PV Based Power Management system using Smart Inverter

Shivali Jain[1], Nikita Kamble[2], Utkarsh Mondkar[3], Vindhya Ranpise[4], Sarika Kuhikar[5]

[1,2,3,4]*Student, Department of Electronics Engineering, Vivekanand Education Society Institute of Technology, Mumbai ,Maharashtra, India*
[5]*Proffesor, Department of Electronics Engineering, Vivekanand Education Society Institute of Technology, Mumbai ,Maharashtra, India*

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Abstract - *Many photovoltaic system has been using battery storage system in order to tackle the issue regarding the power.This paper also covers the losses involved in power transmission. Information about the photovoltaic system with battery storage has been included in it. The previously happened research has been also included in it. Inverter , solar panel, buck converter and battery bank are the 4 main blocks of the system mentioned in this paper. The circuits that we have made are also included in this paper for our reference. Our aim is to provide a detail view on the power management in the solar PV system.*

Key Words: ***PV battery, Inverter, MPPT, Transformer, microgrid, battery bank.***

1.INTRODUCTION

As we all know that, there is scarcity of non-renewable resources such as petrol, diesel etc, which in turn increases the importance of renewable resources such as solar, wind and hydro. In the recent times the photovoltaic cell has become of great importance due to its characteristics like available in large quantity and clean nature. Due to this the installation cost of PV technology has been reduced significantly. Global warming is another reason for shifting to renewable sources of energy. The main application are household appliances, solar car, data communication uses PV power generation. But the main problem arrives is the power fluctuation in the PV system. At the same time this technology is difficult to implement due to its irradiance behaviour and continuously changing surrounding temperature. This is the reason that battery storage system is more coming into the picture.

The PV system stated in the paper consist of solar panel, an inverter, buck converter, battery bank. There are 2 paths in the system first which is directly going from solar to inverter and second one is from solar to battery bank to buck converter to inverter. This thing is necessary as in daytime we have the sunlight but there is no solar energy in the night. So, we stored the power in the battery bank for the night purpose. In past no of power management methods for PV battery system has been proposed in the literature. Some of them are discussed below. A wind PV battery-based energy management and control system has been introduced but the only problem it had was not being able to control the reactive power. After that another wind PV battery-based system cane into the picture which mainly focuses on optimization cost and size but it neglected the issue of dynamic power balancing, one more problem it had was it required huge data of past 30 years for power estimation by wind turbine and PV array. Another method was also proposed which focused on optimization instead of control methods. All of these methods were mainly focusing on power management between main PV battery unit and remaining generation units.

The system which is used to improve the power failure tragedy and also to improve the power quality of system is small scale microgrid. We have to study the stability and performance of PV battery system for the different loading effect, voltages and frequency. Effect of solar irradiance will result in the dynamic performance of the microgrid. Therefore, in order to have a stable system we need to modalized grid connected system. The very first step in the implementation is to model and to simulate the microgrid power system. PSCAD can be used to perform modelling. We can compare this microgrid to a rural hospital which requires 24*7 power supply.

The system we have implemented is earlier also implemented but with lots of losses occurring in their system. The similar system was implemented in [1] but in that project they have majorly focused own control and management and not on losses occurring in the system. The PV array we are using are considering its MPPT. We are going to place our solar at 20^0 inclination from ground considering the latitude longitude of Mumbai. At this inclination we are getting the maximum output from our PV array. This idea was discussed in [2] and in that they have also mentioned about MPPT which is discussed in section III. The grid which is discussed in [1] is of very high ratings whose implementation at college level is not possible so we have implemented a small scale microgrid taking the guidance of [3]. In [3] they have implemented a microgrid using both PV and wind turbine and have represented its simulation. We have implemented buck converter in the battery bank path whose guidance is taken from [4].

2. BLOCK DIAGRAM

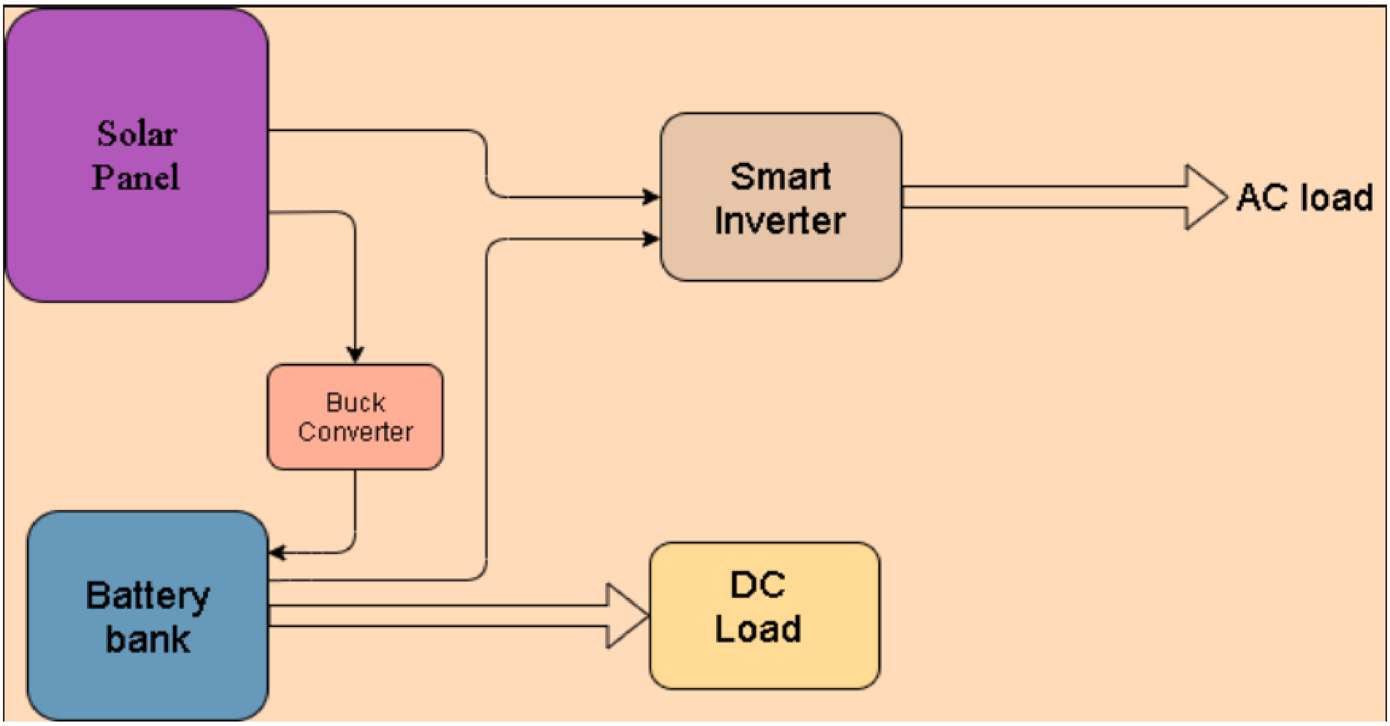

Fig -1

3. PV ARRAY:

As we all know because of Global Transition when the resources are shifted to renewable resource just to meet the consumers need for power. The photovoltaic (PV) is gaining huge acceptance among all the other available renewable resources. The use of PV power generations gives a lot of advantages such as it is portable, can be used in various applications (like household appliances, solar cars), it gives clean power. Besides the advantages, the fluctuations in the output of PV power cannot be ignored. So, to avoid the fluctuations battery storage is used. Thus, the performance of both the PV and the battery is taken into consideration. This microgrid representation gives a constant 24*7 supply. To maintain this constant supply, the battery is used at its full capacity i.e. 80-100%. The PV array also has a MPPT point know as Maximum Power Point Tracking. At this point the PV works at its Maximum power at any given temperature. The MPPT controller compares the PV array output and the battery voltage, and finds the best voltage to charge the battery i.e. put maximum current into the battery. It basically optimizes the match between the PV array and the battery bank or utility grid. The cases in which the battery works depends on the load, when the load demand is increased i.e. more than the PV array can supply the battery supplies the power and discharges according to the discharging rate. When the load is less, the PV array satisfies the load demand, and once the demand is satisfied it charges the battery. In the fig (2), the slope at MPPT point is zero. The buck converter is being controlled by this MPPT controller if applied. In our system we have not implemented the MPPT controller.

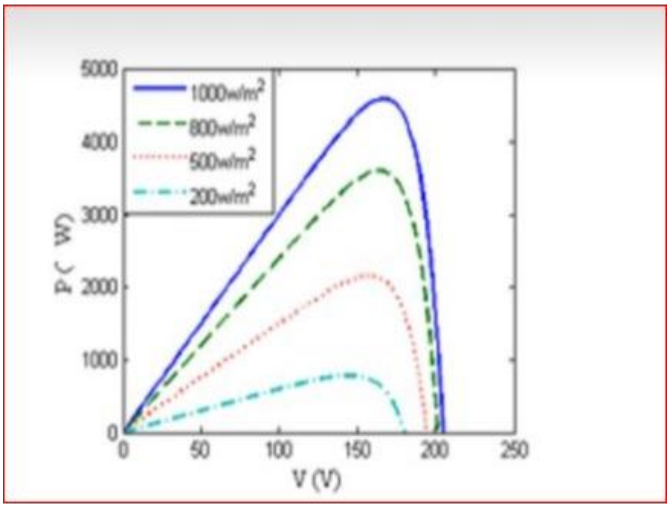

Fig -2

4. BUCK COPNVERTER:

The PV array we are using is giving us output of 18-20V, but the battery we are using is of 12V. So, we need to use a DC-DC buck converter to drop the voltage from 18V to 12V.Buck converter steps down the voltage while steps up the current. In this buck converter we have used a voltage regulator for stepping down the voltage to our desired value. The voltage conversion is controlled by a pot attached to it, by adjusting the pot we obtain the constant 12v output to the battery. In this we have use one semiconductor element which is a diode and two storage elements in combination that is capacitor and inductor. To reduce the voltage ripples in the output we can filters made with inductor and capacitor in combination. the buck converter we are implementing is given in fig (3).

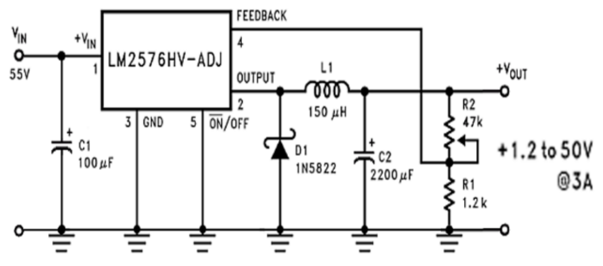

Fig -3

5. INVERTER:

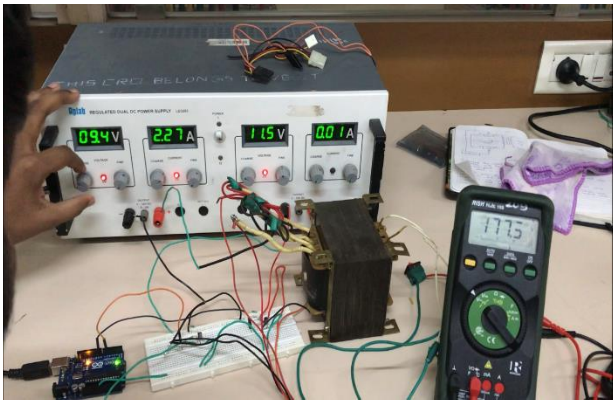

Fig-4.1

In this paper they have implemented a three Phase transformer using a three-phase inverter. They have operated their inverter in two modes in grid connected mode and islanded mode. In this system the CAPMS sets the mode in which it is operating by setting Islanded pin to 0 or 1 for grid connected mode and islanded mode respectively. In our project, we are building a single-phase inverter using a single-phase transformer. We have used power MOSFETS for proper switching operation to be conducted. The MOSFETS we are using are IRFZ44N (n-channel MOSFET). We are obtaining a 50 Hz frequency from the switching operation of this MOSFETS. We have applied square waveform input pulses from Arduino with a proper dead band, so that while switching between on and off of MOSFETS for small time they both are not on. To avoid this, we have applied a square waveform with proper dead band. The square waveform pulse can be adjusted with the pot attached to the Arduino. We are applying square waveform with minimum width as our input voltage is very large compare to the voltage it should be applied to the inverter. The solar panel we are using is generating 18-20 V output voltage. In the [1], they have joined a buck converter before the energy from solar goes to inverter. In our project to reduce the losses occurring from buck converter, we are not using the buck converter but instead of that we are making our inverter smart. Depending on the input voltage from solar panel our Arduino will change the pulse width of the square pulses we are applying from the Arduino to the MOSFETS.

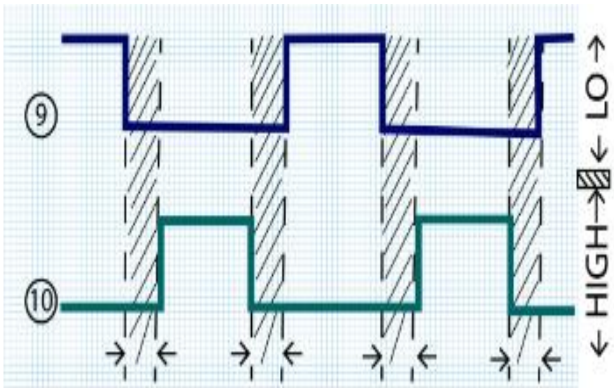

Fig-4.2

The main operation of the inverter in this project is to convert the DC to AC power. The proper designing steps of the inverter generally first includes deciding the load but here we have designed the inverter for the utility grid. Through the utility grid it can be used for many purposes. We have observed the output waveform of the inverter on CRO. While getting the output we didn't use the attenuation resistance cable for CRO so we got some attenuation in the output signal.

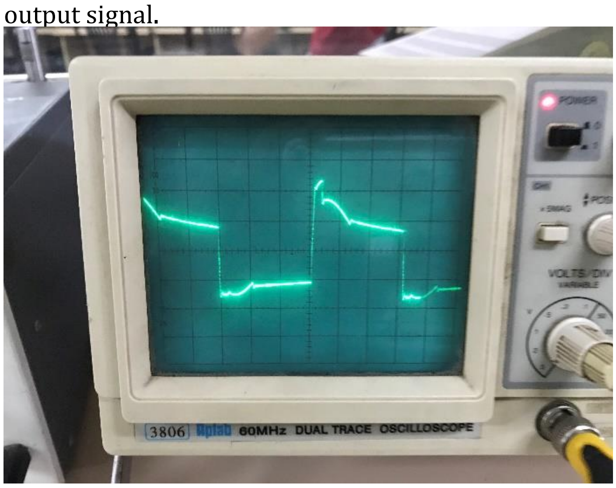

Fig-4.3

6. RESULTS:

We are getting 18-20V output from the solar panel we are using. we are applying it to the inverter and battery bank to get the DC load AC load working. In DC load we are applying a CPU fan of 5V. The current rating of the fan used is 0.27A which gives 2500 RPM. In the AC load we are connecting a bulb of 100W having current rating of 0.45 mA. This system has minimized the losses of buck converter in the AC load path by removing the buck converter from its path and making the inverter smart. This system is effective and reduces the losses to some extent.

7. CONCLUSIONS:

Power management is the greatest need of the time. There are lots of losses involved in power transmission. There are some fixed losses due to pen circuit, leakage current and dielectric losses this cannot be removed completely. We in this project have tried to reduce the losses to some extent. We cannot completely remove losses in power transmission but we can reduce it. In this project we have tried to done that only by removing the buck converter and making the inverter smart.

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BIOGRAPHIES

Shivali Jain student of Bachelor of engineering in Electronics from Vivekanand Education Society Institute of Technology, Mumbai University, Mumbai, India.

Nikita Kamble student of Bachelor of engineering in Electronics from Vivekanand Education Society Institute of Technology, Mumbai University, Mumbai, India.

Utkarsh Mondkar student of Bachelor of engineering in Electronics from Vivekanand Education Society Institute of Technology, Mumbai University, Mumbai, India.

Vindhya Ranpise student of Bachelor of engineering in Electronics from Vivekanand Education Society Institute of Technology, Mumbai University, Mumbai, India.

Prof. Sarika P. Kuhikar received M. Tech. in Power Electronics and Power System from G.H. Raisoni Institute of Engineering and Technology for Women, R.T.M Nagpur University, Nagpur, India. Currently working as Assistant Professor at Vivekanand Education Society Institute of Technology, Mumbai University, Mumbai, India