Grid-Interfaced Solar PV Powered System for Electric Vehicle Battery Application

B. Pakkiraiah[1*], *P.* Madhav[1], *R.* Vishnu[1], *O.* Nitish Kumar[1], *E.* Nithish[1], *P.* Ravikanth[1]

[1]Gokaraju Rangaraju Institute of Engineering and Technology, EEE Department, Hyderabad

Abstract – The main aim of the project is to develop a system to charge the electric vehicle battery continuously and to control the three phase grid system. The perturb and observe method is used to get the maximum power from the solar PV array. The electric vehicle battery is connected at bi directional converter at the DC link and the Dc link is also connected at to the voltage source converter, this electric vehicle battery gets charged at low load demand and discharged at high load demand. This converter usually maintains the maximum power at the DC link by this the electric vehicle battery can be charged by taking a low rated battery to store energy of extra power. An adaptive recursive digital filter is used in better way to the maximum results with grid-connected solar PV-Electric vehicle battery system. The system with recursive filter control is controllable when the solar insolation is changing and load demand change. VSC works efficiently without any disturbance under no solar power generation and transfers the reactive power to the grid. The project is done with the help of simulation in MATLAB and test results on a hardware prototype is done through both in steady state conditions and dynamic conditions.

1 Introduction

Both the cheaper price of PV modules and the trend towards rising global oil prices have increased significantly. The rapid growth of the EVB as a new mode of transportation has also been hastened by the rise in demand for grid integration of solar photovoltaic (PV) arrays with electric vehicle battery (EVB) charging systems. Due to the unconnected issue with solar PV power caused by changes in temperature and solar insolation, enhanced P&O methods and maximum power point tracking (MPPT) approaches are required, adding to the system's complexity. The utility grid-integrated solar PV system's innovative converter, which converts both DC to DC and DC to AC, has a low-cost, high-efficiency single-stage architecture. To lessen the effects of solar PV arrays, such as voltage increases or peak load demand, the battery integrated plug-in EVs and the vehicle-to-grid concept.Several working modes, including EV to grid, utility grid to EV, solar PV power to utility grid, and solar power to charge EVB. This method improves the utility grid's power quality by reducing harmonics and correcting power factor. The EVB is charged and discharged in accordance with the change in load. At low unit prices of electric energy/absolute load situations or high unit prices of electric energy, the current controller also regulates the charging or

* Corresponding author: pakki1988@gmail.com

discharging operation of the EVB respectively. The IEEE-519 standard is followed when measuring the THD for grid currents.

2 PV Array

A PV cell is a combinations of photovoltaic modules, one of which is shown in figure 1. Each PV array is made of multiple combinations of PV cells The sun energy is transformed into electrical energy using these cells.. PV modules are also called as solar panels. Solar panels are widely is used because they are weather resistant and they are very efficient to use. Major problem with this PV array is it can't generate energy when is no solar energy and also due to weather conditions it cannot absorbs the maximum power. Now we are using this PV array for charging of the electric vehicle battery and the extra power generated is given to the grid by this we can save the extra energy generated by the solar PV array and also we can use this upto maximum extent based on use.

Fig. 1 PV Array

These panels are used in household, industries and many other companies. Now a days people are keeping this panels on their roof top to store the energy when they are constructing their house.
PV cells works on the principle of photovoltaic effect that can convert light energy into electricity. These solar panels absorbs solar energy from the sun this energy helps to flow of charge in solar panel between two layers. To produce the highest output voltage, the solar panels are wired either in series or parallel.

3 Control Schemes

The control schemes consists of Bi directional converter, Voltage source converter, MPPT technique.

3.1 BI-DIRECTIONAL CONVERTER

Bidirectional converters are now primarily utilised in electric vehicles. Another name for it is a DC-DC half-bridge converter. The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in antiparallel across one another. A bidirectional converter functions both ways.A Half-Bridge DC-DC converter is another name for it.

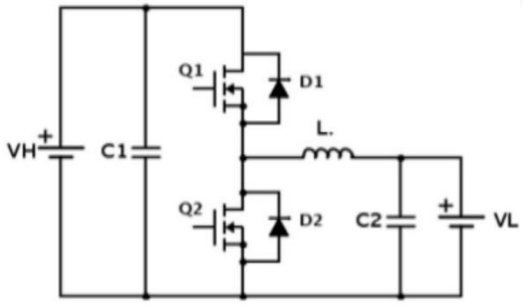


Fig. 2 Bi Directional converter circuit

3.2.1 Description

Now a days Bidirectional converter is mainly used in electric The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in anti parallel across one another. A bidirectional converter functions both ways. A Half-Bridge DC-DC converter is another name for it. The resultant circuit, a bidirectional converter, performs both boost and buck operations when the buck and boost converters are coupled in anti parallel across one another. The functionality of a bidirectional converter is reciprocal. Depending on how Mosfets Q1 and Q2 are turned on, the circuit described above can operate in either buck mode or boost mode. Due to the fact that the anti-parallel diodes D1 and D2 function as freewheeling diodes, the circuit can adjust the voltage supplied across the switches Q1 and Q2 in parallel as needed. To ensure that the inductor current flows continuously, the minimum inductor size is set at an inductor value that is 25% bigger than the minimum inductor value.To cut switching losses, lower switch costs, and boost converter efficiency, switching frequency selection is crucial. Boost Mode, Mode 1: Switch Q2 and diode D1 start conducting in this mode based on duty cycle, but switches Q1 and D2 are always off. Additionally, it is possible to divide this mode of operation into two intervals dependent on the conductivity of the switch Q1 and the diode D2. Buck Mode, Mode 2: In this mode, switch Q2 and diode D1 are always off, whereas switch Q1 and diode D2 begin to conduct as the duty cycle increases. The conductivity of the switch Q2 and the diode D1 can also be used to divide this mode into two intervals.

3.2VOLTAGE SOURCE CONVERTER

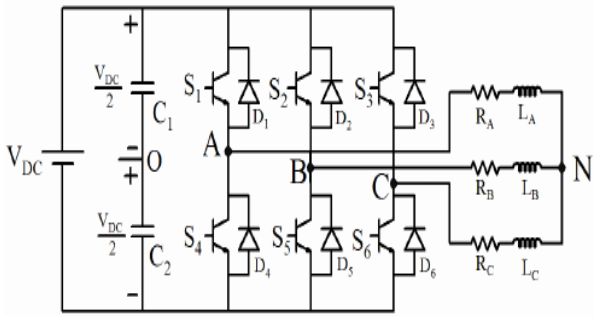


Fig. 3 Voltage Source Converter Circuit

3.2.1 Description:

During the day time the voltage source converter works as inverter which converts DC to AC to the grid. Because during day time power supplied to the battery is by solar panel.

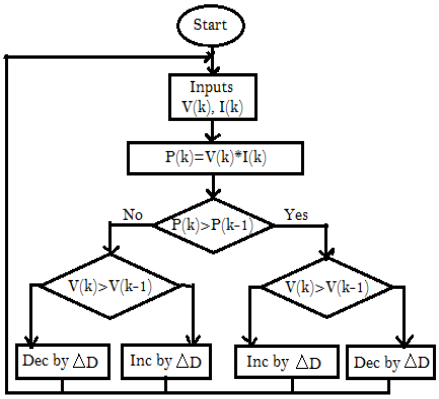
During night solar power is not active so the power is generated by the grid so the converter acts as rectifier which converts AC to DC.
In order to store the excess power during times when there is less need for it, a battery with a low voltage rating is selected. The grid's energy management and control strategies with regard to the PV battery system are presented. The voltage source converter is operated using a recursive digital adaptive filter-based control approach, which automatically detects when to run in rectifier mode and inverter mode.

3.3MPPT ALGORITHM

3.3.1 Description

The output of the PV array does not remains constant because change in the temperature and irradiance we cannot provide constant temperature and irradiance to the PV array practically. To get the highest output power from the PV array we use different MPPT techniques. This will give maximum power from the different energy sources. In this we are using two MPPT techniques P and O method and Incremental Conductance method because generally they are used in many industries and they are most popular. This method is used to get the maximum output from the solar panels.

3.3.2 P and O Algorithm Method:



From the above flowchart first we read the input voltage and current then we calculate the power from this. We will add one step delay and memory block to store the previous value. Now we will compare the present values and previous values if it is greater than or it is positive we will move to the other step if the condition is not met we go back to the previous step. When we reach the maximum point the operating point oscillates around that point. Then we will reverse it the obtained point is maximum power point. In this way we use the P and O method. It is very simple to understand and very easy to use. But it does not track maximum power when atmospheric conditions changes.
This method varies the power of the before step with the power of the new step The flow chart of P&O MPPT algorithm is described and method has been discussed.
The operating point near the maximum power point if dP/dV>0.
The operating point departs from the maximum power point if dP/dV is less than 0.

4 SYSTEM MODELING

4.1 System configuration

The solar PV-EVB charging system was connected to the utility grid. The DC link of the VSC, which has three insulated gate bipolar transistor legs and converts DC current into

AC, is connected to the solar PV array. As a result, using a bidirectional converter reduces expenses and losses. The common DC link includes a bidirectional DC-DC converter are connected to the point of common connection (PCC) via interface inductors. A ripple filters is linked to the Point of Common Coupling to reduce switching harmonics produced by the voltage source converter, which also includes the non-linear load.

The parameters of the system are

Bidirectional Converter: L=0.2H and R=50 ohms

Three phase grid: Cf =10μF, Rf =5ohms, fgrid =50Hz, Vab =220V, Lf=5mH

Vdc =360 V, Cdc =3mF.

Filter parameters: constants of filter τ1 = 12e-3, minimum frequency fs = 40 Hz, Proportional gain Kp=0.8,Integral gain Ki = 0.2

Battery data: Nominal voltage(v) = 1.2 V, Rated Capacity(Ah) = 6.5 Ah, Fully charged Voltage(v) = 1.4136 V, Nominal Discharge Current(A) = 1.3A

4.2 Control schemes

Control strategies The MPPT technique, recursive digital filter control of the VSC, and DC-DC buck-boost converter control of the EVB make up the system's control structure.

4.3 MPPT controller

P&O algorithm is used in the MPPT technology to obtain the greatest solar PV array power. The Vdc inputs serve as the DC link reference voltage, which is the MPPT control output. This maximum DC output voltage is given to the battery to gets charged by this controller it can also gets constant power supply without any variations.

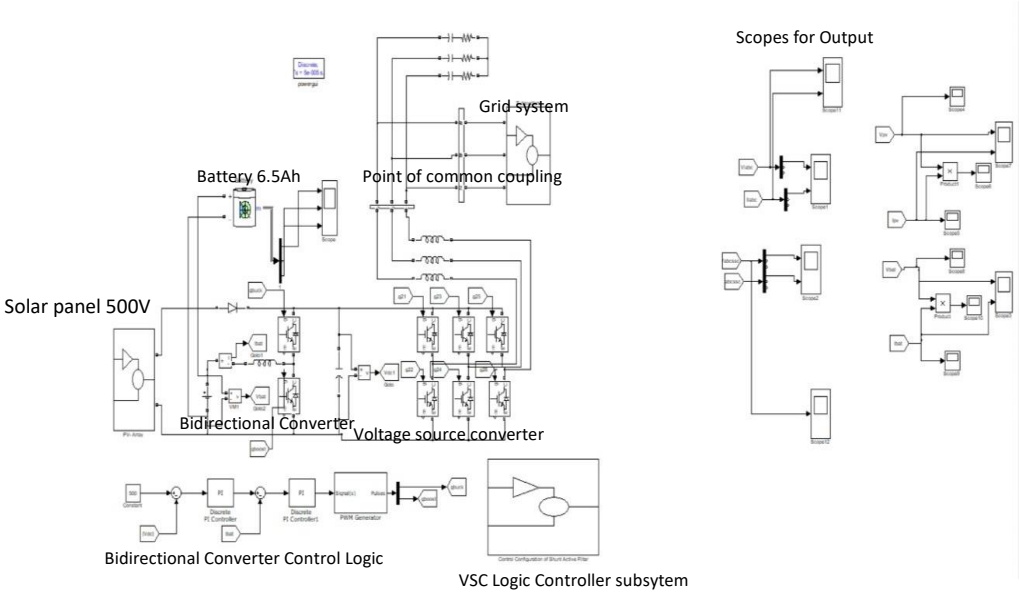


Fig. 4 Solar PV EVB Grid-interfaced simulation circuit

5 Results and Discussions

5.1 Steady State Output Characteristics

Presented about the steady state characteristics by giving constant values for solar insolation for 1000 irradiance and 25 degree celcius. The input voltage is of 500v for solar panel.
The output of voltage and current at the grid side is 200v avg and 20A avg. The output is pure sinusoidal because of maintaining the unity power factor and the values are fixed.

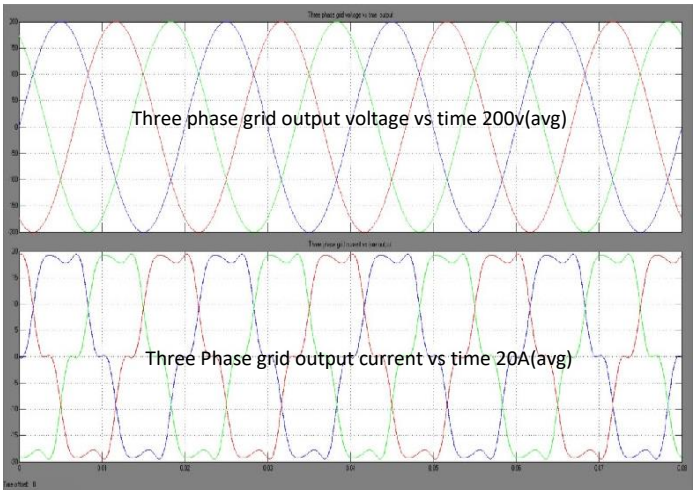


Fig. 5 Three phase sequence output characteristics of voltage, current

5.2 Output of the system by change in load

It is shown how the system responds when there is a load demand. The solar PV power remains constant while the load changes. Vpv and Ipv are unaffected. As the load decreases, the battery charge percentage rises, necessitating additional power storage for the EV battery.

5.3 Output of the system for change in solar insolation

Figure 6 depicts the system's performance when solar insolation is decreased, or when there is no solar electricity. As a result, the phase changes, the power flow direction is reversed, and the VSC acts as an active power filter. Given that load demand is constant, the supplies power to the load. Because there is less power transmission and there is no solar power, the discharge current of the battery decreases and eventually falls to zero.
Figure 7 depicts how the system behaves when there is a change in solar insolation. The magnitudes of ipv and ivsca are increased along with the solar irradiation. Thus, as solar insolation increases, more power is delivered to grid and battery also gets charged.

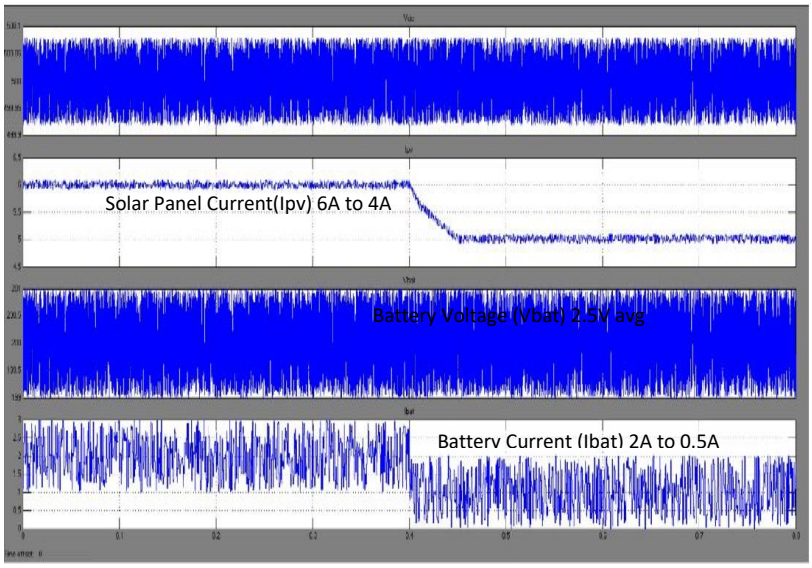


Fig. 6 Voltage of solar panel, Current in solar panel Ipv , Dc output voltage , Dc output current

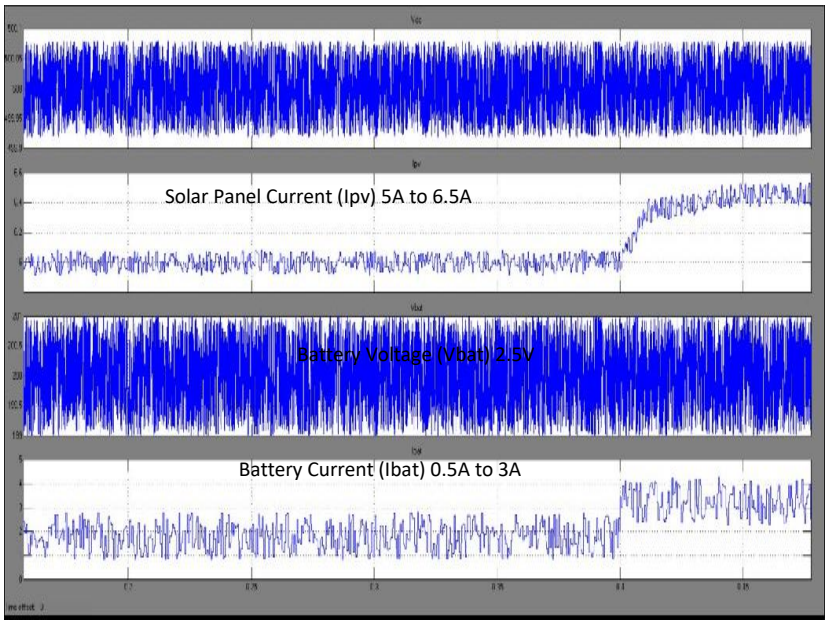


Fig. 7 Voltage of solar panel, Current in solar panel Ipv, Dc output voltage , Dc output current

5.3 Hardware prototype

It consists of solar panel 10W 0.5A, Lithium ion battery 8v, 5 pin relay, Transformers, Inverter, Bridge Rectifier, Bulb. This hardware prototype gives an idea about the real time project. This prototype perfectly works under different conditions and tested during different climatic conditions.

Here 5 pin relay is used to operate the system in two modes whether is rectifier or inverter mode. When there is a higher load demand, the solar energy is directly sent to the grid; however, when there is a lower load demand, the additional energy is used to charge the

battery. The voltage is stepped up and down using transformers. The LED screen displays the battery voltage.
The LED indicator shows the solar power is there and the power transferred through voltage regulator to supply the constant power to the system.
When there is no solar power the battery can be charged by the grid. By this the continuous power supply is given to the battery. When the battery charging is full on the availability of solar this extra power is transferred to the grid. By this there is no wastage in the power.
Lithium ion battery is used for the fast charging and it is long lasting. This battery is removable and kept in the electric vehicle at any time based on the use by this we can achieve easy use equipment.

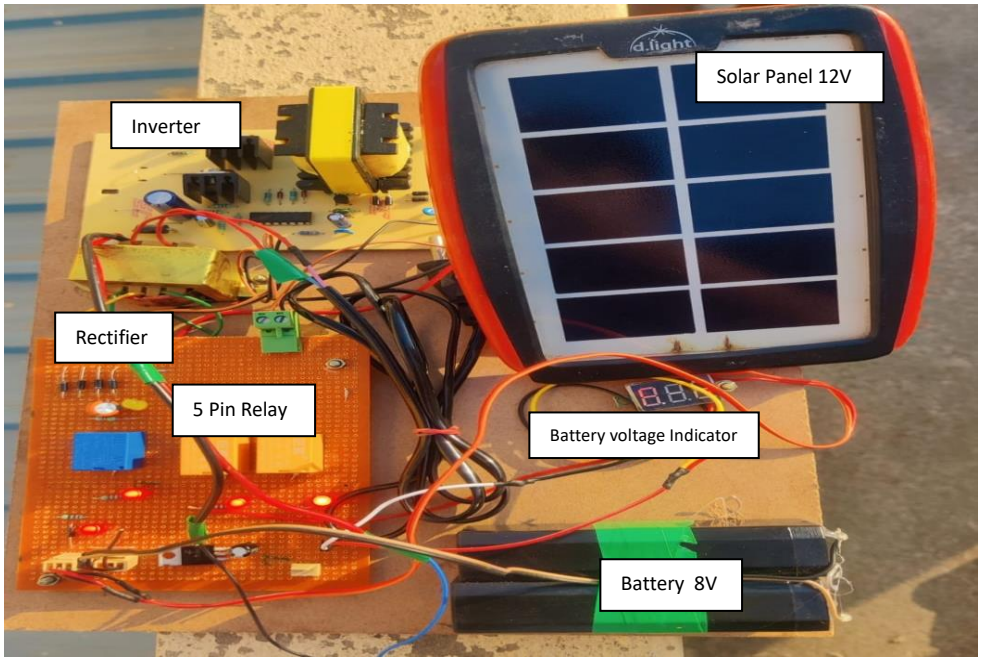


Fig. 8 Hardware Prototype

6 Conclusion

This grid-connected electric vehicle battery powered by solar PV has been built. By lowering harmonics and giving the system suitable quality power, this method supplies the grid active power while also guaranteeing an improvement in power quality. When the load demand is low, the electric vehicle battery stores more energy; when the load demand is high, it releases energy. To achieve MPPT voltage at the DC link, the electric vehicle battery is integrated over a bidirectional DC-DC converter. The electric car battery has been charged and discharged using a buck-boost converter. By switching the functions of the inverter to the rectifier and vice versa, No phase delay was induced by the recursive filter approach and by doing so, the harmonics are decreased. The simulation is run in MATLAB with a unity power factor operation and grid current harmonic reduction. The system's steady state and dynamic behaviour are shown when a solar PV array's solar insolation varies. The hardware prototype is developed based on the simulation the equipment gives the idea to build the real project and the estimated values are under prescribed limit.

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