTEM (BMS):
Block diagram:

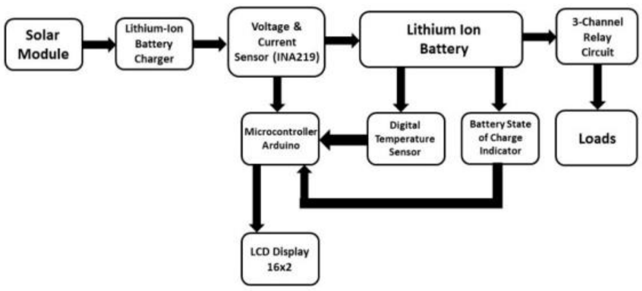


Figure2: Block diagram of BMS

IV. SYSTEM OVERVIEW:
(1).Specifications:
Solar Module:
Solar Module is a source of energy, which generates DC power using Photovoltaic effect. Solar Module is formed after connecting multiple solar cells in Series. Solar Cells are connected in series to form desired voltage. In this project 20W x 2 Poly/Mono Solar Modules will be used in order to charge Lithium Ion Battery. These two Solar Modules will be placed on MS structure with Tracking Mechanism in order to change the Tilt angle and Azimuth angle.

Lithium Ion Battery:

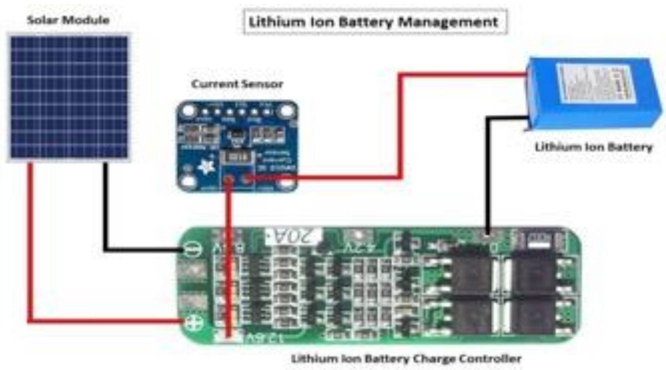


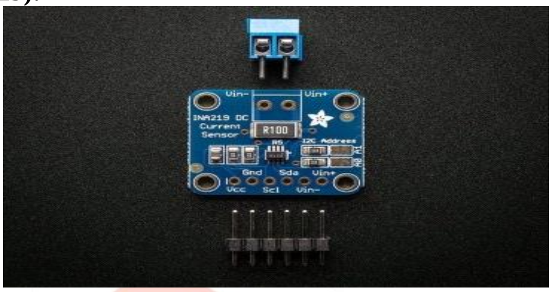
Figure3: Li-ion BMS

A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry. During a discharge cycle, lithium particles in the anode are ionized and isolated from their electrons. The lithium particles move from the anode and go through the electrolyte until they arrive at the cathode, where they recombine with their electrons and electrically neutralize. The lithium particles are sufficiently little to have the option to travel through a small scale porous separator between the anode and cathode. To a limited extent in view of lithium's little size (third just to hydrogen and helium), Li-ion batteries are fit of having an exceptionally very high voltage and charge storage per unit mass and unit volume. The functional block diagram of system is as shown in figure3.

Lithium Ion Battery Charger:

Right now will assemble a two stage Battery charger (CC and CV) that could be utilized as to charge Lithium ion or lithium polymer batteries. The battery charger circuit is intended for 12V lithium battery pack (four 18650 in Series) which we usually use in many robotics project but the circuit can be effortlessly changed to fit in lower or marginally higher battery Packs like to construct 3.7 lithium battery charger or 12v lithium ion battery Charger. As we know there are instant Chargers accessible for these batteries, yet those that are inexpensive are very slow and those that are fast are very expensive.

Voltage and Current Sensor (INA219):

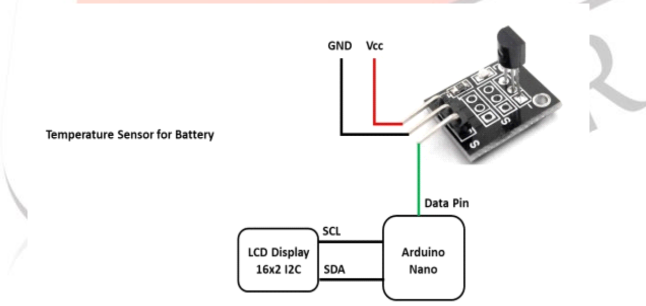


Most current-estimating gadgets, for example our current panel meter are just useful for low side estimating. That implies that aside from on the off chance that you have to get battery included, you have to stick the estimation resistor between the target ground and genuine ground. In the event that the voltage drop over the resistor is relative to the current draw, this utilizes the ground reference will change with fluctuating current. The INA219 chip is lot more brilliant - it can deal with high side current estimating, up to +26VDC, despite the fact that it is controlled with 3 or 5 v.

Battery State of Charge Indicator:

There are few different ways to get Lithium-Ion State of Charge (SoC) estimation or Depth of Discharge (DoD) for a lithium battery. Few strategies are very muddled to implement and require complex gear. SoC estimation using Open Circuit Voltage Method (OCV). All types of batteries make them thing in like manner: the voltage at their terminals decreases or increases relying upon their charge level. When the battery is fully charged, voltage will be highest and lowest when it is empty. This relation between voltage and SOC depends straightforwardly upon the battery innovations utilized.

Temperature Sensor:



The DS18B20 is a 1-wire Temperature sensor which is programmable from maxim integrated. It is broadly used to measure temperature in hard situations like in mines or soil etc. The chocking of the sensor is rough and furthermore bought with a waterproof option making the mounting procedure simple. It can measure a wide range of temperature from -55°C to +125° with a decent accuracy of ±5°C. Every sensor has a unique address and requires one pin of the MCU to transfer data so it an awesome decision for estimating temperature at numerous points without compromising of your digital pins on the microcontroller. This Temperature sensor is used to Monitor the temperature of the Lithium Ion Battery.

Arduino Uno:

Arduino is an open-source gadgets which is easy to utilizing and programming. Arduino Uno has total 14 pins, from which 6 pins provide PWM output and 6 pins provides analog inputs. Instructions as well as programming is fed through portable drive. For this you can use the programming language and the Software (IDE) arguing.

Relay Circuit:

In this project, three channel relay circuit will be implemented, which will be used to control the load based on battery state of charge. Loads will be made ON and OFF based on the priority.

LCD Display:

In order to monitor the battery voltage & current and Temperature, 16x2 LCD displays are used. Arduino Microcontroller will be used for measurement and display.

(2).Forecasting of State of Charge of Battery:

The forecasting of the batteries SoC (State of Charge) is important part of system. There are some techniques for estimating SoC. These methods can be applied for all types of battery system. Coulomb counting method is chosen for calculating SoC.

This is most common technique for estimation of SoC and it utilizes battery current perusing numerically integrated over the use time frame to figure SoC values given as below

$$SoC = SoC(t_0) + \frac{1}{C_{rated}} \int_{t_0}^{t_0+\tau} (I_b - I_{loss})\, dt$$

Where = initial SoC, = rated capacity, = battery current and = current consumed by loss reaction.

The coulomb counting method then compute remaining limit by collecting charge move in or out of the battery. Accurate operation of this method first estimate initial SoC. The SoC of battery can be determined by coordinating the charging and discharging currents over the working time frame.

V. METHODOLOGY:

(1) Depending upon load (Priority based operation):

In this case, first we measures voltage and current of the system then we go for checking load means what is load conditions right now in our system. If we have two loads in our system, among which one is our regular load and other is emergency load. When emergency conditions occur in the system, then regular load is automatically cut down and only emergency load remains ON. So that by considering priority of load, We can manage battery operation.

(2) Depending upon Atmospheric conditions:

We know that atmospheric conditions, especially temperature highly affects on life of battery. So that it is necessary to protect battery from high temperature and atmospheric conditions by using Battery management system (BMS). If atmospheric conditions are not suited for our battery then using different sensors like temperature sensor, humidity sensor environmental condition get monitored battery automatically shut down.

(3) Protection against overcharging:

Sometimes even battery gets fully charged but solar panels still provides continuous input to the battery, which is unnecessary. If a better BMS is not there then it cause swelling of the battery. Also some other adverse effect on the battery. The BMS continuously check battery voltage and when battery charged up to its specified level, then input voltage, charging current automatically cut down.

(4) Protection against deep discharge:

Sometimes charging of a battery gets stopped in system but load continuously ON. In this condition battery leads to deep discharge. In this case, charge controller gives signal to the system for cut down the load. By using signal from charge controller, system load instantly cut down and battery remains safe and protected from the deep discharge.

VI. CONCLUSION:

This paper has shows designing, monitoring and management of Solar PV Li-ion battery. SoC is Estimated by using Coulomb counting method. The battery management technology will play major role in reliable and economic operation of the solar PV system. The cost of the electricity was decreases or maintain constant by using battery management system, thereby improving life of the battery. The system is design in order to regulate power and voltage. Also reduce the fluctuation in the system. The varying atmospheric conditions can tends to battery left in state of overcharge or deep discharge both these conditions of the battery have adverse effect on lifespan of the battery. The BMS will utilize charge controllers to enable maximum safety to the solar panel to be deliver to the battery.

VII. REFERENCE:

[1] Namani Rakesh. , T. Santosh. , Udugula Malavya. , D. Rishikesh. ; "Battery Management System for Solar PV Panel." Int. Conf. on Innovative mechanism for industry application (ICIMIA 2017).
[2] Waleed Obaid. , Abdul-Kaddir Hamid,Chaouki Ghenai. ; "Hybrid PEM Fuel-Cell-Diesel-Solar Power System Design with Fussy Battery Management System and Weather Forecasting for Electrical Boats; (2018)".
[3] Sailen Nair. , William Becerra Gonzalez. , James Braid. ; "Battery Monitoring and Energy Forecasting for an Off-Grid Solar Photovoltaic Installation," 2019 SAUPE/RobMech/PRASA Conference Bloemfontein, South Africa, January 28-30, 2019
[4] Mamoona Khalid. , Abdul Kashif Janjua., Hassan Abdullah Khalid. ; "Effect of PV panel orientation on Battery in a Solar Generation System. "; 4th International Conference on Power Generation Systems and Renewable Energy Technologies (PGSRET) Sept 10-12, 2018, Islamabad, Pakistan.
5] Mayuri Upsani. , Prof. Sangita Patil. ; "Grid Connected Solar Photovoltaic System with Battery Storage for Energy Management."; Proceedings of the Second International Conference on Inventive Systems and Control (ICISC 2018).
[6] Shengyong Liu Xing Zhang. , Hai bin Guo. , Jun xie. ; "Multiport DC/DC Converter for Stand-alone Photovoltaic Lighting System with Battery Storage."; Int. Conf. on Electrical and Control Engineering, vol.5 No. 2. PP. 3894-3897, June 2010.