ANALYSIS AND CHARGE CONTROL OF LITHIUM ION BATTERY WITH APPLICATION FOR OFF-GRID PV SYSTEM

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Abstract. For the implementation of the PV micro grid, initially we designed the PV module. Once the PV module is designed we then decided to use P&O technique as an MPPT technique. The output pulse of the MPPT technique is then fed to the boost converter as gate pulse. The output of PV with dc to dc converter is then fed to DC grid from where the 3-phase Inverter with LC filter which converts the DC to 3-phase AC system and then is fed to load. Also the battery system with bidirectional controller is followed by a charge controller is also connected to DC micro grid so that the battery can charge or discharge as per the application.

1. Introduction
Initially we studied about the lithium ion battery. For better understanding we purchased a 3.7V 18650 INR LI-ION battery and with the help of CH-Instrument we analyzed its characteristics. Then for the charge control of the lithium ion battery we studied about the bidirectional converter from which we had idea on how the battery will charge and discharge with respect to the converter. Once this is cleared then we were focused on the practical implementation of bidirectional converter so we decided to design and analyze the off-grid PV Micro grid where we used PV to feed the load. The real use of bidirectional converter was needed so that the power from PV can be fed to load along with charging the battery with respect to the charge controller and also to let battery discharge when PV alone cannot meet the load demand.

2. MATLAB analysis of Lithium-Ion Battery
In the Simulink model it consists of a controlled temperature sensor which helps to maintain the controlled temperature difference regardless of heat flow rate. Then the block is followed by Convective heat transfer block. Then it consists of the lithium cell of 1 RC which means the Thevenin’s model if battery with one resistor and one capacitor. Then the blocks are voltage and current sensors. In this block the input is temperature and Currents. The Simulink model [1] is shown below at Figure 1.

![Figure 1. Simulink Model of Lithium Ion Battery](image-url)
3. Bidirectional Converter

The bidirectional converter [2] in the Simulink was created with the help of a DC source and two Mosfets where the mosfet gates were fed by Pulse Generator and Not gate to feed individual gate pulse where by changing the duty cycle we can observe the charging and discharging cycle of the battery along with the State of charge of battery and the voltage response for both charging and discharging modes. For this analysis we set the state of charge of the battery to 50 and the voltage to 24V. The outputs were observed for.

(i) STATE OF CHARGE

(ii) VOLTAGE

(iii) CURRENT

The Simulink block is shown below at Figure 2.

4. PV Grid

For the Simulation of the PV grid, initially the PV module was designed with the inclusion of the MPPT technique and Boost converter as described in the block diagram. After the designing of the PV cell we then designed the battery management system [4] with the help of bidirectional converter and charge controller. Then with the help of simple series LC branch we created the dc grid and connected the PV and the Battery management system to the grid as discussed in the block diagram.

Then we designed the 3-phase inverter with the LC filter and then we feed the power to the 3-phase load. The load is designed with the help of 3-Phase series RLC load where only the resistor is considered.[5]

Simulink block of the PV Grid is shown at Figure 3.
5. OUTPUTS

5.1. Simulation of Lithium-ION Battery
The output at Figure 4 is divided into 4 labels for four different parameter. The first window of the output shows the charging and discharging of current for a LI-ION battery. The current axis is in mAh and is let to charge and discharge in range of 20mAh in both the axis. The second window shows the terminal voltage and third window shows the SOC and the fourth window shows the Temperature.

5.2. Bidirectional chopper output
The first block of the output shows the SOC characteristics of battery with bidirectional chopper where the second block of the output shows the current characteristics of battery with bidirectional chopper and the last block of the output shows the voltage characteristics of battery with bidirectional chopper.
5.3. **PV Grid Outputs**

The PV grid outputs are given below figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

**Figure 5.** The output is for the voltage and current characteristics of battery connected in the grid.

**Figure 6.** The voltage and current characteristics of battery.
Figure 7. The overall output in the system with respect to PV, Load and Battery

Figure 8. PV voltage with MPPT

Figure 9. The first window of the output represents 3-phase line voltage and second window represents 3-phase voltage
5.4. Inverter output

![Battery discharge characteristics](image)

Figure 10. Battery discharge characteristics

6. Conclusion
Power electronic converters can be used in the modelling of solar module and in the MPPT in order to increase the energy extracted from solar resources. A bidirectional converter is very useful in between the PV system and battery so that power can be transferred between PV system and battery, as Bidirectional converter helps the power to flow in both direction. The simulation were effective as during the designing of bidirectional converter we were able to control the SOC of Li-Ion battery and also, during low load the PV was supplying the load and battery was being charged and during high load, the demand is met by both PV and battery, which was the objective of the simulation.

7. Future scope
Since it is a renewable energy grid, we can add other forms of renewable energy like Wind energy as an external source of power along with the solar energy. The PV cell can be designed with much more power rating so that it can be applicable for feeding power in remote area. The design of inverter can be upgraded so that it will have low harmonics for larger application with reduced in THD and TDD.

Further study can be done in the area of lithium ion battery with respect to impedance control for better performance and life span of the battery. We can also design the new charge controller for the battery that will help for faster response than it is having now with consideration of state of charge along with the current control. We can focus for ON-Grid connection of renewable energy.

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